

**Ivy Material Utilization Center**  
**Revised Corrective Action Plan**

**April 30, 2004**

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## 1.0 Executive Summary

Under contract to the Rivanna Solid Waste Authority (RSWA), Environmental Standards, Inc. (Environmental Standards) and Malcolm Pirnie, Inc. (Malcolm Pirnie) have prepared this Corrective Action Plan (CAP) in partial fulfillment of the requirements set forth in the Virginia Solid Waste Management Regulations (VSWMR). The corrective action program (CAP) requirements of the VSWMR are specified in 9VAC20-80-310, and are administered by the Virginia Department of Environmental Quality (VA DEQ) as relative to the VA DEQ-permitted (Permit No. 125) Ivy Material Utilization Center (Ivy MUC, or Site).

The purpose of this CAP is to present a Site-specific remediation plan that is intended to be protective of human health and the environment, that attain Site Groundwater Protection Standards (GPS), control sources of release to the environment, and comply with applicable state and federal standards for the management of solid waste. This CAP is submitted in a format consistent with *Draft Submission Instructions No. 17, Design of a Correction Action Plan (CAP) Concerning Groundwater Contamination at Regulated Sanitary, CDD, and Industrial Landfills*, V.3-03, and applicable reference(s) in the VSWMR.

The CAP consists of the following individual elements: the main Corrective Action Plan; a Corrective Action Monitoring Plan (CAMP); a Phase 1 *In-situ* Engineered, Enhanced Bioremediation Work Plan (Phase I EBR Work Plan); an Intrinsic Bioremediation Work Plan (IBR Work Plan); a Surface Water Monitoring Plan (SWMP); a work plan for implementation of an Interim Measure at the Paint Pit (Paint Pit Interim Measure Work Plan); and an Operations and Maintenance Plan (O&M Plan). In this submittal, certain elements of each plan are necessarily presented in a generalized format; these elements will be detailed as the Phase I EBR progresses and information becomes available.

Groundwater at the Site is found in each of three somewhat interconnected hydrogeologic units: the overburden, saprolite, and fresh bedrock (consisting of horizontal Schist and Gneiss layers). Groundwater impacts at the Site, in excess of current GPS, are presumed attributable to six waste management cells and a seventh disposal area referred to as "the former Paint Pit area." Each cell has been formally closed in accordance with the VSWMR and the Solid Waste Facility Permit No. 125. The most recently closed cell, Cell 2-unlined, underwent capping in August 2002, but its final closure system is currently being repaired because of a variety of factors, including adverse weather.

The GPS exceedances observed during 2003 groundwater compliance sampling events (Spring 2003) are generally consistent with earlier events that identified volatile organic compounds VOCs in excess of Site GPS. Analytical results of samples from three GPS compliance wells exhibited organic compounds in excess of the GPS during the June 2003 semiannual compliance-monitoring event. VSWMR mandates that the exceedances require remedial action.

An exception to the historical consistency of organic and inorganic groundwater data at the Ivy MUC is a GPS exceedance of the inorganic analyte barium. Barium was identified at concentrations exceeding the GPS in one monitoring well and is currently being evaluated.

To address exceedances of the GPS in the aquifer beneath specific areas of the Ivy MUC, the remedy described in this CAP includes a combination of several corrective actions. A number of in-place controls have already been initiated in accordance with Solid Waste Facility Permit requirements and RSWA's proactive response to remediating groundwater affected by waste disposal activities. Coupled with active groundwater remedial action, the controls in this CAP are considered critical components of the long-term Site remedy. The corrective action components comprising the Site remedy are presented below.

- *In-situ* Engineered, Enhanced Bioremediation (EBR).
- Intrinsic Bioremediation (IBR).
- Paint Pit Interim Measures.
- Existing in-place controls (landfill gas collection and control system, leachate collection and removal system, waste cell final closure systems, and western groundwater pump and treat system).
- Institutional controls (fencing, eventual deed restrictions).
- Presumptive remedies (storm water management, closed cell cap maintenance).

EBR is a proven technology that was judged during preparation of the Assessment of Corrective Measures (ACM) capable of reducing the Site constituents of concern (COCs) to concentrations below their respective GPS. The technology can degrade or convert many organic chemicals into nontoxic or less toxic compounds (*i.e.*, mass reduction in source areas and plume degradation). Results of the microcosm study (laboratory testing) on samples of impacted Ivy MUC groundwater indicate that introduction of a sodium lactate substrate with subsequent Pinellas Dechlorinating Enrichment (PDE) bioaugmentation can stimulate complete dechlorination of VOCs in the laboratory within approximately 30 days.

Based on the results of the microcosm study and recommendations by the study authors, an initial phase of EBR (Phase 1) will be implemented in the MW-17 area of the Ivy MUC. This Phase I EBR will evaluate aquifer-specific effectiveness and application methods for batch additions of sodium lactate followed by bioaugmentation as necessary to promote biodegradation of the observed VOCs within the impacted aquifers at the Site. The Phase I EBR will consist of the installation of injection and observation wells, batch substrate additions, and bioaugmentation. Periodic monitoring of groundwater upgradient and downgradient of the treatment zone will allow the effectiveness of the remedy, under Site conditions, to be evaluated. Injection and observation wells will be completed into two zones of the subsurface, the overburden/saprolite zone, and the fractured bedrock. Following CAP approval by VA DEQ, a public comment period, and integration of the CAP into Permit 125, the Phase I EBR will be indicated and is expected to last approximately 660 days (22 months); a final study report will be submitted to VA DEQ.

Successful demonstration of this initial phase of EBR will provide confirmation that EBR can reduce the concentrations of VOCs in the aquifer to the extent necessary to maintain compliance with permitted GPS at locations beyond the points of compliance. The specific methodologies developed during the Phase I EBR, including substrate and bioaugmentation application rates, application frequency, and suitability of injection and monitoring well spacing,

will be utilized in the design and development of subsequent phases of EBR including likely full-scale deployment.

RSWA proposes that the extent of EBR deployment be consistent with those points of compliance known to exceed the applicable GPS. The magnitude of subsequent phases of EBR deployment will be reevaluated to maintain consistency with groundwater quality information developed between the submittal of this plan and EBR deployment on a broader Site basis (extent may be increased/decreased depending on semi-annual groundwater monitoring results).

In addition, pending successful demonstration via the Phase I EBR, the RSWA will evaluate the application of EBR proximal to the former Paint Pit area to decrease observed concentration of VOCs in the deep bedrock. The intent, however, is not for RSWA to meet GPS levels immediately beneath the former Paint Pit area; rather, it is anticipated that application of the remedy in this area (as well as in the other waste areas) could provide additional long-term benefits to the groundwater.

During implementation of the Phase I EBR, Intrinsic Bioremediation (IBR) will be conducted at other points of compliance where current exceedances of Site GPS have been observed. Implementation of IBR will be conducted in order to actively facilitate reduction of chlorinated hydrocarbon concentrations at these locations, and collect characterization data while the Phase I EBR is being implemented.

A detailed report of groundwater analytical data and associated conclusions from the supplemental former Paint Pit investigation have been submitted to VA DEQ under separate cover. The results of the analysis of samples from a shallow observation well located within the former Paint Pit area confirmed residual groundwater contamination resulting from past disposal practices. Analysis of bedrock groundwater samples collected beneath the Paint Pit area indicate that several of the VOCs identified in the shallow zone are also present at deeper horizons, but other VOCs were not. Further, with few exceptions, the concentrations of constituents detected in the bedrock aquifer were lower than those observed in the overburden. Constituents identified in bedrock water samples that were not detected in the saprolite unit directly underlying the Paint Pit area generally consist of VOC degradation by-products, which are likely attributable to the microbial degradation of chlorinated VOCs.

Although analysis of groundwater samples from the former Paint Pit area bedrock wells yielded positive results for VSWMR Appendix 5.1 constituents similar to those found exceeding Site GPS in a few of the compliance wells, the former Paint Pit area is not believed to represent the single, dominant source of groundwater impacts at the Ivy MUC. Nevertheless, the magnitude of residual groundwater contamination appears sufficient to warrant localized treatment in an effort to expedite meeting GPS criteria, particularly in the North Drainage Area. RSWA is at this time considering implementation of an interim remedial measure in the former Paint Pit area during the evaluation of the Phase I EBR. During this 2-year period, RSWA is evaluating installing and operating a soil-vapor extraction (SVE) system in the area of the former Paint Pit. Details of the implementation of this interim measure are identified in the attached Paint Pit Interim Measure Work Plan. The final decision on SVE implementation in the former Paint Pit area will depend on several factors, including budgetary constraints and potential future groundwater issues (such as the unplanned barium work). Regardless of whether SVE is

implemented, if the Phase I EBR suggests that the EBR remedy will be successful site-wide, EBR will be incorporated at the former Paint Pit area in a subsequent phase.

Finally, a Surface Water Monitoring Plan has been developed and included in this CAP. The SWMP has been developed to monitor surface water conditions before and during implementation of the CAP.

## 2.0 Introduction

The Rivanna Solid Waste Authority (RSWA) retained Environmental Standards, Inc. (Environmental Standards) and Malcolm Pirnie, Inc (Malcolm Pirnie) to provide professional environmental consulting and remediation services related to the remediation of groundwater at the Ivy Material Utilization Center (Ivy MUC or Site). The Ivy MUC operates under Solid Waste Facility Permit No. 125. Specifically, the RSWA directed Malcolm Pirnie and Environmental Standards to prepare a Corrective Action Plan (CAP) to comply with the corrective action program requirements of the Virginia Solid Waste Management Regulations (VSWMR) stipulated in 9VAC20-80-310, *et. seq.* as administered by the Virginia Department of Environmental Quality (VA DEQ).

### 2.1 CAP Purpose

The purpose of the CAP is to present a written Site-specific remediation plan that is protective of human health and the environment, that can attain Site groundwater protection standards (GPS), that controls the source of the releases responsible for a GPS exceedance, and that complies with applicable state and federal standards for the management of solid waste.

### 2.2 Regulatory Requirements

The format of this CAP is consistent with *Draft Submission Instructions No. 17, Design of a Correction Action Plan (CAP) Concerning Groundwater Contamination at Regulated Sanitary, CDD, and Industrial Landfills, V.3-03 (submission instructions)* and other applicable reference(s) as well as the regulations set forth in 9 VAC 20-80-310, Corrective Action Program of the VSWMR.

The submission instructions referenced above are applicable to all solid waste facilities conducting groundwater monitoring under the requirements of the VSWMR, promulgated by the Virginia Waste Management Board, December 21, 1988, as amended. As directed under 9 VAC 20-80-310.B, the RSWA must choose a remedial remedy and present that choice to the Director in a written CAP. These submission instructions have been designed to address the technical content requirements of a CAP.

### 2.3 CAP Organization

The CAP is organized into eleven sections as presented below.

**Section 1 - Executive Summary:** Section 1 provides a brief description of the extent of the groundwater release, a summary of contaminants of concern, and a summary of the remedies chosen for corrective action.

**Section 2 - Introduction/Regulatory Requirements (this Section):** Section 2 provides an introduction to the Corrective Action Program, a description of the purpose of the CAP, the regulatory requirements associated with the CAP, and document organization.

**Section 3 - Site Description:** Section 3 presents a brief summary of the Site location, monitoring well network, hydrologic conditions affecting contaminant migration, and a listing of potential on-site receptors. Topics included are the physical setting (USGS map and land use issues), aquifer recognition (names of aquifers, structural controls, constituents of concern, and potentiometric map), monitoring network (locations and descriptions of wells), and potential receptors (aquatic terrestrial, and human).

**Section 4 - Site Remedy:** Section 4 describes the selected Site remedy and presents factors that support the selected corrective actions. This section of the CAP also describes contingencies for interim actions or alternative remedies as required. Information of the remedy design and specifications, remedy implementation, project schedule, and the operations and maintenance plan are also included in this section.

**Section 5 - Corrective Action Monitoring Program:** Section 5 contains a summary of the Corrective Action Monitoring Plan (CAMP), including the corrective action monitoring well network, the groundwater constituent list, and the groundwater sampling frequency.

**Section 6 - Scheduled Performance Evaluations:** Section 6 addresses how the RSWA will evaluate the performance of remedial actions. Specific performance evaluation criteria topics are identified in this section.

**Section 7 - Public Participation Plan:** Section 7 provides public participation information related to the corrective action program, including the location of a data repository to meet the US EPA's RCRA public participation guidelines and the identification of the name, address, and phone number of the RSWA Contact Person to whom questions from the general public may be submitted.

**Section 8 - Completion of Corrective Action:** Section 8 describes the actions that will be undertaken and the information that will be submitted to VA DEQ to meet the requirements of 9 VAC 20-80-310.C.5 and 6, when the Corrective Action Monitoring Program indicates that no GPS exceedances have been identified for a period of 3 consecutive years.

**Section 9 - References:** Section 9 presents a list of documents and publications utilized during the development of this CAP.

**Tables:** This section provides tables related to information referenced in the text.

**Figures:** This section includes figures and drawings related to site conditions and remedy design.

**Appendices:** This section includes detailed plans including the CAMP, Phase I EBR Plan, IBR Monitoring Plan, O&M Plan, SWMP Plan and Paint Pit Interim Remedial Measures.

### 3.0 Site Description

A thorough description of the Site including the local and regional setting is presented in the Nature and Extent Study (NES; prepared by Joyce Engineering, Inc. [JEI] in 1996), the NES Addendum (JEI, 1999), and the Assessment of Corrective Measures (ACM; prepared by Malcolm Pirnie and Environmental Standards in October 2002, and revised on April 7, 2003). The reader is referred to these documents for detailed information regarding the Site. A summary of the most pertinent Site-related information is provided in the following subsections.

#### 3.1 Physical Setting

The Ivy Material Utilization Center (Ivy MUC) is located west of the City of Charlottesville in Ivy, Albemarle County, Virginia (Figure 3-1). The Ivy MUC consists of a 300-acre property, of which approximately one-third has been used for permitted landfilling operations (Figure 3-2). The remaining two-thirds of the property is comprised of Ivy MUC operations and maintenance structures; waste transfer areas; leachate and storm water management ponds; borrow areas; and undisturbed, forested, and managed green space. Broad Axe Creek and US Interstate 64 bound the northern property line. Virginia Route 637 bounds the Ivy MUC southern property line. The Ivy MUC abuts private property on the east and is bordered by private property and a stream on the west.

There are six formally closed waste cells at the IMUC (Figure 3-2).

- Cell 1-lined and Cell 1-unlined are located in the central-south area of the Ivy MUC;
- Cell 2-lined (located in the west central portion of the Ivy MUC, west of Cell 1-lined) and Cell 2-unlined comprise the eastern area of the Ivy MUC; and
- Cell 3-lined and Cell 3-unlined are located in the northwestern portion of the Ivy MUC.

A seventh disposal area, referred to as “the former Paint Pit area,” is centrally located in the Ivy MUC. The former Paint Pit area is surrounded by Cell 3-unlined, Cell 1-lined, Cell 1-unlined, and Cell 2-unlined.

Waste cells and the former Paint Pit area have been closed and all have at least one VSWMR-compliant overlying cap system. The last cell to be closed, Cell 2-unlined, underwent capping in August 2002. The cap to Cell 2-unlined is currently being re-engineered and repaired because of a variety of factors (mainly adverse weather). The Ivy MUC cap systems for each Ivy MUC cell meet or exceed VA DEQ closure standards and these cap systems and their construction characteristics have been approved by VA DEQ.

Four cells (Cell 3-unlined, Cell 1-lined, Cell 2-lined, and Cell 3-lined) and the former Paint Pit area have active gas extraction systems that are connected to a vacuum collection system. The active Ivy MUC gas extraction system, an in-place control, extracts Ivy MUC-generated gases to the flare system located in the southwest property area. Also located in this area is the air stripper building, which is part of the western pump and treat system (PTS), an additional in-place control.

Of note in the western area of the Ivy MUC are the leachate pump station and leachate storage basin. The pump station and storage basin serve to collect leachate from the bottom liners of Cell 1-lined, Cell 2-lined, and Cell 3-lined.

Municipal solid waste (MSW), construction and demolition debris (CDD), and asbestos-containing materials were accepted at the Ivy MUC from 1973 to July 1998. No formal records were maintained of the specific nature of waste materials accepted at the Ivy MUC from 1968 to 1973.

A designated area for disposal of waste solvents (the former Paint Pit area) closed in approximately 1980. The former Paint Pit area was initially closed with three low permeability soil and synthetic VA DEQ-approved cap systems.

After July 1998, only CDD waste was accepted when the Ivy MUC ceased acceptance of other waste types. On-site waste disposal ended by September 1, 2001; however, clean fill material is still accepted.

### 3.1.1 Topography

Site topography is shown in Figure 3-3. Contours are based on aerial survey methods completed by Bell Surveys on February 6, 1997, and as updated within the limits of Cell 2-unlined on October 8, 2001. Once Cell 2-unlined has been capped and final grading and seeding has been completed, the Ivy MUC will be resurveyed; this survey is expected to be done during the fall of 2004.

Ground surface elevations at the Ivy MUC range from approximately 540 feet to 770 feet above mean sea level (MSL). The point of maximum elevation is located in the southwestern corner of the property on an isolated hill. Three intermediate high elevation points exist within the Ivy MUC property at Cell 1-unlined, Cell 2-unlined, and Cell 3-unlined.

Site topography consists of moderately steep rolling hills and longitudinal ridges separated by broad valleys. Generally, the Site slopes from the Ivy MUC towards unnamed tributaries of Broad Axe Creek along the property's north, east, and west sides. The property topographical low is located along the northern property boundary at the point where Broad Axe Creek exits the property. Topographic features are illustrated in Figure 3-3.

### 3.1.2 Area Land Use

The Ivy MUC is set in a rural area that consists of undeveloped woodlands and maintained agricultural pasturelands. Immediately adjacent to the property's eastern and western boundaries are private residential properties, each consisting of a few acres.

The Peacock Hill residential subdivision, a 350-acre residential development (195 home sites) located north of US Interstate 64, is the closest clustered residential setting. The subdivision is located approximately 1 mile from the Ivy MUC. A church and cemetery are located less than

1 mile from the property's southwestern property line. A privately owned historical site, Malvern Farm, is located east of the Ivy MUC property. Construction has begun on a subdivision south of the Site immediately across Route 637.

### 3.1.3 Physiography

The Ivy MUC is located in the Piedmont Physiographic Province of Virginia, east of the Blue Ridge Mountains (Figure 3-4). According to information obtained from the College of William and Mary (2003), the Piedmont is the largest physiographic province in Virginia. This province is bounded on the east by the Fall Zone, which separates the province from the Coastal Plain, and on the west by the mountains of the Blue Ridge province. The province is characterized by gently rolling topography, deeply weathered bedrock, and a relative paucity of solid outcrop. Rocks are strongly weathered in the Piedmont's humid climate and bedrock is generally buried under a thick (6-120 feet) blanket of saprolite. Outcrops are commonly restricted to stream valleys where saprolite has been removed by erosion. The topography becomes somewhat more rugged with proximity to the Blue Ridge, where local hills formed of more resistant rock occur.

A variety of igneous and metamorphic rocks make up the bedrock of the Piedmont Province. Most of these rocks range in age from Proterozoic to Paleozoic and form the internal core of the ancient Appalachian mountain belt. Triassic sedimentary rocks, diabase dikes, and basalt flows are present in a number of grabens and half-grabens that formed during the early stages of rifting associated with the opening of the Atlantic Ocean. Rivers and streams carrying sand, silt, and mud flowed into these lowland rift basins burying swamps and marshes, later producing small coal measures.

Many rocks exposed in the Piedmont have a complex geologic history and some may have formed in regions outside of North America. The oldest rocks are about 1.1 billion years old and occur in an area just west of Richmond known as the Goochland terrane. Rocks of the Goochland terrane bear many similarities to Grenville-age rocks in the Blue Ridge province, including the presence of anorthosite in the small Montpelier body. Other terranes include Cambro-Ordovician igneous rocks that are interpreted to be the remains of an ancient volcanic arc (much like the present-day Aleutian Islands) that collided with and accreted onto the eastern edge of North America during a period of Appalachian mountain building. Granitic rocks of Paleozoic age are common and also formed during this time.

Many terranes, such as those in the vicinity of the Ivy MUC, have experienced multiple episodes of metamorphism and deformation, resulting in a complex geologic province.

### 3.2 Possible On-Site Risks

The current understanding of potential human health and ecological risks associated with the Ivy MUC is based on the Preliminary Risk Assessment that was presented in the Nature and Extent Study (NES) by CTI (1996), two benthic community surveys conducted by VA DEQ in 1996 and 1999, and an ecological survey conducted by Environmental Standards in 2002.

Assessments of the on-site risks are detailed in these documents and are summarized in the following subsections.

### 3.2.1 Potential On-Site Human Health Risks

The risk evaluation presented in the 1996 NES was prepared by CTI and addressed potential exposures and risk characterization for human health.

CTI considered actual or potential exposure to soil or surface water at the Ivy MUC to present a nominal level of potential risk to human health. CTI examined surface water as a principal exposure medium for human receptors. CTI noted that restricted access to the Ivy MUC property, on-site collection of storm water, no known proximate surface water intakes, and no recreational use of the adjacent creeks significantly minimize the potential for human exposure. The same is true today.

Low compound concentrations in near surface soils, the restricted use of the Ivy MUC, and the use of containment caps minimize the risk for human exposure to soil. For on-site groundwater, the 1996 NES concluded there were no unacceptable non-carcinogenic hazards.

Potential cancer risks identified in the CTI report were conservatively evaluated on the basis of drinking untreated groundwater directly from an impacted on-site monitoring well (MW-17D), for a lifetime (the estimate was based on a 170-pound person, drinking 2 liters of water a day from well MW-17D, virtually every day of the year for 30 years).

While the likelihood of an individual ever drinking water from a groundwater well installed beneath the Ivy MUC property is virtually zero, it is noteworthy that the report's authors estimated that an individual's lifetime cancer risk would only increase by four hundredths of a percent from approximately 30 percent (the background cancer risk) to 30.04 percent (this includes incorporation of very conservative exposure scenarios).

### 3.2.2 Potential On-Site Ecological Risks

Historical risk-associated documents developed for the Ivy MUC include the Preliminary Risk Assessment (JEI, 1996), a memorandum from VA DEQ to C. R. Smith (1996), and a memorandum from VA DEQ to D. Kain (1999). The ecological risk assessment portion of the 1996 Preliminary Risk Assessment document entailed a screening-level analysis of surface water samples collected from various on-site monitoring points. The analysis indicated that maximum concentrations of organic compounds (semivolatile organic compounds [SVOCs] and volatile organic compounds [VOCs]) did not exceed acute or chronic federal Ambient Water Quality Criteria (AWQC) established for the protection of freshwater organisms. Maximum concentrations of copper, mercury, and zinc exceeded chronic AWQCs; however, the report concluded that there were "...no readily apparent patterns of [copper, mercury, and zinc] in surface water...that would warrant concern for ambient water quality in the vicinity of the Ivy property."

Semiannual analyses of surface water samples from Broad Axe Creek and its western tributary during compliance monitoring events did not yield concentrations of copper, mercury, and zinc at levels in excess of chronic AWQCs.

The invertebrate community assessment conducted in 1996 included the collection of benthic invertebrates from a reference location (a small tributary to Broad Axe Creek on the eastern portion of the Ivy MUC) and two other locations (one north of the reference location and one on the unnamed tributary west of the waste cells). Biometric scores generated from the identification and enumeration of collected invertebrates indicated that no noticeable impairment of benthic communities was detected at stream locations draining the Ivy MUC compared to the reference stream; however, the document concluded that “meaningful information could not be generated by further work using benthic studies.”

The benthic community assessment conducted in 1999 focused on four locations at the Ivy MUC: two sites in the unnamed tributary bordering the western portion of the Ivy MUC and two sites in Broad Axe Creek. Two of the four sites (one in the unnamed western tributary and one in Broad Axe Creek) were upstream of potential influence by the Ivy MUC; the other two sites drained the Ivy MUC. Resulting community metrics indicated an ecological change in the downstream portion of the western tributary attributed more to dissimilarities in the level of deposition, embeddedness, and other physical habitat features rather than toxicity.

Additionally, the magnitude of the impairment did not indicate a violation of water quality standards. In Broad Axe Creek, there was no evidence of impairment of the benthic community below the Ivy MUC.

During July 2002, an ecological survey of the Ivy MUC area was conducted by an Environmental Standards qualified ecologist trained in ecological risk assessment and community-level evaluations. In general, observations made during the July 2002 survey suggested a healthy ecological community in the riparian/wetland areas adjacent to the Ivy MUC. Much of the focus of the ecological survey was placed on visual detection of ecological impairment of the aquatic and semi-aquatic habitats present.

According to the Virginia National Heritage Program (VA NHP), sponsored by the Virginia Department of Conservation and Recreation, the Ivy MUC does not coincide with areas of known occurrences of rare plants or animals in Albemarle County (VA DCR, 2002). Currently, the United States Fish and Wildlife Service (US FWS) has designated 70 species as threatened, endangered, or experimental populations in Virginia. The list includes 57 animal species and 13 plant species. No threatened or endangered species, as identified by the US FWS, were noted during the July 2002 ecological survey.

### 3.3 Aquifer Characteristics

The following subsections identify the characteristics of the impacted aquifer, hydrogeologic conditions, and the nature and extent of constituents that have been identified in groundwater samples in excess of the Site GPS.

### 3.3.1 Nature of Impacted Aquifer

The Site is underlain by three major hydrogeologic units: the overburden, saprolite, and fresh bedrock (consisting of horizontal Schist and Gneiss layers).

The uppermost unit (overburden) consists primarily of silty residual soils with minor amounts of sand and clay. Sandy alluvial deposits are present in and beneath portions of the creeks bordering the Site. The thickness of measurable overburden encountered at the Site ranged from zero at rock outcrops to over 60 feet below ground surface (bgs), with an average range in thickness of approximately 2 to 25 feet. The overburden acts as an unconfined aquifer, and the hydraulic conductivity of this material is estimated to be on the order of  $10^{-5}$  centimeters per second (cm/sec). Overburden samples typically exhibited streaking and micaceous composition.

The overburden grades downward into the middle unit (saprolite), which consists of friable sand and silt with relict gneiss structure, containing fragments of gneiss and mica schist grading to highly fractured weathered bedrock. The thickness of measurable saprolite encountered at the Site ranged from zero at rock outcrops to 46 feet bgs, with an average range in thickness of approximately 15 to 20 feet. The hydraulic conductivity of this material was estimated to be on the order of  $10^{-5}$  cm/sec. Saprolite sampled at the Site typically exhibit remnant foliation, features, and fragments of the parent rock.

The saprolite unit grades downward into the bottommost unit of competent, unweathered mica schist and gneiss bedrock with few fractures. Fractures decrease in number with increasing depth. Fractures observed in bedrock are predominantly near-horizontal or coincident with contacts between schist and gneiss layers. The depth to measurable bedrock encountered at the Site ranged from zero at outcrops to approximately 70 feet bgs, with an average range in depths of approximately 3 to 40 feet bgs. The hydraulic conductivity of bedrock encountered at the Site was estimated to be on the order of  $10^{-4}$  cm/sec and is believed to be primarily controlled by fractures existing in the bedrock.

### 3.3.2 Structural Control on Constituent Migration

Constituent migration within the saprolite may be expected to be related to higher permeability zones that may exist within remnant foliations characteristic to this geological unit. The results of hydrogeologic studies within this unit indicate that the degree to which these higher permeability zones exist and are interconnected is relatively low. Seepage velocities within this unit have been calculated to be on the order of 5 to 50 feet per year.

Within the bedrock unit, groundwater flow is expected to be controlled by fracture size, frequency, and interconnectedness. Existing hydrogeologic evaluation data suggest that fracture size and interconnectedness is highly variable within the bedrock; however, on average, seepage velocities are expected to fall within the range of 5 to 50 feet per year. To date, no coring of the bedrock has taken place at the Ivy MUC. The specific characteristics of the

fractures are key to successfully implementing the proposed remedy; consequently, a coring program has been proposed as part of the Phase I EBR Work Plan (Appendix A).

### 3.3.3 Constituents of Concern

Groundwater impacts, in excess of the Site GPS, at the Site have been reported at several wells downgradient of Ivy MUC waste disposal cells. The former Paint Pit area groundwater assessment is addressed in subsequent sections (including recent groundwater sampling and analysis efforts in that area); however, the other historical exceedances were presented in the Assessment of Corrective Measures (ACM) and are not repeated in this CAP. Since the monitoring program began, constituent concentrations in groundwater have changed or are somewhat variable; the discussion that follows is based on the GPS exceedances observed in the June 2003 Compliance monitoring event completed by Environmental Standards (Table 3-1).

#### **Volatile Organic Compounds (VOCs)**

The GPS exceedances observed in the June 2003 event are generally consistent with earlier events that identified VOCs in excess of Site GPS. Analytical results of samples from three wells (MW-2, MW-17, and MW-32) exhibited VOC concentrations in excess of the GPS during the June 2003 semiannual compliance monitoring event. VOCs found to exceed the Site GPS during this sampling event included 1,2-dichloropropane; benzene; *cis*-1,2-dichloroethene; isobutyl alcohol; methylene chloride; tetrachloroethene; trichloroethene; and vinyl chloride.

#### **Semivolatile Organic Compounds (SVOCs)**

The compound bis (2-ethylhexyl) phthalate (BEHP) was identified as the sole SVOC to exceed the site-specific GPS. BEHP is a common laboratory contaminant and the detection of this analyte in excess of a GPS is a random, transient occurrence and is somewhat suspect. In the June 2003 event, BEHP was identified at a laboratory-estimated concentration slightly in excess of the GPS.

#### **Barium**

An exception to the general consistency of data at the Ivy MUC is the GPS exceedance of the inorganic analyte barium. Barium was identified in MW-32 at a concentration of 6,600 micrograms per liter ( $\mu\text{g/L}$ ) in June 2003. The GPS for barium is 5,823  $\mu\text{g/L}$ . This exceedance was confirmed in a subsequent verification resampling event in July 2003 when the concentration was reported as 6,200  $\mu\text{g/L}$ . VA DEQ was informed of this exceedance pursuant to permit requirements in a letter from RSWA to VA DEQ on August 20, 2003.

Barium has only recently (since July 2003) been identified in groundwater samples from MW-32 at verifiable concentrations in excess of the GPS. With approval and oversight by VA DEQ, a focused nature and extent study (NES) for barium has been initiated in the vicinity of MW-32.

RSWA has authorized additional investigative actions to more fully investigate the barium GPS exceedance in MW-32. This evaluation will assist RSWA in evaluating the potential need to undertake a remedy specifically for this analyte in this area of the landfill.

In early September 2003, Environmental Standards collected total (unfiltered) and dissolved (filtered) groundwater samples at MW-32, MW-34, MW-34DD, MW-9 and MW-10 for barium analysis. The purpose of this first step was to evaluate potential temporal variations in barium concentrations detected in MW-32 groundwater samples and to evaluate, in a gross sense, the potential aerial extent of a possible barium "plume" in this area of the landfill property.

Outlying wells did not show significant concentrations of barium (relative to historical and background data), suggesting that barium from the IMUC is not leaving the property; as a result of the consistent GPS exceedance for barium in MW-32, the need for monitoring wells more proximate to MW-32 was evaluated. Additional wells near MW-32 would serve to more fully delineate the extent of the potential plume within the landfill boundary and to better characterize the potential plume for possible remedial action.

The first phase of activities undertaken in September 2003 constituted the beginning of a focused barium Nature and Extent (NES) investigation in accordance with 9 VAC 20-80-300.B.3.g.(1). Since sampling of the wells, five additional new barium-NES wells (MW-32D, MW-39, MW-39D, MW-40, and MW-40D) have been installed in the area of MW-32 (November 2003). These wells were surveyed during December 2003 and sampled for the first time in early January 2004. Data from this initial sampling event is currently under validation review for quality assurance/quality control purposes.

Following the completion of this NES for barium, RSWA will initiate a risk assessment and/or an assessment of corrective measures (ACM) for barium in groundwater in this area of the Ivy MUC. It is not the intent of RSWA, however, to change focus from the VOC-driven CAP at this time. It is anticipated that barium investigation activities will parallel the actions outlined in this CAP.

As part of Site work, RSWA will provide status reports to VA DEQ, including an evaluation of barium in groundwater as sampling and analysis of groundwater from the newly installed barium NES wells (MW-32D, MW-39, MW-39D, MW-40, and MW-40D) is completed. These data are expected to provide additional information regarding the characteristics and mobility of barium in the aquifer at the Ivy MUC.

The remedy selected during the ACM process, EBR, will be evaluated under Site conditions through the implementation of Phase I EBR Work Plan (see Section 4.1.1) in the vicinity of MW-17. Though specifically designed to degrade chlorinated VOCs, the remedy is expected to consume the non-chlorinated VOCs through co-metabolic processes. Barium is not expected to be directly affected through implementation of the remedy, although it is possible that observed concentrations and mobility of barium might change through secondary effects of the microbial processes and changes in geochemical conditions.

VA DEQ is requiring RSWA to implement an IBR remedy (see Section 4.1.2) in areas of the Site where compliance monitoring has identified GPS exceedances (vicinity of MW-2, MW-5, MW-17, MW-32, and potentially MW-36 and MW-37). The purpose of implementing IBR in

these areas is to satisfy the VA DEQ requirement of immediate implementation of a corrective remedy at the locations of all GPS exceedances beyond the points of compliance.

#### 3.3.4 Groundwater Flow

Groundwater flow in the overburden and saprolite is likely to move at different rates through alternating thin layers of more permeable sands interlayered with less permeable silts or clays occurring at different elevations in the aquifer. Groundwater flow in bedrock is likely to move at different rates dependent upon the degree and orientation of fracturing and the nature of the fractures in the subsurface.

Regionally, groundwater flows to the north, generally mirroring, as a subtle expression, topographic contours. Within the Site, groundwater flows to the north, east, and west in a radial pattern toward Broad Axe Creek and its western tributary. Shallow groundwater flow (in the overburden and saprolite) and the water table surface are largely influenced by, and generally mirror Site topography. In the deeper bedrock unit, groundwater flow is generally consistent with regional flow, although fracturing may impart a different small scale (tens of feet) flow direction from that indicated by the shallow groundwater potentiometric surface.

Water table depth at the Site ranges from as much as 73 feet bgs on hilltops to as little as 4 feet bgs in the drainage areas, with two known cases of artesian conditions (the potentiometric head of the groundwater is higher than the ground surface) occurring in the vicinity of the northern drainage area immediately adjacent to the main stem of Broad Axe Creek (MW-26D and MW-41).

Horizontal hydraulic gradients observed at the Site range from approximately 0.16 ft/ft on hill-slopes adjacent to areas of groundwater discharge to approximately 0.01 ft/ft on flat to gentle-sloping areas. See Figure 3-5 for presentation of Site hydrological information. Vertical gradients as indicated by depth-to-water measurements collected from nested wells during the June 2003 compliance sampling event show a wide range in interpreted gradients. In the area of MW-17 and MW-19, located to the north of Cell 2-unlined, potentiometric head in the bedrock well is 15 feet to 20 feet lower than that observed in the shallower wells. To the east of Cell 2-unlined, using the MW-5 series wells, the bedrock well has a potentiometric surface approximately 10 feet higher than the shallower wells. Near the western tributary to Broad Axe Creek, the potentiometric surface measured in MW-33DD is approximately 2 feet to 5 feet lower than that observed in the shallower wells in that nest. The nested wells located in the median of I-64, the MW-35 series wells, show the shallow and deep well with a similar potentiometric surface whereas the middle, saprolite well has a potentiometric surface over 15 feet deeper.

Aquifer recharge occurs through vertical surface water and precipitation infiltration in the higher elevations of the Site, with additional contributions from the upland slope areas surrounding the waste cells and the man-made unlined sediment ponds that collect surface runoff. Largely, groundwater remains in the shallow aquifers until it is discharged to surface water at or near the ground surface. A minor amount of overburden/saprolite groundwater is presumed to descend vertically into the bedrock aquifer via the relict weathered fracture network.

Environmental Standards evaluated aquifer connectivity during a hydrogeologic investigation conducted at the Site in July 2003. Forty-eight-hour pumping tests were performed at two nested-well locations (MW-19 and MW-33) where groundwater levels in pumping wells (screened in the bedrock aquifer) experienced significant drawdown, while groundwater levels in observation wells (immediately adjacent to the pumping wells, screened in the saprolite and overburden aquifers, respectively) exhibited no fluctuations from static elevation. These data suggest that the hydraulic units are poorly connected hydraulically, though groundwater at the Site is considered to be interconnected sufficiently to enable the various geologic units to be characterized as one aquifer (based on the observation that impacted groundwater is identified in the overburden, saprolite, and bedrock).

### 3.3.5 The Former Paint Pit Area

A summary of groundwater analytical data and associated conclusions from the Paint Pit Investigation Report completed in December 2003 (submitted separately) is provided in the following paragraphs. A detailed presentation of these data are provided in the March 2004 Malcolm Pirnie report titled "*Inactive Ivy Landfill Addendum to Paint Pit Investigation Report.*"

The results of the analysis of samples from OW-1 (a relatively shallow saprolite observation well located within the former Paint Pit area) confirmed the detection of various VOCs, including benzene, chloroform, dichloromethane, toluene, and trichloroethene, and several SVOCs, including acetophenone, benzyl alcohol, bis(2-chloroethoxy)methane, cresol (*o*, *m*, and *p*), naphthalene, and phenol.

Three bedrock wells were installed in the former Paint Pit area (OW-1DD, OW-3DD, and OW-4DD) as part of this recent investigation. The analysis of groundwater samples from these wells indicates that several VOCs identified in OW-1 were not identified in the newly installed bedrock wells. Of the compounds identified that were common to both OW-1 and the bedrock wells, the concentrations of constituents detected in the bedrock wells are, in general, lower than that observed in the overburden. Exceptions to this generality are methylene chloride, which was detected at a greater concentration in OW-4DD, and trichloroethene, which was detected at a greater concentration in OW-3DD. Both of these VOCs were detected at relatively low concentrations when compared to the solubility limit of each constituent. Other constituents identified in the bedrock wells that were not detected in OW-1 generally consist of degradation by-products that are likely attributable to the microbial degradation of chlorinated VOCs in the overburden.

Although analysis of groundwater samples from the bedrock wells identified the presence of VSWMR Appendix 5.1 constituents, the former Paint Pit area is not believed to represent a major contributing source of ongoing groundwater impact due to the significant degree of hydraulic isolation provided by the multi-cap system, the separation of the base of the former Paint Pit area from the static groundwater level, and the absence of free liquids encountered between the base of the former Paint Pit area and the groundwater.

### 3.4 Groundwater Monitoring Well Networks

Two groundwater monitoring well networks will be utilized as part of the implementation of the CAP. The first is the Compliance Monitoring System, which consists of the existing monitoring well network defined in the Site's operating permit. The groundwater monitoring wells in this network are designed to monitor Site groundwater to identify new or varying releases from the waste disposal cells.

The second monitoring well network is the Corrective Action Monitoring System (CAMS), which is designed to monitor the performance of corrective actions employed at the Ivy MUC. More details of the Site Compliance Monitoring System are provided in the following subsections; considerable detail is presented in the appended CAMP (Appendix B).

#### 3.4.1 Compliance Monitoring System (CMS)

Groundwater Compliance monitoring at the Site is currently in an *Assessment Monitoring Program* status in accordance with 9 VAC 20-80-300.B.3 of the VSWMR. This Program includes a requirement to compare groundwater analytical results with the Site Groundwater Protection Standards (GPS), which were incorporated into the Ivy MUC Solid Waste Management Permit #125 on April 1, 1999.

In accordance with Virginia Solid Waste Management Regulations (VSWMR) 9 VAC 20-80-300.B.3, VA DEQ requires RSWA to sample Compliance wells associated with Ivy MUC closure at the Site on a semiannual basis for the analytes listed in VSWMR Appendix 5.1, including VOCs, SVOCs, pesticides, herbicides, cyanide, sulfide, and metals.

The Compliance Monitoring System (CMS) (Figure 3-2) consists of 13 wells, including one upgradient well (MW-7) and 12 downgradient wells (MW-2, MW-3, MW-5, MW-6, MW-8, MW-11, MW-12, MW-13, MW-17, MW-18, MW-31, MW-32). All Compliance monitoring wells are constructed of 2-inch diameter Schedule 40 PVC pipes, with screen slot width of 0.010 inch, with the exception of MW-17 and MW-18, which are constructed of 2-inch diameter stainless steel well materials.

Pursuant to a request by VA DEQ, construction of two new monitoring wells (MW-36 and MW-37) for the purpose of replacing monitoring wells MW-12 and MW-13 in the Compliance Monitoring System was completed in 2003. Monitoring wells MW-12 and MW-13 remain active Compliance monitoring wells until their replacement by MW-36 and MW-37 is incorporated into the Site operating permit.

Efforts to continue to effectively monitor Site groundwater characteristics may require installation of additional and/or replacement monitoring wells. Compliance monitoring well placement will be determined by examining pertinent hydrological information and groundwater characteristics.

### 3.4.2 Corrective Action Monitoring System

The Corrective Action Monitoring System (CAMS) is a network of observation wells that will be constructed for the purpose of monitoring the performance of implemented corrective actions (EBR and IBR). The wells that comprise the CAMS have been (in the case of the barium NES wells which are to be included in the CAMS) or will be installed during the implementation of the CAP.

The CAMS will be used to monitor the performance of groundwater corrective actions. The location and construction of monitoring wells that form the CAMS will be established as an ongoing activity as part of implementation of the CAP. Currently, the CAP has been developed to address groundwater impacts from a variety of VOCs. As a result, the CAMS is designed to monitor the VOC-impacted groundwater. Changes in groundwater chemistry during the course of CAP implementation may result in modifications to the CAMS and the design bases identified in the following sections.

#### **Organic Compounds**

The location and final construction details of the CAMS monitoring points will be defined during implementation of the Phase I EBR Work Plan and IBR Work Plan and subsequent deployment of additional phases of EBR. The purpose of these monitoring wells will be to provide access to groundwater upgradient and downgradient of the injection wells installed as part of the VOC remedy. Through direct measurement and analysis of samples collected from these monitoring points, the effectiveness and efficiency of the VOC remedy will be evaluated. The proposed location and construction of the Phase I EBR and IBR CAMS monitoring wells are defined within their respective Work Plans (included as Appendix A and Appendix C respectively).

The CAMS monitoring wells installed as part of the Phase I EBR will be sampled on a semimonthly and monthly basis beginning at least 1 month prior to the initial injection of substrate. At each monitoring well, *in-situ* measurements of dissolved oxygen (DO), pH, temperature, and oxidation-reduction potential (ORP) will be collected. Samples will then be collected for laboratory analysis for total organic carbon (TOC), VSWMR Appendix 5.1 VOCs, RSK gasses (methane, ethane, and ethane), nitrates, and sulfates.

#### **Barium**

As identified in Section 3.3.3 of this CAP, the characteristics and mobility of the barium-impacted groundwater will be periodically evaluated during implementation of the Phase I EBR. This evaluation will occur through periodic collection and analysis of samples from the barium NES wells (namely MW-32D, MW-39, MW-39D, MW-40, and MW-40D) and Compliance well MW-32.

The monitoring wells defined to monitor barium-impacted groundwater (MW-32, MW-32D, MW-39, MW-39D, MW-40, and MW-40D) will be sampled on a quarterly frequency. At each monitoring well, measurements will be collected for DO, pH, temperature, and ORP. Samples will be collected for laboratory analysis for VSWMR Appendix 5.1 VOCs and barium.

### 3.4.3 Sentinel Groundwater Monitoring Well Network

A Sentinel Well network has been established at the IMUC as part of a calendar year (CY) 2000 Settlement Agreement between RSWA and a group of neighboring property owners. The current Sentinel Well network consists of five monitoring wells (Batton Well, BW-1DD, MW-35DD, MW-38, and MW-41). These wells are monitored on a semiannual basis in accordance with the private Settlement Agreement. The Sentinel Well network, as the term is applied herein, is not included within Compliance or Corrective Action monitoring programs that will be regulated by VA DEQ as part of the closure permit.

### 3.4.4 Other Groundwater Monitoring Wells

The majority of other groundwater monitoring wells that exist at the Site (BW-1D, MW-4, MW-5D, MW-5DD, MW-9, MW-10, MW-14, MW-15, MW-16, MW-17D, MW-17DD, MW-19, MW-19D, MW-19DD, MW-20, MW-20D, MW-21, MW-21D, MW-22, MW-25, MW-26, MW-26D, MW-27, MW-30D, MW-32D, MW-33, MW-33D, MW-33DD, MW-34, MW-34DD, MW-35, MW-35D, MW-36, MW-37, MW-39, MW-39D, MW-40, MW-40D, OW-1, OW-1DD, OW-3DD, and OW-4DD) were constructed during prior nature and extent study work at the Site. Where practical, these wells will be utilized as monitoring wells during implementation of the CAP. None of these wells are proposed to be abandoned at this time.

Table 3-2 identifies the current and proposed, as part of this CAP, Site monitoring wells and their associated monitoring program(s).

## 4.0 Site Remedy

This section describes the selected Site remedy and factors supporting the selected corrective action. This section of the CAP also describes contingencies for interim actions or alternative remedies if they are required. Detailed information of the remedy design and specifications, remedy implementation, project schedule, and the operations and maintenance plan are also included in this section.

### 4.1 Remedy Design and Specifications

To address exceedances of the GPS throughout specific areas of the IMUC, the remedy includes a combination of several corrective actions. A number of in-place controls have already been initiated at the Ivy MUC as part of the Solid Waste Facility Permit requirements and RSWA's proactive response to remediating groundwater affected by waste disposal activities. Along with aggressive groundwater remedial action, these controls are considered critical components of the Site remedy and are included in this Corrective Action Plan (CAP). The corrective action components comprising the Site remedy are cited below.

- *In-situ* Engineered, Enhanced Bioremediation (EBR).
- Intrinsic Bioremediation (IBR).
- Paint Pit Interim Corrective Measure.
- Existing in-place controls (landfill gas collection and control system, leachate collection and removal system, waste cell final closure systems, and western groundwater pump and treat system).
- Institutional controls (fencing, eventual deed restrictions).
- Presumptive remedies (storm water management, closed cell cap maintenance).

An overview of each component of the remedy, along with the design and technical specifications associated with each, is presented in the following sections. In addition, a discussion of how the remedy will meet the objectives is provided. The objectives of the corrective action program at the Ivy MUC are:

- Protect human health and the environment;
- Attain the appropriate GPS;
- Control sources of releases;
- Meet VSWMR standards of management of solid waste; and
- Meet each of the requirements of 9 VAC 20-80-310.B.3.

If interim measures, other than the Paint Pit Interim Measure discussed in this document, are required to protect human health and the environment, the measure will be consistent with the objectives of and will contribute to the performance of the remedy.

The factors listed below will be considered in determining if interim measures are warranted.

- Time required to develop and implement the final remedy.
- Actual or potential exposure of nearby receptors to hazardous constituents.
- Actual or potential contamination of drinking water supplies or sensitive ecosystems.
- Further degradation of the groundwater that may occur if remedial action is not initiated expeditiously.
- Weather conditions that may cause the constituents to migrate or be released.
- Risks of fire or explosion or potential for exposure to constituents as a result of an accident or failure of a container or handling system.
- Other situations that may pose threats to human health and the environment.

If the selected remedy is found to be incapable of achieving the required protection standards, alternative corrective measure methods are provided in Section 6.4 of this CAP.

#### 4.1.1 In-situ Engineered, Enhanced Bioremediation (EBR)

Following the selection process described in the ACM, an EBR remedial technology was selected for further laboratory and Site study.

##### **Overview**

EBR is a proven technology that is judged capable of bringing the Site constituents of concern (COCs) below their respective GPS in the affected geologic strata. Case studies testifying to the effectiveness of bioremediation at similar sites are presented in Appendix F of the ACM. The EBR remedy can degrade or convert many organic chemicals into nontoxic or less toxic compounds (*i.e.*, mass reduction in source areas and plume degradation).

Biodegradation of COCs is now occurring at the Site without enhancements based on two observations:

- The presence in the aquifer of compound *cis*-1,2-dichloroethene (a biodegradation product of TCE with no known historical or current source at the Site). *Cis*-1,2-dichloroethene concentrations in groundwater have increased over the past 5 years.
- The available groundwater quality data with respect to chlorinated hydrocarbons indicate that there has been an overall decreasing trend in compound concentrations over time.

The degree of Site remediation will depend on the following factors: constituent concentrations and volume; success in nutrient delivery; degree of biofouling (decreased injection well performance through the accumulation of microbial cultures); and evaluation and modification of Phase I EBR results. The effectiveness of the remedy will be monitored through traditional groundwater sampling methods. Based on contaminant degradation over the last several years at the Site, it is anticipated that the effectiveness of EBR at the Site will be good.

EBR is relatively simple to implement and can be tailored to an individual site by the choice of injection locations (spatial location and subsurface injection zone) and the amount of treatment materials (*e.g.*, microbial substrates) injected. Implementation of EBR utilizes standard

construction practices. Minimal space is needed other than that required for the observation and injection wells. Substrates, microbial cultures, and associated equipment are readily available, though some time is required to create sufficient microbial culture for field deployment activities.

Wells may require periodic maintenance to reduce the degree of biofouling in the well annular space. Injection wells are especially susceptible to biofouling in low permeability media such as the media that occur at the Site. Replacement wells may be required if biofouling is extensive. Performance monitoring (further described in Section 6.0) will be conducted during implementation to assess the biological activity and remedy effectiveness in groundwater.

It is expected that treatment with EBR will reduce chemical concentrations in groundwater to levels below GPS with no harmful residuals, effluents, or discharges. No deleterious material will be placed in the environment. In fact, the selected remedy will promote beneficial microbial life in the groundwater regime. The restrictions imposed by the in-place controls discussed in the following section will further reduce risks to the public and the environment.

### **Design and Specifications**

Conceptually, the EBR remedy includes a material injection well system that will be installed to inject substrate and microbial cultures into the subsurface. Substrate injection and bioaugmentation will act to create groundwater characteristics that are conducive to microbial reduction of the Site chlorinated VOCs. This process will enhance the rate of ongoing compound destruction in the subsurface. A bench-scale laboratory treatability study (microcosm study) has been completed to determine the effectiveness of native microbial cultures at degrading Site chlorinated VOCs, to identify modification to groundwater geochemistry that would stimulate chlorinated VOC degradation, and to determine whether non-native microbes would be necessary to achieve complete chlorinated VOC degradation.

### **Microcosm Study**

The first step in furthering the viability of this remedial option was to conduct a bench-scale laboratory study (a microcosm study) to determine if native microbial populations could be stimulated to degrade the chlorinated VOCs in the Site groundwater or if native microbial populations could not effect a complete degradation of these VOCs, whether introduction of a non-native culture could be used to achieve the desired results.

Terra Systems, Inc. (TSI) conducted a microcosm study under contract to Environmental Standards to evaluate the potential for anaerobic bioremediation of the chlorinated VOCs found as contaminants at the Site. The objectives of the laboratory treatability study are presented below.

- Determine if and to what extent the native microbial population can degrade the chlorinated solvents with and without additional substrate.
- Evaluate potential substrates to determine which substrate may work best at the Site.
- Evaluate the potential applications of emulsified soy-bean oil as a slowly degradable substrate.

- Evaluate the potential for Bioaugmentation with the Pinellas Dechlorinating Enrichment (PDE) culture to enhance the extent and rate of chlorinated solvent degradation.

On October 24, 2003, TSI produced a final report outlining the findings of the microcosm study completed on groundwater samples collected from impacted areas of the Site. The complete report, which is summarized herein, is provided in Appendix D.

The microcosm study consisted of the collection of representative groundwater samples from Site wells in areas with groundwater impacts by chlorinated VOCs (*i.e.*, MW-19, MW-26, and MW-33D). Several 1000-mL amber glass jars were filled with groundwater from each respective well. Prior to sample collection, each jar was purged with nitrogen gas to minimize potential oxygen contact with the samples. In the laboratory, subsamples were prepared to form specific microcosms. In the set of microcosms prepared from the samples from each well, two control samples were prepared.

The first control consisted of unamended water (*i.e.*, water to which no substrate or biological cultures were added); the second control consisted of sterile control (*i.e.*, water that was sterilized in order to evaluate the potential for non-biological degradation of the chlorinated VOCs). A variety of substrates were added with the other microcosms to determine if they could stimulate the native microbiological cultures to effect degradation of the chlorinated VOCs. Substrates used during this microcosm study consisted of methanol, sodium lactate, and SRS™ (an edible oil emulsion). Though found to stimulate the greatest degree of chlorinated VOC degradation, sodium lactate was unable to effect complete degradation of the chlorinated VOCs to ethene.

To investigate whether a non-native microbial culture could carry the degradation process to completion, the sodium lactate amended microcosm was bioaugmented with the Pinellas Dechlorinating Enrichment (PDE). This microcosm was found to stimulate complete dechlorination of VOCs within approximately 30 days. An anaerobic Phase I EBR was recommended as the next step for treatment. Batch additions of lactate followed by bioaugmentation are anticipated to promote biodegradation of the observed TCE within the impacted aquifers at the Site.

### **Phase I EBR**

Based on the results and recommendations of the microcosm study, a Phase I EBR Work Plan has been developed to evaluate the use of sodium lactate, as a substrate, and PDE, as a bioaugmentation culture, as the principal components of the EBR remedy. The proposed Phase I EBR Work Plan for Site groundwater is provided in Appendix A.

As described in the work plan, the Phase I EBR will consist of the installation of injection and observation wells, batch substrate additions, and bioaugmentation. Periodic monitoring of groundwater upgradient and downgradient of the treatment zone will allow the effectiveness of the remedy, at the Phase I EBR scale, to be evaluated. Injection and observation wells will be completed into two zones of the subsurface – the overburden/saprolite zone and the fractured bedrock. Following a public comment period and amendment of the Site Solid Waste Permit by VA DEQ, the Phase I EBR is expected to last approximately 660 days (22 months); a final study report will be submitted to VA DEQ.

## Conceptual Design

Specific design criteria for the broader Site implementation of the EBR remedy cannot be fully assessed at this point due to the need to evaluate specific operational details during the Phase I EBR implementation. The treatment area for the remedy will include areas adjacent to the waste boundary with exceedances of the GPS. The area that currently exhibits GPS exceedances (based on historical data up to and including the June 2003 compliance monitoring event) would be the focus of full-scale remedy implementation and is presented on Figure 4-1. Proposed injection and observation wells for subsequent phases of EBR deployment are shown in Figure 4-2.

It should be noted that the delineation of the impacted groundwater plumes and the treatment zones will be refined after completion of the Phase I EBR. As noted on the figures presented in the ACM, the configuration of the impacted groundwater plumes has been changing over the past 5 years and may continue to do so. Changes in impacted groundwater plumes would necessitate revising the configuration of the treatment zone(s) for subsequent phases of EBR deployment.

Although a specific detailed design for subsequent phases of EBR deployment will not be provided in this CAP, general design will follow that described in the Phase I EBR Work Plan with modifications based on the findings of the Phase I EBR. Design and construction modifications resulting from implementation of the Phase I EBR will include a detailed description of the components listed below.

- Boring installation (including the design, location, and number of borings).
- Observation well installation construction (including the design, location, and number of wells).
- Injection well installation construction (including the design, location, and number of wells).
- Substrate injection (including details on substrate quantity, composition, injection pressure, and injection schedule).
- Bioaugmentation (including details on microbial culture production, culture injection specifics, and injection schedule).

Typical observation and injection well schematics are presented in the Phase I EBR Work Plan. Upon satisfactory implementation of the Phase I EBR, these schematics will provide the basis (as modified, if necessary) for the deployment of subsequent phases of EBR.

Specific solid waste disposal areas within the Ivy MUC (including the former Paint Pit area) are not a focus of the Phase I EBR, nor are these areas required to be addressed specifically. These areas are not specifically a subject of the Phase I EBR because the level of investigative detail required during the Phase I EBR would result in potentially unacceptable health & safety considerations, a large expense, and undue complexity in the evaluation process (control of as many variables as possible will be difficult). If the Phase I EBR indicates that the remedy may be successful, RSWA will also consider developing a concentrated bioremediation program focused on the interior areas of the Ivy MUC. Specifically, additional focus will be given relative

to remedial efforts in the vicinity of the former Paint Pit area to augment site-wide groundwater remedial efficiency.

At this time, prior to evaluating the results of the Phase I EBR, it is not possible to describe the manner in which the former Paint Pit area will explicitly be addressed assuming that the remedy is successful. Given successful implementation at the Phase I EBR scale, it is anticipated that the application of EBR to groundwater proximal to the former Paint Pit area will significantly reduce the concentration of VOCs observed in the fractured bedrock. The intent, however, is not for RSWA to meet the Site GPS immediately beneath the former Paint Pit area; rather, application of the remedy in this area (as well as the other waste areas) could provide additional long-term benefits to the groundwater observed at the perimeter of the Site as monitored at the relative points of compliance.

#### 4.1.2 Intrinsic Bioremediation (IBR)

On December 30, 2003, RSWA submitted a draft Corrective Action Plan (Draft CAP) to the VA DEQ. The document was intended to fulfill the requirements set forth in VSWMR 9 VAC 20-80-310, Part V, (5) (B). Having reviewed the Draft CAP, VA DEQ provided comments to the RSWA in a letter dated March 2, 2004 (1<sup>st</sup> Technical Review).

The 1<sup>st</sup> Technical Review of the Draft CAP included several VA DEQ suggestions and additional requirements to be included in a Revised CAP prior to VA DEQ considering the CAP “complete.” Specifically, it was required by VA DEQ that “those areas which fall outside the initial area-specific EBR will be monitored...with appropriate well network pairs and the appropriate performance monitoring list noted by EPA.”

The *Intrinsic Bioremediation Work Plan* (Appendix C), describes the process to be used to comply with VA DEQ’s requirement and to describe the manner in which intrinsic bioremediation (IBR) will be deployed at Ivy MUC.

RSWA intends to use the IBR Work Plan results at the Ivy MUC to achieve two fundamental goals:

- To collect seasonally dependent, longer-term Ivy MUC aquifer and geochemical information for characterization prior to the (intended) Site-wide deployment of the ACM-specified EBR remedy.
- To verify that even without EBR deployment, the native microbial population in the aquifer beneath the Ivy MUC is reducing, to some degree, the mass of primary VOCs, (e.g. tetrachloroethene; trichloroethene; 1,1,1 -trichloroethene, etc.) found in groundwater beneath the Site.

Largely, the methods and protocols describes in the IBR Work Plan are based on various United US EPA guidance documents; in particular, US EPA’s *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (US EPA, 1998) and other documents authored by Todd Wiedemeier.

In order to confirm that laboratory analytical results are reflective of expected field performance, the RSWA has elected to deploy EBR at the Site using a phased approach. This approach allows for the careful examination of a small-scale, first phase EBR program to begin near groundwater monitoring well MW-17.

One critical aspect of EBR deployment is potential variations in the understanding of the Site-wide groundwater geochemical conditions throughout the aquifer beneath the Site. This information will be used to better engineer EBR deployment design and to establish pre-remediation water quality characteristics in the affected aquifer. By understanding groundwater geochemistry beneath the landfill on a seasonal (quarterly) basis over a 2-year period, trends in groundwater chemistry can be better understood. This understanding will lead to a better-designed EBR deployment process, when EBR is “scaled up” to a Site-wide remedy.

Further, while EBR uses naturally occurring microbes and an innocuous bio-edible substrate, it is likely that accelerating microbial activity in the aquifer will result in changes to groundwater chemistry. By collecting data on a quarterly basis for 2 years (8 quarters) prior to site-wide deployment of the EBR technology, a better understanding of groundwater chemical changes will emerge.

Based on current Phase I EBR scheduling, it is anticipated that the IBR monitoring program will occur for 2 years (8 quarters). However, if there is a delay in site-wide EBR deployment, RSWA will continue the quarterly IBR monitoring program until EBR is deployed Site-wide. Alternatively, if EBR proves unsuccessful, IBR will be considered as an alternative in-place remedy.

Conversely, if it can be demonstrated that EBR is successful within a shorter time frame, the RSWA reserves the opportunity to deploy EBR on an accelerated schedule and modify the IBR monitoring program accordingly.

#### 4.1.3 Paint Pit Interim Measure

Although analysis of groundwater samples from the former Paint Pit area bedrock wells yield positive results for VSWMR Appendix 5.1 constituents similar to those found exceeding Site GPS in a few of the compliance wells, the former Paint Pit area is not believed to represent the single, dominant source of groundwater impacts at the Ivy MUC. Nevertheless, the magnitude of residual groundwater contamination appears sufficient to warrant localized treatment in an effort to expedite meeting GPS criteria, particularly in the North Drainage Area.

RSWA is at this time considering implementation of an interim remedial measure in the former Paint Pit area during the evaluation of the Phase I EBR. During this 2-year period, RSWA is evaluating installing and operating a soil-vapor extraction (SVE) system in the area of the former Paint Pit. Details of the implementation of this interim measure are identified in the attached Paint Pit Interim Measure Work Plan (Appendix E). The final decision on SVE implementation in the former Paint Pit area will depend on several factors, including budgetary constraints and potential future groundwater issues (such as the unplanned barium work). Regardless of whether SVE is implemented, if the Phase I EBR suggests that the EBR remedy will be

successful site-wide, EBR will be incorporated at the former Paint Pit area in a subsequent phase.

RSWA intends this potential Paint Pit interim measure to achieve two fundamental goals:

- To reduce the mass of potential source material in the vadose zone of the former Paint Pit area.
- To provide significant remedial benefits in the former Paint Pit area without causing adverse groundwater conditions to develop which would inhibit eventual deployment of the selected groundwater remedy identified in the Assessment of Corrective Measures (ACM), *In-situ* Engineered, Enhanced Bioremediation (EBR).

#### 4.1.4 In-place Controls

A number of in-place controls are already operational and, therefore, specific design data are provided in other documents. This subsection presents an overview of these existing in-place controls, along with a discussion on how the controls are being used to address Ivy MUC-affected groundwater.

#### **Landfill Gas Collection and Control System (LFGCCS)**

Landfill gas is typically comprised of approximately 50 percent methane, 50 percent carbon dioxide, and minor amounts of nitrogen and oxygen (via air intrusion). The build-up of methane and other gases, collectively known as Landfill Gas (LFG), beneath the cap is controlled by a Landfill Gas Collection and Control System (LFGCCS). LFG is controlled at the Site for three primary reasons: to prevent the accumulation and migration of potentially explosive quantities of LFG; to prevent the development of gas pressure within the waste disposal cells that would have the potential to damage the cell caps; and to provide for the collection and destruction of LFG to the extent necessary to abate potential odor impacts to Site neighbors. To meet these objectives, gas extraction wells and passive vents have been drilled into the waste cells to provide preferential flow paths for gas migration. The LFGCCS collects the migrating gas, thereby reducing the pressure on the underside of the cap system (produced by ongoing LFG generation), which prevents damage to the waste disposal cell caps and reduces the driving mechanism for lateral gas migration and release of odor. By managing the collection and migration of LFG, VOCs in the waste mass and LFG odors are reduced. Collection and control of LFG is regulated in accordance with 9 VAC 20-80-280.

Both passive venting and active gas extraction are used at the Site. The passive venting system consists of wells that penetrate through the final closure system and into the waste, which vents migrating gas to the atmosphere. This type of system is used within waste disposal areas that are anticipated to have relatively limited LFG generation either due to the age of the buried waste or the composition of the waste (*e.g.*, CDD is not expected to produce as much LFG as MSW). Specifically, Cell 1-unlined and Cell 2-unlined are provided with passive LFG control systems. The remaining four cells and former Paint Pit area are provided with active LFG extraction systems that consist of vertical extraction wells, a vacuum collection system, and a flare system to combust the collected LFG.

The gas wells generally penetrate 80% of the waste depth with perforations limited to portions of the wells deeper than 20 feet below ground surface. The estimated maximum waste disposal depth is 110 feet in the unlined waste disposal cells and 100 feet in lined waste disposal cells. The use of vertical extraction wells is practically limited to areas in which the waste depth exceeds 40 feet in unlined waste disposal cells (20 feet of solid pipe over 10 feet of perforated pipe over the lowermost 10-foot thick lift of waste) and 50 feet in lined waste disposal cells where the “cushion” between the bottom of the well and the bottom liner is expanded to 20 feet. In the active gas collection system, collected gases are exhausted via an electrically powered blower through a network of HDPE collection piping to an enclosed flare where combustion occurs. Combustion allows for the destruction of the methane and other contaminants, such as VOCs and SVOCs, typically with a 98% efficiency rate.

The specific design, construction, and operation and maintenance requirements of the LFGCCS at the facility are documented in detail in the Site Solid Waste Facility Permit (No. 125, Permit Module II, Permit Attachment III-2 – “Gas Management Plan – Attachment A”) as well as in the construction certification document submitted to VA DEQ following construction of the active LFGCCS (Gas Management System, Phase I, As-Built Certification dated August 1999).

The LFGCCS removes COCs in the form of gas from the waste mass. By reducing the COCs within the landfill, there are fewer COCs available in the waste mass that may possibly leach or partition into groundwater. Further, the collection system reduces the gas pressure within the waste mass (primarily active collection but to a lesser degree passive venting as well), thereby reducing the propensity for VOCs to partition from the gaseous phase to the aqueous phase. The LFGCCS is, therefore, acting to abate groundwater impacts.

### **Leachate Collection and Removal System (LCRS)**

Historical landfill regulations did not require bottom liners or leachate collection systems to prevent the waste mass from contacting the surrounding soil and groundwater. Cell 1-unlined, Cell 2-unlined, Cell 3-unlined, and the former Paint Pit area were constructed in accordance with these regulations. Surface water percolating through the waste mass in these unlined cells may be expected to leach some constituents from the waste mass as the water migrates through the underlying soil and into groundwater (the percolating liquid with dissolved material from the landfill is called “leachate”).

Subsequent regulations required all landfill cells to be lined with a relatively impervious liner to reduce the potential for leachate migration to the groundwater. Regulations also required a leachate collection and removal system (LCRS) to direct the liquid in the waste mass (leachate), which collects on the relatively impervious liner, to treatment/storage. Based on these subsequent landfill regulations, the remaining cells (Cell 1-lined, Cell 2-lined, and Cell 3-lined) were constructed with bottom liners and LCRSs. Specifically, Cell 1-lined was constructed with a 24-inch thick compacted soil bottom liner, and Cell 2-lined and Cell 3-lined were constructed with 60-mil HDPE bottom liners. Leachate from each of the lined cells is piped to, and collected in, a leachate storage basin, which is pumped periodically and transported to the Moores Creek Wastewater Treatment Plant, operated by the sister organization, Rivanna Water and Sewer Authority, for treatment.

The operation and maintenance of the LCRS will be in accordance with guidance and requirements of the VSWMRs as set forth in 9 VAC 20-80-290 as required by the facility's waste management permit which states that "Module II, Operations" is "By Regulation" (Permit No. 125, Permit Module II-Operations).

### **Final Closure Cap Systems**

Historically, municipal waste was deposited in six distinct areas, referred to as cells, and a small area known as the former Paint Pit area. Once a cell was full (*i.e.*, has reached its capacity limit), a containment cap, consisting of low permeability soil and/or synthetic materials, was placed over the waste as part of the closure process. The cap covers the buried waste and limits surface water infiltration into the waste mass. By controlling water infiltration into the waste mass, the generation of leachate is controlled. Reducing, to the maximum extent practicable, the amount of leachate generated at the landfill, in turn, reduces the potential for groundwater impacts.

Each of the six waste cells, as well as the former Paint Pit area, has received final closure cap systems in accordance with, or exceeding, the requirements of the VSWMR and the Site Solid Waste Facility Permit. The approved Site Closure Plan included as part of Permit Module XII documents the aerial extent of the final closure cap systems as well as the various physical designs implemented for each waste cell. Further documentation for the final closure systems constructed at the Site are provided in detail in the Closure Certification reports submitted to the VA DEQ as required by the VSWMR.

The reports cited below were submitted to VA DEQ to substantiate that final closure cap systems were constructed in accordance with the requirements of the VSWMR and the Site operating permit.

- Cell 1-lined, Cell 2-lined, and the former Paint Pit area – Closure Certification Documents submitted August 1998.
- Cell 2-unlined, Eastern Slope Closure – Closure Certification Documents dated December 1998.
- Cell 1-unlined – Closure Certification Documents dated July 1998.
- Cell 3-lined & Cell 3-unlined – Closure Certification Documents dated January 1999.
- Cell 2-unlined – Closure Certification Documents submitted November 2002.

Operation and maintenance of the waste disposal cell final closure cap systems will be in accordance with the requirements of the VSWMR and the Site Closure and Post Closure Plans (No. 125, Permit Module XII and XIII – Closure and Post-Closure Care).

## Western Pump and Treat System

RSWA voluntarily installed the western groundwater pump and treat system (PTS), which began operation in 2000. The system was installed by RSWA as part of a plan to protect groundwater quality on the western side of the Site. Based on the apparent effectiveness of the system, the PTS will be incorporated as an in-place control and, as such, is considered part of the proposed future corrective measures at the Site. As shown in Figure 4-3, the PTS is located to the west of Cell 2-lined and Cell 3-unlined and to the southwest of Cell 1-unlined. The primary purpose of the PTS is to collect and treat liquids from the three areas at the western edge of the Site indicated below.

- Groundwater from the saturated portion of the overburden in the area adjacent to MW-2 and MW-3.
- Landfill-affected shallow groundwater from the interceptor trench located adjacent to the western tributary to Broad Axe Creek.
- Landfill affected groundwater from the underdrain of Cell 2-lined.

By collecting liquid flows from the underdrain, interceptor trench, and groundwater from the overburden, the PTS captures, removes, and treats groundwater in this area of the landfill. Further operation of the PTS is intended to mitigate impacts to shallow groundwater and provide additional protection to nearby surface water. A logic flow diagram depicting the range of processes included in the PTS system is provided as Figure 4-4. As the figure shows, the PTS's programmable logic control (PLC)-driven control network is used to continuously monitor various system information (as necessary) to automatically control pumping and treatment requirements and to activate alarms (when needed) during periods of automatic shutdown. Operation and maintenance (O&M) practices for the PTS are described in further detail in the PTS O&M Plan, Appendix F.

The following quantitative data have been developed regarding the contributing sources to the PTS: total flow, 14 gallons per minute (gpm); flow from the shallow groundwater pumping wells, 10 gpm; flow from the underdrain, 4 gpm; and flow from the interceptor trench, 0 gpm. The lack of flow measured from the interceptor trench is likely a result of the severe drought conditions that existed within the region during the measurement period in 2002. It is expected that specific flow amounts will vary somewhat during periods of higher precipitation and seasonally high water periods. Based on influent and effluent sampling conducted at the air stripper (see Table 4-1), the treatment system is effectively treating the liquids collected by the PTS.

Prior to installation and operation of the PTS, impacted groundwater discharges to the surface waters of the western tributary of Broad Axe Creek had been observed and documented by local residents and the VA DEQ. Since the operation of the PTS, these events have ceased and the PTS appears to be meeting its stated goals.

Based on its apparent effectiveness, the PTS is included as an in-place control as part of the development of a corrective measure for the Site. The rationale for including the PTS as an on-going part of any remedy at the landfill is based on the system's currently demonstrated performance in managing impacted shallow groundwater in the area west of the Site. In addition, the system serves an appropriate protective role in mitigating potential impacts to the

unnamed western tributary of Broad Axe Creek. It is important to document, however, that any of the three sources collected and treated by the PTS may be terminated when EBR efforts progress from Phase I EBR deployment to subsequent phases of EBR deployment. At a minimum, it is anticipated that the nine vertical collection wells serving the saturated portion of the overburden will be eliminated to avoid withdrawal of substrate and bioaugmentation cultures from the aquifer.

### **Former Paint Pit Area**

Detailed investigations have been conducted as summarized in the Paint Pit Report dated March 2002, and Addendum dated March 2004, developed by Malcolm Pirnie. The report provides background information as well as documentation of the in-place controls that are currently provided at the former Paint Pit area. The former Paint Pit area has the in-place controls indicated below.

- Final closure cap system consisting of a 14-foot to 23-foot thick multi-layered composite cap system comprised of no less than three distinct caps; this system effectively eliminates surface water infiltration and percolation through the former Paint Pit Area.
- LFGCCS control system capable of providing vacuum to the former Paint Pit Area to the extent necessary to limit the release of VOCs to the atmosphere and to decrease the subsurface gas pressure, thereby increasing the propensity for partitioning of VOCs from the aqueous phase to the gaseous phase (with subsequent transport for destruction at the flare).

Each of the above-cited controls provides a net benefit by either directly removing VOCs from the former Paint Pit area or by reducing the potential for production of leachate from the former Paint Pit area impacted soils. As such, these systems are considered in-place controls and are elements of this CAP. Operations and maintenance activities for these controls are consistent with requirements for the individual in-place controls listed above for the LFGCCS, LCRS, and Final Closure Cap System.

#### 4.1.5 Surface Water Monitoring Program

On December 30, 2003, RSWA submitted the Draft CAP to be implemented at the Site to the VA DEQ. The document was intended to fulfill the requirements set forth in VSWMR 9 VAC 20-80-310, Part V, (5) (B). Following its review of the Draft CAP, VA DEQ provided comments to the RSWA in a letter dated March 2, 2004 (1<sup>st</sup> Technical Review).

The 1<sup>st</sup> Technical Review of the Draft CAP included several VA DEQ suggestions and additional requirements to be incorporated in a Revised CAP before VA DEQ would consider the CAP “complete.” Specifically, VA DEQ stipulated that “the facility should include a site-wide surface water monitoring program.”

The *Surface Water Monitoring Plan (SWMP)*, presents the process that will be used to comply with VA DEQ’s requirement and the manner in which surface water monitoring will be undertaken at the Site. The SWMP has been developed in accordance with Virginia Water Quality Standards Regulations 9 VAC 25-260-5 *et seq.*

The SWMP is intended to define the scope-of-services necessary to appropriately characterize and monitor surface water quality during implementation of the Site CAP.

The objectives of the Surface Water Monitoring Plan (Appendix G) are to describe the manner in which data will be collected to characterize baseline surface water quality and to monitor longer-term potential impacts to the Site surface water systems during implementation of the CAP. Identification of water quality changes may require adjustments to the SWMP to provide for adequate monitoring of the surface water systems.

The specific objectives of the Surface Water Monitoring Program are as follow:

- Evaluate and document the chemical, physical, and biological integrity of the surface water (40 CFR 130.4[b]).
- Define the overall ecological integrity of the Site's surface water system.

The procedures described in Appendix G are intended to provide for a comprehensive evaluation of surface water quality aquatic life and wildlife core and supplemental indicators consistent with guidance in US EPA *Elements of a State Water Monitoring and Assessment Program* (March 2003). Specifically, dissolved oxygen, temperature, conductivity, pH, habitat assessment, landscape conditions, health of organisms, and chemicals of concern in the water column will be evaluated.

- Assess the concentrations of potential Ivy MUC constituents in surface water during implementation of the CAP and ensure that these concentrations meet established 9 VAC 25-260-140 criteria. Evaluation of the compound concentrations will include consideration of low compound concentrations that do not exceed criteria but that could degrade water quality by nourishing undesirable or nuisance aquatic plant life.
- Address prior visual inspections of the surface water systems that suggested the presence of an orange-colored filamentous flocculate in Broad Axe Creek. The SWMP includes identifying and assessing the potential impact of the filamentous flocculate observed in the stream. Data will be collected to determine, if practicable, the identification of the substance (*i.e.*, algal or bacterial).

Determinations will be made whether the flocculate is inimical to the stream's water quality or serves as an indicator of other potential impacts to the system. If necessary, appropriate corrective measures will be developed to ensure the integrity of the stream.

In order to achieve the SWMP goals identified above, the activities listed below will be undertaken.

- Baseline reconnaissance that includes a visual assessment of in-stream characteristics, biological components, filamentous flocculate distribution, and collection and analysis of microbiological samples will be conducted. Samples of the observed filamentous flocculate will be collected from the stream for laboratory analysis. Additionally, field

locations of monitoring points will be marked and surveyed by a Virginia-licensed surveyor.

- Visual examinations of surface water systems will be conducted on a quarterly basis and will include qualitative assessments of in-stream characteristics, biological components, and flocculate occurrence monitoring.

Surface water samples will be collected and analyzed on a quarterly basis. Surface water samples will be collected for analysis in accordance with the SWMP document (Appendix G)

#### 4.1.6 Institutional Controls

In addition to the in-place controls operating at the Site, other precautions will be taken to close the Site in a manner that will continue to protect human health and the environment. These other precautions fall into the category of institutional controls (ICs). US EPA defines ICs as non-engineered instruments, such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use. ICs are generally used in conjunction with, rather than in lieu of, engineering measures.

When Site closure is completed, a notice will appear in the local newspaper to inform the public and the Clerk of the Circuit Court of Albemarle County of its inactive status. Any conveyance of the property that is presently defined as the Inactive Ivy Landfill will come with a deed notice of the former usage of the property. VA DEQ will receive a copy of the deed notice as recorded. A survey plat prepared by a professional land surveyor registered in the Commonwealth of Virginia will be submitted to the Clerk of the Court within 90 days after the final closure is completed. The plat will indicate the approximate limits of the waste, monitoring well locations identified by number, and a note of the RSWA's obligation to restrict disturbance of the Site. Deed restrictions will prohibit activities that will disturb in-place controls, expose waste materials, or promote contaminant migration such as digging or groundwater pumping (for non-remedial purposes). Access to the Site is, and will continue to be, restricted by the use of clearly marked barriers and locked gates. Site maintenance will be continued throughout the duration of the post-closure care period on a periodic basis. Maintenance activities will include mowing the vegetative cover, reseeding bare areas, removal of unwanted vegetation that could damage the final cover of the caps, removal of sediment from the sediment ponds, and upkeep of equipment. These ICs will help protect the in-place controls from damage and reduce potential exposure of humans to contaminated media.

#### 4.1.7 Presumptive Remedy

Presumptive remedies, as defined in 9 VAC 20-80-310.A.4, will be utilized at the Site to manage concentration and mobility of impacted groundwater. Predominantly, these presumptive remedies are discussed in earlier sections as in-place controls. With respect to barium-impacted groundwater in the area of MW-32, the use of presumptive remedies is proposed as an interim remedial measure until the full nature and extent of the barium impact is assessed.

As stated in Section 3.3.3, barium has been observed in groundwater samples from MW-32 at concentrations exceeding the Site GPS. At present, a nature and extent study (Focused Barium NES) has been initiated in this area to identify the extent and mobility of the barium-impacted groundwater. As of the preparation of this document, five additional groundwater monitoring wells (MW-32D, MW-39, MW-39D, MW-40, and MW-40D) have been installed and developed. Groundwater sampling activities of these wells and MW-32 commenced in early 2004.

With the recent closure of Cell 2-unlined, it is expected that changes in barium concentrations and mobility will be observed. This expectation is based on the proximity of MW-32 to Cell 2-unlined and an assumption that the minimization of infiltration into the waste disposal cell will begin to lessen the dissolution and mobility of potential barium source material within the waste mass.

Prior to and during implementation of the CAP, ongoing barium monitoring will be performed through the collection and analysis of groundwater samples from the new barium NES wells and MW-32. The goal of this monitoring is to establish the extent and rate of barium-impacted groundwater mobility and to ensure that off-site migration is not observed. When a sufficient base of data is developed to understand the barium mobility and its interaction with the corrective action remedy, the need for a specific remedial response will be evaluated. During this monitoring period, VA DEQ will be provided periodic reports that summarize the data developed, the extent of barium migration, the trend(s) observed in barium concentrations, and the need for development of a barium-specific risk assessment or corrective action.

## 4.2 Remedy Implementation

This section of the CAP describes, in general terms, the remedy startup procedure, including the initial phase of enhanced bioremediation and regulatory permits required as a result of remedy implementation.

### 4.2.1 Phase I EBR Work Plan

The Phase I *In-situ* Engineered, Enhanced Bioremediation Work Plan (Phase I EBR Work Plan, Appendix A) defines the goals, field activities, and assessment criteria that will be utilized to evaluate the potential effectiveness of the selected remedial technology for the Site. Phase I EBR is being implemented to determine the effectiveness of this somewhat pioneering approach prior to broader Site deployment.

Activities proposed to be undertaken as part of the Phase I EBR will be completed in compliance with applicable federal, Commonwealth, and local regulations as well as relevant, applicable, and appropriate US EPA and VA DEQ guidance.

Activities associated with broader Site implementation of the EBR remedy will be described in a Phase I EBR Final Report after the successful completion of the Phase I EBR.

#### 4.2.2 IBR Work Plan

The Intrinsic Bioremediation Work Plan (IBR Work Plan, Appendix C) defines the goals, field activities, and assessment criteria that will be utilized to evaluate the effectiveness of this remedial technology at the Site. IBR is being implemented to actively facilitate the reduction in concentrations of chlorinated hydrocarbons in areas not addressed by the Phase I EBR. Additionally, IBR will provide data that will be useful during deployment of subsequent phases of EBR site-wide.

Activities proposed to be undertaken as part of IBR implementation will be completed in compliance with applicable federal, Commonwealth, and local regulations as well as relevant, applicable, and appropriate US EPA and VA DEQ guidance

#### 4.2.3 Required Permits

In employing the EBR remedy, certain materials and/or organisms will be injected directly into the subsurface. Details regarding specific proposed biochemical concentrations, chemical injection duration, well locations, and equipment designs are presented in this document; a “conceptual-level concurrence” from US EPA Region III was previously pursued by Environmental Standards.

Review of US EPA documentation made available on the federal level, the US EPA website (e.g., a December 27, 2000, memo from Elizabeth Cotsworth, Director Office Solid Waste, to the Interstate Technology & Regulatory Cooperation Group and attending memo), and a letter from US EPA Region IX Office of Solid Waste Deputy Director Mathew Hale to Ms. Peggy Harris (Appendix A, Attachment 2) clearly indicated that decisions have been made by US EPA relative to the applicability of RCRA Section 3020(b) to the proposed remedy currently being contemplated for Site groundwater.

Based on federal-level documents, it was Environmental Standards’ interpretation of US EPA’s policies that the remedy proposed to be tested would be acceptable and exempt from formal permitting needs under the federal interpretation of RCRA Section 3020(b) assuming Site groundwater is extracted, mixed with the appropriate injection materials, and re-injected into the target contaminated aquifer.

To confirm Environmental Standards’ interpretation of the applicability of RCRA and the Underground Injection Control (UIC) permitting program, Mr. Mark Nelson, Hydrologist with US EPA Region III, was contacted. Mr. Nelson confirmed that the injection of the materials into the aquifer as described in this plan does not require a special permit and stated that the activity in Virginia is “regulated” by US EPA Region III.

Mr. Nelson stated that a plan (presumably this document) should be provided to his attention at US EPA Region III offices in Wheeling, West Virginia. Mr. Nelson and his associates will review the plan, and assuming they find the plan adequate, US EPA Region III will issue a Rule Authorization Letter (RAL). This RAL will provide comments on the proposed plan, with a particular focus on the injection wells and monitoring program; assuming that documentation is

adequate, US EPA Region III will acknowledge that the proposed injection is appropriate and can proceed.

#### 4.3 Project Schedule

VA DEQ Submission Instruction No. 17 (V 3-03) requires this document to provide a general timeline or schedule, including trigger dates that start from the date the Site Solid Waste Permit is amended.

Given the reliance of the CAP on the progressive development of a site-specific EBR methodology for the target constituents and aquifers, the schedule provided herein consists of relative trigger dates for all elements limited to their general description in a sequential manner.

The proposed schedule is provided on the table below.

<b>Element</b>	<b>Timing (Earliest Possible)</b>
Revised CAP submittal to VA DEQ	April 30, 2004
VA DEQ deems CAP "complete"	May 30, 2004
Amendment of Permit 125 to include CAP	October 1, 2004
Initiate Phase I EBR and IBR including initial Site work activities (See Phase I EBR and IBR Work Plans)	To begin immediately following Permit Amendment (October 1, 2004)
VA DEQ review and concurrence with Phase I EBR Final Report recommendations	Approximately October 2006 (24 months after initiation of the Phase I EBR)
Engineering/Design Phase as necessary to project results of the Phase I EBR to subsequent phases of EBR deployment	To begin immediately following receipt of VA DEQ concurrence with Phase I EBR recommendations, approximately November 2006
Construction of subsequent phases of EBR	Immediately following receipt of DEQ concurrence with Phase I EBR recommendations, approximately November 2006
Termination of IBR	Immediately following substantial construction completion of subsequent phases of EBR
Performance Monitoring	Will initiate December 30, 2004. A specific performance monitoring schedule for subsequent phases of EBR deployment will be included in the Phase I EBR Final Report
Anticipated date for completion of Site remedies	Approximately June 2011 (The ACM states the anticipated time estimate for completion of Site remedies is 7 years. Results of the Phase I EBR will be used to re-evaluate this time estimate)

#### 4.4 Operations and Maintenance Plan

VA DEQ Submission Instruction No. 17 (V 3.03) requires this document to provide an operations and maintenance (O&M) plan for the specific remedies. Specific EBR O&M criteria and requirements for subsequent phases of EBR deployment cannot be fully assessed at this point but will be developed during the Phase I EBR. The O&M requirements for the in-place controls, included as part of this CAP, are described and defined in Section 4.1.4. The O&M requirements for IBR are expected to be negligible but are discussed in the IBR Work Plan (Appendix C). Typically, these controls and their O&M requirements are subject to the Solid Waste Facility Permit.

Although a specific EBR O&M plan will not be provided in this CAP, the Phase I EBR Final Report will include a detailed EBR O&M Plan that outlines procedures for the activities identified below.

- Performing operations.
- Long-term mechanical maintenance.
- Monitoring of Site equipment.
- Names and contact numbers for critical Site personnel responsible for oversight of the EBR O&M activities.

Relative to these specific procedures, the EBR O&M Plan will specify VA DEQ notification within 24 hours of discovery of a deficiency or failure of operational systems, including, a written report documenting the cause of the deficiency or failure within 15 days of occurrence.

## 5.0 Corrective Action Monitoring Program (CAMP)

VSWMR regulations require that this CAP include an update to the Site groundwater monitoring plan that takes into account additional wells installed on Site as monitoring points in conjunction with the NES/ACM and or CAP. The updated groundwater monitoring plan, identified as the Corrective Action Monitoring Program (CAMP), is provided as Appendix B.

The CAMP includes the two different monitoring well networks specified below.

- A compliance monitoring system (CMS) network that monitors for the assessment and/or Phase II monitoring program constituents.
- A Phase I EBR and IBR performance monitoring network (the Corrective Action Monitoring System [CAMS]) that monitors groundwater quality for COCs, as well as additional constituents using industry-accepted methods by which enhanced bioremediation is evaluated.

In some cases, an individual well may serve more than one purpose. The number and spacing of wells utilized in a performance network have been based on site-specific groundwater flow-rate conditions. Based on currently available information and because the proposed remedy includes *in-situ* bioremediation, the proposed CAMS wells have not be spaced at a linear distance that exceeds an anticipated 5-year groundwater flow path.

The CAMP must describe the function of each network, the frequency of groundwater monitoring, and the list of the constituents to be sampled. Pursuant to existing VA DEQ guidance, site-specific information indicates that the CMS described in Appendix B meets the criteria of the associated monitoring program (*i.e.*, Assessment) as required under 9 VAC 20-80-300.B.3. In addition, current Site information also indicates that the CAMS meets the criteria of 9 VAC 20-80-310.C.1.a. (2) and (3), and 9 VAC 20-80-310.A.2.a and b.

As noted in VA DEQ Submission Instructions No. 17 (V 3-03), the full CAMP document has been included as Appendix B to the CAP. This section of the CAP contains only a summary of the monitoring system, frequency, and constituent list and references the CAMP noting that a copy of the document will be inserted into the Site permit as an attachment to the appropriate Permit Module XIV (14).

As required under the VSWMR, the updated CAMP will be complete and inserted in the Ivy MUC Permit prior to the actual initiation of the remedial action as outlined in 9 VAC 20-80-310.C.1.b.

### 5.1 Corrective Action Monitoring Well Network

The existing CAMS is summarized on Table 3-2 and shown in Figure 3-2.

The CMS (Figure 3-2) consists of 13 wells, including one upgradient well (MW-7) and 12 downgradient wells (MW-2, MW-3, MW-5, MW-6, MW-8, MW-11, MW-12, MW-13, MW-17,

MW-18, MW-31, and MW-32). All CMS wells are constructed of 2-inch diameter Schedule 40 PVC pipes, with screen slot width of 0.010 inch, with the exception of MW-17 and MW-18, which are constructed of 2-inch diameter stainless steel well materials.

Pursuant to VA DEQ's request, construction of two new monitoring wells (MW-36 and MW-37) for the purpose of replacing monitoring wells MW-12 and MW-13 in the CMS was completed in 2003. Monitoring wells MW-12 and MW-13 will remain active CMS wells until their replacement by MW-36 and MW-37 is incorporated into the Site operating permit.

### 5.2 Groundwater Constituent List

The proposed groundwater constituent list is identified and addressed in detail in Appendix B. A summary of the proposed constituents, the purpose of their analysis, and the proposed laboratory analytical methods are identified on Table 5-1.

### 5.3 Groundwater Sampling Frequency

The proposed groundwater constituent sampling frequency is identified and addressed in detail in Appendix B. A summary of the proposed sampling frequency on a well-by-well basis is provided on Table 5-2.

## 6.0 Scheduled Performance Evaluations

The selected remedy needs to be evaluated at the Phase I EBR-scale; accordingly, the RSWA can identify in only Phase I EBR-based terms (for the first several months) that the remedial action is performing as designed. A broader performance evaluation program will be implemented assuming that the Phase I EBR demonstrates that the selected remedy will be potentially effective site-wide. IBR performance evaluations will be implemented as identified in the IBR Work Plan, Appendix C.

The scheduled evaluation of the Phase I EBR and IBR will be submitted in report form, titled "Corrective Action Site Evaluation" (CASE), on at least a quarterly basis during the Phase I EBR and IBR execution period (approximately 2 years) and will include, at a minimum, technical information sufficient to address specific performance issues as described in the following subsections.

### 6.1 Performance Evaluation Topics

Developing an evaluation of the remedy relative to the performance evaluation topics listed below will be included as part of the CASE.

- Has the remedial action shown the ability or potential ability to achieve cleanup standards at the point of compliance based on site-specific groundwater quality data?
- Has the remedial action shown operational reliability based on site-specific operational logs?
- Has the remedial action remained on schedule, based on that proposed in the CAP?
- Has the remedial action demonstrated protectiveness of Human Health & Environment (HHE)?
- Has the remedial action shown any negative impact to safety or potential safety of Site personnel?
- Has the remedial action shown any negative impact to other media (air, soils, etc.)?
- Has the remedial action generated "residuals" that are more hazardous to HHE than the original COCs?
- Has the remedial action met the anticipated start-up, operational, and O&M costs as defined in the ACM?

Specific criteria regarding evaluation of the Phase I EBR and IBR remedies are provided in Appendix A (for Phase I EBR) and Appendix C (for IBR) of this document.

## 6.2 Performance Criteria Topics

An evaluation of the remedy relative to the performance evaluation criteria cited below will be included as part of the CASE. The evaluation criteria topics in the CASE will include the topics listed below.

- Summary of the most recent groundwater quality sampling events and the corresponding results with a note on statistical trends observed in concentration data.
- Summary of the most recent groundwater elevation data with respect to monitoring well network functionality.
- Summary of the most recent lateral and vertical plume boundaries as shown on a potentiometric surface map.
- Summary of the amount, quantity, or characteristics of any residuals generated as part of remedial actions, as well as a discussion on the disposal (release) method for such residuals.

Specific criteria regarding performance of the Phase I EBR and IBR remedies are provided in Appendix A (for Phase I EBR) and Appendix B (for IBR) of this document.

## 6.3 Corrective Action Site Evaluation Report Submittals

Corrective Action Site Evaluation (CASE) reports will be signed by a qualified groundwater professional. Demonstrated qualifications of the individual may include those listed below.

- An American Institute of Professional Geologists Certified Professional Geologist; “CPG” with a specialty in hydrogeology.
- A National Groundwater Association Certified Groundwater Professional (CGWP).
- A Virginia-licensed Professional Geologist.

A specific reporting schedule for the Phase I EBR and IBR is provided in the respective Work Plans (Appendix A and Appendix B, respectively). In general, assuming the Phase I EBR remedy is successful and the remedy is deployed at the Site in subsequent phases, CASE reports will be submitted to the VA DEQ no later than 180 days after the corresponding groundwater sampling event; the schedule will be established in Module XIV (14) of the Ivy MUC Permit.

## 6.4 Implementation of Alternate Corrective Methods

If the data presented in the Phase I EBR Final Report conclusively show that, over a sufficient amount of time, the selected remedy cannot achieve the cleanup standard, the RSWA will explore implementation of other remedial methods or techniques as required under 9 VAC 20-80-310.C.2. RSWA will initiate this additional action within 180 days of noting that the corrective action has shown insufficient progress in reducing contaminant levels to below respective GPS.

During evaluation of these other remedial methods, IBR will continue to be implemented at the Site using the procedures and methods identified in Appendix C.

Based on currently existing information, it is believed that two other alternatives could meet or exceed the requirements under 9 VAC 20-80-310.C.3. These secondary actions are specified below and may include other alternatives evaluated as part of the ACM.

#### CAP Alternative 1

- *In-situ* chemical oxidation for the reduction of COCs in impacted groundwater.
- Existing in-place controls.
- Institutional controls.

#### CAP Alternative 2

- Pump impacted groundwater to an air stripper with vapor destruction via flare treatment for the reduction of COCs (*i.e.*, “Pump and Treat”).
- Existing in-place controls.
- Institutional controls.

## 7.0 Public Participation Plan

As suggested in the VA DEQ's Submission Instructions for Corrective Action Plans, this section of the CAP identifies where a data repository will be established to meet the US EPA's RCRA public participation guidelines.

The data repository will contain the documents listed below, delivered within 30-days of Permit amendment, and subsequently within 30-days of VA DEQ delivery.

- A copy of the amended Permit.
- The NES/ACM.
- The CAP.
- Copies of each CASE report.
- Copies of reports documenting the completion of Corrective Action, or proposals to alter the remedy chosen in the original CAP.
- Copies of public notices related to the CAP.
- Transcripts of public hearings related to the implementation or alteration of the CAP.

### 7.1 Location of Public Repository

The RSWA will maintain a public repository of Ivy MUC Corrective Action documents and related reports at two locations open to the public. One set of documents will be maintained at the Jefferson-Madison Regional Library Central Location (201 East Market Street, Charlottesville, Virginia), and one set will be maintained at the Crozet Library (Route 240, Crozet, Virginia). Information on both libraries is available at <http://jmrl.org/main/main.htm>.

In addition, to the maximum extent practicable, documents will be posted in portable document format (PDF) on the RSWA World Wide Website. The homepage address of this website is <http://monticello.avenue.org/Gov/RSWA/home.html> or <http://www.rivanna.org>.

### 7.2 Additional Location of Reports for Public Review

Ivy MUC CAP-related documents will also be maintained at the Rivanna Solid Waste Authority administrative office. The RSWA office is located at the address indicated below.

Rivanna Solid Waste Authority  
695 Moores Creek Lane (formerly 200 Franklin Street)  
Charlottesville, VA 22902-9016

Documents can be reviewed by arranging for an office visit within normal business hours. Preferred times for individuals to review documents are between the hours of 9:00 am and 4:00 pm.

### 7.3 Site Contact Information

The RSWA Executive Director and the Environmental and Safety Manger are identified as Ivy MUC contact persons to who questions from the general public may be submitted. The Executive Director and the Environmental and Safety Manager are knowledgeable about Site conditions, concerns, and aspects of the corrective measure selected as the Site remedy. The Executive Director and Environmental and Safety Manger can be contacted at (434) 977-2970 or via e-mail at [info@rivanna.org](mailto:info@rivanna.org).

## **8.0 Completion of the Corrective Action**

Section 8 includes a description of the actions that will be undertaken and information that will be submitted to meet the requirements of 9 VAC 20-80-310.C.5 and 6, if the Corrective Action Monitoring Program indicates there have been no GPS exceedances for a period of 3 consecutive years.

The groundwater remedy for the Site will be considered complete when the conditions cited below are met.

- Compliance with the GPS at all points within the plume of contamination that lies beyond the CMS.
- Compliance with the GPS has been achieved by demonstrating that concentrations of Appendix 5.1 constituents have not exceeded the GPS for a period of 3 consecutive years using the appropriate statistical procedures and performance standards.
- All actions required to complete the remedy have been satisfied.

Upon completion of the remedy, RSWA will notify the VA DEQ Director within 14 days by submitting a certification that the remedy has been completed in compliance with the requirements listed above. The certification will be signed by RSWA and by a qualified groundwater scientist.

A more detailed description of the requirements listed above and procedures to meet these requirements is presented in the following sections.

### 8.1 Compliance with GPS

One of the requirements for completion of the corrective action is that RSWA must show compliance with the GPS at all points within the plume of contamination that lies beyond the CMS. Compliance will be shown for all CMS wells (currently there are 13 compliance wells) and all CAMS wells.

### 8.2 Methodology for Compliance with GPS

Compliance with the GPS will have been achieved by demonstrating that concentrations of Appendix 5.1 constituents have not exceeded the GPS for a period of 3 consecutive years using the appropriate statistical procedures and performance standards. As stated above, data from CMS and CAMS wells must show compliance with the GPS. It is assumed that the CAMS wells, along with the CMS wells, will be sampled and analyzed on at least a semiannual basis for the Appendix 5.1 constituents until 3 consecutive years of analytical data show compliance with the GPS.

The statistical analysis methods and reporting to be utilized for the CAMS sampling events are described in the CAMP (Appendix B).

### 8.3 Completion of Remedial Actions

The final requirement for presenting completion of the remedy is the performance of all required actions associated with the remedy. These actions include controls and actions discussed in Section 4.1 of this CAP such as those listed below.

- Completion of groundwater remediation requirements.
- Completion and maintenance of in-place controls.
- Completion and implementation of institutional controls.

A summary of completion of the above controls/actions is provided in the following subsections.

#### 8.3.1 Groundwater Remediation

Removal of groundwater-related remediation equipment includes the actions indicated below.

- Sealing and abandoning groundwater monitoring wells as appropriate using the current abandonment procedures.
- Removing delivery equipment, gauges, and controls used for the implemented remedy.

#### 8.3.2 In-place Controls

Maintenance of the in-place controls includes the actions identified below.

- Inspection, maintenance, and repair of cell caps and covers.
- Protective actions to preclude contact with waste-affected media including maintenance of perimeter fencing and posting of the Ivy MUC property prohibiting trespassing by unauthorized individuals.
- Continued operation of the LFGCCS until such time as the cells no longer produce gases in combustible quantities.
- Operations and maintenance of leachate collection and management devices.

#### 8.3.3 Institutional Controls

Completion of remedial actions will require continued implementation of existing institutional controls.

Appropriate public notifications, meetings, and other VSWMR obligations associated with termination of remedial activities as appropriate at the time the corrective action is deemed complete will be completed.

## 9.0 References

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