HAY ROAD SLUDGE DRYING SITE
CHERRY ISLAND
WILMINGTON, DELAWARE

Schnabel Reference 06150049

FOR

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

SITE INVESTIGATION AND RESTORATION BRANCH
391 LUKENS DRIVE
NEW CASTLE, DE 19720

December 20, 2006

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PREPARED BY

Schnabel Engineering
510 East Gay Street, West Chester, Pennsylvania 19380
Phone (610) 696-6066 Fax (610) 696-7771

Michael S. Roscoe, P.G.
Senior Associate

Dennis G. Grubb, Ph.D., P.E.
Senior Associate

EXECUTIVE SUMMARY

The Delaware Department of Natural Resources and Environmental Control (DNREC) retained Schnabel Engineering North, LLC (Schnabel) to perform an objective and independent third party evaluation of the proposed remedy for the DuPont Hay Road "Iron Rich" Site. The scope of services includes:

- Review of Technical Information
- Review of Remedial Alternatives
- Evaluation of Remedial Alternatives
- Review of Risk Assessments
- Review of Public Records
- Review of DuPont's Reponses to the Public Record
- Reporting

This report addresses each of the listed tasks in detail while this Executive Summary consolidates the findings and conclusions of each of the tasks.

We are providing this executive summary solely for purposes of overview. Any party that relies on this report must read the full report. This executive summary omits several details, any one of which could be very important to the proper application of the report.

The primary findings of the overall evaluation indicate concerns and/or deficiencies in the information and submittals relating to the: (1) Dredged Material (DM); (2) Ground water; (3) IRM; (4) Remedial Investigation/Risk Assessment (RI/RA); and (5) Focused Feasibility Study (FFS).

Dredged Material

It is the conclusion of our evaluation that the DM upon which the IRM is currently stored, and upon which it will be permanently stored in the proposed remedy, has not been sufficiently characterized. As presented in DuPont's documents and from our practical experience, there may be areas within the proposed remedy's footprint where hydraulic conductivities are on the order of $1x10^{-2}$ centimeters per second (cm/sec) or more (DuPont's June 9, 2000, Proposal for Remedial Action). This indicates that contamination may be relatively mobile. Additionally, the contamination data from the top two to twelve inches of the DM indicates that this horizon has already been impacted by iron, manganese, and hexachlorobenzene (HCB) from the IRM, as compared to regional DM contaminant levels. For these reasons, we believe that additional definitive data regarding the DM should be collected and analyzed from within the footprint of the proposed remedy. Correspondingly, the risk assessment and FFS process should be updated to reflect these data.

Ground Water

It is the conclusion of our evaluation that the ground water underlying the IRM has not been fully characterized, and ground water monitoring locations are not located to effectively: (1) establish the existing impacts of the stockpiled IRM on the ground water quality, and (2) to monitor the future impact of the proposed remedy. This includes the lack of ground water data within the footprint of

the IRM and in at least one key downgradient location near the point of discharge to the Delaware River. Additionally, semi volatile organic compounds such as HCB and hexachlorobutadiene (HCBD) reported in IRM and DM samples, which are potential constituents of concern (COC), have not been analyzed in past and current ground water monitoring events. Because of this, ground water has not been sufficiently characterized to effectively perform a focused FS and the associated risk assessment.

IRM

The evaluation of the IRM in relation to the proposed remedy indicates that the IRM has not been sufficiently characterized to allow for the effective risk assessment of the proposed remedy. The lack of characterization includes the lack of site-specific hydraulic conductivities established for the IRM and the significance of HCB, including its potential presence as a dense non-aqueous liquid (DNAPL) occurring within the IRM media. The lack of such characterization and related conceptualization with respect to the fate and transport modeling, risk assessment, and evaluation of remedial alternatives may be significant.

Risk Assessment

To the extent that site characterization data and conceptualization (of IRM and DM) serves as the foundation of the risk assessment, the human health and ecological risk assessments for the site may have significant shortcomings. Our evaluation indicates that related shortcomings and inconsistencies include representation of source/exposure point concentrations, conceptual assumptions, and input parameters used in fate and transport modeling analyses.

Moreover, the human health risk assessment (HHRA) has ignored a potentially critical exposure scenario related to offsite downwind receptors (including potential sensitive receptors). Similarly, the ecological risk assessment (ERA) appears to have inappropriately excluded hazards related to potential direct exposure to COC by wildlife (avian and terrestrial species were observed foraging in the IRM during our site reconnaissance visit), and the observed vegetation on the IRM pile serving as a potential food source and habitat for such wildlife. The ERA should also be revised to properly reflect the potential for migration of COC to relevant surface water bodies. Additionally, the off-site ecological exposure point concentrations and the subsequent ecological risk to aquatic organisms and human receptors vary significantly with COC concentrations in the IRM/DM, the vertical permeability of the IRM, and the hydraulic conductivity of the DM. These types of data should be collected from within the footprint of the IRM pile and its immediate vicinity for effective off-site ecological risk characterization.

Risk management practices, including implementation of worker health and safety measures, have been proposed as the basis for addressing potential direct exposure to the IRM. While in concept this rationale is sound, the site reconnaissance visit revealed the absence of such measures and practices by workers present at the site. This included the apparent lack of use of personal protective equipment and monitoring during operations and activities at/or immediately adjacent to the IRM during the site visit. Such risk management measures should be strictly enforced in order to protect workers.

Remedial Feasibility Studies

Remedial action objectives (RAOs) are established and were used in the feasibility, screening, and evaluation of proposed remedies. We believe the RAOs presented within DuPont's remedial feasibility studies are deficient. Additionally, the FFS proposes only to monitor ground water during/after the remedial measures, and has used language which appears to preclude corrective actions that require ground water manipulation, removal and/or treatment. The allowable concentrations provided for iron, manganese and HCB do not appear to be protective of human health and the environment. The RAOs for iron, manganese and HCB are too high to effectively protect humans and the ecology. For example, the RAO for HCB corresponds to the migration of free product (undiluted HCB).

Regarding the proposed remedy, we believe DuPont has overstated the design life of capping systems. They have apparently based these values on the durability and longevity of the base polymer used in a geomembrane, but the base polymer strength does not necessarily reflect its ability to perform the intended function once installed. We believe it is more likely on the order of a few decades. The longevity of geosynthetic clay liners (GCLs) is under increased scrutiny, and their use in capping systems is not likely to perform well. Regarding DuPont's other leading remedy, source removal and disposal, we believe that it was not exhaustively evaluated, particularly for the use of rail transportation options (in lieu of trucking).

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1.0 INTRODUCTION

The Delaware Department of Natural Resources and Environmental Control (DNREC) retained Schnabel Engineering North, LLC (Schnabel) to perform an objective and independent third party evaluation of the proposed remedy for the DuPont Hay Road "Iron Rich" Site. The scope of services includes the following tasks:

- Task 1 - Review of Technical Information
- Task 2 - Review of Remedial Alternatives
- Task 3 - Evaluation of Remedial Alternatives
- Task 4 - Review of Risk Assessments
- Task 5 - Review of Public Records
- Task 6 - Review of DuPont's Reponses to the Public Record
- Task 7 - Reporting

The following report is presented to complete Task 7 requirements and contains discussions of each of the tasks. Tasks 5 and 6 have been combined into a single section.

Schnabel contracted with ETIC and LRM Consulting, Inc. to support this effort on Task 4 activities. Their report (Appendix A) focuses principally on the risk assessment and data adequacy elements of the RI/RA. ETIC also supported Schnabel's efforts in the remaining tasks.

2.0 TASK 1 - TECHNICAL INFORMATION REVIEW

2.1 INTRODUCTION

Schnabel performed a review of documents, data, and information submitted to the Delaware Department of Natural Resources and Environmental Control (DNREC) by DuPont regarding the DuPont Hay Road Site in Wilmington, Delaware. The purpose was to evaluate the technical information and provide a professional opinion as to whether or not this data is sufficient to characterize the site and identify constituents of potential concern on the site.

We used the documents and reports submitted to DNREC by DuPont and its consultants regarding the proposed remediation of the Iron Rich Material (IRM) staging area for this review. Additionally, DuPont submitted reports and information to DNREC concerning closed Cells 1, 2, and 3 which are adjacent to and immediately west of the area of concern (Table 2-1). These reports which DuPont used to characterize the overall site including areas beneath the IRM are referenced but not included in DuPont's current submittals: mainly the Remedial Investigation/Risk Assessment (RI/RA) and Risk Assessment Reports. We did not assess these reports as part of his task because they were used for information purposes only.

The project documents that we reviewed for this task are listed in Table 2-1. We believe that these documents represented the overall public record on these issues, and contained sufficient information to conduct our evaluation. We also reviewed the guidance documents listed in Table 2-2, which recommend and or require the following factors be evaluated in characterizing a site and its hazardous substances:

1. With respect to physical setting and site characterization:

    a. Operational history
    b. Geology
    c. Hydrology
    d. Hydrogeology
    e. Soils
    f. Depth to saturation zone
    g. Hydraulic gradient
    h. Meteorology/Climate data
    i. Proximity to human population
    j. Proximity to surface water
    k. Proximity to wetlands
    l. Proximity to drinking water aquifers
    m. Proximity to floodplains

2. The nature and extent of contamination at the facility.

3. Potential routes of exposure.

4. With respect to hazardous substances present:

    a. Amount of material
    b. Concentrations
    c. Characteristics
    d. Environmental fate and transport
    e. Bioaccumulative properties
    f. Persistence
    g. Mobility
    h. Form

5. Current and potential ground water and surface water use.

6. Potential ecological injury including injury to natural resources.

7. The contribution of the substance to contamination of the air, land, water or food chain.

We have used the above list as the basis for the following evaluation of information and data contained within the referenced DuPont submittals.

2.2 PHYSICAL SETTING AND SITE CHARACTERIZATION

2.2.1 Operational History

DuPont provides a detailed synopsis of the site location and description as well as facility history and production volumes. The location of IRM produced prior to stockpiling is provided (i.e., within the confines of Cells 1, 2 and 3). Multiple maps are provided to illustrate the location of monitoring wells and test points used for historical site assessment. Overall, it is our opinion that DuPont adequately described the operational history of the facility in relation to the IRM.

2.2.2 Geology and Soils

The regional and local geology information provided is well documented. Stratigraphy, mineralogy and depositional environments are assessable through the evaluation of drill logs and geologic cross sections provided as attachments.

The strata/soil and sediments underlying the site (dredged material) are described in sufficient detail. Particle size and sorting are evaluated in an earlier report. Additionally, soil characteristics and engineering properties of the dredged material underlying the IRM are presented and evaluated in earlier investigative reports. DuPont's most recent submittal (the RI/RA) consolidates the results of these studies into a few representative samples. Permeability data is provided for several sampling locations west of the IRM storage pile. However, samples of the material beneath the IRM storage pile were not collected, and therefore not evaluated for their permeability characteristics. This issue is discussed further under Task 5.

The hydrogeologic data is mainly presented in the geology section of the submittals. Ground water flow maps and subsurface profiles were used to depict the ground water profile and hydraulic gradient. Ground water quality data is provided in multiple tables included with the submittals. The seasonal variations in the rate and volume of ground water, surface water interactions, recharge and discharge areas are not discussed in sufficient detail.

The chemical evaluation of the dredged material (DM) was performed and presented in multiple investigative reports, the summary of which was attached as tables to the RI/RA. It is our opinion that sufficient data was presented regarding the chemical characteristic of the DM in specific areas of the site, but we believe that this data may not reflect the IRM's impact on the dredged material in the eastern portion of the site. Additional comments and information regarding this aspect can be found in Tasks 2, 3, 4, 5, and 6.

2.2.3 Hydrology and Saturation Zones

Surface water information is provided for the Delaware River, Shellpot Creek and stormwater runoff (outfall D002). Analytical data was provided from these locations from as early as 1993 and as recent as 2005. On site stormwater sediment transportation and deposition are addressed by the use of several sediment control devices. Sufficient information and data were provided detailing both surrounding bodies of water including flow, stream dimensions, and water quality. Insufficient information was provided on flooding tendencies and surface to ground water relationships.

2.2.4 Meteorology and Climate

Meteorology data was collected from the Greater Wilmington New Castle County Airport, which is 6.2 miles southwest from the site. This data was considered by DuPont to be representative of conditions at the site, and included data on the average precipitation and wind speeds. Neither temperature data nor discussions on extreme weather conditions were present. The temperature may have little relevance to the IRM; however, extreme weather conditions including hurricanes and associated flooding which pose possible threats were not discussed.

2.2.5 Proximities

In their submittals, DuPont reported proximities to the nearest residence, neighborhood, hospital, surface water bodies, and drinking water wells. No information was provided for the proximity to wetlands or floodplains. However, the IRM storage pile is reported to be outside the 100-year floodplain based on the Federal Emergency Management Agency (FEMA) Flood Insurance Map.

During a recent on-site visit, we noted that there is a topographic low in the berm separating the site from the Delaware River near the southeast corner of the site and near stormwater outfall D002. This topographic low may alter the effectiveness of the berm in relation to high stage flooding. Because of this, it is our opinion that the reliance on the FEMA Flood Insurance Map is not sufficient. A more accurate comparison of the IRM's elevation in relation to the various flood levels should be assessed to determine the IRM's proximity and relation to the various flood levels.

It should be noted that an assessment of a 100-year flood on the project site was provided in DuPont's document dated June 15, 2005. However, there is a discrepancy between this document and the RI/RA report on the elevation of the 100-year flood. Also worth noting, these flood levels incorporate tidal effects, but not necessarily storm surges.

2.3 NATURE AND EXTENT OF CONTAMINATION

DuPont states in their submittals that there are two potential sources of contamination at the site: IRM, and DM.

2.4 IRM

For the IRM, several potential constituents of concern (COC) are listed based on the United States Environmental Protection Agency's (US EPA's) ground water risk assessment, which was used to

form the K-178 listing. The extent of these COC and several other constituents within the IRM are presented in tables attached to the Final RI/RA Report, and we believe them to be sufficient for characterization of the IRM.

2.4.1 Dredged Material (DM)

Information was not provided regarding the chemical characterization of the DM prior to DuPont's activities at the site. Recent samples of DM were collected for chemical analysis from within the confines of the original 22.5 acre IRM storage area footprint. It is our opinion that by limiting the sample locations to the previous IRM footprint, they did not achieve an adequate determination of the extent or presence of IRM-related contamination within the DM. A sample of DM that has not been in contact with IRM should be collected and analyzed to compare and establish the extent of IRM-related contamination, if any, in the dredged material. For additional information and comments on this subject, please see Tasks 2, 3, 4, 5, and 6.

2.4.2 Ground Water

The impact of the IRM and the dredged material on the ground water is provided in tables attached to the Final RI/RA Report (May 14, 2004), which reports that concentrations of iron, manganese, and chloride are above the Federal Safe Drinking Water Act's Secondary Maximum Contamination Levels (SMCL) upgradient as well as downgradient of the project site. DuPont states that the contributing cause is most likely associated with the historic DM. However, the source may be the IRM used as cover for Cells 1, 2, and 3 or the IRM itself. It should be noted that concentrations of iron and manganese in the DM beneath the IRM at this location are approximately twice the levels detected in DM stored in other regional confined disposal facilities (CDFs) along the Delaware River. Because of this, we believe that this data does not adequately address the ultimate source of ground water contamination.

2.5 POTENTIAL ROUTES OF EXPOSURE

The exposure pathways that were considered in DuPont's RI/RA Report include: direct contact, air/wind dispersion, ground water, and surface water.

2.5.1 Direct Contact

The direct contact exposure route with IRM is limited due to the security measures currently in place at the project site. Currently, direct contact with IRM by ecological receptors, contrary to DuPont's reports, is likely. We observed birds, rabbits and a fox on the IRM pile during our on-site visit on July 5, 2006. However, it is believed that the completion of the proposed remedy will reduce/eliminate the direct contact route, and therefore the data are sufficient.

2.5.2 Air

Air/wind-dispersed exposure route is most likely to be encountered by workers during the implementation of the proposed remedy. This route can be minimized by the use of personal protective equipment. The possibility of wind dispersion is currently limited due to temporary

measures, and vegetation growth. A polymer coating, Soil Sement®, utilized for dust control measures is periodically sprayed atop the IRM. A substantial vegetative growth has also limited the amount of air dispersion. It is our opinion that the information presented within the submittals is sufficient.

2.5.3 Ground Water

The ground water exposure route and supporting data are not sufficiently described in the documents as they apply to current conditions. Instead, focus is placed on the reduced leachate generating potential once a capping system is installed. With analytical data demonstrating the current leaching potential, we believe more emphasis should have been placed on the mobility and persistence of the COC. The migration path and expected exposure pathways are addressed in subsequent paragraphs of the Final RI/RA Report. No drinking water sources are within the vicinity of the site.

2.5.4 Surface Water

Surface water exposure routes include ingestion of fish and direct contact with surface water by recreational users and aquatic organisms. Mechanisms contributing to surface water contamination include stormwater runoff and wind dispersion. Stormwater runoff is monitored per the Solid Waste Landfill Post-Closure Permit. Wind dispersion is minimized as previously discussed. Additionally, during construction activities, wind dispersion of the IRM will be controlled by preventative measures. No other discussion on possible surface water exposures is included other than in the risk assessment. It is our opinion that the data and site practices are sufficient to characterize the risk of surface water contact.

2.6 CHARACTERISTICS OF HAZARDOUS SUBSTANCES

2.6.1 Amount of Material

The amount of IRM is estimated in DuPont's discussions on site history and description. The concentrations of COC can be averaged from the analytical data provided from the EPA's investigative report. This information could then be used to assess the amount of each COC, if needed.

2.6.2 Contaminants and Concentrations

As mentioned previously, the COC were selected from the US EPA's ground water risk assessment guidelines. Although, these were the only constituents selected for concern, other constituents were analyzed during soil and water testing. The analytical results for these other constituents were generally below detection limits, and below regulatory action levels.

2.6.3 Environmental Fate and Transport

Environmental fate and transport of the contaminants are discussed under the route of exposure topic.

2.6.4 Persistence and Bioaccumulative Properties

Persistence and bioaccumulative properties, including mobility and form, were not evaluated or presented in relation to contamination at or from the site. DuPont states in its RI/RA report that IRM does not support vegetation, and therefore is not a likely source of food for birds or burrowing animals. However, since the time the RI/RA report was submitted, vegetation has grown on the IRM, and therefore warrants consideration. It should be noted that this would not be an issue under either remedial alternative.

2.7 GROUND WATER AND SURFACE WATER USE

The potential and current ground water and surface water uses and users are discussed and effectively delineated in DuPont's submittals.

2.8 ECOLOGICAL AND NATURAL RESOURCES INJURY

The site, though not a robust wildlife habitat, does support a variety of wildlife. As noted previously, several types of birds and mammals were observed on-site. Ecology and natural resource injury was not discussed except in relation to the risk assessment, which concluded that a capping system would eliminate or reduce direct exposure and off-site migration. This in turn would minimize or eliminate ecological or natural resource injury. Discussions regarding IRM impact to surface and ground water can be found in the "Potential Routes of Exposure" and "Nature an Extent of Contamination."

It should be noted that during the site visit, we observed several erosion and surface maintenance issues which exposed the IRM to the environment, and potentially the wildlife currently on and passing through the site.

2.9 CONTAMINANT CONTRIBUTIONS

Data regarding the contribution of the COC to air, land, water, or food chain contained in the various DuPont submittals, with the exceptions noted in the "Potential Routes of Exposure" and "Nature an Extent of Contamination" in Tasks 2, 3, and 4, were sufficient to characterize the contribution of the contaminants to the various media.

2.10 CONCLUSION

The multiple investigative reports performed on the Hay Road Sludge Drying Site did not provide sufficient information and data to assess the site. Information was haphazardly extracted from prior studies and reports and, because of this the relevant information was not always effectively presented. Similarly, because information was extracted from multiple past reports, the tables summarizing the chemical properties of various media appear to be thrown together in an unorganized manner. This approach has lead to the potential of incorrect perceptions and confusion.

It should be noted that Tasks 2, 3, and 4 involve the evaluation of the data in relation to remedial alternatives and risk assessments regarding site specific exposure pathways and related risks. These evaluations may determine data deficiencies in certain areas that have not been addressed above.

TASK 1 - TECHNICAL INFORMATION REVIEW

Table 2-1

Project Documents

Title	Date	From
Geotechnical Investigation Proposed Cherry Island Landfill Cell 2	August 4, 1977	Woodward-Clyde Consultants
Supplemental Geotechnical Investigation Cherry Island Landfill Expansion Area	June 13, 1979	Woodward-Clyde Consultants
Geotechnical Investigation for Proposed cell No. 4 Cherry Island Landfill	April 2, 1990	Woodward-Clyde Consultants
Report of Geotechnical Investigation Cherry Island Landfill Closure	November 9, 1992	DuPont Engineering Technology (DuET)
Proposal for Remedial Action and Transmittal of Pre-design Investigation Results DuPont Cherry Island Landfill	June 6, 2000	DuET
Scope of Work for Remediation of Iron-Rich Staging Area	July 24, 2001	DuPont Corp. Remediation Group (CRG)
Estimation of Dioxin/Furan TEQs in Delaware River water, Sediments and Fish Due	July 26, 2001	R. Green, DNREC
Fish Contamination In Shellpot Creek	July 1, 2001	R. Green, DNREC
Cherry Island Staging Area Potential Historic Release Assessment	November-01	DuET, CRG, and DuPont Haskell Laboratory
Staging Pile Material Exposure and Risk Evaluation	September-01	ENVIRON International Corporation
Cherry Island Staging Area Potential Historic Release Assessment Update	September-02	DuET, CRG, and DuPont Haskell Laboratory
Screening Assessment of Shellpot Creek	September-02	ENVIRON International Corporation
2002 Annual Hydrogeologic Report Cherry Island Landfill	January 29, 2003	CRG
Cherry Island Staging Area Potential Historic Release Assessment Update	December-03	DuET, CRG, and DuPont Haskell Laboratory
Final Remedial Investigation/Risk Assessment Report Cherry Island Landfill Iron-Rich Staging Area/Hay Street Sludge Drying Site (DE-024)	May 14, 2004	CRG
Focus Feasibility Study Cherry Island Landfill Iron-Rich Staging Area/Hay Street Sludge Drying Site (DE-024)	June 18, 2004	CRG
DNREC Proposed Plan of Remedial Action DNREC Project No. (DE-0024)	December 14, 2004	DNREC
Cherry Island Ground Water Sampling Data	April 6, 2005	Lancaster Laboratories
Updated Remedy Implementation Risk Evaluation	April 8, 2005	ENVIRON International Corporation
Cherry Island Ground Water Sampling Data	May 23, 2005	Alta Analysis Lab
Response to DNREC "Items That Need Additional Support" Cherry Island Iron-Rich Staging Area	June 15, 2005	DuPont Engineering

TASK 1 - TECHNICAL INFORMATION REVIEW

Table 2-2

Governing Regulations and Guidance

Title	Date	From
HSCA Guidance Manual	October-94	DNREC
Remediation Standards Guidance under the Delaware HSCA	December-99	DNREC
Delaware Regulations Governing Hazardous Substance Cleanup	February-02	DNREC
Uniform Environmental Covenants Act (Delaware adopted in 2005)	August-03	UECA
Standard Operating Procedures for Analytical Programs Under HSCA	October-04	DNREC

3.0 TASK 2 - REVIEW OF REMEDIAL ALTERNATIVES

3.1 INTRODUCTION

A focused feasibility study considering a limited number of remedial alternatives or the use of a presumptive remedy may be used in lieu of a normal feasibility study with the prior approval of the Department (DNREC). The following is a technical review of the document titled "Focused Feasibility Study-Cherry Island Landfill-Iron Rich Staging Area/Hay Road Sludge Drying Site (DE-024) Wilmington, Delaware" submitted by DuPont to the Delaware Department of Natural Resources and Environmental Control (DNREC) in partial satisfaction of specific regulatory requirements for the site. The review focused on the evaluation of the proposed remedial alternatives presented in the Focused Feasibility Study (FFS) to assess if the appropriate remedial alternatives were selected for screening (Subtask 1). Additionally, the review included an evaluation to determine if the screening process was appropriate and consistent with HSCA guidelines (Subtask 2).

Applicable Guidance

The following is a list of referenced guidance applied to the completion of this task:

- Code of Federal Regulations Title 40: Protection of Environment Parts 260-268 (40 CFR Parts 260-268)
- Delaware Hazardous Substance Cleanup Act (67 Del. Laws, c. 326 § 1)
- Department of Natural Resources and Environmental Control Contract for Professional Services, Attachment A, *Scope of Services Environmental Evaluation of the Proposed Remedy Hay Road Sludge Drying ("Iron Rich") Site*-May 25, 2006
- Delaware HSCA Guidance Manual Section 5, *Identification of Remedy*-October 1994
- Regulations Governing Hazardous Substance Cleanup Section 8.5, *Feasibility Study*-September 1996

Associated Documents

The following is a list of the most common documents referenced to complete this task:

- Scope of Work for the Voluntary Cleanup Agreement Cherry Island Iron-Rich Staging Area Site, Edge Moor, Delaware-July 26, 2001
- VCP Agreement-September 11, 2001
- Final Remedial Investigation/Risk Assessment (RI/RA) Report-May 14, 2004
- Focused Feasibility Study-June 18, 2004

3.2 SUBTASK 1 - REMEDIAL ALTERNATIVE SELECTION

To thoroughly assess the appropriateness of the selected remedial alternative, we reviewed various sections of the FFS in detail to check underlying assumptions and data.

Only those sections which were found to contain major questionable assumptions and conclusions bearing on the selection process are discussed below. Additional information, conclusions and recommendations regarding this topic can be found under Subtask 2 which follows this section.

The following discussion is organized by the Sections and Subsections contained within the FFS.

3.2.1 Section 2.0 - Development and Screening of Remedial Action Alternatives

3.2.1.1 Section 2.1 - Introduction

Section 2.1 short circuits the remediation technology evaluation by suggesting that the iron rich material (IRM) can only be treated by two approaches: Containment with institutional controls, and source removal & disposal. No technical justification for this statement is provided in later sections in the FFS. We are aware that DuPont has historically been and is currently actively engaged in evaluating remediation technologies and approaches. It does not appear that their experience acquired over the past 20 years has been brought to bear on the IRM challenge in terms of technology innovation, identification, selection and evaluation.

Upon cursory review, it appears that traditional pump & treat (the wastewater treatment plant is next door), funnel and gate technology, permeable reactive barriers, traditional stabilization/solidification (S/S), source removal and recycling of the IRM for mineral recovery (e.g., smelting) of iron (25% by dry weight) and manganese all apply as possible candidates for legitimate remedial implementation. Specifically, removal and metals recovery would also clearly resolve any issues associated with hydrocarbon contamination. Our discussion of these potential remedial alternatives has not taken into consideration that once the IRM is excavated and removed it becomes a RCRA K178 (hazardous) waste.

Moreover, containment need not solely take the form of capping with geomembranes, geosynthetic clay liners, but also may take the form of slurry walls, HDPE cut-off walls, and grout curtains, etc. These approaches have not been included as possible technologies nor reasons to discount them. It may very well be that a slurry wall in conjunction with a low permeability soil liner is equally protective of ground water and surface water.

Site redevelopment which could include multiple building footprints and paved areas all serve to minimize infiltration of precipitation, and continued site use can provide a revenue source for operations and maintenance (O&M). These issues should be factored into the overall site management approach to account for their incremental contributions to reducing the migration and hazards associated with the COC.

3.2.1.2 Section 2.2 - Identification of General Remedial Action Alternatives

This section appears to conflict with Section 2.1 in that remedial alternatives beyond the two "presumptive" remedies are presented. DuPont has not provided any technical documentation from prior projects or the literature that the proposed alternatives technically apply to the management of the IRM. As stated above, this list and the possible variations should be larger (possibly closer to 10 candidate technologies/approaches).

3.2.1.3 Section 2.3 - Identification and Screening of Process Option Technology Types

The identification and screening of site management options for addressing the long term disposition of the IRM are deficient. It is not clear: (1) which of the COC is driving remediation decision making; (2) if there is a hierarchy between the compounds; and (3) what (numerical) remedial targets are assigned for each COC.

Ordinarily, when tasked with treating a variety of COC in a waste material or at a site, a net is widely cast to determine all of the potentially applicable technologies for each COC, then the group as a whole. The applicability of each technology should have been established and understood in the context of the fate and transport of each COC.

Accordingly, a technology matrix identifying all possible technologies for implementation should have been developed with a level of specificity that would allow the various options to be ranked on the basis of the proven implementation, ability to effectively treat/immobilize/isolate each of the COC, etc. A list of commercial technologies, treatment trains and approaches should have been initially developed, then winnowed down on the basis of a critical and rigorous technical review. The mechanisms of treatment for each COC should have been identified with statements regarding anticipated treatment efficiency and permanence. The advantages, disadvantages and limitations (other than cost) of each approach and its technical merit have not been rigorously presented and considered.

To this potential technology list, the additional parameters required by the DNREC HSCA regulations should have been secondarily applied to determine if the solution can be applied in the State of Delaware. In other words, the DNREC HSCA regulations do not tell you what technologies apply to a given contamination/remediation scenario. Once the technologies are identified and vetted, the DNREC HSCA criteria are additionally applied (see Subtask 2 below). Lastly, other site management tools (deed restrictions, fencing, and security) intended to support the primary remedial approach should be presented separately, as they do not address remediation of the COC whatsoever. Accordingly, the format and list of remedial options presented in Section 2.3 are deficient.

Lastly, Table 2-Identification and Screening of Remedial Technologies of the FFS merely states that technologies are retained or rejected without a detailed explanation or justification. Nor is there any apparent logic that is being uniformly applied to the alternatives that were retained or rejected. The definition, context, and threshold criteria associated with the screening methods and designations are not rigorously or objectively presented. As stated above, the containment and treatment response actions are incompletely presented in terms of actual candidate technologies. Moreover, there are inconsistencies in the applied criteria. For instance, fencing is retained because it has the ability to prevent direct contact with IRM as does 24-hour security, but the latter is rejected because it does not eliminate the off-site transport threat (neither does fencing). So both should be retained or both should be rejected since they are virtually the same thing—means to control site access.

Additionally, the two treatment alternatives shown in Table 2 of the FFS are both rejected on the basis of "Not practicable or cost effective," which are two separate criteria that need to be independently defined and applied. However, we must conclude that the real reason cannot be "cost

effective" because "Source Removal and Disposal" has been retained with an estimated cost of $386 million.

While we cannot say that vitrification will be less than the amount listed for removal and disposal, traditional stabilization and solidification (S/S) for this type of material could be potentially much less than the source removal option, as may be other legitimate remediation candidate technologies.

The subsequent improvement in the geotechnical properties of the IRM associated with some other options may allow sufficient geotechnical strength for warehousing applications without the need for capping of any kind. If traditional S/S is viable and once the site is closed, the site could be redeveloped. The UECA allows for these options. Given the proximity to I-495, it appears that the site may be attractive to developers, warehousing and commercial entities. Additional information on this subject can be found in Section 4.

3.2.2 Section 3.0 - Detailed Analysis of the Alternatives

3.2.2.1 Section 3.1 - Detailed Analysis of Alternative 1

This alternative can be summarized as conventional landfill capping.

During the hearings, in Section 3.1.6, and in the June 15, 2005, letter, DuPont indicated that the lifetime of a geomembrane (GM) used for capping purposes may be upwards of 270 to 450 years based on the half-life of the GM, i.e., the time that the basic engineering parameters of the base polymer are reduced to 50% of their original value. DuPont's source of this information was White Paper #6 authored by the Geosynthetics Research Institute (GRI) (GRI, 2005b), which outlines the three stages of polymer degradation. Polymer stability in this regard must be differentiated from the actual in-situ performance of geosynthetics, in that the stability of the polymers is irrelevant if the installed geosynthetic is not adequately performing the intended function (reinforcement, separation, drainage, etc.), which speaks more directly to the concern of the public regarding the integrity and longevity of the capping system.

As summarized in Koerner (1998) and GRI White Paper #4 (GRI, 2005a) there are many factors which impact the design properties and in-situ performance of geosynthetics, including installation damage (tears, punctures, improper seaming, folds, stress concentrations), creep, particle intrusion/blinding, chemical and biological clogging, etc., the severity of which depends on the intended function of the geosynthetic. To account for these issues and depending on the sensitivity and/or critical nature of the intended function, a series of reduction factors (RFs) are applied to the ultimate strength, hydraulic conductivity, and other engineering parameters in a similar fashion. These RFs are then multiplied together, producing an overall RF that may be conservatively on the order of 10 to 20, depending on the exact geosynthetic application. The respective engineering parameter is then divided by the overall RF, which has the net effect of applying a *defacto* factor of safety (FS~10 to 20) to the engineering parameter of concern, thereby yielding an "allowable value" for design.

GRI (2005a) indicates that the use of an "allowable value" does not apply to GMs, because the containment function is somewhat different than geosynthetic applications involving strength and

drainage. Instead, it is noted in GRI (2005a) that the as-received properties should be used in design with no reduction factors, but generous factors of safety (FS) should be applied in the final design. If the RFs routinely applied to strength and drainage applications produce FSs on the order of 10 to 20, then the generous FSs applied to GM should be at least of this magnitude or probably higher. If DuPont's statement of lifetime for GM is based on polymer stability, then applying an FS on the order of 10 reduces the useful lifetime to 27 to 45 years. However, as stated earlier, failure of a GM is not practically defined as when the base polymer fails, but when the GM fails to continue limiting water or vapor flow below a specified threshold value. Peggs (2003) indicates that the maximum operational life of HDPE liners is on the order of 25 years.

Foose et al. (2001a,b; 2002) and Pegg (2003) provide a summary of leakage rates through liner systems, including those of greater sophistication than that proposed by DuPont. Leakage is to be expected and with 73% of the occurrences can be linked to the placement of cover materials over (on top of) the GM (Peggs, 2003). Cover systems are not that well studied, but if liner experience is to be our guide, DuPont's position on the expected performance should be considerably more modest than that presented. If DuPont believes the performance of GMs is substantially longer than what can be summarized from the literature, it should use data from its own capping systems to bolster its case.

Additionally, DuPont has discussed in the FFS the possible use of geosynthetic clay liners (GCLs) in lieu of a geomembrane; HDPE being the most preferred of the available polymers. The durability of GCLs is now drawing much attention and scrutiny due to the emerging concerns with the long-term performance of GCLs (Benson et al., 2004; Jo et al., 2005, 2006). Adverse interactions between the IRM and the GCL due to their high metal concentrations can be expected. Implementing either liner option, GM or GCL, has the potentially unintended consequence of rendering the site completely unusable for redevelopment or other industrial uses for the simple reason that any new foundation systems (i.e., piles) or ground improvements (e.g., compaction, utilities) would likely damage the liner. In essence, the installation of a liner of any kind effectively removes the parcel from further industrial use which is inconsistent with the perceived value of the tract of land. These factors should be more fully considered and addressed in the FFS.

3.2.2.2 Section 3.2 - Individual Analysis of Alternative 2

This alternative can be summarized as conventional excavation and removal by trucking only. The tone of this section appears to heavily emphasize the impracticability of this solution based on the risk assessment which indicates high transportation related risk via trucking. DuPont notes that the primary risk involved in this option is not handling the IRM, but rather offsite transportation to a disposal facility, and that this risk is 400 times greater than the capping solution, the preferred presumptive remedy.

It is our opinion that the transportation risk associated with the removal of the IRM is a false dilemma for four main reasons: (1) DuPont assumed and accepted the initial transportation risk of moving the IRM from the Edge Moor facility to the IRM stockpile (whether they understood the risk at that time is another matter); (2) DuPont ships IRM to the current disposal option in South Carolina on a regular basis, and has assumed and accepted that transportation risk as a standard business practice; (3) risks associated with trucking will be borne by subcontractors and their insurers, and do not necessitate or correlate with direct IRM exposure (transportation is not an exposure pathway);

and (4) other transportation options were not explored that significantly reduce both the risk and the cost of the removal & disposal action.

The excavation activity associated with this alternative can use standard equipment associated with large scale construction to optimize costs, and standard dust control practices can be implemented to mitigate offsite migration of IRM particles. DuPont has indicated in both the public meetings (March 2005) and in various reports that this risk is minimal and that placing IRM in containers presents no special challenges. The costs provided by DuPont for the IRM excavation shown in Section 1 of Table 4 of the FFS appear reasonable. The key issue then is an economic solution for transportation, regardless of whether the final disposition is disposal or resource recovery (i.e., metals extraction/ recycling/recovery).

DuPont has considered trucking as the only method of transportation to only one IRM disposal facility with a total estimate of 29.5 million miles and associated cost of $54.7 million. We consider the inclusion of only one option deficient, especially as DuPont already transports the currently produced IRM by rail from the Edge Moor facility. With respect to IRM disposal, DuPont has not identified a range of other facilities that can accept K178 listed wastes.

Moreover, the breaking point on transportation which favors rail over trucking is on the order of 300 to 500 miles one-way. Accordingly, there are two leading candidate transportation scenarios to be explored here involving rails, though others may exist: (1) trans-shipment of the IRM back to Edge Moor facility for loading onto gondola railcars; or (2) establishing a rail spur into the IRM site to enable direct loading of gondola cars onsite.

In Scenario 1 above, the roundtrip haul between the CI site and Edge Moor is less than 4 miles. For a triaxial truck with a 22.5 ton capacity, this constitutes 22,250 trips or approximately 89,000 miles, which is much less than the 29.5 million miles projected by DuPont for source removal and disposal. Gondola rail cars have an operational capacity on the order of 100 tons, requiring a total of 5,000 cars for the duration of the project. The Edge Moor facility is paved, which would limit the potential release of IRM during re-handling operations of the IRM.

Scenario 2 eliminates the road transportation entirely and re-handling operations at Edge Moor. A rail spur into the IRM site would have to be established including a bridge over the Shellpot Creek. The capital investment represented by the rail spur could add significant value to the property for re-sale purposes. Direct loading of gondola railcars from 30-ton off-road haul trucks may be more cost effective than under Scenario 1. Regardless, these are potentially viable options that were apparently not addressed, but should be evaluated.

3.2.3 Concluding Remarks and Recommendations

Remedial Alternative Screening Process

As discussed above, it is our opinion that the initial remedial alternative screening process did not consider a broad range of available remedial technologies, which had they been incorporated into the process may have passed the screening process. The choice of a "presumptive remedy(ies)" resulted in two extreme choices. Additionally, risks were incorporated and evaluated in the screening process

that: (1) have previously been accepted by DuPont in its regular operations, and (2) are not normally used in risk assessments.

Screened/Selected Remedial Alternatives

The useful life of the capping alternative has not been properly or rigorously established. Moreover, the installation of a cap essentially precludes continued industrial use of the site.

The offsite disposal alternative evaluation was not conducted in sufficient detail to accurately quantify the costs and risks.

Because of these two conclusions, there is the possibility that the most appropriate remedial alternative was not evaluated or proposed.

3.3 SUBTASK 2 - APPROPRIATENESS OF THE ALTERNATIVES SCREENING PROCESS AND HSCA CONFORMANCE

As required by Task 2 Subtask 2, we performed an in-depth review of the remedial alternatives screening process that was completed by the Corporate Remediation Group (CRG), an alliance between DuPont and URS Diamond, which was conducted to assess the process's appropriateness and adherence to Hazardous Substance Cleanup Act (HSCA) guidelines. The review centered on the FFS and associated documents submitted to DNREC by DuPont.

We conducted this evaluation of the remedial alternatives screening process assuming all requirements under the Voluntary Cleanup Program (VCP) Agreement other than the remedial alternatives screening process were conducted in accordance with applicable requirements as defined by Section 5.1.1 of the Delaware HSCA Guidance Manual.

3.3.1 General Comments

A focused feasibility study considering a limited number of remedial alternatives or the use of a presumptive remedy may be used in lieu of a normal feasibility study with the prior approval of the Department (DNREC). After a review of the in-hand and public record documents, it does not appear that prior approval for DuPont to perform a focused feasibility study was applied for or granted in any formal document. Section 3, paragraph four of the Scope of Work for the Voluntary Cleanup Agreement submitted to DNREC by DuPont states: *"The report (Feasibility Study) should be submitted in draft form for DNREC'S review. Once DNREC comments are incorporated, the PRP will issue a final focused feasibility study report."* DNREC's response to this document emphasized that the use of a presumptive remedy in the Feasibility Study was not applicable to this section (referring to *Feasibility Study*). A letter dated June 23, 2004, from DNREC to DuPont acknowledged receipt and approval of the report on June 18, 2004.

The FFS submitted by CRG referenced an out-of-date revision of the Delaware HSCA Guidance Manual. The study referenced a 1991 revision versus the latest and correct revision of October 1994 as outlined in the VCP Agreement. Through our correspondence with DNREC, it was established that no 1991 revision exists; therefore, the mistake is believed to be an error carried throughout the

document. However, small differences between the FFS and the 1994 Guidance Manual suggest that guidance may have been obtained from a source other than the 1994 revision.

Additionally, we noticed slight differences between the FFS and the Guidance Manual in regards to the reference of appendices. Appendix C, *Suggested FS Report Format* of the Delaware HSCA Guidance Manual is referenced as Appendix B in Section 1.1 of the FFS. The most prominent difference between the two documents is the layout. Although only a recommendation, Appendix C of the Guidance Manual, 1994, suggests the use of an *Introduction, Development of Remedial Action Alternatives, Screening of Alternatives, and Detailed Analysis of Alternatives* as a sufficient layout. The FFS submitted by CRG combined the second and third recommendations into one category entitled: *Development and Screening of Remedial Action Alternatives*. Also a subsection of the fourth recommendation was extracted as a stand alone section entitled: *Recommendation of Preferred Alternative and Justification*. A further discussion of certain FFS sections submitted by the CRG follows.

3.3.2 FFS Evaluation by Section

The following discussion references Sections and Subsections contained within the FFS.

3.3.2.1 Section 1.0 - Introduction

The introduction sufficiently describes the historic background of the site and facility in accordance with applicable guidance.

3.3.2.2 Section 2.0 - Development and Screening of Remedial Action Alternatives

3.3.2.2.1 Section 2.1 - Introduction

Although an incorrect HSCA Guidance Manual reference was cited, as previously noted, the basic components to address the Iron Rich Material (IRM) in accordance with the Guidance Manual were considered and followed. The degree to which these components were utilized is assessed in the corresponding sections.

This section also addresses the performance of a focused feasibility study emphasizing the review of a limited number of alternatives. Here it is claimed that the contamination problem points directly to two proven remedial technologies, capping with institutional/engineering controls and source removal and disposal. The appropriateness of performing the limited evaluation of remedial technologies was discussed previously in this section. The evaluation of whether these two selected remedial alternatives were indeed the best solutions is reviewed in Subtask 1 of Task 2.

3.3.2.2.2 Section 2.2 - Identification of General Remedial Response Actions

According to the Guidance Manual, identification of remedial response actions should include the specific contamination they are meant to address and the volume or area which exceeds the remedial action objectives (RAO) for the contamination. The FFS and particularly Table 1 of the FFS,

Identification of Remedial Response Actions, sufficiently describes the multiple media of concern and their relation to the contaminants of concern (COC), but fails to provide an assessment of the volume or area that exceeds the RAO for the COC. A discussion limited to the IRM reviews the volume and area of IRM in Section 1.4 of the FFS.

Although outside the scope of this task, another issue concerns the lack of numeric values for the quantitative RAO. Objectives 2 and 4, referencing Section 1.3.2 *Quantitative Remedial Action Objectives,* are more qualitative than quantitative. The assignment of finite qualitative goals for the cleanup effort may not be sufficient in order to adequately assess cleanup goals and standards. It is our opinion that the RAO should be reassessed to provide distinct quantitative goals.

3.3.2.2.3 Section 2.3 - *Identification and Screening of Process Options Technology Types*

Remedial technologies were selected and screened as summarized in Table 2 of the FFS. The screening process is documented and formatted in a manner nearly identical to the example Table 5-2 of the Guidance Manual.

Paragraph six of Section 2.3 of the FFS describes the use of a presumptive remedy established in the RAO, thereby limiting the remedial alternatives reviewed to two. A summary analysis of these two remedies as well as Institutional/Engineering Controls is claimed to be provided in Table 3 of the FFS. This table, assumed to mirror Table 5-3 of the Guidance Manual, is not apparently included in the FFS. Table 3 of the FFS is actually a cost analysis of remedial Alternative 1 referenced in paragraph seven. DuPont should provide this table and associated tables.

3.3.2.2.4 Section 2.4 - Development of Remedial Alternatives

It is our opinion that Section 2.4 of the FFS is deficient. The requirements' intended purpose, once the alternatives are identified, is to provide a detailed development of these alternatives to aid in the subsequent screening and evaluation of these alternatives. It should include a conceptual design of the various technology components as well as potential interactions among the technologies selected for the various media. The Guidance Manual has an extensive list of topics and information that should be addressed and provided. The FFS limits the use of this section to a brief introduction of the two selected remedial alternatives. Partial descriptions of the selected alternatives are included in Sections 3.1.1 and 3.2.1, but not to the extent recommended by the Guidance Manual.

3.3.2.3 Section 3.0 - Detailed Analysis of Alternative

The objective of this section is to present the relative advantages and disadvantages of the selected alternatives. This is completed by using the alternatives against ten criteria DNREC uses to select a preferred alternative. The relative strength and weaknesses for each approach should be listed in a qualitative and quantitative manner. The degree of uncertainty should be addressed as well. This process may be completed by either a direct comparison of the alternatives to their satisfaction of the criteria or by evaluating each alternative against the criteria and then comparing the alternatives to each criterion. The CRG selected the latter approach. However, a comparison of the alternatives for each criterion was not documented within the FFS. Appendix C of the Guidance Manual mentions

this step as optional as discussed on Pages 5-8 of the Guidance Manual; however, no such discussion was found. For alternatives that equally satisfy the ten criteria, an evaluation of capital expenses shall be used to establish preference. The CRG included cost as an eleventh criterion. Our review of the evaluation of each alternative in relation to the eleven criteria follows.

3.3.2.3.1 Section 3.1 - Detailed Analysis of Alternative 1 - Capping and Institutional/Engineering Controls

- Protection of public health, welfare, and the environment: Compliance cleanup levels or conditional cleanup levels are sufficiently addressed through the assessment of RAOs, as well as the use of ground water restrictions.

- Compliance with laws and regulations: Insufficient information is provided in this section. The RCRA Subtitle C, Hazardous Waste Regulations referenced would not be the only regulations or permits required under this remedial alternative.

- Community acceptance: The information for this section was not attainable at the time the report was filed; therefore, it should be considered now.

- Remediation monitoring: The RCRA Subtitle C, Hazardous Waste Regulations referenced above requires a bi-annual inspection. No mention of inspection methods or frequencies is addressed other than the ground water sampling requirements referencing Section 1.3.2. The Guidance Manual suggests considering the consequences of a failed remedy in this section; however, this was not evaluated.

- Permanence: This section discusses the permanence of the cap, but fails to address the multiple media or relationship to the COC. This section should address the amount of contamination destroyed, treated, left behind, and/or effectively eliminated as well as the associated risk.

- Technical practicability: The likelihood of success, ease of implementation, and reliability of technology, as well as the availability of the technology and services, are sufficiently addressed.

- Restoration time frame: A sufficient implementation schedule for this remedial alternative was not presented. The estimated time required to implement the alternative was provided. However, the time until the principal threats, secondary threats, or RAOs are addressed was not discussed.

- Reduction of toxicity, mobility and volume of contamination: This section sufficiently describes the mobility of the contamination on a qualitative basis, and the reduction in volume and toxicity on a quantitative basis.

- Long-term effectiveness: This section discusses the contamination remaining on site and the associated risk, and the permanence of the cap, but fails to address the multiple media or relationship to the COC. It also briefly mentions the requirement of a long-term operation

and maintenance program for repairs. However, it fails to address the difficulties associated with this long-term operation and maintenance program, the potential for the remedy's failure, and the associated risks.

- Short-term effectiveness: The moderate risks associated with the implementation of this remedy are sufficiently addressed. However, it fails to discuss the ease or availability of mitigation measures.

- Cost: There is no guidance provided for the assessment of the capital and operation maintenance cost effectiveness.

3.3.2.3.2 Section 3.2 - Detailed Analysis of Alternative 2 – Source Removal & Disposal

- Protection of public health, welfare, and the environment: Compliance cleanup levels or conditional cleanup levels are sufficiently addressed through the assessment of RAOs. This section includes information on the short-term associated risk, which should be addressed with the short-term effectiveness criterion.

- Compliance with laws and regulations: The applicable laws are directly and indirectly addressed through the reference to RCRA regulations and standards.

- Community acceptance: The information for this section was not attainable at the time the report was filed; therefore, it should be considered now.

- Remediation monitoring: While it may be true that removing the IRM would remove the source of contamination; it would not however remove the necessity of monitoring. The migration of contaminants outside of the IRM would require continued monitoring in order to determine the extent and condition of past contamination.

- Permanence: This section sufficiently describes the permanence of the remedy. It does not however discuss the residual contamination after the IRM has been removed.

- Technical practicability: The technical practicability has not in our opinion been sufficiently evaluated. The likelihood of this remedy meeting the performance specifications, the reliability of the technology, and the review of available technologies and specialists are not addressed. The ability to construct and implement the technology was sufficiently discussed.

- Restoration time frame: A sufficient implementation schedule for this remedial alternative was not presented. The estimated time required to implement the alternative was provided, but the time until the principal threats, secondary threats, or RAOs are addressed was not discussed.

- Reduction of toxicity, mobility and volume of contamination: This section sufficiently describes the mitigation of principal risks and the volume of containments removed from on-

site. The additional information provided in regards to the end product of incineration is beyond the scope of the FFS and is the concern of the incineration company.

- Long-term effectiveness: The long-term effectiveness of the remedy is not sufficiently addressed. Similar to the previous remedy, this section fails to address the potential for the remedy's failure and any associated risks.

- Short-term effectiveness: The analysis sufficiently evaluates the protection of the community, workers and environment during the implementation of the remedy. More detail on short term risks would have been appropriate in this section versus scattered throughout the above listed criteria.

- Cost: There is no guidance provided for the assessment of the capital and operation maintenance cost effectiveness.

3.3.2.4 Section 4.0 - Recommendation of Preferred Alternative

DNREC does not provide guidance for the selection of the preferred alternative remedy other than the selection criteria above. Documentation of the comparative analysis process should be provided. As mentioned above, when the first ten criteria are equally satisfied for each alternative, then the capital and operation and maintenance cost effectiveness are to be evaluated.

There are many differences between the two alternatives that may be used to distinguish one from the other. This evaluation should have been based on the evaluation of the first ten criteria prior to cost. Besides community acceptance, all other criteria were able to be evaluated at the time the FFS was filed. This section's only reference to a comparison made between the two alternatives is a cost-effectiveness decision. It is our opinion that a full evaluation of criteria should be assessed and presented.

3.3.3 Concluding Remarks and Recommendations

The following recommendations may aid in the completion of or providing further clarification on issues relating to the FFS. Some recommendations may not be necessary to meet the objectives of a feasibility study, but would indicate to the public DuPont's intention of making an unbiased evaluation of remedial alternatives.

The first recommendation is that the current FFS be reviewed for quality assurance purposes. Evaluate the discrepancies mentioned in this report for merit and make appropriate corrections as necessary. Discrepancies include, but are not limited to: incorrect reference to the appropriate guidance manual, reference to non-existent data in Table 3, and incorrect references or appendices. Also, the use of a presumptive remedy in a focused feasibility study may not be the most appropriate format. A full feasibility study may be more appropriate given the sensitive nature of the issue in the eyes of the general public.

Although only a suggested guidance, we recommend that Appendix C, *Suggested FS Report Format* of the Delaware HSCA Guidance Manual be followed more precisely. By following the Guidance

Manual's format, little room is left for error and question due to the consistency allotted by the Manual itself. Similarly, any deviance from the suggested Guidance should include a justification. Specifically, any presumptive measure should be fully documented with correspondences, dates, and the results of the discussion.

A more thorough explanation of any screening process would provide a better understanding of decisions and recommendations they provided. It would leave little doubt in the reader's mind as to the thoroughness of the process and allow for a smooth progression while reviewing the assessment of alternatives. More information could have been provided in multiple sections of the FFS. Three topics that could have benefited by more information are the development of remedial alternatives, the detailed analysis of alternatives, and the cost analysis of the alternatives.

Failure to provide and examine all the details associated with the final selected remedial alternatives may have caused one alternative to look more attractive than the other. It may have caused inflated/deflated costs or elevated/reduced risks. For example, the use of PPE by workers was not considered for Alternative 1 which would have resulted in an altered cost. Also, the failure to evaluate other forms of transportation for Alternative 2 may have distorted the short-term risk by accounting for the increase in truck traffic where marine transport or rail systems may have resulted in lower risk. A thorough analysis and description of available options would limit the perception of holes or flaws in decisions and diffuse the general public's misconceptions.

4.0 TASK 3 - REMEDIAL ALTERNATIVE EVALUATION - EXISTING AND PROJECTED LAND USES

The following is an evaluation of the adequacy of the proposed remedial action objectives (RAOs) in relation to current and potential land uses. This evaluation followed HSCA regulations, and guidance and requirements of the Uniform Environmental Covenants Act (UECA).

The current IRM site is zoned "industrial," which allows for a wide variety of onsite activities. DNREC has no authority to influence or mandate site uses by an owner. However, depending upon the site uses occurring or planned by the site owner, DNREC has the ability and authority to require that the site operations are protective of human health and the environment; and where HSCA and UECA are concerned, the requirements are memorialized by the UECA in a series of deed restrictions.

4.1 UECA

The UECA appears not to prevent redevelopment of the site; it creates a framework to address environmental closure, protection, site obligations and survivability through the enactment of necessary deed restrictions. It allows for amendments, including change of use of the site, re-zoning, etc., and is intended to facilitate property transactions. The UECA provides flexibility to properly manage a site, but it does not speak to the site owner's decision-making regarding remedial technologies and management strategies or land use. These issues are initiated by the site owner, which may include closure and no further use of the land. It is our understanding that DNREC has no jurisdiction in this regard.

That said, our review of the documents prepared by DuPont and their comments in the public meetings (2005) strongly suggest that while the site is zoned industrial, DuPont does not intend to productively use the areas comprised by the current stockpile and previously closed cells. In both the capping solution and removal alternatives, DuPont expresses no interest in the continued industrial use of the site despite requests from the public to make use of the site in some way. What is also clear is that the installation of a geomembrane cover over the stockpile essentially precludes further construction on the land, or will make the construction of structures above a liner very expensive.

The public has expressed an interest in the use of the land as continued industrial and/or rezoning to commercial, or other uses such as public access/parks, etc. None of the documents provided by DuPont suggest that DuPont has met with urban planners, developers, and the City of Wilmington to explore possible uses of the site. This seems very unusual given the urban nature of the site, its waterfront access, and proximity to I-495; all of which make the property very valuable and attractive for productive use, or closure followed by re-development. Future land planning may include such uses as development of the waterfront for port or marina-type activities, expansion of the nearby power and/or wastewater treatment plants, re-zoning to commercial and sale of the property, etc. The lack of any information and complete silence on the subject by DuPont suggest that they intend to close the site, erect a fence, lock the gate and leave the land fallow. There is every indication that the public is opposed to this course of action and will almost certainly continue to petition this through the appropriate venues.

5.0 TASK 4 - REVIEW AND COMMENT ON THE REMEDIAL INVESTIGATION/ RISK ASSESSMENT

As required by Task 4, we have reviewed the risk assessments which DuPont submitted to DNREC. Additionally, we reviewed the parameters used and the assumptions made within these risk assessments to determine their appropriateness and reasonableness in relation to HSCA guidelines. To support this effort, Schnabel contracted with ETIC and LRM Consulting, Inc., whose report has been included as Appendix A.

LRM's report focuses principally on the risk assessment and data adequacy elements of the RI/RA. LRM's comments on the risk assessments related to the 2005 re-evaluation by the World Health Organization (WHO) of toxicity equivalency factors (TEFs) for several specific congeners of 2,3,7,8-TCDD are presented in Appendix A (Attachment 1). The following sections outline the major deficiencies identified by Schnabel with regard to the RI/RA, and are presented below by section of the RI/RA.

5.1 FINAL RI/RA

5.1.1 Section 2.3 - Hydrogeology

The presented hydrogeology information is deficient to sufficiently characterize the conditions. Section 2.3 does not present the advection-diffusion-reaction equation (ADRE) for solute transport. Accordingly, the "ground water" movement does not properly account for the (additional) diffusive transport which is an important component of solute transport in fine-grained media such as IRM and DM. As discussed in Appendix A, DuPont's consultant, URS Diamond Group, has used a value of 1.7E-06 cm/sec for the hydraulic conductivity of the dredged material to calculate the seepage velocity of ground water, and the travel time for ground water and dissolved chemical transport from beneath the IRM pile to the banks of Shellpot Creek. Importantly, as presented in DuPont's documents, there are areas to the west of the IRM pile where hydraulic conductivity of the dredged material is on the order of $1x10^{-2}$ cm/sec (see DuPont's June 9, 2000, Proposal for Remedial Action). Although, hydraulic conductivity data are not available for the dredged material underneath the IRM pile, presence of sand lenses observed during the previous drilling in the area, and practical experience suggests that higher hydraulic conductivities are also expected within the footprint of the IRM pile. Using a hydraulic conductivity of $1x10^{-2}$ cm/sec, ground water seepage velocities are approximately four orders-of-magnitude higher than that those calculated by DuPont's consultant; correspondingly, chemical transport would be similarly accelerated. Also worth noting is that chemical transport will likely be accelerated due to the high concentration gradients (metals and organics) occurring between the IRM and underlying DM, and may act independently of a prevailing hydraulic gradient.

5.1.2 Section 2.7 - Ecology

The sensitive ecological receptors as presented by DuPont's consultant are deficient to sufficiently characterize the ecological risk from the IRM pile. For example, during a site reconnaissance visit conducted by staff from LRM, Schnabel, DuPont, and DNREC in July 2006, substantial vegetative

growth was noted on the IRM which serves as a source of food for wildlife. Correspondingly, avian species and terrestrial wildlife, including a red fox, were observed foraging on the IRM pile. DuPont should necessarily include a formal habitat study and, if applicable, include an assessment of potential exposure to endangered and/or special-status species relevant to the region.

5.1.3 Section 3.1.1 - Iron Rich

As discussed elsewhere, DuPont and DuPont's consultant Environ appear to have not used or cited the correct property data for hexachlorobenzene (HCB) and other compounds in their evaluations and assessments. A frequently used source for chemical property data is USEPA/600/8-90/003 which indicates that the solubility limit of HCB is $6x10^{-3}$ mg/L and the octanol-water partitioning coefficient (K_{ow}) is $1.75x10^{5}$. The values provided by Verschveven (1988) are in general agreement with these values.

The first important comparison of this data to the IRM information is that the detection limit for HCB (0.2 mg/L) reported by Lancaster Laboratories for the TCLP non-volatile extraction is approximately 3 times the solubility limit of HCB. The detection limit reported by Geosystems is 0.4 mg/L for similar analyses.

The significance of these discrepancies is that if pure HCB was present in the pores of the IR TCLP sample, its equilibrated pore water concentration would be completely undetected by the laboratory for any NAPL mole fraction up to purity (0 to 100% HCB). This means that on the basis of ground water samples (and/or TCLP), ground water data cannot be used to determine the presence or absence of DNAPL in the IRM stockpile. This leaves the soil data as the leading means by which to reasonably detect or rule out the presence of DNAPL.

Table 1 (page 3 of 3 of the RI/RA) of the IRM analysis prepared by DuPont is based on data reported by Lancaster Laboratories (and others) and indicates that there is between approximately 12 to 55 mg/kg HCB in the IR filter cake. For IR filter cake sample #DPE-SO-01, Lancaster Laboratories reports a value of 26 mg HCB/kg dry solid. For reference purposes, it is important to note that the convention for reporting soil contamination is to report the total mass of the COC occurring in the soil or soil-like media on the basis of the dry solids, regardless of whether the HCB was actually sorbed onto the particle surfaces, dissolved in water, present as a gas in the air-filled pores, or occurred as a separate liquid phase. In essence, the total contamination is "lumped together" and reported against the total soil mass - an easy measure to quantify.

Using this data to estimate the occurrence and potential fate of the HCB in the IRM, the total amount of HCB occurring in the filter cake sample must be "re-distributed" back into the phases that are recognized to occur in the original IR [solids (or organic matter), liquids (water, NAPL) and gases (air)] based on soil-volume and density relations and other representative characteristics of the soil or soil-like media which are important for chemical partitioning purposes. At equilibrium, the mass of HCB in each phase is not equal; its energy state is. Equating its energy between phases, or HCB's ability/preference to leave one phase for another, is estimated using a "fugacity" type calculation (USEPA 600/R-94/120).

Table 5-1 was prepared using a fugacity calculation based on the "soil concentration" of HCB in the IR filter cake sample (DPE-SO-01) using the minimum, average, and maximum values reported by DuPont. The physical properties are as referenced. For the simulation, the total mass detected was "re-distributed" among the solid (sorption via Freundlich isotherm), water, and (potential) NAPL phases given the non-volatile nature of HCB. The potential NAPL phase was considered to consist entirely of HCB (mole fraction equals unity) due to the very low to non-detect values of other organic COC (i.e., NAPL constituents). As the actual porosity (n) or organic matter content (f_{oc}) of the IR was not measured or reported, we conducted a parametric analyses using these parameters to determine how sensitive the distribution of HCB is based on these unknown parameters (Appendix B).

The porosity values (0.2 to 0.6) were taken to be representative to typical soil/sludge conditions, whereas the f_{oc}(0.1) was held constant as a conservatively high value to overestimate sorption in the absence of actual data (also upper limit for Freundlich isotherm applicability). Table 5-2 indicates that given the soil concentrations of HCB detected in the IRM, free (pure) product of HCB ranging between approximately 10 and 90 liters/m^3 of IRM is predicted. Even if the NAPL was not pure HCB, the absence of other organic COC suggests it is close to purity (X_{HCB}>0.9), which will not significantly change the result (e.g., NAPL does not disappear), and certainly well above what would be considered by the 10% rule (Mackay and Cherry, 1989; Feenstra and Cherry, 1990).

The main conclusion to be drawn from this simulation is that significant quantities of HCB exist in the IRM, and the soil concentrations point to the presence of free product. The other possible outcome is that the HCB occurs as an organic solid. Verschueren (1983) reports that HCB may occur as a white powder, so whether the HCB is occurring as a solid organic phase or DNAPL, it is present in significant quantities that will serve as a long-term source of ground water contamination that will remain entirely undetected by the current analytical procedures if the detection limits are not lowered.

Table 5-2 repeats the same general calculation, but is based on the HCB soil concentrations in the dredged material (DM). The HCB concentration in the case is on the order of 1.1 mg/kg (RI/RA), and the specific gravity and f_{oc}s have been adjusted to reflect DM properties. NAPL is again predicted to occur for the same range of porosities simulated, despite very high organic matter contents (though the sorption of HCB in DM is expected to be extremely complex and high). As HCB is not naturally or historically occurring in DM (to Schnabel's best knowledge), the presence of HCB in the DM suggests that HCB from the IR has already migrated downwards into the underlying DM at concentrations that suggest the presence of free product. As a solid, HCB would not migrate, but leach soluble HCB. This is a secondary indication that the HCB occurs as a NAPL.

The environmental data on HCB combined with these simulation results are strongly suggestive that HCB occurs as a DNAPL. It is therefore incumbent on DuPont to better characterize the IRM and the DM underlying the stockpile and DuPont IRM site to provide more definitive information regarding the potential presence of DNAPL. DNAPL does not require the infiltration of rainwater to migrate, and the presumptive capping solution will not prevent or attenuate any migration that can or has already occurred. This may also mean that the source removal option, if selected and implemented, may have to commence at elevations lower that previously thought.

5.1.4 Section 4.0 – Contaminant Fate and Transport

5.1.4.1 Potential Pathways of Exposure

The pathways of exposure identified by DuPont for the IRM staging area pile are deficient. DuPont ignored potential onsite ecological receptors (see above - avian and terrestrial wildlife were observed to be foraging on the IRM during a recent site visit) that may be exposed to the existing vegetation on the IRM pile for the direct exposure pathway. Exposure to chemicals from windblown deposition of particulates from the IRM pile to potential downwind offsite receptors has not been considered in the RA. Both of these pathways should be included in the revised risk assessments.

5.1.4.2 Ground Water Surface Water Discharges

In calculating exposure point concentrations (i.e., concentrations at which receptors would be exposed to chemicals) due to chemical transport from the IRM pile and the dredged material to the Delaware River and Shellpot Creek, DuPont's consultant has ignored the potential presence of sand lenses in the dredged material and applied arbitrary dilution factors (to simulate mixing of ground water with the surface water). These arbitrary and incorrect assumptions have resulted in increasing chemical cleanup levels for both the IRM and the dredged material; DNREC should reject these assumptions and the cleanup levels should be accordingly recalculated by DuPont's consultant.

Additional specific comments are included in Appendix A. They should be addressed by DuPont, and the risk assessments should be revised accordingly.

5.1.5 Section 5. 0 – Baseline Risk Assessment

5.1.5.1 Cleanup Standard Option for Human Health

The baseline human health risk assessment (HHRA) provided cumulative risk estimates for direct exposure to COC in impacted media (IRM, dredged material, and ground water) using Method I – Modified Uniform Risk Based Standard (URS) Approach of the DNREC guidance (Section 5.1). This approach is consistent with DNREC standards. The calculated cumulative carcinogenic risks are 2.0×10^{-5} and 1.96×10^{-6} from exposure to IRM and dredged material, respectively; both estimates are within the target acceptable risk range of 1.0×10^{-6} to 1.0×10^{-4}.

Because 2,3,7,8-TCDD was not reported above laboratory reporting limits, carcinogenic risk from direct exposure of dioxin and dioxin-like compounds in the IRM was not included in the calculated direct exposure cumulative carcinogenic risk. Average total TEQ levels in terms of 2,3,7,8-TCDD are 1,016 parts per trillion (ppt), which exceed DNREC's 2,3,7,8-TCDD threshold of 40 ppt. DNREC currently does not have a TEQ action level for dioxin and dioxin-like compounds, and may follow Region III EPA guidance (fax correspondence from DNREC, dated December 13, 2006). In a 1998 document (*Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-26*), USEPA recommends a TEQ action level of 5,000 to 20,000 ppt for dioxin and dioxin-like compounds. The average TEQ value (1,016 ppt using the 2005 WHO TEFs) in IRM is below the current commercial/industrial threshold. Provided DNREC establishes a TEQ action level consistent with current USEPA standard, and the new dioxin and dioxin-like compounds analytical data to be

collected from IRM (see data gap discussion elsewhere) is less than the USEPA commercial/industrial threshold, human health risk from direct exposure to these compounds contained in the IRM is not anticipated to be significant (see Appendix A - Attachment 1).

5.1.5.2 Ecological Risk Assessment

The identified pathways of exposure in the ERA are not complete. As discussed above, the onsite direct exposure pathway should be considered by DuPont's consultant, and the ERA should be revised accordingly.

For the surface water exposure scenario, the exposure point concentrations resulting from chemical transport from IRM and the dredged material should be reevaluated for comparison with existing DNREC standards for aquatic species (see comments in Section 5.1.4.2 above and in Appendix A - Attachment 1), and the excess human carcinogenic risk as a result of consumption of impacted fish should be recalculated.

For the surface water exposure scenario resulting from windblown deposition of IRM during dry weather and stormwater runoff during wet weather, DuPont's consultant has conducted an air dispersion modeling to estimate the exposure point concentrations for fish and other aquatic species which in turn would be consumed by human receptors. Calculated carcinogenic risk for dioxin and dioxin-like compounds ($2.0x10^{-7}$ to $1.8x10^{-6}$ using 1998 WHO TEFs and $2.27x10^{-7}$ to $2.04x10^{-6}$ using 2005 WHO TEFs) was within the acceptable risk range of $1.0x10^{-6}$ to $1.0x10^{-4}$. However, for dioxin and dioxin-like compounds, excess carcinogenic risk calculated by DNREC staff from existing analytical data of fish tissue samples collected from Shellpot Creek (at Hay Road) were on the order of $1.1x10^{-3}$ to $2.1x10^{-5}$ (2001 DNREC Internal Presentation). In addition to the dioxin contribution from the IRM pile, background dioxin levels in sediment may be contributing to the higher risk levels calculated using the fish tissue samples. Unless a presence of high background dioxin levels is established in sediments in the vicinity of the site and surrounding areas, a reassessment of DuPont's approach (and modeling) conducted to estimate the exposure point concentrations and subsequent excess carcinogenic risk is necessary to accurately estimate the carcinogenic risk as a result of exposure of fish (and subsequently humans) to dioxin-impacted sediments.

5.1.6 Section 7.0 - Proposed Remedial Action Objectives (RAOs)

The following problems are evident in the DuPont's proposed quantitative RAOs.

The statement of the 4th bullet which reads "prohibiting the withdrawal of ground water for other than environmental monitoring purposes…," precludes DuPont from using continuous and/or pulsed ground water pump-and-treat, or any other ground water removal scheme to mitigate against ground water contamination, once detected, and/or documented. Once the ground water is contaminated, corrective action involving any form of ground water manipulation appears completely precluded by the proposed RAO. DNREC should reject this RAO.

The last portion of the 5th bullet reads: "the maximum concentrations allowed in ground water will be 726,787 mg/L for iron, 242,262 mg/L for manganese and 1.9 mg/L for hexachlorobenzene."

Together, the iron and manganese total 969,049 mg/L. For reference purposes, "mg/L" has the same ratio as parts per million (ppm) (10^{-6}) based on the assumption of a dilute aqueous solution as the density of water is 1 g/cm^3. As such, the concentrations proposed for iron and manganese are essentially meaningless as ~970,000 mg/L is 97% by weight, disregarding the density of iron/manganese which may have increased this amount.

For perspective, the total dissolved solids (TDS) of brackish water are on the order of 1,000 to 10,000 mg/L (Freeze and Cherry, 1979), which may be taken to be approximately representative of the mid- to lower reaches of the Delaware River. TDS refers to the salts/residue remaining after the evaporation of the water (which would likewise occur if the IR-laden ground water was allowed to dry out. Ocean water has on the order of 10,000 to 100,000 mg/L of TDS, and brine water has greater than 100,000 mg/L TDS (Freeze and Cherry, 1979). For comparison, the salt content (~TDS) of the Dead Sea in Israel is on the order of 31.5% (315,000 ppm or mg/L).

Lastly, as indicated previously, the aqueous solubility limit of HCB is $6x10^{-3}$ mg/L which constitutes very little mass in the aqueous pore space. The RAO for the HCB of 1.9 mg/L is approximately 316 times greater than the solubility limit, which means that water saturated with HCB and actual droplets of HCB are permitted to migrate offsite, both undetected and untreated (see discussion on possible presence of DNAPL and detection limits), the latter occurring due to the constraint applied by the fourth RAO coupled with the very high permissible limit of HCB proposed by the fifth RAO. The RAO of 1.9 mg HCB/L roughly corresponds to a droplet on the order of 12 mm diameter migrating offsite in every liter of water. DNREC should reject this RAO.

6.0 TASK 5 - REVIEW OF PUBLIC RECORDS AND COMMUNITY CONCERNS & TASK 6 - REVIEW AND COMMENT ON RESPONSES

We reviewed various Public Record documents as part of Task 5 to identify the principal community concerns, and to provide a professional opinion (Task 6) as to whether or not these concerns have been properly addressed by the proposed remedy, by publicly available data, or by responses from E.I. DuPont de Nemours and Company (DuPont), and/or Department of Natural Resources and Environmental Control (DNREC). In certain cases, earlier technical reports not listed below were reviewed to compare historic data with information that was presented and submitted at the Public Hearings (hearings).

The primary Public Record documents which were reviewed consisted of the following:

- DuPont-DNREC Consent Order (October 30, 2001)
- Proposed Plan of Remedial Action-DNREC (December 14, 2004)
- PowerPoint presentation of DNREC's January 7, 2005, Workshop
- March 5, 7 and 9, 2005, Public Hearing transcripts and exhibits
- Updated Remedy Implementation Risk Evaluation-DuPont (April 2005)
- DuPont's June 15, 2005, report titled Responses to DNREC "Items That Need Additional Support"
- Various e-mails from concerned citizens to DNREC (2005)
- SHWMB Memorandum: Technical Review (June 27, 2005)

Additional subsidiary reports and documents were reviewed during the course of our investigation (Table 2-1).

6.1 PUBLIC CONCERNS

We grouped the principal public concerns that we noted during our review of the referenced documents into the following five areas:

1. Onsite versus offsite management of the Iron Rich Material (IRM).

    - Implementation of the proposed remedy.
    - The permanent loss of usable and public access land along the Delaware River.
    - The proximity of the IRM to the Delaware River, 100-year and 500-year floodplains.

2. The occurrence of hazardous compounds within the IRM, and their impact on the surrounding environment.

    - Dioxins in "large" amounts within the IRM.
    - Amounts and types of radioactive material within the IRM.
    - Hexachlorobenzene within the IRM (see Task 4).
    - Ferric Chloride within the manufacturing process and the IRM.
    - Arsenic at high concentrations within the IRM.

- Ground water and surface water contamination.

3. Regulatory.

    - The relationship of the major events including the DNREC-Resource Conservation and Recovery Act (RCRA) enforcement dates, the placement of the site into the Voluntary Cleanup Program (VCP) by DNREC, the Consent Order, and the K178 waste classification by the U.S. Environmental Protection Agency (EPA).
    - Relocation/movement of the IRM on site in 2002.
    - The justification and timing for the increase in the DNREC arsenic action level.
    - The permanent presence of "hazardous waste" and an unlicensed and unlined "hazardous waste landfill" in close proximity to the Delaware River, and located within the City of Wilmington and surrounding communities.
    - Extension of the public comment period.

4. Selection of remedial alternatives and performance of risk assessments.

    - Study effectively limited to two alternatives.
    - Disparity between the two alternatives.
    - Actual cost of the high cost alternative.
    - Thoroughness of the risk assessments including radionuclide issues.

5. The short-term and long-term safety of the proposed remedy.

    - Durability of the liner.
    - Lack of a bottom liner.
    - Condition of the existing cells.
    - DuPont's long-term future involvement at the site.

The following is a review and an evaluation of DuPont's and/or DNREC's responses to the principal concerns listed above. This review does not incorporate or reflect the findings of Tasks 2, 3 or 4 contained in earlier sections of this report.

6.2 ONSITE VERSUS OFFSITE MANAGEMENT

The primary concern expressed by the public and their representatives at the hearings and in documentation submitted to DNREC was the possibility of the IRM remaining on site rather than treating and disposing it off site. Additionally, concerns were expressed about the implementation of the proposed remedy and the subsequent and permanent loss of valuable riverfront property for either industrial or public use. To the public, DuPont's closure plan has the appearance of "fencing off the site forever" without consideration of possible alternative uses including redevelopment. The public perception of the proposed remedy is that it establishes an unlicensed hazardous waste landfill located within Wilmington's city limits, and immediately adjacent to the Delaware River and Shellpot Creek.

6.2.1 Implementation

The implementation of any remedy at the site was a concern of many. In addition to disagreeing with the selected alternative, there were concerns on how implementation activities were going to impact air, ground water, surface water, the Shellpot Creek, and the Delaware River. Even though the final design of the proposed remedy has not been completed or approved, it will ultimately include construction safeguards and procedures that will address these concerns. It is our opinion that this type of information should have been made available or explained in greater detail at the hearings.

6.2.2 Loss of Land

Concerns about the permanent loss of land immediately adjacent to the Delaware River were expressed at the hearings. Several members of the public believe the current proposal will remove potentially valuable land from future generations' use, and that neither DNREC nor DuPont is treating this as a serious concern.

6.2.3 Delaware River

There were several questions and concerns related to the IRM's close proximity to the Delaware River and Shellpot Creek. One of these concerns was the effect that global warming and increased hurricane occurrence may have on the IRM. Questions were associated with the location of the IRM within the 100-year and 500-year floodplains. It is our opinion that DuPont adequately addressed these issues in their document dated June 15, 2005: "Items That Need Additional Support."

6.3 OCCURRENCE OF HAZARDOUS COMPOUNDS

Related to the primary concern were numerous questions regarding the types, concentrations, and volumes of contaminants contained within the IRM. These concerns included the following contaminants: dioxins, hexachlorobenzene, PCBs, arsenic and radioactive materials including radon. However, the constituents of concern (COC) receiving the most attention by the public and specifically addressed were dioxins, radioactive materials and hexachlorobenzene.

6.3.1 Dioxins

Many of the participants had questions concerning the dioxin concentration levels, the meaning of the dioxin data and how this data was used in the risk assessments. Dioxin discussions at the hearings included the "discovery" of dioxin in the IRM product between 1990 and 2000, its impact on the subsequent storage of the IRM in the staging area, its impact on the local ground water and surface water, and the potential of the contaminant being dispersed by wind.

DuPont's responses to the dioxin questions at the hearings focused on several of the more notable dioxins, but did not provide sufficient detail regarding the overall concentrations and potential impact of dioxin at the site.

DuPont provided additional dioxin and PCB data in their June 15, 2005, response to DNREC's request. However, the information on dioxins and PCBs is presented in attachments not included with the main document, and therefore not readily accessible by the general public.

It is our opinion that dioxin data presented for soil, IRM, dredged material, ground water and surface water in DuPont's reports is difficult to read, and is not presented in a consolidated form. This is the case with most of the other COC addressed in DuPont's initial and final reports.

We believe that DuPont should generate a summary document that consolidates all of the existing dioxin data for all media, and provides an overview of the dioxin types, concentrations, volumes and relationships to US EPA and DNREC regulatory limits for both soil and ground water.

It should be noted that the dioxin 2,3,7,8-TCCD was not detected above its method detection limit within the samples used by DuPont in its risk assessment.

6.3.2 Radioactive Materials

Questions regarding the amounts and types of radioactive materials present in the raw ore feedstock and the IRM were raised at the hearings and in subsequent e-mail communications to DNREC from concerned citizens. DNREC determined that DuPont's responses to these questions during the hearings did not adequately address or answer these questions and concerns. Hence, DuPont submitted additional information on April 5, 2005, to the Hearing Officer regarding radioactive materials for inclusion in the hearing record. Upon reviewing this information, in May 2005 DNREC requested DuPont to provide further information on this issue. In response to this request, DuPont submitted additional radioactive material data as part of their June 15, 2005, document.

In this latest response, DuPont again addressed the various radioactive decay series as well as adding information on concentrations of the two primary radionuclides that are present in the ore feedstock and IRM samples (U238 and Th232). These concentration levels are well below the 500 ppm action levels established by the US EPA. However, these concentrations were not converted to "actual amounts" of radioactive material within the IRM (i.e., ppm to pounds) as several had requested at the hearings. Additionally, DuPont provided information on the decay daughter isotopes, but concentration information was not provided. Background data for "natural materials found in the earth's crust (soils, rocks, minerals) and in material derived from them, such as fertilizer, building materials (beach sands, granites, clays, brick)..." as discussed by DuPont during the hearings were not provided by DuPont.

In summary, we believe that DuPont's responses adequately addressed this concern, but the conclusions and information were not effectively communicated during the hearings and in their subsequent response documents to DNREC.

6.3.3 Hexachlorobenzene

Hexachlorobenzene (HCB) was mentioned as a concern during the hearings. Particularly, a concern was expressed regarding hexachlorobenzene exceeding the Uniform-Risk Based Standard (URS) and not being listed as a COC on the "Proposed Plan of Remedial Actions."

Schnabel found that DuPont included HCB as a listed COC throughout their documentation. It is important to note that the "Proposed Plan of Remedial Actions" document did not provide a list of COC, and as such would not have been misleading the public in regards to HCB.

However, Schnabel has performed several simulations with the IRM data which suggest that HCB may be present as a DNAPL (Task 4).

6.3.4 Other COC Concerns

Besides the variety, volume and concentrations of the COC discussed above, there were many questions and concerns related to other COC expressed at the hearings. There was noticeable confusion in regards to ferric chloride and arsenic, as well as an overall concern for the impact on surface and ground water.

6.3.4.1 Ferric Chloride

In addition to the main COC discussed above, there were numerous questions regarding ferric chloride and its part in the process and in the products that DuPont manufactures at the Edge Moor facility. A general misconception prevailed throughout the hearings, confusing the ferric chloride acid sold for use in wastewater treatment with ferric chloride once contained in impoundments, and with the ferric chloride contained in the IRM.

During the hearings, DuPont provided an explanation differentiating the ferric chloride sold to the City of Wilmington and in the IRM, and provided the information associated with the limited amount of IRM that had been used or sold offsite. DuPont provided a brief explanation on the ferric chloride process and related changes while addressing a similar topic in Item 10 of their June 15, 2005, document. They have also provided a flow chart illustrating the past and current manufacturing processes.

It is Schnabel's opinion that DuPont adequately addressed these concerns.

6.3.4.2 Arsenic

Several questions were raised concerning the concentration of arsenic within the IRM.

Although arsenic has been shown to exceed the action level for total arsenic in several samples, it occurs below non-detect levels in TCLP analytical testing of the IRM, the underlying dredged material and within the ground water. This is not surprising, as arsenic predominantly occurs as an oxy-anion, and is therefore more soluble under neutral and alkaline conditions.

A problem we encountered in evaluating arsenic data for the site is that it is scattered in various reports, and very little of this data has been consolidated in summary tables for ease of evaluation by the public. Also the few consolidated tables provided in various documents have not been updated to provide the correct arsenic action level. It is our opinion that this data should be updated, consolidated, and made available to the public.

6.3.4.3 Ground Water and Surface Water

There were concerns expressed at the hearings that the contaminants listed above may already be in the ground water and surface water (both the Shellpot Creek and Delaware River), or could eventually end up there if the IRM was to be managed on site.

During the hearings and in subsequent submittals, DuPont provided data on several COC from Shellpot that were analyzed from samples collected upstream and adjacent to the project site. This data, although not conclusive, indicate a possible source upstream and upgradient of the project site. It is our opinion that this information did not fully address this concern, and we recommend that the data be consolidated in a summary report regarding this issue.

DuPont and DNREC noted during the hearings that the proposed remedy will be designed to reduce the potential for surface or ground water contamination and will include strict maintenance, monitoring, and reporting procedures. Although the final design that includes these procedures has not been completed (lacking DNREC approval of the proposed remedy), an effort should be made to outline the major components of this maintenance program. In this way, the public can better understand what will be required of DuPont, now and in the future, on this critical issue.

It is Schnabel's opinion that the documents reviewed and the data presented at the hearings do not adequately address the current conditions, nor the long term potential of contaminants migrating from the IRM to the ground water, and then to the surface water. This issue is discussed in further detail in the Safety of the Proposed Remedy (below) and in Tasks 3 and 4 of this report.

6.4 REGULATORY

Another concern and confusion expressed by the community during the hearings regarded the application and timing of various state and federal regulations and programs to the IRM storage area, the material in Cells 1, 2 and 3, and the material currently being generated and managed off site. The timing of the DNREC RCRA enforcement dates, the placement of the site into the VCP by the DNREC, the Consent Order, the K178 waste classification by the US EPA, movement of the IRM after reclassification, and the brief comment period were also questioned by the public.

There were questions expressed during the hearings regarding the status of the site within various programs including DNREC's Brownfield Program. According to current criteria, the site does not qualify for the Brownfield Program because: (1) the site has not been listed by DNREC as a brownfield site, and (2) DuPont is a "responsible party" and current owner of the site. This conclusion would allow the project and site to be placed into DNREC's Voluntary Cleanup Program (VCP). This classification information was adequately presented by the DNREC during the hearings.

Several concerns were expressed during the hearings regarding the consolidation of the IRM pile in the summer of 2002. A question was posed asking if the consolidation of the IRM constitutes being "actively managed," thereby classifying the IRM as hazardous waste. Neither DuPont nor DNREC adequately addressed this issue during the hearings or in subsequent responses and communications. The term "actively managed," as it relates to the IRM, has not been effectively defined or explained by DNREC.

Concerns regarding the increase in the DNREC action level for arsenic were expressed during the hearings. In June 2004, DNREC established a new risk-based clean up standard for arsenic based on a hazard index value of 23 parts per million (ppm). In March 2002, the average background level for arsenic was established to be 11 ppm. The adoption of these standards and, in particular, the timing of the adoption, caused/created confusion and speculation among the public. Additionally, the public believes that DNREC representatives did not give an adequate explanation at the hearings regarding the chronology of the regulatory change in arsenic action levels, although DNREC does provide a thorough explanation on their webpage.

The regulatory framework by which DuPont's "hazardous waste" (K178) will end up in an unlined "hazardous waste landfill" was questioned by a majority of those giving testimony at the hearings. It is our opinion that the explanations given by DNREC at the hearings were not detailed enough or sufficiently organized to adequately address the expressed concerns.

It is Schnabel's opinion that both DuPont and DNREC provided information during the hearings on the complicated issue regarding the relationship and timing between the regulation adoption and key events. However, due to the nature of the hearings, a thorough and coherent explanation was not possible. The poorly selected format of the technical review tended to generate more confusion than assistance. We believe that a summary document should be completed that provides a step by step chronology of the events associated with classifying the IRM along with the underlying regulatory reasoning. This summary should also address the "rehandling" issue (stockpile consolidation).

It is important to note that an attempt to gain an understanding of various issues related to the regulatory history of the IRM staging pile was conducted by the Site Investigation and Restoration Branch (SIRB). A technical review consisting of questions and answers dated June 27, 2005, was generated for this purpose, and was to be used in preparation of an SIRB technical response document.

Regarding requests to extend the comment period, we believe that the subsequent extension (with the exception of DuPont's submittal of data near the end of the comment period, which prevented adequate public review) adequately addressed this concern/request.

6.5 SELECTION OF ALTERNATIVES AND RISK ASSESSMENTS

A portion of the hearings was devoted to the selection of the remedial alternatives and the subsequent risk assessments of the two selected alternatives.

6.5.1 Alternative Selection

Although DNREC and the USEPA have established and published formal screening methods and procedures for selecting a remedial alternative [utilized by DuPont (see Task 2 Subtask 2)], DuPont and DNREC did not provide clear explanations of these procedures or of the details of DuPont's screening process during the hearings. Because of this, the public was suspicious of the selection process that evaluated two alternatives that were dramatically different in costs and approach. It should be noted that the documents DNREC submitted at the initiation of the hearings included a

portion of this information, but the governing regulation and procedures were not fully explained at the hearings.

6.5.2 Alternative Cost

There were several comments concerning the discrepancy in the costs of the two remedial alternatives that were selected for risk assessment. The validity and accuracy of the high cost alternative was also questioned. Although DNREC documents submitted at the initiation of the hearing contained most of this information, explanations of why the costs of these two alternatives were so different, and why certain cost components of the high cost alternative were not looked at and evaluated (e.g., rail and barge versus truck transportation), and were not presented.

We believe that a summary document that contains additional detailed cost information for both alternatives, and outlines the steps and the results of the screening process would help support the conclusions derived by the screening and selection process. There are additional comments on the remedial alternative screening, selection, and costing process contained in Task 2 of this document.

6.5.3 Thoroughness of the Risk Assessments

As was the case with the alternative selection concerns, DNREC and the USEPA have established and published formal methods and procedures for conducting risk assessments [utilized by DuPont (see Task 4)]. During the hearings, DNREC and DuPont responded to questions regarding this process, but these responses did not sufficiently answer or address all of the concerns. Because of this, DNREC requested DuPont to provide additional information and data on this issue. DuPont in their June 15, 2005, response provided additional information to DNREC.

Based on our review of the initial submittals and the June 15, 2005, response document, it is our opinion that DuPont has adequately addressed DNREC's request for additional data, but neither DuPont nor DNREC have adequately communicated this information to the public.

It is important to note that DuPont's risk assessments of the two remedial alternatives were thoroughly evaluated under Task 4 of this document. The opinion expressed within this task applies only to the review of DNREC's and DuPont's responses to the public concern, and does not apply to the accuracy and applicability of the DuPont's risk assessments.

6.6 SAFETY OF THE PROPOSED REMEDY

The proposed remedy includes the design, installation and long term maintenance of a capping system consisting of a geosynthetic liner covered by soil and topsoil. The proposed remedy did not include a bottom liner system for the IRM storage pile.

6.6.1 IRM Stockpile Capping System

The transcripts from the hearings include questions and comments concerning the capping system and the integrity of the geosynthetic liner. The expected length of service for this material was a re-occurring concern.

Data submitted by DuPont and URS Diamond, DuPont's consultant, during the hearings and in subsequent submittals to DNREC concerning this topic, provided limited information regarding the types and life expectancy of geosynthetic liners. This issue is more completely discussed in Task 2 in this report.

6.6.2 Bottom Liner

The transcripts from the hearings include questions and comments concerning the lack of a bottom liner for the proposed remedy. One concern was that leachate from the IRM would migrate downward into the ground water and subsequently into the Shellpot Creek and the Delaware River. As indicated in previous Tasks, this appears to be the case.

DuPont and their consultants presented data at the hearings and in their subsequent submittal to DNREC (June 15, 2005) that alleviated the need for a bottom liner due to the nature and hydraulic character of the underlying dredged material. Additionally, the capping system will be designed to prevent surface water from entering the IRM. Therefore, DuPont determined that there will be no leachate generated that could migrate to the ground water. It should be noted that analytical data from samples collected of the dredged material indicate that the IRM may have already impacted the dredged material at this location.

However, results from in situ and laboratory tests that were used by DuPont to determine hydraulic conductivities and hydrogeologic characteristics of the DM were from various on site locations west of the IRM storage area. The data from these tests indicate that the permeability of the dredged material at these locations west of the IRM storage pile varies from 10^{-5} to 10^{-7}. It is important to note that there is no hydraulic conductivity data presented for the DM directly beneath the 15.5 acre IRM storage area.

The method of placing the underlying dredge material at this location within a bermed confined disposal facility (CDF) in all likelihood included pumping of the DM into the CDF at different locations. This method creates distinct gradational grain size zones ranging from course sand near the discharge point to clay particles farther away. Areas of increased permeability were noted in past geotechnical investigations which confirm this characteristic. Therefore, there may be areas of DM having a relatively high permeability beneath the IRM which may require additional investigation and characterization. It should be noted that these past reports recommended that the dredge material be amended with bentonite clay materials to provide the required permeability characteristics.

Regarding the potential impact of the capped IRM material coming in direct contact with the local ground water, it is important to note that the bottom elevation of the proposed IRM storage area is substantially above the local ground water table. Because of this, ground water is not expected to come in contact with the IRM.

The evaluation of DuPont's proposed remedial alternatives and risk assessments was conducted in Tasks 3 and 4, respectively. Our conclusions regarding the bottom liner were made independently of these tasks.

6.6.3 Condition of Cells 1, 2, and 3

There were several questions asked during the hearings regarding the classification, condition, maintenance and content of Cells 1, 2, and 3. It is important to note that these cells are not part of the proposed remedy or the regulatory action at the project site.

However, the proximity of these cells to the current stockpile, and the fact that they contain essentially the same material and are without bottom liners, will make it extremely challenging to identify the exact source of subsurface contamination in the future.

The concerns associated with the classification of Cells 1, 2, and 3 were related to the permitting process and regulations, as they may pertain to the proposed remedy. DuPont adequately addressed this relationship of the permitting process, plus cited governing regulations.

Questions were posed inquiring of the maintenance requirements of the closed cells. DuPont's responses to these questions during the hearings were detailed and informative, and outlined the construction and long term maintenance of this area including vegetation types and surface repairs. We believe that the public concerns relating to this issue were adequately addressed by DuPont.

Regarding the content of the closed Cells 1, 2 and 3, the public expressed concern that the same IRM had been included in these cells as well. DuPont answered with a brief description of the contents, and stated that IRM had been used as part of the cover system. No other detailed information was provided on this issue by DuPont during the hearings or in subsequent submittals. Due to the fact that Cells 1, 2, and 3 are not a part of this evaluation, it is Schnabel's opinion that data submitted was sufficient.

6.6.4 DuPont's Long Term Responsibility

There were numerous questions about the 30-year nature of the Proposed Remedy and the possibility of DuPont abandoning the site in the future.

DNREC and DuPont both responded to these questions during the hearings, but their responses only addressed the 5-year and 30-year elements of the proposed remedy. There were no definitive answers or explanations given regarding what happens when DuPont vacates the property and abandons the project before or after the 30-year time frame.

Observations made during a recent site visit (July 2006) indicated that several surface areas were in need of repair under the current operations and maintenance procedures. This does not bode well for DuPont's long-term stewardship of the site.

We believe that DuPont, in conjunction with DNREC, should provide the public additional and detailed information on this issue. In particular, they should provide how the 5-year review mechanism works, the level of DNREC's involvement in the process, and the post closure period.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 Remedial Feasibility Study

7.1.1.1 Feasibility Study

It is our conclusion that the remedial action objectives (RAO) that were established and used by DuPont in the feasibility, screening, and evaluation of proposed remedies were deficient because proposed concentrations for iron, manganese, and hexachlorobenzene are too high to be protective of human health and the environment. Because of this, the FFS may not have resulted in an appropriate remedy. Additionally, the FFS proposes to only monitor ground water during/after the remedial measures, and has used language which appears to preclude corrective actions that require ground water manipulation, removal and/or treatment.

7.1.1.2 Selected Remedy

It is the conclusion of our evaluation that DuPont overstated the design life of the selected remedy (capping system), because it was based on durability and longevity values of the geomembrane base polymer. However, the base polymer durability does not necessarily reflect its ability to perform the intended function once installed. We believe that the design life is more likely on the order of a few decades. Regarding DuPont's other leading remedy, source removal and disposal, we have concluded that it was not thoroughly evaluated, particularly for the use of rail transportation options (in lieu of trucking) which would significantly reduce the cost and the apparent risk.

7.1.2 Risk Assessment

To the extent that site characterization data and conceptualization (of IRM and DM) serves as the foundation of the risk assessment, the human health and ecological risk assessments for the site have significant shortcomings. Our evaluation indicates that related shortcomings and inconsistencies include representation of source/exposure point concentrations, conceptual assumptions, and input parameters used in fate and transport modeling analyses.

Moreover, the human health risk assessment (HHRA) has ignored a potentially critical exposure scenario related to offsite downwind receptors (including potential sensitive receptors). Similarly, the ecological risk assessment (ERA) appears to have inappropriately excluded hazards related to potential direct exposure to COC by wildlife (avian and terrestrial species were observed foraging in the IRM areas during our site reconnaissance visit), and the observed vegetation on the IRM pile serving as a potential food source and habitat for such wildlife. Additionally, the off-site ecological exposure point concentrations and the subsequent ecological risk to aquatic organisms and human receptors vary significantly with COC concentrations in the IRM and dredged material, the vertical permeability of the IRM, and the assumed hydraulic conductivity of the DM. These types of data should be collected from within the footprint of the IRM pile and its immediate vicinity for effective off-site ecological risk characterization, and the ERA should be revised accordingly to reflect new data. Further, cumulative human health carcinogenic risk calculated by DNREC staff as a result of

consumption of impacted fish using dioxin and dioxin-like compound analytical fish tissue data collected from Shellpot Creek is approximately 10 to 5,000 times higher than that calculated by DuPont for this exposure scenario. Unless high dioxin levels are established in sediments in and around the vicinity of the site, the excess human health risk for this exposure scenario should be recalculated by DuPont.

Both the HHRA and the ERA have used the 1998 WHO toxic equivalency factors (TEFs) to calculate TEQ for dioxin and dioxin-like compounds. In a June 2005 meeting of experts from the WHO and the International Program on Chemical Safety (IPCS) held in Geneva, Switzerland, revised values of TEFs (2005 WHO TEFs) were proposed. Should the 2005 WHO TEFs be formally revised by the WHO and formally adopted by the United States Environmental Protection Agency (USEPA), both the HHRA and the ERA should be revised accordingly to reflect these revisions.

Lastly, risk management practices, including implementation of worker health and safety measures, have been proposed as the basis for addressing potential direct exposure to the IRM. While in concept this rationale is sound, the site reconnaissance visit revealed the absence of such measures and practices by workers present at the site. This included the apparent lack of use of personal protective equipment and monitoring during operations and activities at/or immediately adjacent to the IRM during the site visit. Such risk management measures should be strictly enforced in order to protect workers.

7.1.3 Media

7.1.3.1 Dredged Material

It is the conclusion of our evaluation that the dredged material upon which the IRM is currently stored, and upon which it will be permanently stored in the proposed remedy, has not been sufficiently characterized. As presented in DuPont's documents, where hydraulic conductivities on the order of 1 to 10^{-2} cm/sec have been reported for dredged sediments to the west of the IRM pile (DuPont's June 9, 2000, Proposal for Remedial Action), and from our practical experience there may be areas within the proposed remedy's footprint where similar hydraulic conductivities of the dredged material may exist. Ground water travel times and chemical transport rates at these hydraulic conductivity values will be significantly higher than those calculated by DuPont. Additionally, the analytical data from the top two to 12 inches of the dredged material indicates that this horizon has already been impacted by iron, manganese, and hexachlorobenzene from the IRM, as compared to regional dredged material contaminant levels.

7.1.3.2 Ground Water

It is the conclusion of our evaluation that the ground water underlying the IRM has not been fully characterized, and ground water monitoring locations are not positioned to effectively: (1) establish the existing impacts of the stockpiled IRM on the ground water quality, and (2) monitor the future impact of the proposed remedy. This includes the lack of ground water data within the footprint of the IRM, and in at least one key downgradient location near the point of discharge to the Delaware River. Additionally, semi volatile organic compounds such as hexachlorobenzene and

hexachlorobutadiene reported in IRM and DM samples, which are potential COC, have not been analyzed in past and current ground water monitoring events. Because of this, ground water has not been sufficiently characterized to effectively perform a FFS and the associated risk assessment.

7.1.3.3 IRM

The evaluation of the IRM in relation to the proposed remedy indicates that the IRM has not been sufficiently characterized to allow for the effective risk assessment of the proposed remedy. The lack of characterization includes the lack of site-specific hydraulic conductivities established for the IRM and the significance of hexachlorobenzene, including its potential presence as a dense non-aqueous liquid (DNAPL) occurring within the IRM. The detection limits of the analytical procedures may have to be lowered, particularly in the case of HCB. The lack of such characterization and related conceptualization with respect to the fate and transport modeling, risk assessment, and evaluation of remedial alternatives may be significant.

7.2 RECOMMENDATIONS

The following activities are recommended to address the deficiencies and concerns stated above:

IRM

We believe that up to five representative samples should be collected of the IRM currently stored from within the footprint of the proposed remedy located in the eastern portion of the site. The following tests should be performed on the IRM samples:

- Hydraulic conductivity
- Dioxin/Furans
- PCBs
- Volatiles including hexachlorobenzene
- Chlorides
- Sulfates
- Grain size analysis
- Moisture
- Density

Samples should be collected from appropriately spaced borings with the proposed locations approved by DNREC.

Dredged Material

In conjunction with the advancement of the recommended borings, we believe that representative samples of the dredged material be collected at 2.5-ft intervals beneath the stored IRM. Additionally, samples of dredged material in the southeast corner of the site should be collected at 2.5-ft intervals. A minimum of 10 ft of dredged material should be sampled at each location. The following tests should be performed on the dredged material samples:

- Hydraulic conductivity
- Dioxin/Furans
- Metals
- PCBs
- Volatiles including hexachlorobenzene
- Chlorides
- Sulfates
- Loss on Ignition
- Grain size analysis
- Moisture

Samples should be collected from appropriately spaced borings with the proposed locations approved by DNREC.

Ground Water

To establish the quality of the ground water within the footprint of the proposed remedy and downgradient of the IRM storage pile, a ground water well should be installed and sampled. The sample should be analyzed for the following parameters:

- Dioxin/Furans
- PCBs
- Metals
- Volatiles including hexachlorobenzene

Hydraulic conductivity data should be collected from selected horizons in conjunction with the installation of this well.

Feasibility Study

Upon completion of the recommended data gathering activities, the FFS should be revised to incorporate the new data and the feasibility of each of the remedies in the screening process should be re-evaluated to determine their rankings and appropriateness.

Risk Assessment

Upon completion of the recommended data gathering activities and the incorporation of the additional testing and analytical results into the revised FFS, we are recommending that the risk assessments of the selected remedies be revised to reflect the inclusion of the new data.

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REFERENCES

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APPENDIX A

LRM, Inc.'s Risk Assessment Evaluation Report

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APPENDIX A

TASK 4 – REVIEW OF GROUNDWATER FATE AND TRANSPORT MODELING AND RISK ASSESSMENT CONDUCTED IN THE REMEDIAL INVESTIGATION/RISK ASSESSMENT REPORT (RI/RA)

LRM Consulting, Inc. (LRM), under contract with Schnabel Engineering (Schnabel), performed a review of documents, data, information, data analyses, and risk assessment performed by Dupont and submitted to the Delaware Department of Natural Resources and Environmental Control (DNREC) for the DuPont Hay Road Site (Site), located in Wilmington, Delaware. LRM's review focused on the assumptions made and data analyses conducted in support of the Risk Assessment (RA) and the results of the RA presented by DuPont in the *Final RI/RA Report* (DuPont/URS Diamond, May 2004) submitted to the DNREC. Additionally, LRM's review included an evaluation to determine if the RA was appropriate and consistent with the *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act (HSCA)* (DNREC, December 1999).

A brief description of the various components of the Risk Assessment (Sections 4.2 through 4.4), followed by LRM's comments is presented in the following sections:

4.1. Presentation of Reports Reviewed

4.2. Data Used for Risk Assessment and Associated Fate and Transport Modeling

4.3 Human Health Risk Assessment
- 4.3-1 Exposure Pathways
- 4.3-2 Exposure Point Concentrations
- 4.3-3 Risk Characterization

4.4 Ecological Risk Assessment
- 4.4-1 Exposure Pathways
- 4.4-2 Exposure Point Concentrations/Risk Characterization

LRM's conclusions that identify the key shortcomings in the assumptions, calculations, and the results of the RA are presented in Section 4.5. A list of references is presented in Section 4.6.

4.1 PRESENTATION OF REPORTS REVIEWED

LRM reviewed various reports as part of Task 4 related to the approach, assumptions, and results of the RA conducted for the site, including the chemical fate and transport modeling performed in support of the RA. Specifically, the following reports were reviewed:

1) Cherry Island Staging Area, Potential Historic Release Assessment dated November 2001, Revised September 2002, and 2nd Revision 8 December 2003 (DuPont, 2003).
2) Final Remedial Investigation/Risk Assessment Report, Cherry Island Iron Rich Staging Area/Hay Street Sludge Drying Site (DE-024) (DuPont/URS Diamond, May 2004).

To gain an understanding of the relevant data collected at the site, which served as the foundation to the chemical fate and transport modeling and the RA, the following reports were also reviewed:

1) Report of Geotechnical Investigation, Cherry Island Landfill Closure, Edge Moor Plant (DuPont, November 1992).
2) Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results, DuPont Cherry Island Landfill, Edge Moor, Delaware (DuPont, June 2000).
3) 2002 Annual Hydrogeologic Report, Cherry Island Landfill, DuPont Edge Moor Plant (DuPont/URS Diamond, January 2003).

4.2 DATA USED FOR RISK ASSESSMENT AND FOR ASSOCIATED FATE AND TRANSPORT MODELING

A brief description of the Site data (i.e., data used for the risk characterization) by DuPont is presented in Section 4.2-1. Key shortcomings associated with the site characterization data are presented in Section 4.2-2.

4.2-1 Data Presented

The Final Remedial Investigation/Risk Assessment report (RI/RA), includes the approach and results of site characterization activities performed at the site. The RI/RA includes characterization data for the iron rich material (IRM) pile, the dredged material located adjacent to the IRM pile, groundwater at locations upgradient and downgradient of the IRM pile (within the dredged material, the river bank deposits located underneath the dredged material, and the Potomac Formation [i.e., the first aquifer zone]), storm water from an outfall (D-002) downstream of the IRM pile, and upstream and downstream surface water samples from the Shellpot Creek and the Delaware River, respectively.

Table 1 presents the locations and number of samples (along with the analytes tested) for each media at the site.

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TABLE 1: ANALYTES TESTED BY MEDIA FOR THE DUPONT IRON RICH SITE (Page 1 of 2)

Analyte Type	IRM Source Based COCs	IRM		Dredged Material Soil	
		IRM Analytes Tested	Number of Sample Locations	Dredged Material Analytes Tested	Number of Sample Locations
Metals	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Nickel, Potassium, Silver, Sodium, Thallium, Vanadium, and Zinc	2	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc	3
SVOCs	SVOCs - Hexachlorobenzene, Hexachlorobutadeine, and Pentachlorobenzene	SVOCs (Including Hexachlorobenzene and Hexachlorobutadiene) Does not Include Pentachlorobenzene	2	Includes Hexachlorobenzene and Hexachlorobutadiene (Does Not Include Pentachlorobenzene)	3
PCBs(Dioxin and Non Dioxin Like PCBs)	PCBs	PCBs	7	PCBs	3
Chlorinated Dioxins/Furans	Chlorinated Dioxins/Furans	Chlorinated Dioxins/Furans	7	Not Conducted	3
VOCs	Not Listed	VOCs	2	VOCs	3
TCLP Metals	Not Listed	Volatile, Pesticides, Herbicides, and Semi Volatiles are Non Detect (Partial of Priority Pollutant List) - 2 EPA Samples, (1 Sample 2 Tests(Test 1 23 Metals TCLP Metals - Iron - 348 mg/L, Manganese - 252 mg/L, Test 2 - Barium - 2.06 mg/L, Hexavalent Chromium - Non Detect)	3	Not Conducted	NA
SPLP – Metals	Not Listed	23 Metals (1 Sample 2 Tests SPLP Metals - Iron - 0.18 mg/L, Manganese - 16.3 mg/L, Test 2 - Iron Not Conducted, Barium -0.77 mg/L, Mercury - 0.00038 mg)	1	Not Conducted	NA
Pesticides	Not Listed	Pesticides	2	Pesticides	3

Note:
Reference for this table and contents: 2004 DuPont/URS Diamond RI/RA Report
COCs = Chemicals of Concern
EPA = Environmental Protection Agency
IRM = Iron Rich Material
NA = Not Analyzed
mg/L = Milligrams Per Liter
PAH = Polynuclear Aromatic Hydrocarbons
PCBs = Poly Chlorinated Biphenyls
SPLP = Synthetic Precipitation Leaching Procedure
SVOCs = Semi Volatile Organic Compounds
TCLP = Toxicity Characteristic Leaching Procedure
TDS = Total Dissolved Solids
TOC = Total Organic Carbon
VOCs = Volatile Organic Compounds

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TABLE 1: ANALYTES TESTED BY MEDIA FOR THE DUPONT IRON RICH SITE (Page 2 of 2)

Analyte Type	IRM Source Based COCs	Dredged Material Groundwater			Storm Water		Surface Water/Sediments	
		Dredged Material Groundwater Analytes Tested	Number of Sample Locations	Not Included	Storm Water Analytes Tested	Number of Sample Locations	Surface Water/Sediments Anlalytes Tested	Number of Sample Locations
Metals	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, Vanadium, Zinc	Arsenic, Beryllium, Cadmium,Chromium, Copper, Iron, Lead, Manganese, Nickel, Selenium, Vanadium, Zinc, and Chloride	4	Antimony, Mercury, Thallium	Dissolved and Total Arsenic, Copper, Lead, Nickel, Silver, and Zinc. Total Sodium	1	Dissolved and Total Arsenic, Cadmium, Chromium, Copper, Iron, Lead and Selenium Chlorides, TDS, TOC – Surface Water Only	2 (Upstream and Downstream)
SVOCs	SVOCs - Hexachlorobenzene, Hexachlorobutadeine, and Pentachlorobenzene	Not Conducted	NA	NA	Total and Dissolved PAHs	1	Not Conducted	NA
PCBs(Dioxin and Non Dioxin Like PCBs)	PCBs	Not Conducted	NA	NA	Totals	1	Sediments Only	2 (Upstream and Downstream)
Chlorinated Dioxins/Furans	Chlorinated Dioxins/Furans	Not Conducted	NA	NA	Totals	1	Sediments Only	2 (Upstream and Downstream)
VOCs	Not Listed	Not Conducted	NA	NA	Not Conducted	NA	Not Conducted	NA
TCLP Metals	Not Listed	Not Conducted	NA	NA	Not Conducted	NA	Not Conducted	NA
SPLP – Metals	Not Listed	Not Conducted	NA	NA	Not Conducted	NA	Not Conducted	NA
Pesticides	Not Listed	Not Conducted	NA	NA	Not Conducted	NA	Not Conducted	NA

Note:
Reference for this table and contents: 2004 DuPont/URS Diamond RI/RA Report
COCs = Chemicals of Concern
EPA = Environmental Protection Agency
IRM = Iron Rich Material
NA = Not Analyzed
mg/L = Milligrams Per Liter
PAH = Polynuclear Aromatic Hydrocarbons
PCBs = Poly Chlorinated Biphenyls
SPLP = Synthetic Precipitation Leaching Procedure
SVOCs = Semi Volatile Organic Compounds
TCLP = Toxicity Characteristic Leaching Procedure
TDS = Total Dissolved Solids
TOC = Total Organic Carbon
VOCs = Volatile Organic Compounds

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2-2 Data Adequacy Assessment

An assessment of the data adequacy for each media tested at the Site is described in this section. Where applicable, key shortcomings associated with these data are presented. Related evaluation included assessment of the adequacy of the number of samples collected for soil, groundwater, and surface water at critical locations, and the adequacy of analytes tested in samples collected from the various media.

4.2-2.1 IRM Sampling

Currently, the IRM pile contains approximately 420,000 cubic yards of IRM. DuPont stockpiled IRM at the Site between 1997 through 2001. In 2001 prior to the consolidation of the IRM pile, the areal extent of the pile covered approximately 22.9 acres. The current extent of the IRM pile approximates 15.9 acres, following the 2001 consolidation of the IRM and surface application of a polymer coat. Comments on the sampling frequency and the adequacy of the laboratory analysis conducted on the samples are presented below.

Sampling Frequency

For the 420,000 cubic yards of IRM stockpiled onsite, a total of 7 samples were collected from the IRM at the Edge Moor Plant. To date, no insitu analytical data has been collected from the IRM pile. Given the volume of IRM material, the 7 samples is insufficient to adequately characterize this volume of stockpiled material. Moreover, the RI/RA does not provide a rationale to support the adequacy of the sampling frequency. It is recommended that a quantitative rationale for data adequacy be prepared and documented and samples be collected in a manner consistent with that rationale. Examples of such a rationale include the US Environmental Protection Agency's (USEPA's) Data Quality Objectives (DQO) process (USEPA, 1994).

Adequacy of Laboratory Analyses

As discussed previously in Schnabel's review of Task 1 (Technical Information Review), several constituents of concern (COCs) are identified for the IRM based on USEPA's groundwater risk assessment, which was used to form the K-178 listing. The IRM samples were tested for all the listed COCs, except pentachlorobenzene. A rationale for exclusion of pentachlorobenzene from the analyte list should be provided; alternatively, this analyte should be analyzed in laboratory analyses of relevant samples.

Additionally, The RI/RA does not refer to soil physical characteristic data for the IRM (e.g., permeability, grain size distribution, etc.). Site-specific estimates of these parameters are critical for estimation of the vertical groundwater recharge from the IRM pile to underlying shallow groundwater and estimates of IRM deposition (carried by wind) to downwind locations (i.e., Shellpot Creek, Delaware River, and potential downwind human receptors) (see Section 4.4-2 for additional comments).

4.2-2.2 Dredged Material

A total of twelve samples were apparently collected from the dredged material; the sampling locations were outside the current extent of the IRM pile, but below the historical footprint of the IRM pile prior to its consolidation. The collected samples were subject to field screening (metals using X-Ray Fluorescence spectroscopy and Volatile Organic Compounds [VOCs] using a field Gas Chromatograph); however, only 3 of these samples were shipped to the laboratory for analyses. Comments on the sampling frequency and the laboratory analyses are presented below.

Sampling Frequency

The number of samples collected for laboratory analyses (i.e., three) is considered insufficient considering the large area (~22.9 acres in 2001 prior to the polymer coat application) covered by the IRM pile. All of these sample locations were outside the footprint of the current 15.9 acre IRM pile and the samples were collected from within the top 2 to 12 inches of the dredge material. Importantly, no specific rationale was provided to support the adequacy of the sampling frequency of the dredged material, the maximum depth of sampling, and the absence of sampling from areas underneath the existing footprint of the IRM pile. Therefore, it is recommended that additional sampling be conducted and/or a quantitative evaluation of data adequacy be provided to justify the sampling performed to date.

Adequacy of Laboratory Analyses

As discussed above only 3 samples from the dredged material were subjected to laboratory analyses.

Selected PCBs, dioxins/furans were detected in the collected IRM samples; however, the dredged material was not tested for these analytes. In the RI/RA, no specific rationale was provided for exclusion of these analytes from the list of chosen analytes for the dredged material samples.

In addition, the presence of IRM-related SVOCs (e.g., hexachlorobenzene and hexachlorubatadiene) in the dredged material samples (collected 2 to 12 inches below ground surface [bgs]), which are typically not associated with regional dredged material (DM), suggests the migration of COCs from the IRM to the underlying dredged material. DM Samples below this depth are necessary to determine the depth of impacts to the dredged material underneath the IRM pile.

As with the IRM, it appears that data reflecting the physical properties of dredged material underlying the IRM pile (e.g., permeability, grain size distribution, etc.) at and around the immediate vicinity of the IRM pile were not presented in the RI/RA report; estimates of these parameters are critical for the estimation of the vertical recharge from the IRM pile through

the dredged material to shallow groundwater and the subsequent transport through the dredged material to the Delaware River and the Shellpot Creek. It is recommended that such data be collected in support of fate and transport analyses and estimation of exposure point concentrations.

4.2-2.3 Groundwater

In the vicinity of the IRM pile, shallow groundwater within the dredged material (typically 20 feet below ground surface [bgs]), intermediate groundwater within the river bank deposits (typically 50 feet bgs), and deep groundwater within the First Aquifer Zone (typically 90 feet bgs) are monitored periodically at one nested well cluster upgradient of the IRM pile and at two nested well clusters downgradient of the IRM pile (one cluster is located upgradient of the Shellpot Creek and the other cluster is located upgradient of the Delaware River).

Adequacy of Monitored Locations

At and around the vicinity of the IRM pile, only three well clusters are monitored at the locations discussed above. Importantly, no monitoring wells or other groundwater data exist for locations underneath the historic or the current footprint of the IRM pile. Additionally, groundwater is not being monitored at the sediment control basin constructed downstream of the IRM pile and upstream of the storm water outfall D-002, located in the southeastern portion of the Site. This sediment control basin was constructed to prevent storm water runoff carrying sediment transport from the IRM into the outfall. The construction of the sediment basin has resulted in the diversion of stormwater runoff from the IRM pile into this basin. Because the Site receives substantial precipitation (~45 inches) year-round, significant storm water appears to collect within this sediment basin, which necessarily contributes to significant vertical infiltration of IRM-impacted water and recharge of shallow groundwater (see Figure 1). At a minimum, a monitoring well to monitor quality of shallow groundwater (within the dredged material) should be considered at this critical location.

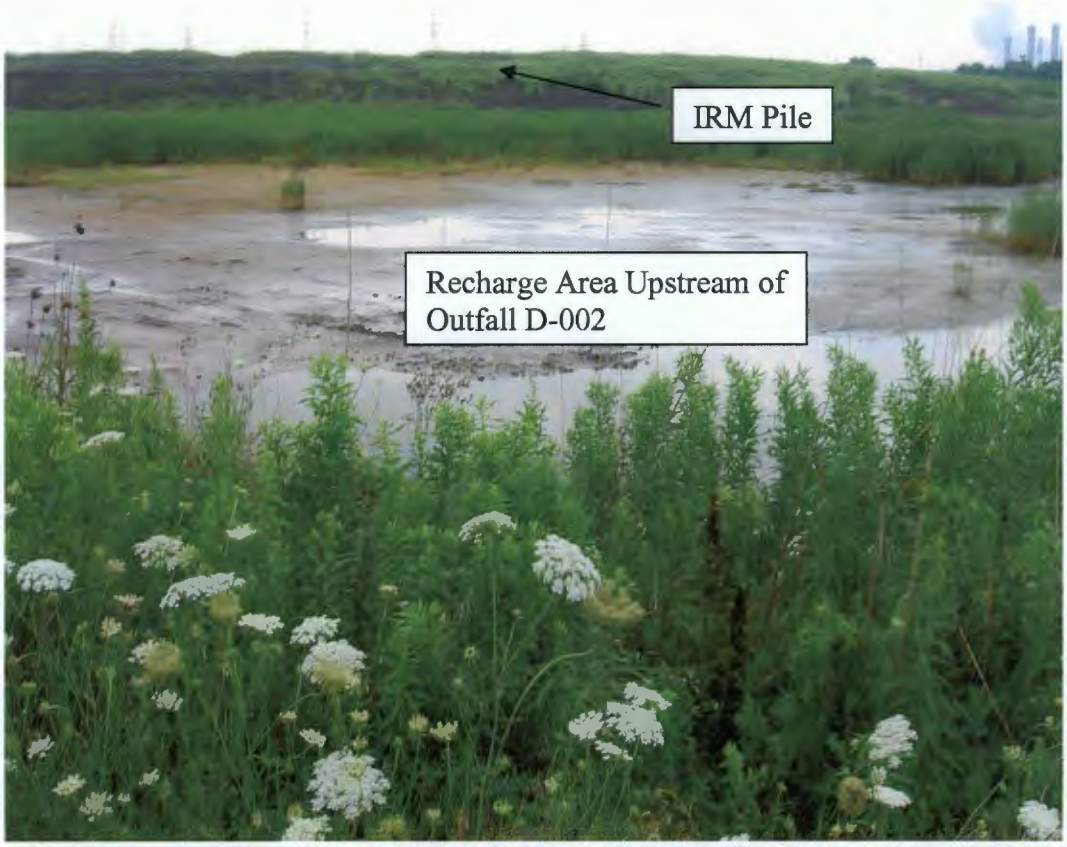

FIGURE 1: POTENTIAL GROUNDWATER RECHARGE AREA UPSTREAM OF OUTFALL D-002 AND DOWNSTREAM OF THE IRM PILE (SOUTHEASTERN CORNER OF SITE)

Adequacy of Laboratory Analyses

As discussed above, groundwater samples are collected from 3 wells screened within the dredged material (the shallow groundwater zone) and the underlying zones (intermediate and deep). The groundwater samples are analyzed for metals included in the USEPA COC list for IRM. However, hexachlorobenzene, hexachlorobutadiene, and pentachlorobenzene also included in the COC list are not being tested. Also, selected PCBs, dioxins/furans, which were also detected in the IRM samples, have not been analyzed for in the groundwater samples. These analyses should be performed or a sound rationale for their exclusion should be provided.

Further, hydraulic conductivity data for the shallow groundwater zone within the vicinity of and underneath the IRM pile do not appear to have been used and/or available. Apparently, the only such data available are from slug tests, aquifer pump tests, and laboratory tests in wells/soil borings, all of which are located several hundred feet to the west of the IRM pile.

Given the wide range in estimated permeabilities (4.30E-07 cm/sec to 4.6E-02 cm/sec, see Attachment Table 1) in these tests, additional hydrogeologic evaluation is necessary at and around the IRM pile area.

4.2-2.4 Storm Water

DuPont collects storm water samples on a quarterly basis from outfall D-002, located downstream of the IRM pile.

Sampling Location/Frequency

Based on the existing topography of the Site, which results in storm water runoff from the IRM pile toward the outfall, the location of the storm water sampling is considered appropriate.

Adequacy of Laboratory Analyses

The collected samples are tested for total/dissolved (i.e., fitered/unfiltered) metals and SVOCs and total (i.e., unfiltered) PCBs and chlorinated dioxins/furans. The laboratory analyses performed is considered adequate.

4.2-2.5 Surface Water/Sediments

Surface water and sediment samples are collected on a semi-annual basis from two locations, 200 feet to the west of the Hay Road Bridge (to the northwest of the IRM pile) and at the confluence of the Shellpot Creek and the Delaware River; these locations are upstream and downstream of the Site.

Sampling Location/Frequency

The sample locations are considered adequate and have been approved by DNREC.

Adequacy of Laboratory Analyses

The surface water samples are tested for total and dissolved metals and the sediment samples are tested for PCBs and chlorinated dioxins and furans. SVOCs (e.g., hexachlorobenzene, hexachlorobutadiene, etc.), which have been detected in the IRM and the dredged material, were excluded from the analyte list. A rationale for exclusion of these compounds from the analyte list should be provided; otherwise these compounds should be included in the laboratory analyses.

4.3 HUMAN HEALTH RISK ASSESSMENT

For direct exposure to potential commercial/industrial receptors, a human Health Risk Assessment (HHRA) was conducted using maximum concentrations of COCs in the IRM and

the dredged material. The risk assessment was conducted consistent with DNREC's *Remediation Standard Guidance Document Under the Delaware Hazardous Substance Cleanup Act*, dated December 1999 (DRNEC, 1999). Based on existing and intended land use at the Site, the risk assessment was conducted to estimate total cumulative risk of exposure to COCs from affected media (IRM and dredged material) for onsite industrial workers and was conducted in accordance with the DNREC guidance.

A brief description of the exposure pathways considered complete in the HHRA, estimation of related exposure point concentrations, and the estimated risk for restricted land use (i.e, industrial use) is presented in the subsections below. Also presented are comments related to each of these components of the HHRA.

4.3-1 Exposure Pathways

Direct exposure (through ingestion and dermal contact) to COCs present in the IRM and the dredged material for industrial workers conducting maintenance at the IRM staging area was considered to be the only complete exposure pathway in the HHRA. LRM concurs with this assessment for onsite workers, provided appropriate health safety measures are in place to minimize onsite maintenance worker exposure to COCs.

However, exposure to COCs from windblown deposition of particulates from the IRM pile to potential downwind offsite receptors has not been considered in the RA. This is a potentially critical exposure scenario which may result in exposure to COCs for nearby residential or other sensitive receptors. Accordingly, this exposure scenario should be quantitatively evaluated. Exposure by inhalation of COCs in windblown particulates from the IRM pile for onsite DuPont maintenance workers was considered minimal. This is considered appropriate because of the current presence of an interim polymer coat and the planned LLDPE cap, which should reduce the potential for COCs to become airborne from the IRM pile. Further, as discussed by DuPont, exposure may be addressed by appropriate occupational health practices (e.g., dust monitoring and control).

Ingestion of COC-affected groundwater contained in the dredged material was considered incomplete in the HHRA because site groundwater is not anticipated for drinking water use. However, the HHRA does estimate the cumulative risk due to ingestion of COC affected groundwater currently contained in the dredged material. Estimating the cumulative risk via this exposure pathway is inconsistent with the designation of this exposure pathway as incomplete, and its inclusion in the HHRA should be reconsidered or otherwise justified for consistency.

4.3-2 Exposure Point Concentrations

Exposure point concentrations are defined as the concentrations at the point of potential contact with contaminated media by potential receptors. The HHRA made use of the maximum COC concentrations in IRM and the dredged material as exposure point concentrations for direct exposure scenarios. This is consistent with the DNREC guidance.

However, as discussed in Section 4.2-2,1, the IRM was not tested for pentachlorobenzene (listed as a COC in the IRM by the USEPA). Also several analytes listed as potential COCs by the USEPA for the IRM (potential source of COCs to the underlying dredged materials) were excluded from testing of the dredged material. Unless a rationale is provided for exclusion of these chemicals from the list of analytes, additional characterization and estimation of exposure point concentrations for these COCs (if detected above laboratory reporting limits) may be required.

4.3-3 Risk Characterization

The HHRA provided cumulative risk estimates for direct exposure to COCs in impacted media (IRM, dredged material, and groundwater) using Method I – Modified Uniform Risk Based Standard (URS) Approach of the DNREC guidance (Section 5.1).

In the IRM and dredged material, multiple analytes were detected at concentrations exceeding the URS, but at concentrations less than one-order-of-magnitude above the URS. The cumulative carcinogenic risks of exposure to COCs for each media were calculated by estimating the risk for each analyte and by adding together (cumulative risk) the risk and the hazard for all the analytes. The non carcinogenic hazard was also calculated in a similar manner (i.e., by calculating the hazard for each individual analyte and by adding together the hazard for all analytes). This approach is consistent with the DNREC guidance document. The cumulative carcinogenic risks are 2.0E-05 and 1.96E-06 for exposure to IRM and dredged material respectively; both estimates are within the target acceptable risk range of 1.0E-06 to 1.0E-04.

Because 2,3,7,8-TCDD was not reported above laboratory reporting limits, carcinogenic risk from direct exposure of dioxin and dioxin like compounds in the IRM was not included in the calculated direct exposure cumulative carcinogenic risk. Average total TEQ levels in terms of 2,3,7,8-TCDD is 1,016 parts per trillion (ppt), which exceeds the DNREC's 2,3,7,8-TCDD threshold of 40 pppt. DNREC currently does not have a TEQ action level for dioxin and dioxin like compounds and may follow Region III EPA guidance (fax correspondence from DNREC, dated 13 December 2006). In a 1998 document (*Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-26*), USEPA recommends a TEQ action level of 5,000 to 20,000 ppt for dioxin and dioxin like compounds. The average TEQ value (1,016 ppt using the 2005 WHO TEFs) in IRM is below the current commercial/industrial threshold. Provided DNREC establishes a TEQ action level consistent with current USEPA standard and the new dioxin and dioxin like compounds analytical data to be collected from IRM (see data gap discussion elsewhere) is less than the UESPA commercial/industrial threshold, human health risk from direct exposure to these compounds contained in the IRM is not anticipated to be significant (see Attachment 1).

4.4 ECOLOGICAL RISK ASSESSMENT

Evaluation of the ecological risk assessment (ERA) for the Site was based on assessing the potential for ecological exposure at offsite locations. Specifically, the estimation of cumulative ecological hazards corresponding to exposure to COCs by offsite receptors (e.g., fish in surface water bodies, human consumption of impacted fish, and human recreational contact) were evaluated.

4.4.1 Exposure Pathways

Onsite Ecological Risks

The ERA did not evaluate onsite ecological risk through direct exposure of COC-impacted IRM to existing wildlife in the area. The rationale provided by DuPont to exclude this exposure pathway was that the IRM does not support vegetation (i.e., source for food) or a habitat for wildlife. However, during a site reconnaissance visit conducted by staff from LRM Schnabel, Dupont, and DNREC in July 2006, substantial vegetative growth was noted on the IRM. This vegetation serves as a source of food for wildlife (see Figure 2). Correspondingly, avian species and terrestrial wildlife, including a red fox, were observed foraging on the IRM pile. Accordingly, the ERA should include a quantitative evaluation of direct exposure pathways to appropriate ecological receptors, including exposure via relevant food chains. This analysis should necessarily include a formal habitat study and, if applicable, include an assessment of potential exposure to endangered and/or special-status species relevant to the region.

FIGURE 2: EVIDENCE OF VEGETATION ON THE IRM PILE

OffSite Ecological Risk

The Site is located adjacent to the Delaware River and one of its tributaries Shellpot Creek (herein referred to as Surface Water Bodies). Due to the proximity of the Delaware River (within 300 feet from the edge of the IRM pile) and Shellpot Creek (within 200 feet from the edge of the IRM pile), potential ecological risks to surface water bodies from COCs contained within the IRM and the shallow groundwater were evaluated in the ERA.

Based on the Delaware River Basin Commission (DRBC) Regulations (DRBC, 2005), this portion of the Delaware River (and the Shellpot Creek) is located within Zone 5 and is not designated for drinking water purposes. Accordingly, the following potential exposure pathways were considered complete in the ERA for offsite receptors in the Surface Water Bodies.

1. Deposition of sediments from the IRM pile through wind blown dispersion and/or through surface water runoff and exposure to COCs contained within these sediments through consumption by existing aquatic organisms in the surface water bodies.
2. Deposition of sediments from the IRM pile through wind blown dispersion and/or through surface water runoff, accumulation of COCs contained in the sediments in fish tissue, and potential human exposure to COCs through consumption of the fish.
3. Discharge of potentially affected shallow groundwater to the adjacent surface water bodies, and exposure to COCs through direct contact by existing aquatic organisms (e.g., fish species) in the surface water bodies.
4. Discharge of potentially affected shallow groundwater to the adjacent surface water bodies, accumulation of COCs in the fish tissue and potential human exposure through the consumption of the fish.
5. Discharge of potentially affected shallow groundwater to the adjacent surface water bodies, and potential human exposure to transported COCs through recreational contact.

The exposure pathways considered in the ERA for offsite ecological receptors are considered adequate.

4.4-2 Exposure Point Concentration/Risk Characterization

4.4-2.1 Exposure Pathways 1 and 2 (Windblown and Storm Water Related Transport)

As discussed above, 5 exposure pathways were considered complete by DuPont for offsite ecological receptors. The ERA considered exposure pathways 1 and 2 (identified above) were complete when the IRM pile remained uncovered (from 1997 to 2001). Under this exposure pathway, it was assumed that COCs contained within the IRM would be transported to the Delaware River and the Shellpot Creek by wind deposition during dry weather and/or storm water runoff during wet weather. Following its consolidation and application of polymer coat in Year 2001, the ERA considered this pathway incomplete. This assumption is not entirely accurate because of the observed erosion from the IRM pile observed during the recent Site visit.

A brief outline of the approach used in the ERA is presented below:

1. Non-dioxin-like PCB compounds, dioxin-like PCB compounds, and dioxins/furans in the IRM were identified as COCs.
2. For dioxins and furans, results from individual congeners were converted to 2,3,7,8-TCDD equivalent using the 1997 (World Health Organization-Toxicity Equivalent Factor (WHO-TEF) and the results were summed to derive the total toxic equivalent quotient (TEQ) for each sample.
3. Average concentrations of the three identified COCs were estimated using data collected from the IRM samples.
4. Annual sediment loads from windblown deposition and storm water runoff were estimated using (Industrial Source Complex Short Term) ISCST3 (Air Dispersion Model) and

Washington Metropolitan Urban Runoff Manual and total annual load was calculated by summing the individual sediment loads from windblown deposition and storm water runoff.

5. For years 1997 through 2001, average annual mass loads of the COCs in the transported sediment were estimated by multiplying the sediment load (calculated under Step 4) with the average concentration of the COCs (calculated in Step 3).
6. The maximum value of the average annual load (year 2000) of each COC was divided by the harmonic mean flow of the measured gaging stations (7.9E+12 liters per year) to estimate the predicted in stream concentration of each COC.
7. The predicted in-stream concentration of each COC was then compared with the more stringent of the water quality criteria, which would be protective of both the aquatic organisms and of human consumption of impacted fish.

In addition to the approach described above, the ERA also calculated the carcinogenic risk to human receptor (via fish consumption) as follows:

1. The average annual mass loads for each COC (for years 1997 through 2001) were summed to estimate the total mass load over the five year period for each COC.
2. The calculated total mass load for each COC was divided by the dry mass of sediment impacted by the COC to estimate the COC sediment concentration.
3. The estimated sediment concentration was used to estimate COC concentrations in fish, the life time average daily dose for human receptors consuming the fish for each COC, the carcinogenic risk for each COC, and the overall carcinogenic risk (estimated by adding the carcinogenic risk for each COC).
4. The overall carcinogenic risks were estimated for 4 scenarios (i.e., 1 kilometer [km] deposition radius and 9 mile per hour [mph] wind, 1 km deposition radius and 15 mph wind, 3 km deposition radius and 9 mph wind, and 3 km deposition radius and 15 mph wind) and they ranged from 2.0E-07 to 1.8E-06 using WHO 1998 TEFs (and 2.27×10^{-7} to 2.04×10^{-6} using 2005 WHO TEFs) (see Attachment 1).

Comments on the ERA for these exposure pathways are as follow:

1. The ERA did not provide an explanation on the rationale behind the exclusion of the remainder of the COCs (e.g., hexachlorobenzene, hexachlorobutadiene, etc.) listed by the USEPA for IRM.
2. Consistent with the initial date of this assessment, DuPont used the 1998 WHO-TEFs for dioxins. More recently in 2005, WHO has proposed new TEFs for dioxins and these values should be considered for the RA or rationale should be provided by DuPont for continued use of the 1998 TEFs (see above).
3. Use of average concentration of COC is inconsistent with the approach used in the estimation of human health risk, where the maximum COC concentrations were used in the risk calculations.
4. Backup data from the ISCST3 modeling conducted by DuPont is not available to LRM; therefore the basis of the IRM particle size distribution used in this modeling could not be reviewed. If geotechnical data exists to corroborate the assumptions made by DuPont, it

should be included in the RA. The particle size distribution of the IRM is critical to the estimation of emission rates and the subsequent dispersion based transport and downwind deposition of COC impacted IRM sediments.

5. The basis for the selection of other soil physical properties (i.e., permeability) necessary for the estimation of storm water runoff (containing IRM) should be presented in the ERA.
6. In the calculation of risks to human receptors consuming the impacted fish, the ERA assumed that COC mass was carried to the Delaware River and the Shellpot Creek only over a 5-year period (between 1997 and 2001, when a polymer coat was applied to the IRM pile); this assumption is inaccurate because of the observed erosion from the IRM pile during LRM's recent site visit. Therefore, COC mass transport and discharge to the sediments is likely ongoing (since 2001) and the carcinogenic risk to human receptors is potentially higher than those calculated in the ERA.
7. DNREC staff (presented in a 2001 internal presentation) calculated excess carcinogenic risk to be on the order of 1.1×10^{-3} to 2.1×10^{-5} from existing analytical data of fish tissue samples collected from Shellpot Creek (at Hay Road). Unless high background dioxin levels are established in the site vicinity, a reassessment of DuPont's approach (and modeling) conducted to estimate the exposure point concentrations and subsequent excess carcinogenic risk is necessary to accurately estimate the carcinogenic risk for this exposure scenario (see Attachment 1).

4.4-2.2 Exposure Pathways 3, 4, and 5 (Discharge from IRM Pile and From Existing COC-Impacted Groundwater Contained in the Dredged Material)

As discussed above, exposure pathways (3, 4, and 5) were also considered complete in the ERA for offsite ecological receptors. These pathways focused on transport of COCs from the IRM pile to underlying shallow groundwater followed by transport to the Delaware River/Shellpot Creek. Also considered in this assessment was the transport of COCs already present in shallow groundwater within the dredged material to the Delaware River/Shellpot Creek.

Potential Ecological Hazards from COCs Contained in the IRM Pile

A brief outline of the approach used in the ERA to estimate ecological hazards from the IRM pile (i.e., contribution from the IRM pile) for the No-Cap scenario is presented below:

1. Each analyte identified by the USEPA as a COC for the IRM was identified as a potential COC for these exposure pathways.
2. The most stringent threshold (i.e., from USEPA, DNREC, and DRBC values) were identified as the Water Quality Criteria for each COC for the two receptors of concern (aquatic and human receptors).
3. The process of leaching from the IRM pile to the Delaware River and the Shellpot Creek was simulated as a two step process: a vertical step through the IRM and the vadose zone (using the model Hydrologic Evaluation Leaching Procedure [HELP]) and a horizontal step through groundwater in the saturated zone (using the model Analytical Transport

[AT]-123D). An attenuation factor (AF1) was estimated as a ratio of leachate COC concentration in the IRM pile to the concentration in groundwater at the point of discharge (i.e., adjacent to the Delaware River or the Shellpot Creek).

4. Additionally, an attenuation factor of AF2 was estimated to account for dilution in the surface water. In evaluating aquatic species, AF2 was set at 10 and in evaluating human receptors, AF2 was estimated to be the ratio of surface water flow to groundwater flow.
5. The Water Quality Criteria for each analyte was then multiplied by the appropriate attenuation factors (AF1 and AF2) to estimate the closure screening level (CSL_L) leachate concentration for each COC in the IRM.
6. The estimated CSL_L for each COC was then compared with their respective maximum reported concentrations.

While the general approach used in estimating potential ecological hazards is appropriate, the application of attenuation factor, AF2, used to account for dilution in surface water is considered highly unorthodox and inconsistent with standard ERA practices for estimation of discharge point concentrations for groundwater discharge to surface water exposure pathways. For such exposure scenarios, estimated concentrations in groundwater for each COC at the point of groundwater discharge to surface water are directly (i.e, without dilution) compared to applicable water quality criteria. Use of arbitrary dilution factors without appropriate references and/or justification is considered inappropriate. The AF2 should either be conservatively removed from the calculation and/or otherwise justified based on precedence of its use and/or regulatory approval for ERAs

Additionally, in the estimation of the attenuation factor, AF1, several parameters play a critical role. Among these factors are the vertical permeability of the IRM pile, hydraulic conductivity of the shallow groundwater zone (contained in the dredged materials), the organic carbon coefficient (foc) of the aquifer sediments, and the organic carbon coefficients (Kocs) of selected chemicals. While data may not exist for the vertical permeability of the IRM and foc of the shallow aquifer zone at and around the vicinity of the IRM pile and the variation of these parameter values may have some impact on the calculated AF1 values, wide range of data (4.3E-07 cm/sec to 4.6E-02 cm/sec) has been reported for the hydraulic conductivity of the shallow aquifer zone (i.e., data collected from borings located several hundred feet to the west of the IRM pile). AF1 is highly sensitive to values of hydraulic conductivity of the shallow groundwater zone. Estimated values of AF1 (following a time period of 1,000 years into the future) using an average value of the reported hydraulic conductivities (4.8E-03 cm/sec[1]) for two of the COCs, iron and manganese, and corresponding values of CSL_L (without the dilution factor AF2) are presented below for comparison with the estimated values in the ERA (see Table 3). The recalculated values of CSL_L are several orders of magnitude lower than those calculated in the RI/RA (DuPont calculated values were >1E+06 mg/L). More importantly, the recalculated values of CSL_L for both iron and manganese are lower than the maximum reported toxicity characteristic leaching procedure (TCLP) concentrations of these chemicals (348 mg/L for iron and 252 mg/L for manganese). Under these conditions, an ecological threat above permitted levels would exist to both aquatic and human receptors in the Delaware River. It should, however,

be noted that for the lower end of the reported range of hydraulic conductivities, the values of CSL_L are significantly higher (>1E+6 mg/L) and approach the values calculated by DuPont.

While it is acknowledged that installation of a LLDPE cap over the IRM pile (as proposed in the RI/RA) will reduce vertical recharge of COC impacted leachate to shallow groundwater, thereby reducing the extent of COC impacts in shallow groundwater, and minimizing the subsequent COC impacted discharge to the Delaware River (and the Shellpot Creek), it is important to note that the performance of such a cap system has not been evaluated over a period of 1,000 years and beyond. Based on Schnabel's assessment of the available data on linear low density polyethylene (LLDPE) caps (see Task 2), the satisfactory performance of the LLDPE cap over such a large time period is considered highly unlikely. Therefore, it is important that values of the attenuation factor (AF1) and the closure screening levels (CSL_L) be properly estimated by collecting site-specific hydrogeologic (e.g., hydraulic conductivity) and other soil physical and chemical data (e.g., f_{oc}) for the IRM and the underlying dredged material to confirm the presence or the absence of future ecological threats.

TABLE 3: ESTIMATED ATTENUATION FACTORS AND CSL_L IN MILLIGRAMS PER LITER (1,000 YEAR SIMULATION)

Chemical	Environ Calculated CSL_L(mg/L)	Recalculated AF1	Recalculated CSL_L, HHC (mg/L)	Recalculated CSL_L, AC (mg/L)
Iron	>1E+6	31.9	9.6	31.9
Manganese	>1E+6	128.9	12.9	NA

NA = Not Available
HHC = Human Health Criteria
AC = Aquatic Criteria

Note:
1) To calculate average value of hydraulic conductivity from reported values (estimated using field data [i.e., radial hydraulic conductivity] and laboratory data [i.e., vertical permeability]), if values reported were those of vertical permeability, these values were multiplied by 10 (consistent with the approach used by ENVIRON in the ERA).

Graphs depicting the attenuation in iron concentration relative to distance from the edge of the IRM pile to the Delaware River (assuming a uniform source concentration of 348 mg/L, after 1,000 years) for two values of hydraulic conductivity (4.8E-03 and 1.7E-05 cm/sec) are presented in Figure 3.

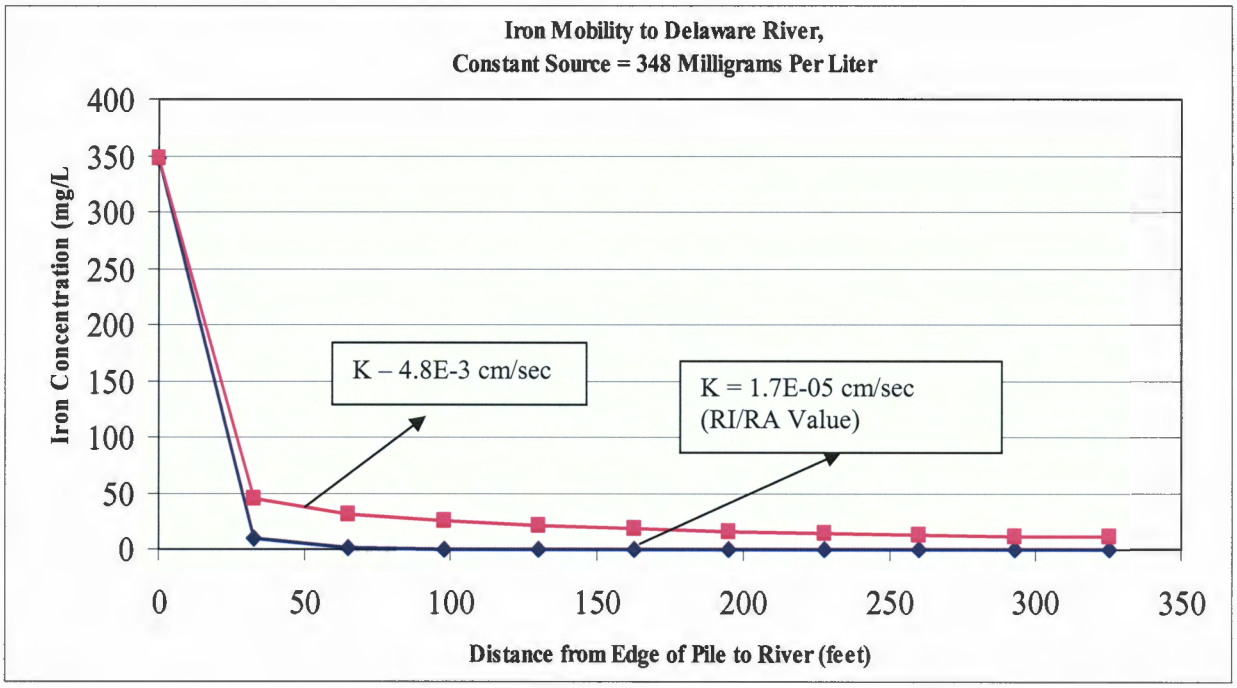

FIGURE 3: SIMULATION OF IRON CONCENTRATIONS (MILLIGRAMS PER LITER) FROM EDGE OF IRM PILE TO DELWARE RIVER IN FEET

Specific comments regarding the risk calculations conducted for these exposure pathways are as follows:

1. In the RI/RA, a value of 1.7E-05 cm/sec was used as the hydraulic conductivity of the shallow groundwater zone within the dredged material. A wider range of values (4.3E-06 cm/sec to 4.6E-02 cm/sec) is reported in soil borings/wells to the west of the IRM pile. DuPont should collect additional data underneath or in the immediate vicinity of the IRM pile.
2. Attenuation factors (AF2) used to simulate the dilution of groundwater in the surface water is inconsistent with the approach typically recommended by agencies.
3. Solubility limit of hexachlorobenze is reported as 6.2 milligrams per liter (mg/L) in the RI/RA; however, value reported in references (e.g., USEPA, 1990) is much lower and is equal to 6.2 micrograms per liter (ug/L).
4. The basis for the selection of other geotechnical properties (i.e., permeability of IRM, porosity and $_{foc}$ of dredged material) necessary for the estimation of the closure screening levels is not presented.
5. While conducting the modeling for transport of manganese in shallow groundwater using a uniform source concentration, a uniform manganese concentration of 25.7 mg/L (from a

synthetic precipitation leaching procedure [SPLP]) was used in the RI/RA; however a higher value of 252 mg/L has been reported in a TCLP test conducted on an IRM sample (DPE-SO-01, Sample Date: 09/07/99). Use of the lower SPLP value is inconsistent with the use of TCLP for iron, which was used to conduct the modeling for iron transport.

Potential Ecological Hazards from COCs Contained in Shallow Groundwater

A brief outline of the approach used in the ERA to evaluate ecological hazards from the COCs already present in the dredged material is presented below:

1. Average concentration of iron and manganese in wells screened within the dredged material adjacent to the Delaware River (MW-35) and to the Shellpot Creek (MW-33) were estimated using reported historical analytical data in these wells.
2. Daily mass loading of iron and manganese to the Delaware River and the Shellpot Creek were calculated by multiplying the groundwater flow rate into these surface water bodies by the their estimated average concentrations (calculated in Step 1).
3. The estimated daily iron and manganese mass loads were then divided by an attenuation factor that simulates mixing in the Delaware River and the Shellpot Creek (i.e., AF2 described above) to estimate the resultant in-stream concentrations.
4. The estimated in-stream concentrations was then compared with the most stringent water quality for each COC (i.e., protective of human consumption of fish).

Specific comments related to these exposure pathways are as follow:

1. No explanation is provided on the rationale behind the exclusion of the remainder of the COCs (e.g., hexachlorobenzene, hexachlorobutadiene, etc.) listed by the USEPA.
2. Use of average concentration of COC is inconsistent with the approach used in the estimation of human health risk, where the maximum COC concentrations were used in the risk calculations.
3. A value of 4.8E-03 feet per day (~1.7E-06 cm/sec) was used as the hydraulic conductivity of the shallow groundwater zone within the dredged material for this assessment. This value is inconsistent with the use of 1.7E-5 cm/sec for the dredged material for the calculation of impact from the COC contained in the IRM. Importantly, use of these low values of hydraulic conductivity in the ERA ignores the presence of high permeability sand lenses within the dredged material.
4. The basis for the selection of other soil physical properties (i.e., porosity) necessary for the estimation of COC transport should be presented in the ERA.

4.5 CONCLUSIONS

Based on the review of the RI/RA and other associated reports, several potentially significant shortcomings exist in the approach to the RA for the subject Site. These include:

1. Inadequate site characterization (sampling and laboratory analysis) of the IRM, the dredged material underneath the IRM, and the shallow groundwater contained in the dredged material underneath the IRM.
2. Inadequate soil physical (e.g., permeability, grain size distribution, etc.) characterization of IRM and dredged material underneath and around the immediate vicinity of the IRM pile.
3. Inadequate hydrogeologic (e.g., hydraulic conductivity) characterization of shallow groundwater zone contained in the dredged material underlying the IRM pile.
4. Inappropriate exclusion of wind-blown deposition pathway for transport of COC-contained IRM for exposure by potential downwind human receptors in the baseline HHRA.
5. Inappropriate exclusion of direct exposure pathways to COC impacted IRM for potential onsite wildlife in the ERA.
6. Inconsistent approach toward the selection of COCs for inclusion in the various risk assessment components.
7. Inconsistent approach to estimation of exposure point concentration for the HHRA and the ERA (i.e., usage of maximum COC concentration for HHRA and average COC concentration for ERA).
8. Exclusion of the potential for presence of high permeability sand lenses within the dredged material by assuming low values of hydraulic conductivity (1.7E-05 and 1.7E-06 cm/sec) in estimating transport of COCs from the IRM pile to the Delaware River and Shellpot Creek.
9. Improper use of apparent arbitrary attenuation factors to simulate mixing of COC-impacted groundwater in Delaware River and Shellpot Creek, thereby, inaccurately increasing closure screening levels for leachate in the IRM that would be protective of aquatic organisms and human receptors (who consume the aquatic organisms) in the surface water bodies.

4.6 REFERENCES

1992 DuPont. Report of Geotechnical Investigation, Cherry Island Closure, Edge Moor Plant. November

1999. DNREC. Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act. December

2000. DuPont. Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results. June

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2004 DuPont/URS Diamond. Final Remedial Investigation/Risk Assessment Report, Cherry Island Iron Rich Staging Area/Hay Street Sludge Drying Site. May

2005 DRBC. Water Quality Regulations, Administrative Manual, Part III, Delaware River Basin Commission, September

1990 UESPA, Basics of Pump and Treat Groundwater Remediation Technology Prepared by GeoTrans, Inc. for the US Environmental Protection Agency

1994 USEPA, Guidance for the Data Quality Objective Process, September

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ATTACHMENT TABLE 1: ESTIMATES OF VERTICAL PERMEABILITY/HYDRAULIC CONDUCTIVITY

Document	Date	Sample Location	Value (cm/sec)	Analysis Method	Hydraulic Conductivity for Calcs (cm/sec)
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-33R	3.63E-05	Slug Test	3.63E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-41A	1.34E-05	Slug Test	1.34E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-45A	3.20E-03	Slug Test	3.20E-03
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-RAW-1	4.60E-02	Slug Test	4.60E-02
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-RAW-2	1.30E-02	Slug Test	1.30E-02
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-RAW-3	1.00E-02	Slug Test	1.00E-02
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	MW-RAW-4	3.20E-03	Slug Test	3.20E-03
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	PZ-11	2.58E-05	Slug Test	2.58E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	PZ-12	1.2E-07/8.15E-04	Shelby Tube/Lab Test and Slug Test	4.08E-03
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	PZ-13	1.20E-05	Slug Test	1.20E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	PZ-14	1.10E-05	Shelby Tube/Lab Test	1.10E-04
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	PZ-15	1.70E-06	Shelby Tube/Lab Test	1.70E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	T-11	1.09E-05/7.4E-07	Shelby Tube/Lab Test	5.82E-05
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	T-14	7.60E-07	Shelby Tube/Lab Test	7.60E-06
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	T-23	4.30E-07	Shelby Tube/Lab Test	4.30E-06
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	T-26	1.80E-04	Shelby Tube/Lab Test	1.80E-03
Attachment "G" Proposal for Remedial Action and Transmittal of Pre-Design Investigation Results	feb-may 00	T-8	4.70E-07	Shelby Tube/Lab Test	4.70E-06
				Average in cm/sec	**4.80E-03**

Note: In order to estimate radial hydraulic conductivity from Shelby Tube Measurements, the vertical hydraulic conductivity measurements were multiplied by 10.

ATTACHMENT 1

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ATTACHMENT 1

The 2005 WHO Reevaluation of TEFs for Dioxins and Dixon-Like Compounds

In June 2005, a meeting of experts from the World Health Organization (WHO) and the International Programme on Chemical Safety (IPCS) was held in Geneva Switzerland, during which toxic equivalency factors (TEFs) for dioxin-like compounds were reevaluated (Society of Toxicology, 2006)[1]. Decisions regarding revisions to TEFs were made based on a combination of unweighted relative effect potency (REP) distributions from the TEF database published by Haws et. Al. (*Toxicol. Sci*, 2006, 89:4-30), expert judgment, and point estimates. In summary, previous TEFs were assigned in increments of 0.01, 0.05, 0.1, etc., but for this reevaluation it was decided to use half-order-of-magnitude increments on a logarithmic scale of 0.03, 0.1, 0.3, etc. Specifically, the expert panel implemented changes in TEFs for 2,3,4,7,8-pentachlorodibensofuran (PeCDF) (TEF = 0.3), 1,2,3,7,8-PECDF (TEF = 0.03), octachlorodibenzo-p-dioxin (OCDD) and octachlorodibenzofuran (OCDF) (TEFs = 0.0003), and several other compounds as shown on Exhibit 1.

Additivity, an important prerequisite of the TEF concept, was again confirmed in this meeting. Correspondingly, it was concluded that experimental evidence further suggests non-dioxin-like aryl hydrocarbon receptor agonists/antagonists may be able to impact the overall toxic potency of TCDD and related compounds, which warrants further investigation in the future. Moreover, other individual and groups of compounds were identified for possible future inclusion in the TEF concept, including 3,4,4'-TCB (PCB 37), polybrominated dibenzo-p-doxins (PBDDs), and dibensofurans (PBDFs) mixed PBDDs and PBDFs, and polyhalogenated naphthalenes and polybrominated piphenyls (PBBs).

Lastly, concern was raised in the meeting about direct application of the TEF approach to abiotic matrices such as soil when performing human health risk assessments. This is problematic as the present TEF methodology is primarily intended for estimating exposure, intake, and related risks via oral ingestion. Recognizing this limitation, a number of future approaches to determine alternative or additional TEFs were identified; these will be the subject of continued evaluation.

In relation to the WHO's reevaluation of the TEQ, the USEPA, in June 2006, proposed revisions to the reporting requirements for the Toxics Release Inventory (TRI) dioxin and dioxin-like compounds category. Per USEPA's current requirements, facilities provide total estimates of dioxin releases in grams. While useful, total releases are not the best measure of the actual toxicity of dioxins because each compound has its own toxicity level, which at times varies considerably from one dioxin compound to another. To this end, the USEPA has proposed a weighted value referred to as toxic equivalents (TEQs),

[1] Society of Toxicology, 2006. The 2005 World Health Organization Re-Evaluation of Human and Mammalian Toxic Equivilancy Factors for Dioxins and Dioxin-Like Compounds, Oxford University Press, July 7th.

which are calculated based on chemical-specific TEFs. In their proposed rules[2], the USEPA refers to "proposing to use the TEF scheme developed by the WHO in 1998, which is the most recent internationally agreed upon TEF scheme". However, the USEPA acknowledges the WHO's recent study (ongoing at the time of the USEPA's proposed ruling) and specifically indicates the following: "Should the WHO revise its recommended TEFs, the Agency (i.e, USEPA) anticipates that it would revise the TEFs listed above (i.e, 1998 WHO TEFs) to reflect the most recent scientific consensus."

Based on the above rationale, consistency exists between the revised TEFs recently reevaluated by the WHO and the USEPA's approach to implementation of TEFs in the reporting and risk assessment process. As indicated in Appendix D of Schnabel (2006)[3], the risk assessments performed by URS Diamond Group and ENVIRON Corporation should be revised to include all relevant exposure pathways and scenarios, together with the latest TEFs for dioxins as set forth by the WHO and the USEPA. This recommendation is discussed further below.

Recommended Reevaluation of Dioxin/Furan Risk Assessment Performed by URS Diamond Group/ENVIRON Corporation

URS Diamond Group conducted a human health risk assessement for the direct exposure of chemicals of potential concern (COCs) in impacted media (i.e., IRM, dredged material, and groundwater) to potential onsite commercial receptors. ENVIRON Corporation conducted an off-site ecological risk assessment to assess the ecological risk to potential receptors (i.e., aquatic organisms, human exposure through consumption of fish, and human recreational contact) in the Delaware River and Shellpot Creek, located adjacent to the site.

This section provides an updated evaluation on the dioxin/furan portion of the risk assessment as it relates to the use of TEFs (the 1998 WHO TEFs used by URS Diamond Group/ENVIRON Corpration and the new 2005 WHO TEFs) in calculating the total TEQ of dioxin and furan compounds in terms of 2,3,7,8-TCDD. The risk assessments should be accordingly revised to address these updated comments and the other outstanding comments/concerns presented in our evaluation of the risk assessments in Appendix A of Schnabel (December 2006).

Revised TEQs in Terms of 2,3,7,8-TCDD for IRM Samples

Using the new 2005 WHO TEFs for dioxin/furan compounds, the revised TEQs for each of the eleven samples collected from the IRM are presented in Table 1, Exhibit 2 (the analytical data is provided in Exhibit 3 [Appendix D of the ENVIRON Corporation

[2] Federal Register/Vol. 70, No. 43, Monday, March 7, 2005 (40 CFR Part 372)

[3] Schnabel Engineering Report, October 2006

Report][4]. The updated average TEQ for the eleven samples is estimated to be 1,153 parts per trillion compared to the average TEQ of 1,016 parts per trillion using the 1998 WHO-TEFs. The updated average TEQ is approximately 13% higher.

In a fax correspondence, dated 4 November 2006, DNREC provided Schnabel with additional 2,3,7,8-TCDD analytical data for samples collected from the IRM process. 2,3,7,8-TCDD was below laboratory reporting limits in the collected samples (see Exhibit 4). However, analytical data for other congeners, which have been historically reported at higher concentrations in the IRM (e.g., OCDD, OCDF, 1,2,3,4,7,8-HxCDF, etc) and are used in the determination of the total TEQ were not included in the analytical data set. This data, if available, should be utilized in calculating the total TEQ for these samples and included in the determination of the average TEQ (i.e., exposure point concentration) for the estimation of carcinogenic risk for on and off-site human receptors and on and offsite ecological receptors.

Human Health Risk Assessment

URS Diamond Group compared the detected 2,3,7,8-TCDD and 1,2,3,7,8,9-HxCDD concentrations with DNREC direct exposure thresholds (for restricted use, i.e., commercial receptors). Because the detected concentrations were below the exposure thresholds, dioxin/furan compounds were excluded from the determination of the baseline cumulative cancer risk to human receptors (see Table 1b, Exhibit 2). However, it should be noted that the total average TEQ in terms of 2,3,7,8-TCDD (calculated in Table 1, Exhibit 2) exceeds its DNREC threshold of 40 ppt.

Unless DNREC approves exclusion of dioxin/furan compounds from the determination of the cancer risk, dioxin/furan compounds should be included in the baseline human health risk assessment. DNREC currently does not have a TEQ action level for dioxin and dioxin like compounds and may follow Region III USEPA guidance (fax correspondence from DNREC, dated 13 December 2006). In a 1998 document (*Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-26*), USEPA recommends a TEQ action level of 5,000 to 20,000 ppt for dioxin and dioxin like compounds. The average TEQ value (1,016 ppt using the 1998 WHO TEFs and 1,153 ppt using the 2005 WHO TEFs) in IRM is below the current commercial/industrial threshold. Provided DNREC establishes a TEQ action level consistent with current USEPA standard and the new dioxin and dioxin like compounds analytical data to be collected from IRM is less than the UESPA commercial/industrial threshold, human health risk from direct exposure to these compounds contained in the IRM is not anticipated to be significant

No dioxin/furan analytical data is currently available for the dredged material. This data gap should be addressed by DuPont and these compounds should be accordingly in the

[4] ENVIRON Corporation, 2nd Revision December 8, 2003. Cherry Island Staging Area Potential Historical Risk Assessement.

determination of excess cancer risk as a result of direct exposure of dredged material to human receptors.

Ecological Risk Assessment

For the exposure pathway of windblown deposition/storm water runoff of IRM into the Delaware River/Shellpot Creek and subsequent exposure to sensitive ecological and human receptors, dioxin/furan compounds were included in the list of chemicals of concern. However, the risk assessment should be revised to include the updated average TEQ (using the 2005 WHO-TEFs) (see Tables 2a and 2b of Exhibit 2).

More importantly, DuPont should consider in their reassessment, dioxin and dioxin-like compound analytical data of fish tissue samples collected from Shellpot Creek (at Hay Road). An internal risk calculation conducted by DNREC staff (in 2001) indicated that the excess carcinogenic human risk due to fish consumption was on the order of 1.1×10^{-3} to 2.1×10^{-5}. The calculated risks are approximately 10 to 5,000 times higher than those calculated by DuPont. However, it should be noted that, in addition to the dioxin contribution from the IRM pile, background dioxin levels in sediment may be contributing to the higher risk levels calculated using the fish tissue samples. Unless presence of high background dioxin levels are established in sediments in the vicinity of the site and surrounding areas, a reassessment of DuPont's approach (and modeling) conducted to estimate the exposure point concentrations and subsequent excess carcinogenic risk is necessary to accurately estimate the carcinogenic risk as a result of exposure of fish (and subsequently humans) to dioxin impacted sediments.

Lastly, for the exposure pathways related to transport of chemicals of concern (including dioxin/furan compounds) from the IRM and from the dredged material to the Delaware River and Shellpot Creek, comments presented in Appendix D of Schnabel (2006) should be addressed and the cleanup level for dioxin/furan compounds (i.e., total TEQ in terms of 2,3,7,8-TCDD) should be recalculated in the revised risk assessment.

EXHIBIT 1

The International Programme on Chemical Safety (IPCS)

WHO ILO UNEP

Compound	WHO 1998 TEF	WHO 2005 TEF*
chlorinated dibenzo-p-dioxins		
1,2,3,7,8-PeCDD	1	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.0001	**0.0003**
chlorinated dibenzofurans		
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	**0.03**
2,3,4,7,8-PeCDF	0.5	**0.3**
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.0001	**0.0003**
non-ortho substituted PCBs		
PCB 77	0.0001	0.0001
PCB 81	0.0001	**0.0003**
PCB 126	0.1	0.1
PCB 169	0.01	**0.03**
mono-ortho substituted PCBs		
105	0.0001	**0.00003**
114	0.0005	**0.00003**
118	0.0001	**0.00003**
123	0.0001	**0.00003**
156	0.0005	**0.00003**
157	0.0005	**0.00003**
167	0.00001	**0.00003**
189	0.0001	**0.00003**

* Numbers in bold indicate a change in TEF value

Reference - *Van den Berg et al*:
The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds

ToxSci Advance Access, 7 July 2006

EXHIBIT 2

TABLE 1

RECALCULATED TEQs For Dioxin/Furans Using WHO-2005 TEFs

Analyte I.D.	WHO TEF (Environ)	WHO-2005 TEF	EM-IR-S01			EM-IR-S03			EM-IR-05			EM-IR-S06			EM-IR-207			Edge Moor Iron Rich		
			EM-IR-S01 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EM-IR-S03 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EM-IR-05 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EM-IR-S06 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EM-IR-207 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	Edge Moor Iron Rich (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ
OCDD	0.0001	**0.0003**	300	0.03	0.09	780	0.078	0.234	472	0.0472	0.1416	560	0.056	0.168	1065.9	0.10659	0.31977	1000	0.1	0.3
1,2,3,7,8-PeCDF	0.0500	**0.0300**	755.81	37.7905	22.6743	517.5	25.875	15.525	268	13.4	8.04	264	13.2	7.92	640.9	32.045	19.227	750	37.5	22.5
OCDF	0.0001	**0.0003**	686046.51	68.604651	205.813953	570000	57	171	418000	41.8	125.4	92400	9.24	27.72	2197727	219.77273	659.3182	1,000,000	100	300
Other Congeners	No Change Between WHO-TEF (Environ) and WHO-2005 TEF																			
Cumulative Difference Betw WHO-2005 TEF and WHO-TEF (Environ)			122.15			103.81			78.33			13.31			426.94			185.20		
Total TEQ for All Congeners for Each Sample				1569.6			741.4			619.8			353.3			931.6			1475.7	

Analyte I.D.	WHO TEF (Environ)	WHO-2005 TEF	EMI-5			EMI-6			EMI-7			EMI-8			El Iron Rich		
			EMI-5 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EMI-6 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EMI-7 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	EMI-8 (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ	El Iron Rich (pg/g)	Environ Calculated TEQ	WHO-2005 TEQ
OCDD	0.0001	**0.0003**	1190	0.119	0.357	483	0.0483	0.1449	1260	0.126	0.378	298	0.0298	0.0894	189	0.0189	0.0567
1,2,3,7,8-PeCDF	0.0500	**0.0300**	683	34.15	20.49	125	6.25	3.75	2370	118.5	71.1	223	11.15	6.69	169	8.45	5.07
OCDF	0.0001	**0.0003**	1,200,000	120	360	141,000	14.1	42.3	1,240,000	124	372	485,000	48.5	145.5	162,000	16.2	48.6
Other Congeners	No Change Between WHO-TEF (Environ) and WHO-2005 TEF																
Cumulative Difference Betw WHO-2005 TEF and WHO-TEF (Environ)			226.58			25.80			200.85			92.60			29.06		
Total TEQ for All Congeners for Each Sample				1014.5			313.1			3330.2			472.6			357.4	

Average TEQ from All Eleven Samples

	Average TEQ (ppt)	Average TEQ (ppb)
WHO TEF (Environ)	1016.3	1.016
WHO-2005 TEF	1453.1	1.453

Previously Calculated TEQ (from WHO TEF[Environ]) for Individual Congers and Total

Revised Calculated TEQ (from WHO TEF-2005) for Individual Congers and Total

Note:

SEE 2nd Revision 2003 ENVIRON REPORT " CHERRY ISLAND STAGING AREA - POTENTIAL HISTORIC RELEASE ASSESSMENT", APPENDIX A, ATTACHED HEREIN

(Page 1 and 2 - Dioxin/Furan' Page 3: Dioxin Like PCBs)

SEE LRM COMMENT (SHADED IN GREEN)

Table 1b

Iron Rich Analysis Compared to DNREC Uniform Risk-based Remediation Standards (from URS- Diamond Group RI/RA Report)

Analyte	Concentration, In Sample										Statistics				DNREC Human Health, Soil Remediation Standards:
	EM-IR-S01		EM-IR-S03		EM-IR-S05		EM-IR-S06		EM-IR-S07		Avg	Max	Min	Std. Dev	
Semi-Volatile Organic Compounds:	ppm (mg/kg) In Sample										ppm (mg/kg) In Sample				
Hexachlorobenzene		13.31		37.46		12.37		15.43		54.96	25.70	54.96	12.37	18.29	4 mg/kg
Dioxins Compounds:	ppt (pg/g) In Sample										ppt (pg/g) In Sample				
2,3,7,8-TCDD [CAS #1746-01-6]	<	0.86	<	0.93	<	0.58	<	0.37	<	0.41	0.63	0.93	0.37	0.11	40 ppt
1,2,3,7,8,9-HxCDD [CAS #19408-74-3]	<<	4.70	<	4.78		3.46	<	1.17	<<	23.64	7.55	23.64	1.17	4.07	1,000 ppt
PCBp Totals Isomers:	ppb (ng/g) In Sample										ppb (ng/g) In Sample				(none)
Total monoCB	<<	0.00	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.00	0.00	0.00	0.00	
Total diCB	<<	0.00	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.00	0.00	0.00	0.00	
Total triCB		0.12	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.02	0.12	0.00	0.05	
Total tetraCB		1.18		0.64		0.31		0.20		0.49	0.56	1.18	0.20	0.38	
Total pentaCB	<<	0.00		0.28	<<	0.00	<<	0.00		0.35	0.13	0.35	0.00	0.17	
Total hexaCB		0.12		2.14	<<	0.00		0.30		6.36	1.78	6.36	0.00	2.70	
Total heptaCB		1.37		1.95	<<	0.00		1.79		8.52	2.73	8.52	0.00	3.33	
Total octaCB		8.09		1.01		4.94		0.25		0.92	3.04	8.09	0.25	3.4	
Total nonaCB		19.51		6.10		15.20		2.70		3.98	9.50	19.51	2.70	7.4	
Total decaCB		344		900		343		763		1,606.82	791.40	1606.82	343.00	519	
Total PCB		375		912		363		768		1627	809	1627	363	278	1,000 ppb (ug/kg)
% Solid In Iron Rich Filter Press Sample:		43%		40%		34%		44%		44%					

*All Concentrations, RLs, and MDLs are corrected for percent solids, i.e. reported on a "dry weight basis".

Values underlined in this Table was corrected on 4/19/04 to reflex the "dry wt. basis".

SEE LRM COMMENT (SHADED IN GREEN)

Table 1b

Iron Rich Analysis Compared to DNREC Uniform Risk-based Remediation Standards (from URS- Diamond Group RI/RA Report)

	Concentration, In Sample					Statistics				
Analyte	EM-IR-S01	EM-IR-S03	EM-IR-S05	EM-IR-S06	EM-IR-S07	Avg	Max	Min	Std. Dev	DNREC Human Health, Soil Remediation Standards:

Exceeds DNREC's URS for Protection of Human Health, Non-Critical Water Resource Area, Restricted Use, Surface Soil (mg/kg), 12/99.

LRM Comment - This is the 2,3,7,8-TCDD concentrations and not Total TEQ (for all congeners) in terms of 2,3,7,8-TCDD Total Average TEQ Exceeds Direct Exposure DNREC Threshold

TABLE 2A
Recalculated Comparison of Estimated Dioxin/Furan Concentration for Comparison with DNREC Threshold

Class of Compound	Total IRM Loading for Year 2000	Environ Estimate COPC Conc in Iron Rich, g/kg IR	New Estimate Based on WHO-2005 TEFs, g/kg IR	Environ Estimated Year 2000 Predicted Mass Loading, mg	New Estimated Year 2000 Predicted Mass Loading Based on WHO-2005 TEFs, mg	Environ Estimated In Stream Concentration (ng/L)	New Estimate In Stream Concentration , WHO 2005 TEFs (ng/L)	DRBC Water Quality Standard (ng/L)
Dioxins/Furans	22,662	1.02E-06	0.00000115	2.30E+01	26.0613	2.90E-06	3.28E-06	1.40E-05
Dioxin Like PCBs[1]	22,662	1.60E-11	Not Calculated	3.30E-04	Not Calculated	4.20E-11	Not Calculated	Not Available
Non Dioxin Like PCBs[2]	22,662	8.09E-04	Not Calculated	18,333	Not Calculated	2.30E-03	Not Calculated	4.40E-02

Notes:
1) Effect on Total TEQ for Dioxin Like PCBs Due to Change in WHO TEFs is Insignificant
2) No Effect on Non Dioxin Like PCBs Due to Change in WHO-TEFs

Previously Calculated In Stream Concenrrations (from WHO TEF[Environ])

Revised Calculated In Stream Concentrations (from WHO TEF-2005)

IR = Iron Rich
g/kg = grams per kilogram
mg = milligrams
ng/L = nanograms per liter

TABLE 2B

Recalculated Ecological Risk - Pathway for Human Consumption of Impacted Fish

Class of Compound	Risk Range		Risk Range	
	Min	Max	Min	Max
Dioxins/Furans	2.00E-07	1.80E-06	2.26E-07	2.0ME-06
Dioxin Like PCBs[1]	1.80E-16	1.60E-15	Not Calculated	Not Calculated
Non Dioxin Like PCBs[2]	3.90E-10	3.30E-09	Not Calculated	Not Calculated
Total Environ Estimate	2.00E-07	1.80E-06		
	Total New Estimated Based on WHO-2005 TEQs		2.27E-07	2.04E-06

Notes:

1) Effect on Total TEQ for Dioxin Like PCBs Due to Change in WHO TEFs is Insignificant

2) No Effect on Non Dioxin Like PCBs Due to Change in WHO-TEFs

Previously Calculated Risk Range (from WHO TEF[Environ])

Revised Calculated Risk Range (from WHO TEF-2005)

EXHIBIT 3

Iron Rich Material Dioxin/Furans Analytical Results

All anlaysis were performed by Alta Labs.

Dry Weight Basis

Sample ID #:																							
Sample ID:			EM-IR-S01			EM-IR-S03			EM-IR-05			EM-IR-S06			EM-IR-207			Edge Moor Iron Rich	
Date Sampled:	WHO-TEF		6/12/01	TEQ		6/14/01	TEQ		6/25/01	TEQ		6/26/01	TEQ		6/27/01	TEQ		09/07/99	TEQ
Analyte			pg/g	pg/g		pg/g	pg/g		pg/g	pg/g		pg/g	pg/g		pg/g	pg/g		pg/g	pg/g
% Solids	(dry)		43%			40%			34%			44%			44%				
2,3,7,8-TCDD	1.0000	<	0.85	0.85	<	0.925	0.9	<	0.584	0.584	<	0.363	0.363	<	0.4	0.4	<	0.46	0.46
1,2,3,7,8-PeCDD	1.0000	<	1.93	1.93	<	5.2	5.2	<	1.23	1.23	<	1	1.000	<	1.6	1.6	<	0.64	0.64
1,2,3,4,7,8-HxCDD	0.1000	<	2.93	0.29	<	5	0.5	<	1.56	0.156	<	1.19	0.119	<	4.3	0.4	<	1.60	0.16
1,2,3,6,7,8-HxCDD	0.1000	<	3.30	0.33	<	5.55	0.6		4.3	0.43	<	1.38	0.138	<	5.0	0.5	<	1.60	0.16
1,2,3,7,8,9-HxCDD	0.1000	<	4.70	0.47	<	4.775	0.5		3.49	0.349	<	1.16	0.116	<<	23.6	2.4	<	1.40	0.14
1,2,3,4,6,7,8-HpCDD	0.0100		9.95	0.10	<	6	0.1		16.1	0.161		4.36	0.044	<	5.6	0.1		5.4	0.05
OCDD	0.0001		300.00	0.03		780	0.1		472	0.0472		560	0.056		1065.9	0.1		1,000.0	0.10
2,3,7,8-TCDF	0.1000		125.81	12.58		144.75	14.5		53.5	5.35		71.1	7.110		141.8	14.2		170.0	17.00
1,2,3,7,8-PeCDF	0.0500		755.81	37.79		517.5	25.9		268	13.4		264	13.200		640.9	32.0		750.0	37.50
2,3,4,7,8-PeCDF	0.5000		231.86	115.93		66.5	33.3		77.8	38.9		30.8	15.400		77.7	38.9		140.0	70.00
1,2,3,4,7,8-HxCDF	0.1000		4744.19	474.42		3800	380.0		1440	144		1480	148.000		3431.8	343.2		9,200.0	920.00
1,2,3,6,7,8-HxCDF	0.1000		2348.84	234.88		417.5	41.8		1480	148		181	18.100		352.3	35.2		620.0	62.00
2,3,4,6,7,8,-HxCDF	0.1000		1244.19	124.42		115	11.5		792	79.2		41.7	4.170		78.9	7.9		85.0	8.50
1,2,3,7,8,9-HxCDF	0.1000		330.23	33.02	<<	215.25	21.5		116	11.6		95.4	9.540	<<	406.8	40.7		280.0	28.00
1,2,3,4,6,7,8-HpCDF	0.0100		38604.65	386.05		10875	108.8		11500	115		2500	25.000		15272.7	152.7		16,000.0	160.00
1,2,3,4,7,8,9-HpCDF	0.0100		7790.70	77.91		3950	39.5		1960	19.6		1850	18.500		4159.1	41.6		7,100.0	71.00
OCDF	0.0001		686046.51	68.60		570000	57.0		418000	41.8		924000	92.400	<<	2197727.3	219.8		1,000,000.0	100.00
Total			742546.45	1569.60		590908.95	741.4		436186.56	619.8		931083.45	353.3		2223395.752	931.6		1035356.10	1475.7
Percent OCDF			92%			96%			96%			99%			99%			97%	

< = nondetect

<< = detected peaks that could be the compound but did not exactly match the signature of the compound

Iron Rich Material Dioxin/Furans Analytical Results

All anlaysis were performed by Alta Labs.

Dry Weight Basis

Sample ID #:			EMI-5			EMI-6			EMI-7			EMI-8			EI				average	Geometric	Geometric Mean
Sample ID:			Iron Rich			Iron Rich			Iron Rich			Iron Rich			Iron Rich						
Date Sampled:	WHO-TEF		10/20/00 180	TEQ		10/21/00 070	TEQ		10/21/00 164	TEQ		10/22/00 090	TEQ		10/18/00	TEQ					
Analyte			pg/g	pg/g		pg/g	pg/g		pg/g	pg/g		pg/g	pg/g		pg/g	pg/g			pg/g	pg/g	pg/g	pg/g
% Solids	(dry)		40%			44.9%			47.0%			43.1%			45.50%							
2,3,7,8-TCDD	1.0000	<	0.884	0.88	<	0.791	0.79	<	0.952	0.95	<	1.05	1.05	<	0.927	0.93	<		0.75	0.75	0.70	0.70
1,2,3,7,8-PeCDD	1.0000	<	1.7	1.70	<	1.59	1.59	<	5.58	5.58	<	1.54	1.54	<	2.41	2.41	<		2.22	2.22	1.81	1.81
1,2,3,4,7,8-HxCDD	0.1000	<	8.48	0.85	<	3.88	0.39	<	10.9	1.09	<	3.11	0.31	<	6	0.60	<		4.45	0.44	3.58	0.36
1,2,3,6,7,8-HxCDD	0.1000	<	8.84	0.88	<	4.13	0.41	<	12.5	1.25	<	3.41	0.34	<	6.31	0.63	<		5.12	0.51	4.27	0.43
1,2,3,7,8,9-HxCDD	0.1000	<	8.57	0.86	<	3.97	0.40	<	11.6	1.16	<	3.23	0.32	<	5.68	0.57	<		6.56	0.66	4.65	0.46
1,2,3,4,6,7,8-HpCDD	0.0100		21.6	0.22		42.3	0.42		34.7	0.35		16.7	0.17		9.21	0.09			15.63	0.16	11.80	0.12
OCDD	0.0001		1190	0.12		483	0.05		1260	0.13		298	0.03		189	0.02			690.72	0.07	583.89	0.06
2,3,7,8-TCDF	0.1000		148	14.80		15.6	1.56		531	53.10		47.4	4.74		21.2	2.12			133.65	13.37	86.61	8.66
1,2,3,7,8-PeCDF	0.0500		683	34.15		125	6.25		2370	118.50		223	11.15		169	8.45			615.11	30.76	433.44	21.67
2,3,4,7,8-PeCDF	0.5000		75.2	37.60		47.8	23.90		271	135.50		39	19.50		61.8	30.90			101.77	50.89	80.69	40.34
1,2,3,4,7,8-HxCDF	0.1000		5670	567.00		707	70.70		22000	2200.00		2010	201.00		1010	101.00			5044.82	504.48	3056.09	305.61
1,2,3,6,7,8-HxCDF	0.1000		721	72.10		630	63.00		2650	265.00		556	55.60		677	67.70			966.69	96.67	717.63	71.76
2,3,4,6,7,8,-HxCDF	0.1000		71	7.10		327	32.70		286	28.60		251	25.10		377	37.70			333.52	33.35	199.48	19.95
1,2,3,7,8,9-HxCDF	0.1000	<	459	45.90		78.9	7.89	<	1270	127.00	<	155	15.50		106	10.60	<		319.33	31.93	222.97	22.30
1,2,3,4,6,7,8-HpCDF	0.0100		6540	65.40		7650	76.50		22600	226.00		8330	83.30		6340	63.40			13292.03	132.92	10528.05	105.28
1,2,3,4,7,8,9-HpCDF	0.0100		4490	44.90		1240	12.40		16900	169.00		1990	19.90		1410	14.10			4803.62	48.04	3466.99	34.67
OCDF	0.0001		1,200,000	120.00		141,000	14.10		1,240,000	124.00		485,000	48.50		162,000	16.20			820343.07	82.03	622838.41	62.28
Total			1220097.3	1014.5		152361.0	313.1		1310214.2	3330.2		498928.4	472.6		172391.5	357.4			846679.06	1016.28	648929.99	777.28
Percent OCDF			98%			93%			95%			97%			94%				96%			

Iron Rich Material PCB Analytical Results

All analysis performed by Alta Labs

Site:	Edge Moor														
Sample	Iron Rich														
Date of Sample		6/12/01		6/14/01		6/25/01		6/26/01		6/27/01					
Wet or Dry Basis		Dry		Dry		Dry		Dry		Dry					
% Solid		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]					
		Concentration ppb (ng/g), In Sample										Statistics			
Analyte	Samples	EM-IR-S01		EM-IR-S03		EM-IR-S05		EM-IR-S06		EM-IR-S07		Avg	Max	Min	Std. Dev
PCBp	ppb (ng/g)														
PCB-77		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-81		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-105		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-114		<	0.11	<	0.13	<	0.40	<	0.29	<	0.11	0.21	0.40	0.11	0.13
PCB-118		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-123		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-126		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-156		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-157		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-167		<	0.11		0.87	<	0.14	<	0.10	<	0.11	0.27	0.87	0.10	0.34
PCB-169		<	0.11	<	0.13	<	0.14	<	0.10	<	0.11	0.12	0.14	0.10	0.02
PCB-170		<	0.11	<	0.13	<	0.14		0.11		0.44	0.19	0.44	0.11	0.14
PCB-180		<	0.27	<	0.33	<	0.72	<	0.52	<	0.27	0.42	0.72	0.27	0.19
PCB-189		<	0.11	<	0.13	<	0.14	<	0.10		0.16	0.13	0.16	0.10	0.02
PCBp Totals Isomers															
Total monoCB		<<	0.00	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.00	0.00	0.00	0.00
Total diCB		<<	0.00	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.00	0.00	0.00	0.00
Total triCB			0.12	<<	0.00	<<	0.00	<<	0.00	<<	0.00	0.02	0.12	0.00	0.05
Total tetraCB			1.18		0.64		0.31		0.20		0.49	0.56	1.18	0.20	0.38
Total pentaCB		<<	0.00		0.28	<<	0.00	<<	0.00		0.35	0.13	0.35	0.00	0.17
Total hexaCB			0.12		2.14	<<	0.00		0.30		6.36	1.78	6.36	0.00	2.70
Total heptaCB			1.37		1.95	<<	0.00		1.79		8.52	2.73	8.52	0.00	3.33
Total octaCB			8.09		1.01		4.94		0.25		0.92	3.0	8.1	0.2	3.4
Total nonaCB			19.51		6.10		15.20		2.70		3.98	9.5	19.5	2.7	7.4
Total decaCB			344.19		900.00		343		763		1606.82	791	1607	343	519
Total PCB			375		912		363		768		1627	809	1627	363	517
Percent Total decaCB			92%		99%		94%		99%		99%				

< = nondetect
<< = detected peaks that could be the compound but did not exactly match the signature of the compound

EXHIBIT 4

DNREC/SIRB

11/02/2006 14:48 302-395-2601

S.No	Sample ID	Test description	Units	2378 TCDD Conc (dry basis)	Sampling date	Comment	Sample source	Total # of samples	DL in Method Blank
1	EMI-5	Iron Rich - TCLP	pg/L	4.260	10/20/00	Concentration below method detection calibration limit. Parent iron rich sample was non-detect. Three other Iron Rich - TCLP samples showed non-detect	Iron rich-TCLP	4	0.697
2	EM-FS-S07	Baseline sampling PBT reduc prog	pg/g	8.248	06/27/01	One of 6 baseline samples of floc solids, other 5 non-detects, last sample in 11/05	SCDS Floc Solids	6	0.123
3	EM-SC-01-09-12-1 1252	R&D Test	pg/g	5.260	09/12/01	R&D testing under non-routine operating conditions on same day. Sample EM-HC-01-09-13-10805 concentration below method detection calibration limit.	SCDS	149	0.191
4	EM-SC-01-09-01-1 1337	R&D Test	pg/g	12.200	09/13/01		SCDS	149	0.191
5	EM-SC-01-09-01-1 1217	R&D Test	pg/g	3.570	09/13/01		SCDS	149	0.191
6	EM-SC-01-09-13-1 0810	R&D Test	pg/g	3.080	09/13/01		SCDS	149	0.191
7	EM-SC-01-09-13-1 1138	R&D Test	pg/g	2.060	09/13/01		SCDS	149	0.191
8	EM-HC-01-09-13-1 0805	R&D Test	pg/g	0.304	09/13/01		HCDS	29	0.191
9	IR-Press # 1 12/12	R&D Test	pg/g	0.272	12/12/03	R&D testing under non-routine operation. Concentration below method detection calibration limit. 48 other samples showed non-detect (during routine operation)	Waste water sludge	49	0.0617
10	EM-DTD40524-0805	2Q04 TRI Reporting	pg/g	[0.288]	05/24/04	EMPC value; concentration below method detection calibration limit. 71 other samples show non-detect	Iron Rich	72	0.234
11	EM-OF040716-0945	3Q04 TRI Reporting	pg/L	[2.08]	07/16/04	EMPC value; concentration below method detection calibration limit. 73 other samples show non-detect	Outfall	74	1.52
12	RW-C404	4Q04 TRI Reporting	pg/L	[10.9]	11/10/04	River water intake, EMPC value.	River water	55	4.86
13	EM2-CY-200510-4A	Ore/recovered ore study - baseline	pg/g	1.09	10/06/05	Within operating range, but non-routine roaster temperature	Roaster Cyclone	2	0.197
14	EM2-BH-200510-4	Ore/recovered ore study - baseline	pg/g	[0.376]	10/14/05	Within operating range, but non-routine roaster temperature. EMPC value; concentration below method detection calibration limit	Bag House	2	0.197
15	Bed Dump Material	Baseline sampling	pg/g	0.384	12/05/05	Concentration below method detection calibration limit. Re-sampling was non-detect	Bed dump	2	0.231

Trgs
Iron + Eroded EMPC [illegible] – 40 pg/g lam

APPENDIX B

Iron Rich DNAPL Simulation Calculations

DNREC-DUPONT IR
Project Number: 06150049
NAPL Volume calculation per m3
HCB = i

Assume (for IR)
n= variable
foc= 0.01

			Reference
Ciw,sol (mg/L)	6.00E-03	USEPA 600/8-90/003	
Kow	1.70E+05	USEPA 600/8-90/003	
Mwi (g/mol)	284.8	Verschueren	
SG (g/cm3)	2.044	Verschueren	
Solids (g/cm3)	4.4	IR solids; USEPA#DPE-S0-01	
Max Mass, i (mg/kg)	54.96	Lancaster Labs, DPE-S0-01	
Ave Mass, i (mg/kg)	25.7	Lancaster Labs, DPE-S0-01	
Min Mass, i (mg/kg)	12.37	Lancaster Labs, DPE-S0-01	

TABLE 5-1

	Max soil value HCB			Ave soil value HCB			Min soil value HCB		
n	M,T, init (g)	Vnapl (m3)	Vnapl (L)	M,T, init (g)	Vnapl (m3)	Vnapl (L)	M,T, init (g)	Vnapl (m3)	Vnapl (L)
0.20	193459.2	0.09	94.64	90464	0.04	44.25	43542.4	0.02	21.29
0.25	181368	0.09	88.72	84810	0.04	41.48	40821	0.02	19.96
0.30	169276.8	0.08	82.81	79156	0.04	38.72	38099.6	0.02	18.63
0.35	157185.6	0.08	76.89	73502	0.04	35.95	35378.2	0.02	17.30
0.40	145094.4	0.07	70.98	67848	0.03	33.19	32656.8	0.02	15.97
0.45	133003.2	0.07	65.06	62194	0.03	30.42	29935.4	0.01	14.64
0.50	120912	0.06	59.15	56540	0.03	27.65	27214	0.01	13.31
0.55	108820.8	0.05	53.23	50886	0.02	24.89	24492.6	0.01	11.98
0.60	96729.6	0.05	47.32	45232	0.02	22.12	21771.2	0.01	10.65

USEPA 600/8-90/003 (1990). "Basics of pump-and-treat ground-water remediaton technology," USEPA, Ada, OK, March (NTIS PB90-274549)
Verschueren, K., 1983. "Handbook of environmental data on organic chemicals," 2nd Ed., Van Nostrand Reinhold Co., NY, NY

DNREC-DUPONT DM
Project Number: 06150049
NAPL Volume calculation per m3
HCB = i

Assume (for IR)
n= variable
foc= 0.1
foc= 0.01
foc= 0.001

					Reference
			Ciw,sol (mg/L)	6.00E-03	USEPA 600/8-90/003
			Kow	1.70E+05	USEPA 600/8-90/003
			Mwi (g/mol)	284.8	Verschueren
			SG (g/cm3)	2.044	Verschueren
			Solids (g/cm3)	2.45	Grubb et al. 2006
		Ave	Mass, i (mg/kg)	1.1	Lancaster Labs, DPE-S0-01

TABLE 5-2

	foc=0.1			foc=0.01			foc=0.001		
n	M,T, init (g)	Vnapl (m3)	Vnapl (L)	M,T, init (g)	Vnapl (m3)	Vnapl (L)	M,T, init (g)	Vnapl (m3)	Vnapl (L)
0.20	2156.00	0.00	1.00	2156.00	0.00	1.05	2156.00	0.00	1.05
0.25	2021.25	0.00	0.93	2021.25	0.00	0.98	2021.25	0.00	0.99
0.30	1886.50	0.00	0.87	1886.50	0.00	0.92	1886.50	0.00	0.92
0.35	1751.75	0.00	0.81	1751.75	0.00	0.85	1751.75	0.00	0.86
0.40	1617.00	0.00	0.75	1617.00	0.00	0.79	1617.00	0.00	0.79
0.45	1482.25	0.00	0.68	1482.25	0.00	0.72	1482.25	0.00	0.72
0.50	1347.50	0.00	0.62	1347.50	0.00	0.66	1347.50	0.00	0.66
0.55	1212.75	0.00	0.56	1212.75	0.00	0.59	1212.75	0.00	0.59
0.60	1078.00	0.00	0.50	1078.00	0.00	0.52	1078.00	0.00	0.53

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