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Executive Summary of the Removal Action Investigation/Remedial Investigation Report (Revision 2.0) for the East Cement Kiln Dust Area and Alternatives Evaluation (Revision 3.0) for the East Cement Kiln Dust Area

Site Name: Bay Harbor Cement Kiln Dust Site
Location: Bay Harbor, Michigan

Purpose

This document was prepared for the Bay Harbor Regional Stakeholders Group and represents an executive summary of the following two documents relating to activities at the East Cement Kiln Dust (CKD) Area of the Little Traverse Bay (LTB) CKD Release Site near Petoskey, Michigan:

1. June 4, 2009 Removal Action Investigation/Remedial Investigation Report East CKD Area - Revision 2.0
2. August 31, 2009 Alternatives Evaluation East CKD Area - Revision 3.0

The Removal Action Investigation/Remedial Investigation Report (RI Report) and the Alternatives Evaluation (AE Report) were prepared on behalf of CMS Land Company and CMS Capital, LLC (referred to collectively as CMS). Findings for the East CKD Area that are significantly different compared to the West, Seep 2 and Seep 1 CKD Areas are described in Sections 2.3, 2.6, 3.1(*Interim Response Activities and Effectiveness*), 3.2 (*Contaminants of Concern*), 3.3-3.4, and Tables 1 and 2.

Section 1. Introduction

- The LTB CKD Release Site, located along five miles of shoreline on Little Traverse Bay of Lake Michigan, is approximately five miles west of the City of Petoskey, and located in Resort Township, Emmet County, Michigan. The location of the East CKD Area relative to the entire LTB Site is shown in Figure 1.

Figure 1. Location of the West CKD Area, Seep 2 CKD Area, Seep 1 CKD Area and East CKD Area of the LTB Release Site (excerpted from Figure 1-1 of the RI Report).

- The source of contamination at the East CKD Area is CKD. Potential contaminants of concern (COCs) (discussed in Section 2.5) may be released from the CKD through leaching (dissolving soluble CKD matter in water) by infiltrated water or ground water, or from a breach of the soil cover.

Section 2. The RI Report

2.1 RI Report Background

- The RI Report describes the investigation activities at the East CKD Area, which were completed prior to March 31, 2008. A summary was included in the RI Report that describes results of the interim response activities completed at the East CKD Area.
- The objectives of the RI activities were to generate the data necessary to complete the East CKD Site characterization (i.e., identify additional CKD leachate release areas, and identify the nature and extent of contamination) and evaluate final remedy alternatives for addressing current and potential threats to public health, welfare and the environment from CKD waste material.

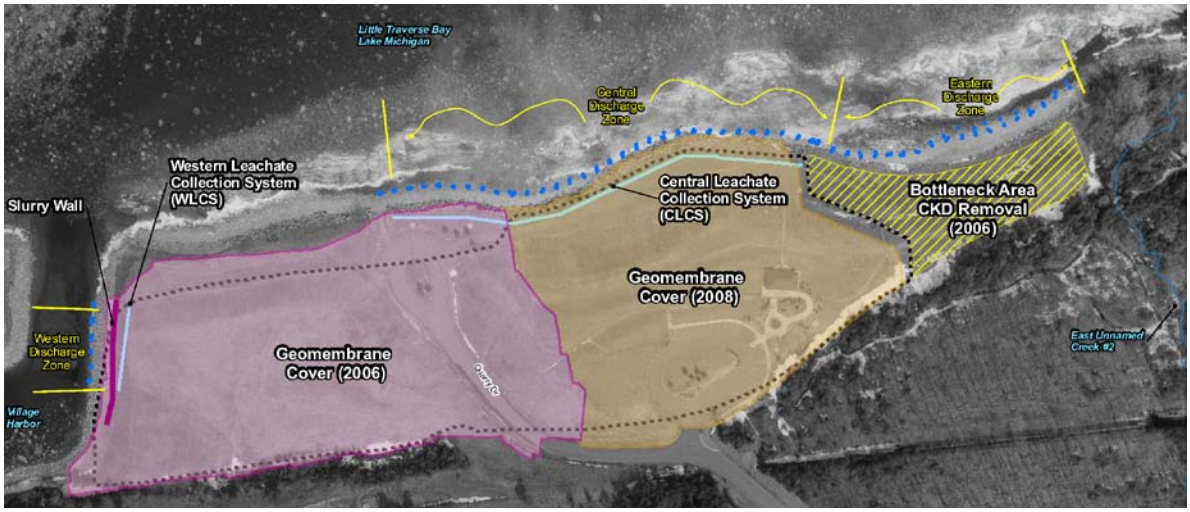

Figure 2. Site Layout and Remedial Action Features of the East CKD Area (excerpt taken from Figure 7 of the AE Report).

2.2 Study Area Investigation

- Investigations and methods used were described in detail in the RI Report and included examination of land surface features; contaminant source investigations including unconsolidated material sampling (CKD and non-CKD) and leachate; meteorological investigations; surface water investigations; geological investigations; soil and vadose zone (the unsaturated zone between the water table and the land surface) investigations; ground water investigations; and ecological investigations.

2.3 Physical Characteristics of the Study Area

- The land surface at the East CKD Area generally slopes toward Lake Michigan, from south to north.

- The targeted survey of the shoreline in fall 2005 defined three areas with high pH readings (see Figure 2).
- The geology of the LTB Site is limestone or shaley limestone bedrock and the uppermost portion is weathered with a relatively thin cover of dispersed deposits. Investigations revealed that the limestone bedrock was highly fractured.
- The direction of horizontal ground water flow over most of the East CKD Area is from south to north with discharge into Lake Michigan. The western portion of the East CKD Area discharges to the Village Harbor boat channel. The general flow is consistent with non-uniform flow affected by shoreline geometry and hydraulic gradient (which is the slope of the water table and represents the driving force for the flow).
- There were no effects detected from the municipal well pumps in the City of Petoskey.
- The static ground water elevations and flow directions are not greatly affected by Lake Michigan's tidal fluctuations.

2.4 Nature and Extent of Contamination

- Contaminants of concern (COCs) were identified by evaluating samples from the East CKD Area against applicable criteria (see Section 2.5).
- The extent of the CKD was determined by both drilling and geophysical survey methods. The CKD occupies a footprint area of approximately 10 acres.
- The volume of CKD in the East CKD Area is approximately 360,000 cubic yards, 25 to 50 percent of which is below the water table.
- Surface water samples were collected in targeted shoreline water quality surveys in spring 2005, fall 2005 (October/November) and spring 2006. Some criteria were exceeded in the collected samples including pH, total dissolved solids, chloride, mercury and other metals. Data collected during these surveys defined the impacts and extent of the "discharge zones" (see Figure 2).

2.5 CKD/Leachate Chemistry and Contaminant Fate and Transport

CKD Characteristics

- Cement kiln dust is a byproduct of manufacturing Portland cement. The specific characteristics of CKD vary due to differences in raw materials, kiln (furnace) fuel used, and a number of other factors. In general, CKDs are mixtures of fine particles of unreacted raw limestone, enriched with alkali (potassium and sodium), sulfate, halides, some organic matter derived from kiln fuel, elements that condense with CKD as exhaust gases cool, and other volatile inorganic materials.

Leachate Chemistry Discussion

- When water comes in contact with CKD, it reacts with solid-phase minerals in the CKD and is converted to leachate.
- Chemical reactions between CKD and water impart specific properties to leachate, including: high levels of sodium and potassium and low levels of calcium and magnesium (as compared with natural waters); high pH; high concentrations of sulfate, mercury and total dissolved solids (TDS); varying concentrations of aluminum and iron; and fatty acid surfactants (molecules similar in structure to detergent) from the organic matter in CKD.

Potential East CKD Site COCs

- Table 1 presents the potential East CKD Site COCs in ground water, surface water and/or unconsolidated materials (including non-CKD and CKD) that exceeded Michigan Part 201 Generic Cleanup Criteria.
- Analytical data for surface water samples were compared to potentially applicable Michigan Part 31[1] surface water criteria.

Groundwater (monitoring well samples):

Residential Drinking Water Criteria	chloride, nitrogen (total), pH, TDS, sulfate, aluminum, antimony, arsenic, iron, lead, manganese, nickel, selenium, sodium, vanadium
Groundwater Surface Water Interface Criteria	chloride, ammonia, pH, TDS, antimony, chromium, copper, lead, mercury, nickel, selenium, silver, vanadium

Unconsolidated Materials (non-CKD and CKD):

Drinking Water Protection Criteria	nitrogen (total), sulfate, aluminum, antimony, arsenic, chromium, iron, lead, magnesium, thallium
Groundwater Surface Water Interface Protection Criteria	ammonia, chromium, copper, mercury, selenium, silver, thallium, zinc
Direct Contact Criteria	chloride, arsenic, lead

Surface Water:

Surface Water Human Cancer and Non-Cancer Drinking and Non-Drinking Water Criteria	Chloride, pH, TDS, antimony, mercury
Final Chronic and Acute, Aquatic Maximum and Wildlife Values	Chloride, pH, TDS, mercury, selenium, vanadium, zinc

Table 1. Criteria exceeded by potential Site COCs in ground water, surface water and/or unconsolidated materials (including non-CKD and CKD) (from the RI Report, pp. 109-110).

Potential Routes of Migration

- Potential COCs might be released from the CKD pile through leaching by infiltration of surface water or ground water, or from a breach of cover soils. These potential COCs can then migrate along exposure pathways as ground water (i.e., water in the saturated zone), leachate (i.e., water reaching the surface through the unsaturated zone), particulates transported as a solid (as in slope failure), suspended sediment in runoff, or as airborne particulate.
- All of the potential East CKD Site COCs identified are inorganic and are not subject to biodegradation, with the possible exception of ammonia. Many of the COCs are subject to changes in oxidation states (they are able to react with other chemicals), or may react in precipitation (when a chemical comes out of solution as a solid) or adsorption reactions (when a chemical adheres or sticks onto the surface of a particle).

[1] For background information on Michigan Part 31 see: http://www.michigan.gov/documents/deq/deq-ess-p2tas-waterguidance-Part31ofNREPA_209536_7.pdf

- The migration of the potential East CKD Site COCs is controlled by a number of factors. Movement of leachate/ground water is likely the predominant migration mechanism, but will only be significant in areas of downward or lateral gradients. Lake Michigan is the regional ground water discharge area for the aquifer beneath the East CKD Site.

2.6 Baseline Risk Assessment

- The potential risks to human health posed by the contaminants are evaluated in this section.
- The conclusion from the evaluation is that "other than pH there appears to be no significant risk uniquely associated with plausible exposures to any of the parameters evaluated under conservative assumptions." This finding is consistent with the findings of the Federal Agency for Toxic Substances and Disease Registry (ATSDR) and the Michigan Department of Community Health (MDCH) Consultation, which evaluated the CKD leachate release at the East CKD Area.[2]
- Surface water is not used currently nor anticipated to be used as a source for drinking water, and the risk to fish consumers would not be significantly reduced even if release of persistent bioaccumulative toxins (PBTs), such as mercury from CKD, were eliminated because of their low flux relative to the larger source of PBTs in the Great Lakes from airborne deposition.

2.7 RI Report Summary and Conclusions

- An Interim Leachate Recovery System (ILRS) for the East CKD Area was designed and constructed, and is in operation as required by the AOC. Effectiveness monitoring showed the East CKD Area ILRS to be effective in that no pH values greater than pH 9 were measured in 2007. Higher pH measurements were monitored east of the CLCS in April 2008, and were attributed to snowmelt and rainfall infiltration, but this was prior to the installation of the cover system.
- The mechanisms of migration have also been defined and preferred ground water pathways have been identified. In addition, aquifer characteristics were determined, allowing CMS to evaluate feasibility and engineering requirements to allow selection of appropriate remedial actions.

Section 3. The AE Report

3.1 AE Report Background

- The AE Report evaluates and compares possible remedial action alternatives for the East CKD portion of the LTB CKD Release Site. The alternatives range in technical feasibility and cost and provide a range of protection for human health and the environment.
- The AE Report describes the remedial action alternatives, the extent of affected media, and criteria used to determine which remedial alternative will be most effective at the East CKD Site.

Interim Response (IR) Activities

- Leachate Migration Controls include: installation of Central and West Leachate Collection Systems (CLCS, WLCS), and a ground water flow slurry wall vertical barrier downgradient of WLCS, which have been operational since November 15, 2006; and the construction of upgradient

[2] Results were published in *Health Consultation, Bay Harbor Cement Kiln Dust Seep Discharge, Bay Harbor, Emmet County, Michigan (ATSDR, 2005).*

diversion wells and forcemain (discharge pipeline of a pumping station), constructed in 2008 and 2009.

- Leachate Generation Controls include: CKD excavation of the eastern portion bottleneck (see Figure 1) and consolidation above the water table in the western area of the East CKD Site, completed September 2006; construction of the west cover system in 2007, and the east cover system in 2008; construction of storm sewer system improvements from 2006 to 2008; and construction of upgradient diversion wells and forcemain in 2008 and 2009.

Effectiveness of IR Actions

The effectiveness of the IR actions at protecting human health and the environment is evaluated through the following three lines of evidence: (1) effectiveness monitoring – lakeshore pH control; (2) mercury flux analysis; and (3) surface water quality data.

- Effectiveness monitoring: with completion of the cover system in 2008, the continued effectiveness of the IR has been demonstrated in 2009. No pH measurements above pH 9 were observed on the lake side of the WLCS or CLCS in 2009.
- Mercury flux analysis: using a modeling approach, calculations were performed using water quality data collected between February and March 2006, prior to IR actions; these calculations were compared to those based on 2008 and 2009 ground water quality data. Mercury flux values have decreased overall since IR activities.
- Surface water quality: samples were collected between January and May 2006, prior to IR actions; these samples were compared to those after the leachate collection system (WLCS and CLCS) was operational. Potassium was used as a representative parameter as well as pH, aluminum, vanadium and mercury. All the parameters measured decreased substantially after IR activities.

In summary, the AE Report states that the IR actions appear to be effectively mitigating all parameters evaluated.

East CKD Site Conceptual Model

The East CKD conceptual Site model was developed and refined based on investigation activities and also from IR activity analysis and effectiveness monitoring. The model considers CKD location, geology, hydrogeology, surface water, leachate generation from infiltration, saturated CKD (where ground water contacts CKD), interflow from perched ground water (ground water separated from the main body of ground water by an unsaturated zone) upgradient of the CKD Area, ground water flow, leachate migration and COCs.

3.2 Identification and Screening of Technologies: Introduction, Remedial Action Objectives and ARARs, General Response Actions, Identification and Screening of Technology Types and Process Options

A broad range of remedial technologies were screened, combined into alternatives and evaluated. Remedial Action Objectives (RAOs) are the basis for evaluating possible remedial technologies and remedial action alternatives. Further response activities are required to integrate the IR actions as appropriate and ensure adequate financial resources. RAOs for the East CKD Area consider current and potential future risk and comply with Applicable or Relevant and Appropriate Requirements (ARARs) and are:

- Protection of human health by reducing exposure to soil, ground water, and surface water exceeding water quality standards.
- Protection of the environment by minimizing leachate migration.

Contaminants of Concern

RAOs were established (either using state or federal standards, whichever is more stringent) for soil/CKD, ground water, surface water and site-specific COCs. The State of Michigan Part 201 Rules have been identified as the most stringent ARARs for both CKD leachate and surface water impacted by ground water venting. The following COCs have been identified for source materials at the East CKD Site:

- ***Soil****:* chloride and arsenic.
- ***Ground Water***: chloride, percent ammonia that will become NH_3 in surface water, pH, total dissolved solids (TDS), sulfate, and metals, including aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, mercury, selenium, sodium, and vanadium.

In accordance with U.S. EPA guidance, three criteria are used to screen technologies and process options: effectiveness, implementability, and cost. The evaluation of effectiveness incorporates short and long term impacts to the East CKD Site and is based on the following factors: (1) the ability of a process option to address the COCs at the Site; (2) the ability of the process option to function under the conditions specific to the Site; and (3) the potential for adverse impacts to occur during implementation of the process option. The East CKD Site-specific response actions that were screened and evaluated were as follows:

Soil (CKD)

- No action (retained as a control).
- Institutional controls (retained and includes land development and use restrictions, i.e., proposed continued use as a park).
- Excavation with off-site disposal (retained because it is a commonly used response action, meets RAOs; the most viable option).
- Excavation and reuse, and excavation and off-site treatment (not retained because of the anticipated implementability and effectiveness challenges associated with these technologies).
- Containment and isolation by containment cell construction, horizontal barriers (flexible membrane liner), vertical barriers and consolidation (retained as most viable option).
- Dynamic compaction (not retained because the acceptance of this technology by neighboring property owners is questionable due to ground vibrations and noise pollution).

Leachate and CKD-Impacted Ground Water

- No action (retained as a control).
- Institutional controls (retained and include prohibition of ground water used as drinking water).
- Collection/removal by extraction wells or collection trenches (retained because these are demonstrated technologies effective at controlling ground water migration and are capable of collecting large volumes of water).

- Containment and isolation using upgradient extraction wells (retained because it is potentially effective in minimizing ground water flow through the contaminated media and can be used to collect a large volume of water in order to contain the ground water at the East CKD Site).
- Slurry wall/grout injection (retained because it can be effective at limiting migration of ground water containing chemical compounds; effective if used in conjunction with leachate collection processes).
- Downgradient hydraulic containment using an infiltration gallery (retained because it reduces ground water gradient through contaminated media and provides localized barrier to transmission of upgradient ground water).
- Horizontal barriers (retained for screening of remedial technologies for CKD-impacted ground water, particularly as horizontal barriers were retained for CKD).
- On-site treatment of ground water by the physical/chemical treatment of neutralization (retained because it has demonstrated effectiveness in treating high pH waters).
- Monitored natural attenuation (retained although targeted shoreline surveys show it is not effective alone).

Leachate Management Response Actions

Any final remedial alternatives that will include leachate collection will also require collection and disposal of water as a long term remedy component.

- On-site treatment at a wastewater treatment facility with discharge to surface water via a new National Pollutant Discharge Elimination System (NPDES) permit.
- On-site pretreatment and disposal to an off-site Publicly Owned Treatment Works (POTW) for treatment and discharge to surface water via an existing NPDES permit.
- Off-site disposal using deep well injection.
- On-site disposal at a deep well was included in the screening of process options at MDEQ's request.
- Off-site land application of collected leachate.
- Evaporation of leachate using an off-site evaporation pond.

The retained technology types and process options were combined and assembled into alternatives and evaluated and screened.

Sections 3.3-3.4 Development and Screening of Alternatives. Detailed Analysis of Alternatives: Introduction, Individual Analysis of Alternatives, Comparative Analysis

The alternatives address all affected media. The alternatives were screened on the basis of short term and long term effectiveness.

Alternative 1: No Action

- This was considered as a baseline for comparison of other remedial actions.

Alternative 2: Existing IR Actions and Diversion

- This consists of on-site CKD consolidation, compaction and contouring; the incorporation of an impermeable cover system; active leachate migration control (including leachate collection, and a vertical barrier); natural attenuation; ground water diversion; treatment and disposal of leachate; institutional controls; and upgradient ground water diversion wells.
- This alternative is representative of existing IR actions with the addition of upgradient ground water diversion wells.
- Institutional controls provide community protection in the form of ground water use restrictions and engineered cover maintenance.
- The total cost for this alternative, including long term operation and maintenance (O&M) costs, is $26 million.

Alternative 2a: Existing IR Actions

- This consists of on-site CKD consolidation, compaction and contouring; the incorporation of an impermeable cover system; active leachate migration control (using beach collection drains); treatment and disposal of leachate; natural attenuation; and institutional controls (excludes upgradient ground water diversion).
- This alternative is identical to Alternative 2 except that upgradient ground water diversion wells are not included in this alternative. This alternative is representative of existing East CKD Area IR conditions. Existing IR actions include installation of the WLCS and CLCS, installation of the slurry wall vertical barrier downgradient of WLCS, excavation of CKD from the bottleneck area, an upgradient interflow collection drain, and an impermeable cover system.
- The total cost for this alternative, including long term O&M costs, is $30 million.

Alternative 3: Existing IR Actions without Leachate Collection with In Situ Treatment of Ground Water and Institutional Controls

- This consists of CKD consolidation, compaction and contouring; the incorporation of an impermeable cover system; on-site treatment of leachate migrating toward Lake Michigan; and institutional controls. There would be no collection of leachate. The on-site treatment would include injection of carbon dioxide through a gas-diffusion line in a shallow ground water sparging system, constructed similar to the collection trench. This would neutralize the ground water and correct the high pH with minimal precipitation.
- This alternative integrates the IR actions, in that the leachate collection systems installed were designed to accommodate sparging systems, should that be a preferred alternative.
- The institutional controls for this alternative are the same as those described for Alternative 2.
- The total cost for this alternative, including long term O&M costs, is $21 million.

Alternative 4: CKD Removal

- This consists of removal of CKD entirely from the East CKD Site, and backfilling of these areas with clean soil. This alternative uses none of the IR actions at the East CKD Site and is therefore inconsistent with the AOC. It is expected to take two construction seasons and will increase the flux of COCs to the lake for one full construction season.
- The total cost for this alternative, including long term O&M costs, is $78 million.

Alternative 4a: On-Site Containment Cell

- This alternative consists of removal of CKD from the entirety of the East CKD Site, placing imported clean backfill below the ground water table, constructing an on-site containment cell within the existing CKD footprint, relocating CKD to the on-site containment cell, constructing a cover system, and restoring the existing park with modified grades.
- This alternative is expected to take three construction seasons to complete. The institutional controls for this alternative are the same as those described for Alternative 4.
- This alternative uses none of the IR actions installed at the East CKD Site and, in fact, removes all of them and is therefore inconsistent with the AOC.
- This remedy will dramatically increase the flux of these parameters to the lake for at least one full construction season.
- The total cost for this alternative, including long term O&M costs, is $78 million.

Detailed Analysis of Alternatives

Detailed analysis of the retained alternatives was done against a set of nine evaluation criteria identified in the NCP[3]; this analysis was used as a basis to compare the relative advantages and disadvantages of each alternative. The criteria include:

1. Protection of human health and the environment.
2. Compliance with ARARs (chemical-, action- and location-specific ARARs and other advisories).
3. Long term effectiveness (remaining risk, effectiveness of controls).
4. Reduction of toxicity, mobility, and volume (through treatment, remaining contaminants after treatment).
5. Short term effectiveness (protection of community and workers during remedial action, environmental impacts, time to complete remedial actions).
6. Implementability (reliability, availability of off-site treatment, equipment, technologies).
7. Cost (capital, operating and maintenance).
8. Community acceptance.
9. State acceptance.

Criteria included under numbers 1 through 7 and 9 were used in this detailed analysis of alternatives. The overall score is used to rank the alternatives and is developed from individual scores that are based on the ability of the alternative to meet each of the seven criteria. Each of the seven criteria is weighted evenly and a score between 1 and 5 is assigned. A score of 1 is assigned when low achievement of the criterion is expected, 3 when moderate achievement is expected, and 5 when high achievement is expected. The highest achievable overall score is 35. Table 2 includes the score of each alternative.

Alternative Analyzed	Total Points	Comments
1 – No Action	16	Used as a baseline to compare other alternatives. Low achievement of all criteria except

[3] U.S. EPA, 2003. *Subchapter J – Superfund Emergency Planning, and Community Right-to-Know Programs, Part 300 – Nationwide Oil and Hazardous Substances Pollution Contingency Plan,*[40 CFR Ch. I (7-1-03 Edition)].

		implementability and cost.
2 – Existing IR Actions and Upgradient Diversion	31	Favorable alternative. Moderate to high achievement for seven of the eight criteria. Cost is competitive compared to other Alternatives. Upgradient diversion provides source control and enhances migration control over the range of conditions observed at the East CKD Site.
2a – Existing IR Actions	28	Reliable and effective remedial technologies. Cost and effectiveness lower than Alternative 2.
3 – IR Actions without Leachate Collection with Sparge Wall Systems	26	Reliability has not been shown over the long term. Lower control of COCs compared to Alternatives 2 and 2a.
4 – CKD Removal	19	Poor short term effectiveness. Potential safety hazards for workers during remedial actions. High costs, lower community acceptance compared to Alternatives 2, 2a and 3.
4a – On-site Containment Cell	17	Lowest short term effectiveness. Higher potential safety hazards for workers. Lowest implementability due to technical difficulty in constructing cell.

Table 2. Comparative Analysis of Alternatives Evaluated against NCP Criteria.