Final Approved Removal Action Work Plan
July 28, 2005
Little Traverse Bay CKD Release Site
Emmet County, Michigan

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1.0 Introduction

This Removal Action (RA) Work Plan (Work Plan) has been prepared on behalf of CMS Land Company and CMS Capital, LLC to describe the RA activities to be conducted as per the Administrative Order on Consent for Removal Action (AOC or Order), Little Traverse Bay CKD Release Site (Site) (Docket No. VW-05-C-810, February 22, 2005). CMS Land Company and CMS Capital, LLC (referred to collectively as CMS) have agreed to carry out all activities required by the Order. This RA Work Plan provides a description of, and the schedule for, the actions required by the Order. The Work Plan actions required by the Order, proposed objectives, and corresponding activities are summarized in Table 1-1. The Site location is shown on Figure 1-1.

The Order requires that CMS perform all actions required pursuant to the Order in accordance with all applicable local, state, and federal laws and regulations except as provided in Section 121(e) of CERCLA, 42 U.S.C. §6921(e), and 40 CFR §300.400(e) and 300.415(j). The Order requires that CMS identify the specific applicable or relevant and appropriate requirements (ARARs) for the Site under federal law. The Site ARARs are summarized in Table 1-2. The identification of ARARs is done to establish early in the process those state and federal regulations that are potentially applicable to the investigation and the remediation of a site. This is accomplished by making an objective determination of whether the requirement specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a site. Even if it is determined that a requirement is not applicable to a specific release, the requirement may still be appropriate to the circumstances of the release, and identified as such.

Some of the requirements are identified as “to be considered”. This category consists of advisories, criteria, or guidance that were developed by EPA, or other federal agencies, or states that may be useful in developing the remedy for the site.

The RA described in this Work Plan is considered to be a time-critical RA as defined by the National Contingency Plan (NCP) because, following United States Environmental Protection Agency (U.S. EPA) review and approval of this Work Plan, CMS is required to initiate the RA activities within six months of being notified by U.S. EPA Region V. A more detailed schedule for the work is presented in Section 9.0.

This Work Plan describes the removal actions planned to identify and recover CKD leachate releases along the lakeshore of Little Traverse Bay, the investigation activities that will be used to better define the nature and extent of the CKD deposits and associated groundwater impacts, and the assessment of long-term remedial alternatives to control the CKD leachate release. This Work Plan and associated documents describe Site access, health and safety, and quality management as per the following requirements of Paragraph 15 of the Order:

i. Provide Site security and restrict access to known high-pH "cement kiln dust" (CKD) leachate release areas to the north and east of Coastal Drive.

ii. Prepare a Site Health and Safety Plan and Site Control and Access Management Plan.

iii. Evaluate all other areas along the lakeshore of the Site for potential releases to surface water.

iv. Restrict access to CKD leachate release areas that may be identified during the lakeshore evaluation.

v. Implement recovery of high-pH leachate from CKD leachate release areas for treatment on-Site and/or arrange for off-Site treatment, storage and disposal.

vi. Continue recovery of high-pH leachate described above until interim response activities can be designed, constructed and demonstrated to be effective.

vii. Design, construct, and implement operation of interim recovery systems until long-term remedial controls can be designed, constructed and demonstrated to be effective.

viii. Confirm the effectiveness of the above actions and develop/implement a monitoring program that measures releases of high-pH leachate and hazardous substances.

ix. Perform operation and maintenance of the measures described above until long-term remedial controls can be designed and constructed and demonstrated to be effective.

x. Investigate the nature and extent of hazardous substances, pollutants, or contaminants at the Site from CKD waste material, evaluate alternatives for addressing such threats, and prepare a report of the results of this investigation.

The above measures are intended as an interim response action to control releases from the Site and not intended to represent the long-term remedy for the Site. Long-term remedial alternatives will need to be based upon a more thorough understanding of the physical, geologic, and hydrogeologic setting of the Site.

The Work required by the Order will be completed according to the Site-specific Quality Assurance Project Plan – Revision 1.0 dated April 26, 2005 (QAPP) (Barr, 2005b), the Project Health and Safety Plan – Revision 3.0 dated May 2, 2005 (PHASP) (Barr, 2005a), and the Site Control and Access Management Plan – Revision 1.0 dated April 4, 2005 (SCAMP) (Barr, 2005c) prepared for the Site according to the Order. These plans have been approved by the U.S. EPA. The QAPP and PHASP were approved by the U.S. EPA in letters dated May 4, 2005. The SCAMP was approved in a letter dated April 19, 2005 becoming effective upon approval of the PHASP on May 4, 2005. In addition, all investigation and related work will be completed according to Barr's Quality Management Plan (QMP) for Data Collection and Management of Contaminated Site Assessment and Remediation Projects (Barr, October 3, 2003) which was approved by Ida Levin, U.S. EPA in an October 1, 2003 memorandum to Tim Drexler, Remedial Project Manager. An electronic copy of the QMP was transmitted to the U.S. EPA on February 25, 2005 in an e-mail addressed to the Site On-Scene Coordinator (OSC).

Applicable portions of the ASTM International *Standard Guide for Design of Groundwater Monitoring Systems in Karst and Fractured-Rock Aquifers* (D-5717-95) have been followed in developing the Work Plan for the investigation activities described in Section 5.0. Additional sources of background information used in development of this work plan are summarized in Section 1.3 and Appendices A through D, F, and G.

1.1 Site Location and Description

1.1.1 Site Location

The Little Traverse Bay CKD Release Site is located along 5 miles of shoreline on Little Traverse Bay of Lake Michigan (Figure 1-1). The Site is approximately 5 miles west of the City of Petoskey, and located in Resort Township, Emmet County, Michigan (Township 34N, Range 6W, Sections 2 through 10).

1.1.2 Site Description

The Site is currently a multi-use area with mixed residential, commercial, open space, and recreational (golf course and park) land uses (BH, 2004) and is currently owned by a combination of private property owners (primarily residences or open lots), Bay Harbor Golf Club, Inc. (golf course), Bay Harbor Company (roads, commercial, and undeveloped/open space), and Resort Township (East Park).

1.1.2.1 West CKD Area

The "West CKD Area" includes the pile of CKD and the undeveloped rocky beach area north of the pile as shown on Figure 1-1. The West CKD Area is currently owned by Bay Harbor Golf Club, Inc. (which owns and operates a golf course on the Site). A golf course fairway and rough areas have been constructed over the CKD pile. The West CKD Area is bounded by Lake Michigan on the north, developed and undeveloped residential properties to the west and south, and the golf course club house to the east. West-unnamed creek flows from U.S. Highway 31 north through a constructed pond (Pond #1) on the south side of the West CKD Area, along the east side of the West CKD Area, and into Lake Michigan.

The pH was measured in the West-unnamed creek as part of the targeted shoreline survey (May through June 2005). The pH was measured at approximately 25-foot intervals along the creek from the outfall at Lake Michigan to Quarry Ridge Road. The pH readings ranged from 7.86 to 8.39 at the time of the targeted shoreline survey. Due to the proximity of West-unnamed creek to the West CKD Area, this surface water feature may be a leachate migration pathway. Site investigation activities will be conducted to evaluate the potential migration of CKD leachate hydraulically connected to this creek.

1.1.2.2 Pine Ridge Court Area

The "Pine Ridge Court Area" consists of the rocky beach area located north of several residential properties (lots 3-6) located along Pine Ridge Court as shown on Figure 1-1. Releases of CKD leachate were detected along the shore of the Little Traverse Bay of Lake Michigan at the Pine Ridge Court Area during the completion of the expedited targeted shoreline survey in May and June of 2005. The Pine Ridge Court Area is bounded by Lake Michigan on the north, privately owned undeveloped properties to the east and west, and bounded to the south by privately owned residential properties and, across Coastal Ridge

Drive, golf course fairway and rough areas. This area is located adjacent to the area identified as the Seep 2 CKD Area and will be considered as part of the Seep 2 CKD Area for investigation purposes.

1.1.2.3 Guard Rail Seep Area

The "Guard Rail Seep Area" consists of the rocky beach area located north of Coastal Ridge Drive as shown on Figure 1-1. This area is located within the area identified as the Seep 2 CKD Area and will be considered as part of the Seep 2 CKD Area for investigation purposes. Releases of CKD leachate were detected along the shore of the Little Traverse Bay of Lake Michigan at the Guard Rail Seep Area during the completion of the expedited targeted shoreline survey in May and June of 2005. The private roadway adjacent to the Guard Rail Seep Area is owned by Bay Harbor Company. The Guard Rail Seep Area is bounded by Lake Michigan on the north and undeveloped properties to the east and west. The Guard Rail Seep Area is bounded to the south by Coastal Ridge Drive and the Seep 2 CKD pile.

1.1.2.4 Seep 2 CKD Area

The "Seep 2 CKD Area" includes the pile of CKD and the developed and undeveloped rocky beach area north of the pile as shown on Figure 1-1. The Seep 2 CKD Area is currently owned by Bay Harbor Golf Club, Inc. (golf course), private property owners, and Bay Harbor Company. Golf course fairway and rough areas have been constructed over the CKD pile. Residential properties and Coastal Ridge Drive are located between the CKD pile and Lake Michigan on the north. The Seep 2 CKD Area is bounded by Lake Michigan on the north, developed and undeveloped residential properties to the west, east and south, and Coastal Ridge Drive and the Seep 1 CKD Area to the east.

1.1.2.5 Seep 1 CKD Area

The "Seep 1 CKD Area" includes the pile of CKD and the undeveloped rocky beach area north of the pile as shown on Figure 1-1. The Seep 1 CKD Area is currently owned by Bay Harbor Golf Club, Inc. (golf course), and private property owners. Golf course fairway and rough areas have been constructed over the CKD pile. The Seep 1 CKD Area is bounded by Lake Michigan on the north and by developed and undeveloped residential properties to the west, east, and south. East-unnamed creek #1 borders the Seep 1 CKD Area on the east. The pH was measured in the East-unnamed creek #1 as part of the targeted shoreline survey (May through June 2005). The pH was measured at approximately 25-foot intervals along the creek from the outfall at Lake Michigan to U.S. Highway 31. The pH readings ranged from 7.17 to 8.26 at the time of the targeted shoreline survey. Due to the proximity of East-unnamed creek #1 to the Seep 1 CKD Area, this surface water feature may be a leachate migration pathway. Site investigation activities will be conducted to evaluate the potential migration of CKD leachate hydraulically connected to this creek.

1.1.2.6 East CKD Area

The "East CKD Area" includes the pile of CKD and the undeveloped rocky beach area north of the pile as shown on Figure 1-1. The East CKD Area is currently owned by Resort Township. A park area with parking facilities, sanitary facilities, picnic area, playground equipment, and open areas have been constructed. The East CKD Area is bounded by Lake Michigan on the north, the Bay Harbor marina complex to the west, East-unnamed creek #2 to the east, and a wooded area with bike trail to the south. East-unnamed creek #2 flows over an approximate distance of 1,200 feet from U.S. Highway 31 north to its discharge point into Lake Michigan. The pH was measured in the East-unnamed creek #2 as part of the targeted shoreline survey (May through June 2005). The pH was measured at approximately 25-foot intervals along the creek from the outfall at Lake Michigan to U.S. Highway 31. The pH readings ranged from 8.01 to 8.20 at the time of the targeted shoreline survey. Due to the proximity of East-unnamed creek #2 to the East CKD Area, this surface water feature may be a leachate migration pathway. Site investigation activities will be conducted to evaluate the potential migration of CKD leachate hydraulically connected to this creek.

1.2 Site History

Previously, the majority of the Site was designated for industrial use and included mining operations and cement production. The dominant features associated with historical Site use include a former cement plant, shale quarry, central limestone quarry, eastern limestone quarry, and four separate CKD stockpiles (NTH, 1994). Historical features are referenced throughout this section and are shown on Figure 1-2. Historical references are documented in Section 11.0. Copies of the aerial photographs reviewed (EDR, 2004b) are included in Appendix C. Copies of the Sanborn Fire Insurance Maps (EDR, 2004a) are included in Appendix D.

1.2.1 Mining Operations

The presence of quarries at the Site was first described in the geological report compiled by R.V. Kesling et al., (1974) which provides a description of bedrock exposures observed in 1902 along Little Traverse Bay. The report included descriptions and locations of three quarries on the Site (Kesling, 1974). The quarries observed in 1902 included the Bay Shore Lime Company Quarry 1 (near the west line of Section 4 of Resort Township), Bay Shore Lime Company Quarry 2 (in the center of Section 6 of Resort Township), and the Rose/W.E. Smith Quarry (NW ¼ , NE ¼, Section 9 of Resort Township). The locations of these quarries are shown on Figure 1-2. No further information was readily available on these quarries and their operational history or duration; however, they do not appear to be active at the time of the 1938 aerial photograph, the earliest available aerial photograph of the Site (EDR, 2004b).

Four additional quarries at the Site were identified as being active in the 1920s (Kesling, 1974). One small quarry was reported in the southwest portion of Resort Township, Section 5 (1926 Quarry, Figure 1-2) (Kesling, 1974). No further information was readily available on this small quarry's operational history or duration of operations; however, it does not appear to be active at the time of the 1938 aerial photograph (EDR, 2004b). Three other quarries (one large and two smaller) were reported in the southwest portion of Resort Township, Section 6 as being associated with the Northern Lime Company (Kesling, 1974). The Northern Lime Company quarries appeared to have ceased operating by the time the 1952 aerial photograph was taken (EDR, 2004b).

The Bell Quarry was documented in 1930 in the northern portion of Section 8 of Resort Township and described in the 1974 Kesling report at the location of the shale quarry shown on Figure 1-2. The first documentation of the shale quarry is an aerial photograph from 1965 (EDR, 2004b). According to aerial photographs, the shale quarry appeared to undergo expansion through 1981 (EDR, 2004b).

The eastern limestone quarry is shown on a 1929 Sanborn Map (EDR, 2004a). The 1938 aerial photograph documents the presence of the eastern quarry (EDR, 2004b). The central limestone quarry is the dominant feature on aerial photographs of Resort Township, Sections 2, 3 and 10 from 1938 through 1992 (EDR, 2004b). According to aerial photographs, the central limestone quarry appears operational through the 1980s (EDR, 2004b). An area with little vegetation connected to the central quarry by a large haul road is visible west of the quarry in 1952 through the 1990s (EDR, 2004b). This area is labeled as “overburden from the limestone quarry” in published environmental reports (Johnson, 1988) and as a gravel pit in the historical topographic map from 1958 (USGS, 1958).

1.2.2 Industrial Operations

The first available record of industrial development on the Site is a 1904 Emmet County title record for Resort Township, Section 9 (Traverse, 1991). In 1904, Section 9 is listed under the ownership of Petoskey Stone & Lime Company. In subsequent title listings, the area is also referenced as being owned by the Petoskey Crushed Stone Company and the Petoskey Portland Cement Company (Traverse, 1991). A 1913 Sanborn Map shows a group of buildings directly east of the central limestone quarry labeled Petoskey Crushed Stone Company and a second group of buildings on the western Site boundary labeled Northern Cement & Lime Company (also referenced as Northern Lime Company in subsequent maps) (EDR, 2004a and 2004b). The 1913 Sanborn Map is the first record of cement production at the Site.

According to Sanborn maps, the Petoskey Company expanded between 1919 and 1929 and consisted of a cement plant and multiple outbuildings and quarries (EDR, 2004a). Very little expansion of the Petoskey Company buildings is visible in the aerial photographs and maps from 1929 through the 1990s (EDR, 2004b). The Northern Cement & Lime Company appeared to have ceased operations between 1938 and 1952 (EDR, 2004b). No information regarding the operational history of the Northern Cement & Lime Company or Petoskey Company was readily available for this review.

CKD was placed on the Site in large stockpiles from approximately 1921 to 1980 (NTH, 1994). Historical locations of the CKD stockpiles are shown on Figure 1-2 (Johnson, 1988). Two stockpiles with overburden from the quarries were also stored at the Site, as shown on Figure 1-2 (Johnson, 1988).

According to title records, Penn-Dixie Cement Corporation/Penn-Dixie Industries, Inc. purchased a portion of the Site in Section 9, including the Petoskey Company buildings, in 1955 (Traverse, 1991). Penn-Dixie’s operations reportedly included mining operations in the eastern and central limestone quarries and the shale quarry (NTH, 1994). The mined limestone and shale were used as raw ingredients for cement production (NTH, 1994). In

1980, Penn-Dixie filed for bankruptcy, and the Dundee Cement Company purchased the Penn-Dixie land and cement plant in 1981 (Traverse, 1991). In 1990, Dundee Cement Company became part of Holnam Inc. Neither Dundee Cement Company nor Holnam, Inc. manufactured cement at the Site. During the time these entities owned the Site, it was used as a docking and distribution facility for bulk materials (Traverse, 1991). No other information on land use was available for the years the Site was owned and operated by Dundee Cement Company (1981 through 1989).

1.2.3 Development History

In 1989, a 300-acre parcel in what is now the central portion of the Site was sold to Bay Resort Properties Limited Partnership. This parcel included the eastern and central limestone quarry areas, overburden stockpiles, the former cement plant area, and areas of miscellaneous debris and equipment (NTH, 1994). Dundee Cement Company retained ownership of the remaining portions of the Site (approximately 756 acres), which included two detached parcels on either side of the 300-acre parcel (NTH, 1994). The remaining parcels (at that point owned by Holnam, Inc.) were sold to the Bay Resorts Properties Limited Partnership in the 1990s (NTH, 1994).

An environmental plan dated November 17, 1993 was developed to reclaim the 300-acre parcel pursuant to Michigan's Reclamation of Mining Lands, Part 631 of the Natural Resources and Environmental Protection Act, 1994 PA. 451 as amended (NTH, 1994). On July 11, 1994 an Administrative Agreement and Covenant Not to Sue between Bay Harbor Company, its Signatories and the State of Michigan Department of Natural Resources (now Department of Environmental Quality) was signed for the development of the Site (NTH, 1994). In July of 1994, redevelopment of the Site was initiated by Bay Harbor Company for the current multi-use development (NTH, 1994). In December 1995, the Resort Township East Park portion of the Site was transferred by Bay Harbor Company to Resort Township, Emmet County for development of a park (NTH, 1996).

As part of the development of the Bay Harbor area, a number of restoration activities were reportedly conducted. The CKD piles were graded, contoured and covered with a minimum of 6 inches of overburden to build portions of the golf course. The cover and vegetation were designed to eliminate direct contact exposure to the CKD. In the western shale quarry area of the Site, the walls and floor of the quarry were contoured and stabilized for safety purposes.

Rock stockpiles remaining at various locations across the Site were used to bring the eastern quarry area to grade. Debris and rubbish located at the Site were reportedly characterized and recycled or taken off-Site for disposal. Abandoned equipment remaining at the Site was reportedly removed for salvage or disposal. Additional remedial actions, including the installation of the existing Seep 2 collection drain, were also initiated as described in Section 1.3.3.

1.3 Summary of Available Information (Sources Reviewed)

Available information regarding the physical characteristics of the Site is summarized below. Information sources included: reports and data from previous investigations, regional information, and information sources used to develop the Site history summarized in Section 1.2. Previous investigation analytical data are summarized in Appendix A. Data from a 2004 non-intrusive geophysical investigation of the Site are summarized in Appendix B. Historic aerial photographs and Sanborn Fire Insurance Maps are included in Appendix C and Appendix D, respectively.

This information was reviewed and evaluated so that a conceptual model could be developed for the Site. The conceptual model describes the geologic setting, vertical and horizontal distribution of the CKD materials, and groundwater flow in the areas of the CKD deposits. The conceptual model discussion in this section refers to three areas: (1) the Seep 1 and Seep 2 CKD area, (2) the West CKD area, and (3) the East CKD area. These three areas are shown in Figures 1-3 and 1-4. The conceptual model was developed using the following information sources:

- Historical Site information (including aerial photographs (Appendix C), Sanborn Fire Insurance Maps (Appendix D), and Site development documentation reports);
- The results of a 1995 investigation of portions of the Site (summarized in Section 1.3.3);
- Regional geologic and hydrogeologic information;
- Lineament data analysis;
- Regional groundwater well data;
- Site topography;

- Geophysical survey data (including Electromagnetic Induction (EM), Streaming Potential (SP), Very Low Frequency EM (VLF), Direct Current Resistivity Imaging (DCR), Multi-channel Analysis of Surface Waves (MASW), and Seismic Refraction (Refraction)) from surveys conducted in late 2004 (Appendix B);
- Geologic observations of bedrock exposures in the vicinity of the Site;
- pH, temperature, and specific conductance measurements in on-shore leachate accumulation zones and in Lake Michigan in November and December 2004 and March 2005 (Appendix A); and
- November/December 2004 on-shore leachate accumulation zone and Lake Michigan sampling and laboratory analysis for total dissolved solids (TDS), metals, sulfate, ortho-phosphate, chloride, total alkalinity, bicarbonate alkalinity, carbonate alkalinity, nitrate and hardness (Appendix A).

Published data references and data sources are documented in Section 11.0.

1.3.1 Geologic Setting

1.3.1.1 Topography

In general, the ground surface at the Site slopes from south to north (toward Lake Michigan). The regional topography as it existed in 1983 after cement plant operations were discontinued, but prior to redevelopment of the Site, is shown on Figure 1-4 (USGS, 1983).

Based on the lakeshore slopes in the surrounding area, it is likely that the pre-development topography at the four CKD areas sloped gently downward toward the lake, with the slope becoming steeper and forming a bluff or steep slope in the vicinity of the lakeshore. The current surface elevation at the Seep 1 CKD area is up to 50 feet higher than the inferred natural topographic elevation and the current surface elevation at the Seep 2 CKD area is up to 45 feet higher than the inferred natural topographic elevation. The West and East CKD areas are both up to 19 feet higher than the inferred natural topography.

Conceptual cross sections A to A’, B to B’, and C to C’ show the current surface topography as well as the inferred pre-development topography at the Seep 1 and Seep 2 CKD areas (Figures 1-5, 1-6, and 1-7). The inferred pre-development surface profile, where shown on the cross sections, is based on the landscape shown on Figure 1-4 or the surface profile of nearby areas not apparently disturbed by the golf course construction or historical quarrying operations. The cross section locations are shown on Figures 1-3 and 1-4.

The pre-development topography in the West CKD area was likely very similar to the current surface topography, with a steeper slope in the vicinity of what is now a buried CKD pile. The West CKD area now forms a 250-foot-wide bench just above the lake shore as shown in profile on the conceptual cross section D-D' (Figure 1-8).

In the vicinity of the East CKD area, an upland area overlooks the lake. The pre-development topography likely sloped steeply down to the vicinity of present-day Highway 31 (approximate elevation 680 feet above mean sea level (MSL)). North of Highway 31 the slope lessened, forming a gently sloping bench approximately 500 feet wide. From the bench the slope likely dropped down a steep embankment to the lake shore. Conceptual cross section E-E' in Figure 1-9 shows the inferred past-land-surface profile and the current-day profile.

1.3.1.2 Geology

The native geology at the Site consists of thinly bedded (1 to 4 inches) to very thickly bedded (>3 feet) limestone or shale bedrock overlain by a thin mantle of weathered bedrock and/or unconsolidated deposits. The unconsolidated deposits are either glacial or lacustrine silty clay to sandy gravel sediment material (Farrand, et al., 1984). Rocks of the Traverse Group (primarily limestone with some shale) make up the uppermost bedrock unit beneath the Site (Kesling, et al., 1974 and Milstein, 1987). Observations of exposed bedrock indicate that the Traverse Group in the vicinity of the Site is comprised primarily of limestone, with generally flat-lying bedding. However, between the East CKD area and the Seep 1 and 2 CKD areas, the limestone beds in an outcrop above the Bay Harbor marina were seen to dip gently northeastward and southwestward at 5 to 10 degrees, forming a subtle anticline structure with its fold axis trending northwest to southeast.

In all outcrops observed in the vicinity of the Site, the limestone bedding planes are cross-cut by abundant near-vertical fractures. Fractures in the vicinity of the Seep 1 and 2 CKD areas are generally oriented NW-SE with a secondary set of fractures oriented SW-NE. Fracture spacing is generally consistent from one outcrop to another, ranging from approximately 1 to 2 feet. Barr infers that the bedrock beneath the West and East CKD areas has similar fracture and bedding plane configurations.

West CKD Area – Unconsolidated Materials

Based on geophysical survey information (Appendix B), the CKD fill deposit at this location is up to 20 feet thick. Native unconsolidated sediments and fill appear to fill what may be a bedrock ravine as indicated on the conceptual cross section (Figure 1-8). A soil cover is reported to cap the West CKD area.

West CKD Area – Bedrock Topography and Features

The bedrock surface at the West CKD area is inferred to be nearly level, with a gentle slope toward the lake shore until the vicinity of Quarry Ridge Road as shown on Figure 1-8. In the vicinity of this road, the geophysical profiling suggests that a buried bedrock ravine may be present, with a bottom elevation below the current lake level. This inferred buried bedrock ravine lines up with a re-entrant feature south of the CKD deposit, shown by the topographic contours on Figure 1-4. This surface drainage feature in turn is aligned with the northern end of Lake Walloon (located 3,500 feet south of Highway 31) (USGS, 1983). Barr infers that at some time in the past a ravine was possibly eroded in the bedrock at this location near the lakeshore. The potential buried bedrock ravine now lies beneath the West CKD area.

Seep 1 and 2 CKD Areas – Unconsolidated Materials

Interpreted geophysical data, historical documents (NTH, 1995), and ground surface elevation data (USGS, 1958 and 1983) were evaluated to assess the distribution of native unconsolidated materials and CKD fill above the bedrock in the Seep 1 and 2 CKD areas. Native materials overlying bedrock in the Seep 1 and 2 CKD areas are reportedly sand, silty sand, or sandy clay with thicknesses ranging from 1 to 15 feet. These native materials are overlain by CKD across much of the Seep 1 and 2 CKD areas.

The conceptual cross sections on Figures 1-5 and 1-6 show the estimated extent of the CKD-containing fill deposits in the Seep 1 CKD area. The conceptual cross sections of the Seep 1 CKD area were developed by incorporating the geophysical results, bedrock outcrop observations, Site surface topography, and logs of two existing wells (OW-3 and OW-4). Generally, the thickest area of the CKD fill, in the western part of the Seep 1 CKD area, coincides with an area of CKD shown in historical documents. Available historical information indicates the eastern part of the Seep 1 CKD area was composed primarily of quarry overburden. However, geophysical data and surface features observed at the Seep 1 CKD area suggest that CKD may also be present across the eastern portion of the Seep 1 CKD Area. Based on geophysical data combined with the surface topography data, the Site conceptual model interprets the Seep 1 CKD deposits to encompass the area shown on Figure 1-4 and to contain approximately 500,000 cubic yards of CKD. A soil cover is reported to cap the Seep 1 CKD piles (Figures 1-5 and 1-6).

The Seep 2 CKD area is shown on Figure 1-4. The CKD fill is generally thickest in the east and west ends of this area as indicated by historical documents, geophysical data, and surface topography. The conceptual cross-section of the Seep 2 CKD area (Figure 1-7) was developed by incorporating the geophysical results, bedrock outcrop locations, Site surface topography, and logs of three existing wells (OW-2 and OW-2A, and a City of Petoskey test well beside Highway 31). CMS will identify which specific test well was utilized to U.S. EPA upon approval of this Work Plan. As shown on the conceptual cross section C-C' in Figure 1-7, the CKD fill deposit is inferred to rest either directly on competent limestone bedrock or on top of piled bedrock debris. The Seep 2 CKD deposit is inferred to have a soil cover approximately 2 feet thick as shown on Figure 1-7.

Seep 1 and 2 CKD Areas – Bedrock Topography and Features

The bedrock surface in the Seep 1 and Seep 2 CKD Areas is generally higher in elevation south, west, and east of the CKD piles and lower near the beach to the north. The bedrock surface in the southwest portion of the Seep 1 CKD Area is approximately 660 ft. MSL. Where exposed along the beach, the bedrock surface forms a wave-cut bench with minor amounts of cobble/sand cover. The bedrock bench along the shoreline is coincident with the Lake Michigan elevation (577.5 ft. MSL). Observed bedrock outcrops, measured bedrock elevations, and interpreted geophysical data indicate that bedrock in the vicinity of the Seep 1 and 2 CKD Areas does not slope uniformly northward. The data indicate that what appear to be buried bedrock features (e.g., ravine and quarry features) are covered with natural deposits and/or fill beneath the western portion of the Seep 1 CKD Area and extend into the Seep 2 CKD Area.

A set of the regional lineament features observable on the aerial photograph shown on Figure 1-3 appears to extend through the Seep 1 and Seep 2 CKD Areas. The Site conceptual model interprets the lineation to be low areas on the bedrock surface likely associated with bedrock structural features such as a fracture zone or large-scale fractures, which are susceptible to increased localized dissolution and/or erosion. The Rose/W.E. Smith quarry is shown on Figure 1-2 at the intersection of the lakeshore and a lineation feature in the central Seep 2 CKD Area and a "gravel pit" is shown on the eastern portion of the Seep 1 CKD Area

(USGS, 1958). This combination of features suggests that either gravel deposits preferentially accumulated in these areas or the bedrock was more fractured making it an attractive source of aggregate.

East CKD Area – Unconsolidated Materials

Based on the geophysical surveys (Appendix B), leveled quarry debris, soil fill and/or CKD fill are interpreted to fill the topographic low as shown on Figure 1-9. In the late 1990s, this area was graded and grass was planted to create a recreational park area. Based on the geophysical surveys, approximately 2 feet of topsoil with vegetation covers the fill at this location and the fill may be more than 50 feet thick.

East CKD Area – Bedrock Topography and Features

Based on the geophysical data (Appendix B) and observations at the Site, the bedrock surface at the East CKD Area is inferred to slope steeply down from the upland located south of the Site. The bench described at this location earlier also appears to be reflected in the bedrock surface. The original bedrock surface likely sloped steeply down to the lake shore and a bluff face may have been present in this area. A quarry was developed west of this area and, based on the presence of a potential trough in the bedrock surface mapped during the geophysical survey, quarrying may have occurred at the location of the East CKD Area. The conceptual cross section (Figure 1-9) shows this bedrock topography inferred from the geophysics.

1.3.2 Hydrologic/Hydrogeologic Setting

1.3.2.1 Surface Hydrology

While the climate at the Site is moderated by the adjacent lake, annual temperatures range from as high as 99 degrees Fahrenheit (^{0}F) to as low as -19^{0}F seasonally. The annual average maximum temperature is 53^{0}F and the average minimum is 36^{0}F based on 1952 to 1980 measurements recorded at the Petoskey, Michigan station (Michigan State Climatologist, 2005). The region receives between 27 and 35 inches of precipitation annually, based on National Oceanic and Atmospheric Administration (NOAA) records for the 30-year period 1970 to 2000, measured at Alpena, Houghton Lake, and Grand Rapids, Michigan (NOAA, 2005).

Historically, the greatest amount of precipitation occurs from July through November. The lowest precipitation months are typically February and March. During December through early March the ground is generally frozen and therefore the majority of precipitation infiltration to groundwater must occur during April through November.

There is a surface water divide located approximately 1/2 mile south of the Site at an approximate elevation of 790 ft. MSL. Surface water south of this divide flows generally south-southwest toward Walloon Lake, with an elevation of approximately 680 ft. MSL. Surface water north of the divide flows generally north to Lake Michigan, which has an elevation of approximately 578 ft. MSL (chart datum is 577.5 ft. [US Army Corps of Engineers, 2005]) (Figure 1-4).

An unnamed creek (East-unnamed creek #1) forms the eastern boundary of the Seep 1 CKD Area, and is visible on Figures 1-3 and 1-4. The creek falls from an elevation of approximately 645 ft. MSL at its intersection with U.S. Highway 31 south of the Site to approximately 578 ft. MSL at its discharge point into Lake Michigan (over a distance of approximately 1,900 feet). A second unnamed creek (East-unnamed creek #2) forms the eastern boundary of the East CKD Area. The creek falls from an elevation of approximately 672 ft. MSL at its intersection with U.S. Highway 31 southeast of the Site to approximately 578 ft. MSL at its discharge point into Lake Michigan (over a distance of approximately 1,200 feet). A third unnamed creek (West-unnamed creek) flows from U.S. Highway 31 down to a constructed pond (Pond #1) on the south side of the West CKD Area. Pond #1 drains into Lake Michigan around the east side of the West CKD area (Figures 1-3 and 1-4). The Site conceptual model assumes that East-unnamed creek #1 and #2 and West-unnamed creek represent a surface expression of the water table elevation across these areas of the Site. The Site conceptual model also assumes the wetlands (Wetland Area #1) located southwest of the Seep 2 CKD Area are a surface expression of the water table in this area of the Site (Figure 1-3). This assumption will be verified by groundwater gauging and sampling events. Gauging of surface water bodies and monitoring wells and subsequent potentiometric surface mapping will be used to verify the relationships between surface water bodies and the local groundwater table. The Site conceptual model will be revised accordingly.

Starting in the 1950s, quarrying and filling resulted in the filling in and/or diversion of surface drainage ways at the West CKD area and the Seep 1 and 2 CKD areas. The further alteration of the surface drainage at the Site culminated with development of the golf course complex, including creation of wetlands and ponds south of the West CKD and the Seep 2 CKD Areas. Based on 1938 and 1952 historical aerial photographs, between East-unnamed creek #1 and West-unnamed creek, five small perennial creeks or drainage ways were distributed at intervals of 500 to 1200 feet apart. Each of the ephemeral creeks drained northward into the lake. By the time of the 1952 aerial photograph, apparent quarrying and/or filling had occurred at the Seep 1 CKD Area, blocking the eastern-most of the five small drainage ways. The mouth of the East-unnamed creek #1 was also blocked and shifted approximately 40 feet eastward (Figure 1-3).

A 1981 aerial photograph shows disturbed areas at the Seep 1, Seep 2, and East and West CKD areas, reflecting apparent filling or re-grading. The five drainage ways between the West-unnamed creek and East-unnamed creek #1 were all diverted or blocked by the filling at the Seep 1, Seep 2, and West CKD areas (Figure 1-4).

By 1998, with completion of the golf course complex, several small wetlands were created along the south side of the Seep 2 and West CKD areas (Figure 1-3). The West-unnamed creek was diverted into Pond #1 which currently drains around the east edge of the West CKD area and into Lake Michigan (Figure 1-3).

In addition to the surface water drainage pattern described above, there is a system of subsurface drains beneath the golf course fairways and greens. The drains were installed at the time of the golf course construction to prevent ponding of surface water on the course. Appendix F contains drawings of the drain locations and engineering calculations for surface area drainage. An investigation is needed to confirm the exact locations of the drains and confirm the surface area drainage. The golf course also has a subsurface water distribution system supplying water for a sprinkler irrigation system. Appendix F also contains drawings of the irrigation system. The volume of water infiltrating through the subsurface soils from the sprinkler system is unknown. Section 5.2.6.1 includes planned investigation activities to collect data which will be used to calculate the net input of water from golf course infiltration (both irrigation water and precipitation) into the Site conceptual model.

1.3.2.2 Hydrogeology

In general, the regional groundwater system at the Site flows from south to north toward Lake Michigan, the regional discharge point for groundwater in the area. Based on visual observations of exposed bedrock at quarries and outcrops in the area, it is apparent that the flow of groundwater within the bedrock occurs primarily through fractures and along bedding planes. Numerous seeps and springs can be observed flowing from thinly bedded outcrop exposures across a wide range of elevations at the Site, indicating that perched groundwater may migrate at elevations above the regional water table in some areas of the Site. No visible indications of large-scale karst features were observed on or near the Site surface; however, the Site is located in a region known to have karst features (USGS HA730-J). Apparent zones of lower electrical resistivity and/or zones of lower seismic shear wave velocities, which can be associated with voids or fracture zones, are indicated on seismic profiles of the bedrock at the Site.

The depth to groundwater within the four CKD investigation areas is variable and groundwater gradient generally slopes towards Lake Michigan. The hydraulic gradient appears to steepen toward the lake, and ranges from 0.04 to 0.07 feet/foot (average value of 0.06 feet/foot), based on ground water table slopes inferred from adjacent stream profiles, monitoring well data, and the profiles of local drainage path ways within the Site area (Figure 1-4) (NTH, 1995).

There have been no direct measurements of the specific hydrogeologic characteristics (e.g., hydraulic conductivity, porosity) of the individual geologic units at the Site. However, some generalizations can be made based on the nature of the lithological units. The sandy over-burden materials can be assumed to have relatively high permeabilities (with hydraulic conductivities on the order of 10^{-1} to 10 feet per day (ft/day) and effective porosities of 5 to 25 %), while the fractured bedrock and the unconsolidated units rich in clay can be assumed to have lower permeabilities (with hydraulic conductivities ranging from 10^{-7} to 10^{-1} ft/day and effective porosities of 0.1 to 20 %) (Heath, 1987 and Freeze and Cherry, 1979).

While the bulk hydraulic conductivity of a fractured limestone unit may be low, the fractures within a fractured limestone bedrock can have hydraulic conductivities as high as 10 to 200 ft/day with effective porosities less than 1% (0.01 to 0.1%) (personal communication-Muldoon, 2005) (Streltsova-Adams, 1978). Given the average gradient of the groundwater table and fractured limestone conductivities of 10 to 200 ft/day, discharge rates as high as 4 to 90 gallons per day per square foot (gpd/ft^2) of aquifer cross section are plausible for the fractured bedrock.

Based on a gradient of 0.06, an assumed hydraulic conductivity range for fractured and weathered limestone bedrock of 10 to 200 ft/day, and an effective porosity of 0.1%, the average linear flow velocity of groundwater could range from 600 to 12,000 ft/day.

Geophysical data (interpreted CKD thickness data and observations of high electrical conductivity) and measured groundwater elevation data indicate that a portion of the CKD deposits may be below the regional water table in each of the areas. Therefore, the Site conceptual model assumes that a portion of the CKD is saturated in all of the investigation areas at the Site. This assumption will be verified as part of investigation activities described in Section 5.0 of this work plan.

1.3.2.3 Water Quality

The geologic and hydrogeologic conceptual models have been combined to develop a model of the mechanisms and distribution of water quality impacts related to leachate release from CKD deposits. As described below, groundwater contacting CKD-containing fill materials typically exhibits the following downgradient groundwater characteristics: elevated pH with respect to background, high specific conductivity, high total dissolved solids and sulfate, and elevated concentrations of a number of the constituents including arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, manganese, nickel, sodium, and selenium (U.S. EPA, 1998). Groundwater contacting CKD-containing fill deposits resulted in downgradient leachate plumes with these characteristics at 13 CKD disposal sites examined by the U.S. EPA, including the Penn-Dixie Cement Site (now known as the Little Traverse Bay CKD Release Site) (U.S. EPA, 1998).

The downgradient leachate plume at this Site exceeded the Federal Maximum Contaminant Level (MCL) for lead; Federal Secondary Drinking Water Standards for pH and total dissolved solids; State groundwater criteria for sodium, sulfate, arsenic, iron, lead, and cadmium; and state water quality standards for arsenic, chromium, copper, lead, mercury, and nickel (U.S. EPA, 1998).

Samples of the CKD leachate collected from the existing Seep 2 collection drain system have exhibited pH values ranging from 11.2 (2/28/1996) to 11.42 (12/11/2004), as well as elevated total dissolved solids (11,000,000 µg/L - 2/28/1996) and sulfate (3,900,000 µg/L - 2/28/1996) concentrations. The following elevated metal concentrations have been detected in leachate samples collected from this collection drain system; arsenic (44 µg/L - 2/28/1996), cadmium (100 µg/L - 9/11/1996), chromium (110 µg/L - 9/11/1996), iron (740 µg/L - 2/28/1996), lead (560 µg/L - 9/11/1996), mercury (4.7 µg/L - 9/11/1996), nickel (110 µg/L - 2/28/1996), potassium (6,000,000 µg/L - 2/28/1996), sodium (300,000 µg/L - 2/28/1996), and zinc (180 µg/L - 9/11/1996). Appendix A, Table A-1 provides a summary of the analytical data collected from the existing Seep 2 collection trench.

West CKD Area

No groundwater monitoring wells exist in this area. Geophysical data (EM profiling) suggest that potential high electrical conductivity conditions are present in the shallow subsurface adjacent to, and downgradient from, the CKD piles. Appendix B contains a summary of the geophysical activities, data, and interpretations.

CKD leachate has been observed discharging along the shoreline of Lake Michigan in the West CKD Area. Elevated pH and conductivity readings have been measured along the shore of the West CKD Area. On December 2, 2004 four pH readings were measured above 9.0 with associated specific conductivity readings ranging from 8,184 to 14,986 µs/cm^2.

The maximum detected concentrations of the following constituents have been detected within one sample (West-Seep 2) collected from the shore of the West CKD Area during the April 12, 2005 U.S. EPA sampling; aluminum (2,200 µg/L), arsenic (5.2 µg/L), chromium (11 µg/L), copper (9 µg/L), iron (1,000 µg/L), lead (4 µg/L), selenium (10 µg/L), vanadium (17 µg/L).

The shoreline of the West CKD Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined an area approximately 550 feet wide with indications of CKD leachate impact (pH readings ranging from 9.01 to 12.41 and elevated specific conductivity readings). Elevated pH readings (>9.0) were measured up to 60 feet northward into Lake Michigan. The targeted shoreline survey also revealed a 220 foot wide area with elevated pH readings east of the West-unnamed creek. The pH readings in this area ranged from 9.01 to 9.60.

Pine Ridge Court Area

No groundwater monitoring wells exist in this area and no samples have been collected from this area. The shoreline of the Pine Ridge Court Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined two areas, separated by approximately 160 feet, with indications of CKD leachate impact. One area is located north of Lots 3 and 4 (approximately 240 feet wide and 30 feet northward into Lake Michigan) with pH readings ranging from 9.0 to 10.42 and elevated specific conductivity readings. The second area is generally located north of Lot 6 (approximately 40 feet wide and extended up to 10 feet northward into Lake Michigan with pH reading ranging from 9.01 to 9.65).

Guard Rail Seep Area

No groundwater monitoring wells exist in this area and no samples have been collected from this area. The shoreline of the Guard Rail Seep Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined two areas separated by approximately 90 feet with indications of CKD leachate impact. The western area is approximately 35 feet wide and extended up to 10 feet northward into Lake Michigan with pH readings ranging from 9.02 to 9.39 and elevated specific conductivity readings. The eastern area is approximately 35 feet wide and extended up to 5 feet northward into Lake Michigan with pH reading ranging from 9.09 to 9.71.

Seep 2 CKD Area

Groundwater samples previously collected from monitoring wells downgradient of the Seep 2 CKD area (wells OW-1, OW-1AR, OW-2 and OW-2A) indicate that subsurface water beneath the CKD pile in this area has elevated pH, high total dissolved solids, and elevated concentrations of arsenic, cadmium, iron, potassium, sodium, sulfate, and chloride, compared to the upgradient monitoring wells OW-4R and OW-5 concentrations (Appendix A). Historically, the maximum detected concentrations of the following constituents were found within groundwater samples collected from the Seep 2 CKD Area; arsenic (2 µg/L within OW-1 and OW-2), cadmium (1.3 µg/L within OW-1AR), chromium (17 µg/L within OW-1AR), copper (40 µg/L within OW-2), iron (3,200 µg/L within OW-1), lead (8 µg/L within OW-2), mercury (0.2 µg/L within OW-2), potassium (1,400,000 µg/L within OW-2), sodium (96,000 µg/L within OW-2), and zinc (30 µg/L within OW-1AR).

The geophysical data suggest the presence of buried bedrock debris on top of competent bedrock as well as possible areas of high electrical conductivity. The high electrical conductivity is interpreted as an indication of possible CKD leachate impacts to groundwater. The full vertical extent of the observed groundwater impacts (i.e., depth of “plume”) has not been defined at this area of the Site. A full discussion of the geophysical survey, including methods and findings, is provided in Appendix B.

CKD leachate has been observed discharging along the shoreline of Lake Michigan and elevated pH and conductivity readings have been measured in the Seep 2 CKD Area. On November 4, 2004 several pH readings were measured above 9.0 along the shore of the Seep 2 CKD Area. The conductivity readings associated with these pH values ranged from 8,304 to 20,417 µs/cm^2.

Historically, the maximum detected concentrations of the following constituents have been observed within samples collected from the shore of the Seep 2 CKD Area: arsenic (220 µg/L within WEST CKD SEEP collected on 9/7/2004), barium (13 µg/L within WEST CKD SEEP collected on 9/7/2004), cadmium (1.3 µg/L within West Seep collected on 10/9/1996), chromium (53 µg/L within WS-2 collected on 8/24/1995), copper (130 µg/L within West Seep collected on 9/24/1996), iron (19,000 µg/L collected within WS-2 collected on 8/24/1995), lead (44 µg/L within WS-2 collected on 8/24/1995), mercury (0.9 µg/L within WS-2 outfall lake collected on 7/2/1996), molybdenum (500 µg/L within WEST CKD SEEP collected on 9/7/2004), nickel (260 µg/L within WS-2 collected on 8/24/1995), potassium (13,000,000 µg/L within WS-2 collected on 8/24/1995), selenium (110 µg/L within WEST CKD SEEP collected on 9/7/2004), silver (52 µg/L within West Seep collected 9/13/1995), sodium (950,000 µg/L within WS-1 collected 8/24/1995), strontium (40 µg/L within WEST CKD SEEP collected on 9/7/2004), titanium (53 µg/L within WEST CKD SEEP collected on 9/7/2004), vanadium (190 µg/L within WEST CKD SEEP collected on 9/7/2004), and zinc (130 µg/L within West Seep collected on 8/6/1996).

The shoreline of the Seep 2 CKD Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined an area approximately 500 feet wide with indications of CKD leachate impact (pH readings ranging from 9.00 to 12.09 and elevated specific conductivity readings). Elevated pH readings (>9.0) were measured up to 30 feet northward into Lake Michigan.

Seep 1 CKD Area

Groundwater samples previously collected from monitoring wells downgradient of the Seep 1 CKD Area (wells OW-3A and OW-3R) indicate that subsurface water downgradient of the CKD has elevated pH, high total dissolved solids, and elevated concentrations of sulfate, chloride, potassium, and sodium, relative to the upgradient monitoring well OW-4R concentrations (Appendix A). Historically, the maximum detected concentrations of the following constituents have been found within groundwater samples collected from the Seep 1 CKD Area; arsenic (3 µg/L within OW-3R), cadmium (0.2 µg/L within OW-3R), chromium (7 µg/L within OW-3R), iron (2,700 µg/L within OW-3A), lead (4 µg/L within OW-3A), mercury (0.3 µg/L within OW-3A), potassium (220,000 µg/L within OW-3R), sodium (31,000 µg/L within OW-3R), and zinc (30 µg/L within OW-3A).

These findings are similar to what has been found in CKD leachate observed at other sites (U.S. EPA, 1998). Geophysical surveys of the Seep 1 CKD Area suggest the presence of zones with high electrical conductivity. The high electrical conductivity is interpreted as an indication of CKD leachate impacts to groundwater. The full vertical extent of the observed groundwater impacts (i.e., depth of “plume”) has not yet been defined at this area of the Site. A full discussion of the geophysical survey, including methods and findings, is provided in Appendix B.

CKD leachate has been observed discharging along the shoreline of Lake Michigan in the Seep 1 CKD Area. Elevated pH and conductivity readings have been measured along the shore of the Seep 1 CKD Area. On November 4, 2004 several pH readings were measured above 9.0 along the shore of the Seep 1 CKD Area. Elevated conductivity readings were also observed, ranging from 499 to 10,730 µs/cm^2.

Historically, the maximum detected concentrations of the following constituents have been detected within samples collected from the shore of the Seep 1 CKD Area: aluminum (810 µg/L within Seep/East collected on 3/15/2005), arsenic (47 µg/L within Seep #1 collected on 11/28/1995), cadmium (0.7 µg/L within Seep #1 WS-1 collected on 5/31/1996), chromium (29 µg/L within Seep #1 collected on 11/28/1995), copper (30 µg/L within Seep #1 and Seep #1 WS-1 collected on 11/28/1995 and 5/31/1996, respectively), iron (1,400 µg/L collected within Seep #1 WS-1 collected on 5/31/1996), lead (4.0 µg/L within Seep/East collected on 3/15/2005), mercury (0.2 µg/L within Seep #1 collected on 11/28/1995), nickel (120 µg/L within Seep #1 collected on 11/28/1995), potassium (6,600,000 µg/L within Seep #1 collected on 11/28/1995), selenium (17 µg/L within Seep/East collected on 3/15/2005), silver (0.8 µg/L within Seep #1 collected on 5/31/1996), sodium (420,000 µg/L within Seep #1 collected on 5/31/1996), vanadium (34 µg/L within Seep/East collected on 3/15/2005), and zinc (70 µg/L within Seep #1 collected on 11/28/1995).

The shoreline of the Seep 1 CKD Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined two areas separated by approximately 160 feet with elevated pH with indications of CKD leachate impact. The western area is approximately 840 feet wide and extended up to 110 feet northward into Lake Michigan with pH readings ranging from 9.00 to 12.45 and elevated specific conductivity readings. The eastern area is approximately 25 feet wide and extended up to 15 feet northward into Lake Michigan with pH readings ranging from 9.03 to 9.13.

East CKD Area

No groundwater monitoring wells exist in this area. Geophysical data (EM profiling) suggest that potential high electrical conductivity conditions are present in the shallow subsurface adjacent to, and downgradient from, the CKD pile. A full discussion of the geophysical survey, including methods and findings, is provided in Appendix B.

CKD leachate has been measured discharging along the shoreline of Lake Michigan in the East CKD Area. Elevated pH and conductivity readings were identified by the U.S. EPA on November 22, 2004, with pH readings ranging from 8.64 to 10.43. On March 11 and March 15, 2005 several pH readings were measured above 9.0 along the shore of the East CKD Area. Elevated conductivity readings were also observed, ranging from 2,200 to 3,400 $\mu s/cm^2$.

The maximum detected concentrations of the following constituents were found within one sample (East Park-Seep1) collected by the U.S. EPA from the shore of the East CKD Area on March 15, 2005: aluminum (4,700 µg/L), arsenic (32 µg/L), copper (6.3 µg/L), selenium (8.0 µg/L), and vanadium (170 µg/L).

The shoreline of the East CKD Area was surveyed as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. The targeted shoreline survey defined two areas separated by approximately 340 feet with elevated pH with indications of CKD leachate impact. The western area is approximately 400 feet wide and extended up to 80 feet northward into Lake Michigan with pH readings ranging from 9.00 to 12.08 and elevated specific conductivity readings. The eastern area is approximately 250 feet wide and extended up to 10 feet northward into Lake Michigan with pH readings ranging from 9.00 to 10.75.

1.3.3 Previous Investigations and Response Actions

1.3.3.1 1995 Hydrogeologic Investigation

During January 1995 to April 1995, NTH Consultants, Ltd. (NTH) conducted a hydrogeologic investigation at the Bay Harbor Development. The purpose of the investigation was to evaluate hydrogeologic conditions and monitor groundwater quality in the area of the "central-western" CKD pile and associated seep (the area currently defined as the Seep 2 CKD Area). A total of 21 test pits and 8 test borings were advanced to characterize subsurface conditions and allow collection of groundwater samples. The test pits were excavated to depths ranging from 1 foot to 16.3 feet below ground surface. During excavation, soil conditions were logged by an NTH field geologist. Field measurements of pH were performed in selected test pits where groundwater was encountered. Measurements of pH ranged from 8.0 at TP-2 to 10.2 at TP-1. Test borings were advanced to depths ranging from 21 feet to 56 feet below ground surface and were completed with monitoring wells. Five wells (OW-1 through OW-5) were installed to monitor the shallow portion of the bedrock aquifer. Three wells (OW-1AR, OW-2A, and OW-3A) were installed to monitor groundwater quality in the deeper portions of the bedrock aquifer. Static water levels at the well locations were measured by NTH personnel on two occasions following well installation. Based on these water level measurements, groundwater flow was interpreted to be towards the north-northeast to Lake Michigan. NTH collected one round of groundwater samples from the monitoring wells. The samples were submitted for laboratory analysis of pH, TDS, and various metals. Based on the results of groundwater sampling, NTH concluded that the extent of CKD-impacted groundwater was limited to a localized area on the northeast side of the "central-western" CKD pile. In response to the findings of the hydrogeologic investigation, a 1,200-foot long drain system was installed near the base of the CKD pile, currently known as the Seep 2 CKD Area, to intercept seep water before it entered Lake Michigan. The locations of the NTH wells are shown on Figure 1-2. The data were submitted to and reviewed by MDEQ, and the parties agreed to install the collection line as negotiated in the Administrative Agreement and Covenant Not to Sue entered into between CMS, MDEQ and the State of Michigan.

1.3.3.2 Historical Seep 2 Collection Drain Construction and Operation

As part of the agreement between Bay Harbor Company and the MDEQ, a leachate collection drain was constructed in 1997 at what is now known as Seep 2. The collection drain runs approximately 1,200 feet along Coastal Ridge Drive. It is constructed of an 8-inch diameter, perforated, rigid PVC pipe. The pipe is surrounded by 24 inches of drain stone and is wrapped in a geotextile cloth. The depth of the pipe varies from approximately 4 feet at the western end to 17 at the deepest point. A heavy plastic liner was installed at the bottom and on the Lake side of the trench. Collected leachate flowed to a sump (currently called the lower lift station), where it was pumped through a 2-inch PVC force main to the City of Petoskey sewer system.

1.3.3.3 Pre-Treatment System Construction and Operation

In 2003 CMS contractors designed and constructed a pre-treatment plant to adjust the pH of the CKD leachate collected at the existing Seep 2 collection drain. The original force main was disconnected from the City sewer and extended to the treatment plant location. The pH of the leachate is adjusted by using concentrated sulfuric acid to neutralize the leachate to acceptable pH levels. Two pH probes are used to monitor pH levels as the leachate enters and exits the plant. The probe that measures treated leachate has two alarm set points for low pH and high pH. The alarm points are set at 6.5 for low pH and 9.5 for high pH. The pH of both probes is recorded and the probes are automatically cleaned and calibrated. The treated leachate was then delivered to the City sewer by a newly constructed discharge line. A daily log is kept to ensure that water quality standards for the city are met.

The plant was designed to handle 50 gallons per minute or 72,000 gallons per day. The plant is monitored and maintained on a daily basis by CMS personnel. A copy of the Pre-Treatment Facility Basis of Design is included in Appendix G.

1.3.3.4 Collection System Shutdown and Restart

In December of 2003 the plant began to experience low flow problems. The pumps at the upper lift station could not keep up with the water volumes from the lower station. In January 2004 the station was shut down to correct this problem. Over the next few months an extensive investigation was conducted of the entire system. This process was hampered by severe winter weather conditions. It was finally discovered that the discharge line between the pre-treatment facility and the City sanitary sewer line was becoming clogged with an unknown precipitate. The discharge line was not designed to be cleaned, as it contained many short radius ells that prevented the passage of the cleaning tools. By June 2004, the restrictions were dug up and cleanouts installed to allow for routine maintenance and to ensure that the problem would not repeat itself. At that time, the City of Petoskey requested that automatic volume and alarm shutdowns be installed. CMS and City negotiated and entered into a Consent Decree enabling the restart of the treatment plant in early September, 2004. On September 7, 2004 the system was restarted and has only been shut down for short periods for routine maintenance and cleaning to date.

1.3.3.5 MDEQ and U.S. EPA Investigations

In August 2004, reddish-brown discoloration was observed along the shoreline of the Little Traverse Bay of Lake Michigan. The MDEQ conducted investigations of the shoreline of Lake Michigan and documented pH measurements exceeding 12. Following MDEQ investigations of the CKD leachate releases into Lake Michigan, U.S. EPA conducted several monitoring and sampling events across the entire Little Traverse Bay CKD Release Site.

On September 30, 2004 U.S. EPA personnel and contractors conducted field pH monitoring along the shore of the Little Traverse Bay, downgradient of the Seep 1 and Seep 2 CKD Areas. Within shoreline areas exhibiting discoloration, pH values ranged from 10.02 to 13.06. On November 4, 2004, two discrete areas of pooled leachate with elevated pH levels (the Seep 1 and Seep 2 CKD Areas, Figure 1-1) were investigated by Barr Engineering Company (as a consultant to CMS), and Weston Solutions, Inc. (as a consultant to U.S. EPA). Elevated pH readings (pH >9.0) were recorded in some of the on-shore leachate accumulation zone in both of these areas. On November 22, 2004, Weston Solutions, Inc. (as a consultant to the U.S. EPA) conducted monitoring at the East CKD Area and at the Seep 1 and 2 CKD Areas. Five monitoring points located along the shoreline of the East CKD Area exhibited pH readings ranging from 8.64 to 10.43. The Seep 2 CKD Area pH readings ranged from 8.87 to 12.75 and the Seep 1 CKD Area pH readings ranged from 12.97 to 13.13.

On March 11 and 15, 2005 U.S. EPA conducted an investigation of Lake Michigan surface water, just off-shore, downgradient of the Seep 1 and Seep 2 CKD Areas and the East CKD Area. Monitoring and sampling was conducted at locations where the ice sheet thickness was either reduced or absent, indicating the location of a possible seep. Five monitoring and two sampling locations were off-shore of the East CKD Area. Analysis of water samples collected at the East CKD Area indicated pH values ranging from 11.37 to 11.90. In addition, the investigation, including laboratory analysis of samples, identified impacted portions of Lake Michigan associated with the Seep 1 CKD Area further east than previously measured.

The existing data for the Site is included in Appendix A. Table A-1 contains data that were obtained in the laboratory. Table A-2 contains data that were obtained in the field. These tables contain data from the historical record for the site, as well as data obtained by the U.S. EPA contractor and Barr Engineering and their subcontractors. Each sample is labeled with the available sampling location information. For samples collected by Barr, the GPS coordinates are typically included. Copies of the Weston Solutions, Inc. reports are also included in Appendix A. The locations of the monitoring wells referred to in the data tables are shown in Figure 1-2. Historic data are labeled with the location information that was contained in the historical record.

1.3.3.6 Preliminary Non-intrusive Data Collection Activities

Concurrent with discussions with the MDEQ, CMS began preliminary non-intrusive data gathering activities at the Site starting on November 4, 2004. These activities consisted of geophysical investigations, review of available information regarding the Site setting, a preliminary lakeshore evaluation, limited on-shore leachate accumulation zone sampling, etc. This data collection was suspended on December 2 during negotiations with U.S. EPA as to the Order. This non-intrusive information was used to develop the conceptual model of the Site. Previous investigation analytical data are included in Appendix A and the geophysical data are included in Appendix B. Appendix B also includes a written summary of the methods used in the geophysical investigation, the methods used in interpreting the data collected (including methods used to avoid biasing the investigation results due to the presence of subsurface utilities), a summary of the findings from the investigation, and a listing of the recommendations made based on the results of the investigation (i.e. discussion of recommended boring bedrock coring locations).

1.3.4 Cement Kiln Dust

Cement kiln dust (CKD) is a by-product of Portland cement production. In the United States, the manufacture of Portland cement typically involves roasting a finely ground proportional mix of raw materials in a rotary kiln (U.S. Dept. of the Interior, 2004).

1.3.4.1 Environmental Characteristics

The specific chemical, mineralogical, and physical characteristics of CKD vary from plant to plant. Such variation is due to differences in raw feed materials, type of kiln operation, dust collection facility, and fuel used in operating the kiln. In general, CKDs are particulate mixtures of partially calcined and un-reacted raw limestone feed, clinker dust, and fuel ash, enriched with alkali sulfates, halides, and other volatile inorganic materials. Particulates of the raw materials, partially processed feed, and components of the final product are entrained in the combustion gases flowing countercurrent to the feed as it travels through the Portland cement kiln system (Portland Cement Association, 2003). These particulates and combustion gas precipitates are collected in the particulate matter control device (PMCD) and are collectively referred to as CKD. The dust is a very heterogeneous mixture of materials. The specific characteristics of a particular CKD are dependent on the raw materials, fuels, kiln pyroprocessing type, overall equipment layout, and type of cement being manufactured.

The type of kiln, the chemical makeup of the raw materials, fuel, and the condition of the system operations all affect the chemical configuration of the CKD. Portland cement specifications usually limit the amounts of sodium and potassium allowed in the final product. Because bypass CKD contains a large quantity of these minerals, CKD is usually removed from the process. Typical chemical composition of CKD is listed below (Portland Cement Association, 1996):

Typical CKD Composition

CONSTITUENT	% BY WEIGHT	CONSTITUENT	% BY WEIGHT
$CaCO_3$	55.5	Fe_2O_3	2.1
SiO_2	13.6	KCl	1.4
CaO	8.1	MgO	1.3
K_2SO_4	5.9	Na_2SO_4	1.3
$CaSO_4$	5.2	KF	0.4
Al_2O_3	4.5	Others	0.7

CKD may also contain the following trace metals at concentrations above background levels; antimony, arsenic, cadmium, lead, mercury, selenium, silver, strontium, and zinc (U.S. EPA, 1998).

Water contacting CKD typically exhibits the following downgradient leachate characteristics: elevated pH with respect to background, high specific conductivity, high total dissolved solids and sulfate, and elevated concentrations of arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, sodium, and selenium (U.S. EPA, 1998). Water contacting CKD-containing fill deposits resulted in downgradient CKD leachate plumes with these characteristics at 13 CKD disposal Sites examined by the U.S. EPA (U.S. EPA, 1998).

1.3.4.2 Physical Characteristics

CKD is a fine, powdery material of relatively uniform size. Typical physical properties are listed below (USDOT, 2005):

Typical Range of Physical Properties of Cement Kiln Dusts

Property	Value
Gradation	75% passing 0.030 mm (No. 450 sieve)
Maximum Particle Size	0.300 mm (No. 50 sieve)
Specific Surface(cm2/g)	4600 - 14,000
Specific Gravity	2.6 - 2.8

Approximately 75 percent of CKD particles are finer than 0.030 mm (No. 450 sieve). The maximum particle size of most CKD is about 0.30 mm (No. 50 sieve), with the Blaine fineness ranging from about 4600 (coarser) to 14000 (finer) cm^2/g. In comparison, the Blaine fineness of Portland cement is about 3500 to 3800 cm^2/g. The specific gravity of CKD is typically in the range of 2.6 to 2.8, less than that of Portland cement (specific gravity of 3.15). Uncompacted CKD has a loose density of only about 30 lb/ft^3, but can be compacted to about 85 to 95 lb/ft^3 using conventional soils compaction practices.

US EPA has estimated the permeability of CKD ranging from 1×10^{-6} to 1×10^{-3} cm/sec, which is similar to coal fly ash when placed under similar conditions (U.S. EPA, 1997). It is likely that permeability will vary greatly, depending on density of the material when placed and at present, and moisture content both when placed and at present. It would appear that CKD placed in an uncontrolled fill would likely have a permeability of at least 1×10^{-5} cm/sec.

1.3.4.3 Remedial Alternatives

Typically, containment and isolation methods have been effective as management options for CKD sites. Containment and isolation may be achieved through some combination of capping, stabilization or other infiltration controls, cutoff walls, surface water diversion, pumping, wick drains, erosion controls, deed restrictions, removal or other remedial alternatives.

1.3.5 Technical Background Document on Groundwater Controls at CKD Landfills (Draft EPA Document)

This U.S. EPA technical background document is a valuable resource that can be used during consideration and development of groundwater controls (e.g. infiltration controls, cutoff walls, surface water diversion, pumping, wick drains) for the Site (U.S. EPA, 1998).

1.3.6 Portland Cement Association of America CKD Document

The Portland Cement Association of America has published several useful technical documents on cement and CKD that can also serve as valuable resources during the implementation of the Order.

1.4 Discussion of Potential Remedial Options for CKD Piles

Identifying potential remedial alternatives requires investigation activities and data to determine appropriate and effective long-term remedies for the Site. In order to assure that the required data are collected, it is necessary to understand the range of potential remedies that may ultimately be applied to the Site. In accordance with the Order, the goals of the long term remedy are to:

- Integrate the interim response activities as appropriate;
- Prevent unacceptable exposures to surface waters and sediment impacted by CKD material;
- Design, construct and operate long-term response activity to prevent discharge of groundwater containing hazardous substances above state criteria from the Site to the surface waters of the state;
- Prevent unacceptable risk to humans by direct contact with CKD Waste Material;
- Prohibit exacerbation, prevent new releases and unacceptable exposure and place land use and resource use restrictions related to CKD Waste Material;
- Construct and maintain erosion control measures for underlying CKD Waste Material;

- Ensure adequate financial resources are available in an acceptable form and amount to assure the performance of the response activities necessary to protect human health and the environment in perpetuity;
- Ensure that any other unacceptable exposures are adequately addressed and assure the effectiveness and integrity of the long-term response activities.

These goals are to be achieved through: (a) removal of CKD Waste Material, (b) containment and isolation of CKD Waste Material, or (c) other remedial alternatives. Containment and isolation may be achieved through some combination of capping, stabilization or other infiltration controls, cutoff walls, surface water diversion, pumping, wick drains, erosion controls, deed restrictions, or other remedial alternatives.

2.0 Proposed Scope of Work

2.1 Project Planning and Support

2.1.1 Project Planning

2.1.1.1 Kick-off Meeting

The U.S. EPA has already completed an initial visit to the Site and has met with CMS to discuss the project. However, CMS believes that it would be valuable to have a kick-off meeting during the first week of work at the Site after approval of the RA Work Plan.

2.1.1.2 Site Visit

The U.S. EPA has already completed an initial visit to the Site. As discussed above, CMS believes that it would be valuable to have a site visit meeting during the first week of work at the Site after approval of the RA Work Plan. This will allow the U.S. EPA to observe first-hand the initial stages of the on-site work, and to discuss any concerns that they might have regarding how the work is starting or scheduled to proceed.

2.1.1.3 Evaluate Existing Information

Existing data and information related to the Site has been reviewed and evaluated. Sections 1.2 and 1.3 present a summary of this evaluation. References reviewed and cited are listed in Section 11.0.

2.1.1.4 RA Work Plan

An initial version of the RA Work Plan (Revision 0) was submitted to the U.S. EPA on March 3, 2005. In accordance with informal verbal comments received from the U.S. EPA on March 21, 2005 and the “Interim Response/Remedial Investigation/Feasibility Study Outline” provided to CMS on March 30, 2005, the RA Work Plan was revised (Revision 1, April 4, 2005). Additional verbal comments were provided to CMS on April 12, April 20, and May 6, 2005 and the RA Work Plan was revised (Revision 2, this version). Subsequent sections of this Work Plan describe the tasks to be completed that are designed to prevent direct contact exposure with CKD leachate, prevent the migration of CKD leachate to Lake Michigan, investigate the nature and extent of hazardous substances at the Site, and to determine the nature and extent of current and potential threats to the public health, welfare and the environment from CKD Waste Material.

An evaluation of alternatives for addressing such threats that meet the goals described in Section 1.4 will be prepared and submitted to the U.S. EPA following completion of the RA activities as described in Section 6.7.

2.2 Preparation of Plans for Additional Targeted Data Collection

2.2.1 Site Control and Access Management Plan

The Site Control and Access Management Plan (SCAMP) (Revision 0) was submitted to the U.S. EPA on March 3, 2005 (Barr, 2005c). In accordance with informal verbal comments received from the U.S. EPA on March 21, 2005, Revision 1.0 of the SCAMP was prepared and submitted to the U.S. EPA for review on April 4, 2005. The SCAMP was approved by the U.S. EPA in a letter dated April 19, 2005.

2.2.2 Project Health and Safety Plan

The Project Health and Safety Plan – Revision 0 (PHASP) was submitted to the U.S. EPA on March 3, 2005 (Barr, 2005a). The PHASP – Revision 3.0 dated May 2, 2005 was approved by the U.S. EPA in a letter dated May 4, 2005. The PHASP documents the potential hazards associated with the Site. The PHASP will be used to ensure that work conducted at the Site is completed safely and also help to ensure that any authorized visitors to the Site are aware of the potential risks.

The PHASP was prepared consistent with U.S. EPA Standard Safety Guide (PUB 9285.1-03, PB 92-963414 (June 1992), currently applicable Occupational Safety and Health Administration (OSHA) regulations found in 29 C.F.R. Part 1910, and MIOSHA standard, Part 432 Hazardous Waste Operations and Emergency Response.

All CMS contractors, Barr Engineering Company (Barr) employees, and Barr subcontractors working at the Site will have attended the 40-hour initial hazardous waste operations (HAZWOPER) training, will have kept current with an 8-hour refresher annually, and will have had at least three days of supervised on-Site training. All Barr employees and Barr subcontractor on-Site management and supervisors directly responsible for, or who supervise employees on-Site will, in addition to the training listed above, have at least 8 additional hours of specialized training.

2.2.3 Quality Assurance Project Plan

Revision 0 of the Quality Assurance Project Plan (QAPP) was submitted to the U.S. EPA on March 3, 2005 (Barr, 2005b). Revision 1.0 of the QAPP dated April 26, 2005 was approved by the U.S. EPA in a letter dated May 4, 2005. The QAPP was designed to conform to U.S. EPA guidance regarding sampling, quality assurance/quality control (QA/QC), data validation, and chain of custody procedures. The CMS subcontractor laboratories that are going to perform the analyses participate in a QA/QC program that complies with appropriate U.S. EPA guidance. The laboratories that will be analyzing the samples have documented Quality Systems that comply with ANSI/ASQC E-4 1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs"(American National Standard, January 5, 1995), and "EPA Requirements for Quality Management Plans (QA/R-2)(EPA/240/B-01/02)". CMS-contracted laboratories that will be analyzing samples as part of this investigation are accredited under the National Environmental Laboratory Accreditation program (NELAP).

Section A of the QAPP lays out the project management organization and defines project responsibilities. Section B of the QAPP addresses measurement data acquisition and covers in detail how field and laboratory data will be collected and managed throughout all phases of the project. Section C of the QAPP discusses the quality assurance oversight activities of the project team and Section D addresses how the data will be validated prior to use in making decisions for the project.

If the U.S. EPA approves analyses of additional parameters, an amendment to the QAPP will be submitted to the U.S. EPA.

2.2.4 Sampling and Analyses Plan

The elements of the Field Sampling Plan are included as Section 4.0 and 5.0 of this RA Work Plan. The QAPP and the Field Sampling Plan together are defined in the National Contingency Plan as the Sampling and Analysis Plan (SAP). The SAP is intended to be consistent with the appropriate sections of "Quality Assurance/Quality Control Guidance for

Removal Activities: Sampling QA/QC Plan and Data Validation Procedures" (OSWAR Directive No. 9360.4-01, April 1, 1990).

2.2.5 Baseline Ecological Investigation Plan

The Baseline Ecological Investigation Plan is discussed in Section 5.2.8.

2.2.6 Interim Recovery Plan for Addressing Shoreline Seep Areas

The interim recovery plan for addressing shoreline seep areas is presented in Section 4.0.

2.3 Project Management

2.3.1 Meetings, Project Management, and Reporting

A kick-off meeting and site visit will be conducted as described in Sections 2.1.1.1 and 2.1.1.2. Monthly meetings will be scheduled with the U.S. EPA to discuss progress on the work and issues that may come up during the implementation of the RA.

CMS will submit written progress reports to the U.S.EPA describing actions taken pursuant to the Order. These progress reports will be submitted weekly from the Effective Date of the Order until 60 days after approval of the Work Plan. After the 60 day period, progress reports will be submitted every 30 days until the termination of the Order.

The progress reports will describe all significant developments during the preceding period including actions performed, problems encountered, analytical data received during the period, and the developments and actions anticipated during the next reporting period. The report will also include a schedule of actions to be performed, anticipated problems and planned resolution of past or anticipated problems.

2.4 Contractor and Subcontractor Procurement

2.4.1 Identification of Contractors and Subcontractors

In accordance with the Order, the U.S. EPA was notified within 5 days of the Effective Date of the Order that CMS was retaining Barr Engineering Co as CMS's lead contractor. Along with the notification, CMS provided the U.S. EPA with Barr's qualifications. CMS will also notify the U.S. EPA of the name and qualifications of other contractor(s) or subcontractor(s) retained to perform the Work at least 5 business days prior to commencing of such work. If the U.S. EPA disapproves of a selected contractor, CMS will retain a different contractor and will notify the U.S. EPA of that contractor's name and qualifications within 3 business days of the U.S. EPA's disapproval.

2.4.2 Contractor QA/QC Program

The Barr Engineering Company Quality Management Plan (QMP) was submitted to the U.S. EPA on February 25, 2005. The QMP demonstrates Barr's compliance with ANSI/ASQC E-4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs" (American National Standard, January 5, 1995). The QMP was prepared consistent with "EPA Requirements for Quality Management Plans (QA/R-2)" (EPA/240/B0-1/002) as required by U.S. EPA.

3.0 Community Relations

This section of the Work Plan describes the stakeholders for the project, proposed community relations and communications activities to be conducted in concert with the RA investigation and interim response activities, and procedures for assessing the adequacy of the CMS community relations efforts. The goals of the CMS community relations efforts are to:

- Identify stakeholders and community groups initially and revise throughout the project
- Provide opportunities for stakeholders and the community to gain knowledge about the project
- Inform stakeholders and the community about actions to be undertaken through the course of the project
- Establish an information repository
- Provide forums to address community and stakeholder concerns

3.1 Community Communications to Date

To date there has been direct communication with property owners in the immediate vicinity of the seeps, with broader media coverage related to the initial discovery of the Site and the investigation and assessment efforts conducted by CMS, the Michigan DEQ, U.S. EPA, and the Michigan Department of Community Health.

CMS/Bay Harbor has held discussions with property owners and commented on its actions to date to local media. Media coverage also included reports based on interviews with regulatory agency staff and summaries of the MDEQ report regarding their September 2004 site inspection. Signs have been posted in the immediate vicinity of known seep areas.

3.2 Identified Stakeholders

Stakeholder and community groups who have expressed interest or who could potentially be interested by the Site include:

- U.S. EPA
- Michigan DEQ
- Little Traverse Bay Bands of Odawa Indians
- Northwest Michigan Community Health Agency
- Michigan Department of Community Health
- Resort Township
- City of Petoskey

- Emmet County
- Bay Harbor Development property owners, staff, and visitors
- Bay Harbor Golf Club staff and visitors
- Residents and visitors of surrounding areas
- Bay Harbor and area business owners
- Little Traverse Bay Conservancy
- Tip Of The Mitt Watershed Council
- Members of the public using Little Traverse Bay

3.3 Community Relations Activities

To successfully implement the goals stated above with the stakeholders and community, CMS will create and maintain a variety of communications channels to provide information to the public. The first of these channels will be a website dedicated to the Site. The website will provide background information on the Site, anticipated activities, and contact information for additional information. The website address will be conveyed directly to identified stakeholder and community groups, as well as to local newspapers of general circulation to be included in any stories covering the Site. Local media outlets are listed in Table 3-1.

Second, brochures describing the project, anticipated activities, and answering common questions will be distributed as needed or as requested to appropriate parties and locations. Periodic outreach to local media including radio, television and print media will be conducted. Public presentations will also be offered to resident, business, or community groups. Regular discussions are also planned with area elected officials.

3.4 Assessment of Community Relations Activities

The effectiveness of the Community Relations Activities will be assessed periodically to determine if other outreach methods are necessary. The stakeholder groups will also be reviewed to determine if the target audience needs to be expanded and what methods would be effective to do so.

4.0 Expedited Removal Actions and Interim Response

4.1 Expedited Removal Actions

4.1.1 Implementation of the SCAMP

The SCAMP will be implemented according to the schedule transmitted within U.S. EPA's April 19, 2005 approval.

4.1.2 Targeted Shore Survey.

The targeted shore survey was completed in May and June 2005 per the U.S. EPA approval letter dated May 2, 2005. Initially the survey focused on the following priority areas: areas with known leachate impacts, specifically the entire length of shore beginning at the western edge of the Seep 2 CKD Area and extending through the eastern edge of the Seep 1 CKD Area and the entire length of shore at the West and East CKD Areas; areas with residential properties adjacent to the shore; and portions of the shore containing brown or discolored water just off shore, as identified during the Northwest Michigan Community Health Agency over-flight completed on April 21, 2005.

The measurements collected during the targeted shore survey were collected to provide information for evaluating the boundaries of the areas in the lake and along the shore affected by the discharge of leachate from the CKD leachate release areas. This evaluation will guide necessary ongoing placement of fencing, leachate recovery, warning buoy placement, and the interim leachate recovery system installation. The targeted shore survey was conducted at 25-foot horizontal intervals and on days and at times when leachate dilution from wind, wave and current conditions was least likely to occur.

Specifically, per the U.S. EPA May 2, 2005 approval letter, the targeted shore survey was conducted in the following manner:

- The initial survey points in each area were located using GPS methods. The 25-foot horizontal intervals between sampling points were measured using a hand-held laser range finder or a rigid spacing device.

- At each survey point, the location was recorded using GPS methods. Specific conductance, pH, and temperature of the water at the survey point were measured using a YSI Model 556 MPS Water Quality Monitoring System. The near-shore surface water in the lake was surveyed in water approximately 2 inches deep. If elevated pH (i.e., pH > 9.0) was measured at any location, additional measurements were collected moving out into the lake approximately perpendicular to the shore at horizontal intervals of approximately 5 feet. Measurements continued to be made at approximately 5-foot intervals out into the lake until pH < 9.0 was measured. The specific conductance, pH, and temperature measurements were made as close as possible to the lake bottom at each location. The 5-foot spacing between locations was measured with a rigid spacing device. In addition to moving north at 5-foot intervals, the investigation also moved south, up the beach, to on-shore leachate accumulation zones present on the beach.

- The targeted shore survey included the above measurements for on-shore leachate accumulation zones. A visual survey was conducted at and between each survey point to determine the presence or absence of on-shore leachate accumulation zones. This visual survey extended from the shore/lake water interface to the southern boundary of the beach. When any on-shore leachate accumulation zones were identified, the approximate quantity of the zones was determined. If there were five or fewer on-shore leachate accumulation zones identified at the survey point, the water quality parameters were measured in each zone. If there were more than five on-shore leachate accumulation zones, the water quality parameters were measured in at least five zones, with a bias towards zones appearing most dark brown or otherwise discolored. No fewer than 10% of the total number of on-shore leachate accumulation zones, or 5 zones (whichever was greater) were surveyed at any one survey point. In portions of the shore with relatively few on-shore leachate accumulation zones, a best effort was made to identify and survey each zone. The geographic coordinates were collected at each on-shore leachate accumulation zone surveyed, and a unique identifier was assigned to each zone surveyed so that the zone can be located in future shore survey events.

- The field instrument was maintained and calibrated according to the standard operating procedure for the YSI Model 556 in the QAPP and the instrument was operated according to the manufacturer’s directions.

U.S. EPA is reviewing the results of the targeted shore survey and will determine if any further activities are required pursuant to U.S. EPA’s approval letter dated May 2, 2005.

4.1.3 Over-flights

CMS has retained professional flight services and will conduct over-flights on at least a 14-day interval for the purpose of observing and documenting existing and potential leachate releases. Over-flight photography will be scheduled on days when wind, waves and light conditions are most conducive to good visualization of the shoreline features. All shoreline areas of the Site will be photographed during each flight for comparison with photography from previous over-flights. CMS will provide an over-flight schedule to U.S. EPA, and if U.S. EPA determines that a different over-flight date is appropriate, the over-flight will occur on the date selected by U.S. EPA if the flight services contractor is available. U.S. EPA will attempt to provide 8-hour notice prior to requiring an over-flight. Flights will continue until ice is present in the Lake. Flights will resume each spring when ice is no longer present in the Lake. The schedule for over-flights may be adjusted to accommodate the need to observe the shoreline following potentially significant events, such as heavy rainfall. The frequency of these over-flights may be reduced or terminated at the direction of the U.S. EPA OSC. Copies of all photographs generated during the over-flights shall be provided to U.S. EPA upon completion of the over-flight.

4.1.4 Removal Action Notification

For work within the shoreline of Lake Michigan, a permit is typically required from the State of Michigan and potentially from the U.S. Army Corps of Engineers. The administrative requirements for these permits are not applicable under the provisions of the National Contingency Plan (NCP) for Removal Actions. However, because the work contained in this Work Plan must comply with the substantive requirements of these regulatory authorities, CMS shall consult closely with these authorities during the implementation of the work.

4.1.5 Leachate Recovery

Paragraph 15.v requires that, to the maximum extent practicable as determined by U.S. EPA, all high pH leachate must be recovered from all CKD leachate release areas. Vacuum recovery activities, as described in U.S. EPA's May 2, 2005 letter, will no longer be required at the present time. U.S. EPA reserves the right to require such recovery to resume if it later determines it to be necessary.

4.2 Interim Leachate Recovery System

Subparagraph 15.vii of the AOC requires that CMS design, construct, and begin operating interim recovery systems to address high-pH leachate releases from the CKD areas until long-term engineering controls can be designed, constructed and demonstrated to be effective. CMS will design and install an interim leachate recovery system at each CKD leachate release area. Also, CMS will complete the engineering design of an isolation/containment system (Section 4.2.7). This isolation/containment system design or approved alternative contingency system will be implemented in the event that the interim leachate recovery systems are not effective as described in 4.2.7.

The following sub-sections present a conceptual design for interim recovery at high pH leachate release areas. The interim leachate recovery systems will consist of a collection trench, as described herein (collection trench) for Seep 1 and Seep 2. For the West CKD, East CKD, Pine Ridge Court, and Guard Rail Seep Release Areas, the interim leachate recovery system will consist of a collection trench or, if approved by U.S. EPA, alternative engineering controls as described in Sections 4.2.2.2 and 4.2.2.3 to prevent the release of high pH leachate to lakeshore areas and Lake Michigan.

4.2.1 Description

Collection trenches will consist of polyethylene collection drains (sometimes referred to as beach collection drains or collection drains). The purpose of these recovery systems will be to collect leachate before it reaches lakeshore areas and Lake Michigan.

The collection trenches are expected to be placed approximately parallel with the shoreline and along the southern edge of the beach (see Figure 4-1). The conceptual design is that 6-inch diameter collection drains will be placed in an excavation a minimum of 2 ½ feet deep and completely surrounded by a 6-inch thick layer of gravel so that the top of the drain is approximately 2 feet below the beach surface. The gravel will be extended to the ground surface above the drain. Cover rock will be installed immediately above the gravel layer surrounding the drain (see Figure 4- 2).

The conceptual design for the interim leachate recovery systems includes the installation of pre-cast reinforced concrete lift stations to collect leachate from each collection trench. The conceptual lift station design is shown in Figure 4-3. The lift stations will have (1) all pipe penetrations into the lift station constructed with watertight boots to prevent groundwater seepage from or into the lift station, (2) concrete ballast added to the base to offset buoyancy forces, (3) a flat, pre-cast concrete cover with a stainless steel access hatch capable of being locked, and (4) an approximately 4-inch-diameter vent pipe. The drains will discharge through a system of sliding gate valves into the lift station. Multiple gate valves may be used to control individual segments of each collection drain.

CMS anticipates that the lift stations will be designed as duplex pump stations, sized to meet a wide range of influent flows. The selected pumps will likely be a submersible design. Barr expects that the pump operation will be controlled using four float switches located within each lift station and each lift station will have controls that are independent of the other lift station. The specific design conditions for each lift station pump will be implemented based on the conditions encountered at each leachate release area.

For these systems, a locked, NEMA 4, weather-proof pump-control cabinet will be located adjacent to the lift station and outfitted with a red alarm light to indicate the presence of an alarm condition at the specific lift station. The conceptual collection trench design assumes that either underground force-mains will be installed to convey leachate from the interim recovery system lift stations to the existing pre-treatment facility or another engineering solution will be employed. At this time it is assumed that the proposed force-mains will be constructed of high-density polyethylene (HDPE).

4.2.2 Conceptual Design Basis

Collection trenches will be designed to control the elevation of the surface of the saturated zone to a level below that of the beach surface. The proposed drains will be installed so the bottom of the drain is a minimum of approximately 2 ½ feet below the beach surface, or below the International Great Lakes Datum (IGLD, 1985) low water datum for Lake Michigan (577.5 feet above MSL), whichever is deeper. The shoreline elevation near the drains will be surveyed prior to installation to ensure that the drain elevation is below the design elevation. Placing the drain at this elevation should capture leachate below the elevation of any on-shore leachate accumulation zones. The rate of leachate removal necessary to maintain the surface of the saturated zone at the drain elevation has not been precisely determined, as the hydrogeologic investigations necessary for those estimates have not been completed. Preliminary estimates of flow rates are expected to be on the order of 0.02 gallons/minute/linear foot of drain.

Augmentation at each of the following interim leachate recovery systems will be made to achieve the required leachate recovery (to the maximum extent practicable as determined by U.S. EPA).

4.2.2.1 Seep 1 and Seep 2 Leachate Release Areas

In accordance with this Work Plan and the schedule set forth in Section 4.3, collection trenches placed along the southern edge of the existing beach will be installed as a part of the interim response for the Seep 1 and Seep 2 leachate release areas. The initial collection trenches will be installed to a depth of 2 ½ feet below beach level to intercept high pH leachate before it migrates to lakeshore areas and Lake Michigan. The effectiveness of the collection trenches will be evaluated using the procedure described in Section 4.2.5.

4.2.2.2 West CKD and East CKD Leachate Release Areas

In accordance with this Work Plan and the schedule set forth in Section 4.3, upon completion of the collection trenches for Seep 1 and Seep 2 leachate release areas, collection trenches will be installed along the southern edge of the existing beach in the West CKD and East CKD leachate release areas. The initial collection trench will be installed to an approximate depth of 2 ½ feet below beach level to intercept high pH leachate before it migrates to lakeshore areas and Lake Michigan. The effectiveness of the interim responses will be evaluated using the procedures described in Section 4.2.5.

Based on the construction of the collection trenches for the Seep 1 and Seep 2 leachate release areas and site conditions, CMS may propose alternative engineering controls with equivalent effectiveness, as determined by U.S. EPA, to prevent the release of high pH leachate to lakeshore areas and Lake Michigan. If approved by U.S. EPA, CMS will construct such controls in accordance with the conditions of U.S. EPA approval.

4.2.2.3 Pine Ridge Court and Guard Rail Seep

In accordance with this Work Plan and the schedule set forth in Section 4.3, upon completion of the collection trenches for Seep 1 and Seep 2 leachate release areas, CMS shall propose interim recovery systems for the Pine Ridge Court and Guard Rail Seep leachate release areas to prevent release of high pH leachate to lakeshore areas and Lake Michigan. CMS will construct such controls as approved by U.S. EPA. The effectiveness of the collection trenches will be evaluated using the procedure described in Section 4.2.5.

4.2.3 Installation

The subsurface and geologic conditions will be assessed during the installation of the collection trenches via test-pitting, push-probe, or any other investigative methodology deemed necessary. The objectives of the subsurface geologic assessment will be to preliminarily evaluate geologic conditions (such as fractures) and to further investigate geologic conditions that may require augmentation of the interim leachate recovery systems. If the documented subsurface conditions indicate the need for augmentation of the interim leachate recovery systems, augmentation, such as, but not limited to additional lateral drains and/or recovery wells at or upgradient of the trenches, shall be installed to further facilitate collection of high pH leachate.

Bedrock is expected to be less than 2 feet below the existing ground surface at the seep locations. The collection drains will be placed in trenches installed using a hydraulic excavator with a hoe-ram or equivalent equipment to reach the installation depth of 2 ½ feet below the beach surface or the depth of IGLD low water datum for Lake Michigan (577.5 feet). Trench depth and other design parameters may be augmented based on the subsurface and geologic conditions encountered to enhance recovery of high pH leachate. Any augmentations proposed by CMS are subject to U.S. EPA approval.

Excavated material will be used for backfill to the extent practicable. Material that is not used as backfill will be sampled/characterized and properly disposed of at a licensed off-Site disposal facility, following the procedures defined in the AOC. Graded fill material may be imported to the Site, if necessary, to be used as backfill around the collection drains.

Upon implementation of construction of the trenches, all accumulating leachate shall be recovered immediately. The recovery of leachate accumulating within collection trenches during construction will be accomplished using a pump system. This recovery will be initiated concurrent with construction/trenching activities to ensure that any leachate flowing into the trench will be recovered. During construction, monitoring of this high pH leachate recovery will consist of the monitoring of pH of downgradient on-shore leachate accumulation zones and the downgradient shoreline of Lake Michigan using the same pH monitoring procedures as described in Section 4.2.5. The portions of the shoreline area where leachate recovery is occurring during trench construction shall be evaluated on a weekly basis.

The collection drains installed inside the trenches will be surrounded by backfilled bedrock or gravel. The collection pipes will discharge to lift stations that will be installed as a component of the leachate recovery systems. The force-mains will be buried at least 4 feet below the existing ground surface to prevent freezing. When bedrock is encountered at depth shallower than 4 feet, the force-main may be buried at least 3 feet below the existing ground surface and insulated.

4.2.4 Conceptual Recovery System Operation Plan

The rate of discharge from the collection drains will be controlled by the sliding gate valves and the elevation of Lake Michigan. The elevation of the gates will be set based on the elevation of Lake Michigan and will be adjusted, if necessary, to maintain a leachate elevation in the drain equal to or lower than Lake Michigan. The elevation of the gates will be adjusted, as necessary, with the objective of achieving the performance standard of pH below 9.0 in surface water, including Lake Michigan. Leachate entering the drain and flowing over the gates will enter the lift stations and will be pumped to the on-Site pre-treatment building.

It is anticipated that the lift station pumps will operate automatically based on the level of leachate entering the lift station from the beach collection drains. The pumps will be operated at a rate necessary to control releases of all high pH leachate into areas of the leachate release zones along the Lake Michigan shore. The lift station float switches will be set so that a sufficient inward gradient to the collection drain is induced and the releases are controlled. The float switches will be set at the highest elevations where this objective is met. This approach provides the necessary control at the leachate release area using the lowest practical pumping rate. Emergency shut-off controls will be used to shut off the system, if it fails to operate properly, and provide an alarm to the pre-treatment system operator.

The operation of the interim recovery will be monitored by collecting data for the following parameters:

- Leachate volume (daily)
- pH of the collected leachate (daily, composite of all collected leachate)
- Lake Michigan water elevations (daily)

4.2.4.1 Management of Recovered Leachate

The recovered CKD leachate will be treated on-Site or arrangements will be made for off-Site treatment, storage, and disposal. All storage and transportation and disposal of recovered leachate wastes will be conducted in accordance with all applicable law and regulation and U.S. EPA policy and guidance regarding such discharge and disposal. In addition, prior to any off-Site disposal at a publicly owned treatment works (POTW), or elsewhere, CMS will demonstrate, in writing to U.S. EPA, compliance with all applicable laws and regulations and U.S. EPA policy and guidance regarding such discharge and disposal.

4.2.5 Monitoring

Paragraph 15.viii of the AOC requires that CMS confirm the effectiveness of the interim recovery systems and develop and implement a monitoring program that measures releases of high pH leachate and hazardous substances which may continue to be released to surface waters.

4.2.5.1 Effectiveness Monitoring

The following effectiveness monitoring plan will be implemented to evaluate the effects of the interim leachate recovery systems on high pH leachate releases to lakeshore areas and Lake Michigan. The schedule for the effectiveness monitoring plan is described in Section 4.3. The effectiveness of the interim leachate recovery systems will be evaluated at each CKD leachate release area as follows:

- **Documentation of reduction in number and volume of on-shore leachate accumulation zone number and volume:** Daily, a qualified person will walk the beach along the interim leachate recovery systems to conduct a visual inspection and document the reduction in on-shore leachate accumulation zones until the effectiveness of the systems can be assessed. The visual inspection frequency will be adjusted when warranted, if and as approved by U.S. EPA. If any on-shore leachate accumulation zones are identified, a pH measurement will be taken using the protocols that are described for pH measurement contained in the project QAPP (Barr, 2005b).

- **Monitoring of surface water and leachate release areas along the down-gradient shore in each leachate release area:** Survey crews will monitor the pH and conductivity of near shore surface waters using the following procedures:

    - The initial survey points in each area will be located using GPS methods. The 25-foot horizontal intervals between sampling points will be measured using a hand-held laser range finder or a rigid spacing device.

  - At each survey point, the location will be recorded using GPS methods. The pH and specific conductivity of the water at the survey point will be measured using a YSI Model 556 MPS Water Quality Monitoring System or instrument with equivalent capability. The near-shore surface water in the lake will be surveyed in water approximately 2 inches deep. If elevated pH (i.e., pH > 9.0) is measured at any location, additional measurements will be collected moving out into the lake approximately perpendicular to the shore at horizontal intervals of approximately 5 feet. Measurements will be continued to be made at approximately 5-foot intervals out into the lake and as close to the lake bottom as possible until pH < 9.0 is measured. The 5-foot spacing between locations will be measured with a rigid spacing device.

  - The survey will include the above measurements for all on-shore leachate accumulation zones. A visual survey will be conducted at and between each survey point to determine the presence or absence of on-shore leachate accumulation zones. This visual survey will extend from the shore/lake water interface to the collection trench. The geographic coordinates will be collected at each on-shore leachate accumulation zone surveyed, and a unique identifier will be assigned to each zone surveyed so that the zone can be located in future shore survey events.

  - The field instrument will be maintained and calibrated according to the standard operating procedure for the YSI Model 556 in the QAPP and the instrument will be operated according to the manufacturer's directions.

- Aerial over-flights of the leachate release areas shall be conducted to evaluate visual indicators of the continued release of high pH leachate and other hazardous substances which may continue to be released to Lake Michigan as provided in Section 4.1.3.

If the results of the effectiveness monitoring indicate an ongoing release of high pH leachate which results in a measurable pH above 9.0 in Lake Michigan, then CMS shall implement the Interim Leachate Recovery System Contingency Plan in accordance with Section 4.2.7.

All work shall be conducted in accordance with the approved Project Health and Safety Plan.

4.2.5.2 Monitoring Program

In addition to the effectiveness monitoring activities described above, a monitoring and sampling program designed to evaluate releases of high pH leachate and hazardous substances that may continue to be released to surface waters shall be implemented. The sampling and monitoring activities conducted in this program are intended to provide additional data regarding concentrations of hazardous substances and shall not be utilized to evaluate the performance of the collection trenches for purposes of compliance with the AOC or the need to augment the systems. This monitoring and sampling program shall be implemented at the same frequency as the effectiveness monitoring program. The elements of this monitoring and sampling program are presented below.

Surface Water: Surface water sampling shall be conducted at each interim leachate recovery system. A minimum of three surface water samples will be collected during each sampling and monitoring event from downgradient of each leachate release area to measure for high pH leachate and other hazardous substances which may continue to be released to Lake Michigan. For sampling purposes, the length of each leachate release area will be divided into three equal sectors. One surface water sample will then be collected from each sector at the location of the highest pH monitoring point, as determined during the effectiveness shore survey described above. If any on-shore leachate is encountered, a minimum of one sample will be collected from the location exhibiting the highest field-measured pH value.

The sampling procedures established within Section 5.2.6.2 for surface water sampling shall be utilized and these samples will be analyzed for the parameters listed in Table 5-1A, including low level mercury analysis.

Groundwater: A minimum of three downgradient monitoring well nests will be installed along the length of each interim recovery system collection drain to measure for high pH leachate and other hazardous substances which may continue to be released to Lake Michigan.

The nested groundwater monitoring wells shall be installed and sampled using the vertical aquifer profiling, monitoring well installation, and groundwater sampling procedures established within Section 5.2.6.2. Groundwater samples from these wells will be collected during each sampling and monitoring event. The groundwater samples will be analyzed for the parameters listed in Table 5-1A, including low level mercury analysis.

The results of the effectiveness monitoring plan and hazardous substance/pH sampling will be provided to the U.S. EPA as part of progress reporting.

4.2.5.3 Pre-Treatment Plant Monitoring

In addition, a qualified person will monitor the performance of the pre-treatment system on a daily basis. The pre-treatment system is equipped with a continuous pH monitor, and system performance sensors that, in the event of a failure to operate properly, activate a telephone dialer system to alert the pre-treatment system operator. The lift station pumps associated with the interim leachate collection system will be connected to an alarm system that will be activated in case of pump failure, and which will turn off the beach collection system lift station pumps.

4.2.6 Operation and Maintenance Plan

The AOC requires that CMS perform operation and maintenance of the interim leachate recovery systems until such time as long-term engineering controls can be designed and constructed and demonstrated to be effective to prevent CKD leachate releases to lakeshore areas and surface waters. Following demonstration of the effectiveness of the interim leachate recovery systems, an interim recovery system operation and maintenance plan will be prepared and submitted to the U.S. EPA for review and approval.

4.2.7 Interim Recovery System Contingency Plan

In the event that portions of the interim leachate recovery systems are ineffective, as determined by U.S. EPA, in preventing releases of high pH leachate to Lake Michigan, then leachate isolation/containment systems designed pursuant to Section 4.2.7.1 shall be installed in those portions of a leachate release area where U.S. EPA has determined the interim recovery system to be inadequate and maintained until the interim recovery system has been appropriately augmented. For the purposes of this section, leachate release areas shall include the first 10 feet of Lake Michigan where high pH leachate has accumulated. The effectiveness of the interim recovery systems shall be based on whether there continues to be an ongoing release of high pH leachate which results in a measurable pH above 9.0 in Lake Michigan as determined by the results of the effectiveness monitoring plan (Section 4.2.5).

In establishing the schedule for implementation, U.S. EPA will consider any proposal by CMS to augment an interim leachate recovery system. U.S. EPA may defer implementation of the isolation/containment system(s) if it determines that the proposed augmented systems will be effective and timely in preventing the release of high pH leachate to Lake Michigan. Any such proposal for augmentation shall be implemented in accordance with schedule approved by U.S. EPA.

U.S. EPA will consider the experience of isolation/containment at areas where it is initially implemented when it directs and schedules implementation of containment at subsequent areas.

In the event that the on-site pretreatment system is overloaded due to excessive volume or unable to operate, the leachate in excess of the capacity of the pretreatment system will be trucked directly to a facility for treatment and disposal in accordance with Section 4.2.4.1. Trucking will be done by a firm licensed to carry these materials and the trucks will be placarded and carry proper manifests in accordance with Michigan Department of Transportation regulations.

In the event that there is a failure of the interim leachate collection system or force main, vacuum trucks and/or pumps will be employed to manually collect all high pH leachate and transport it to either the on-site pretreatment system or to an off-site treatment and disposal facility. These vacuum trucks and/or pumps may be deployed to the locations of the collection trenches if the upstream infrastructure (force mains, pumps, piping) is not operational.

In addition to the design of the isolation/containment system set forth in Section 4.2.7.1, CMS has the option of also designing an alternative contingency system which is equally effective in containing and isolating release of high pH leachate to Lake Michigan as the design provided in Section 4.2.7.1. The design for an alternative contingency system shall be submitted to U.S. EPA for approval no later than the time for submittal of the design for the isolation/containment system set forth in Section 4.2.7.1. In the event that U.S.EPA approves the alternative contingency system, this system shall be installed in lieu of the system set forth in Section 4.2.7.1 in accordance with the schedule approved by U.S. EPA.

4.2.7.1 Leachate Isolation and Containment

Concurrent with the installation of the interim leachate recovery system, an isolation/containment system will be designed to isolate the shoreline releases of high pH leachate, minimizing its contact with Lake Michigan surface water, and to contain the high pH leachate. This isolation/containment system will be designed for potential use at each CKD leachate release area (West CKD Area, Pine Ridge Court, Guard Rail Seep, Seep 2, Seep 1, and East Park) in the event the interim leachate recovery system is not effective. Upon completion of the isolation/containment system design, U.S. EPA shall approve the design. If necessary, to ensure the effectiveness of the isolation/containment systems, U.S. EPA may modify the design prior to approval. This isolation/containment system shall be deployed only at the portions of the lakeshore where the U.S. EPA has determined that the interim leachate recovery is ineffective as provided in Section 4.2.7.

The isolation/containment system shall be designed to be placed approximately 10-feet into Lake Michigan to effectively isolate/contain the near-shore leachate release points. The system will be designed so that the shore side water level will be controlled by pump systems so that the level does not spill over the top of the isolation systems. If necessary to prevent spillover, the design will include portable pipe/hose systems to deliver potential spillover water to existing lift stations for transport to the pre-treatment system or directly to over-the-road waste hauling tanker trucks for off-Site disposal. The design will provide that spillover water containing high pH leachate will be collected and managed in accordance with all applicable laws, regulations, and U.S. EPA policy and guidance. The leachate isolation/containment system(s) shall be maintained until the liquid within the containment system has a pH <9.0 or until U.S. EPA otherwise determines that the containment system(s) are unnecessary in light of current Site conditions.

4.3 Schedule

Seep 1 and Seep 2 Interim Leachate Recovery Systems: Construction of recovery infrastructure (force mains, lift stations, trenches, piping, etc) shall begin no later than 14 calendar days from this approval. Construction of collection trenches shall begin no later than 20 days from this approval for Seep 1 and no later than 30 days after this approval for Seep 2. The construction of the interim leachate recovery systems (Seep 1 and 2) shall be completed within 60 days of the initiation of construction.

West CKD and East CKD Interim Leachate Recovery Systems: Construction will begin no later than 14 days after completion of the Seep 1 and Seep 2 interim leachate recovery systems and will proceed along the same schedule as set forth above unless modified by U.S.

EPA. In the event U.S. EPA approves alternative engineering controls, CMS shall construct such controls in accordance with the schedule approved by U.S. EPA.

Pine Ridge Court and Guard Rail Seep Interim Leachate Recovery Systems: Within 30 days from completion of the interim leachate recovery systems for the Seep 1 and Seep 2 leachate release areas, CMS shall propose interim leachate recovery systems for the Pine Ridge Court and the Guard Rail Seep leachate release areas. CMS shall construct such interim recovery systems in accordance with the schedule approved by U.S. EPA.

Monitoring: During construction of the collection trenches, lakeshore pH monitoring pursuant to Section 4.2.3 shall be conducted on a weekly bases during the period of leachate recovery.

Effectiveness monitoring pursuant to Section 4.2.5.1 shall begin within five days of startup of each interim leachate recovery system. Effectiveness monitoring of the interim leachate recovery systems shall be conducted on a bi-weekly basis for the first month of operation and on a monthly basis thereafter.

CMS may request that U.S. EPA approve any alterations to the long-term effectiveness monitoring schedule in the event that data show stable and effective high pH leachate recovery through the operation of the interim leachate recovery systems.

The monitoring program conducted pursuant to Section 4.2.5.2 shall begin upon approval of the Section 5 Work Plan in accordance with the same schedule set forth above for effectiveness monitoring.

Isolation and Containment System Design and Interim Recovery System Contingency Plan Implementation: CMS shall complete and submit to U.S. EPA the design for the leachate isolation/containment system provided for in Section 4.2.7.1 and any alternative contingency system no later than 60 days from this approval. Implementation of the leachate isolation/containment system or an approved alternative contingency system shall be in accordance with the schedule approved by U.S. EPA.

At each interim leachate recovery system, effectiveness monitoring pursuant to Section 4.2.5.1 shall be conducted for a period of at least 4 weeks following the completion of trench installation and system startup to evaluate the effectiveness of the interim leachate recovery system. If, following this period of effectiveness monitoring, U.S. EPA determines that the interim leachate recovery system, in whole or in part, is ineffective in preventing the release of high pH leachate to Lake Michigan, then the interim recovery system contingency plan shall be implemented. Installation of the required isolation/containment system shall be completed within the schedule set by U.S. EPA in accordance with Section 4.2.7.

5.0 RA Investigation Activities ("Data Acquisition")

The RA Investigation activities described in this section will generate the data necessary to: complete the Site characterization and evaluate long-term remedial alternatives for addressing current and potential threats to public health, welfare and the environment from CKD waste material. The Site characterization objective of this RA Investigation is to:

> "*Evaluate all other areas along the lakeshore of the Site with pathways for releases to surface waters, including Lake Michigan, with the objective of identifying additional CKD leachate release areas which may not have been identified; but may be causing a threat of direct contact or threat of release of high pH releases to surface water, including Lake Michigan."*
>
> and
>
> *"Investigate the nature and extent of hazardous substances, pollutants or contaminants at the Site to determine the nature and extent of current and potential threats to public health, welfare or the environment from CKD Waste Material…."* (AOC, 2005)

The RA Investigation activities will focus on data collection via intrusive methods (e.g., drilling), down-hole geophysical methods, aquifer testing, and sampling and analysis. The selection of RA Investigation methods and drilling/sampling locations was based on the preliminary Site conceptual model presented in Sections 1.3.1 and 1.3.2 and the following data gaps identified by CMS and its consultant:

Geology Data Gaps

- **Detailed Bedrock Surface Topography and Bedrock Features –** Surficial mapping and observations at the Site, historical documents, and geophysical investigation activities have provided preliminary data which indicate: (1) likely presence of local bedrock depressions and possible fracture zones and (2) groundwater flow may be focused along bedding planes and/or through fractured zones in the bedrock at the Site.

  Delineation of the bedrock surface topography, and thus the thickness and position of CKD-containing deposits, is needed to assess the quantity and distribution of CKD below the water table, if present. Evaluation of bedrock features such as weathering, fractures, bedding, and solution enhancement is important for developing an accurate understanding of the groundwater flow system at the Site.

- **Distribution of Native Unconsolidated Soil Overlying Bedrock –** Mapping the distribution of native unconsolidated soil will serve to define the extent of CKD fill at the Site and provide information regarding groundwater flow above the bedrock.
- **Distribution of CKD** – The lateral extent of CKD can be generally inferred from geophysical data, Site topography, and historical records. However, the specific horizontal and vertical boundaries of the CKD material must be defined to evaluate and, ultimately, select the long-term remedial alternatives for the Site.

Hydrogeology Data Gaps

- **Hydraulic Characteristics of Bedrock, Unconsolidated Soil, and CKD –** Specific measurements characterizing seep and groundwater flow mechanisms, velocities, and volumes have not been made. In order to develop an accurate understanding of groundwater flow and distribution, the hydrogeologic characteristics of each relevant subsurface unit present at the Site should be measured.
- **Groundwater Flow Direction, Identification of Perched Groundwater Zones, and Hydraulic Gradients (horizontal and vertical)** – Detailed information regarding perched groundwater location(s) and hydraulic gradients is required to quantify groundwater flow directions, mechanisms and distribution of groundwater impacts.
- **Locations and Characteristics of Preferential Flow Zones, if any –** The Site is in a region with known karst features, the lineament analysis indicated a potential linear feature crossing through the Seep 1 CKD Area, and geophysical anomalies were identified during the development of this Work Plan that could represent large-scale geologic features. Each of these observations suggests that preferential flow zones are possible. Such preferential flow paths, if they exist, could significantly impact groundwater flow at the Site. Identifying and characterizing these zones will be important to understanding their influence on groundwater flow and direction.
- **Quantification of Groundwater and Surface Water Flow -** The data described will be used to develop a numerical mathematical model of the groundwater flow system at the Site. This model will be used to assess the effectiveness of potential long-term remedial alternatives for the Site. Development of this model will rely on the geologic and hydrogeologic data described above and surface water balance inputs (e.g., precipitation, irrigation, run-on, transpiration, and run-off).

Water Quality Data Gaps

- **Groundwater Quality/Geochemistry** – Groundwater samples were collected at the Site between 1995 and 1996 from a limited number of wells (Table 2-1) (NTH, 1995). No groundwater samples have been collected or analyzed since that time. Water quality data, including geochemistry data and groundwater flow data, are needed to evaluate long-term remedial alternatives for the Site. Information for evaluating the groundwater or soil buffer capacity, potential mobilization of metals, or scaling/plugging that might occur in treatment system equipment.

5.1 Mobilization and Demobilization

5.1.1 Field Support, Equipment, Supplies, Facilities

The investigation program described in this RA Work Plan will include up to 4 drill rigs operating at the Site at any given time, plus the potential for 2 additional crews conducting down-hole geophysical testing and aquifer testing.

During drilling activities, an experienced Barr geologist will be present at each drilling location to provide oversight and conduct geologic logging. An experienced environmental technician or geologist will also be present at each drilling location during geophysical logging and aquifer testing.

In addition to the Barr staff collecting data at each of the drilling or geophysical/aquifer testing locations, Barr will have a dedicated field superintendent for the project. The field superintendent will be responsible for leading and coordinating the day-to-day field activities and resources (including Barr staff and subcontractors) and will coordinate the collection and transfer of Site data on a daily basis. It is anticipated that either the field superintendent and/or project manager will be at the Site during all Site drilling activities.

Barr will mobilize the majority of the testing and analytical equipment used by on-Site staff (e.g., pH/conductivity meters, pressure transducers, data loggers, cell phones) from in-house equipment supplies. Pumps used for aquifer testing will be supplied by the drilling subcontractor. The down-hole geophysical logging equipment will be supplied by the geophysics subcontractor. Drilling-related supplies will be mobilized to the Site by the drilling subcontractor.

The drilling contractor will operate a secured lay-down area for the storage and staging of equipment and supplies, and for the temporary storage of investigation-derived waste (IDW) prior to removal from the Site. It is anticipated that the secured lay-down area will be at the East CKD Area.

Barr will operate a Project Field Office located at the secured East CKD Area. The Project Field Office will be supplied with working office space and with telecommunications equipment (telephone, fax, and high-speed internet).

Prior to the start of drilling, a utility clearance will be conducted. Public utilities will be cleared using the MISS DIG system, the State of Michigan one-call system. Private utilities in the Investigation areas include golf course sprinkler piping and wiring. Barr understands that the golf course sprinkler pipes are made of plastic. The sprinklers are reportedly connected to a timer via wires that follow the sprinkler water pipes. An attempt to identify the paths of the water pipes will be made, either by having a private utility locator place an electric signal on each of the wires coming from the timer and then tracing the signal, or by other methods available to the utility locator. For boring locations in the vicinity of utility corridors (i.e. within 20 feet of roadways), soil vacuum utility locating techniques will be attempted to locate those utilities. If site conditions preclude the use of the soil vacuum techniques, a hand-auger or hand-probe will be used to supplement the MISS DIG locating system.

Care will be taken to minimize surface disturbance during the drilling program. Precautions will include setting aside sections of turf at sampling locations that will be replaced upon completion of work at that location, containerizing any drilling cuttings or purge water, and, if needed placing mats, timbers, planks, or other materials to minimize disturbance to the ground surface by the drilling equipment. Site restoration will be done upon completion of the drilling activities.

5.2 Field Investigation

Field investigation activities will be performed according to the standard procedures presented in the QAPP (Barr, 2005b), as approved by U.S. EPA. The Investigation will adhere to the requirements of Barr's Quality Management Plan (QMP) (Barr, 2003). Down-hole tools will be decontaminated between holes according to the procedures described in the QAPP (Barr, 2005b). Decontamination fluids will be containerized and managed as Investigation Derived Waste (IDW) as discussed in Section 5.2.9.

Samples will be described in the field by a qualified geologist or geological engineer. Non-CKD unconsolidated materials will be described according to ASTM D2488, and CKD will be described according to the standard procedure described in the QAPP (Barr, 2005b).

5.2.1 Topographical Surveys

Aerial photogrammetric methods have been used to obtain a topographic map of the Site and sufficient area around the Site to facilitate investigation of potential Site impacts and design of potential remedies. The mapping was completed in accordance with national map standards and shows spot elevations and surface elevation contours, buildings, roads, vegetation area limits, water bodies, and other significant Site features visible from aerial photography. Mapping was completed based on the state plane coordinate system (NAD 83) and mean sea level (MSL) vertical datum (NAVD 88) at a scale suitable for the intended uses. The survey was flown on April 5, 2005, while the control survey was completed in the fall of 2004. The RA Work Plan figures have been revised to include the more recent aerial imagery and topographic contours.

Boring, water sampling, and water measurement locations will be surveyed using a Trimble Pro-XRS backpack GPS system. This is a mapping-grade GPS receiver capable of sub-one meter accuracy. Ground surface elevations and top-of-well-casing elevations will be surveyed using traditional rod and level survey methods.

Ground surface and groundwater level measuring-point elevations for each boring will be surveyed relative to a government-established vertical control monument (e.g. USGS, Michigan DOT). If an established benchmark cannot be identified near the Site, a permanent benchmark will be set. The ground surface elevation at each boring location will be surveyed to the nearest 0.1 foot, and the groundwater elevation measuring point will be surveyed to the nearest 0.01 foot. After wells are installed, the ground surface and top-of-casing elevations will be surveyed relative to the Site benchmark to the closest 0.1 foot and 0.01 foot, respectively. For all Site wells, the groundwater elevation measuring point will be the top of casing on the north side of the well.

5.2.2 Water Temperature Mapping of Seeps and Shoreline

During certain times of the year, groundwater may be warmer than surface water into which it discharges. This may be particularly true in the early spring just after ice-out, when surface water is still very cold. Water temperature mapping may be able to identify preferred subsurface water discharge zones. Depending on conditions in the surface water body, the discharging groundwater may mix rapidly with the surface water which may, in return, reduce the chances of identifying or detecting preferred zones of groundwater discharge.

5.2.2.1 Aerial Survey

An aerial thermometry survey was performed in an attempt to identify any preferred zones of subsurface water discharge to Lake Michigan. This aerial survey included infrared and visual imagery of the near shore lake areas in the vicinity of the Site (including the Seep 1 Area, Seep 2 Area, West CKD Area, and East CKD Area). Flying the survey immediately after ice-out in the spring provides the best opportunity to obtain useful information from the survey. The later in the spring the survey is flown, the less likely that useful information on any preferred subsurface water discharge zones will be obtained. The contractor who completed the survey, ArgonST, flew the survey at night to minimize potential reflected heat interferences from the limestone outcrops and cobble beaches that may mask any groundwater discharge related temperature differences.

This aerial survey was intended to provide additional information on the subsurface water and surface water interaction in the vicinity of the CKD disposal areas. The presence or absence of preferred subsurface water discharge zones could affect the design of the ultimate long-term remedial alternatives implemented at the CKD disposal areas. This survey did not prove to be very useful in detecting the presence of groundwater flow into Lake Michigan. A copy of the survey results is included in Appendix A. A report will be prepared and submitted to U.S. EPA by September 1, 2005 discussing CMS' and its consultant's interpretation of the aerial thermometry survey results. Included within this report CMS shall provide discussion of the reasons why the aerial thermometry survey was not effective. Based on U.S. EPA's review of this report, additional thermometry may be required to identify potential preferred subsurface water discharge zones.

5.2.2.2 Manual Mapping

Direct measurement of near-shore lake water temperature was conducted as part of the targeted shoreline survey approved by the U.S. EPA in a letter dated May 2, 2005. These data are included in Appendix A. A YSI Model 556 MPS Water Quality Monitoring System was used for the measurements. Manual mapping of near-shore lake water temperature will be conducted during the additional lakeshore survey events (Section 5.2.6.2). Additional monitoring events shall be conducted in September and November 2005 and April and June 2006. At each monitoring location, the temperature measurement will be plotted in conjunction with the geographic coordinates to generate ArcView Shapefiles illustrating the near-shore lake water's temperature gradients.

5.2.3 Extent and Characterization of CKD Piles

Borings will be used to characterize the unconsolidated material, including CKD. Borings to characterize the unconsolidated material and confirm the elevation of the bedrock surface will be advanced using direct-push drilling methods with continuous sampling. In the event that direct-push drilling is not feasible due to subsurface obstructions above the bedrock surface, the borings will be advanced using rotary (i.e., hollow-stem auger or tricone bit) or rotasonic drilling methods.

Borings will be designated with a number using the following format: BX0yy. In this numbering scheme, B indicates that it is a boring; X will identify the area as follows: 1=Seep 1 CKD Area, 2=Seep 2 CKD Area, 3=West CKD Area, and 4=East CKD Area; and yy refers to sequential borehole number in each investigation area.

5.2.3.1 West CKD Area

The 20 boring locations proposed for the West CKD Area are shown on Figure 5-4. Borings B3001 through B3011 will be advanced to the top of bedrock using direct-push drilling methods. In general, the objectives of borings B3001 through B3011 are to determine the nature and thickness of unconsolidated materials above the bedrock, to confirm the elevation of the bedrock surface, and to determine the moisture content in the unconsolidated materials. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-6. Anticipated depths of each boring are shown in Table 5-7.

5.2.3.2 Seep 2 CKD Area

The 52 boring locations proposed for the Seep 2 CKD Area are shown on Figure 5-3. Borings B2001 through B2017 will be advanced to the top of bedrock using direct-push drilling methods. In general, the objectives of borings B2001 through B2017 are to determine the nature and thickness of unconsolidated materials above the bedrock, confirm the elevation of the bedrock surface, and determine the moisture content in the unconsolidated materials. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-4. Anticipated depths of each boring are shown in Table 5-5.

5.2.3.3 Seep 1 CKD Area

Borings are planned for the Seep 1 CKD Area at 33 locations as shown on Figure 5-2. In general, the objectives of borings B1001 through B1012 are to determine the nature and thickness of unconsolidated materials above the bedrock, confirm the elevation of the bedrock surface, and determine the moisture content in the unconsolidated media. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-2.

Borings B1001 through B1012 will be advanced to the top of bedrock using direct-push drilling methods. The depth to bedrock at each boring location has been estimated using the surface elevations in the Seep 1 CKD Area and the top elevation of competent bedrock interpreted from the results of the geophysical surveys. Depths of borings B1001 through B1012 (i.e., the estimated depth to bedrock at each planned location) are shown in Table 5-3.

5.2.3.4 East CKD Area

The 23 boring locations in the East CKD Area are shown on Figure 5-5. Borings B4001 through B4015 will be advanced to the top of bedrock using direct-push drilling methods. In general, the objectives of borings B4001 through B4015 are to determine the nature and thickness of unconsolidated materials above the bedrock, confirm the elevation of the bedrock surface, and determine the moisture content in the unconsolidated media. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-8. Anticipated depths of each boring are shown in Table 5-9.

5.2.4 Hydrogeological Investigations

Borings and monitoring wells will be installed at selected locations to obtain information on groundwater elevations. In order to evaluate vertical as well as horizontal hydraulic gradients and potential vertical differences in water geochemistry, monitoring well nests will be installed. It is anticipated that each well nest will consist of a water table well and up to three deeper wells. In general, monitoring well nests in each CKD disposal area will be located upgradient of the CKD, within the footprint of the CKD, and downgradient of the CKD. Screened intervals for each monitoring well nest will be determined, based on the results of the vertical profiling, as follows:

1. One screened interval will be placed at a depth to transect the water table.

2. One screened interval will be placed at a depth where the pH is <9.0. It is possible that a pH<9.0 cannot be attained in wells installed in the CKD piles and downgradient of the piles. In this event, consultation with a U.S. EPA geologist will be conducted to select the screened interval.

3. One screened interval will be placed at a depth where the highest pH is recorded based upon the vertical aquifer sampling.

4. The two additional screened intervals will be placed within zones exhibiting pH > 9.0. The screened intervals will be placed at depths to screen the two intervals within the borehole exhibiting the highest groundwater yields.

5. In the event that during the vertical aquifer sampling, pH readings are < 9.0, then one screened interval will be placed at the water table, one screened interval will be placed at the depth where the highest pH is recorded, and the remaining two screened intervals will be placed in the zones exhibiting the two highest groundwater yields.

If screened intervals cannot be selected based upon the criteria described above, consultation with a U.S. EPA geologist will be necessary to select the screened intervals for the monitoring well nest.

These permanent monitoring wells will be the only mechanism used to collect groundwater samples for low level mercury analysis. Upon receiving analytical data that exceeds the GSI criteria for mercury (1.3 ng/L) or the established background concentration for mercury in groundwater at the Site, additional monitoring wells will be proposed for installation to the U.S. EPA and the MDEQ in an effort to vertically and horizontally define the extent of mercury in the groundwater. The low level mercury sampling methods and approach to monitoring the GSI will be consistent with the MDEQ RRD Operational Memorandum No. 2, specifically Attachment 7 Low Level Mercury Sampling Specifications.

The monitoring wells will be installed in boreholes and bedrock corings drilled using either rotary (i.e., hollow-stem auger or tricone bit) or rotasonic methods, depending on their location and depth.

If the water table is in the unconsolidated material, the water table well will be constructed of 2-inch-diameter PVC riser pipe and a 2-inch-diameter PVC screen (no. 10 slot or other appropriate slot size). The deeper wells will be completed with 2-inch-diameter PVC riser pipe and either open-hole construction or 2-inch-diameter PVC screen (no. 10 slot or other appropriate slot size) depending on the conditions encountered during drilling of nearby borings. Stainless-steel well materials will be used if it is determined that PVC materials are not structurally adequate for deep wells. All wellheads will be completed as flush mounts.

In order to obtain representative groundwater hydrologic information and water quality samples, monitoring wells (both new and existing wells) will be developed prior to analytical sampling. Wells will be developed via bailing or pumping and surging techniques according to the applicable procedures contained in Appendix E. Appendix E contains Barr Standard Operating Procedures for Developing Monitoring Wells and associated references. Monitoring wells will be developed to remove sediment and establish hydraulic connection to the aquifer. A minimum of three well volumes will be removed from the well. If it is determined that any drilling fluids have been lost during the drilling process, an additional volume of water equal to three times the amount of fluid lost will also be removed from the well. After removing the third well volume, readings for pH, temperature, specific conductance, and turbidity will be recorded. Well development will continue until these readings stabilize for two consecutive well volumes (±0.1 units for pH, ±10 percent for specific conductance, ± 1EC for temperature, and ±10 percent for turbidity).

Borings will be designated with a number using the following format: BX0yy. In this numbering scheme, B indicates that it is a boring; X will identify the area as follows: 1=Seep 1 CKD Area, 2=Seep 2 CKD Area, 3=West CKD Area, and 4=East CKD Area; and yy refers to sequential borehole number in each investigation area.

New monitoring wells will be designated as follows: WX1yy for water table wells, WX2yy for wells monitoring the first bedrock flow zone below the open interval of the adjacent water table well, WX3yy for wells monitoring the next deepest bedrock flow zone at the each location, and WX4yy for wells monitoring a third (and the deepest) bedrock flow zone at each location. In this numbering scheme, W indicates that it is a monitoring well and X will identify the area as follows: 1=Seep 1 CKD Area, 2=Seep 2 CKD Area, 3=West CKD Area, and 4=East CKD Area. In the well identifiers, yy refers to the sequential location number for each CKD area. For example, wells in the first well nest in the Seep 1 CKD Area will have the following numbers: W1101, W1201, W1301, and W1401.

5.2.4.1 Unconsolidated Materials

West CKD Area

The 20 boring locations in the West CKD Area are shown on Figure 5-4. Borings B3001 through B3011 will be advanced to the top of bedrock using direct-push drilling methods. Borings B3012 through B3020 will be advanced into the bedrock using rotasonic drilling methods. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-6. Anticipated depths of each boring are shown in Table 5-7.

In addition, during the expedited shoreline survey conducted in May and June 2005, a 220 foot wide area with elevated pH readings east of the West-unnamed creek was identified. The specific conductivity readings observed in this area were lower than the readings observed directly off-shore of the West CKD Area. However, these readings appear to be within the similar range of specific conductivity readings observed off-shore from the East CKD Area. CMS will either conduct intrusive investigative activities (in both unconsolidated materials and bedrock), as set forth in this section, along the shoreline and upgradient of this 220 foot wide area east of the West unnamed creek, or will provide the U.S. EPA with additional data to demonstrate that the elevated pH readings observed during the targeted shoreline survey are not associated with CKD leachate.

Monitoring wells are planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B3014 and B3015. Preliminary locations for downgradient well nests include the locations of borings B3016, B3018, and B3019. The results of the geophysical surveys and the preliminary conceptual model for the West CKD Area suggest that these locations are appropriate for monitoring CKD leachate beneath and downgradient of the CKD. It is anticipated that a water table well will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling and borehole logging/testing activities described above. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Seep 2 CKD Area

The 52 boring locations in the Seep 2 CKD Area are shown on Figure 5-3. Borings B2001 through B2017 will be advanced to the top of bedrock using direct-push drilling methods. Borings B2018 through B2052 will be advanced using rotasonic drilling methods. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-4.

Monitoring wells are also planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B2019, B2020, and B2025. Preliminary locations for downgradient well nests include the locations of borings B2030, B2035, B2038, B2041, B2047, and B2050. It is anticipated that a water table well that is open at or near the bedrock surface will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling and borehole logging/testing activities described above. In addition, water table monitoring wells will be installed at B2045, B2046, B2048, B2049, B2051, and B2052. The results of the geophysical surveys and the preliminary conceptual model for the Seep 2 CKD Area suggest that these locations are appropriate for monitoring leachate within the CKD footprint and downgradient of the CKD. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Seep 1 CKD Area

Borings are planned for the Seep 1 CKD Area at 33 locations as shown on Figure 5-2. Borings B1001 through B1012 will be advanced to the top of bedrock using direct-push drilling methods. Borings B1013 through B1033 will be advanced into the bedrock using rotasonic drilling methods. Depths of borings B1001 through B1033 (i.e., the estimated depth to bedrock at each planned location) are shown in Table 5-3. The rationale for the installation of each boring and the approximate coordinates are summarized in Table 5-2.

Monitoring wells are also planned within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B1021, B1022, B1024, and B1016. Preliminary locations for downgradient well nests include the locations of borings B1013, B1014, B1031, and B1032. The results of the geophysical surveys and the preliminary conceptual model for the Seep 1 CKD Area suggest that these locations are appropriate for monitoring CKD leachate within the footprint of the CKD and downgradient of the CKD. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

East CKD Area

The 23 boring locations in the East CKD Area are shown on Figure 5-5. Borings B4001 through B4015 will be advanced to the top of bedrock using direct-push drilling methods. Borings B4016 through B4023 will be advanced into the bedrock using rotasonic drilling methods. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-8. Anticipated depths of each boring are shown in Table 5-9.

Monitoring wells are also planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B4016 and B4020. Preliminary locations for downgradient well nests include the locations of borings B4017, B4018, B4022, and B4023. The results of the geophysical surveys and the preliminary conceptual model for the East CKD Area suggest that these locations are appropriate for monitoring CKD leachate beneath and downgradient of the CKD. As with the upgradient well nest, it is anticipated that a water table well will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling and borehole logging/testing activities described above. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Background

At the West CKD Area, Borings B3012, B3013, and B3020 will be drilled at locations on golf course property interpreted to be outside and upgradient of the area in which CKD is present. An upgradient monitoring well nest will be installed at the location of boring B3020. It is anticipated that the water table at this location will be above the bedrock surface. This well nest will consist of a water table well and up to three deeper wells.

Borings B2042 and B2044 will be drilled at the Seep 2 CKD Area at locations interpreted to be outside the area in which CKD is present. Boring B2043 will be drilled at a location south of the golf course property that is upslope of the CKD and is interpreted as being upgradient of the CKD as well. Two upgradient monitoring well nests are planned at the Seep 2 CKD Area at the locations of borings B2043 and B2044. It is anticipated that the water table at these locations will be at or near the bedrock surface. The well nests will consist of a water table well and up to three deeper wells. Existing monitoring well OW-5 is proposed as the water table well for the well nest at boring B2044. Prior to using OW-5, or any other pre-existing (i.e. installed before 2005) monitoring well, within the groundwater monitoring network at this site, the well will first be re-developed following the procedures provided within Appendix E and its functionality evaluated prior to its incorporation. The open intervals of the deeper wells in the nests will be determined based on observations made during the drilling of borings B2043 and B2044 and the results of the borehole geophysical logging of these holes.

At the Seep 1 CKD Area, borings B1025, B1026, B1027, B1029, and B1033 (Figure 5-2) will be drilled at locations interpreted to be outside the area in which CKD is present. Borings B1030 and B1033 (Figure 5-2) will be drilled south (upgradient) of the golf course property. Two upgradient monitoring well nests are planned for the Seep 1 CKD Area at the locations of borings B1030 and B1033. It is anticipated that the water table at this location will be at or near the bedrock surface. This well nest will consist of a water table well and up to three deeper wells. The open intervals of the deeper wells in the nest will be determined based on observations made during the drilling of borings B1030 and B1033 and the results of the borehole geophysical logging of these holes.

At the East CKD Area, boring B4021 will be will be drilled at a location interpreted to be outside and upgradient of the area in which CKD is present. An upgradient monitoring well nest will be installed at the location of boring B4021. It is anticipated that the water table at this location will be above the bedrock surface. This well nest will consist of a water table well and up to three deeper wells.

Extent of Contamination

The borings described in Section 5.2.3 will be used to define the extent of CKD. The borings and wells described in this section will be used to define the extent of CKD leachate impacts in the unconsolidated material. The borings and wells described in Section 5.2.4.2 will be used to define the extent of CKD leachate impacts in the bedrock.

5.2.4.2 Bedrock Characterization

Vertical and angled borings will be used to characterize bedrock. The bedrock borings will be advanced using rotasonic drilling methods. The outer casing advanced as part of the rotasonic drilling method will be used to restrict movement of groundwater above the bedrock into the bedrock coring via the borehole in the unconsolidated material. The inner casing advanced as part of the rotasonic drilling method will also restrict the vertical movement of groundwater in the bedrock coring as the hole is advanced in the bedrock. Upon completion of drilling, the inner casing will be removed from the hole and down-hole geophysical logging and aquifer testing will be completed in each hole. In the event that rotasonic drilling methods are not feasible, the borings will be advanced using rotary coring drilling methods. If rotary coring drilling methods are used, a temporary casing or hollow-stem auger that extends from the ground surface to the top of the bedrock will be used to restrict movement of any groundwater above the bedrock into the bedrock coring via the borehole in the unconsolidated material.

In addition to vertical borings drilled at each location, angle borings will be drilled next to select coring locations to intersect vertical fractures. Angled bedrock corings will be identified by adding an “A” after the coring location designator. These angled bedrock corings will be drilled at a 45^{o} angle (the angle may be adjusted based on field conditions) to an elevation of approximately 560 ft MSL. Information obtained during the development of this Work Plan indicates that there are two main, near-vertical fracture orientations at the Site and that these fracture orientations have a bearing of approximately 300^{o} to 330^{o} and approximately 45^{o} to 70^{o}. In each CKD disposal area, one angled bedrock coring will be drilled approximately normal to the northwest-trending fracture orientation and a second angled bedrock coring will be drilled approximately normal to the northeast-trending fracture orientation. These angled bedrock corings should provide information on spacing of the near-vertical fractures in the bedrock away from the unconfined surfaces of natural outcrops and old quarry walls.

West CKD Area

The 20 boring locations in the West CKD Area are shown on Figure 5-4. Borings B3012 through B3020 will be advanced into the bedrock using rotasonic drilling methods. Two of the bedrock coring locations have been selected for an angled borehole in addition to the vertical borehole to assist in the collection of data for characterizing near-vertical fractures in the bedrock. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-6. Anticipated depths of each boring are shown in Table 5-7.

Monitoring wells are also planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B3014 and B3015. Preliminary locations for downgradient well nests include the locations of borings B3016, B3018, and B3019. The results of the geophysical surveys and the preliminary conceptual model for the West CKD Area suggest that these locations are appropriate for monitoring CKD leachate beneath and downgradient of the CKD. It is anticipated that a water table well will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling, borehole geophysical logging, and aquifer testing activities. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Seep 2 CKD Area

The 52 boring locations in the Seep 2 CKD Area are shown on Figure 5-3. Borings B2018 through B2044, B2047, and B2050 will be advanced into the bedrock using rotasonic drilling methods. Two of the bedrock coring locations have been selected for an angled borehole in addition to the vertical borehole to assist in the collection of data for characterizing near-vertical fractures in the bedrock. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-4.

Monitoring wells are also planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B2019, B2020, and B2025. Preliminary locations for downgradient well nests include the locations of borings B2030, B2035, B2038, B2041, B2047, and B2050. The results of the geophysical surveys and the preliminary conceptual model for the Seep 2 CKD Area suggest that these locations are appropriate for monitoring CKD leachate within the CKD footprint and downgradient of the CKD. As with the upgradient well nests, it is anticipated that a water table well that is open at or near the bedrock surface will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling, geophysical logging and aquifer testing activities. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Seep 1 CKD Area

Borings are planned for the Seep 1 CKD Area at 32 locations as shown on Figure 5-2. The rationale for the installation of each boring and the approximate coordinates are summarized in Table 5-2. Borings B1013 through B1033 will be advanced into the bedrock using rotasonic drilling methods. Two of the bedrock coring locations have been selected for an angled borehole in addition to the vertical borehole to assist in the collection of data for characterizing near-vertical fractures in the bedrock (Tables 5-2 and 5-3). Corings B1013, B1014, B1017, B1022, and B1025 through B1028 (Figure 5-2) will be drilled at locations where geophysical results indicate the possible presence of fractures. Angle borings will be drilled next to coring locations B1017 and B1027.

Monitoring wells are also planned within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B1021, B1022, B1024, and B1016. Preliminary locations for downgradient well nests include the locations of borings B1013, B1014, B1031, and B1032. The results of the geophysical surveys and the preliminary conceptual model for the Seep 1 CKD Area suggest that these locations are appropriate for monitoring CKD leachate within the footprint of the CKD and downgradient of the CKD. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

East CKD Area

The 23 boring locations in the East CKD Area are shown on Figure 5-5. Borings B4016 through B4023 will be advanced into the bedrock using rotasonic drilling methods. Two of the bedrock coring locations have been selected for an angled borehole in addition to the vertical borehole to assist in the collection of data for characterizing near-vertical fractures in the bedrock. Location coordinates for each boring and the objective(s) for each boring are shown in Table 5-8. Anticipated depths of each boring are shown in Table 5-9.

Monitoring wells are also planned at locations that are interpreted to be within the footprint of the CKD and downgradient of the CKD. Preliminary locations for well nests within the footprint of the CKD are at the locations of borings B4016 and B4020. Preliminary locations for downgradient well nests include the locations of borings B4017, B4018, B4022, and B4023. The results of the geophysical surveys and the preliminary conceptual model for the East CKD Area suggest that these locations are appropriate for monitoring CKD leachate beneath and downgradient of the CKD. As with the upgradient well nest, it is anticipated that a water table well will be installed at each of these locations and additional, deeper wells will be constructed based on the results of the drilling, geophysical logging, and aquifer testing activities described above. The final number and locations of monitoring wells within the CKD footprint and downgradient of the CKD will be determined based on data collected during the drilling program.

Background

At the West CKD Area, Borings B3012, B3013, and B3020 will be drilled at locations on golf course property interpreted to be outside and upgradient of the area in which CKD is present. An upgradient monitoring well nest will be installed at the location of boring B3020. It is anticipated that the water table at this location will be above the bedrock surface. This well nest will consist of a water table well and up to three deeper wells.

Borings B2042 and B2044 will be drilled at locations interpreted to be outside the area in which CKD is present at the Seep 2 CKD Area. Boring B2043 will be drilled at a location south of the golf course property that is upslope of the CKD and is interpreted as being upgradient of the CKD as well. Two upgradient monitoring well nests are planned at the Seep 2 CKD Area at the locations of borings B2043 and B2044. It is anticipated that the water table at these locations will be at or near the bedrock surface. The well nests will consist of a water table well and up to three deeper wells. Existing monitoring well OW-5 will serve as the water table well for the well nest at boring B2044. The open intervals of the deeper wells in the nests will be determined based on observations made during the drilling of borings B2043 and B2044 and the results of the borehole geophysical logging of these holes.

At the Seep 1 CKD Area, borings B1025, B1026, B1027, and B1029 (Figure 5-2) will be drilled at locations interpreted to be outside the area in which CKD is present. Borings B1030 and B1033

(Figure 5-2) will be drilled at a location south (upgradient) of the golf course property. Two upgradient monitoring well nests are planned for the Seep 1 CKD Area at the locations of borings B1030 and B1033. It is anticipated that the water table at these locations will be at or near the bedrock surface. The well nests will consist of a water table well and up to three deeper wells. The open intervals of the deeper wells in the nest will be determined based on observations made during the drilling of borings B1030 and B1033 and the results of the borehole geophysical logging of these holes.

At the East CKD Area, boring B4021 will be will be drilled at a location interpreted to be outside and upgradient of the area in which CKD is present. An upgradient monitoring well nest will be installed at the location of boring B4021. It is anticipated that the water table at this location will be above the bedrock surface. This well nest will consist of a water table well and up to three deeper wells.

Extent of Contamination

The borings described in Section 5.2.3 will be used to define the extent of CKD. The borings and wells described in Section 5.2.4.1 will be used to define the extent of CKD leachate impacts in the unconsolidated material. The borings and wells described in Section 5.2.4.2 will be used to define the extent of CKD leachate impacts in the bedrock.

5.2.5 Determination of Geologic and Hydrogeologic Properties

Geophysical logging and aquifer testing in the borings and monitoring wells is planned to provide data that will be used to fill data gaps regarding the nature of the Site hydrogeology; these data will then be used to refine the preliminary Site conceptual model. The objectives for the investigation include measurement of hydrogeologic parameters, identification/characterization of potential preferential flow zones in the bedrock, and characterization of subsurface water quality.

5.2.5.1 Borehole Geologic and Geophysical Logging

Samples of the unconsolidated materials and bedrock cores will be examined to determine the thickness of the geologic units, lithology, stratigraphy, presence of solution features (in bedrock), and fracture frequency and orientation (in bedrock).

Applicable portions of the ASTM International *Standard Guide for Design of Groundwater Monitoring Systems in Karst and Fractured-Rock Aquifers* (D-5717-95) will be used in the field when determining the thickness of beds, weathering, lithology, stratigraphy, presence of solution features, and fracture frequency and orientation in bedrock.

Borehole samples will be described in the field by a qualified geologist or geological engineer. Non-CKD unconsolidated materials will be described according to ASTM D2488 and CKD will be described according to the standard procedure described in the QAPP (Barr, 2005b).

As the bedrock coring is advanced through saturated material, the pH of groundwater encountered in the bedrock coring will be measured and logged approximately every ten feet. Prior to measuring the pH, each interval will be purged following the standard procedure for well purging described in the QAPP.

Once each bedrock borehole is completed, a series of down-hole geophysical tests will be conducted. These down-hole tests will include temperature, caliper, spontaneous potential (SP), resistivity, flow meter, natural gamma, sonic, and optical televiewer logging. An acoustic televiewer log will be substituted if borehole water clarity is too low for high quality optical televiewer data. It is anticipated that, due to the fractured nature of the bedrock, conditions encountered in the bedrock corings will likely be heterogeneous and may vary widely from one hole to the next. In order to characterize the expected range of variation, the borehole geophysical logs identified above will be used in a "tool box" approach. That is, the logs will be run in each hole, and as data are collected, the effectiveness of each logging tool will be continually evaluated. Any logging tools that are determined to not be providing useful information due to Site conditions will be eliminated from the suite of tools used in the remainder of the boreholes. Data that will be collected with each of the geophysical logging tools are summarized in the following table.

Borehole Geophysical Method	Data Obtained
Temperature Log	Borehole fluid temperature and in-hole flow
Caliper Log	Borehole diameter and fracture locations
SP Log	Vertical variations in water quality, lithologic data, may be useful in identifying high conductivity bedrock fracture zones
Resistivity Log	Lithologic data, may be useful in identifying high conductivity bedrock fracture zones
Flow Meter Log	In-hole flow, location and apparent hydraulic conductivity of permeable bedrock intervals
Natural Gamma Log	Lithology in both cased and uncased portions of the borehole
Sonic Log	Porosity and lithology in both cased and uncased portions of the borehole
Optical Televiewer Log	Location, orientation, and character of fractures and solution openings in bedrock, strike and dip of bedding planes, groundwater flow

5.2.5.2 Vertical Aquifer Sampling

One of the objectives of the planned bedrock corings is to characterize the vertical extent of the CKD leachate in the context of all applicable criteria. However, it is recognized that the vertical extent of any mercury plume emanating from the CKD piles cannot be vertically defined using vertical aquifer sampling methods. Permanent monitoring wells will be the only mechanism used to collect groundwater samples for low level mercury analysis. The protocol of proposing additional permanent monitoring wells to vertically and horizontally define the extent of elevated mercury concentrations in the groundwater established within Section 5.2.4 will be the methodology of delineating the mercury plume.

It is anticipated that CKD leachate may be encountered in the bedrock at several of the bedrock coring locations. Available information indicates that the potential exists for leachate from the CKD to be slightly denser than groundwater. Therefore, the possibility of a denser plume of CKD leachate exists.

Measurements of pH and specific conductance will be used as the indicator of CKD leachate. The pH will be measured every 10 feet as the bedrock corings are advanced. If elevated pH, indicative of a plume of CKD leachate, is not encountered in a boring, then the boring will be advanced to approximate elevation 560 ft MSL (i.e., approximately 20 feet below lake level). However, if the pH indicates the presence of a plume of CKD leachate, then the bedrock corings will be terminated at the elevation where pH is less than or equal to 9.0 or competent bedrock is encountered, as determined by a Barr Geologist in consultation with a U.S. EPA geologist.

After completion of the geophysical logging in each bedrock coring, up to three borehole packer intervals will be selected for sampling and aquifer testing based on the results of the logging. Borehole packer intervals will be determined as follows:

1. One borehole packer interval will be placed at a non-impacted depth where the pH is <9.0 (if encountered).

2. One borehole packer interval will be placed at a depth where the highest pH is recorded based upon the vertical aquifer sampling.

3. The additional borehole packer interval will be placed in a zone within the borehole exhibiting the highest groundwater flow and a pH >9.0.

4. In the event that during the vertical aquifer sampling, pH readings are < 9.0, then one borehole packer interval will be placed at the water table, one borehole packer interval will be placed at the depth where the highest pH is recorded, and one borehole packer interval will be placed at the zone exhibiting the highest groundwater flow.

If borehole packer intervals cannot be selected based upon the criteria described above, consultation with a U.S. EPA geologist will be necessary to select the bedrock packer intervals for that bedrock coring.

The borehole packer interval to be sampled/aquifer tested will be isolated with inflatable packers beginning with the zone closest to the bottom of the hole. The inflatable packers will be placed into the selected bedrock coring depth interval. The packer assembly will include a pressure transducer beneath the lower packer (if the lower packer is not placed at the bottom of the bedrock coring), a pressure transducer in interval between the packers, and a pressure transducer above the upper packer (if the water level in the bedrock coring is sufficiently far above the upper packer to allow submersion of the transducer). These pressure transducers will be connected to a Hermit 3000 datalogger manufactured by In Situ, Inc. which will be used to monitor hydraulic heads above, within, and below the isolated sampling/testing zone. The packer assembly will have a submersible sampling pump capable of lifting water from the selected bedrock coring interval to the surface installed between the packers.

Three to five casing volumes of water will be purged from the isolated borehole packer interval in which the pump is set. After this purging, a stabilization test as described in the QAPP (Barr, 2005b) will be performed. Upon reaching stabilization as defined in the QAPP or after pumping of an additional three casing volumes, whichever occurs first, the pH, specific conductance, and temperature of the water pumped from the isolated borehole packer interval will be measured using the YSI 556. A sample will then be collected from the pump discharge line following procedures described in the QAPP. This sample will be sent to the laboratory and analyzed for the metals (total and dissolved) and general parameters in Tables 5-1. The mercury analysis for water samples collected during vertical aquifer sampling will be the “standard” mercury method, EPA 7471. This sampling procedure will be repeated for each of the selected flow zones in each bedrock coring.

If the isolated borehole packer interval zone in which the pump is set is pumped dry and does not recover at least 90% of the hydraulic head within 4 hours, then testing of the zone will be terminated and that interval will not be sampled.

5.2.5.3 Aquifer Testing

Aquifer testing is planned for each unconsolidated material soil boring and bedrock borehole. As described below, aquifer testing in unconsolidated materials will be conducted in the lowest saturated zone above bedrock and aquifer testing in bedrock boreholes will be conducted at intervals determined by bedrock logging and the downhole geophysics. The aquifer testing in bedrock boreholes will be conducted in the zones with indications of highest groundwater flow.

Unconsolidated Material

After sampling the saturated zone closest to the bottom of a soil boring, an aquifer test will be conducted in this zone. A temporary well point will be placed in the borehole and the formation will be allowed to collapse around the screen. If the formation does not collapse around the well screen, a sand pack will be placed around the screen and a bentonite seal will be placed above the screened interval. The well will be developed following the procedures described in the QAPP (Barr, 2005b) to ensure a good hydraulic connection to the surrounding saturated material. After the water level equilibrates, the water level will be measured and a pressure transducer connected to a Hermit 1000C or 3000 datalogger manufactured by In Situ, Inc. will be placed in the temporary well point. The transducer/datalogger system will be used to monitor/record water levels during the aquifer test.

A solid 5-foot-long PVC rod (a.k.a., a slug) will be rapidly lowered as far as possible below the water level in the temporary well. Changes in water level will be measured and recorded by the pressure transducer and datalogger. This is known as a slug-in test. After the water level in the temporary well returns to equilibrium within the formation, the slug will be rapidly removed and the changes in water level will again be measured and recorded. This is known as a slug-out test. Two additional slug-in/slug-out test pairs will be conducted to provide data for evaluating the appropriateness of the data analysis method to be used (e.g., Butler, 1997). As recommended by Butler (1997), in the second slug-in test the length of the slug placed below the water level will be reduced by a factor of two.

This aquifer test procedure will be repeated in each soil boring unless it is determined that the unconsolidated materials are homogeneous. In this case, the test procedure will be repeated in a minimum of four borings in each area. A qualified hydrogeologist will analyze the water level data from the slug tests to estimate the hydraulic conductivity of the unconsolidated materials. If the temporary well screen extends above the water table, only the slug-out test results for that temporary well will be analyzed.

Bedrock

After completion of the borehole geophysical logging in each bedrock boring, up to three borehole intervals will be selected for aquifer testing based on the results of the logging. Aquifer testing will be completed in the zones with the highest apparent groundwater flow.

The borehole zone to be sampled/aquifer tested will be isolated with inflatable packers beginning with the zone closest to the bottom of the hole. A pump and a pressure transducer will be installed in between the packers before the assembly is lowered into the hole. The pressure transducer will be connected to a Hermit 1000C or 3000 datalogger and used to monitor water levels during and after pumping from the isolated borehole packer zone. If possible, packers will also be set such that the next highest flow zone in the bedrock coring is also isolated so that a pump test can be conducted between two intervals. A pressure transducer connected to a Hermit 1000C or 3000 datalogger will be used to monitor water level in this second flow zone during and after pumping of the lower flow zone.

Three to five borehole volumes of water will initially be purged from the isolated borehole packer zone in which the pump is set. Discharge rate will be measured and recorded periodically as pumping proceeds. If the isolated borehole packer zone in which the pump is set is pumped dry and does not recover at least 90% of the hydraulic head within 4 hours, then testing of the zone will be terminated. However, if the head in the pumped borehole packer flow zone has recovered to at least 90% of the pre-pumping level within 4 hours, then the borehole packer zone pumping will re-start until at least 3 borehole volumes have been removed.

At the completion of pumping, groundwater samples will be collected, the pump will be turned off, and the total pumping time recorded. Water level recovery in the pumped interval and in the next highest isolated borehole packer interval, if any, will be monitored via the pressure transducers and recorded on the Hermit datalogger. Recovery will be allowed to continue until the hydraulic head in the pumped interval has returned to at least 90% of the pre-pumping level. Water level data from the pumping and recovery periods will be analyzed by a Barr hydrogeologist to estimate the hydraulic conductivity of the formation in the tested interval.

5.2.6 Hydrologic Investigations-Surface Water

5.2.6.1 Water Cycle Monitoring

CMS will establish procedures that will routinely measure the parameters of pH, conductivity, temperature, flow rates, and water levels within each Site creek, and within each of the screened intervals within a nested well location at each CKD investigative area. Additionally, one long-term continuous water level monitoring station shall be established within Lake Michigan. These long-term, continuous monitoring procedures shall be described in a protocol to be developed by CMS and submitted to the U.S. EPA for approval by August 20, 2005. The procedures described in the protocol shall be implemented at the Site within 14 days after U.S. EPA approval.

Groundwater modeling and calibration will provide the best water balance possible. Once developed, the model can be numerically manipulated to simulate the groundwater component as well as the surface water component of leachate generation. Once Site conditions are understood, sound long term solutions to the problem can be devised. As part of the development of the groundwater flow model, data will be collected from field activities for the purpose of quantifying the surface-hydrology water-balance components of recharge and discharge to the saturated zone. The model will be initially developed based on the preliminary conceptual model for groundwater flow at the Site, using existing data and information such as the location and elevation of surface water bodies near the Site, local information on precipitation (annually averaged and seasonal), and available information on the regional geology and surface-water hydrology. This preliminary conceptual model will be calibrated to the extent that existing water and flow data allow.

Surface-hydrology components of the water balance that will be considered in the development of the groundwater flow model include:

- local precipitation and variations in precipitation, including short-term, high-intensity storms
- climatological factors, such as temperature
- estimates of evaporative and evapotranspirative components, including evaporative losses from ponds and wetlands
- inputs/losses from flowing streams
- losses from ponds and wetlands via vertical seepage
- variations in seepage from variations in unsaturated zone conditions (including CKD) that result in spatial variations in average recharge
- Gains from saturated flow components to Lake Michigan and adjacent seepage areas

- Application of irrigation and subsurface seepage interception by drains

The groundwater flow modeling approach that will be used in this study is inherently a quantitative water balance approach. Potentiometric head distribution and flow rates in groundwater flow models are typically most sensitive to spatial and temporal variations in recharge. Recharge encompasses surface-hydrologic process that determines flow through the unsaturated deposits, including CKD deposits. An automated inverse optimization approach to model calibration will be employed in order to quantitatively estimate all of the components of the water balance – including recharge, hydraulic conductivity distributions, and interaction with surface-water features. Values of saturated hydrologic parameters such as horizontal and vertical hydraulic conductivity will be obtained through aquifer testing procedures. These aquifer tests will provide detailed site data that will constrain the range of recharge conditions at the site because the potentiometric head distribution and seepage rates are directly a function of saturated hydrologic parameters and recharge.

As RA investigation activities commence and more detailed data are collected, the model parameters will be updated with the new data, such as localized water level and hydraulic conductivity measurements. Simulations will be performed using the model to ascertain whether or not there are significant data gaps in the investigation results. As data is collected and the model calibration progresses, the model will be used to evaluate the groundwater and surface water contribution to the generation of CKD leachate and appropriate remedial actions that would minimize CKD leachate generation. As needed, water fluxes will be iteratively estimated which will enable anticipation of leachate generation and capture aspects of the project.

Continuous water level and temperature monitoring will be performed for a period of 12 months at the following locations in each CKD disposal area: one upgradient well nest, one of the well nests within the CKD footprint, and one downgradient monitoring well nest. MiniTrolls manufactured by In Situ, Inc. will be used for this monitoring. The continuous water level data collected from these wells will be compared to data recorded by an on-Site meteorological station. This meteorological station will be installed at either the Seep 1 or Seep 2 CKD Area and used to track on-Site precipitation as well as local barometric pressure, wind direction and speed, temperature, humidity, and evaporation/evapotranspiration data. The data collected from the groundwater wells, meteorological monitoring, and data from the nearest local weather monitoring station will be used to quantify the surface-hydrology water-balance components of recharge and discharge to the saturated zone.

Appendix F contains drawings showing the locations of the golf course drains. The locations and construction will be verified by field inspection. If possible, recording flow meters will be placed on the golf course under drain discharge lines in the Seep 1, Seep 2, and West CKD Areas to provide additional data for assessing infiltration events. Data will be downloaded from the MiniTrolls during each groundwater sampling event. The dataloggers will be removed from the wells and placed on clean plastic sheeting prior to sampling and reset in the wells after the sampling is completed.

Infiltration Study

Regional infiltration rates for groundwater modeling and hydrogeologic evaluation will be estimated from a combination of soil survey data, precipitation data (from local gauge records), climatological data, land use data, and automated inverse optimization modeling of the groundwater flow model. In addition, physical properties of the unconsolidated materials will be characterized in order to evaluate infiltration and vertical migration of surface water. If more deterministic approaches are found to be necessary during groundwater flow model calibration, the Richards equation, in combination with the modified Van Genuchten approach will be used to estimate infiltration through the unsaturated cover soils and CKD deposit. A water balance approach will be used in the golf course areas to attempt to estimate the rate of infiltration induced by irrigation, but will depend upon the availability of the data on water use from past and current golf course operations.

Evapotranspiration Study

Pan evaporation records will be used in conjunction with climatological information (i.e. humidity, wind speed, etc), seasonal sun angle, and a regionally applied reference evapotranspiration plot to calculate monthly averages for evapotranspiration based on land use/vegetation type in the immediate vicinity of the site (should such calculations be necessary for remedial investigation and design).

Leachate Levels

Data collected as described in Section 5.2.5.3 will be used to estimate the extent and characteristics of CKD leachate levels at the site.

5.2.6.2 Lake Michigan

Bathymetric Survey

Lake Michigan bathymetry contours (5 meter intervals) provided on the state of Michigan GIS website will be employed to evaluate water depth and lake bottom topography adjacent to the Site.

Shoreline Survey Monitoring

For the purpose of evaluating areas along the lakeshore with pathways for release of CKD leachate to surface water, regular shoreline survey monitoring events shall be conducted for a period of 12 months. The shoreline survey monitoring events shall be conducted in May, September, and November 2005 and April and June 2006. The shoreline survey monitoring events are included under the "On-going Data Collection" task in the schedule provided in Figure 9-1. The activities that will be conducted as a part of each shoreline survey event are listed in the following three subsections.

On-Shore Leachate Accumulation Zone Monitoring

For the purposes of this Work Plan, on-shore leachate accumulation zones are defined as pools of water on the beach that are not affected by wave action, thus indicating that the zones are not directly connected to the lake by surface flow. The first on-shore leachate accumulation zone monitoring event was conducted in May and June 2005. The specific conductance, temperature, and pH of leachate accumulation zones on the beach areas between each of the four CKD areas and Lake Michigan were measured by placing the probe module of a YSI Model 556 in the accumulation zone as per the May 2, 2005 U.S. EPA approval letter for the targeted shore survey. Data from this survey are included in Appendix A. Additional monitoring events shall be conducted in September and November 2005 and April and June 2006.

During each event, water samples will be collected from at least five of the leachate accumulation zones on the beach at each of the CKD areas, assuming at least five accumulation zones are present at each area. One of the samples will be collected from a leachate accumulation zone with a pH $\leq$ 9.0, while the other samples will be collected from near the four leachate accumulation zones where the highest pH readings were obtained. Due to the transient nature of the on-shore leachate accumulation zones, the exact zones measured in May and June 2005 may no longer be present. If fewer than five leachate accumulation zones are present on the beach at any of the CKD areas, a water sample will be collected from each of the zones. These water samples will be sent to the laboratory for analysis of the metals (total and dissolved concentrations) and general parameters shown in Table 5-1. Water samples collected from on-shore leachate accumulation zones will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). Analytical results for these samples will provide a basis for evaluating the quality of seep water discharging to the zones. These results will be compared to applicable surface water quality standards for Lake Michigan. Sampling and laboratory procedures will be as described in the QAPP (Barr, 2005b).

On-shore leachate accumulation zones will be sampled for the target parameters using the sampling methods outlined in Appendix C of the QAPP. These procedures are consistent with U.S. EPA Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, which is contained in Appendix H. Due to the relatively shallow nature (generally <2 inches) of the leachate accumulation zones, a dedicated pre-cleaned sampling container (ladle, unpreserved sample jar, etc.) will be used to gather the surface water from each leachate accumulation zone. This sampling container will be used to fill all appropriate laboratory containers. This procedure will be followed for all parameters in conjunction with the procedures outlined in the QAPP (Appendix C, pages 1-2, and 19-20) as appropriate.

The field instrument will be maintained and calibrated according to the standard operating procedure for the YSI Model 556 in the QAPP and the instrument will be operated according to the manufacturer's directions. Sampling locations will be recorded using GPS survey methods so that the locations can be located for future sampling events, if needed.

Creek Monitoring

The first creek monitoring event was conducted in May and June 2005. The specific conductance and pH of water within the three creeks located adjacent to the CKD areas (as described in Section 1.3.2.1, East – unnamed creek #1 and #2 and West – unnamed creek) were measured approximately every 25 feet starting at their discharge points at Lake Michigan to locations approximately 100 feet upgradient of their respective CKD piles. These data are contained in Appendix A. The specific conductance and pH were measured by placing the probe module of a YSI Model 556 in the creek water. Additional monitoring events shall be conducted in September and November 2005 and April and June 2006.

Monitoring of the three on-site creeks will also occur after rain events. Through the implementation of the continuous, long-term creek monitoring activities described in Section 5.2.6.1, a dataset will be developed plotting changes in pH and conductivity within the creeks following rain events. CMS shall develop a schedule to monitor pH and specific conductance of the creeks to evaluate potential impacts to the creeks if long-term, continuous monitoring indicates elevated pH levels during or after rain events. This monitoring will be conducted under a schedule approved by U.S. EPA. Based on the initial experience of creek monitoring following rain events, U.S. EPA will establish a schedule to collect water samples using the methodologies described below.

During each creek monitoring event, water samples will be collected from two locations within each creek as part of the RA investigation. One of the samples will be collected from the creek outfall and one sample will be collected from a location upgradient of the CKD area. These water samples will be sent to the laboratory for analysis of the metals (total and dissolved concentrations) and general parameters shown in Table 5-1. Water samples collected from the creeks will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). Analytical results for these samples will provide a basis for evaluating the quality of creek water. These results will be compared to applicable surface water quality standards for Lake Michigan. Sampling and laboratory procedures will be as described in the QAPP (Barr, 2005b).

The creek monitoring locations will be sampled for the target parameters using the sampling methods outlined in Appendix C of the QAPP. These procedures are consistent with U.S. EPA Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, which is contained in Appendix H. Due to the relatively shallow nature (generally <12 inches) of the creeks, a dedicated pre-cleaned sampling container (ladle, unpreserved sample jar, etc.) will be used to gather the surface water from each creek location. This sampling container will be used to fill all appropriate laboratory containers. This procedure will be followed for all parameters in conjunction with the procedures outlined in the QAPP (Appendix C, pages 1-2, and 19-20) as appropriate.

The field instrument will be maintained and calibrated according to the standard operating procedure for the YSI Model 556 in the QAPP and the instrument will be operated according to the manufacturer's directions. Sampling locations will be recorded using GPS survey methods so that the locations can be located for future sampling events, if needed.

Offshore Leachate Monitoring

The first offshore leachate monitoring event was conducted in May and June 2005. The specific conductance, temperature, and pH were measured at 25-foot intervals in the near-shore portions of Lake Michigan as part of the U.S. EPA approved targeted shore survey. The targeted shore survey was approved in a letter dated May 2, 2005. Data from this survey are included in Appendix A. Additional offshore leachate monitoring events shall be conducted in September and November 2005 and April and June 2006.

During each monitoring event, five surface water samples will be collected from the lake adjacent to each of the known CKD areas as close to the shoreline as possible. These samples will be analyzed for the list of metals (total concentrations) and general parameters shown in Table 5-1. Water samples collected from the surface water will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). One of the samples collected from the lake adjacent to each CKD area will be from a location where the measured surface-water pH $\leq$ 9.0. The other four samples will be collected from locations where the measured surface water pH > 9.0, if this condition is present. All samples will be collected following procedures described in the QAPP (Barr, 2005b).

Surface water sampling locations will be sampled for the target parameters following methods in Appendix C of the approved QAPP. These procedures are consistent with U.S. EPA Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels, which is contained in Appendix H. Unpreserved and precleaned sampling containers will be submerged to a depth of approximately 1 inch off the lake bottom and opened/filled at that depth. Once filled, the container will be recapped prior to bringing the sample to the surface. All laboratory containers containing preservatives will be filled from a unpreserved sampling container and will not be submerged. This procedure along with those included in the QAPP will be followed for the low-level mercury sampling as well as for all other target parameters.

Analytical results from the analyses of the surface water samples for metals and general parameters will be compared to applicable surface water quality criteria for Lake Michigan to allow a preliminary evaluation of risks to public health and the environment posed by the impacted water. The target analyte list, sampling methods, and laboratory procedures are described in the QAPP (Barr, 2005b).

The field instrument will be maintained and calibrated according to the standard operating procedure for the YSI Model 556 in the QAPP and the instrument will be operated according to the manufacturer's directions. Sampling locations will be recorded using GPS survey methods so that the locations can be located for future sampling events, if needed.

Over-Flights

CMS has retained professional flight services and will conduct over-flights on at least a 14-day interval for the purpose of observing and documenting existing and potential leachate releases. Over-flight photography will be scheduled on days when wind, waves and light conditions are most conducive to good visualization of the shoreline features. All shoreline areas of the Site will be photographed during each flight for comparison with photography from previous over-flights. CMS will provide an over-flight schedule to U.S. EPA, and if U.S. EPA determines that a different over-flight date is appropriate, the over-flight will occur on the date selected by U.S. EPA if the flight services contractor is available. U.S. EPA will attempt to provide 8-hour notice prior to requiring an over-flight. Flights will continue until ice is present in the Lake. Flights will resume each spring when ice is no longer present in the Lake. The schedule for over-flights may be adjusted to accommodate the need to observe the shoreline following potentially significant events, such as heavy rainfall. The frequency of these over-flights may be reduced or terminated at the direction of the U.S. EPA OSC. Copies of all photographs generated during the over-flights shall be provided to U.S. EPA upon completion of the over-flight.

5.2.6.3 Evaluate/Install Groundwater Surface Water Interface Monitoring Wells

The following principles will be considered in the development of a GSI monitoring well network to meet the requirements of Sections 20120a(1) and 21304a of the State of Michigan Natural Resource and Environmental Protection Act, 1994 PA 451, R 299.5706a(4) and R 299.5716(6):

Based upon previous hydrogeological investigations (NTH, 1995) and observed discharging of CKD leachate along the shoreline (both above and below the lake level) the GSI pathway is relevant at the Little Traverse Bay CKD Site. Furthermore, analytical results from the seep collection trench, the currently identified seep areas, and Lake Michigan demonstrate that hazardous substances in CKD leachate may be expected to vent to surface water in concentrations that exceed the generic GSI criteria. Previous investigations and observations establish that there is a hydraulic connection from the groundwater at the site to the surface waters of the state. Surface waters of the state are defined as the Great Lakes and their connecting waters, inland lakes, rivers, streams, impoundments, open drains, wetlands, and other surface bodies of water within the confines of the state. This includes intermittent streams, creeks, brooks, ditches, drains or wetlands. The designation of groundwater not in an aquifer does not mean the GSI pathway is not relevant.

Factors that will be considered to investigate the full extent and impact of hazardous substances in CKD leachate that vent to surface waters in concentrations that exceed GSI criteria include the proximity of the surface waters, the direction of groundwater movement, preferential pathways, the mass of hazardous substances present at the Site, and any documented Site-specific evidence of natural attenuation. Fate and transport modeling may be used to predict whether there is a reasonable likelihood of exceeding GSI criteria, but will be confirmed by field measurements.

For purposes of evaluating the GSI, applicable criteria include all hazardous substances released or otherwise affected by the release (reactions, breakdown products, etc.) and water quality characteristics. Should a target detection limit for a hazardous substance be greater than the risk-based GSI criterion, the target detection limit can be substituted for the risk-based values as the cleanup criterion until such time as the target detection limit is equal to or lower than the risk-based GSI criterion. Should the background groundwater concentration for a hazardous substance be greater than the risk-based GSI criterion, background can be substituted for the risk-based values as the cleanup criterion. Background in groundwater means the concentration or level of a hazardous substance which exists in the groundwater at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site. Background in groundwater will be determined on a site-specific basis. GSI cleanup criteria can include generic GSI criteria, site-specific GSI criteria, and mixing zone based GSI criteria.

Some generic chemical-specific GSI criteria depend upon whether the surface water is protected as a drinking water source. The Great Lakes and their connecting waters are protected as a drinking water source.

Generic chemical-specific GSI criteria may be based upon Tier I or Tier II water quality values depending on the amount of toxicity data were available at the time the water quality standards were developed. Tier I values represent a complete toxicity data set, and Tier II values an incomplete set. The Tier I or II designation is indicated in the Part 31, Rule 57 Water Quality Values spreadsheet. Less stringent human health values must be protective of designated uses of the surface waters of the state and must be based on sound scientific rationale. Site-specific criteria must be numerical criteria expressed as hazardous substance concentrations in groundwater.

GSI samples will be representative of the CKD leachate within the contaminant plume venting to the surface water. Contaminant concentrations will be measured in the contaminant plume or in the path of the contaminant plume at points located as close to the surface water body as feasible, where and when groundwater gradients show that the groundwater is moving toward the surface water body. GSI compliance monitoring points will be selected after taking into consideration changes in the groundwater flow direction, so that samples from the GSI wells are representative of groundwater flowing to the surface water. GSI monitoring points must be downgradient of the release and should, wherever possible, be in locations where groundwater is not normally recharged by the surface water (i.e., where periodic flooding and associated bank storage is not a factor). Water surface elevations in the surface water and groundwater must be determined before and during each sampling event in order to demonstrate that groundwater is and has been moving toward the surface water body for a period time adequate to preclude dilution of groundwater with surface water.

The selected GSI monitoring points will be permanent vertical wells installed at locations in the saturated zone that are representative of groundwater entering the surface water. Monitoring well locations will be as close as practical to surface waters where groundwater flow direction is toward the surface water. Samples will be representative of groundwater, not surface water. The direction of groundwater flow and hydraulic gradient will be determined during each sampling event by measurement and evaluation of water surface elevation levels in each sampling location and the receiving surface water body. The GSI monitoring well network will be designed to monitor both the highest concentrations and full distribution, which includes the entire horizontal and vertical extent, of hazardous substances that exceed applicable criteria in the aquifer at the area of compliance. The monitoring points will include the interval or intervals that represent the highest concentrations of hazardous substances.

Should the need arise to use alternative GSI monitoring points other than described above, a proposal will be submitted to U.S. EPA for review and approval. The proposal will contain a precise definition of where and how the plume is venting to surface waters, and must identify and document the chemical, physical, or biological processes that would result in reduction of the hazardous substances between the location of generic GSI monitoring wells and the location of any proposed alternative monitoring points.

5.2.7 Geophysical Investigation

Down-hole geophysical investigation techniques will be employed to log the boreholes as described in Section 5.2.5.1.

5.2.8 Baseline Ecological Investigation

A baseline ecological evaluation will provide metrics for delineating areas impacted by CKD leachate releases and for monitoring the progress of remediation along the shoreline and in adjacent surface waters demonstrated to be impacted by releases of CKD leachate.

The baseline ecological investigation will initially consist of the evaluation of existing water quality and biological data from Little Traverse Bay. Data previously collected by the U.S. EPA, the state of Michigan, Barr Engineering Company, the Little Traverse Bay Bands of Odawa Indians, and other sources as identified by the U.S. EPA will be compiled and evaluated.

CMS has retained Dr. Ishwar Murarka (www.ishinc.biz) to work with CMS and Barr Engineering Company to complete the evaluation of existing data and identify the appropriate approaches and methods that will be incorporated into a Baseline Ecological Investigation work plan. The outline for this work plan is currently being developed by U.S. EPA and its supporting agencies, including the United States Fish and Wildlife Service. It is anticipated that this work plan will include surface water quality monitoring, collection of target biota, and an analysis of fate and transport of the CKD leachate and associated hazardous substances in the receiving water body. This work plan will also include sediment sampling and/or toxicity testing for select organisms if deemed necessary by the U.S. EPA.

The optimal baseline ecological investigation program would be one that incorporates existing protocols currently used by the U.S. EPA, State of Michigan, and the Little Traverse Bay Bands of Odawa Indians.

Within 30 days upon receipt of the U.S. EPA aforementioned outline, CMS shall prepare and submit to the U.S. EPA the Baseline Ecological Investigation Work Plan. Approval of this sub-work plan will follow the processes in paragraph 16.b of the Order.

5.2.9 Management and Disposal of Investigation-Derived Waste

Before shipping any hazardous substances, pollutants, or contaminants from the Site to an off-Site location, CMS will obtain U.S. EPA certification that the proposed receiving facility is operating in compliance with the requirements of CERCLA Section 121(d)(3), 42 U.S.C. § 9621(d)(3), and 40 CFR § 300.440 as per the Order. Water and soil samples are not considered investigation-derived waste (IDW). They will be placed in laboratory-provided containers, transported, analyzed, and disposed as per the QAPP (Barr, 2005b).

Investigation-Derived Waste generated during the RA Investigation will include drilling cuttings composed of CKD and CKD mixed with native soils, drilling fluids, and purge water from boreholes and monitoring wells. Bedrock core samples will not be considered to be IDW. Rather, the bedrock cores will be investigative samples that will be retained. Upon completion of the field inspection/description, the cores will be placed in core storage boxes and stored in a secure location so that they will be available for future inspection and study.

The native soils and CKD drilling cuttings will be segregated and containerized in drums or roll-off boxes. Laboratory analyses of representative samples will be performed as required by applicable regulations and the disposal facility to characterize the IDW solids prior to disposal. It is anticipated that disposal as non-hazardous waste will be appropriate for the native soils and CKD drilling cuttings.

To the extent possible, water will be decanted from the drilling cuttings. Water decanted from the drilling cuttings and water pumped or otherwise removed from the boreholes will be placed in polyethylene tanks or drums. Analyses of the IDW fluids will be performed as required by applicable regulations to characterize the IDW fluids prior to disposal. The IDW fluids will be disposed of at an appropriate facility in accordance with applicable regulations.

An IDW staging area will be constructed in a secure location not accessible to the public to protect against the possibility of vandalism. Containers filled with IDW will be properly labeled as required by applicable regulations and placed in this staging area while awaiting disposal. This staging area will be lined with polyethylene sheeting and surrounded by a berm or curbing to contain any IDW that may be released from the waste containers.

If investigation activities occur during periods when sub-freezing temperatures are expected, the IDW containers will not be filled completely to allow for expansion if water in the containers freezes.

5.2.10 Community Supply Well Evaluation

A survey will be conducted to identify any nearby (within 5,000 feet of the Site boundaries) water supply wells. The locations of these water supply wells will be determined and an analysis of the potential for CKD leachate to migrate into the maximum setback zones shall be provided within the Final Removal Action Report. The locations of the proposed boring/monitoring well locations will be submitted to the City of Petoskey to ensure that the City of Petoskey is informed of the advancement of borings/monitoring wells within any wellhead protection zone.

5.3 Sample Analysis

5.3.1 CKD Material

5.3.1.1 Chemical Analysis

Representative samples of the CKD will be collected and sent to the laboratory and analyzed for the parameters in Table 5-1. The following table summarizes the number of samples planned for analyses at each area:

Area	No. of CKD Samples
West CKD Area	11
Seep 2 CKD Area	17
Seep 1 CKD Area	12
East CKD Area	15

5.3.1.2 Physical Property Analysis

Porosity, Permeability, and Grain Size

All unconsolidated material samples collected from borings will be examined for moisture content in the field. Representative samples of the CKD will be collected for laboratory testing. Tests performed on these samples will include grain size distribution and saturated or unsaturated vertical hydraulic conductivity (samples collected using Shelby tubes or equivalent) depending on saturation conditions observed in the field. These direct measurements will be used to estimate porosity of the samples. The following table summarizes the number of samples planned for analyses at each area:

Area	No. of CKD Samples
West CKD Area	11
Seep 2 CKD Area	17
Seep 1 CKD Area	12

East CKD Area	15

5.3.2 CKD Leachate Sampling

5.3.2.1 Chemical Analysis

CKD leachate samples will be collected as the boreholes are advanced and from monitoring wells in areas impacted by CKD leachate. Sampling procedures are described in the QAPP (Barr, 2005b). The CKD leachate samples will be sent to the laboratory and analyzed for the metals (total and dissolved) and general parameters in Table 5-1. CKD leachate samples collected from borings or monitoring wells completed on the beaches or adjacent to another surface water body will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). CKD leachate samples collected from borings or monitoring wells in upland locations will generally be analyzed according to the "standard" mercury method, EPA 7471.

5.3.3 Unconsolidated Material

5.3.3.1 Chemical Analysis

Representative samples of the unconsolidated materials will be collected and sent to the laboratory and analyzed for the parameters in Table 5-1. The following table summarizes the number of samples planned for analyses at each area:

Area	No. of Unconsolidated Material Samples
West CKD Area	11
Seep 2 CKD Area	17
Seep 1 CKD Area	12
East CKD Area	15

5.3.3.2 Physical Property Analysis

Porosity, Permeability, and Grain Size

All unconsolidated material samples collected from borings will be examined for moisture content in the field. Representative samples of the unconsolidated material will be collected for laboratory testing. Tests performed on these samples will include grain size distribution and saturated or unsaturated vertical hydraulic conductivity (samples collected using Shelby tubes or equivalent) depending on saturation conditions observed in the field. These direct measurements will be used to estimate porosity of the samples. The following table summarizes the number of samples planned for analyses at each area:

Area	No. of Unconsolidated Material Samples
West CKD Area	11
Seep 2 CKD Area	17
Seep 1 CKD Area	12
East CKD Area	15

5.3.4 Bedrock Core Sampling

5.3.4.1 Physical Property Analysis

The objectives for the bedrock investigation include identification/characterization of potential preferential flow zones in the bedrock and characterization of subsurface water quality. Bedrock cores will be examined to determine the thickness of bedrock beds, weathering, lithology, stratigraphy, presence of solution features, and fracture frequency and orientation.

Applicable portions of the ASTM International *Standard Guide for Design of Groundwater Monitoring Systems in Karst and Fractured-Rock Aquifers* (D-5717-95) will be applied in the field when determining the thickness of bedrock beds, weathering, lithology, stratigraphy, presence of solution features, and fracture frequency and orientation. Bedrock core samples will be described in the field by a qualified geologist or geological engineer.

5.3.5 Groundwater Sampling

5.3.5.1 Chemical Analysis

Groundwater samples will be collected from each of the monitoring wells quarterly for one year. Sampling procedures are described in the QAPP (Barr, 2005b). The groundwater samples will be sent to the laboratory and analyzed for the metals (total and dissolved) and general parameters in Table 5-1. Water samples collected from all permanent monitoring wells will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). Also, groundwater samples will be collected from the downgradient wells during the first round of groundwater sampling for analyses of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) according to U.S. EPA Methods 8260B and 8270C. If VOCs or SVOCs are not found in these samples, no further rounds of groundwater samples will be analyzed for these parameters.

5.3.6 Surface Water

5.3.6.1 Chemical Analysis

Five surface water samples will be collected from the lake adjacent to each of the known CKD areas as close to the shoreline as possible. These samples will be analyzed for the list of metals (total concentrations) and general parameters shown in Table 5-1. Water samples collected from the surface water will be analyzed according to the "low-level" mercury method, EPA 1631 (mercury analysis)/7471 (all other metals). One of the samples collected from the lake adjacent to each CKD area will be from a location where the measured surface-water pH is $\leq$ 9.0. The other four samples will be collected from locations where the measured surface water is pH > 9.0. All samples will be collected following procedures described in the QAPP (Barr, 2005b).

Analytical results from the analyses of the surface water samples for metals and general parameters will be compared to applicable surface water quality criteria for Lake Michigan to allow a preliminary evaluation of risks to human health and the environment posed by the impacted water. The target analyte list, sampling methods, and laboratory procedures are described in the QAPP (Barr, 2005b).

5.3.6.2 Physical Property Analysis

Temperature and specific conductance of the near-shore surface water will be measured adjacent to the shoreline as discussed in Section 4.1.2.

5.4 Analytical Support and Data Validation

5.4.1 Prepare and Ship Environmental Samples

All analytical samples will be collected in the field in accordance with this RA Work Plan and the QAPP (Barr, 2005b). Samples will be collected to minimize potential contamination from outside sources.

Each laboratory sample to be transported will be marked with a permanent marker directly on the container or on adhesive labels that will remain on the container. Each container will be marked with a proper U.S. DOT transportation description, the sample designation and the names and addresses of the senders and receivers. Proper shipping papers will accompany each shipment of samples. All samples will be shipped for delivery within 2 days of sample event completion. All analytical samples will be shipped on ice via a same-day or next day delivery service. More information on sample preparation and shipping is available in Section B3, and Appendix C of the QAPP.

5.4.2 Coordinate with Appropriate Sample Management Personnel

Prior to collection, an order for sample containers will be placed with the subcontracted analytical laboratory. At that time other information such as date of collection, required analysis, and number of samples will be given to the laboratory project manager. This contact will allow the laboratory to prepare for the incoming sample volumes and analysis. TriMatrix has received a copy of and approved the QAPP (Barr, 2005b) for the project.

5.4.3 Implement U.S. EPA- Approved QA Program

A QAPP (Barr, 2005b) for this project has been developed using U.S. EPA quality guidelines and has been forwarded to all affected parties. In addition, this project is being managed following the U.S. EPA approved QMP (Barr, 2003). The quality assurance staff at Barr and at the subcontractor laboratory will be responsible for assuring that these documents are followed.

5.4.4 Provide Sample Management

Both Barr and the subcontractor laboratory have distinct programs for sample management from collection to disposal. These processes are described in Sections B and Appendix C of the QAPP (Barr, 2005b) for Barr's process and Appendix A of the QAPP for the subcontractor laboratory.

5.4.5 Perform Data Validation

Data validation will be performed on every sample collected as part of this work plan following the procedures indicated in Section D of the QAPP (Barr, 2005b).

5.4.5.1 Review Analysis Results

The laboratory will provide Barr with a full analytical data package including a data summary, a QA summary and all analytical raw data. A data validation following US EPA Contract Laboratory Program (CLP) procedures will be performed on all analytical data.

5.4.5.2 Provide Written Documentation

A data quality section will be included in the RA Nature and Extent Characterization Report. It will contain the result of the data validation as well as explanations of any qualifiers added.

5.5 Provide Electronic Data in U.S. EPA Format

An electronic data deliverable will be presented to U.S. EPA upon request. All data will be provided to the U.S. EPA following the Region 5 Staged Electronic Data Deliverable (SEDD) guidelines. If an alternative data format is required, Barr will work with the EPA Region 5 data quality staff to provide the desired format upon written request of the U.S. EPA. This data deliverable will be prepared in the format the U.S. EPA provides and will include all required fields that relate to the project.

5.6 Data Evaluation and Reporting

5.6.1 Data Evaluation

5.6.1.1 Data Usability Evaluation and Field QA/QC

Data validation will be performed on every sample collected as part of this work plan following the procedures indicated in Section D of the QAPP (Barr, 2005b).

All analytical samples will be collected in the field in accordance with this RA Work Plan and the QAPP. Samples will be collected to minimize potential contamination from outside sources.

5.6.1.2 Data Reduction, Tabulation, and Evaluation

The laboratory will provide Barr with a full analytical data package including a data summary, a QA summary and all analytical raw data. Upon receipt from the laboratory, the data will be loaded electronically into Barr's Laboratory Information Management System (LIMS). All electronic data will be verified using the original laboratory hardcopy report, all qualifiers from the data validation steps will be added and data summary tables will be created. Data validation will be conducted following U.S. EPA Contract Laboratory Program (CLP) procedures as indicated in Section D of the QAPP (Barr, 2005b). Copies of these data summaries will be provided in the RA report.

5.6.2 RA Investigation Report

5.6.2.1 Draft RA Report

The Order requires that a report be prepared to present the results of the RA investigation conducted to determine the nature and extent of hazardous substances, pollutants or contaminants at the Site. The RA Nature and Extent Delineation Report will include a summary of Site history, a complete summary of the non-intrusive and intrusive investigation tasks, and tabulation and interpretation of the data collected during the non-intrusive and intrusive investigations. Figures and tables will clearly show the results of the investigation. The report will also include field and laboratory data summary tables, maps, and geologic cross-sections. Figures depicting groundwater elevations and interpreted gradients will also be presented.

5.6.2.2 Final RA Report

The final RA Nature and Extent Delineation Report will consider U.S. EPA and other stakeholder written comments and is subject to the approval of U.S. EPA before it will be considered final in accordance with Paragraph 15.x of the Order.

6.0 Remedial Alternative Screening

6.1 Site Data Evaluation and Alternatives Evaluation

Data obtained from the field activities will be used to refine the Site conceptual model, develop a groundwater model, identify any additional data gaps and necessary additional field data collection activities, and evaluate long-term remedial alternatives for addressing the CKD leachate impacts identified at the Site.

Groundwater modeling will be used to integrate and synthesize the assembled information on Site geology and hydrogeology as well as contaminant characteristics, including location, flow, and advective transport (i.e., particle tracking) into a quantitative framework that can be used to both understand the current conditions at the Site, and to evaluate the impact and effectiveness of potential changes in Site characteristics (such as infiltration rates and groundwater flow velocity) due to various remedial alternatives (such as CKD removal, capping or leachate extraction). The groundwater flow model will serve multiple purposes, including:

- guiding the investigation as it proceeds and helping to modify it, if necessary;
- evaluating and analyzing the investigation data to further the understanding of the Site and to refine the conceptual hydrogeologic model; and
- providing a predictive tool to assist in evaluating and designing long-term remedial alternatives.
- providing a tool to organize and synthesize the array of data being collected.

In order for the groundwater flow model to be a guide for the RA investigation and an analysis tool for the evaluation of response actions, the model will be initially developed based on the preliminary conceptual model for groundwater flow at the Site, using existing data and information such as the location and elevation of surface water bodies near the Site and available information on the regional geology. This preliminary conceptual model will be calibrated to the extent that existing water and flow data allow.

As RA investigation activities commence and more detailed data are collected, the model parameters will be updated with the new data, such as localized water level and hydraulic conductivity measurements. Simulations will be performed using the model to ascertain whether or not there are significant data gaps in the investigation results. Based on these simulations, RA investigation activities may be modified. For example, aquifer tests performed on the Site will be simulated with the model and a comparison will be made between observed data and model simulations. Based on the agreement (or lack thereof), the model will either be confirmed or modified. The modified model will then be used to focus investigation activities on collecting data that will make the model more representative and increase its reliability as a predictive tool for designing long-term remedial alternatives. By continually improving the model in parallel with investigation activities, data collection activities will be optimized and the model will be ready to use for evaluating long-term remedial alternatives as quickly as possible.

It is anticipated that the finite-element code FEFLOW (WASY Software, 2004) will be employed to develop the groundwater flow model. FEFLOW provides for steady and unsteady flow using a standard equivalent porous media approach but also allows for explicit modeling of discrete fractures and fracture zones, based on orientation, aperture, and fracture width. Dual-density modeling can also be performed using FEFLOW, which may be necessary at this Site because of the potentially high total dissolved solids concentrations in the groundwater. Model calibration will be performed using FEFLOW's built-in automated inverse optimization code (which is similar to the codes PEST and UCODE). Standard solute-transport modeling is also performed in FEFLOW. A single model grid will likely be developed for the Site area but local telescoping mesh refinement models may be developed for individual locations, as warranted.

The effects of potential remedial alternatives will be modeled by adjusting model input parameters. For example:

- The effects of the removal of all CKD material from the site and replacement with clean fill can be simulated to determine the time required for the release of CKD leachate and other hazardous substances into surface waters, including Lake Michigan, to stop.
- Reducing infiltration by capping can be simulated to determine the net reduction of flow to Lake Michigan.
- Groundwater diversion measures can be evaluated with simulated withdrawal points or diversion walls upgradient from the CKD areas.
- Groundwater collection or pumping scenarios can be evaluated with simulated withdrawal points to determine the potential volume of water that may need to be removed (and treated) to achieve capture.

Simulating multiple scenarios with the groundwater model will help to focus the evaluation and optimization of interim response activities, evaluation and selection of long-term remedial alternatives for the Site, and to optimize the effectiveness of the selected remedial alternatives.

6.2 Feasibility Study Report

6.2.1 Draft Feasibility Study Report

As required under Section VII.15.x of the Order, the Respondents will conduct an evaluation of alternative response actions that build on the removal activities and investigation results, and which will address the following goals:

- Preventing unacceptable exposures to surface waters and sediment impacted by CKD waste material;
- Preventing discharge of groundwater containing hazardous substances at concentrations above state criteria to surface waters of the State;
- Preventing unacceptable risk from human direct contact with CKD waste material;
- Preventing exacerbation, new releases, and unacceptable exposure to CKD waste material
- Ensuring that any other unacceptable exposures are adequately addressed

These goals are to be met through:

- Integrating the interim response actions described in this work plan and any modification thereof;
- Designing, constructing and operating a long-term response activity
- Placing land use and resource use restrictions related to the CKD waste material
- Constructing and maintaining erosion control measures for buried CKD waste material
- Assuring the effectiveness and integrity of the long-term response activities
- Ensuring adequate financial resources are available in an acceptable form and amount to assure the performance of the response actions necessary to protect human health and the environment in perpetuity

The boundaries of the CKD piles will be surveyed. If land and resource use restrictions are ultimately necessary, the boundaries of those restricted areas will also be surveyed at that time.

The alternatives analysis will consist of: (1) development of remedial alternatives (at this point, likely involving removal, isolation, and/or containment of CKD waste materials) that could be applied along with land and resource use restrictions to address the response action goals; (2) screening those alternatives based on their short- and long-term effectiveness, implementability, and cost; and (3) developing a detailed analysis of those alternatives coming out of the screening step against the NCP criteria of:

- Overall protection of human health and the environment (threshold criteria)
- Compliance with ARARs (threshold criteria)
- Long-term effectiveness and permanence (primary balancing criteria)
- Reduction of toxicity, mobility and volume through treatment (primary balancing criteria)
- Short-term effectiveness (primary balancing criteria)
- Implementability (primary balancing criteria)

- Cost (primary balancing criteria)
- State Acceptance (modifying criteria)
- Community Acceptance (modifying criteria)

The results of this evaluation will be summarized in the Feasibility Study section of the Final Report.

6.2.2 Final Feasibility Study Report

The final Feasibility Study Report will consider U.S. EPA and other stakeholder written comments and is subject to the approval of U.S. EPA before it will be considered final in accordance with Paragraph 15.x of the Order.

7.0 Development of Removal Action Report

CMS is required to prepare and submit a final report summarizing the interim actions taken to comply with this Order within 90 calendar days after completion of all Work required by Section VIII of the Order. The final report must conform with the requirements set forth in Section 300.165 of the National Contingency Plan entitled “OSC Reports” and with the guidance set forth in “Superfund Removal Procedures: Removal Response Reporting – POLREPS and OSC Reports” (OSWER Directive No. 9360.3-03, June 1, 1994). The final report will include a good faith estimate of total costs or a statement of actual costs incurred in complying with the Order, a listing of quantities and types of materials removed off-Site or handled on-Site, a discussion of removal and disposal options considered for those materials, a listing of the ultimate destinations(s) of those materials, a presentation of the analytical results of all sampling and analyses performed, and accompanying appendices containing all relevant documentation generated during the RA.

The final report will also consist of the following elements:

1. Interim Removal Action Implementation.
2. Nature and Extent Characterization.
3. Feasibility Study for long-term remedial alternatives.
4. Post-Removal Action Site Control.

Future submittals will be developed based on the scope of work established in the MDEQ agreement anticipated under Section VIII.15.x of the Order (Section 8) and are anticipated to include periodic monitoring data summary reports, long-term response action design report(s), and response action implementation reports.

8.0 Post-Removal Action Activities

8.1 Post-Removal Action Site Control

A Post-Removal Action Site Control proposal for maintenance of the removal action interim recovery system and appropriate continued Site access, security, and institutional controls will be developed concurrent with the RA implementation and submitted with the RA Nature and Extent Delineation Report. The Post-Removal Site Control proposal will address the requirements of Section 300.415(l) of the NCP and OSWER Directive No. 9360.2-02. It is anticipated that Site Controls will also be an element of the long-term response actions for the Site, and their final form will be described in future submittals.

9.0 Schedule

The schedule for activities to be undertaken pursuant to Section 4 of this Work Plan is set forth in Section 4.3. Figure 9-1 is included as a schedule for anticipated major tasks. As displayed in the schedule presented in Figure 9-1, the major task start and end dates are projected as follows:

- Drilling – Initiate within 15 days after U.S. EPA approval of RA Work Plan and complete within 145 days after approval.

- On-going Data Collection – Initiate within 30 days after U.S. EPA approval of RA Work Plan and complete within 465 days after approval.

- Groundwater Modeling – Initiate within 45 days after U.S. EPA approval of RA Work Plan and complete within 480 days after approval.

- Data Evaluation – Initiate immediately upon collection of field data and complete within 225 days after U.S. EPA approval of RA Work Plan.

- Reporting – Submit Draft RA/FS Report within 650 days after U.S. EPA approval of RA Work Plan. Submit the Final RA/FS Report within 75 days after completion of U.S. EPA review of the Draft RA/FS Report

These task elements of the schedule will be broken down to provide further detail on mobilization, completion dates for site activities related to these respective work elements prior to implementation. These shall be provided to U.S. EPA within Progress Reports submitted in accordance with Paragraph 20 of the Order.

10.0 Project Staff

10.1 CMS Land Company

David Sporer is the CMS Land Company (CMS) Project Coordinator

The Project Coordinator is responsible for implementing the project, and has the authority to commit the resources necessary to meet project objectives and requirements. The Project Coordinator is also responsible to ensure that technical, financial, and scheduling objectives are achieved successfully. He will provide the major point of contact and control for matters concerning the project for CMS. The responsibilities of the CMS Project Coordinator include:

- Acquire and apply resources as needed to ensure performance on the project.
- Ensure that contractors and subcontractors comply with Order and complete the actions as described in the U.S. EPA approved plans.
- Receipt of notices or communication from U.S. EPA (receipt by Project Coordinator will constitute receipt by CMS).
- Send all submissions to U.S. EPA OSC and courtesy copies to routing list.
- Ultimately responsible for project quality.
- Submit weekly progress reports until 60 days after approval of work plan and every 30th day thereafter.
- Notify U.S. EPA of proposed offsite waste shipments and obtain their approval.
- In case of an accidental release of waste material, Project Coordinator is responsible to see that appropriate actions are taken and report release to OSC and National Response Center.
- Direct all project activities.
- Submit final report with Project Coordinator certification of truth, accuracy and completeness.
- Submit proposal for post-removal site control.
- Review all project deliverables.
- Represent the project team at meetings and public hearings.
- Provide final signature on all assessments.
- Seek permission to deviate from work plan or schedule if it should become necessary.
- Monitor work to determine if additional work is necessary to protect human health and the environment.

The Project Coordinator may delegate some of these responsibilities to competent individuals.

10.2 Barr Engineering Company (Barr)

At the direction of the CMS Project Coordinator, Barr has responsibility for oversight of all phases of the study and design performed at the Site. Barr will collect the necessary field samples according to project needs, and provide technical interpretation.

Dean Malotky is the Barr Principal-in-Charge

The Principal-in-Charge has overall responsibility for verifying that the project meets the established objectives and quality standards. The Principal-in-Charge is the primary contact for contractual issues and for resolving quality concerns. The Principal-in-Charge has responsibility for overall project management and product quality. Specific responsibilities of the Principal-in-Charge include:

- Leading and overseeing contract negotiations and development, including contract terms, scope, schedule, and budget
- Involvement with overall management, administration, and technical quality of the project
- Providing independent quality review and validation for technical and contractual issues
- Monitoring client satisfaction for contract work
- Resolving contractual or quality issues

Ellen Richard is the Barr project manager

The project manager is the CMS primary contact for technical issues and day-to-day performance of the project. The project manager is the primary contact within Barr for project direction. Specific responsibilities of the project manager include:

- Involvement in contract negotiation of scope, schedule and budget
- Matching project needs with staff abilities and communicating project requirements to project team members
- Overall direction of technical aspects of the project including defining project objectives and developing detailed implementation plans for each phase of the project
- Responsibility for project quality, including technical correctness and completeness, contract compliance, and budget and schedule compliance

Ward Swanson is the Barr QA manager

The role of the QA manager is to provide an independent review of the product and the process to see that the work meets quality standards. He is responsible for auditing the implementation of the QA program in conformance with the requirements of this QAPP, and the demands of specific project tasks. Specific responsibilities of the QA manager include:

- Providing QA technical assistance to project staff
- Reporting on the adequacy, status, and effectiveness of the QA program on a regular basis to the project manager
- Data validation
- Initiation, tracking and review of corrective actions

Barr Field Superintendent

The role of the field supervisor is to schedule, coordinate, and manage on-site data collection activities. In general, the responsibilities of the Field Supervisor will include the following:

- Lead and coordinate day-to-day field activities
- Provide day-to-day coordination with the project manager on technical issues that arise during field work
- Coordinate and manage field personnel
- Coordinate and oversee subcontractors
- Ensure field work is proceeding on schedule
- Identify problems at the field-staff level and discuss resolutions with the project manager, implement and document corrective action procedures, and provide communication between field staff and project management
- Implement protocols for tracking and organizing analytical samples collected and shipped from the site as per the QAPP
- Implement protocols for data management, organization, and backup as per the QAPP
- Ensure field equipment is in working order and coordinate replacement or repair as necessary;
- Meet/communicate (in coordination/conjunction with project manager) with regulators that visit the site

Barr Design Engineer

The role of the design engineer is to evaluate the field investigation data, design interim response action activities that will achieve the project objectives, and coordinate the operation, maintenance, and monitoring of the interim response action systems. Also, the design engineer will have primary responsibility for conducting the feasibility study and evaluating long-term remedial options. In general, the responsibilities of the design engineer will include the following:

- Direct the completion of interim response design calculations,
- Coordinate with the project manager on the progress of interim response design activities,
- Manage the preparation of plans and specifications for the installation of the interim response action,
- Coordinate and oversee the on-site project representative during installation of the interim response action,
- Monitor and track contractor performance (cost) and the interim response action implementation schedule,
- Coordinate the development of the interim response action operation, maintenance, and monitoring plan,
- Coordinate the implementation of protocols for tracking, reviewing, organizing, and reporting the analysis of operation and performance monitoring samples collected and shipped from the site as per the QAPP
- Coordinate the aspects of the feasibility study.
- Meet/communicate (in coordination/conjunction with project manager) with regulators, as needed.

10.3 Subcontractors and Support

Additional contractors and subcontractors will be identified as discussed in Section 2.4.1 and will meet the quality assurance and quality control requirements as discussed in Section 2.4.2.

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