Appendix G

DESIGN OF FABRIC-FORMED CONCRETE MAT (FCM)
Revised August 2013

REITZ & JENS, INC. CONSULTING ENGINEERS	PROJECT AMEREN LABADIE UWL
	SUBJECT DESIGN OF FABRIC-FORM CONCRETE MAT EROSION PROTECTION
DATE 6/12/2012 BY JLF	Proj. Number 2008012455 SHEET 1 OF 1

REVISED JULY 2013

DESIGN OF FABRIC-FORMED CONCRETE MAT (FCM)

FCM IS FOR EROSION PROTECTION OF PERMANENT EXTERIOR SLOPE OF BERMS. FROM FLOODPLAIN ANALYSIS BY CDG, HIGHEST VELOCITIES OCCUR ALONG WEST BERM AT STA. 57.38 (RM).

MAX. VELOCITY = 1.30 TO 1.40 FPS

DEPTH OF FLOW (Y) = EL 481.6-465 = 16.6 FT FOR 100-YR FLOOD

FROM FHWA HEC-23, VOL. 2 (SEPT. 2009), CHAPTER 9

$$\text{FACTOR SAFETY (FS)} = \left[\frac{\mu(t)(\gamma_c-\gamma_w)\cos\theta\cos\alpha-\tau_{DES}}{\sqrt{[t(\gamma_c-\gamma_w)\sin\theta]^2+\tau_{DES}^2}}\right]$$

WHERE μ = COEFF. BASE SHEAR = TAN δ

RECOMMENDED δ FOR FCM ON FILTER GEOFABRIC OVER COHESIVE SOIL IS 32.5°

$\therefore\ \mu = \tan(32.5^\circ) = 0.637$

t = THICKNESS OF FCM, TRY HYDROTEX FILTER POINT (FP) LINER FP220, WHICH IS 2.2" THICK, OR 0.183 FT

γ_c = UNIT WEIGHT OF FINE AGGREGATE CONCRETE

RECOMMENDED γ_c = 130 PCF

γ_w = 62.4 PCF (WATER)

θ = SLOPE ANGLE = 18.435° FOR 1(v)-3(h)

α = SLOPE OF BED, ASSUME 0

$$\text{ASSUME F.S.} = 1.5 = \left[\frac{(0.637)(0.183)(130\text{ PCF}-62.4\text{ PCF})\cos(18.435^\circ)\cos(0^\circ)-\tau_{DES}}{\sqrt{[(0.183')(130-62.4)\sin 18.435]^2+\tau_{DES}^2}}\right]$$

SOLVING, τ_{DES} = 1.294 PSF FOR F.S. = 1.5

DESIGN VELOCITY: $\tau_{DES} = \dfrac{\gamma_w}{Y^{1/3}}\left(\dfrac{n V_{DES}}{K_u}\right)^2$ WHERE K_u = 1.486 (ENG. UNITS)

n = MANNING COEFF.

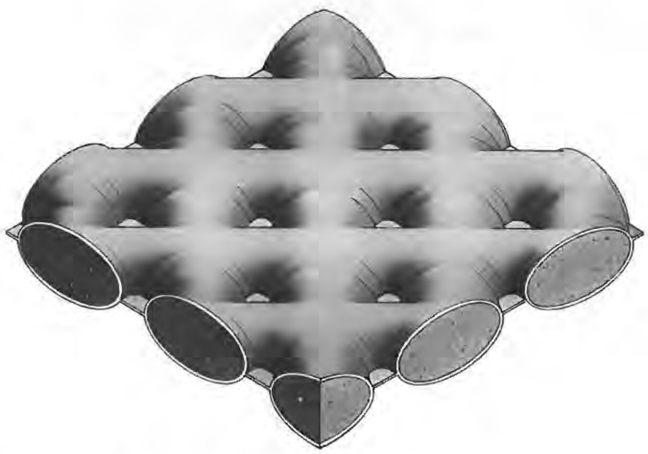
FOR FCM n = 0.03 TO 0.025

$$1.294\text{ PSF} = \frac{62.4\text{ PCF}}{(16.6')^{1/3}}\left(\frac{0.03\cdot V_{DES}}{1.486}\right)^2$$

MAX V_{DES} = 11.4 FPS >> 1.40 FPS ESTIMATED

USE: HYDROTEX FP220 OVER GEOFABRIC OVER COHESIVE BERM FILL

CHECKED BY: JDB 2/14/2013



HYDROTEX™

Specification Guideline

Fabric-formed Concrete Erosion Control Systems

Filter Point Lining

Table 1.0 Typical Dimensions and Weights

Filter Point	FP220	FP400	FP600	FP800	FP1000	FP1200
Average Thickness, mm	56	102	152	203	254	305
Mass Per Unit Area, kg/m²	121	220	330	440	550	661
Filter Point Spacing, mm	127	203	254	305	356	406
Area per Filter Point, cm²	12.9	12.9	40.7	40.7	78.7	78.7
Perimeter per Filter Point, mm	165	165	279	279	381	381
Concrete Coverage, m²/m³	16.6	9.1	6.1	4.6	3.6	3.0
Shear Resistance, kg/m²	54	98	146	195	244	293

Note: Values shown are typical and will vary with weight of concrete and field conditions.

Product Description

Filter Point Linings with filtering points (drains) provide an erosion resistant, permeable concrete lining for ditches, channels, canals, streams, rivers, ponds, lakes, reservoirs, marinas, and protected port and harbor areas. Filter Point Linings have a cobbled surface and a relatively high coefficient of hydraulic friction in order to achieve lower flow velocities and to reduce wave run-up. The filter points provide for the relief of hydrostatic uplift pressure, increasing the system's stability.

Filter Point Linings are generally used in lieu of stone rip rap or slope paving due to their lower cost and higher performance. Filter Point Linings have greater stability than conventional slope paving because of several factors – they can mitigate uplift pressure from ground water, reduce hydraulic uplift of flowing water by slowing channel velocities, and conform to soil contours during installation to reduce the potential for underscour.

Filter Point forms are woven from multifilament and textured yarns. The double-layer fabric is joined by interwoven filter points on controlled centers to form a lining with a deeply cobbled appearance. The spacing of the filter points determines the lining's thickness and weight, while the specially designed filter points relieve hydrostatic pressure and reduce applied stress to the fabric during pumping. Filter Point Linings are available in a wide range of thicknesses.

1.0 GENERAL

1.1 Scope of Work: The Contractor shall furnish all labor, materials, equipment, and incidentals required to perform all operations in connection with the installation of the proposed Filter Point (FP) Lining in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein.

1.2 Description: The work shall consist of installing an unreinforced concrete lining by positioning specially woven, double-layer synthetic forms on the surface to be protected and filling them with a pumpable, fine aggregate concrete (structural grout) in such a way as to form a stable lining of required thickness, weight and configuration.

2.0 MATERIALS REQUIREMENTS

2.1 Fine Aggregate Concrete: Fine aggregate concrete shall consist of a proportioned mixture of Portland cement, fine aggregate (sand) and water. The consistency of the fine aggregate concrete delivered to the concrete pump shall be proportioned and mixed as to have an efflux time of 9-12 seconds when passed through the 19 mm orifice of the standard flow cone that is described in ASTM C 939. Pozzolan, fluidifier or pumping aid conforming to this Specification may be used at the option of the Contractor. The mix shall exhibit a compressive strength of 13.8 MPa at 28 days, when made and tested in accordance with ASTM C 31 and C 39.

2.1.1 Portland cement shall conform to ASTM C 150, Type I or Type II.

2.1.2 Fine aggregate shall conform to ASTM C 33, except as to grading. Aggregate grading shall be reasonably consistent and shall not exceed the maximum size which can be conveniently handled with available pumping equipment.

PROPERTY REQUIREMENTS - FILTER POINT FABRIC[1, 2]				
Property		**Test Method**	**Units**	**Values**
Physical:				
Composition of Yarns				Nylon or polyester
Mass Per Unit Area (double-layer)		ASTM D 5261	g/m^2	403
Thickness		ASTM D 5199	mm	0.6
Mill Width			m	1.92
Mechanical:				
Wide-Width Strip Tensile Strength	- Machine	ASTM D 4595	kN/m	24.5
	- Cross		kN/m	19.3
Elongation at Break	- Machine	ASTM D 4595	%	20
	- Cross		%	30
Trapezoidal Tear Strength	- Machine	ASTM D 4533	N	665
	- Cross		N	445
Hydraulic:				
Apparent Opening Size (AOS)		ASTM D 4751	mm	0.425
Flow Rate		ASTM D 4491	$l/min/m^2$	3665
Flow Rate through Filter Point		ASTM D 4491	$l/min/m^2$	285

Notes:

1. *Conformance of fabric to specification property requirements shall be based on ASTM D 4759, "Practice for Determining the Specification Conformance of Geotextiles."*
2. *All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing."*

2.1.3 Water for mixing shall be clean and free from injurious amounts of oil, acid, salt, alkali, organic matter or other deleterious substances.

2.1.4 Pozzolan, if used, shall conform to ASTM C 618, Class C, F or N.

2.1.5 Plasticizing and air entraining admixtures, if used, shall conform to ASTM C 494 and ASTM C 260, respectively.

2.2 Fabric Forms: The fabric forms shall be as specified, HYDROTEX™ Filter Point (see Note A) forms as manufactured by Geostar Corporation; 74 Perimeter Center East, Suite 7420; Atlanta, Georgia 30346-1803, Tel: 800.253.0561 (770.399.5051); or approved equal. The fabric forms shall be composed of synthetic yarns formed into a woven fabric. Yarns used in the manufacture of the fabric shall be composed of nylon and/or polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight) to improve adhesion to fine aggregate concrete and to improve filtration. Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. Each layer of fabric shall conform to the physical, mechanical and hydraulic requirements referenced herein. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Note A: The engineer shall indicate the Filter Point Lining size required (see Table 1.0). Example: FP400.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven filter points to form a concrete lining with a finished average thickness of (*see Table 1.0*) mm, a nominal mass per unit area of (*see Table 1.0*) kg/m^2, and a deeply cobbled surface appearance. After the form has been filled with fine aggregate concrete, the filter points shall be on approximately (*see Table 1.0*) mm spacing when measured along the diagonal. Filter points shall be formed by interweaving the double-layer fabric to form water permeable drains and attachment points for the control of concrete lining thickness. The interweaving of the fabric layers shall form an area of double density, high strength, single-layer fabric with an area of (*see Table 1.0*) cm^2 and a perimeter of (*see Table 1.0*) mm. All filter points shall be cross shaped and shall have twill weave centers designed to function as drains to relieve hydrostatic uplift pressure.

2.2.2 Mill widths of fabric shall be a minimum of 1.92 meters. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 35 mm by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 182 cm centers.

2.2.3 All factory-sewn seams shall be downward facing as shown on the Contract Drawings. All seams sewn in the factory shall be not less than 15.7 kN/m when tested in accordance with ASTM D 4884. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All stitches shall be sewn simultaneously and be parallel to each other, spaced between 6 and 19 mm apart. Each row of stitching shall consist of 4 to 7 stitches per 25.4 mm. Thread used for seaming shall be nylon and/or polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 400 N when tested in accordance with ASTM D 4632.

2.2.5 The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873, "Guide for Identification, Storage and Handling of Geosynthetic Rolls."

2.2.6 The Contractor shall submit a manufacturer's certificate that the supplied fabric forms meet the criteria of these Specifications, as measured in full accordance with the test methods and standards referenced herein. The certificates shall include the following information about each fabric form delivered:

Manufacturer's name and current address;
full product name;
style and product code number;
form number(s);
composition of yarns; and
manufacturer's certification statement.

2.3 Filter Fabrics: The filter fabrics shall be composed of synthetic fibers or yarns formed into a nonwoven or woven fabric. Fibers and yarns used in the manufacture of filter fabrics shall be composed of at least 85% by weight of polypropylene, polyester or polyethylene. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. These materials shall conform to the physical requirements shown below. The filter fabric shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

PROPERTY REQUIREMENTS - FILTER FABRIC [1, 2]

Property	Test Method	Units	Values
Grab Tensile Strength	ASTM D 4632	N	400
Elongation at Break	ASTM D 4632	%	15
Trapezoidal Tear Strength	ASTM D 4533	N	130
Permittivity	ASTM D 4491	sec^{-1}	0.5

Notes:

1. *Conformance of filter fabrics to specification property requirements shall be based on ASTM D 4759, "Practice for Determining the Specification Conformance of Geotextiles."*
2. *All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354, "Practice for Sampling of Geosynthetics for Testing."*

3.0 DESIGN REQUIREMENTS

Note B: Select the appropriate pair of paragraphs for the final specification based upon the type of hydraulic application.

The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings (velocity, depth, duration, shear stress, pressure, and frequency of immersion) for the design discharges along the structure(s). The stability analysis for each concrete lining shall be accomplished using a factor-of-safety methodology. A minimum factor of safety of 1.5 shall be required.

The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric formed concrete lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by the documented hydraulic performance characteristics derived from tests performed under controlled flow conditions. Test conditions shall conform to test protocol as documented in "Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow."

or

The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings (depth, duration, type of wave, wave height and period, and pressure distribution) for the design wave. The stability analysis for the concrete lining shall be accomplished using the factor-of-safety methodology. A minimum factor of safety of 1.5 shall be required.

The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric formed concrete lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by hydraulic stability calculations derived from mathematical models developed specifically for fabric formed concrete linings and for this purpose.

4.0 CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation

4.1.1 Areas on which fabric forms are to be placed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. All obstructions such as roots and projecting stones shall be removed. Where such areas are below the allowable grades, they shall be brought to grade by placing compacted layers of select material. The thickness of layers and the amount of compaction shall be as specified by the Engineer. Where required by the Contract Specifications, soft and otherwise unsuitable subgrade soils shall be identified, excavated and replaced with select materials in accordance with the Contract Specifications.

4.1.2 Excavation and preparation of aprons as well as anchor, terminal or toe trenches shall be done in accordance with the lines, grades, contours, and dimensions shown on the Contract Drawings.

4.1.3 Immediately prior to placing the fabric forms, the prepared area shall be inspected by the Engineer, and no forms shall be placed thereon until the area has been approved.

4.2 Fabric Form Placement

4.2.1 A filter fabric shall be placed on the graded surface approved by the Engineer.

4.2.2 Fabric forms shall be placed over the filter fabric and within the limits shown on the Contract Drawings. Anchoring of the fabric forms shall be accomplished through the use of anchor, terminal and toe trenches.

4.2.3 Adjacent fabric forms shall be joined before filling with fine aggregate concrete by field sewing or zippering the two bottom layers of fabric together and the two top layers of fabric together. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing, and all zipper seams shall be fastened as shown on the Contract Drawings, except with the approval of the Engineer.

4.2.4 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of one meter to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the downstream edge of the form shall overlap the upstream edge of the next form. In no case shall simple butt joints between forms be permitted.

4.2.5 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.2.6 Immediately prior to filling with fine aggregate concrete, the assembled fabric forms shall be inspected by the Engineer, and no fine aggregate concrete shall be pumped therein until the fabric seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five days.

4.3 Fine Aggregate Concrete Placement

4.3.1 Following the placement of the fabric forms, small slits shall be cut in the top layer of the fabric form to allow the insertion of the filling pipe at the end of the fine aggregate concrete pump hose. These slits shall be of the minimum length to allow proper insertion of the filling pipe. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

4.3.2 Fine aggregate concrete shall be pumped in such a way that excessive pressure on the fabric forms and cold joints are avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given form is discontinued or interrupted for an interval of forty-five or more minutes.

4.3.3 Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of nonwoven fabric or similar material. The nonwoven fabric shall be removed when the concrete is no longer fluid and the concrete surface at the hole shall be cleaned and smoothed by hand. Foot traffic on the filled form shall be restricted to an absolute minimum for one hour after filling.

4.3.4 After the fine aggregate concrete has set, all anchor, terminal and toe trenches shall be backfilled and compacted, as specified by the Engineer.

4.3.5 The Filter Point Lining shall be measured by the number of square meters computed from the payment lines shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes Filter Point fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, and anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

Spec: FP (siu)
Revised December 2001

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Appendix K

Soil Material Volume and
Balance Calculations
Revised August 2013

Ameren Missouri Labadie Energy Center
Construction Permit Application for a Proposed Utility Waste Landfill
Franklin County, Missouri

December 2012, Revised August 2013

Appendix K
Soil Material Volume and Balance Calculations

Appendix K contains calculations of soil needed (required) for construction of the Ameren Missouri Labadie Energy Center Utility Waste Landfill (UWL), and the soil available on-site for the construction. Soil is required for construction of the four general components of the UWL: perimeter berms; liner system; intermediate cover; and final cover system. Operational cover (intermediate) is proposed based on the characteristics of the coal combustion products (CCPs) that will be placed in the UWL.

The perimeter berms are designed with 3:1 side slopes, with a typical berm height of 23 feet, and a 12-foot wide access road on top of the berm. The exterior perimeter berm slopes will be lined with a 2.2-in thick, fabric-formed articulated concrete mat. A 2-feet thick compacted clay liner will be placed on the inside slope of the berm to tie-in with the landfill liner in each phase.

The UWL's final cover system will be two (2) feet of nominally compacted soil capable of sustaining vegetation, underlain by a geotextile cushion, which is underlain by a geomembrane liner.

Three general soil types will be used for construction of the UWL components: Liner-quality, non liner-quality, and vegetative soil. Liner-quality soil describes clayey soils that would meet the requirements of 10 CSR 11.010(10)(B)1 for the landfill liner. Non liner-quality soil describes low plastic clayey soil, silty soils, or sandy soils present at the site. Non liner-quality soils would not be suitable for the landfill liner, but would be used for the construction of the core of the perimeter berms. Vegetative soil describes soils that are capable of sustaining vegetation for the UWL final cover or the outside slopes of the perimeter berms.

The following table summarizes the pertinent acreages and berm volumes for each utility waste landfill component. The acreages and berm volumes were determined from the AutoCAD drawings that depict the three storm water ponds and the layout of the four disposal phases.

UWL Component	Design Parameters	Notes/Comments
Phase 1	Cell 1: 31.4 acres	Stormwater Pond 1: 5.7 acres
Phase 2	Cell 2: 35.2 acres	

Phase 3	Cell 3: 57.1 acres	Stormwater Pond 2: 4.4 acres
Phase 4	Cell 4: 42.8 acres	Stormwater Pond 3: 3.4 acres
Total Permitted Disposal Area	**166.5 acres**	**Includes Cells 1 through 4, excludes the Stormwater Ponds.**
Stormwater Pond 1	5.7 acres	Area at 488' contour
Stormwater Pond 2	4.4 acres	Area at 488' contour
Stormwater Pond 3	3.4 acres	Area at 488' contour
Total Area for Excavation	**180.0 acres**	**Includes Phases 1 through 4 and the Stormwater Ponds.**

Final "Top of Landfill" Area	73.7 acres	Final "flat" top of UWL at closure.
Final "Exterior Side Slopes" Area	92.8 acres	Final slopes at closure.
Total Final Area for Closure	**166.5 acres**	**Total Acreage Requiring Final Cap**

All calculated volumes of soil, both needed and available, are rounded up to the nearest 1,000 yd^3.

The total soil balance for Phases 1 through 4 and the three stormwater ponds, for clay liner, final cap (top and side slopes), and all perimeter berms, reveals a total soil shortage of 2,750,000 CY of on-site soils within the foot print of Phases 1 through 4 and the three stormwater ponds.

Soils available: 1,260,000 CY

Soils needed: (perimeter berms, liner, intermediate and final cover): 4,010,000 CY

Net soil balance for the landfill: -2,750,000CY

An estimated 2,600,000 CY of liner-quality soil is available from a borrow area in Callaway County on property owned by Ameren Missouri. This is greater than the 639,000 CY of liner-quality soil needed. A contractor will supply additional soil for berm core fill and vegetative cover.

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

December 2012, REVISED August 2013

Appendix K
Soil Material Volume and Balance Calculations

Note: All calculated volumes are rounded to the nearest 1,000 CY.
Stripping depth of 1.63 ft is the required minimum for volume of final cover.
Soil balance calculations utilized the minimum stripping depth required.
Stripping depth of 1.75 ft is recommended.

Lifetime Construction: Phases 1 through 4 and Stormwater Ponds

ESTIMATE OF TOTAL SOIL NEEDED

ESTIMATE OF NOMINALLY COMPACTED FINAL COVER SOIL NEEDED

SOIL TYPE REQUIRED: Vegetative

Volume (CY) = Area (AC) x 43,560 SF/AC x 2 ft x 1.1 [shrinkage factor] / 27 CF/CY

Total Area	166.5	AC		
Total Volume of 2 ft Nominally Compacted Final Cover	166.5	AC=	**591,000**	**CY**

ESTIMATE OF UWL LINER SOIL REQUIRED

SOIL TYPE REQUIRED: Liner Quality

Volume (CY) = Area (AC) x 43,560 SF/AC x 2 ft x 1.1 [shrinkage factor] / 27 CF/CY

Disposal Areas	166.5	AC=	**591,000**	**CY**
Pond Areas	13.5	AC=	**48,000**	**CY**
Total Area	180.0	AC		
Total Volume of 2 ft Liner for Disposal Area and Ponds	180.0	AC=	**639,000**	**CY**

ESTIMATE OF GENERAL FILL NEEDED UNDER UWL

SOIL TYPE REQUIRED: Non-Liner Quality

From CADD cut/fill volumes - design grade to existing grade.

Volume of General Site Fill Under UWL & Pond Floors	**780,000**	**CY**

ESTIMATE OF PERIMETER BERM CORE FILL SOIL NEEDED

SOIL TYPE REQUIRED: Non-Liner Quality

From CADD cut/fill volumes - design grade to existing grade, less 2-ft clay liner on slope.

Phase 1	204,115	CY
Phase 2	165,531	CY
Phase 3	393,858	CY
Phase 4	293,945	CY
Pond 1	99,269	CY
Pond 2	93,713	CY
Pond 3	65,730	CY
Total Perimeter Berm Volumes	**1,316,162**	**CY**

ESTIMATE OF GENERAL FILL NEEDED TO REPLACE 1.63' STRIPPING UNDER UWL

SOIL TYPE REQUIRED: Non-Liner Quality

Volume (CY) = Area (225 AC) x Depth (1.63 ft) x 43,560 SF/AC / 27 CF/CY

Volume of Fill to Replace 1.63-ft Stripping in Construction Footprint	**592,000**	**CY**

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

December 2012, REVISED August 2013

Appendix K
Soil Material Volume and Balance Calculations

ESTIMATE OF INTERMEDIATE COVER (IC) NEEDED

SOIL TYPE REQUIRED: Non-Liner

Assumes reuse of IC and maxium area requiring IC < 57 AC

Volume (CY) = Area (57 AC) x Depth (1 ft) x 43,560 SF/AC / 27 CF/CY

Volume of Intermediate Cover	**92,000**	**CY**

ESTIMATE OF TOTAL SOIL NEEDED

Intermediate Cover		
Volume of Intermediate Cover Soil Needed	**92,000**	**CY**
Liner and Cover Systems		
Volume of Final Cover Soil Needed	591,000	CY
Volume of Liner Soil Needed	639,000	CY
Total Needed for Liner and Final Cover Systems	**1,230,000**	**CY**
General Fill and Perimeter Berm Soil Needs		
Volume of General Site Fill Under UWL & Pond Floors	780,000	CY
Volume of Perimeter Berm Core Fill Soil Needed	1,316,000	CY
Volume of 1.63-ft. Stripping Replacement	592,000	CY
Total Needed for General Fill and Perimeter Berm	**2,688,000**	**CY**
Estimated Total Volume of Soil Needed	**4,010,000**	**CY**

ESTIMATE OF SOIL-SPECIFIC REQUIRMENTS

Volume of Liner Quality Soil Needed	639,000	CY
Volume of Vegetative Quality Soil Needed	683,000	CY
Volume of Non-Liner Quality Soil Needed	2,688,000	CY
Estimated Total Volume of Soil Needed	**4,010,000**	**CY**

ESTIMATE OF TOTAL SOIL AVAILABLE

Assumes 1.63 ft of vegetative soil will be excavated from the 225 AC area, 5% swell.

Liner Quality Soil to be Excavated from the Construction Footprint	0	CY
Vegetative Soil to be Excavated from the Construction Footprint	621,000	CY
Non-Liner Quality Soil to be Excavated from the Construction Footprint	0	CY
Total Soil to be Excavated from the Construction Footprint	**621,000**	**CY**
Liner Quality Soil to be Excavated from the Borrow Area	639,000	CY
Made to equal liner soil needed. No surplus from borrow inclued		
Vegetative Soil to be Excavated from the Borrow Area	0	CY
Non-Liner Quality Soil to be Excavated from the Borrow Area	0	CY
Total Soil to be Excavated from the Borrow Area	**639,000**	**CY**
Volume of Liner Quality Soil Available	639,000	CY
Volume of Vegetative Soil Available	621,000	CY
Volume of Non-Liner Quality Soil Available	0	CY
Total Soil Available	**1,260,000**	**CY**

Appendix K
Soil Material Volume and Balance Calculations

SOIL BALANCE FOR PHASES 1 THROUGH 4 AND THE STORMWATER PONDS

TOTAL SOIL BALANCE		
Estimated Volume of Soil Needed	4,010,000	CY
Estimated Volume of Soil Avaiable	1,260,000	CY
Soil Balance	**-2,750,000**	**CY**
SOIL SPECIFIC BALANCE		
Estimated Volume of Liner Quality Soil Needed	639,000	CY
Estimated Volume of Liner Quality Soil Available	639,000	CY
Liner Quality Soil Balance	**0**	**CY**
Estimated Volume of Vegetative Soil Needed	683,000	CY
Estimated Volume of Vegetative Soil Available	621,000	CY
Vegetative Quality Soil Balance	**-62,000**	**CY**
Estimated Volume of Non-Liner Quality Soil Needed	2,688,000	CY
Estimated Volume of Non-Liner Quality Soil Available	0	CY
Non-Liner Quality Soil Balance	**-2,688,000**	**CY**
LANDFILL SYSTEMS BALANCE		
Estimated Liner Quality Soil for Liner Needed	639,000	CY
Estimated Liner Quality Soil for Liner Available	639,000	CY
Liner and Cover System Liner Quality Soil Balance	**0**	**CY**
Estimated Volume of Vegetative Soil for Cover Systems Needed	683,000	CY
Estimated Volume of Vegetative Soil for Cover Systems Available	621,000	CY
Cover Sytem Vegetative Soil Balance	**-62,000**	**CY**
GENERAL FILL AND PERIMETER BERM BALANCE		
Estimated Volume of General Fill and Permieter Berm Core Fill Needed	2,688,000	CY
Estimated Volume of General Fill and Permieter Berm Core Fill Available	0	CY
General Fill and Perimeter Berm Core Fill Balance	**-2,688,000**	**CY**

Appendix L

Landfill Life Estimate

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

January 2013

Appendix L
Landfill Life Estimate

The life of the proposed utility waste landfill (UWL) is estimated based on projected waste volume production rates and the calculated net UWL volume. The total UWL volume was estimated using CADD to measure the volume between a surface 2-feet below the final cover (to adjust for the final cover thickness of 2-feet) and a surface 1-foot above the top-of-liner (to adjust for the protective cover thickness of 1-foot). The net UWL volume was then determined by deducting a volume equal to the area of the relatively flat floor (146.6 acres) times a thickness of 1-foot, to account for the volume occupied by the leachate drainage aggregate layer.

Gross UWL Airspace Volume = 16,513,000 CY

Drainage Layer Volume = 1 ft x 146.6 AC x 43,560 SF/AC x 1 CY/ 27 CF = 236,500 CY

Protective Cover Volume = 1 ft x 166.5 AC x 43,560 SF/AC x 1 CY/ 27 CF = 268,600 CY

Final Cover Volume = 2 ft x 166.5 AC x 43,560 SF/AC x 1 CY/27 CF = 537,200 CY

Net Waste Volume = 16,513,000 – 236,500 - 268,600 - 537,200 = 15,470,700 CY

Two wet flue gas desulfurization (WFGD) systems will come on line at different times, increasing the rate of coal combustion product (CCP) generation over time. The generations rates projected are:

- 2015 to 2019, 2.3 MCY,
- 2020 to 2024, 2.9 MCY,
- 2025 to 2029, 3.6 MCY, and
- 2030 and after, 3.8 MCY every five year period or 760,000 CY/year.*

The amount of landfill volume remaining after the first 15 years would be:

15.5 MCY – 2.3 MCY – 2.9 MCY – 3.6 MCY = 6.7 MCY

The years of life available in the remaining volume is:

6.7 MCY / 760,000 CY/year = 8.8 years

The total landfill life is:

15.0 + 8.8 = 23.8 years

---

* CCP production estimates are drawn from the Reitz & Jens Design Basis dated October 16, 2012.

Appendix M

Erosion Calculations

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri
December 2012

Amendments to Erosion Calculations
Appendix M

EROSION PROTECTION CALCULATIONS

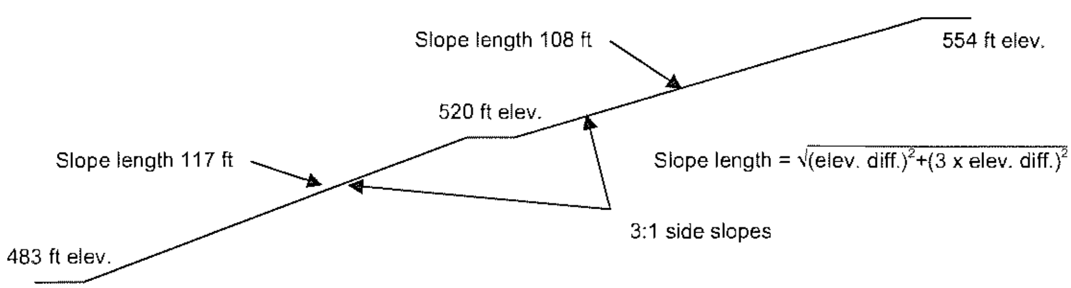
The stormwater drainage structures were checked for erosion control by utilizing the Erosion Control Materials Design Software 4.3 (ECMDS) by North American Green (NAG). This software analyzes erodibility of various channel/slope configurations. The channel/slope is analyzed for erodibility based upon soil type, cover, flow-rate, velocity, Manning's number and channel grade. Channel sections representative of the side slope benches and letdown ditches have been analyzed for erosion using riprap.

SUMMARY OF DESIGN ANALYSIS

1. Typical Landfill Slope Erosion Protection

The typical top of landfill was modeled for erosion using ECDMS, which uses a version of the Revised Universal Soil Loss Equation (RUSLE). The top of the landfill is designed with a minimum 2 percent slope. The maximum distance along the 2 percent slope is 550 ft. The annual soil loss of 0.013 inches per year is less than the permissible 0.03 inches per year, and is considered acceptable (a standard value in ECDMS; see Table 1 and Figure 1a).

The typical side slope was also modeled for erosion using ECDMS. The 3:1 side slope of 225 ft is broken into two sections of approximately 117 ft and 108 ft by a bench at 520 feet elevation. Both segments have annual soil losses less than 0.03 in. The segment with the larger annual soil loss eroded at a rate of 0.017 in/yr (see Table 1 and Figures 1a and 1b).



2. Typical Diversion Structure on Top of Landfill

Flow from the top of the landfill will be directed to the letdowns using diversion structures. The typical diversion structure would have a slope of up to 1 percent, a depth of 1 ft, and side slope of 50:1 and 3:1. ECMDS was used to calculate shear stress resulting from the maximum flow of 4.5 cfs (half the maximum flow in a letdown). Shear stresses were within permissible levels (see Table 1 and Figure 2).

3. Typical Landfill Letdown Structure

The standard letdown design to be utilized at the Ameren Missouri Labadie Power Plant Utility Waste Landfill (8 ft wide bottom and 3:1 side slopes) was checked for permissible shear stress using two types of cover (reinforced vegetation and 22-in riprap). ECMDS was used to calculate shear stress resulting from the maximum flow of 8.9 cfs on the 3:1 bottom slope of the letdowns. The letdown structure flow was calculated in Appendix N using the Rational method, a 25-year, 1-hour storm, the largest area drained by a letdown structure. Shear stresses were within permissible levels (see Table 1 and Figure 3a and 3b).

4. Typical Bench

Benches on the side slope are proposed. They will be at 520 ft elevation and have 1 percent bottom slopes. The bench side slopes will be 3:1 on one side and 10:1 on the other, with a depth of 1.5 ft. As with the letdown structures, these were modeled using ECMDS. The permissible shear stress for a fair stand of vegetation is greater than the estimated shear stress created by a flow of 4.5 cfs (half the maximum flow in a letdown; see Table 1 and Figure 4).

5. Perimeter Ditch

The standard perimeter ditch to be utilized at the Ameren Missouri Labadie Power Plant Utility Waste Landfill (9 ft wide bottom and 3:1 side slopes) was checked for permissible shear stress using a fair stand of unreinforced vegetation. ECMDS was used to calculate shear stress resulting from the maximum flow of 36 cfs. Shear stresses were within permissible levels (see Table 1 and Figure 5).

TABLES

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

Summary Table of Erosion Control
Table 1

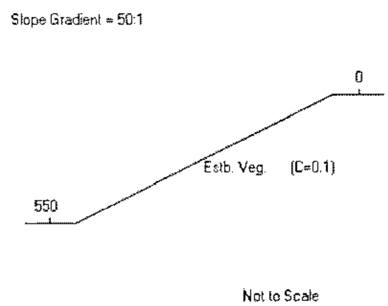
	Structure	Description of Cover and Conditions	Safety Factor	Limitations		
				Limiting Factor	Permissible	Calculated
1a	Typical Top of Landfill	Unreinforced vegetation with a fair stand of bunch growth	2.232	Soil Loss	0.03 in/yr	0.013 in/yr
1b	Typical Side Slope Below Bench	117 feet of cover with an excellent stand of sod growth	2.284	Soil Loss	0.03 in/yr	0.013 in/yr
	Typical Side Slope Above Bench	108 feet of cover with a good stand of mixed bunch and sod growth	1.816	Soil Loss	0.03 in/yr	0.017 in/yr
2	Typical Diversion Structure on Top of Landfill	Unreinforced vegetation with a fair stand of bunch growth	9.04	Shear Stress	4.20 psf	0.46 psf
3a	Typical Letdown	Reinforced vegetation	1.55	Shear Stress	7.00 psf	4.52 psf
3b	Typical Letdown	RipRap	1.23	Shear Stress	7.33 psf	5.98 psf
4	Typical Bench	Unreinforced vegetation with a fair stand of bunch growth	6.49	Shear Stress	4.20 psf	0.65 psf
5	Typical Perimeter Ditch	Good stand of mixed bunch and sod growth	70.17	Shear stress	0.035 psf	0.000499 psf

FIGURES

Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Top of Landfill
Figure 1a

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:10 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.: | SLOPE DESCRIPTION: Typical Top of Landfill

Country	United States
State/Region	Missouri
City	St. Louis
Annual R Factor	210
Total Slope Length (ft)	550
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	210.
Slope Gradient (H:1)	50
Soil Type	Silt Loam
K Factor	0.33
Soil Loss Tolerance (in)	0.03



Reach	Cum. Dist. Begin (ft)	Cum. Dist. End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)			SLT (in)	SF	Remarks
1	0	550	Estb. Veg.	Bunch Type	50-75%	0.134	0.013			0.03	2.232	STABLE
2												
3												
	0	550		**Composite**		0.134	0.013					

Vegetation Density=Percentage of soil coverage provided by vegetation
ASLbare=Average Soil Loss potential of unprotected soil (uniform inches)
MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches)
SLT=Soil Loss Tolerance for slope segment (uniform inches)
Composite=Average soil loss from total slope length (uniform inches)
C=Cover material performance factor (Fraction of soil loss of unprotected)
ASLmat=Average Soil Loss potential w/material (uniform inches)
MSLmat=Maximum Soil Loss potential w/material (uniform inches)
SF=Safety Factor

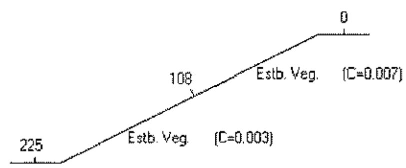
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Side Slope
Figure 1b

North American Green - ECMDS Version 4.3 | 6/14/2012 | 04:31 PM | COMPUTED BY:

PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.: | SLOPE DESCRIPTION:

Country	United States
State/Region	Missouri
City	St. Louis
Annual R Factor	210
Total Slope Length (ft)	225
Protection Type	Permanent
Protection Period (months)	
Beginning Month	
Adjusted R Value	210.
Slope Gradient (H:1)	3
Soil Type	Silt Loam
K Factor	0.33
Soil Loss Tolerance (in)	0.03

Slope Gradient = 3:1



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Reach	Cum. Dist. Begin (ft)	End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)			SLT (in)	SF	Remarks
1	0	108	Estb. Veg.	Mix (Both Sod/Bunch)	>=95%	2.360	0.017			0.03	1.816	STABLE
2	108	225	Estb. Veg.	Sod Former	>=95%	4.378	0.013			0.03	2.284	STABLE
3												
	0	225		**Composite**		3.409	0.015					

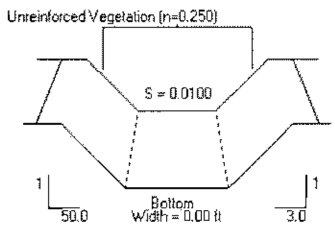
Vegetation Density=Percentage of soil coverage provided by vegetation
ASLbare=Average Soil Loss potential of unprotected soil (uniform inches)
MSLbare=Maximum Soil Loss potential on unprotected soil (uniform inches)
SLT=Soil Loss Tolerance for slope segment (uniform inches)
Composite=Average soil loss from total slope length (uniform inches)
C=Cover material performance factor (Fraction of soil loss of unprotected)
ASLmat=Average Soil Loss potential w/material (uniform inches)
MSLmat=Maximum Soil Loss potential w/material (uniform inches)
SF=Safety Factor

Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Diversion Structure on Top of Landfill
Figure 2

North American Green - ECMDS Version 4.3		10/31/2012	08:15 AM	COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie		PROJECT NO.:		
FROM STATION/REACH:	TO STATION/REACH:	DRAINAGE AREA:		DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
4.5	1.0	0.31	14.68	0.37	0.74



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		C	Mix	50-75%	4.20	0.46	9.04	STABLE
		Soil	Silt Loam				0.035	0.001	48.47	STABLE

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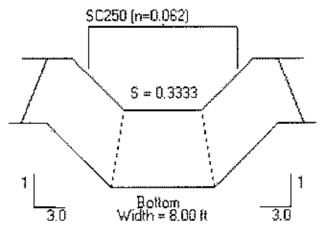
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Reinforced Vegetation Letdown Structure
Figure 3a

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:17 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
8.9	1.0	4.74	1.88	0.20	0.22



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	SC250	Vegetation	2	D	Mix	75-95%	7.00	4.52	1.55	STABLE
	Staple E	Soil	Silt Loam				2.500	0.470	5.32	STABLE

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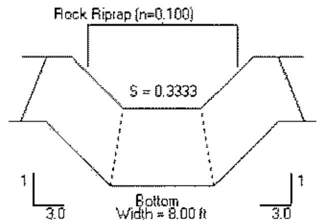
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Riprap Letdown Structure
Figure 3b

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:19 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
8.9	1.0	3.49	2.56	0.26	0.29



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Rock Riprap	Unvegetated					7.33	5.98	1.23	STABLE
	22in									

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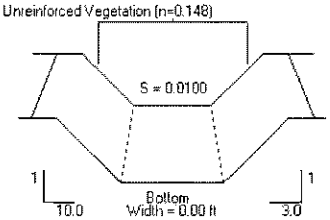
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Bench
Figure 4

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:20 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
4.5	1.0	0.64	7.00	0.51	1.04



LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics				Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
			Phase	Class	Type	Density				
Straight	Unreinforced	Vegetation		C	Bunch	50-75%	4.20	0.65	6.49	STABLE
		Soil	Silt Loam				0.035	0.004	8.06	STABLE

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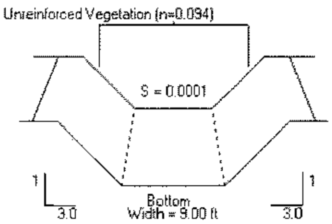
Ameren Missouri Labadie Power Plant
Proposed Utility Waste Landfill
Franklin County, Missouri
Appendix M
Typical Perimeter Berm
Figure 5

North American Green - ECMDS Version 4.3 | 10/31/2012 | 08:23 AM | COMPUTED BY:
PROJECT NAME: Ameren Missouri Labadie | PROJECT NO.:
FROM STATION/REACH: | TO STATION/REACH: | DRAINAGE AREA: | DESIGN FREQUENCY:

HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
36.0	1.0	0.32	112.74	2.86	4.81



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LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	Unreinforced	Vegetation		C	Bunch	50-75%	4.20	0.03	139.90	STABLE
		Soil	Silt Loam				0.035	0.000499	70.17	STABLE

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Appendix N

Stormwater Calculations

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
December 2012

Appendix N

STORMWATER DRAINAGE STRUCTURE SUMMARY

10 CSR 80-11.010 (8)(B)1.F.II of the Missouri Solid Waste Management Regulations requires that "On-site drainage structures and channels shall be designed to prevent flow onto the active portion of the utility waste landfill during peak discharge from at least a twenty-five (25)-year storm…." 10 CSR 80-11.010 (8)(B)1.F.III of the Missouri Solid Waste Management Regulations requires that "On-site drainage structures and channels shall be designed to collect and control at least the water volume resulting from a twenty-four (24)-hour, twenty-five (25)-year storm." In this document, the capacities of the stormwater drainage structures are calculated and compared to expected storm flows using the Rational Method equation. Channel design calculations utilized a 1-hour, 25-year storm intensity as the basis for estimating runoff and peak discharge. The 1-hour intensity storm results in a larger peak flow than the 24-hour intensity storm. Pond storage capacity calculations utilized the 24-hour, 25-year storm intensity for the peak design volume.

Drainage Areas and Flows

To determine the spacing of letdown structure, limits on the grade within the side benches were set. The flow line of the benches were set at a grade of 200H:1V (0.5%), and were limited to a depth of 1.5 feet difference in elevation along the length of the bench. Using those limits, the letdown structures were spaced approximately 600 feet apart, with benches rising away in both directions from each letdown structure. Figure N-1 shows the locations of letdown structures. The first letdown ditch is expected to be built in line with the eastern side of Pond 1 in Cell 1. From this location, letdown structures are numbered proceeding clockwise around the footprint of the landfill. Ponds are located on Figure 1 and are numbered in the order they are expected to be constructed.

Table N-1 is a summary of the letdown structures and is set up to indicate which pond will serve each letdown structure. The letdown structure flows are directed to the nearest pond. Table N-1 lists:

- a location at a letdown structure or pond,
- the distance along the perimeter of the side-slope crest,
- the side slope area below the top of slope which is conservatively assumed to collect in the perimeter ditch at the letdown ditch,
- the side slope area below the top of slope is also assumed to flow into the perimeter ditch through the letdown structure,
- the sum of the total drainage area flowing in the letdown structure,
- the sum of all areas served by the perimeter ditch at and above the letdown structure,
- the flow contributed to the perimeter ditch at each letdown structure, and;
- the cumulative flow in the perimeter ditch at the location of each letdown structure.

The table is set up to allow convenient coordination with the tables estimating the water profiles in the perimeter ditch.

Capacity

The Rational Method was used to estimate the landfill's runoff. The rational method equation is:

$$Q = CIA$$

Where: Q is the flow rate (cfs)
C is the runoff coefficient (unitless)
I is the rainfall intensity (in/hr)
A is the drainage area (acres)

A runoff coefficient of C=0.4 is used and is considered representative for low to moderate permeability soils with emergent ground cover on steep slopes.

Areas served by side benches and letdowns are expected to be less than 11 acres each. For a 25-yr, 1-hr storm, the expected rainfall is 2.63 in/hr and the anticipated runoff from 11 acres is:

$$Q = 0.4 \text{ X } 2.63 \text{ in/hr X } 11 \text{ ac X } 43{,}560 \text{ ft}^2\text{/ac X } 1 \text{ ft/12 in X } 1 \text{ hr/3,600 s} = 11.67 \text{ cfs}$$

The 25-yr, 1-hr storm intensity (2.63 in/hr) is used as more conservative than the 25-yr, 24-hr storm intensity of 5.6 in. The 24-hr storm intensity would require the flow to be adjusted by dividing by 24 hours; 5.6 in/24 hr. = 0.233 in/hr. The storm intensity table is found in Rainfall Frequency Atlas of the Midwest by Floyd A. Huff and James R. Angel, Table 7 (http://www.sws.uiuc.edu/pubdoc/B/ ISWSB-71.pdf). Capacity for flow was evaluated for top of slope diversion berms, intermediate bench diversion berms (side benches) and letdown structures. The largest flow of 11.67 cfs is also used in Appendix M to test the stability of these structures for erosion during peak flow.

Manning's equation was used to calculate the flow capacity of the three types of drainage features: top of slope diversion berms; intermediate bench diversion berm; and letdown structures. Manning's equation is:

$$Q = (1.49/n)(A)(rH)^{2/3}(s)^{1/2}$$

Where: Q is the flow rate (cfs)
n is Manning's coefficient of roughness (unitless)
A is the drainage area (ft^2)
r_H is the hydraulic radius (ft), which equals A/P_w, where P_w is the wetted perimeter, and
s is the slope (ft/ft).

Manning's equation is also used to define the water profile in the perimeter ditch.

Top of Slope Diversion Berms

The purpose of the top of slope diversion berms is to inhibit rill erosion on the upper part of the landfill cap and at the top of the 3:1 slope. Diversion berms are placed on the cap to direct run-off to the letdown structures. The diversion berms are simple mounds of soil constructed as a V-notch channel. The berms are modeled with Manning's equation using a triangular cross-section with side slopes of 3:1 and 50:1 (2%). The following calculation shows the capacity of a berm carrying 0.5 ft. of water with a flow line of one-half percent (0.5%), using a typical n value of .020 for the coefficient of roughness, and an area of 6.63 sq. ft.

$$Q = (1.49/0.020)(6.63)(0.25)^{2/3}(0.005)^{1/2} = 13.9 \text{ cfs} > 11.67 \text{ cfs}$$

This capacity exceeds the flow anticipated at each individual letdown structure shown on Table N-1.

Intermediate Bench Diversion Berm (Side Benches)

The intermediate benches are 1.5 ft deep and have a flowline of one-half percent (0.5%). They have a triangular cross-section with side slopes of 10H:1V and 3H:1V. When full, they have a cross-sectional area of 14.625 sq. ft., a wetted perimeter of 19.8 ft and a hydraulic radius of 0.74 ft. The coefficient of roughness is 0.025.

$$Q = (1.49/0.025)(14.625)(0.74)^{2/3}(0.005)^{1/2} = 50.4 \text{ cfs} > 11.67 \text{ cfs}$$

This capacity exceeds the flow anticipated at each individual letdown structure shown on Table N-1.

Letdown Structure

The letdowns are 1.5 ft deep and have a maximum flowline slope of 33% (3:1). They have a trapezoidal cross-section with and 8 ft bottom and 3:1 side slopes. When full, they have a cross-sectional area of 18.8 sq. ft., a wetted perimeter of 17.5 ft and a hydraulic radius of 1.1 ft. The typical coefficient of roughness equal to 0.035 was used.

$$Q = (1.49/0.035)(18.8)(1.1)^{2/3}(0.33)^{1/2} = 492 \text{ cfs} > 11.67 \text{ cfs}$$

Table N-1 and Figure N-1 (see attached) show the estimated areas served and the estimated flows from each berm and letdown structure.

Perimeter Ditch

Because the perimeter ditch is long and flat and it is expected to flow at a "subcritical" level. Therefore, Manning's equation used alone does not model its capacity well. A combination of Manning's equation and Bernoulli's equation were used to describe the flow in the perimeter ditch. Bernoulli's equation is

$$H = P/\delta + v^2/2g + Z$$

Where: H is the energy measured as depth of water (ft.)
P is the pressure on the water, taken as zero for open systems
δ is gamma, the unit weight of water (lb/ft^3)
v is the velocity of water (fps)
g is the gravity constant (32 fps^2)
Z is the elevation of the fluid element (ft.)

Bernoulli's equations were used to estimate the energy at each letdown structure leading to a specific stormwater pond. Manning's equation was used to estimate the slope of the energy line between the letdown structures. The perimeter ditch was broken into sections between letdowns (see Figure N-1). The depth of flow at the structure was adjusted to estimate the slope of the energy line necessary to match the distances between letdown structures or a letdown structure and the center of the entrance into a stormwater pond. The combination of these equations is used to evaluate the length of the perimeter ditch and the assumption of non-uniform flow.

The flow for the landfill, calculated using the rational method as described above, was proportionally divided between each section and is shown as a cumulative value approaching each pond.

An energy balance was applied to each section to determine the head loss and rise in depth. Bernoulli's and Manning's equations were used to calculate the depth of flow and elevation of the water level in the perimeter ditch. The attached tables summarize these calculations and show the estimated water elevations in each section (see Tables N-2 to N-7). Since these ponds are built at different times during the life of the landfill, consideration was given to the stormwater volumes to those ponds as each cell is constructed. The ponds generally serve the following cells:

- Pond 1 — Cells 1 and 2 — Tables N-2 and N-3
- Pond 2 — Cells 3 and 4 — Tables N-4 and N-5
- Pond 3 — Cells 3 and 4 — Tables N-6 and N-7

Ponds are placed around the Ameren Labadie Energy Center utility waste landfill where space allowed and to minimize the length of flow in the perimeter ditch. The ditch is modeled with a flat bottom width of 9 feet. At a 3:1 slope, two feet (2 ft.) of cover requires 6 feet of the perimeter ditch space. The difference is the placement of soil cover on the initial phases allows for subsequent development of cells without having the amount of infiltration on the caps. The maximum water elevation in the perimeter ditch for all modeled conditions is 485 ft., which is less than the perimeter berm top elevation of 488 ft.

Stormwater Inlet Crests

Runoff flow enters the ponds over stormwater inlet crests constructed in the top of the perimeter berm. These inlets were modeled as broad-crested weirs. Vennard suggests estimating the flow over a broad-crested weir by calculating the flow over the unit length of the weir using the following equation:

$$q = (2/3)^{3/2} \text{ X } g^{1/2} \text{ X } E^{3/2}$$

Where: q is the flow per unit width of a broad-crested weir (cfs/ft.)
g is the gravity constant (32 fps2)
E is the height of the energy line calculated for the entrance to the pond (ft.)

Since the constraints are dependent with not only the flow rate going into the stormwater ponds, but also the weir length of the pond, both elements must be considered. The stormwater collection ponds have the following minimum weir lengths at elevation 483 feet:

Pond 1:	217 ft.
Pond 2:	65 ft.
Pond 3:	300 ft.

The lowest estimated energy grade line coming into any single pond is 0.511 ft. at the influent to Pond 1. Pond 1 has a weir length of 217 ft (see Table N-3). Pond 1 also has the largest design flow at a combined, estimated 69.77 cfs (see Pond 1, Table N-1). Using the equation above, the capacity of the influent structure to Pond 1 is calculated as:

$$Q = (2/3)^{3/2}(32)^{1/2}(0.646)^{3/2} = 1.59 \text{ cfs/ft.}$$

$$1.59 \text{ cfs/ft} * 217 \text{ ft} = 345 \text{ cfs} > 69.77 \text{ cfs}$$

Therefore, the influent structure to Pond 1 has sufficient capacity for the anticipated design flow.

Pond 2 has the shortest weir length, with a weir length of 65 ft. Pond 2 has an estimated energy grade line of 1.064 ft. (see Pond 2, Table N-5). The combined, estimated design flow into Pond 2 is estimated at 50.37 cfs.

$$Q = (2/3)^{3/2}(32)^{1/2}(0.836)^{3/2} = 2.35 \text{ cfs/ft.}$$

$$2.35 \text{ cfs/ft} * 65 \text{ ft} = 152.75 \text{ cfs} > 50.37 \text{ cfs}$$

Therefore, the influent structure to Pond 2 has sufficient capacity for the anticipated design flow.

It is concluded that the influent structures for the stormwater collection ponds have adequate flow capacity based on their respective weir length and the estimated height of energy grade line entering the ponds.

Stormwater Ponds

Three stormwater ponds will be placed around the landfill for stormwater runoff storage and management. They are identified as Pond 1, collecting runoff from Cells 1 and 2; Pond 2, collecting runoff from Cells 3 and 4; and Pond 3, collecting runoff from Cells 3 and 4. Tables N-8 through N-10 provide stage-storage data for Ponds 1 through 3, respectively. Run-off volumes were calculated using Rational Method theory (i.e., run-off Volume=CIA, where I = rainfall in total inches). A runoff coefficient of C= 0.4 is considered representative of low to moderate permeability soils with emergent ground cover on steep slopes.

A runoff coefficient of C= 1 is used for the stormwater ponds to reflect that any direct rainfall to the pond surface will accumulate completely to the pond's stored volume.

The following table compiles the estimated, maximum runoff volumes to each pond during the 25-year, 24-hour design storm event of 5.6 inches. These pond volumes were checked to see if this volume is available at each respective pond to contain the design storm:

Pond 1	5.7 acres	5.6 in.= 0.47 ft.	c=1	2.7 acre-feet
Cells 1 and 2	66.6 acres	5.6 in.= 0.47 ft.	c=0.4	12.4 acre-feet
			Total=	**15.1 acre-feet**
Pond 2	4.4 acres	5.6 in.= 0.47 ft.	c=1	2.1 acre-feet
Cells 3 and 4	47.8 acres	5.6 in.= 0.47 ft.	c=0.4	9.0 acre-feet
			Total=	**11.1 acre-feet**
Pond 3	3.4 acres	5.6 in.= 0.47 ft.	c=1	1.6 acre-feet
Cells 3 and 4	52.1 acres	5.6 in.= 0.47 ft.	c=0.4	9.8 acre-feet
			Total=	**11.4 acre-feet**

The ponds have been designed with an inlet spillway elevation of 483 feet, and are to be maintained at a minimum 3 foot depth (water surface elevation of approximately 471 feet) to inhibit aquatic vegetation. Based on the stage-storage data found in Tables N-8, N-9 and N-10, the following initial maximum water surface elevations have been determined for each pond that represents the 25-year, 24-hour storm runoff volume. All maximum water elevations are well below a water surface elevation of 483 feet, which is the elevation of the bottom of the perimeter ditch. Therefore, if properly managed, the ponds have excess capacity for the anticipated 25-year, 24-hour storm runoff volume.

Respective Pond	Min Elevation (ft.)	Max Elevation (ft.)	Corresponding Table
Pond 1	471	478	N-8
Pond 2	471	480	N-9
Pond 3	471	477	N-10

Temporary Perimeter Ditch Crossings

As phased construction proceeds, the UWL operator may elect to retain interior berms and their top-of-berm roads during subsequent UWL phases. If interior berms are retained, it will be necessary to provide culverts through the intermediate berms at their intersection with the perimeter ditches. Preliminary culvert sizes have been estimates based on the arrangement of letdown ditches and ponds described by the previous discussion. For the purposes of these preliminary size estimates, we have assumed inlet control and one foot of headwater at the culvert inlets. These culvert sizes were estimated using standard hydraulic charts and equations, and the 25-year, 1-hour design storm event (2.63 in/hr).

Culvert System	Letdown(s)	Accumulative Max. Flow (cfs)	Recommended Culvert Diameter (in.)
East Culvert-Cells 1 and 2	4,5,6,7	22.01	30
West Culvert-Cells 1 and 2	7,8,9,10	26.22	36
East Culvert-Cells 3 and 4	17	6.69	15
West Culvert-Cells 3 and 4	25,26	14.62	24

TABLES

Ameren Labadie Energy Center Utility Waste Landfill Area and Flow At Each Letdown Structure 25-yr, 1-hr Event Table N-1								
Location	Distance	Side Slope Area	Top Area	Total Area	Total Area	Cumulative Area	Flow	
	(ft)	(ac)	(ac)	(sf)	(ac)	(ac)	in letdown, (cfs)	accumulative, (cfs)
LETDOWNS 1-11 (Cells 1 & 2) Flow to Pond 1 Rotating Clockwise from East Side of Outlet Pond 1								
Letdown 2	500	2.17	1.89	176796	4.06	4.06	4.31	35.00
Letdown 3	940	2.75	5.42	356250	8.18	12.24	8.68	30.69
Letdown 4	1450	2.11	3.14	228750	5.25	17.49	5.57	22.02
Letdown 5	1850	2.73	1.40	180000	4.13	21.62	4.38	16.45
Letdown 6	2500	2.51	1.91	192500	4.42	26.04	4.69	12.06
Letdown 7	3000	2.53	4.42	302813	6.95	32.99	7.37	7.37
Flow to Pond 1 Rotating Counter Clockwise from East Side of Outlet Pond 1								
Letdown 1	220	4.19	2.48	290400	6.67	6.67	7.07	34.77
Letdown 11	1020	4.19	4.15	363281	8.34	15.01	8.85	27.70
Letdown 10	1550	2.48	4.82	317813	7.30	22.30	7.74	18.85
Letdown 9	1950	3.80	2.97	295000	6.77	29.07	7.18	11.11
Letdown 8	2920	2.59	1.11	161250	3.70	32.78	3.93	3.93
LETDOWNS 12-29 (Cells 3 & 4) Flow to Pond 3 Rotating Clockwise from East side of Pond 3								
Letdown 14	0	3.24	2.85	265200	6.09	6.09	6.46	18.61
Letdown 15	500	2.81	2.81	244400	5.61	11.70	5.95	12.16
Letdown 16	950	2.81	3.04	254800	5.85	17.55	6.20	6.20
Flow to Pond 2 Rotating Counter-Clockwise from West side of Outlet Pond 2								
Letdown 18	860	4.82	2.18	305000	7.00	7.00	7.43	14.12
Letdown 17	1360	2.81	3.50	274860	6.31	13.31	6.69	6.69
Flow to Pond 2 Rotating Clockwise from East side of Outlet Pond 2								
Letdown 19	600	4.53	1.42	259200	5.95	5.95	6.31	36.25
Letdown 20	1100	2.87	4.99	342300	7.86	13.81	8.34	29.94
Letdown 21	1600	2.87	1.03	170000	3.90	17.71	4.14	21.60
Letdown 22	2100	2.87	1.26	180000	4.13	21.84	4.38	17.46
Letdown 23	2600	3.46	0.09	154800	3.55	25.40	3.77	13.08
Letdown 24	3040	5.17	0.53	248000	5.69	31.09	6.04	9.31
Letdown 25	3790	2.70	3.47	268600	6.17	33.82	6.54	3.27
Flow to Pond 3 Rotating Counter-Clockwise from East-Side of Outlet Pond 3								
Letdown 13	320	1.32	0.22	67200	1.54	1.54	1.64	32.61
Letdown 12	960	3.40	1.32	205900	4.73	6.27	5.01	30.97
Letdown 29	1780	2.70	1.21	170000	3.90	10.17	4.14	25.96
Letdown 28	2240	2.53	2.53	220000	5.05	15.22	5.36	21.82
Letdown 27	2640	2.41	2.41	210000	4.82	20.04	5.11	16.46
Letdown 26	3120	1.89	5.72	331600	7.61	27.66	8.08	11.35
Letdown 25	3330	2.70	3.47	268600	6.17	33.82	6.54	3.27

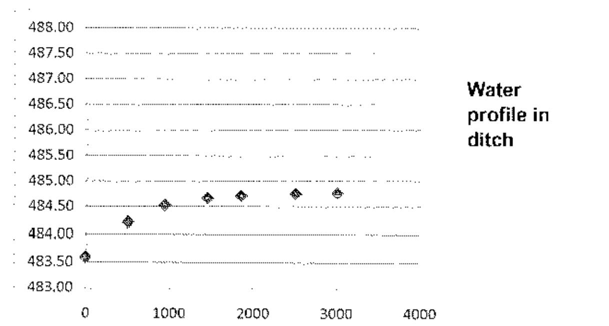
Inputs	25-yr, 1-hr storm	
Intensity	2.63	in
C Factor	0.4	unitless

Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Clockwise from Pond 1
Table N-2

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specfic Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.59	0.59	483				6.35	1.898	0.0560	0.646	0.499				0	0	Pond 1	0	12.06
	0.63		0.0011928				2.082		0.654	0.712	1.24E-03	1.24E-03	528	528				
484.22	1.22	483		9.00	1.2200	15.45	2.266	0.0797	1.300	0.924					500	Letdown 2	500	35.00
	0.31		0.0007271				1.871		0.264	1.019	6.19E-04	6.19E-04	426	955				
484.53	1.53	483		9.00	1.5300	20.79	1.476	0.0338	1.564	1.113					940	Letdown 3	940	30.69
	0.13		0.0002606				1.212		0.110	1.152	2.21E-04	2.21E-04	499	1453				
484.66	1.66	483		9.00	1.6600	23.21	0.949	0.0140	1.674	1.190					1450	Letdown 4	1450	22.02
	0.04		0.0001138				0.817		0.033	1.202	9.48E-05	9.48E-05	351	1805				
484.70	1.70	483		9.00	1.7000	23.97	0.686	0.0073	1.707	1.214					1850	Letdown 5	1850	16.45
	0.04		5.238E-05				0.587		0.036	1.225	4.76E-05	4.76E-05	764	2568				
484.74	1.74	483		9.00	1.7400	24.74	0.487	0.0037	1.744	1.237					2500	Letdown 6	2500	12.06
	0.01		2.724E-05				0.392		0.008	1.240	2.09E-05	2.09E-05	367	2936				
484.75	1.75	483		9.00	1.7500	24.94	0.296	0.0014	1.751	1.243					3000	Letdown 7	3000	7.37

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.

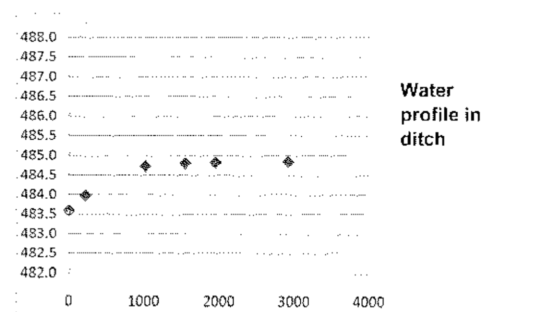


Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Counter Clockwise from Pond 1
Table N-3

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specfic Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.59	0.59	483				6.35	1.898	0 0560	0.646	0.499				0	0	Pond 1	0	12.06
	0.37		0.0016659				2.473		0.458	0.628	2.06E-03	2.06E-03	222	222				
483.96	0.96	483		9.00	0.9600	11.40	3.049	0.1443	1.104	0.757					220	Letdown 1	220	34.77
	0.76		0.0009613				2.093		0.636	0.991	8.04E-04	8.04E-04	791	1013				
484.72	1.72	483		9.00	1.7200	24.36	1.137	0.0201	1.740	1.225					1020	Letdown 11	1020	27.70
	0.07		0.0001422				0.935		0.058	1.246	1.18E-04	1.18E-04	492	1505				
484.79	1.79	483		9.00	1.7900	25.72	0.733	0.0083	1.798	1.266					1550	Letdown 10	1550	18.85
	0.03		5.652E-05				0.578		0.019	1.273	4.40E-05	4.40E-05	442	1947				
484.82	1.82	483		9.00	1.8150	26.22	0.424	0.0028	1.818	1.280					1950	Letdown 9	1950	11.11
	0.02		1.269E-05				0.286		0.013	1.285	1.06E-05	1.06E-05	1182	3129				
484.83	1.83	483		9.00	1.8300	26.52	0.148	0.0003	1.830	1.289					2920	Letdown 8	2920	3.93

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.

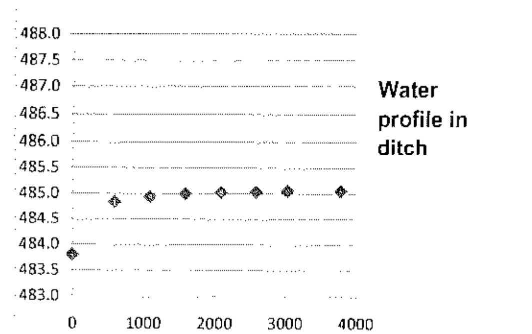


Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Clockwise from Pond 2
Table N-4

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specfic Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.80	0.80	483				9.12	3.975	0.2453	1.045	0.649				0	0	Pond 2	0	36.3
	1.03		0.001709				2.671		0.814	0.969	1.35E-03	1.35E-03	603	603	600			
484.83	1.83	483		9.00	1.8300	26.52	1.367	0.0290	1.859	1.289						Letdown 19	600	36.3
	0.10		0.000208				1.208		0.088	1.317	1.83E-04	1.83E-04	481	1083	1100			
484.93	1.93	483		9.00	1.9300	28.54	1.049	0.0171	1.947	1.346						Letdown 20	1100	29.9
	0.06		0.000111				0.887		0.051	1.363	9.44E-05	9.44E-05	541	1624	1600			
484.99	1.99	483		9.00	1.9900	29.79	0.725	0.0082	1.998	1.380						Letdown 21	1600	21.6
	0.03		5.5E-05				0.650		0.027	1.389	4.94E-05	4.94E-05	545	2170	2100			
485.02	2.02	483		9.00	2.0200	30.42	0.574	0.0051	2.025	1.397						Letdown 22	2100	17.5
	0.01		3.76E-05				0.501		0.008	1.400	2.90E-05	2.90E-05	266	2436	2600			
485.03	2.03	483		9.00	2.0300	30.63	0.427	0.0028	2.033	1.403						Letdown 23	2600	13.1
	0.02		1.68E-05				0.364		0.014	1.407	1.52E-05	1.52E-05	891	3327	3040			
485.05	2.05	483		9.00	2.0450	30.95	0.301	0.0014	2.046	1.411						Letdown 24	3040	9.3
	0.00		5.91E-06				0.150		0.001	1.412	2.59E-06	2.59E-06	423	3749	3790			
485.05	2.05	483		9.00	2.0475	31.00	0.000	0.0000	2.048	1.413						Letdown 25	3790	3.3

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.

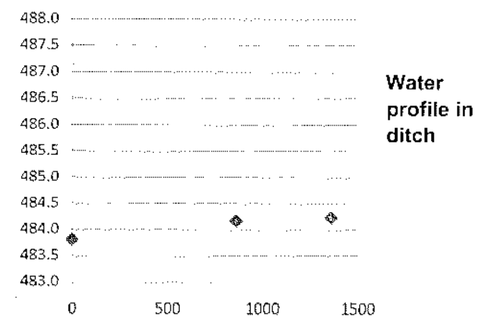


Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Counter Clockwise from Pond 2
Table N-5

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specfic Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.80	0.80	483				9.12	1.530	0.0363	0.836	0.649				0	0	Pond 2	0	14
	0.36		0.000431				1.253		0.338	0.767	4.05E-04	4.05E-04	836	836	860			
484.16	1.16	483		9.00	1.1600	14.48	0.975	0.0148	1.175	0.886						Letdown 18	860	14
	0.06		0.000128				0.704		0.048	0.905	1.03E-04	1.03E-04	468	1304	1360			
484.22	1.22	483		9.00	1.2200	15.45	0.433	0.0029	1.223	0.924						Letdown 17	1360	7

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



Prepared by Gredell Engineering Resources, Inc.

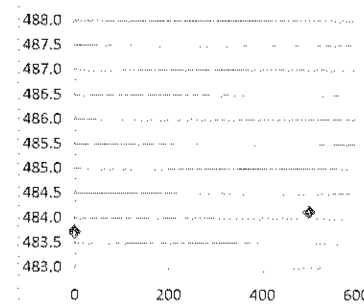
December 2012

Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Clockwise from Pond 3
Table N-6

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specfic Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.72	0.72	483				8.04	1.742	0.0471	0.767	0.593				0	0	Pond 3	0	14
	0.00		0				2.029		0.036	0.593	1.50E-03	1.50E-03	24	24	0			
483.72	0.72	483		9.00	0.7200	8.04	2.317	0.0833	0.803	0.593						Letdown 14	0	19
	0.41		0.000848				1.592		0.338	0.730	7.00E-04	7.00E-04	483	508	500			
484.13	1.13	483		9.00	1.1300	14.00	0.868	0.0117	1.142	0.867						Letdown 15	500	12

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



Water profile in ditch

Prepared by Gredell Engineering Resources, Inc.

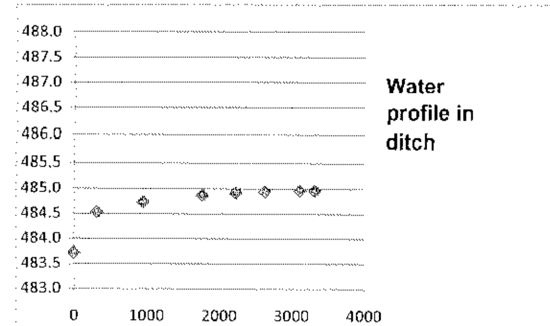
December 2012

Ameren Labadie Energy Center Utility Waste Landfill
Perimeter Ditch Water Profile: 25-yr, 1-hr event
Elevation for Stated Flow
Counter Clockwise from Pond 3
Table N-7

			$S_{s,left}$ = 3		$S_{s,right}$ = 3		Base Width (ft) = 9		Mannings N = 0.02		So (ft) = 0		Runoff Factor for 2.63 in/ hr rainfall= 0.017					
Elevation	Depth	Channel Bottom Elevation	Slope of Water Surface	Adjusted Base	Adjusted Height	Area	Velocity	$v^2/2g$	Specific Energy	Hydraulic Radius	Slope	S-So	Distance	Total Distance	True Distance	Location	Distance from Culvert	Q
							Average Velocity		Change in Specific Energy	Average Hydraulic Radius								
(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(sf)	(fps)	(ft)	(ft)	(ft)	(ft/ft)	(ft/ft)	(ft)	(ft)	(ft)		(ft)	(cfs)
483.72	0.72	483				8.04	4.058	0.2557	0.976	0.593				0	0	Pond 3	0	32.61
	0.81		0.0024				2.813		0.592	0.853	1.77E-03	1.77E-03	334	334	320			
484.53	1.53	483		9.00	1.5300	20.79	1.568	0.0382	1.568	1.113						Letdown 13	320	32.61
	0.20		0.0003				1.415		0.187	1.172	2.94E-04	2.94E-04	635	969	960			
484.73	1.73	483		9.00	1.7300	24.55	1.262	0.0247	1.755	1.231						Letdown 12	960	30.97
	0.14		0.0002				1.106		0.129	1.271	1.61E-04	1.61E-04	803	1772	1780			
484.87	1.87	483		9.00	1.8700	27.32	0.950	0.0140	1.884	1.312						Letdown 29	1780	25.96
	0.05		0.0001				0.860		0.045	1.326	9.21E-05	9.21E-05	491	2262	2240			
484.92	1.92	483		9.00	1.9200	28.34	0.770	0.0092	1.929	1.340						Letdown 28	2240	21.82
	0.03		7E-05				0.670		0.021	1.347	5.47E-05	5.47E-05	381	2643	2640			
484.95	1.95	483		9.00	1.9450	28.85	0.570	0.0051	1.950	1.355						Letdown 27	2640	16.46
	0.02		3E-05				0.480		0.013	1.359	2.77E-05	2.77E-05	480	3123	3120			
484.96	1.96	483		9.00	1.9610	29.19	0.389	0.0023	1.963	1.364						Letdown 26	3120	11.35
	0.00		2E-05				0.250		0.002	1.365	7.50E-06	7.50E-06	246	3369	3330			
484.97	1.97	483		9.00	1.9650	29.27	0.112	0.0002	1.965	1.366						Letdown 25	3330	3.27

Notes:

1. Rainfall event used is 25-yr, 1-hr storm which produces 2.63 inches of rain.
2. Longitudinal slope of channel assumed to be as stated for So.
3. Flows are split generally at half the distance between the entrances to the pond along the perimeter ditch.
4. Flows coming to a letdown structure and from below the bench served by the letdown structure are combined as the flow at the letdown structure for modeling purposes.
5. Model is adapted from Illustrative problem on page 380 in "Elementary Fluid Mechanics" by John Vennard, Wiley and Sons, 1961.



Ameren Labadie Energy Center Utility Waste Landfill
Stormwater Management Pond 1
Pond Volume Calculations
Table N-8

Base Width of Pond in feet	373
Base Length of Pond in feet	573
Rise of Slope in feet	1
Run of Slope in feet	3

WIDTH (FT)	LENGTH	WATER LEVEL (FT)	AVERAGE AREA (SQ FT)	VOLUME PER INCREMENT (VOL/FT)	TOTAL VOLUME OF POND (CU FT)	TOTAL VOLUME OF POND (ACRE FEET)	CAPACITY IN USE (ACRE FEET)	REMAINING CAPACITY (ACRE FEET)	Elevation (FEET)
373	573								468
379	579	1	108,293	108,293	108,293	2.5	-----	-----	469
385	585	2	111,167	111,167	219,459	5.0	-----	-----	470
391	591	3	114,077	114,077	333,536	7.7	-----	-----	471
397	597	4	117,023	117,023	450,558	10.3	0.0	34.3	472
403	603	5	120,005	120,005	570,563	13.1	2.8	31.5	473
409	609	6	123,023	123,023	693,585	15.9	5.6	28.7	474
415	615	7	126,077	126,077	819,662	18.8	8.5	25.8	475
421	621	8	129,167	129,167	948,828	21.8	11.4	22.8	476
427	627	9	132,293	132,293	1,081,121	24.8	14.5	19.8	477
433	633	10	135,455	135,455	1,216,575	27.9	17.6	16.7	478
439	639	11	138,653	138,653	1,355,228	31.1	20.8	13.5	479
445	645	12	141,887	141,887	1,497,114	34.4	24.0	10.2	480
451	651	13	145,157	145,157	1,642,271	37.7	27.4	6.9	481
457	657	14	148,463	148,463	1,790,733	41.1	30.8	3.5	482
463	663	15	151,805	151,805	1,942,538	44.6	34.3	0.0	483
469	669	16	155,183	155,183	2,097,720	48.2	37.8		484

NOTES:
1. The table is valid for a triangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

Elevation:

468	Pond Bottom	
471	Minimum working depth	Three feet of water to prevent growth of objectionable vegetation.
483	Reserve for storm	25 year, 24 hour storm event.
484	Maximum high water	Three feet below emergency spillway.
487	Flood protection elevation	Height of emergency spillway.

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

Ameren Labadie Energy Center Utility Waste Landfill
Stormwater Management Pond 2
Pond Volume Calculations
Table N-9

Base Width of Pond in feet	144
Base Length of Pond in feet	714
Rise of Slope in feet	1
Run of Slope in feet	3

WIDTH (FT)	LENGTH	WATER LEVEL (FT)	AVERAGE AREA (SQ FT)	VOLUME PER INCREMENT (VOL/FT)	TOTAL VOLUME OF POND (CU FT)	TOTAL VOLUME OF POND (ACRE FEET)	CAPACITY IN USE (ACRE FEET	REMAINING CAPACITY (ACRE FEET)	Elevation (FEET)
144	714								468
150	720	1	105,408	105,408	105,408	2.4	-----	-----	469
156	726	2	110,628	110,628	216,036	5.0	-----	-----	470
162	732	3	115,920	115,920	331,956	7.6	0.0	42.0	471
168	738	4	121,284	121,284	453,240	10.4	2.8	39.2	472
174	744	5	126,720	126,720	579,960	13.3	5.7	36.3	473
180	750	6	132,228	132,228	712,188	16.3	8.7	33.3	474
186	756	7	137,808	137,808	849,996	19.5	11.9	30.1	475
192	762	8	143,460	143,460	993,456	22.8	15.2	26.8	476
198	768	9	149,184	149,184	1,142,640	26.2	18.6	23.4	477
204	774	10	154,980	154,980	1,297,620	29.8	22.2	19.8	478
210	780	11	160,848	160,848	1,458,468	33.5	25.9	16.2	479
216	786	12	166,788	166,788	1,625,256	37.3	29.7	12.3	480
222	792	13	172,800	172,800	1,798,056	41.3	33.7	8.4	481
228	798	14	178,884	178,884	1,976,940	45.4	37.8	4.2	482
234	804	15	185,040	185,040	2,161,980	49.6	42.0	0.0	483
240	810	16	191,268	191,268	2,353,248	54.0	46.4		484

NOTES.
1. The table is valid for a rectangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

Elevation:

468	Pond Bottom	
471	Minimum working depth	Three feet of water to prevent growth of objectionable vegetation.
483	Reserve for storm	25 year, 24 hour storm event.
484	Maximum high water	Three feet below emergency spillway.
487	Flood protection elevation	Height of emergency spillway.

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

Ameren Labadie Energy Center Utility Waste Landfill
Stormwater Management Pond 3
Pond Volume Calculations
Table N-10

Base Width of Pond in feet	233
Base Length of Pond in feet	598
Rise of Slope in feet	1
Run of Slope in feet	3

WIDTH (FT)	LENGTH	WATER LEVEL (FT)	AVERAGE AREA (SQ FT)	VOLUME PER INCREMENT (VOL/FT)	TOTAL VOLUME OF POND (CU FT)	TOTAL VOLUME OF POND (ACRE FEET)	CAPACITY IN USE (ACRE FEET)	REMAINING CAPACITY (ACRE FEET)	Elevation (FEET)
233	598								468
239	604	1	70,923	70,923	70,923	1.6	-----	-----	469
245	610	2	73,452	73,452	144,374	3.3	-----	-----	470
251	616	3	76,017	76,017	220,391	5.1	-----	-----	471
257	622	4	78,618	78,618	299,008	6.9	0.0	24.0	472
263	628	5	81,255	81,255	380,263	8.7	1.9	22.2	473
269	634	6	83,928	83,928	464,190	10.7	3.8	20.2	474
275	640	7	86,637	86,637	550,827	12.6	5.8	18.2	475
281	646	8	89,382	89,382	640,208	14.7	7.8	16.2	476
287	652	9	92,163	92,163	732,371	16.8	9.9	14.1	477
293	658	10	94,980	94,980	827,350	19.0	12.1	11.9	478
299	664	11	97,833	97,833	925,183	21.2	14.4	9.7	479
305	670	12	100,722	100,722	1,025,904	23.6	16.7	7.3	480
311	676	13	103,647	103,647	1,129,551	25.9	19.1	5.0	481
317	682	14	106,608	106,608	1,236,158	28.4	21.5	2.5	482
323	688	15	109,605	109,605	1,345,763	30.9	24.0	0.0	483
329	694	16	112,638	112,638	1,458,400	33.5	26.6		484

NOTES.
1. The table is valid for a triangular pond with a uniform interior side slope.
2. The table utilizes the 'end area method' of volume estimation utilizing the area of each one foot increment of pond depth, beginning at the bottom.
3. The volume due to the bottom slope below the 468 feet elevation was not considered in the capacity volume calculations. A minimum depth of three feet in the pond bottom is planned at all times.
4. The upper three feet of the pond are not counted in the capacity volume calculations due to the need to maintain a minimum freeboard to prevent wave damage above the maximum water level at all times.

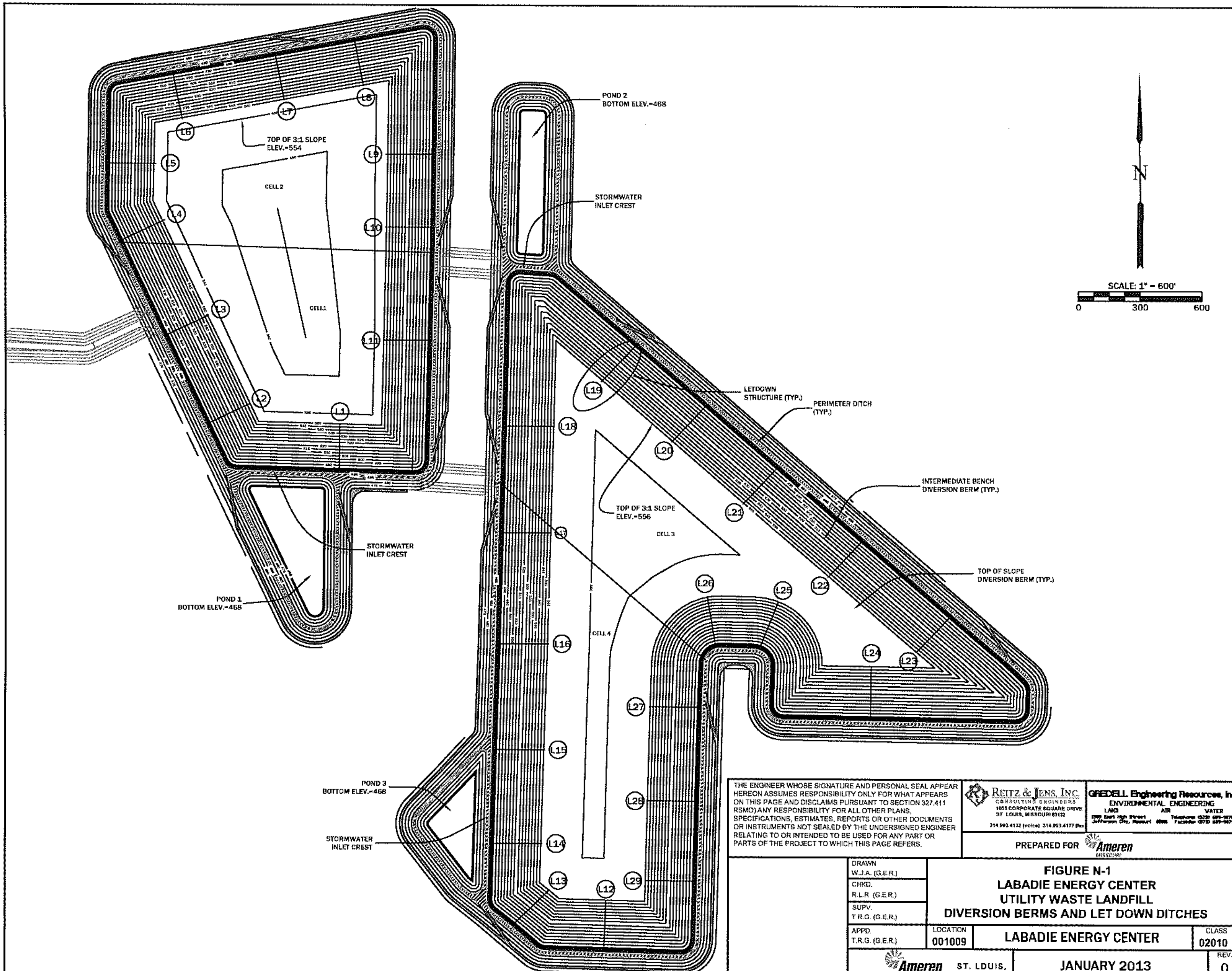
Elevation:

468	Pond Bottom	
471	Minimum working depth	Three feet of water to prevent growth of objectionable vegetation.
483	Reserve for storm	25 year, 24 hour storm event.
484	Maximum high water	Three feet below emergency spillway.
487	Flood protection elevation	Height of emergency spillway.

[1] Rainfall intensities are from RAINFALL FREQUENCY ATLAS OF THE MIDWEST by Floyd A. Huff and James R. Angel, Midwestern Climate Center, 1992, http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf

FIGURES

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\CPA DRAFT OCT 2012\FIG N-1 APPENDIX 11-1-12.dwg, Cover Sheet, 1/22/2013 9:30:43 AM



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APPD. T.R.G. (G.E.R.)	

FIGURE N-1
LABADIE ENERGY CENTER
UTILITY WASTE LANDFILL
DIVERSION BERMS AND LET DOWN DITCHES

LOCATION 001009 | LABADIE ENERGY CENTER | CLASS 02010

Ameren MISSOURI | ST. LOUIS, MISSOURI | JANUARY 2013 | REV. 0

Appendix O

H.E.L.P Model Results

Ameren Missouri Labadie Energy Center
Utility Waste Landfill
Franklin County, MO
December 2012

H.E.L.P. Model Summary Results
Appendix O

This appendix summarizes the H.E.L.P. model results. The model cases and inputs follow the liner and leachate collection design details provided on Sheets 16 through 19 of the plan sheets. Version 3.07 of the Hydrologic Evaluation of Landfill Performance (H.E.L.P.) computer model was used to evaluate the anticipated performance of the design of the leachate collection and cover systems for selected cases. Three cases were modeled: 1.) The initial Coal Combustion Products (CCP) placement, 2.) An "operational" condition, and 3.) The final closed condition. The cases are described below.

Table O-1 (Cell 1), Summary of H.E.L.P. Model Results & Input Parameters, provides a summary of the results from the H.E.L.P. model cases. H.E.L.P. model reports for each case listed in Table O-1 are included in sub-appendices. For consistency, the following assumptions were made:

- The aggregate drainage layer is unaffected by textile intrusion.
- The geocomposite drainage layer is affected by textile intrusion as described by Robert M. Koerner in "Designing with Geosynthetics", fifth edition published in 2005 (Table O-2).
- Where textile intrusion is anticipated, the amount of intrusion resulting from the maximum height of CCP placed on the geocomposite is modeled beginning with the initial placement of CCP and is held constant as additional CCP was placed on the liner.
- The drainage layer is not affected by biological clogging.
- Initial moisture content was user specified in all cases. All layers, where applicable, were modeled at field capacity except for fly ash, which was modeled at 0.22 vol/vol (Provided by Reitz & Jens, Inc.).

The H.E.L.P. Model evaluations were run using precipitation, temperature, solar radiation, and evapotranspiration for St. Louis, Missouri and soil data for the Ameren Missouri Labadie Energy Center UWL. The H.E.L.P. model cases were run for appropriate periods and the peak daily values are presented to represent worst-case conditions.

Properties of the various materials for design of the layers were considered. The H.E.L.P. Model cases utilizing an aggregate drain layer with a minimum hydraulic conductivity of 0.25 cm/sec and only the initial layer of CCP indicates that the minimum value of hydraulic conductivity of locally available aggregate materials resulted in less head on the liner than the regulatory limit of 12 inches. The particle gradation of the protective layer above the drain layer was designed to prevent the fine fly ash from migrating into, and plugging, the drain layer. The protective layer gradation analysis is provided in memo by Bruce Dawson, P.E., dated June 22, 2012 (Appendix O-1). For the alternate use of geocomposites, the manufacturer's stated transmissivity, shown on the product sheets, was reduced using Koerner's method (Table O-2).

Results in Table O-1 are reported for the cases of initial, operating and closed conditions, for aggregate material and geocomposite drain layers for: (1) the 1% base (floor) for the landfill, (2) the 33% side slope; (3) and the Schroeder approximation. Results for the maximum head on the liner, peak daily leachate flow, average annual leachate flow and the annual leachate volume are reported.

The potential effect of geotextile intrusion in the drainage layer was evaluated for the initial placement of CCP over a geocomposite drainage layer. The product data sheets (Appendix O-1) are summarized in the attached table titled "Effect of Reduction Factors on Hydraulic Conductivity", Table O-2. The H.E.L.P. Model cases for the geocomposite drain layer were run with a resultant hydraulic conductivity of 1.3 cm/sec as specified by the GSE PermaNet HL (10oz/yd^2) geocomposite in Table O-2. The transmissivities reported for each geonet are converted into hydraulic conductivity by dividing the transmissivity by the thickness of the geonet. These transmissivities are further reduced by factors for creep, chemical clogging, geotextile intrusion and particle clogging in a method proposed by Koerner in *Designing with Geosynthetics* 5th Edition. Koerner divided (reduced) the transmissivity by each factor. The reduction factors assumed by Koerner are also summarized in the attached table. A brief description of each of the reduction factors follows:

> Creep is the deformation of the geonet under an applied load. The pressure from coal combustion products will reduce the thickness of the geocomposite. Published values for creep are used where available, otherwise a value of 1.8 was assumed. Creep was not considered an influence for gravel.
>
> Chemical clogging occurs when dissolved substances form a precipitate that deposits in the drainage layer. Most of the coal combustion products are expected to have low solubilities in water. A value of 1.8 was assigned to reduce transmissivity by 55% for both the gravel and the geocomposite.
>
> Geotextile intrusion occurs when the geotextile is forced into the geonet. For bonded geotextile-geonet-geotextile composites, this intrusion is considered. A factor of 2 has been assigned to account for geotextile intrusion into the geonet. For the 12 inch gravel layer, geotextile intrusion is not expected to be a significant problem.
>
> Particle clogging from infiltration occurs when particles fill in the openings in the geotextile. In a similar way to a coffee filter protecting the drain in a coffee pot from

plugging, the geotextile serves to protect the geonet or gravel from plugging. Koerner handles particle clogging as a filtration problem. To be consistent with this analysis, the transmissivity was reduced by a factor of 1.8 to account for particle clogging. Dawson provides analysis of local materials to be used to prevent particle clogging.

Koerner also suggests biological clogging. This clogging of the geonet or gravel occurs when microbes have a supply of organic nutrients and water. The disposal of coal combustion products is not anticipated to supply organic nutrients to the extent that a sanitary landfill might. Therefore, it is assumed that biological clogging will not affect the drainage layer and the factor is set at 1.

Taken together, these reductions on the hydraulic conductivity result in a more-than ten-fold reduction in the published values for the geocomposite materials.

The cases modeled include initial, operating and closed conditions. The H.E.L.P. model runs are identified by the conditions modeled and the material used in the leachate collection layer. The case identification numbering system is also explained below:

Condition

- Initial condition is identified by "I" and models the initial phase of construction with waste still below the top of berm. This condition is modeled for a period of seven years (7 yr.).
  - AM signifies aggregate materials used for the leachate drainage layer and is layered (top down) as;
    - Coal Combustion Products. (vertical percolation)
    - A protective layer of graded aggregate to keep fly ash from migrating into the leachate collection layer. (vertical percolation)
    - Geotextile separator between the protective layer and the aggregate materials of the leachate collection layer. (not included in H.E.L.P model)
    - Aggregate materials are clean aggregate with a minimum hydraulic conductivity. (lateral drainage or leachate collection layer)
    - A geomembrane liner (primary liner) is next. (synthetic barrier)
    - Finally, a layer of 2-foot thick compacted clay soil (secondary liner) in contact with the geomembrane to form the composite liner. (soil barrier)
      - Case Identification Numbers 1, 2 and 3 indicate modeling of the 1% floor of the cell, the 33% inner side slope of the cell and the Schroeder approximation of the floor and side slope of the cell. Schroeder's approximation is used to approximate the longest length to the leachate collection pipe in order to accurately estimate head on the liner. It was used for the Initial and Operational cases to model the combined effects of the

33% sidewall and 1% floor of the bottom liner. The equation for Schroeder's Approximation (L') is: length of the bottom slope * (volume of water from the bottom + volume of water at sidewall) / volume of water from the bottom {L'=Lb*(Vb+Vs)/Vb}. Schroeder's approximation was not used on the final, closed condition case. Dr. Paul Schroeder of the USCOE, provided this approximation to the Missouri Department of Natural Resources in response to a question about a very long side slope at another landfill. It is used here to make sure no extreme flows are being missed.

- The designation like R003, is reserved for the use of revisions to any particular run using the format of Rxxx, where xxx is the run number.

- GE signifies geocomposites used in the leachate collection layer and is layered (top down) as:
  - Coal Combustion Products. (vertical percolation)
  - A protective layer of graded aggregate to keep fly ash from migrating into the leachate collection layer. (vertical percolation)
  - The geocomposite is manufactured as a composition of geotextile fabric-geonet-geotextile fabric. (lateral drainage or leachate collection layer)
  - A geomembrane liner (primary liner) is next. (synthetic barrier)
  - Finally, a layer of 2-foot thick compacted clay soil (secondary liner) in contact with the geomembrane to form the composite liner. (soil barrier)

- Operating condition models the placement of coal combustion products above the top of the perimeter berm and having an additional layer of soil placed as an intermediate cover for the cell. The intermediate cover is used for both the aggregate material and the geocomposite leachate models. The operating conditions were modeled for a period of 25 years.
- Closed condition models the placement of a final cap over the top of landfill. For both aggregate materials and geocomposite leachate collection it is modeled as:
  - A vegetative soil layer to support grasses. (vertical percolation)
  - A geotextile used as a cushion and drainage layer. (lateral drainage)
  - A geomembrane liner is used as a primary liner to prevent water from getting to the coal combustion products. (vertical barrier)
  - Layering below follows the pattern in the operating and initial conditions.

The operating condition is found to be the case that produces the most leachate. The precipitation falling on the initial layer of CCP has little chance for storage in the CCP column. It is more quickly transported to the leachate drainage layer and geomembrane liner. The hydraulic head forces this water to flow into the leachate collection system. If the maximum hydraulic head can be maintained below the regulatory limit under the case of initial CCP placement, placement of additional CCP allows for more storage of water within the CCP mass and may lower the maximum hydraulic head on the geomembrane liner.

The H.E.L.P. model cases are sensitive to the length of the flow path of leachate in the drainage layer. As proposed, Phase 1/Cell 1 has the longest flow path present in any of the phases of the UWL. Cell 1 is also the cell that is opened first. The longest distance of 541 feet was scaled from the toe of slope to the leachate collection system perpendicular to contours. The side slope was also modeled and the impact on flow was incorporated using the Schroeder approximation.

As proposed, Phase 3/Cell 3 is expected to have the maximum leachate flow present in any of the phases of the UWL due to size (57 acres). The largest leachate collection zone in Cell 3 is smaller than the largest collection zone in Cell 1. The longest distance of 400 feet (as scaled from the dividing break-line in the leachate collection zone perpendicular to the leachate collection line contours) is significantly shorter than Cell 1. Therefore, Cell 1 represents the worst case scenario.

Critical cases presented indicate that the design parameters proposed will meet the regulatory standards for effectively collecting leachate while not allowing a hydraulic head on the liner that exceeds the regulatory limit of 12-inches. These cases are summarized on Table O-1 with H.E.L.P. results in Appendices O-2 through O-13.

The H.E.L.P. model results indicate that the leachate collection, liner and cover systems meet regulatory requirements. The model results also indicate that peak leachate flows and maximum hydraulic head on the bottom liner occurs during the intermediate operation of each cell when there is an average 20-foot thickness of CCP over the liner and leachate collection system, and intermediate cover is in place. Therefore, the worst case is expected to be short-lived and the performance of the liner and leachate collections system is expected to improve as additional CCP is placed in the disposal cell. After closure, the leachate generation rates drop substantially.

TABLES

Ameren Missouri
Labadie Energy Center Utility Waste Landfill
Franklin, County Missouri

TABLE O-1: SUMMARY OF HELP MODEL RESULTS & INPUT PARAMETERS
for Cell 1

Sub Appendix	Case No.	Acres	Case Modeled	Drainage Layer Material	Drainage Length (ft)	Maximum Head on Liner (in)	Peak Daily Leachate Volume		Average Annual Leachate Volume		Rainfall	
							(ft^3/day)	Flow GPM (GPAD) See Notes 5 & 6	(ft^3/year)	Flow GPM (GPAD) See Notes 5 & 6	Average Annual (ft^3/year)	Peak Daily (ft^3/day)
Initial Waste Placement Condition - Modeled at 7 Years - 7 ft of Waste - No Intermediate Cover												
O-2	IAM1R003	28.1	Cell 1 using Aggregate Material in the leachate collection system for the 1% bottom slope of the landfill.	Aggregate Material	541	0.540	746	NA	91,489	NA	NA	NA
O-3	IAM3R003	31.4	Cell 1 using Aggregate Materials in the leachate collection system. Use Schroeder's approximation for drainage length (See Note 3).	Aggregate Material	725	0.7	812	4.2 (193.4)	108,533	1.5 (70.8)	3,869,852	296,354
O-4	IGE1R003	28.1	Cell 1 using Geocomposite in the leachate collection system for the 1% bottom slope of the landfill.	Geocomposite	541	0.114	803	NA	91,742	NA	NA	NA
O-5	IGE2R003	3.3	Cell 1 using Geocomposites in the leachate collection system for the 33% side slopes of the landfill.	Geocomposite	60	0.012	253	NA	20,904	NA	NA	NA
O-6	IGE3R003	31.4	Cell 1 using Geocomposites in the leachate collection system. Use Schroeder's approximation for drainage length (See Note 3).	Geocomposite	712	0.149	887	4.6 (211.3)	108,979	1.6 (71.1)	3,869,852	296,354

Notes located on Page 3 of 3

Ameren Missouri
Labadie Energy Center Utility Waste Landfill
Franklin, County Missouri

TABLE O-1: SUMMARY OF HELP MODEL RESULTS & INPUT PARAMETERS
for Cell 1

Sub Appendix	Case No.	Acres	Case Modeled	Drainage Layer Material	Drainage Length (ft)	Maximum Head on Liner (in)	Peak Daily Leachate Volume		Average Annual Leachate Volume		Rainfall	
							(ft^3/day)	Flow GPM (GPAD) See Notes 5 & 6	(ft^3/year)	Flow GPM (GPAD) See Notes 5 & 6	Average Annual (ft^3/year)	Peak Daily (ft^3/day)
Intermediate Operating Condition - Modeled at 25 Years - 20 ft of Waste - Intermediate Cover												
O-7	OAM1R003	28.1	Cell 1 Operating Condition with Intermediate Cover using Aggregate Materials in the leachate collection system for the 1% bottom slope of the landfill.	Aggregate Material	541	1.437	2,060	NA	287,168	NA	3,411,430	350,891
O-8	OAM3R003	31.4	Cell 1 Operating Condition with Intermediate Cover using Aggregate Materials in the leachate collection system. Use Schroeder's approximation for drainage length (See Note 3).	Aggregate Material	637	1.66	2,254	11.7 (536.9)	320,708	4.6 (209.3)	3,812,060	392,099
O-9	OGE1R003	28.1	Cell 1 Operating Condition with Intermediate Cover using Geocomposites in in the leachate collection system for the 1% bottom slope of the landfill.	Geocomposite	541	0.336	2,368	NA	287,681	NA	3,411,430	350,891
O-10	OGE2R003	3.3	Cell 1 Operating Condition for 33% side slopes with Intermediate Cover using Geocomposites in the leachate collection system.	Geocomposite	60	0.016	375	NA	36,856	NA	400,631	41,208
O-11	OGE3R003	31.4	Cell 1 Operating Condition with Intermediate Cover using Geocomposites in the leachate collection system. Use Schroeder's approximation for drainage length (See Note 3).	Geocomposite	627	0.4	2,571	13.4 (612.5)	321,394	4.6 (209.8)	3,812,060	392,099

Notes located on Page 3 of 3

Ameren Missouri
Labadie Energy Center Utility Waste Landfill
Franklin, County Missouri

TABLE O-1: SUMMARY OF HELP MODEL RESULTS & INPUT PARAMETERS
for Cell 1

Sub Appendix	Case No.	Acres	Case Modeled	Drainage Layer Material	Drainage Length (ft)	Maximum Head on Liner (in)	Peak Daily Leachate Volume		Average Annual Leachate Volume		Rainfall	
							(ft^3/day)	Flow GPM (GPAD) See Notes 5 & 6	(ft^3/year)	Flow GPM (GPAD) See Notes 5 & 6	Average Annual (ft^3/year)	Peak Daily (ft^3/day)
Closed Condition - Modeled at 30 Years - ~58 ft of Waste - Final Cover												
O-12	CAM1R002	31.4	Cell 1 Closed Condition with Final Cover using Aggregate Materials in the leachate collection system for the 1% bottom slope of the landfill.	Aggregate Material	541	1.322	211	1.1 (50.3)	22,376	0.3 (14.6)	3,785,646	392,099
O-13	CGE1R003	31.4	Cell 1 Closed Condition with Final Cover using Geocomposites in the leachate collection system for the 1% bottom slope of the landfill.	Geocomposite	541	0.044	346	1.8 (82.4)	23,252	0.3 (15.2)	3,785,646	392,099

Notes:

1 Leaf Area Index (LAI) values for the Initial & Operational cases were set at 0.5 to assume bare ground conditions. LAI values for the Closed condition were set at 2.0 to assume average ground conditions. LAI values ranges for the Labadie area are from 0 to 4.5.

2 Geotextile layers at the bottom of the leachate collection protective cover and at the bottom of the Aggregate Material layer are not included in the HELP model cases. The k values of these layers are similar to their adjacent layers and their relatively small thickness make their affect negligible.

3 Schroeder's approximation is used to approximate the longest length to the leachate collection in order to accurately estimate head on the liner. It was used for the Initial and Operational cases to model the combined effects of the sidewall and floor of the bottom liner. The equation for Schroeder's Approximation (L') is: length of the bottom slope * (volume of water from the bottom + volume of water at sidewall) / volume of water from the bottom {L'=Lb*(Vb+Vs)/Vb}. Schroeder's approximation was not used on the closed condition.

4 Depth of waste placement on side slope cases are an average height of waste over/under slope.

5 Gallons per minute (GPM) is calculated from the reported peak and average daily volume in cubic feet per day and cubic feet per year, respectively, within the HELP model cases.

6 Gallons per acre per day (GPAD) is calculated from the reported peak amd average daily volume in cubic feet per day and cubic feet per year, respectively, within the HELP model cases.

7 Schroeder's Approximation was not used for Closed condition cases since no leachate was generated.

8 Vegetative soil modeled as Silt Loam (ML).

9 Initial moisture content was user specified in all cases. All layers (where applicable) were modeled at field capacity except for Fly Ash, which was modeled at 0.22 vol/vol (from R&J).

10 SCS curve numbers were determined by the HELP model in all cases.

11 HELP Model Case No. Description:
Character 1: Denotes the landfill condition modeled. I - initial waste placement, O - intermediate operating, C - closed
Characters 2 - 3: Denote the type of leachate collection system modeled. GE - geocomposite, AM - aggregate material.
Character 4: Denotes the location along the bottom liner that was modeled. 1 - floor (bottom at 1%), 2 - side slope at 33%, 3 - Schroeder's Approximation
Characters 5 - 8: Reserved for the use of revisions to any particular run using the format of Rxxx, where xxx is the run number.

12 NA - Not applicable values in the sum of leachate flow or precipitation.

Ameren Missouri
Labadie Energy Center Utility Waste Landfill
Franklin County, Missouri

EFFECT OF REDUCTION FACTORS ON HYDRAULIC CONDUCTIVITY

For geonet with two sided geotextile

Reduction Factors assumed by Koerner in Designing with Geosynthetics, 5th Ed. 2005

Table O-2

GEONET WITH GEOTEXTILE INTRUSION	GEONET					REDUCTION FACTORS				
MANUFACTURER / MODEL NUMBER	THICKNESS MILS	THICKNESS CM	[1]TRANSMISSIVITY M^2/SEC	[1]TRANSMISSIVITY CM^2/SEC	HYDRAULIC CONDUCTIVITY CM/SEC	CREEP FACTOR	CHEMICAL CLOGGING FACTOR	GEOTEXTILE INTRUSION FACTOR	PARTICLE CLOGGING FACTOR	RESULTANT HYDRAULIC CONDUCTIVITY CM/SEC
GSE PermaNet TRx (8oz/yd^2)	300	0.76	2.2E-03	22	28.9	1.80	1.80	2	1.80	2.5
GSE PermaNet HL (10oz/yd^2)	270	0.69	1.0E-03	10	14.6	1.80	1.80	2	1.80	1.3
GSE PermaNet UL (10oz/yd^2)	300	0.76	1.0E-03	10	13.1	1.80	1.80	2	1.80	1.1

NOTES:

1. Transmissivity as reported for various geocomposites from manufacturer's product data sheets.

APPENDICES

Appendix O-1

1505 E. High Street
Jefferson City, Missouri 65101
Telephone No. (573) 659-9078
Fax No. (573) 659-9079

GREDELL Engineering Resources, Inc.

Memo

To: Rick Roberts, P.E.

From: Bruce Dawson, P.E.

CC: Tom Gredell, P.E.

Date: 6/22/2012

Re: Reitz & Jens:Labadie UWL/Protective Cover Specification Development

---

Proposed Specification Language:
Protective cover shall consist of a well-graded aggregate with a particle size between 9.5 mm and 0.075 mm, with 0 to 10 percent passing the No. 100 U.S. Sieve, a d_{50} particle size of (approximately) 0.5 to 0.9 mm, and a d_{15} particle size of (approximately) 0.2 to 0.4 mm.

Background:
MoDOT concrete sand (Missouri Standard Specifications for Highway Construction Section 1005):

% Passing 3/8" (9.5mm):	100
% Passing No. 4 (4.75 mm):	95-100
% Passing No. 8 (2.38 mm):	70-100
% Passing No. 16 (1.20 mm):	45-90
% Passing No. 30 (0.599 mm):	15-65
% Passing No. 50 (0.297 mm):	5-30
% Passing No. 100 (0.152 mm):	1-10

Estimated Coefficient of Permeability per Eq. 2.4, Peck Hanson Thornburn, p. 40:
$k=CD_{10}^2$, where C=100/cm-sec and D_{10} is expressed in centimeters
for the above gradation, D_{10} will be between 0.0297 and 0.0152 centimeters;
k is therefore estimated to be between 0.023 cm/sec and 0.088 cm/sec

Filter criteria per Table 2.2, Peck Hanson Thornburn, p. 49:
Non-uniform, sub-rounded particles: R50 between 12 and 58; R15 between 12 and 40
Fly ash (from Reitz & Jens Fig 3-1, Labadie): d_{50} approx. 0.027 mm, d_{15} approx. 0.02 mm
Missouri River Sand (from examination of select sieve results from Washington Sand Co.):
D_{50} approx. 0.5 to 0.9 mm, d_{15} approx. 0.2 to 0.35 mm
Resultant ratios: R_{50} between 19 and 33, R_{15} between 10 and 18.

Conclusion:

"Typical" Missouri river sand dredged for concrete sand will protect Fly ash, per PHT Table 2.2 criteria.

Notes:

Develop "Note 5" in Detail Drawings to address Protective Cover Material requirements. Compare to similar material requirements note for non-carbonate aggregate drainage material and provide similar, parallel language.

PRODUCT DATA SHEET

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles are a family of staple fiber needlepunched geotextiles. The geotextiles are manufactured using an advanced manufacturing and quality system to produce the most uniform and consistent nonwoven needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with an in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications.

[*]

AT THE CORE:

A family of geotextiles used for separation, filtration, protection and drainage applications.

Product Specifications

These product specifications meet GRI GT12, GRI GT13 and AASHTO M288

Tested Property[1]	Test Method	Frequency	Minimum Average Roll Value					
			NW4	NW6	NW8	NW10	NW12	NW16
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd²	ASTM D 5261	90,000 ft²	4	6	8	10	12	16
Grab Tensile Strength, lb	ASTM D 4632	90,000 ft²	120	160	220	260	320	390
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb	ASTM D 4833	90,000 ft²	60	90	120	165	190	240
Trapezoidal Tear Strength, lb	ASTM D 4533	90,000 ft²	50	65	90	100	125	150
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.80	1.50	1.30	1.00	0.80	0.60
Water Flow Rate, gpm/ft²	ASTM D 4491	540,000 ft²	135	110	95	75	60	45
UV Resistance % retained after 500 hours	ASTM D 4355	per formulation		70	70	70	70	70
TYPICAL ROLL DIMENSIONS								
Roll Length[2], ft			850	850	600	500	400	300
Roll Width[2], ft			15	15	15	15	15	15
Roll Area, ft²			12,750	12,750	9,000	7,500	6,000	4,500

NOTES:

- [1] The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.
- [2] Roll lengths and widths have a tolerance of ±1%.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

GSE ENVIRONMENTAL™

PRODUCT DATA SHEET

GSE PermaNet HL Geocomposite

GSE PermaNet HL (High Load) geocomposite is manufactured with a GSE PermaNet HL geonet heat-bonded on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd^2 to 16 oz/yd^2. The creep resistant structure of the product ensures continuous flow performance over a broad range of conditions and long durations. The geocomposite works as an efficient drainage medium and is ideal for extremely high compressive stress applications.

[*]

AT THE CORE:

A high load geocomposite with a creep-resistant structure that ensures continuous flow performance and is ideal for extremely high compressive stress applications.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Value		
Geocomposite			6 oz/yd^2	8 oz/yd^2	10 oz/yd^2
Transmissivity[1], gal/min/ft (m^2/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft^2	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft^2	1.0	1.0	1.0
Geonet Core – GSE PermaNet HL (prior to lamination)[2]					
Transmissivity[1], gal/min/ft (m^2/sec)	ASTM D 4716		19 (4 x 10^{-3})	19 (4 x 10^{-3})	19 (4 x 10^{-3})
Compressive Strength, lbs/ft^2	ASTM D 6364	1/540,000 ft^2	40,000	40,000	40,000
Creep Reduction Factor	ASTM D 7406/7361	per formulation	1.2 @15,000 psf	1.2 @15,000 psf	1.2 @15,000 psf
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft^2	100	100	100
Carbon Black Content, %	ASTM D 1603[3]/4218	1/50,000 ft^2	2.0	2.0	2.0
Geotextile (prior to lamination)[2]					
Mass per Unit Area, oz/yd^2	ASTM D 5261	1/90,000 ft^2	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft^2	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft^2	90	120	165
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft^2	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, sec^{-1}	ASTM D 4491	1/540,000 ft^2	1.5	1.3	1.0
Flow Rate, gpm/ft^2	ASTM D 4491	1/540,000 ft^2	110	95	75
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft^2	270	270	270
Roll Width[4], ft			15	15	15
Roll Length[5], ft	Double-Sided Composite Single-Sided Composite		210 240	200 230	180 220
Roll Area, ft^2	Double-Sided Composite Single-Sided Composite		3,150 3,600	3,000 3,450	2,700 3,300

[Product specifications continued on back]

[*]

AT THE CORE:

A high load geocomposite with a creep-resistant structure that ensures continuous flow performance and is ideal for extremely high compressive stress applications.

Product Specifications [continued]

NOTES:

- [illegible] between plates. Contact GSE for [illegible]
- All geotextile properties are [illegible] average roll values except AOS which is a maximum average roll value, and UV resistance which is a typical value.
- Roll widths and lengths have a tolerance of [illegible]
- Modified.

PRODUCT DATA SHEET

GSE PermaNet UL Geocomposite

GSE PermaNet UL (Ultra Load) geocomposite is manufactured with a GSE PermaNet UL geonet heat-bonded on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 6 oz/yd² to 16 oz/yd². The creep resistant structure of this product ensures continous flow performance over a broad range of conditions and long durations. The geocomposite works as an efficient drainage medium and is ideal for extremely high compressive stress applications.

[*]

AT THE CORE:
A very high compressive strength geocomposite with a creep-resistant structure that ensures continuous flow performance over a broad range of conditions and long durations.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			**6 oz/yd²**	**8 oz/yd²**	**10 oz/yd²**
Transmissivity[1], gal/min/ft (m²/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft²	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})	 4.8 (1 x 10^{-3}) 6.2 (1.3 x 10^{-3})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	1.0	1.0	1.0
Geonet Core - GSE PermaNet UL (prior to lamination)[2]					
Transmissivity[1], gal/min/ft (m²/sec)	ASTM D 4716		24 (5 x 10^{-3})	24 (5 x 10^{-3})	24 (5 x 10^{-3})
Compression Strength, lb/ft²	ASTM D 6364	1/540,000 ft²	40,000	40,000	40,000
Creep Reduction Factor	ASTM D 7406/7361	per formulation	1.3 @ 20,000 psf	1.3 @ 20,000 psf	1.3 @ 20,000 psf
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft²	100	100	100
Carbon Black Content, %	ASTM D 1603[4]/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)[2]					
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	6	8	10
Grab Tensile, lb	ASTM D 4632	1/90,000 ft²	160	220	260
Puncture Strength, lb	ASTM D 4833	1/90,000 ft²	90	120	165
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft²	70	80	100
Permittivity, sec⁻¹	ASTM D 4491	1/540,000 ft²	1.5	1.3	1.0
Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	110	95	75
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft²	300	300	300
Roll Width[3], ft			15	15	15
Roll Length[3], ft	Double-Sided Composite Single-Sided Composite		190 200	180 200	150 190
Roll Area, ft²	Double-Sided Composite Single-Sided Composite		2,850 3,000	2,700 3,000	2,250 2,850

[Product specifications continued on back]

[*]

AT THE CORE:
A very high compressive strength geocomposite with a creep-resistant structure that ensures continuous flow performance over a broad range of conditions and long durations.

Product Specifications [continued]

NOTES:

- This is an index transmissivity value measured at stress [illegible] 20,000 psf, gradient [illegible] 0.1, time = 15 minutes, boundary conditions [illegible] between plates. Contact GSE for performance transmissivity value for use in design.
- All geotextile properties are minimum average roll values except AOS (in mm) which is a maximum average roll value and UV resistance which is a typical value.
- Roll widths and lengths have a tolerance of ±1%.
- Modified.

PRODUCT DATA SHEET

GSE FabriNet TRx Geocomposite

GSE HyperNet TRx geonet is produced with a unique one step process that coextrudes creep resistant columns to an intrusion resistant roof. The resulting triaxial geonet is then laminated to a nonwoven geotextile filtration media. This product achieves high in-situ transmissivity from optimally oriented flow channels that maintain porosity because of the intrusion and creep resistant nature of the triaxial structure. The geocomposite provides continuous performance over a broad range of conditions. It is well suited for use in surface water collection and removal systems, gas venting, and landfill drainage applications.

[*]

AT THE CORE:
A high flow geocomposite that achieves high in-situ transmissivity from optimally oriented flow channels that maintain porosity.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			**4 oz/yd²**	**6 oz/yd²**	**8 oz/yd²**
Transmissivity(1), gal/min/ft (m^2/sec) Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/540,000 ft²	12.1 (2.5×10^{-3}) 15.7 (3.2×10^{-3})	12.1 (2.5×10^{-3}) 15.7 (3.2×10^{-3})	10.1 (2.2×10^{-3}) 13.8 (2.9×10^{-3})
Ply Adhesion, lb/in	ASTM D 7005	1/50,000 ft²	1.0	1.0	1.0
Geonet Core - GSE HyperNet TRx (prior to lamination)(2)					
Transmissivity(1), gal/min/ft (m^2/sec)	ASTM D 4716		43.5 (9×10^{-3})	43.5 (9×10^{-3})	43.5 (9×10^{-3})
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength(2), lb/in	ASTM D 5035/7179	1/50,000 ft²	75	75	75
Carbon Black Content, %	ASTM D 1603(1)/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)(3)					
Mass per Unit Area, oz/yd²	ASTM D 5261	1/90,000 ft²	4	6	8
Grab Tensile, lb	ASTM D 4632	1/90,000 ft²	120	160	220
Puncture Strength, lb	ASTM D 4833	1/90,000 ft²	60	90	120
AOS, US sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)
Permittivity, sec⁻¹	ASTM D 4491	1/540,000 ft²	1.8	1.5	1.3
Flow Rate, gpm/ft²	ASTM D 4491	1/540,000 ft²	135	110	95
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mil	ASTM D 5199	1/50,000 ft²	300	300	300
Roll Width(4), ft			15	15	15
Roll Length(4), ft	Double-Sided Composite Single-Sided Composite		160 180	160 170	150 170
Roll Area, ft²	Double-Sided Composite Single-Sided Composite		2,400 2,700	2,400 2,550	2,250 2,550

[Product specifications continued on back]

[*]

AT THE CORE:
A high flow geocomposite that achieves high in-situ transmissivity from optimally oriented flow channels that maintain porosity.

Product Specifications [continued]

NOTES:

- [illegible] 1000 psf, gradient [illegible] boundary conditions [illegible] between plates. Contact GSE for [illegible]
- Tested in machine direction (MD).
- All properties are minimum average roll values except [illegible] which is a maximum average roll value and UV resistance which is a typical value.
- Roll widths and lengths have a tolerance of ±1%.
- Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL®

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

Appendix O-2

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\IAM1R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\IAM1R003.OUT


TIME:  18:23     DATE:  10/30/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  30
          THICKNESS                  =       84.00    INCHES
          POROSITY                   =        0.5410 VOL/VOL
          FIELD CAPACITY             =        0.1870 VOL/VOL
          WILTING POINT              =        0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT =        0.1935 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.499999987000E-04 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0513 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0322 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000000000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	541.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 541. FEET.

SCS RUNOFF CURVE NUMBER	=	96.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	28.100	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.751	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.492	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.564	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.505	INCHES
TOTAL INITIAL WATER	=	27.505	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.71	2.08	3.24	3.42	3.42	5.13
	3.06	2.47	2.32	2.38	2.97	1.75
STD. DEVIATIONS	0.89	1.36	0.81	1.50	1.81	1.30
	1.58	1.66	1.35	1.37	1.62	1.07
RUNOFF						
TOTALS	0.497	0.870	1.175	0.942	1.125	1.829
	1.003	0.656	0.709	0.709	1.119	0.290
STD. DEVIATIONS	0.245	0.749	0.885	0.695	1.168	0.610
	0.757	0.592	0.583	0.721	0.845	0.351

EVAPOTRANSPIRATION

TOTALS	0.462	0.941	2.235	3.028	2.582	3.234
	2.493	1.993	1.446	1.278	1.318	0.780
STD. DEVIATIONS	0.169	0.484	0.287	0.647	0.931	0.966
	0.645	0.994	0.901	0.536	0.214	0.214

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0850	0.0745	0.0800	0.0959	0.1163	0.0949
	0.0621	0.0318	0.0310	0.0575	0.0759	0.0920
STD. DEVIATIONS	0.0801	0.0690	0.0768	0.0839	0.0793	0.0517
	0.0357	0.0257	0.0182	0.0510	0.0689	0.0740

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.1046	0.1005	0.0985	0.1221	0.1432	0.1207
	0.0765	0.0391	0.0395	0.0708	0.0966	0.1133
STD. DEVIATIONS	0.0986	0.0926	0.0946	0.1067	0.0977	0.0658
	0.0440	0.0316	0.0232	0.0628	0.0876	0.0911

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.95 (3.610)	3463147.5	100.00
RUNOFF	10.923 (2.5198)	1114135.75	32.171
EVAPOTRANSPIRATION	21.792 (2.0850)	2222852.00	64.186
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.89692 (0.59928)	91488.367	2.64177

PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00008 (0.00005)	8.339	0.00024
AVERAGE HEAD ON TOP OF LAYER 4	0.094 (0.063)		
CHANGE IN WATER STORAGE	0.340 (1.3845)	34663.22	1.001

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 7

	(INCHES)	(CU. FT.)
PRECIPITATION	2.60	265207.781
RUNOFF	1.896	193392.5780
DRAINAGE COLLECTED FROM LAYER 3	0.00731	745.62543
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000001	0.06296
AVERAGE HEAD ON TOP OF LAYER 4	0.279	
MAXIMUM HEAD ON TOP OF LAYER 4	0.540	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	17.6 FEET	
SNOW WATER	1.38	140819.5620

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3792
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 7

LAYER	(INCHES)	(VOL/VOL)
1	18.3273	0.2182
2	0.8886	0.0741
3	0.4199	0.0350
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	0.000	

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Appendix O-3

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:        C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:    C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:      C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:    C:\HELP\INPUTS\IAM3R003.D10
OUTPUT DATA FILE:             C:\HELP\OUT\IAM3R003.OUT


TIME:  18:36      DATE:  10/30/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  30
           THICKNESS                 =      84.00    INCHES
           POROSITY                  =       0.5410 VOL/VOL
           FIELD CAPACITY            =       0.1870 VOL/VOL
           WILTING POINT             =       0.0470 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.1945 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.499999987000E-04 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0498 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0322 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000000000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	725.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 725. FEET.

SCS RUNOFF CURVE NUMBER	=	96.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.864	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.492	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.564	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.572	INCHES
TOTAL INITIAL WATER	=	27.572	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.71	2.08	3.24	3.42	3.42	5.13
	3.06	2.47	2.32	2.38	2.97	1.75
STD. DEVIATIONS	0.89	1.36	0.81	1.50	1.81	1.30
	1.58	1.66	1.35	1.37	1.62	1.07
RUNOFF						
TOTALS	0.495	0.864	1.152	0.915	1.095	1.790
	0.968	0.641	0.689	0.706	1.099	0.283
STD. DEVIATIONS	0.241	0.742	0.889	0.683	1.148	0.601
	0.729	0.577	0.572	0.739	0.831	0.342

EVAPOTRANSPIRATION

TOTALS	0.465	0.954	2.257	3.008	2.619	3.299
	2.410	2.152	1.455	1.242	1.312	0.784
STD. DEVIATIONS	0.171	0.495	0.292	0.675	1.015	0.980
	0.814	1.029	0.930	0.508	0.268	0.209

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0910	0.0802	0.0855	0.1013	0.1152	0.0928
	0.0644	0.0345	0.0358	0.0665	0.0848	0.1003
STD. DEVIATIONS	0.0845	0.0751	0.0805	0.0853	0.0843	0.0607
	0.0376	0.0249	0.0165	0.0593	0.0744	0.0785

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.1501	0.1449	0.1411	0.1728	0.1901	0.1583
	0.1063	0.0570	0.0611	0.1097	0.1445	0.1655
STD. DEVIATIONS	0.1394	0.1353	0.1328	0.1454	0.1391	0.1034
	0.0620	0.0411	0.0282	0.0978	0.1268	0.1296

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.95 (3.610)	3869851.5	100.00
RUNOFF	10.697 (2.5448)	1219280.12	31.507
EVAPOTRANSPIRATION	21.957 (2.0606)	2502747.50	64.673
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.95219 (0.63655)	108532.078	2.80455

PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00011 (0.00007)	12.764	0.00033
AVERAGE HEAD ON TOP OF LAYER 4	0.133 (0.089)		
CHANGE IN WATER STORAGE	0.345 (1.3618)	39279.45	1.015

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 7

	(INCHES)	(CU. FT.)
PRECIPITATION	2.60	296353.187
RUNOFF	1.874	213547.0620
DRAINAGE COLLECTED FROM LAYER 3	0.00712	811.63214
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000001	0.08958
AVERAGE HEAD ON TOP OF LAYER 4	0.364	
MAXIMUM HEAD ON TOP OF LAYER 4	0.705	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	23.2 FEET	
SNOW WATER	1.38	157357.0940

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3778
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 7

LAYER	(INCHES)	(VOL/VOL)
1	18.3947	0.2190
2	0.9023	0.0752
3	0.4397	0.0366
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	0.000	

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Appendix O-4

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\IGE1R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\IGE1R003.OUT


TIME: 15:22     DATE: 10/30/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  30
          THICKNESS                  =     84.00   INCHES
          POROSITY                   =      0.5410 VOL/VOL
          FIELD CAPACITY             =      0.1870 VOL/VOL
          WILTING POINT              =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1935 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  = 0.499999987000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0513	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0114	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.29999995000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	541.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 541. FEET.

SCS RUNOFF CURVE NUMBER	=	96.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	28.100	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.751	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.492	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.564	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.127	INCHES
TOTAL INITIAL WATER	=	27.127	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.71	2.08	3.24	3.42	3.42	5.13
	3.06	2.47	2.32	2.38	2.97	1.75
STD. DEVIATIONS	0.89	1.36	0.81	1.50	1.81	1.30
	1.58	1.66	1.35	1.37	1.62	1.07
RUNOFF						
TOTALS	0.497	0.870	1.175	0.942	1.125	1.829
	1.003	0.656	0.709	0.709	1.119	0.290
STD. DEVIATIONS	0.245	0.749	0.885	0.695	1.168	0.610
	0.757	0.592	0.583	0.721	0.845	0.351

EVAPOTRANSPIRATION

TOTALS	0.462	0.941	2.235	3.028	2.582	3.234
	2.493	1.993	1.446	1.278	1.318	0.780
STD. DEVIATIONS	0.169	0.484	0.287	0.647	0.931	0.966
	0.645	0.994	0.901	0.536	0.214	0.214

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0846	0.0737	0.0799	0.1030	0.1179	0.0878
	0.0533	0.0256	0.0338	0.0642	0.0804	0.0953
STD. DEVIATIONS	0.0789	0.0691	0.0769	0.0874	0.0751	0.0459
	0.0333	0.0234	0.0220	0.0612	0.0717	0.0749

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0200	0.0191	0.0189	0.0252	0.0279	0.0215
	0.0126	0.0061	0.0083	0.0152	0.0197	0.0226
STD. DEVIATIONS	0.0187	0.0178	0.0182	0.0214	0.0178	0.0112
	0.0079	0.0056	0.0054	0.0145	0.0175	0.0177

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 7

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.95	(3.610)	3463147.5	100.00
RUNOFF	10.923	(2.5198)	1114135.75	32.171
EVAPOTRANSPIRATION	21.792	(2.0850)	2222852.00	64.186
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.89941	(0.59344)	91742.234	2.64910

PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00002 (	0.00001)	2.038	0.00006
AVERAGE HEAD ON TOP OF LAYER 4	0.018 (	0.012)		
CHANGE IN WATER STORAGE	0.337 (	1.3648)	34415.69	0.994

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 7

	(INCHES)	(CU. FT.)
PRECIPITATION	2.60	265207.781
RUNOFF	1.896	193392.5780
DRAINAGE COLLECTED FROM LAYER 3	0.00787	802.88251
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.01516
AVERAGE HEAD ON TOP OF LAYER 4	0.058	
MAXIMUM HEAD ON TOP OF LAYER 4	0.114	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	5.0 FEET	
SNOW WATER	1.38	140819.5620

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3792

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0470

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 7

LAYER	(INCHES)	(VOL/VOL)
1	18.3273	0.2182
2	0.8886	0.0741
3	0.0246	0.0357
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	0.000	

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Appendix O-5

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\IGE2R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\IGE2R003.OUT


TIME:  18: 4      DATE:  10/30/2012


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     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  30
          THICKNESS                  =      42.00   INCHES
          POROSITY                   =       0.5410 VOL/VOL
          FIELD CAPACITY             =       0.1870 VOL/VOL
          WILTING POINT              =       0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.2199 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  = 0.499999987000E-04 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0528 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.29999995000 CM/SEC
SLOPE	=	33.33 PERCENT
DRAINAGE LENGTH	=	60.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 60. FEET.

SCS RUNOFF CURVE NUMBER	=	97.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	3.300	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.962	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.492	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.564	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	20.124	INCHES
TOTAL INITIAL WATER	=	20.124	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.71	2.08	3.24	3.42	3.42	5.13
	3.06	2.47	2.32	2.38	2.97	1.75
STD. DEVIATIONS	0.89	1.36	0.81	1.50	1.81	1.30
	1.58	1.66	1.35	1.37	1.62	1.07
RUNOFF						
TOTALS	0.507	0.889	1.245	1.036	1.208	1.986
	1.093	0.720	0.766	0.767	1.194	0.312
STD. DEVIATIONS	0.257	0.773	0.878	0.747	1.195	0.629
	0.809	0.634	0.624	0.759	0.881	0.379

EVAPOTRANSPIRATION

TOTALS	0.462	0.938	2.218	2.882	2.536	3.000
	2.134	1.840	1.360	1.107	1.207	0.759
STD. DEVIATIONS	0.168	0.481	0.305	0.650	0.941	0.921
	0.606	0.836	0.814	0.498	0.251	0.207

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.1049	0.1204	0.1589	0.1257	0.1343	0.1955
	0.2012	0.1718	0.1394	0.1282	0.1346	0.1299
STD. DEVIATIONS	0.0509	0.0786	0.0829	0.0604	0.1909	0.1581
	0.0932	0.0726	0.0467	0.0489	0.0539	0.0408

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0002	0.0002	0.0003	0.0002	0.0002	0.0003
	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0003	0.0003
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.95 (3.610)	406704.2	100.00
RUNOFF	11.722 (2.5523)	140417.73	34.526
EVAPOTRANSPIRATION	20.443 (1.9893)	244887.45	60.213
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.74498 (0.72759)	20903.158	5.13965

PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)		0.013	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)			
CHANGE IN WATER STORAGE	0.041 (1.0396)		495.82	0.122

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 7

	(INCHES)	(CU. FT.)
PRECIPITATION	2.60	31145.398
RUNOFF	1.940	23245.0449
DRAINAGE COLLECTED FROM LAYER 3	0.02107	252.41109
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00008
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.012	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	1.38	16537.5293
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3556	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 7

LAYER	(INCHES)	(VOL/VOL)
1	9.2876	0.2211
2	0.8712	0.0726
3	0.0072	0.0105
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	0.000	

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Appendix O-6

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\IGE3R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\IGE3R003.OUT


TIME:  18:17     DATE:  10/30/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER  30
           THICKNESS                 =      84.00   INCHES
           POROSITY                  =       0.5410 VOL/VOL
           FIELD CAPACITY            =       0.1870 VOL/VOL
           WILTING POINT             =       0.0470 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.1945 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  = 0.499999987000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0498 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0114 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.29999995000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	712.0 FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 712. FEET.

SCS RUNOFF CURVE NUMBER	=	96.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.864	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.492	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.564	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.194	INCHES
TOTAL INITIAL WATER	=	27.194	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI AND STATION LATITUDE = 38.70 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 7

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.71	2.08	3.24	3.42	3.42	5.13
	3.06	2.47	2.32	2.38	2.97	1.75
STD. DEVIATIONS	0.89	1.36	0.81	1.50	1.81	1.30
	1.58	1.66	1.35	1.37	1.62	1.07
RUNOFF						
TOTALS	0.495	0.864	1.152	0.915	1.095	1.790
	0.968	0.641	0.689	0.706	1.099	0.283
STD. DEVIATIONS	0.241	0.742	0.889	0.683	1.148	0.601
	0.729	0.577	0.572	0.739	0.831	0.342

EVAPOTRANSPIRATION

TOTALS	0.465	0.954	2.257	3.008	2.619	3.299
	2.410	2.152	1.455	1.242	1.312	0.784
STD. DEVIATIONS	0.171	0.495	0.292	0.675	1.015	0.980
	0.814	1.029	0.930	0.508	0.268	0.209

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0897	0.0802	0.0843	0.1100	0.1162	0.0843
	0.0532	0.0260	0.0403	0.0764	0.0909	0.1046
STD. DEVIATIONS	0.0829	0.0754	0.0793	0.0900	0.0818	0.0528
	0.0332	0.0216	0.0263	0.0730	0.0782	0.0795

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0279	0.0274	0.0263	0.0354	0.0362	0.0272
	0.0166	0.0081	0.0130	0.0238	0.0293	0.0326
STD. DEVIATIONS	0.0258	0.0256	0.0247	0.0290	0.0255	0.0170
	0.0104	0.0067	0.0085	0.0228	0.0252	0.0248

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.95 (3.610)	3869851.5	100.00
RUNOFF	10.697 (2.5448)	1219280.12	31.507
EVAPOTRANSPIRATION	21.957 (2.0606)	2502747.50	64.673
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.95610 (0.63050)	108978.195	2.81608

PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00003 (	0.00002)	2.975	0.00008
AVERAGE HEAD ON TOP OF LAYER 4	0.025 (	0.017)		
CHANGE IN WATER STORAGE	0.341 (	1.3369)	38843.12	1.004

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 7

	(INCHES)	(CU. FT.)
PRECIPITATION	2.60	296353.187
RUNOFF	1.874	213547.0620
DRAINAGE COLLECTED FROM LAYER 3	0.00777	886.12292
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.02144
AVERAGE HEAD ON TOP OF LAYER 4	0.075	
MAXIMUM HEAD ON TOP OF LAYER 4	0.149	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	5.8 FEET	
SNOW WATER	1.38	157357.0940
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3778	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 7

LAYER	(INCHES)	(VOL/VOL)
1	18.3947	0.2190
2	0.9023	0.0752
3	0.0346	0.0502
4	0.0000	0.0000
5	10.2480	0.4270
SNOW WATER	0.000	

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Appendix O-7

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\OAM1R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\OAM1R003.OUT


TIME: 19:29     DATE: 10/30/2012


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     TITLE: Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
           COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
          THICKNESS                  =      12.00   INCHES
          POROSITY                   =       0.5010 VOL/VOL
          FIELD CAPACITY             =       0.2840 VOL/VOL
          WILTING POINT              =       0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT =       0.3062 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
        NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

THICKNESS	=	240.00 INCHES
POROSITY	=	0.5410 VOL/VOL
FIELD CAPACITY	=	0.1870 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1947 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999987000E-04 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0455 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0321 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000000000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	541.0 FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	91.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	28.100	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.675	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	61.577	INCHES
TOTAL INITIAL WATER	=	61.577	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	2.08	3.12	3.53	3.24	4.61
	3.36	2.45	2.96	2.30	2.13	2.18
STD. DEVIATIONS	0.86	1.11	0.97	1.36	1.58	2.13
	1.90	1.28	1.45	1.31	1.49	1.09
RUNOFF						
TOTALS	0.391	0.787	0.587	0.212	0.265	0.654
	0.392	0.109	0.234	0.151	0.218	0.161
STD. DEVIATIONS	0.452	0.654	0.824	0.222	0.351	0.754
	0.548	0.144	0.217	0.199	0.266	0.215
EVAPOTRANSPIRATION						
TOTALS	0.569	0.697	2.472	3.494	2.909	3.987
	3.079	2.410	2.233	1.795	1.364	0.859
STD. DEVIATIONS	0.318	0.474	0.492	0.953	1.133	1.415
	1.345	1.087	1.145	0.670	0.512	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.2985	0.2211	0.2083	0.2099	0.1671	0.1134
	0.1469	0.2314	0.2721	0.3079	0.3115	0.3273
STD. DEVIATIONS	0.1400	0.1112	0.1310	0.1158	0.0888	0.0735
	0.1329	0.1607	0.1621	0.1665	0.1407	0.1348
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.3676	0.2981	0.2565	0.2670	0.2058	0.1443
	0.1808	0.2850	0.3462	0.3792	0.3963	0.4030
STD. DEVIATIONS	0.1725	0.1487	0.1613	0.1474	0.1093	0.0935
	0.1637	0.1979	0.2063	0.2051	0.1790	0.1660

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.44 (4.389)	3411429.2	100.00
RUNOFF	4.161 (1.6271)	424391.19	12.440
EVAPOTRANSPIRATION	25.868 (3.1274)	2638658.00	77.348
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.81529 (1.21086)	287167.750	8.41781
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00023 (0.00009)	23.651	0.00069
AVERAGE HEAD ON TOP OF LAYER 5	0.294 (0.126)		
CHANGE IN WATER STORAGE	0.600 (2.1564)	61188.54	1.794

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	350890.344
RUNOFF	1.975	201463.1090
DRAINAGE COLLECTED FROM LAYER 4	0.02019	2059.21289
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000002	0.15823
AVERAGE HEAD ON TOP OF LAYER 5	0.771	
MAXIMUM HEAD ON TOP OF LAYER 5	1.437	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	36.4 FEET	
SNOW WATER	2.22	225988.4530
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4152	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	2.6733	0.2228
2	61.7891	0.2575
3	1.0614	0.0885
4	0.6015	0.0501
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.201	

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Appendix O-8

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\OAM3R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\OAM3R003.OUT


TIME: 11:18     DATE: 10/31/2012


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    TITLE: Ameren Missouri Labadie Proposed Utility Waste Landfill

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   9
           THICKNESS                  =      12.00    INCHES
           POROSITY                   =       0.5010 VOL/VOL
           FIELD CAPACITY             =       0.2840 VOL/VOL
           WILTING POINT              =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.3062 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 30

THICKNESS	=	240.00 INCHES
POROSITY	=	0.5410 VOL/VOL
FIELD CAPACITY	=	0.1870 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1947 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999987000E-04 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0455 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0321 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000000000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	637.0 FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	91.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.675	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	61.577	INCHES
TOTAL INITIAL WATER	=	61.577	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	2.08	3.12	3.53	3.24	4.61
	3.36	2.45	2.96	2.30	2.13	2.18
STD. DEVIATIONS	0.86	1.11	0.97	1.36	1.58	2.13
	1.90	1.28	1.45	1.31	1.49	1.09
RUNOFF						
TOTALS	0.391	0.787	0.587	0.212	0.265	0.654
	0.392	0.109	0.234	0.151	0.218	0.161
STD. DEVIATIONS	0.452	0.654	0.824	0.222	0.351	0.754
	0.548	0.144	0.217	0.199	0.266	0.215
EVAPOTRANSPIRATION						
TOTALS	0.569	0.697	2.472	3.494	2.909	3.987
	3.079	2.410	2.233	1.795	1.364	0.859
STD. DEVIATIONS	0.318	0.474	0.492	0.953	1.133	1.415
	1.345	1.087	1.145	0.670	0.512	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.2996	0.2250	0.2109	0.2098	0.1710	0.1167
	0.1446	0.2252	0.2684	0.3054	0.3103	0.3268
STD. DEVIATIONS	0.1396	0.1117	0.1294	0.1155	0.0896	0.0728
	0.1266	0.1571	0.1604	0.1663	0.1416	0.1353
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.4344	0.3571	0.3057	0.3144	0.2480	0.1748
	0.2096	0.3265	0.4022	0.4429	0.4649	0.4739
STD. DEVIATIONS	0.2025	0.1759	0.1877	0.1730	0.1299	0.1091
	0.1836	0.2278	0.2403	0.2411	0.2122	0.1962

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.44	(4.389)	3812059.7	100.00
RUNOFF	4.161	(1.6271)	474230.69	12.440
EVAPOTRANSPIRATION	25.868	(3.1274)	2948536.00	77.348
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.81367	(1.21238)	320707.656	8.41298
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00027	(0.00011)	30.642	0.00080
AVERAGE HEAD ON TOP OF LAYER 5	0.346	(0.149)		
CHANGE IN WATER STORAGE	0.601	(2.1597)	68554.64	1.798

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	392098.094
RUNOFF	1.975	225122.4840
DRAINAGE COLLECTED FROM LAYER 4	0.01977	2253.52466
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000002	0.20126
AVERAGE HEAD ON TOP OF LAYER 5	0.889	
MAXIMUM HEAD ON TOP OF LAYER 5	1.659	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	42.3 FEET	
SNOW WATER	2.22	252528.0310
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4152	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	2.6733	0.2228
2	61.7891	0.2575
3	1.0614	0.0885
4	0.6412	0.0534
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.201	

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Appendix O-9

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\OGE1R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\OGE1R003.OUT


TIME: 18:55      DATE: 10/30/2012


******************************************************************************

     TITLE: Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   9
           THICKNESS                  =      12.00   INCHES
           POROSITY                   =       0.5010 VOL/VOL
           FIELD CAPACITY             =       0.2840 VOL/VOL
           WILTING POINT              =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.3062 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 30

THICKNESS	=	240.00	INCHES
POROSITY	=	0.5410	VOL/VOL
FIELD CAPACITY	=	0.1870	VOL/VOL
WILTING POINT	=	0.0470	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1947	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999987000E-04	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0455	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0102	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.28999996000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	541.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	91.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	28.100	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.675	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	61.200	INCHES
TOTAL INITIAL WATER	=	61.200	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	2.08	3.12	3.53	3.24	4.61
	3.36	2.45	2.96	2.30	2.13	2.18
STD. DEVIATIONS	0.86	1.11	0.97	1.36	1.58	2.13
	1.90	1.28	1.45	1.31	1.49	1.09
RUNOFF						
TOTALS	0.391	0.787	0.587	0.212	0.265	0.654
	0.392	0.109	0.234	0.151	0.218	0.161
STD. DEVIATIONS	0.452	0.654	0.824	0.222	0.351	0.754
	0.548	0.144	0.217	0.199	0.266	0.215
EVAPOTRANSPIRATION						
TOTALS	0.569	0.697	2.472	3.494	2.909	3.987
	3.079	2.410	2.233	1.795	1.364	0.859
STD. DEVIATIONS	0.318	0.474	0.492	0.953	1.133	1.415
	1.345	1.087	1.145	0.670	0.512	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.2922	0.2075	0.2035	0.2098	0.1508	0.1063
	0.1599	0.2529	0.2804	0.3148	0.3142	0.3278
STD. DEVIATIONS	0.1408	0.1104	0.1359	0.1175	0.0870	0.0816
	0.1536	0.1692	0.1658	0.1653	0.1374	0.1332
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0697	0.0542	0.0486	0.0517	0.0360	0.0262
	0.0382	0.0604	0.0691	0.0751	0.0775	0.0782
STD. DEVIATIONS	0.0336	0.0287	0.0324	0.0290	0.0208	0.0201
	0.0367	0.0404	0.0409	0.0395	0.0339	0.0318

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.44 (4.389)	3411429.2	100.00
RUNOFF	4.161 (1.6271)	424391.19	12.440
EVAPOTRANSPIRATION	25.868 (3.1274)	2638658.00	77.348
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.82031 (1.20619)	287680.219	8.43284
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00005 (0.00002)	5.415	0.00016
AVERAGE HEAD ON TOP OF LAYER 5	0.057 (0.024)		
CHANGE IN WATER STORAGE	0.595 (2.1461)	60694.28	1.779

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	350890.344
RUNOFF	1.975	201463.1090
DRAINAGE COLLECTED FROM LAYER 4	0.02321	2367.64014
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.04056
AVERAGE HEAD ON TOP OF LAYER 5	0.172	
MAXIMUM HEAD ON TOP OF LAYER 5	0.336	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	12.3 FEET	
SNOW WATER	2.22	225988.4530

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4152
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	2.6733	0.2228
2	61.7891	0.2575
3	1.0614	0.0885
4	0.1028	0.1490
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.201	

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Appendix O-10

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\OGE2R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\OGE2R003.OUT


TIME:  19: 9     DATE:  10/30/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   9
           THICKNESS                 =      12.00   INCHES
           POROSITY                  =       0.5010 VOL/VOL
           FIELD CAPACITY            =       0.2840 VOL/VOL
           WILTING POINT             =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.3111 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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                         LAYER  2
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER  30
THICKNESS                   =    120.00    INCHES
POROSITY                    =      0.5410 VOL/VOL
FIELD CAPACITY              =      0.1870 VOL/VOL
WILTING POINT               =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2011 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999987000E-04 CM/SEC


                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00    INCHES
POROSITY                    =      0.4170 VOL/VOL
FIELD CAPACITY              =      0.0450 VOL/VOL
WILTING POINT               =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0473 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.500000007000E-01 CM/SEC


                         LAYER  4
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.69    INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   1.28999996000     CM/SEC
SLOPE                       =     33.33    PERCENT
DRAINAGE LENGTH             =     60.0     FEET
```

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	91.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	3.300	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.734	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	38.694	INCHES
TOTAL INITIAL WATER	=	38.694	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	2.08	3.12	3.53	3.24	4.61
	3.36	2.45	2.96	2.30	2.13	2.18
STD. DEVIATIONS	0.86	1.11	0.97	1.36	1.58	2.13
	1.90	1.28	1.45	1.31	1.49	1.09
RUNOFF						
TOTALS	0.394	0.796	0.601	0.222	0.271	0.671
	0.404	0.112	0.243	0.153	0.222	0.167
STD. DEVIATIONS	0.455	0.656	0.824	0.237	0.357	0.769
	0.555	0.149	0.222	0.209	0.268	0.220
EVAPOTRANSPIRATION						
TOTALS	0.567	0.695	2.466	3.495	2.923	3.983
	3.074	2.428	2.243	1.783	1.378	0.857
STD. DEVIATIONS	0.317	0.472	0.489	0.934	1.114	1.409
	1.344	1.076	1.129	0.666	0.495	0.254
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.2596	0.1940	0.1951	0.2016	0.1607	0.1715
	0.2941	0.3313	0.3130	0.3359	0.3121	0.3079
STD. DEVIATIONS	0.1270	0.0991	0.1028	0.1071	0.1131	0.1970
	0.2319	0.2140	0.1787	0.1565	0.1247	0.1157
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003
	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003
	0.0004	0.0003	0.0003	0.0003	0.0002	0.0002

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.44	(4.389)	400630.5	100.00
RUNOFF	4.257	(1.6530)	50989.73	12.727
EVAPOTRANSPIRATION	25.892	(3.1254)	310166.03	77.419
LATERAL DRAINAGE COLLECTED FROM LAYER 4	3.07670	(1.26999)	36855.824	9.19946
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.015	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.219	(1.7240)	2618.90	0.654

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	41207.762
RUNOFF	2.008	24057.4727
DRAINAGE COLLECTED FROM LAYER 4	0.03123	374.08154
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00009
AVERAGE HEAD ON TOP OF LAYER 5	0.002	
MAXIMUM HEAD ON TOP OF LAYER 5	0.016	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.22	26539.5703
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4162	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	2.6890	0.2241
2	29.9731	0.2498
3	1.0424	0.0869
4	0.0069	0.0100
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.201	

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Appendix O-11

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**                                                                          **
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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\OGE3R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\OGE3R003.OUT


TIME:  19:19     DATE:  10/30/2012


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     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
           THICKNESS                  =      12.00   INCHES
           POROSITY                   =       0.5010 VOL/VOL
           FIELD CAPACITY             =       0.2840 VOL/VOL
           WILTING POINT              =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.3062 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  = 0.190000006000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

THICKNESS	=	240.00 INCHES
POROSITY	=	0.5410 VOL/VOL
FIELD CAPACITY	=	0.1870 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1947 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999987000E-04 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0455 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0103 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.28999996000 CM/SEC
SLOPE	=	1.00 PERCENT
DRAINAGE LENGTH	=	627.0 FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	91.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.675	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	61.200	INCHES
TOTAL INITIAL WATER	=	61.200	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50
START OF GROWING SEASON (JULIAN DATE)	=	98
END OF GROWING SEASON (JULIAN DATE)	=	300
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	2.08	3.12	3.53	3.24	4.61
	3.36	2.45	2.96	2.30	2.13	2.18
STD. DEVIATIONS	0.86	1.11	0.97	1.36	1.58	2.13
	1.90	1.28	1.45	1.31	1.49	1.09
RUNOFF						
TOTALS	0.391	0.787	0.587	0.212	0.265	0.654
	0.392	0.109	0.234	0.151	0.218	0.161
STD. DEVIATIONS	0.452	0.654	0.824	0.222	0.351	0.754
	0.548	0.144	0.217	0.199	0.266	0.215
EVAPOTRANSPIRATION						
TOTALS	0.569	0.697	2.472	3.494	2.909	3.987
	3.079	2.410	2.233	1.795	1.364	0.859
STD. DEVIATIONS	0.318	0.474	0.492	0.953	1.133	1.415
	1.345	1.087	1.145	0.670	0.512	0.255
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	0.2934	0.2093	0.2037	0.2101	0.1532	0.1068
	0.1577	0.2502	0.2796	0.3140	0.3139	0.3278
STD. DEVIATIONS	0.1409	0.1104	0.1354	0.1173	0.0871	0.0799
	0.1512	0.1685	0.1654	0.1657	0.1378	0.1334
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0812	0.0634	0.0563	0.0600	0.0424	0.0305
	0.0436	0.0692	0.0799	0.0868	0.0897	0.0907
STD. DEVIATIONS	0.0390	0.0332	0.0375	0.0335	0.0241	0.0228
	0.0418	0.0466	0.0473	0.0458	0.0394	0.0369

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.44 (4.389)	3812059.7	100.00
RUNOFF	4.161 (1.6271)	474230.69	12.440
EVAPOTRANSPIRATION	25.868 (3.1274)	2948536.00	77.348
LATERAL DRAINAGE COLLECTED FROM LAYER 4	2.81969 (1.20674)	321394.000	8.43098
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00006 (0.00002)	6.895	0.00018
AVERAGE HEAD ON TOP OF LAYER 5	0.066 (0.028)		
CHANGE IN WATER STORAGE	0.596 (2.1473)	67891.99	1.781

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	392098.094
RUNOFF	1.975	225122.4840
DRAINAGE COLLECTED FROM LAYER 4	0.02255	2570.84790
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.05047
AVERAGE HEAD ON TOP OF LAYER 5	0.193	
MAXIMUM HEAD ON TOP OF LAYER 5	0.378	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	13.6 FEET	
SNOW WATER	2.22	252528.0310

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4152

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	2.6733	0.2228
2	61.7891	0.2575
3	1.0614	0.0885
4	0.1182	0.1713
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.201	

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Appendix O-12

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:      C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:  C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:    C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:  C:\HELP\INPUTS\CAM1R002.D10
OUTPUT DATA FILE:           C:\HELP\OUT\CAM1R002.OUT


TIME:  10:41     DATE:  11/ 6/2012


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     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
          THICKNESS                   =       24.00   INCHES
          POROSITY                    =        0.5010 VOL/VOL
          FIELD CAPACITY              =        0.2840 VOL/VOL
          WILTING POINT               =        0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT  =        0.3739 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

THICKNESS	=	700.00 INCHES
POROSITY	=	0.5410 VOL/VOL
FIELD CAPACITY	=	0.1870 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1871 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.499999987000E-04 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0586 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.500000007000E-01 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0333	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.250000004000E-01	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	541.0	FEET

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.684	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	151.282	INCHES
TOTAL INITIAL WATER	=	151.282	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.56	2.15	3.09	3.37	3.44	4.42
	3.38	2.66	2.75	2.18	2.16	2.06
STD. DEVIATIONS	0.95	1.09	0.92	1.36	1.56	2.04
	1.87	1.38	1.45	1.28	1.38	1.14
RUNOFF						
TOTALS	0.526	1.225	0.909	0.418	0.276	0.480
	0.247	0.059	0.080	0.079	0.154	0.203
STD. DEVIATIONS	0.576	0.948	0.891	0.629	0.455	0.841
	0.428	0.136	0.108	0.278	0.318	0.442
EVAPOTRANSPIRATION						
TOTALS	0.579	0.686	2.414	3.399	3.192	4.117
	3.512	3.155	2.504	1.805	1.402	0.887
STD. DEVIATIONS	0.344	0.463	0.611	0.935	1.054	1.402
	1.294	1.039	1.067	0.693	0.423	0.239
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0692	0.0606	0.0887	0.0863	0.0837	0.0804
	0.0777	0.0700	0.0627	0.0653	0.0669	0.0769
STD. DEVIATIONS	0.0184	0.0152	0.0147	0.0121	0.0099	0.0108
	0.0088	0.0070	0.0078	0.0098	0.0162	0.0174

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.0153	0.0134	0.0155	0.0149	0.0146	0.0147
	0.0166	0.0179	0.0182	0.0190	0.0181	0.0180
STD. DEVIATIONS	0.0150	0.0131	0.0150	0.0144	0.0143	0.0140
	0.0153	0.0164	0.0167	0.0177	0.0172	0.0174

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	14.2640	13.7198	18.3089	18.4126	17.3077	17.1844
	16.0783	14.4826	13.3825	13.4937	14.2739	15.8825
STD. DEVIATIONS	3.7982	3.4051	3.0151	2.5653	2.0399	2.3181
	1.8348	1.4688	1.6871	2.0460	3.4631	3.5892

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.1884	0.1819	0.1911	0.1893	0.1803	0.1872
	0.2049	0.2201	0.2310	0.2343	0.2300	0.2222
STD. DEVIATIONS	0.1851	0.1768	0.1850	0.1829	0.1764	0.1785
	0.1889	0.2025	0.2130	0.2178	0.2185	0.2149

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.21	(4.731)	3785646.0	100.00
RUNOFF	4.657	(2.0919)	530826.37	14.022
EVAPOTRANSPIRATION	27.651	(3.0955)	3151747.00	83.255
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.88864	(0.09279)	101289.297	2.67561

AVERAGE HEAD ON TOP OF LAYER 2	15.566 (1.626)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.19631 (0.18384)	22375.322	0.59106
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00016 (0.00014)	18.739	0.00050
AVERAGE HEAD ON TOP OF LAYER 6	0.205 (0.192)		
CHANGE IN WATER STORAGE	0.708 (1.5321)	80679.05	2.131

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	392098.094
RUNOFF	2.442	278376.6560
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003767	429.34015
AVERAGE HEAD ON TOP OF LAYER 2	24.000	
DRAINAGE COLLECTED FROM LAYER 5	0.00185	210.67238
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000001	0.16320
AVERAGE HEAD ON TOP OF LAYER 6	0.706	
MAXIMUM HEAD ON TOP OF LAYER 6	1.322	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	34.3 FEET	
SNOW WATER	2.43	276996.6250

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5010
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	9.4425	0.3934
2	0.0000	0.0000
3	151.3888	0.2163
4	0.8053	0.0671
5	0.6318	0.0527
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

****
****

Appendix O-13

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP\ALPPR612.D4
TEMPERATURE DATA FILE:       C:\HELP\ALPTE612.D7
SOLAR RADIATION DATA FILE:   C:\HELP\ALPSR612.D13
EVAPOTRANSPIRATION DATA:     C:\HELP\ALPEV612.D11
SOIL AND DESIGN DATA FILE:   C:\HELP\INPUTS\CGE1R003.D10
OUTPUT DATA FILE:            C:\HELP\OUT\CGE1R003.OUT


TIME:  10:46     DATE:  11/ 6/2012


******************************************************************************

     TITLE:  Ameren Missouri Labadie Proposed Utility Waste Landfill

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   9
           THICKNESS                    =      24.00   INCHES
           POROSITY                     =       0.5010 VOL/VOL
           FIELD CAPACITY               =       0.2840 VOL/VOL
           WILTING POINT                =       0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.3739 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.190000006000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.34
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

```
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    = 0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      2.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      2.00   HOLES/ACRE
FML PLACEMENT QUALITY        = 3 - GOOD
```

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 30

```
THICKNESS                    =    700.00   INCHES
POROSITY                     =      0.5410 VOL/VOL
FIELD CAPACITY               =      0.1870 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1871 VOL/VOL
EFFECTIVE SAT. HYD. COND.    = 0.499999987000E-04 CM/SEC
```

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4170 VOL/VOL
FIELD CAPACITY               =      0.0450 VOL/VOL
WILTING POINT                =      0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0586 VOL/VOL
EFFECTIVE SAT. HYD. COND.    = 0.500000007000E-01 CM/SEC
```

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.69	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0143	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.29999995000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	541.0	FEET

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 7

TYPE 3 - BARRIER SOIL LINER

MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 720. FEET.

SCS RUNOFF CURVE NUMBER	=	86.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	31.400	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.684	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	150.892	INCHES
TOTAL INITIAL WATER	=	150.892	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ST. LOUIS MISSOURI

STATION LATITUDE	=	38.70	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.50	
START OF GROWING SEASON (JULIAN DATE)	=	98	
END OF GROWING SEASON (JULIAN DATE)	=	300	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.40	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.72	2.14	3.28	3.55	3.54	3.73
3.63	2.55	2.70	2.32	2.53	2.22

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ST. LOUIS MISSOURI

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.60	33.80	43.20	56.10	65.60	74.80
78.90	77.00	69.70	57.90	44.60	34.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ST. LOUIS MISSOURI
AND STATION LATITUDE = 38.70 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.56	2.15	3.09	3.37	3.44	4.42
	3.38	2.66	2.75	2.18	2.16	2.06
STD. DEVIATIONS	0.95	1.09	0.92	1.36	1.56	2.04
	1.87	1.38	1.45	1.28	1.38	1.14
RUNOFF						
TOTALS	0.526	1.225	0.909	0.418	0.276	0.480
	0.247	0.059	0.080	0.079	0.154	0.203
STD. DEVIATIONS	0.576	0.948	0.891	0.629	0.455	0.841
	0.428	0.136	0.108	0.278	0.318	0.442
EVAPOTRANSPIRATION						
TOTALS	0.579	0.686	2.414	3.399	3.192	4.117
	3.512	3.155	2.504	1.805	1.402	0.887
STD. DEVIATIONS	0.344	0.463	0.611	0.935	1.054	1.402
	1.294	1.039	1.067	0.693	0.423	0.239
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0692	0.0606	0.0887	0.0863	0.0837	0.0804
	0.0777	0.0700	0.0627	0.0653	0.0669	0.0769
STD. DEVIATIONS	0.0184	0.0152	0.0147	0.0121	0.0099	0.0108
	0.0088	0.0070	0.0078	0.0098	0.0162	0.0174

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.0109	0.0127	0.0198	0.0117	0.0128	0.0188
	0.0231	0.0227	0.0215	0.0191	0.0160	0.0150
STD. DEVIATIONS	0.0110	0.0127	0.0210	0.0144	0.0145	0.0167
	0.0210	0.0217	0.0209	0.0201	0.0179	0.0169

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	14.2640	13.7198	18.3089	18.4126	17.3077	17.1844
	16.0783	14.4826	13.3825	13.4937	14.2739	15.8825
STD. DEVIATIONS	3.7982	3.4051	3.0151	2.5653	2.0399	2.3181
	1.8348	1.4688	1.6871	2.0460	3.4631	3.5892

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0026	0.0033	0.0047	0.0029	0.0030	0.0046
	0.0055	0.0054	0.0052	0.0045	0.0039	0.0036
STD. DEVIATIONS	0.0026	0.0033	0.0050	0.0035	0.0034	0.0041
	0.0050	0.0052	0.0051	0.0048	0.0044	0.0040

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.21	(4.731)	3785646.0	100.00
RUNOFF	4.657	(2.0919)	530826.37	14.022
EVAPOTRANSPIRATION	27.651	(3.0955)	3151747.00	83.255
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.88864	(0.09279)	101289.297	2.67561

AVERAGE HEAD ON TOP OF LAYER 2	15.566 (1.626)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.20399 (0.19117)	23251.387	0.61420
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00001 (0.00000)	0.773	0.00002
AVERAGE HEAD ON TOP OF LAYER 6	0.004 (0.004)		
CHANGE IN WATER STORAGE	0.700 (1.5276)	79820.97	2.109

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.44	392098.094
RUNOFF	2.442	278376.6560
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003767	429.34015
AVERAGE HEAD ON TOP OF LAYER 2	24.000	
DRAINAGE COLLECTED FROM LAYER 5	0.00303	345.25888
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00762
AVERAGE HEAD ON TOP OF LAYER 6	0.022	
MAXIMUM HEAD ON TOP OF LAYER 6	0.044	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.3 FEET	
SNOW WATER	2.43	276996.6250

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5010
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	9.4425	0.3934
2	0.0000	0.0000
3	151.3888	0.2163
4	0.8053	0.0671
5	0.0164	0.0237
6	0.0000	0.0000
7	10.2480	0.4270
SNOW WATER	0.000	

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Appendix P

Construction Quality Assurance Plan

Ameren Missouri Labadie Energy Center

Construction Quality Assurance Plan for a Utility Waste Landfill
Franklin, Missouri

Ameren Missouri
Power Operation Services
3700 South Lindbergh Blvd.
St. Louis, Missouri 63127

December 2012

GREDELL Engineering Resources, Inc.
1505 East High Street
Jefferson City, Missouri 65101
Phone: (573) 659-9078
Fax: (573) 659-9079

Ameren Missouri Labadie Energy Center
Construction Quality Assurance Plan
Utility Waste Landfill
Franklin County, Missouri

December 2012

Table of Contents

Appendices

1.0 INTRODUCTION

The Missouri Department of Natural Resources Solid Waste Management Program (MDNR-SWMP) requires construction quality assurance (CQA) and construction quality control (CQC) on landfill components to ensure quality landfill construction. Manufacturing Quality Control (MQA) and Manufacturing Quality Assurance (MQA) are also typically completed for the manufactured components of a landfill such as HDPE liners and pipe. CQA is typically performed by a party independent of the Owner/Operator (Owner) and contractor to document the quality of construction on key landfill components. CQC procedures are typically performed by the contractor and/or owner throughout construction to ensure that landfill components are constructed in accordance with applicable construction standards and specifications. MQA is typically performed by the contractor and may also be performed by a party independent of the Owner, while MQC is typically performed by the manufacturer. The technical guidance document entitled Quality Assurance and Quality Control for Waste Containment Facilities (EPA/600/R-93/182) produced by the U.S. Environmental Protection Agency specifically defines the roles that CQA, CQC, MQA, and MQC play during landfill construction:

- CQA: Construction Quality Assurance is a planned system of activities that provides the owner and permitting agencies assurance that the facility was constructed as specified in the design. CQA includes field inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. CQA refers to the measures taken by the CQA agent to assess if the contractor or installer is in compliance with the plans and specifications for a project.

- CQC: Construction Quality Control is a planned system of inspections and materials testing that are used to directly monitor and control the quality of a construction project. CQC is frequently performed by the owner, earthwork contractor and/or geosynthetics installer and is necessary to achieve quality in the constructed or installed system. CQC refers to measures taken to determine compliance with the requirements for material and workmanship as stated in the plans and specifications for the project.

- MQC: Manufacturing Quality Control is a planned system of inspections that is used to directly monitor and control the manufacture of a material. MQC is normally performed by the manufacturer of geosynthetic materials to determine compliance with the requirements for materials and workmanship.

- MQA: Manufacturing Quality Assurance is a planned system of activities that provides assurance that the materials were constructed as specified, and refers to measures taken by the MQA organization, such as manufacturing facility inspections, verifications, audits, and evaluation of raw materials and geosynthetic products.

Typical landfill components that require CQA and/or CQC procedures are:

- Subgrade Excavation and/or Backfilling

- Low Permeability Soil Liner/Cover
- Geomembrane Liner
- Geotextiles and/or Geocomposites
- Drainage Materials

The manufacturer(s) of geosynthetic materials will be required to furnish with their bids documentation of a written, effective MQC program. One component of the manufacturer's MQC program will be a MQA program by an independent, qualified testing agency that will provide documentation with certifications that the manufactured products comply with the requirements for material and workmanship as stated in the plans and specifications for the project.

This Plan is specific to the CQA activities to be completed by an independent third-party and addresses the soil, geosynthetic, and drainage components of the composite liner, leachate drainage and collection and final cover systems to be constructed for the Utility Waste Landfill (UWL) at the Ameren Missouri Labadie Energy Center site in Franklin County, Missouri. This plan has been prepared in general conformance with the State of Missouri Solid Waste Management Rules, and Franklin County Regulations.

This document outlines methods of construction, quality assurance testing procedures, safety and reporting requirements to be followed during construction of the earthwork, liner, and final cover systems at the Labadie UWL. The specific CQC program that will be followed during installation of the landfill components is not included with this document. However, the CQA agent for earthwork, liner and final cover construction for the UWL will coordinate with the contractor(s) and CQC personnel to ensure that construction is in accordance with the approved permit documents, materials' manufacturers and suppliers standards and specifications and other available plans and specifications. If the CQC efforts appear to be insufficient, the CQA agent will coordinate with the contractor(s) to ensure that the permit documents, and plans and specifications are adhered to. The CQA procedures outlined in this document fulfill all requirements of the Missouri Solid Waste Management and Franklin County Regulations and will, by themselves, provide the information and documentation necessary to certify that landfill components were constructed in accordance with the approved permit documents.

A copy of this plan will be maintained at the UWL for use during landfill phase development and final cover construction. Any revisions to the CQA Plan shall require a permit modification to be reviewed by the MDNR-SWMP. The MDNR-SWMP must be kept informed throughout all phases of construction. The MDNR-SWMP and Franklin County Independent Registered Professional Engineer (IPRE) will review all records and results from the implementation of the CQA Plan as part of any Operating Permit Application and Request for Authorization to Operate any area or phase of the UWL.

2.0 GENERAL CONDITIONS

2.1 Responsibility and Authority

Ameren Missouri is ultimately responsible for the implementation of this CQA Plan. The following is a list of responsible personnel:

Owner's Representative

A representative of Ameren Missouri shall be responsible for coordination between the Owner, the construction crew, and the third party CQA Engineer. With the MDNR-SWMP's prior approval, the Owner may delegate this authority, and correspondingly, be responsible to see that the CQA Plan is followed.

CQA Engineer

A professional engineer licensed to practice in Missouri shall be retained by the Ameren Missouri to provide on-site Construction Quality Assurance observations and testing. The CQA Engineer will prepare a final report demonstrating that the substantial requirements of this CQA Plan were implemented. The final report will include the MQC submittals from the manufacturer(s) and the MQA submittals from the independent MQA agencies. In addition, the CQA Engineer or his designee will coordinate, through Ameren Missouri, with the contractor(s) and/or installer(s) and their CQC personnel for the purposes of sharing MQC, MQA, CQA and CQC information. Should it become apparent to the CQA Engineer or his designee that construction quality does not meet the standards established in the Construction Permit; the CQA Engineer will inform the Owner's Representative of the apparent deficiencies so appropriate adjustments can be made. The CQA Engineer will be employed by an organization that operates independently of the Owner, construction contractor(s), landfill operator, and/or permit holder. The CQA Engineer will be responsible for certifying that construction was completed in substantial compliance with the engineering plans and specifications approved by the Construction Permit. Components of the bottom composite liner system, leachate drainage and collection system or final cap system will be not constructed unless the CQA Engineer or the CQA Inspector is present.

CQA Inspector

The CQA Engineer will designate one or more CQA Inspector(s) to perform the duties of the CQA Engineer when they are not present on site or when the extent of the project requires inspection by more than one person. A CQA Inspector shall be a qualified, experienced individual who is able to act for the CQA Engineer to provide necessary on-site CQA observations and testing. The CQA Inspector will document on-site construction activities in a Daily Field Activities Report. An example of this report is included in Appendix A. No component of the bottom composite liner system, leachate drainage and collection system or final cover system will be constructed unless the CQA engineer or CQA inspector is present.

2.2 Inspection and Testing

This CQA Plan describes the inspection and testing of eight critical components of the landfill containment system:

1. Test pad construction and testing
2. Subgrade preparation
3. Compacted soil liner (bottom)
4. Geomembrane liner
5. Geotextile
6. Leachate Drainage and collection system components
7. Geocomposites
8. Protective Aggregate Layer
9. Final Cover system

The following sections outline minimum requirements and guidelines to be followed during execution of the CQA Plan. Information pertaining to the specific tests, testing frequency, level of detail and consistency in reports is presented in each section.

Throughout the construction activities, communication will play a major role in completing a successful construction project and achieving the requirements of the approved plans, specifications, and permit documents. At a minimum, the following communications guidelines will be met:

- **Pre-Construction Meeting:** A meeting involving the Owner, CQA personnel, and the contractor(s) will take place prior to the start of construction. This meeting should include discussion of each party's responsibilities, lines or means of communication, procedures for changes or problems, CQA procedures and requirements, level of the MDNR-SWMP and IPRE involvement, and other issues as they pertain to the construction project.

- **Weekly Progress Meetings:** Regularly scheduled meetings between CQA personnel and the contractor(s) will take place during project construction to review and discuss such topics as previous work, future work, construction problems, schedule revisions, and other issues that require attention.

- **Other Meetings:** Unscheduled meetings will take place as required to address issues such as construction progress and changed conditions as circumstances dictate.

Under all circumstances, the MDNR-SWMP and the IPRE will be given seven days advance notification prior to the start of any test pad construction; excavation of subgrade; placement of soil liner components; and placement of geosynthetic materials. It is understood that the MDNR-SWMP reserves the right to inspect the compacted soil liner during the initial placement of liner and during placement of the geomembrane.

2.3 Floodplain Issues Related to Construction

If a flooding event occurs during cell liner construction, the contractor will be required to monitor the flood conditions and levels outside the cell being constructed. The contractor will be required to monitor the excess hydrostatic uplift pressures on the composite liner. If required by the Owner's Representative, the contractor will be required to mitigate heave due to excess hydrostatic uplift pressures on the composite liner either by placing ballast material on the liner or by flooding the lined area as directed by the Owner's Representative. The contractor will be required to remove the ballast material or water and to restore the Work to the pre-flood condition prior to continuing with construction.

3.0 SOIL LINER CONSTRUCTION

The compacted soil portion of the UWL composite bottom liner system is to be constructed and tested in accordance with the approved permit documents and this CQA Plan. This section covers material conformance testing, general construction procedures, testing during construction, and frequency requirements.

- A test pad will be constructed for soils that will be used for liner construction. For the Ameren Missouri Labadie Energy Center utility waste landfill conformance testing of available soil materials will be performed prior to test pad construction to demonstrate that the soils meet the required specifications.

3.1 Materials Conformance Testing

Soils to be used for liner construction will be classified, excavated, segregated, and stockpiled under the observation of an experienced soils technician.

Prior to construction of the compacted soil component of the liner system, representative samples of the stockpiled materials proposed for use will be collected and tested. This testing will verify that the soils to be used for construction meet project specifications as determined by this pre-qualification testing. The following tests may be performed as prescribed by the CQA Engineer (ASTM standards and tests designations refer to the latest approved version):

Test Method	Test Description
ASTM D 2216	Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils (Atterberg Limits)
ASTM D 422	Particle Size Analysis of Soils
ASTM D 1140	Amount of Soils Finer than the No. 200 Sieve
ASTM D 698	Laboratory Compaction Characteristics of Soil using Standard Effort (Note: The Modified or Reduced Proctor Tests may be substituted or added to the Standard Proctor Test as necessary.)
ASTM D 4767	Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D 5084	Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

ASTM D 2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Soil selected for liner construction must have a group symbol of CL, CH, or SC according to the Unified Soil Classification System. In addition, each soil used for construction must meet the following criteria:

- Allow more than 30 percent passage through a No. 200 sieve
- Have a liquid limit equal to or greater than 20
- Have a plasticity index equal to or greater than 10
- Have a coefficient of permeability equal to or less than that specified in the Project documents, that is $1x10^{-5}$ or $1x10^{-7}$ centimeters per second (cm/sec) or less when compacted to a density and moisture content deemed acceptable by preconstruction testing and test pad construction
- Shall meet or exceed the minimum shear strength properties, both internal and interface with other materials, utilized in the geotechnical design (reference Appendix J of the Construction Permit Application).

Soils meeting all of the above requirements will be used to construct a test pad in accordance with Section 3.2 of the CQA Plan.

After completing the conformance testing described above, the CQA Engineer will complete the appropriate testing and data evaluation needed to develop a compacted soil placement range for the selected borrow material. The placement range will be developed based on previous laboratory testing of the borrow material, if available, as well as the test results obtained from preconstruction testing. The placement range (i.e., "acceptable zone") shall be developed in accordance with the method developed by D.E. Daniel and C.H. Benson (1990), "Water content-density criteria for compacted soil liners", *J. Geotech. Engrg.* ASCE, 116 (12), 1811-130, and soil placement based on the appropriate moisture and dry unit weight values related to the maximum specified hydraulic conductivity. It will be used in conjunction with quality assurance testing during soil liner/final cover construction to achieve the required permeability.

3.2 Test Pad

10 CSR 80-4.010 (10) (C) of the Missouri Solid Waste Regulations requires that a test pad be constructed prior to compacted soil liner construction. Test pad(s) will be constructed following the bottom liner construction techniques. The test pad(s) will verify that the construction and CQA procedures to be used for actual compacted soil liner will provide an adequate liner system. Tests will be completed in a manner that allows evaluation of soil types, construction methods, and/or soil amendments required to achieve the installed liner characteristics approved in the construction permit. Results from test pad construction and changes to proposed construction methods will be submitted to the MDNR-SWMP and IPRE as a Test Pad Construction Report.

MDNR-SWMP and the IPRE will be notified at least 7 days prior to commencing test pad construction activities. Construction procedures for the test pad shall be in accordance with Section 3.4 of this CQA Plan. The test pad will be constructed using the same methods and with the same equipment that will be used to construct the compacted soil liner. The test pad will be large enough to allow construction equipment the room to successfully complete required passes and compaction. Since the test pad will evaluate the construction means and methods to be used during compacted soil liner construction, the procedures used to construct the test pad must be thoroughly documented. The CQA Engineer or their designee will observe all activities completed during test pad construction. Documentation information will include at least the following:

- Source of liner material and associated prequalification testing data
- Make, model, weight, and any other unique information (e.g., compactor pad foot height) for the equipment used during test pad construction (e.g., CAT 815F compactor)
- Methods of soil material placement and compaction including soil hauling and unloading operations, soil spreading, and number of compactor passes
- Description of scarification methods, if utilized
- Moisture conditioning methods used, including equipment, frequency of procedures, and apparent results
- Survey control methods for documenting compacted lift thickness and final pad thickness
- Methods used to prevent damage to completed lifts
- Methods used to prevent placement of deleterious materials
- Methods used to prevent placement of frozen material or the placement of material on frozen ground, if appropriate
- Frequency and methods used for calibrating testing equipment
- Testing results including test pad location, test locations, moisture and density results, and their relationship to hydraulic conductivity based on prequalification testing

At the completion of test pad construction, verification testing will be completed in accordance with the following testing schedule:

- Two laboratory hydraulic conductivity tests will be performed utilizing the Flexible Wall Permeameter Test (ASTM D 5084) on undisturbed samples obtained from the completed test pad. Soil samples will be collected by pushing Shelby tubes at random locations on the test pad
- Bulk samples will be taken to the laboratory for Liquid Limit (LL) and Plasticity Index (PI) and Standard Proctor Compaction tests
- One in-situ hydraulic conductivity test will be performed on the completed test pad using a Sealed Double Ring Infiltrometer Test (ASTM D 5093) or a series of 5 Boutwell Permeameter Tests (ASTM D 6391-99)

- Two test pits will be excavated in the test pad to observe interlift bonding of the test pad. The test pits will be located at random locations in an effort to view representative test pad soil profiles
- Laboratory consolidated-undrained triaxial compression tests will be performed on Shelby tube samples obtained from the test pad to verify the shear strength properties.

Photographs of the verification testing procedures and locations will be taken for visual documentation of the testing.

Should the tests described above indicate that the construction procedures resulted in an insufficient liner system, a new test pad will be constructed using modified procedures and/or materials as agreed to by the CQA Engineer and contractor, and approved by the MDNR-SWMP and the IPRE.

Should the tests described above indicate that the construction procedures resulted in an acceptable liner system; a summary report shall be prepared and submitted to the MDNR-SWMP and IPRE that describes the construction and testing procedures that were used. The report will include the documentation information described above as well as related test results and photographs. The CQA Engineer will certify the report prior to submittal to the MDNR-SWMP. The report will be approved by the MDNR-SWMP and IPRE prior to the construction of additional portions of the liner system.

3.3 Compacted Soil Liner Subgrade Preparation

The CQA Engineer and/or designated CQA Inspector will ensure that the compacted soil liner subgrade preparation/construction is completed in accordance with the approved plans and specifications. In addition, the CQA Inspector will identify unexpected conditions encountered during subgrade construction/preparation and record changes to the plans and construction procedures on the as-built drawings. At a minimum, the designated personnel will complete the following:

- Observe and record the placement of subgrade fill on a regular basis
- Verify that soft, organic or other unacceptable materials are removed prior to fill placement
- Verify that subgrade construction is in accordance with the applicable sampling, testing, and survey program(s)
- Prior to soil liner placement, inspect the subgrade for soft spots, pumping, or deleterious materials and verify recompaction or removal and replacement of identified areas
- Verify that all debris, including plant materials such as trees, stumps, and roots, and rocks of size large enough to interfere with proper placement/compaction are removed prior to subgrade construction and preparation
- Prevent the placement of frozen material or the placement of material on frozen ground
- Record the types of compaction equipment utilized for subgrade construction
- Periodically photograph the subgrade construction and finished subgrade surface

- Verify that prior to compacted soil liner placement, the upper 6 inches of subgrade material is disked, recompacted, and graded to provide a workable surface
- Ensure the finished subgrade is surveyed on a maximum interval of 100 feet center to center, and a maximum interval of 100 feet along each line where a break in slope occurs. Sumps or other similar features shall also be identified. The survey shall be completed by a Missouri registered surveyor to confirm and document subgrade elevations and to establish break-line and other design features of the landfill. The purpose is to ensure that the soil liner, when constructed, is continuous over the bottom footprint of the permitted waste disposal boundary and meets the minimum thickness specified for the project.

3.4 Compacted Soil Liner Construction Procedures

Prior to construction of the soil liner, the subgrade will be graded to the elevations specified on the project plans +/- 0.1 foot. The soil liner material will be placed in accordance with the criteria and procedures developed during preconstruction soil testing, test pad construction, and/or in accordance with project specific guidelines. Construction progress shall be monitored with the initial subgrade survey in combination intermediate surveying during construction, as necessary.

The liner will be placed in accordance with the project specifications, geotechnical report, and approved test pad procedures. Generally, soils will be placed in 6" to 8" thick lifts and compacted to the approved moisture and density tolerances. The soils will be compacted with equipment that kneads, compacts, and interbonds the soil from the bottom of the lift up. Material conditioning procedures and compaction equipment rolling patterns will be consistent with those used in the approved test pad construction, but may be evaluated and modified as necessary to yield a workable, consistent, and suitable liner material placement.

3.5 Quality Assurance Monitoring and Testing

A CQA Inspector, under the supervision of the CQA Engineer, will be present on site to monitor the placement and compaction of the soil liner. A qualified CQA Inspector or CQA Engineer will provide visual classification of borrow soils during landfill construction.

Field moisture and density tests will be performed at a minimum frequency of one per 10,000 square feet per lift and will be completed with a nuclear density gauge in substantial compliance with ASTM D 2922 and 3017. Moisture and density test locations will be selected randomly; however, tests will not be grouped together horizontally or vertically from one lift to another. Results of the moisture and density tests will be recorded on a Nuclear Density Gauge Test Record, similar to the one provided in Appendix A. The nuclear density gauge shall be calibrated in accordance with manufacturer's instructions and ASTM 3017-88 requirements. Nuclear density gauges will be standardized in accordance with manufacturer's recommendations daily or more frequently. Unstable or erratic gauges will not be used for quality assurance testing.

Should the results of field moisture and density tests fall outside the placement range or "acceptable zone", as determined in the test pad construction report, the lift in question will be reworked and retested. The area to be reworked will be bounded by the nearest passing moisture/density test locations as delineated by the CQA Inspectors. Drying, wetting, additional compaction, or a combination thereof will be used to bring the nonconforming area to an acceptable level.

The final liner surface will be smooth and free of large angular particles or foreign objects that may damage the geomembrane liner or prevent contact between the geomembrane and soil liner. The final liner surface will also meet other conditions required by the geomembrane manufacturer or installer for installation of the geomembrane component of the composite liner system.

During soil liner construction, verification testing will be completed to ensure that the borrow material being used for construction has not changed in a manner that greatly affects its engineering properties. The following table indicates the prescribed tests and their approximate frequencies for completion during construction.

Test Method	**Frequency**
Atterberg Limits (ASTM D 4318)	1 test per 5,000 cubic yards of material placed and for each change of material type
Particle Size (ASTM D 422)	1 test per 5,000 cubic yards of material placed and for each change of material type
Moisture-Density Relationship (ASTM D 698)	1 test per 10,000 cubic yards of material placed and for each change of material type
Hydraulic Conductivity (ASTM D 5084)	1 test per 5,000 cubic yards of material placed and for each change of material type.

If the borrow material does not meet the criteria for the testing described in the table above, additional laboratory soil tests will be completed to define an acceptable placement range for the non-conforming material. Alternatively, a new test pad can be constructed as described in Section 3.2 to verify that the soils are liner grade materials and the proper placement range. If liner quality soils are stockpiled on site prior to the beginning of placement, a reduced frequency of verification testing will be requested.

To maintain the integrity of the compacted soil component of the liner or final cover system, thin walled steel tube samples (e.g., Shelby tube) for laboratory hydraulic conductivity testing through the completed liner will be avoided whenever possible. Instead, documentation of the required hydraulic conductivity will be provided by the initial materials conformance testing, including development of an acceptable placement range, and quality control/quality assurance monitoring, observation, and testing during construction, most notably moisture and density testing.

Prior to geomembrane installation over the compacted bottom soil liner or final cover, the moisture content of the compacted soil will be maintained to control desiccation cracking. If desiccation cracks are observed in excess of 1 inch deep, the surface will be lightly scarified, moisture conditioned, recompacted, regraded, and rolled to provide a smooth surface for geomembrane installation.

3.6 Thickness Verification

An independent surveyor licensed to practice in the State of Missouri will verify the thickness of the compacted soil portion of the liner after completion. The independent surveyor will operate independently of the landfill operator, construction contractor, Owner, and permit holder. The surveyor may be employed by the CQA Engineer. Prior to construction of the compacted soil liner, a survey will be completed on a minimum of 100-foot grid system. Additional survey shots will be taken at 100-foot intervals along each line where a break in slope occurs to document the top of subgrade elevations. At the completion of compacted soil liner construction, a survey will be completed at the same approximate locations to verify the required soil component thickness was achieved. Acceptable tolerances for surveying shall be ±0.1 foot for elevations and ±1.0 foot for horizontal coordinates. All results must indicate a liner thickness equal to or greater than that required by the plans and specifications.

4.0 FLEXIBLE MEMBRANE LINER

The geomembrane portion of the composite liner and final cover systems will be constructed and tested in accordance with the approved permit documents, this CQA Plan, and the manufacturer's recommendations and specifications. This section covers material conformance testing, construction methods, and testing requirements.

4.1 Materials Conformance Testing

Prior to construction of the geomembrane portion of the bottom liner or final cover system, the CQA Engineer will obtain one geomembrane sample per 100,000 square feet of geomembrane to be installed. The following tests will be performed by the CQA Engineer to verify that the geomembrane conforms to the project specifications and the manufacturer's MQC/MQA documentation:

- Thickness (ASTM D 5199)
- Density (ASTM D 1505)
- Tensile Properties (e.g., strength, elongation) (ASTM D 638, Type IV)
- Tear Resistance (ASTM D 1004)
- Puncture Resistance (ASTM D 4833)
- Notched Constant Tensile Load (ASTM D 5397)
- Carbon Black Dispersion (ASTM D 5596)
- Carbon Black Content (ASTM D 1603).

For each of the properties listed above, the material will meet current industry standards for the geomembrane material type (e.g., HDPE, smooth) and thickness. Deviations from this testing protocol due to changes in test methods or industry standards may be approved by the CQA Engineer with prior approval by the MDNR-SWMP and IPRE.

For the bottom liner system in the Labadie UWL (Cells I through 4), 60-mil textured (both sides) HDPE will be used for the bottom inside slopes of the perimeter and interior berms. Smooth 60-mil HDPE will be used in the center of each cell from the interior toe of the perimeter berm of each disposal area.

For the final cover system construction, 40-mil smooth HDPE will be used on the top or crown of the landfill. Textured (both sides) 40-mil HDPE will be used on the side slopes.

The CQA Engineer or their representative will log all rolls of geomembrane material that arrive on site and review the manufacturer's MQC certification documentation. Each roll will be documented on a Material Inventory Log similar to that found in Appendix A. Storage of geomembrane material will be in a manner that reasonably protects the material from puncture, denting, deformation of rolls, and other damaging situations, in accordance with the manufacturer's recommendations, prior to its deployment. UV sensitive geosynthetics should be stored in undamaged opaque coverings and protected from standing water during storage.

4.2 Construction Procedures

At the conclusion of soil liner or cover construction, the geomembrane liner will be installed by a third-party geosynthetics contractor in accordance with acceptable industry standards and the manufacturer's recommendations, standards, guidelines, and specifications. The geomembrane supplier or installer will develop a panel layout diagram in accordance with industry standards. The panel layout diagram will be designed so that the majority of the geomembrane seams run perpendicular not parallel with the side slopes, so that no horizontal (parallel with slopes) geomembrane seams are within five (5) feet of grade breaks, such as the toe and top of slopes. The manufacturer will provide the panel diagram to the CQA Engineer.

The subgrade will be compacted to provide a firm, unyielding foundation sufficient for all deployment vehicles to move about the construction area without rutting and pumping. The geomembrane installer will complete a Subgrade Acceptance Form for inclusion in the construction documentation report.

Anchor trenches will be excavated to the lines and widths shown on the construction documents developed in accordance with the approved permit documents. Sharp bends and edges in the anchor trench will be minimized to avoid potential stresses to the geomembrane.

Geomembrane panels will be installed and immediately assigned a number according to a panel numbering system. Panels will be physically identified in the field with a grease pencil or other durable material for reference during seaming and testing operations and project records. Destructive and nondestructive test locations as well as repair locations will be appropriately identified for documentation purposes. Panels will be deployed with a rubber-tired, front loader and special roller bar to assist with unrolling the geomembrane panels at specified locations. Care will be taken to minimize traffic and prevent equipment from damaging the geomembrane or supporting subgrade surface. Sandbags or other approved loading shall be used as necessary to prevent uplift of panels by the wind. Panels will not be deployed in areas of standing water or on frozen subgrade. Any damage to panels during deployment will be noted and repaired by patching and/or spot welding as approved by the CQA Engineer. No more panels will be deployed than can be seamed during that day, unless securely ballasted to prevent movement prior to seaming. A Panel Placement Form will be completed by the CQA Inspector for all panels deployed (see Appendix A).

Steps will be taken to prevent water from getting under the geomembrane during and after deployment. "Shingling" of the panels or completion of seaming for those panels deployed prior to the end of the workday will be used as appropriate to minimize the potential for such occurrence. Additionally, temporary or permanent berms will be constructed where necessary to redirect surface water away from the construction area.

4.3 Quality Assurance Monitoring and Testing

The CQA Inspector will visually inspect the panels for direct contact between the clay liner and the panel surface. It is imperative that the geomembrane maintain intimate contact with the compacted soil liner surface. The CQA Inspector will monitor for panel and seam defects or damage and mark any location of concern for follow-up repair. The geomembrane panels will be seamed together using double wedge fusion welding equipment supported by extrusion welding equipment where conditions make fusion welding impractical. Photo documentation of geomembrane installation and repair procedures will be included in the final CQA Report. Quality assurance monitoring and testing will follow the manufacturer's recommendations or industry standards for installation and seaming.

4.3.1 Trial Welds

Prior to seaming the geomembrane panels, trial welds will be made by the welding equipment to be used during that day's work and tested. The trial welds will be made by the same machine/operator combination and under the same conditions as will be encountered during actual seaming operations for that day. Trial welds will be made at the beginning of each workday, at approximately 4 to 5 hour intervals thereafter, and whenever a new welding machine/operator combination begins work.

For fusion trial welds, testing will include "shear" tests on five samples and top and bottom "peel" tests on five samples each. For extrusion trial welds, five samples will be tested for shear strength and five samples shall be tested for bottom peel strength.

Four out of each five samples tested must meet the following criteria for the test weld to be considered acceptable:

Shear Test

- Exhibit elongation of the parent material prior to parent material failure
- Meet or exceed the required bonded seam strength for either fusion or extrusion welds, whichever is applicable

Peel Test

- Exhibit film tear bond with less than 10 percent separation of the seam
- Meet or exceed the required bonded seam strength for both fusion and extrusion welds

Should trial welds fail, adjustments will be made to the welder, as necessary, and new specimens will be welded and tested. If repeat tests also fail, the subject welding machine will not be used for seaming until deficiencies are corrected and passing trial welds are achieved. All trial welds will be documented by the CQA Inspector on a Trial Weld Log. An example of a Trial Weld Log is included in Appendix A.

4.3.2 Panel Seaming

The CQA Inspector will observe typical panel welding to assure the welding area is kept generally clean and free of moisture, dirt, and debris. "Fish mouths" and wrinkles at seam overlaps that cannot be welded will be cut out and patched with an extrusion welded patch that is approximately round or rectangular with rounded corners. A seam number will be assigned to each seam that reflects the two panels being joined. The CQA Inspector will measure the seams and record the measurements on a Panel Seaming Form similar to the one found in Appendix A. Alternatively, seam layout and dimensions may be determined by locating the corners with Global Positioning System (GPS) equipment capable of identifying locations to an accuracy of ± 1-foot. Additional information to be documented includes date and time of seaming, the welder's initials, machine number, machine speed, and set temperature.

4.3.3 Non-Destructive Testing

All seams that are welded during installation of the geomembrane liner will be non-destructively tested by the Geomembrane Contractor and overseen by the CQA Inspector to check the integrity of the seams. Non-destructive tests will be conducted using the air pressure test or the vacuum test.

Air Pressure Test

Air pressure testing will be completed on seams that have been welded with a fusion welder (wedge welder) using an air pump capable of sustaining 25 to 30 pounds per square inch (psi) of pressure. The Geomembrane Contractor will follow the following procedures:

- Seal one end of the seam channel to be tested
- Insert sharp, hollow needle or other approved pressure feed device with a pressure gauge into the sealed end of the seam
- Energize the air pump to verify the unobstructed passage of air through the seam channel. Should the verification fail, locate the obstruction and test the seam on both sides of the obstruction
- Seal the other end of the seam channel
- Energize the air pump to a pressure of between 25 and 30 psi, close valve, and allow 2 minutes for the injected air to reach equilibrium in the channel prior to recording the initial pressure reading
- Sustain pressure for 5 minutes and note the final pressure reading
- If the air pressure decreases by more than 4 psi during the initial 5-minute test period, locate the faulty area of the seam, make repairs, and retest
- If the air pressure test passes, the air channel should be cut at the opposite end of the seam from the gauge to deflate the seam channel. Keep a record of appropriate test information on a Non-Destructive Test Log similar to the one included in Appendix A.

Vacuum Test

Vacuum testing will be completed on seams that have been welded with an extrusion welder or when the geometry of a seam makes it impossible or impractical to test using the air pressure test. The Geomembrane Contractor shall follow the following procedures:

- If testing a fusion weld trim excess overlap from the seam edges
- Wet the area to be tested with a soapy liquid solution
- Place the vacuum box assembly over the wetted area and apply sufficient pressure to "seat" the box on the test area
- Create a vacuum of 3 to 5 psi to the box, using the pressure gauge on the box to observe pressure readings
- Once a tight seal is verified, observe the area for approximately 15 seconds looking for recurring soap bubbles on the seam
- If leaks (bubbles) are observed, mark the location of each leak for repair
- If no leaks are detected, release the pressure on the vacuum box and move to the next adjacent test location maintaining a minimum 3-inch overlap if applicable
- Maintain a record of appropriate test information on a Non-Destructive Test Log similar to the one included in Appendix A

If specific locations exist where non-destructive testing is not possible or practical, seams will be tested by an alternate method accepted by the CQA Engineer.

4.3.4 Destructive Testing

Destructive testing is conducted to evaluate the strength of welded seams. Destructive testing should be minimized to preserve the integrity of the liner system. Destructive test samples will be taken at an average of once per 500 feet of seam length. The Geomembrane Contractor will follow the following procedures:

- The CQA Inspector will identify seam locations to be sampled and tested. All destructive sample locations will be marked on the geomembrane liner, indicating appropriate information including test number, seams tested and date.
- The Geomembrane Contractor will cut three samples at the selected location: one each for the Geomembrane Contractor, the CQA Inspector, and the Owner's archive. Each sample will be a minimum of 12 inches wide by 18 inches long (or according to minimum laboratory requirements) with the seam centered lengthwise. For fusion welded seams the geomembrane contractor will field test fifteen (15) 1-inch wide test specimens, ten (10) for peel strength and five (5) for shear strength per UWL cell. Five (5) of the peel specimens must come from the top weld, and five (5) must come from the bottom weld. For extrusion welded seams the geomembrane contractor will field test ten (10) 1-inch wide test specimens, five (5) for peel strength and five (5) for shear strength. Welded seam tested strengths must equal or exceed the requirements of the Geosynthetic Institute (GSI) Test Method GM19 (10/3/2011) for 60-mil HDPE component of the composite liner and the 40 mil HDPE component of the final cover system.

  <u>Shear Test</u>

  - All five test specimens must meet or exceed the required bonded seam strength for either hot wedge seams or extrusion fillet seams, whichever is appropriate
  - Shear percent elongation should exceed 50% at break

Peel Test

- All ten (or five out of five) test specimens must meet or exceed the required bonded seam strength for either hot wedge seams or extrusion fillet seams, whichever is appropriate
- Peel separation (incursion depth) should not exceed 25%

- The Owner or CQA Inspector will coordinate with an independent third-party laboratory to perform the same test procedures on the samples retained by the CQA Inspector.
- Failing tests will be addressed by the procedures outlined below. Such criteria will apply to both the field tests and the third-party laboratory tests. Should environmental conditions during testing detrimentally affect field test results, the laboratory tests will govern
- The CQA Inspector will document pertinent destructive test information on a Destructive Test Log similar to the one in Appendix A

Procedures for Destructive Test Failure:

- Two additional destructive samples will be taken one on each side of the failed test location at least 10 feet from its location
- The same testing procedures as described above will be followed to determine whether the additional samples pass or fail
- If the additional tests pass, the portion of the seam between two passing test locations will either be reconstructed or cap stripped
- If either of the additional tests fails, the process will be repeated until a seam length is bounded by two passing tests. At that point, the seam between the two passing test locations will either be reconstructed or cap stripped
- All repaired or replaced seams will be non-destructively tested to verify their integrity. Repairs will be noted on a Repair Report Form similar to the one found in Appendix A

4.3.5 Defects and Repairs

The CQA Inspector and Geomembrane Contractor will monitor the geomembrane liner and seams for defects, holes, blisters, and signs of damage during installation. Portions of the geomembrane or seams that show flaws, destructive test locations, and portions of seams that fail destructive or non-destructive tests will be repaired. Repairs will be completed using patching, extrusion welding, cap stripping, or other means approved by the CQA Inspector. Repairs will be non-destructively tested using methods described in Section 4.3.3 and documented on a Repair Report Form similar to the one in Appendix A.

5.0 GEOTEXTILE

Geotextile fabric required for the project will be installed by a qualified third-party contractor.

Geotextile fabric required for the project will be installed and tested in accordance with the approved permit documents and the manufacturer's guidelines, standards and specifications. Care will be used during construction to ensure that geotextile materials are not damaged. Geotextile filter fabric panels that are placed will be overlapped and bonded together to maintain placement in accordance with the manufacturers or suppliers standard for bonding of adjacent panels of geotextile.

The CQA Engineer or his representative will log all rolls of geotextile material that arrives on site and review the manufacturer's QC certification documentation. Each roll will be documented on a Material Inventory Log similar to that found in Appendix A. Storage of geotextile material will be in a manner that reasonably protects the material from puncture, denting, deformation of rolls, and other damaging situations prior to its deployment. UV sensitive geosynthetics will be stored in undamaged opaque coverings and protected from standing water during storage. Photo documentation of geotextile storage, installation, and repair procedures will be included in the final CQA Report.

5.1 Materials Conformance Testing

Prior to installation the contractor will supply the CQA Engineer with MQC and MQA information and testing documentation on the supplied materials conformance with the design specifications for geotextiles or the CQA Engineer shall obtain one geotextile sample per 100,000 square feet of material to be installed for MQA testing. The following MQC and MQA tests will be performed to verify that the geotextile conforms to the project specifications:

- Mass per unit area (ASTM D 5261/ASTM D 3776); Thickness (ASTM D 5199)
- Grab Tensile (ASTM D 4632)
- Permittivity (ASTM D 4491) (if material is to be used as a filter layer)
- Apparent Opening Size (ASTM D 4751) (if material is to be used as a filter layer)
- Shear strength properties of interface with other geosynthetics, CCPs and soils

For each of the properties listed above, the material shall meet current industry standards for the geotextile material type (e.g., woven, non-woven) and unit weight. Deviations from this testing protocol due to changes in test methods or industry standards shall be allowed with the approval of the CQA Engineer.

5.2 Construction Procedures

In general, the geotextile will be installed according to the manufacturer's recommendations and the project specifications. Proper documentation of the installation will be provided. At a minimum, the following guidelines shall be followed:

- Deployed geotextile will be weighted at its edges during times of excessive wind
- Care will be taken when cutting geotextile in place to not cut or damage other associated geosynthetic materials
- Care will be taken to avoid trapping rocks or other sharp objects between geotextile and geomembrane layers
- Tears or rips in geotextile materials will be patched with like geotextile material
- Geotextiles may be overlapped, stapled, sewn or fusion welded in accordance with the manufacturer's instructions and project specifications

6.0 LEACHATE COLLECTION SYSTEM

The two primary components of the leachate collection system include the aggregate drainage layer or geocomposite drainage net and associated leachate collection pipes. This section covers material conformance testing and general CQA requirements to ensure the leachate collection system is constructed in accordance with the construction and permit documents. Material conformance testing and general CQA observations required for the geocomposite drainage net are discussed in Section 7.0 of this report.

6.1 Aggregate Drainage Layer

Aggregate to be used in the drainage layer will be non-carbonate, well-graded aggregate with a minimum permeability of 0.25 cm/sec and particle diameter of 0.425 mm to13.0 mm. Aggregate placement/spreading techniques that minimize the potential for damage to the underlying geomembrane liner will be used. Specifically, aggregate will be placed by advancing the aggregate in fingers across the geotextile cushion layer overlying the geomembrane. Low ground pressure equipment such as a lightweight, wide-tracked dozer will be used for spreading the aggregate. During aggregate drainage layer installation, periodic visits to the site will be made by the CQA Inspector to observe and document installation procedures.

Prior to placement of the aggregate, representative samples of the stockpiled materials proposed for use will be collected and tested. One sample shall be taken from for every 5,000 CY of aggregate. This testing shall verify that the aggregates to be used for construction meet project specifications as determined by this pre-qualification testing. The following tests may be performed as prescribed by the CQA Engineer:

Test Method	Test Description
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM D 5084	Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

An independent surveyor licensed to practice in the state of Missouri will verify the thickness of the aggregate drainage layer. The surveyor will be independent of the landfill contract operator, construction contractor, Owner, or permit holder. The surveyor may be employed by the CQA Engineer. Following completion of the aggregate drainage layer, a final survey shall be completed on a minimum 100-foot grid system and at 100 foot intervals at along the perimeter to document the top of aggregate elevations. These survey points will be in the same general locations as the subgrade and top-of-clay-liner surveys to allow calculation of drainage layer thickness. Acceptable tolerances for surveying shall be ±0.1 foot for elevations and ±1.0 foot for horizontal coordinates. All results must indicate an aggregate drainage layer thickness equal to or greater than that required by the plans and specifications.

Once the non-carbonate gravel is in place, a geotextile filter will be laid over the top of the gravel and then covered with a single 12 inch layer of aggregate protective cover, to protect the liner, drainage layer, and pipes from damage during construction and initial filling operations.

6.2 Leachate Collection Piping

Leachate collection piping will be installed in accordance with the approved permit documents. The CQA Inspector will observe the placement of the piping to verify that the appropriate slope on the pipe has been achieved. Additionally, visual observation of piping connections will be made to document proper connection of pipe segments and orientation of perforated pipe, where applicable. The placement location of the leachate collection system piping will be documented by a survey by the CQA Engineer or Independent Surveyor at minimum intervals of 100 feet laterally along the pipe length and at changes in horizontal or vertical direction. Acceptable tolerances for surveying shall be ±0.1 foot for elevations and ±1.0 foot for horizontal coordinates. The survey locations will be used to verify the pipe has the appropriate slope.

7.0 GEOCOMPOSITE

Geocomposite material may be installed as an alternate leachate drainage layer instead of the aggregate drainage layer over the geomembrane liner. Geocomposite material will be installed by a qualified contractor. The geocomposite manufacturer will develop a panel layout diagram in accordance with industry standards for the leachate drainage layer as shown on the plan sheets. The manufacturer will provide the panel layout diagram of the geocomposite drainage layer to the CQA Engineer.

Geocomposite material will be tested and installed in accordance with the approved permit documents and manufacturer's installation instructions. Care must be used during construction to ensure that geocomposite materials and geomembrane layer are not damaged.

The CQA Engineer or his representative will log all rolls of geocomposite material that arrive on site and review the manufacturer's QC certification documentation. Each roll will be documented on a Material Inventory Log similar to that found in Appendix A. Storage of geocomposite material will be in a manner that reasonably protects the material from puncture, denting, deformation of rolls, and other damaging situations prior to its deployment. UV sensitive geosynthetics will be stored in undamaged opaque coverings and protected from standing water during storage. Photo documentation of the geocomposite drainage layer storage, installation, and repair procedures will be included in the final CQA Report.

7.1 Materials Conformance Testing

Prior to installation of the geocomposite, the CQA Engineer shall obtain one geocomposite sample per 100,000 square feet of material to be installed for materials conformance testing or obtain equivalent MQA and MQC materials conformance testing from the supplier or installer. The following materials conformance tests and results shall verify that the geocomposite material conforms to the project specifications:

- Ply Adhesion (ASTM D 413)
- Thickness (ASTM D 5199)
- Transmissivity (every fifth sample) (ASTM D 4716)

For each of the properties listed above, the material shall meet current industry standards for the geocomposite material type. Deviations from this testing protocol due to changes in test methods or industry standards will be approved by the CQA Engineer.

7.2 Construction Procedures

In general, the geocomposite will be installed in compliance with the manufacturer's requirements and the project specifications. Proper documentation of the installation will be required. At a minimum, the following guidelines will be followed:

- Deployed geocomposite will be weighted at its edges during times of excessive wind

- Geocomposite to be deployed on slopes will first be anchored and rolled down the slope in a controlled manner
- Geocomposite will not be deployed horizontally across slopes unless approved by the CQA Engineer
- Care will be taken when cutting geocomposite in place to not cut or damage other associated geosynthetic materials
- Care will be taken to avoid trapping rocks or other sharp objects between geocomposite and geomembrane layers
- Tears or rips in the geotextile portion of the geocomposite will be patched with like geocomposite material. Patches will be a minimum of 2 feet beyond the edges of the hole or tear

Adjacent geocomposite rolls will be joined according to project specifications and manufacturer's instructions. At a minimum the following procedures will be followed:

- Tears or rips in geotextile portion of the geocomposite will be patched with like geocomposite material
- Adjacent edges of the geonet along the length of the geocomposite roll will be placed with the edges of each geonet overlapping each other by 4 inches minimum
- The adjacent edges will be joined by tying the geonet structure with plastic (not metal) cable ties spaced every 5 feet along the roll length
- Adjoining geocomposite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geocomposite a minimum of 12 inches across the roll width
- Where the geocomposite is anchored in an anchor trench, the geonet portion should be tied every 6 inches along the geocomposite edges

8.0 PROTECTIVE COVER

This section covers material conformance testing and general CQA requirements to ensure the aggregate protective cover layer is constructed in accordance with the construction and permit documents.

8.1 Aggregate Protective Cover Layer

The aggregate protective cover layer shall consist of well-graded non-carbonate aggregate with a particle size between 9.5 mm and 0.075 mm, with 0 to 10 percent passing the No. 100 U.S. Sieve, a d_{50} particle size of approximately 0.5 to 0.9 mm, and a d_{15} particle size of approximately 0.2 to 0.4 mm. Aggregate protective cover placement/spreading techniques that minimize the potential for damage to the underlying geotextile layer and aggregate drainage layer will be used. Specifically, aggregate protective cover will be placed by advancing the aggregate in fingers across the underlying geotextile filter layer. Low ground pressure equipment such as a lightweight, wide-tracked dozer will be used for spreading the aggregate. During aggregate protective cover layer installation, periodic visits to the site will be made by the CQA Inspector to observe and document installation procedures.

Prior to placement of the protective cover layer aggregate, representative samples of the stockpiled materials proposed for use will be collected and tested. One sample will be taken from for every 5,000 CY of aggregate. Testing will verify that the aggregates meet project specifications as determined by this pre-qualification testing. The following tests may be performed as prescribed by the CQA Engineer:

Test Method	Test Description
ASTM C 136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM D 5084	Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

An independent surveyor licensed to practice in the state of Missouri will verify the thickness of the aggregate protective cover layer. The surveyor will be independent of the landfill contract operator, construction contractor, Owner, or permit holder. The surveyor may be employed by the CQA Engineer. Following completion of the aggregate protective cover layer, a final survey will be completed on a minimum 100-foot grid system and at 100 foot intervals along the perimeter to document the top of aggregate protective cover layer elevations. These survey points will be in the same general locations as the subgrade and top-of-clay-liner surveys to allow calculation of protective cover layer thickness. Acceptable tolerances for surveying shall be ±0.1 foot for elevations and ±1.0 foot for horizontal coordinates. . All results should show an aggregate protective layer thickness equal to or greater than that required by the plans and specifications.

9.0 FINAL COVER CONSTRUCTION

The final cover system will consist of two (2) feet of soil cover overlying a geotextile layer overlying a 40 mil thick HDPE geomembrane layer on the final top and side slopes of the UWL. The two feet of nominally compacted soil of the final cover system will be constructed and tested in accordance with the approved permit documents and this CQA Plan. This section covers material conformance testing, general construction procedures, and testing requirements.

9.1 Materials Conformance Testing

Prior to construction of the nominally compacted soil component of the side slope final cover system, representative samples of the soil materials proposed for use will be collected and tested to verify that the soils meet the project specifications determined by the pre-qualification testing. The soils utilized for the final cover system shall consist of soils classified as CH, CL, ML, SC, and MH soils types according to the Unified Soil Classification System. The CQA Engineer will verify that the soil selected for use in the final cover and the associated placement ranges are capable of meeting the minimum shear strength properties, both internal and interface with geosynthetics and soils, utilized in the geotechnical design (reference Appendix J of the Construction Permit Application). Soil used for the nominally compacted soil layer on the side slopes and top should be adequate to establish and support vegetation.

9.2 Nominally Compacted Soil Construction Procedures

The nominally compacted soil layer of the final cover system will be placed over the geotextile cushion layer above the 40-mil smooth and textured HDPE geomembranes on the final top portion and the side slopes of the UWL. The soil used for the nominally compacted layer should be adequate to establish and support vegetation.

9.3 Quality Assurance

The quality assurance monitoring and testing program for the nominally compacted layer of the final cover system utilizes the same program as that of the compacted clay liner (see Section 3.5). Thickness verification will be completed for the nominally compacted soil portions of the final cover as described in Section 3.6.

10.0 MISCELLANEOUS HDPE PIPING

This section applies to miscellaneous HDPE piping, including stormwater and leachate transport lines and pump intake lines.

10.1 Butt, Heat Fusion Welds

All HDPE pipe and fittings shall be joined using butt, heat fusion welds. All joints will be made in compliance with the manufacturer's recommended practice for heater surface temperature, heating time, applied pressure and cooling time, subject to the CQA Engineer's approval. All joints will be made by trained technicians qualified by the manufacturer and using equipment and controlled procedures approved by the manufacturer.

Pipe joints will be stronger than the pipe itself under both tension and hydrostatic loading conditions. The joints will be leak-tight, homogeneous and uniform throughout. The contractor will submit written documentation certifying compliance with the manufacturer's standard specifications and CQA plan for the butt, heat fusion technique.

11.0 REPORTING

Proper documentation of the CQA process is an important aspect of construction documentation. In addition to the completion of the forms and logs mentioned previously, the following reports will be completed.

11.1 Daily Reports

The CQA Inspector will provide daily written reports to the CQA Engineer during the days when inspections are made. These reports will include information about the work accomplished each day; tests and observations that were made; and descriptions of the adequacy of the work performed. The reports will include the following as appropriate:

- Date, project name, location, cell involved in construction, equipment utilized, and personnel involved in major activities
- Description of weather conditions, including temperature, cloud cover, and precipitation
- Description of the type of construction, inspection, and testing activity for the day
- Location of construction activity for the day
- Location of tests completed
- Discussion of construction methods (i.e., equipment make/model, number of compactor passes, etc.) as they relate to the previous cell or test pad construction
- Results of construction activity (i.e., first lift completed, sump completed, etc.)
- Description of construction materials used including reference to certifications, test results, etc.
- Location of observation activity or location from which the sample(s) were obtained; Standard methods and frequency used for tests
- Results of testing performed (passing or failing); Equipment calibration results
- Construction or testing problems and required actions
- Photographic documentation of construction progress including time, date, location, and name of photographer
- Signature of the CQA Inspector

Appendix A includes example CQA forms, which provide an acceptable format the required information that may be used by the CQA Engineer, including:

- Daily Activities Field Report
- Nuclear Density Gauge Test Record
- Material Inventory Log
- Panel Placement Log
- Trial Weld Log
- Panel Seaming Log
- Non-Destructive Test Log
- Destructive Test Log

- Repair Log

These forms may be modified based on the final project features requiring CQA/CQC oversight.

11.2 Design Change Documentation

On occasion it may be necessary to modify the design during construction activities. The Owner, MDNR-SWMP, and IPRE must approve changes to the design or deviation from the permit documents.

11.3 Deviation from CQA Plan

During the course of construction, deviations from the CQA Plan may be necessary due to various construction issues, permit modifications, regulatory changes, new technology, or changes to accepted standards. Deviations from this CQA Plan will be documented and approved by the Owner and the CQA Engineer.

11.4 Final Documentation Report

At the completion of each cell's liner and leachate collection system construction, or closure of specified area of the landfill, the CQA Engineer will prepare a final CQA Report for submittal with the initial cell's Operating Permit Application (or the Request for Authorization to Operate for subsequent cells) to the MDNR-SWMP and Franklin County. This report will bear the CQA Engineer's Missouri Professional Engineer's seal and date. The CQA Report will contain the following information:

- A certification (signed, sealed, and dated) by the CQA Engineer stating that the construction of the cell has been completed in substantial compliance with the engineering design, CQA Plan and the facility Construction Permit
- As-built drawings (signed, sealed, and dated) by the CQA Engineer or the licensed survey certification (signed, sealed, and dated) by a Missouri registered land surveyor or a Missouri Professional Engineer
- CQA field data and laboratory test results
- CQA inspection records and photographs

The final CQA Report and Operating Permit Application will be submitted to the MDNR-SWMP prior to the cell receiving its first load of waste.

APPENDICES

APPENDIX A

Example CQA Forms

DAILY FIELD ACTIVITIES REPORT

Client Name: ____________________ Date: __________

Start Time: __________

Stop Time: __________

Project Location: ____________________

Task: ____________________

Weather Information

Contractors, Personnel, and Equipment On Site

Work Areas/Boundaries

Testing Equipment Used/Observed and Calibration/Re-Calibration Documentation

Tests Completed/Observed

Work Comments/Observations and Test Results

Material(s) Delivered to Site

SAMPLE

CQA Monitoring Technician

Nuclear Density Gauge Test Record

Date ____________ Page ______ of ________
CQA Technician ____________________

Client Name: ______________________________
Project Name: ______________________________
____
Project Number: ______________________________
Project Location: ______________________________
____

Material Designation: __________ __________
Target Dry Density: __________ __________
Target Moisture Range: __________ __________
Target Percent Compaction: __________ __________

Standard Density: __________
Standard Moisture: __________

Test-Lift Number	Material Designation	Lift Range (in.)	Location	Probe Depth (in.)	Wet Density (pcf)	Water Weight (lbs.)	Dry Density (pcf)	Water Content (%)	Percent Compaction (%)	Pass/ Fail

SAMPLE

Material Inventory Record

Date ______ Page ____ of ____
CQA Technician ______

Client Name: ______

Project Location: ______

Material Type: ______

Project Name: ______

Project Number: ______

Date Received	Roll No.	Lot/ Batch	Roll Size			QC Docs Received	Date Used	Remarks
			Width (ft)	Length (ft)	Area (sq. ft)			

Panel Placement Record

Date ____________ Page _____ of _______
CQA Technician ____________________

Client Name: ______________________________
Project Location: ______________________________
____

Project Name: ______________________________
Project Number: ______________________________

Time	Panel Number	Roll Number	Panel Length (ft)	Panel Width (ft)	Panel Location/Comments

SAMPLE

Trial Weld Record

Date ______________ Page ______ of ________
CQA Technician ______________________________

Client Name: ______________________________
Project Name: ______________________________
____
Project Number: ______________________________
Project Location: ______________________________
____

Specifications: __________ mil

	Wedge	Extrusion
Peel (P)	≥ ______	≥ ______
Shear (S)	≥ ______	≥ ______

______ of ______ bones

Trial Weld Number	Time	Ambient Temp	Installer's QC	Machine Number	Machine Properties	Weld Type	Seamer Initials	Test Values lbs/inch						Pass/ Fail	Type of Material	Comments
								P								
								S								
								P								
								S								
								P								
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Seam/Non-Destructive Test Record

Date ____________ Page ______ of ________
CQA Technician ____________________

Client Name: ______________________________
Project Location: ______________________________
____
____

Project Name: ______________________________
____
Project Number: ______________________________

Seaming Information										Non-Destructive Testing Information										
Time	Seam Number	Seam Length	Seamer Initials	Machine Number	Trial Weld #	Direction Seamed	Weather/ Temp	Destruct Number	Comments	Date Tested	Addn'l Test #'s	Tester Initials	Pressure			Time		P/F	Vacuum Box P/F	Location/ Comments
													Start	End	+/-	Start	End			

Non-Destructive Test Record

Date ____________ Page ______ of ________
CQA Technician ____________________

Client Name: ______________________________
Project Location: ______________________________
____

Project Name: ______________________________
____
Project Number: ______________________________

Test Number	Seam Number	Tester Initials	Pressure			Time		P/F	Vacuum Box P/F	Location/Comments
			Start	End	+/-	Start	End			

Destructive Test Record

Date ______ Page ____ of ____
CQA Technician ______

Client Name: ______
Project Name: ______
______
Project Number: ______
Project Location: ______
______

Specifications: ______ mil

	Wedge	Extrusion
Peel (P)	≥	≥
Shear (S)	≥	≥

______ of ______ bones

Sample ID	Installer's QC	Seam Number	Weld Type	Machine Number	Seamer Initials	Test Values lbs/inch						Field Pass/Fail	Lab Pass/Fail	Location
						P								
						S								
						P								
						S								
						P								
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Repair Record

Date ____________ Page ______ of ________
CQA Technician ____________________

Client Name: ____________________
Project Location: ____________________
____

Project Name: ____________________
____
Project Number: ____________________

Repair Number	Panel/ Seam	Repair Crew	Machine Number	Repair Type	Repair Size	Test Date	Trial Weld Number	Tester Initials	Test P/F	Location/Comments

Appendix Q

Groundwater Sampling and Analysis Plan

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

Groundwater Sampling and Analysis Plan

Ameren Missouri
Power Operation Services
3700 South Lindbergh Blvd.
St. Louis, Missouri 63127

December 2012

GREDELL Engineering Resources, Inc.
1505 East High Street
Jefferson City, Missouri 65101
Phone: (573) 659-9078
Fax: (573) 659-9079

Ameren Missouri Labadie Energy Center
Groundwater Sampling and Analysis Plan
Proposed Utility Waste Landfill
Franklin County, Missouri

December 2012

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1.0 INTRODUCTION

This sampling and analysis plan (SAP) has been prepared by GREDELL Engineering Resources, Inc. for the proposed Ameren Missouri Labadie Utility Waste Landfill, located adjacent to the Labadie Energy Center and approximately two and one-half miles northeast of the town of Labadie and immediately southeast of the Missouri River in northeast Franklin County, Missouri. The proposed utility waste disposal area and surrounding areas to the north, south, and east are currently used primarily for agricultural (row-crop) production. The Labadie Energy Center is located immediately to the west. Labadie Bottom Road marks the approximate western boundary of the site and Davis Road marks the eastern boundary of the site. The general location is shown on Figure 1.

The SAP has been prepared consistent with the rules and regulations promulgated by the Missouri Department of Natural Resources Solid Waste Management Program (SWMP) and the Division of Geology and Land Survey (DGLS), found under 10 CSR 80-11.010(11)(C)2. through 10 CSR 80-11.010(11)(C)6. and 10 CSR 23-4, respectively. This SAP includes the following information: QA/QC procedures to be followed during both field sampling and laboratory analyses; groundwater sample preservation and shipment procedures; a chain-of-custody procedure; and discussion of statistical methods to be followed in the evaluation of groundwater samples gathered in accordance with this plan. Site-specific technical reports were also consulted during development of this plan. They include:

> *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011 by GREDELL Engineering Resources, Inc. and Reitz & Jens, Inc.

> *Construction Permit Application for Utility Waste Landfill, Ameren Missouri Labadie Energy Center*, prepared by Reitz & Jens, Inc. and GREDELL Engineering Resources, Inc.

This SAP is being submitted as an appendix to the solid waste disposal area construction permit application referenced above. The SAP focuses on the implementation of appropriate sampling and analysis procedures for the establishment of a groundwater detection monitoring system at the proposed utility waste landfill. This SAP will help ensure that the landfill development proceeds in an environmentally sound fashion, consistent with Solid Waste Management Law and Rules.

2.0 FACILITY LOCATION

The proposed Labadie UWL is located within the alluvial floodplain of the Missouri River in northeastern Franklin County approximately two and one-half miles northeast of the town of Labadie and six miles north of intersection of State Hwy 100 and Interstate 44 (Figure 1). The National Geodetic Survey indicates the site lies within the northwestern part of Township 44 North, Range 2 East. Portions of the area are part of the "historic" Spanish Land Grant survey system identified as "SUR". The site is located within sections 17 and 20, SUR 384, and SUR 1735. The site has had a historical land use of agriculture.

Groundwater levels are largely influenced by fluctuations in Missouri River level. Depth to groundwater is relatively shallow and varies from two to 13 feet, but levels were noted in some instances to rise up to, and during infrequent high-river stages, may slightly exceed ground surface elevation. Hydraulic gradients are also shallow. Minimum values range from 1.990×10^{-6} ft/ft to 6.161×10^{-5} ft/ft (0.015 to 0.33 ft/mi). Maximum values range from 3.517×10^{-3} ft/ft to 5.534×10^{-4} ft/ft (3 to 18 ft/mi). Calculated hydraulic conductivity values range from 9.47×10^{-2} to 2.15×10^{-2} feet per minute (ft/min), and average 4.91×10^{-2} ft/min. These values fall within the range of hydraulic conductivity values typically ascribed to coarse and medium sand deposits.

3.0 FACILITY BACKGROUND

The Ameren Missouri Labadie Utility Waste Landfill is being proposed as a landfill site to accommodate the waste generated from the flue gas desulfurization units, fly ash, and bottom ash.

The proposed UWL covers a waste boundary area of approximately 166.5 acres of the 813-acre landfill permit boundary within the Ameren Missouri Labadie Energy Center Property. The entire site is zoned by Franklin County as Agricultural Non-Urban (ANU). Improvements within the Labadie UWL permit boundary include the 166.5-acre waste disposal area, stormwater management ponds permitted separately as no discharge wastewater facilities under Missouri Clean Water Law, soil stockpile areas, flood protection berms, perimeter stormwater control structures, site access roads, perimeter security fencing, buffer zones, and groundwater monitoring.

In order to ensure that groundwater is protected a series of groundwater monitoring wells are proposed for installation both upgradient and downgradient of the UWL. Periodic sampling of the groundwater monitoring well system is required under Missouri's Solid Waste Management Regulations, 10 CSR 80-11.010(11).

4.0 PROPOSED GROUNDWATER MONITORING SYSTEM

The proposed groundwater monitoring system consists of 28 permanent wells and one temporary well (Figure 2). Each well will monitor shallow groundwater contained within the unconfined alluvial aquifer that underlies the site as recommended in the Detailed Site Investigation. The wells that generally are downgradient from waste disposal boundaries are designated MW-1 through MW-21. The wells that generally are upgradient from waste disposal boundaries are designated MW-22 through MW-28. Individual well location and depth information is summarized in Table 1. The table also lists a temporary monitoring well (TMW-1) that will serve as a "sentry" for the initial operations within Cell 1. It will be used to supplement water quality data derived from the permanent downgradient wells located along the eastern perimeter of Cell 3.

Justification for the location of the proposed permanent well system is presented in Appendix X of the Construction Permit application. The proposed wells will be installed prior to acceptance of waste. TMW-1 will be removed when Cell 3 becomes operational.

4.1 Well Construction

All monitoring well drilling and construction will be completed in accordance with the Missouri Monitoring Well Construction Code of regulations found in 10 CSR 23-4. A typical monitoring well construction detail for the proposed well installation is provided as Figure 3. Well depths will be in general accordance with Table 1 to ensure full submersion of each 10-ft screen interval. Some allowances may have to be made in actual well location to ensure they do not conflict with planned landfill development, terrain or subsurface irregularities, overhead power lines, or similar encumbrances. This in turn will affect actual well depths, which are based on ground surface elevations.

Drilling and well construction will be completed by a properly permitted monitoring well installation contractor. Drilling logs and monitoring well construction details will be completed subsequent to installation activities and inserted into Appendix 1 of this SAP at a later date.

Proposed monitoring wells will be located such that reasonable access can be gained for the purpose of maintenance and repairs. The surrounding natural drainage will not be impaired. Each well will be placed so as to facilitate surface water drainage surrounding the well.

4.2 Well Development or Redevelopment

Each well will be developed with the use of either disposal bailers or a non-dedicated, submersible pump. In no event will the method used introduce any contaminants into the wells. A minimum of three well volumes of water will be removed or until the well is effectively "dry". A "well volume" includes both the filter pack and casing, as measured from the base of the well to the initial static water level. In addition, the volume of potable water introduced into the well bore while drilling and/or constructing the well, if any, will be removed.

Field measurements of groundwater temperature, pH, and specific conductivity will be recorded during the development process. Field measurements will continue until both temperature and specific conductivity have stabilized to within ten percent between three successive readings. Similarly, pH readings should stabilize within 0.2 pH units.

In addition to the above, development records will include documentation of both pre- and post-development water levels. Final clarity of the water will also be noted.

Redevelopment will be undertaken when 20 percent of the well screen is occluded by sediments, as determined during routine measurements of the depth of the well taken during field sampling events.

5.0 SAMPLING FREQUENCY - DETECTION MONITORING

Detection monitoring is required at all monitoring wells. The sampling frequency required by 10 CSR 80-11.010(11)(C) is twice yearly during the months of May and November, except for initial background water quality monitoring following well installation and prior to operation. The rule requires a minimum of four independent samples to be collected from each well. This requirement allows identification of background concentrations contained in the shallow alluvial aquifer using a statistically valid number of sampling events. Background water quality data are critical to identify in order to allow comparison with subsequent sample analysis to determine if statistically significant increases in target contaminants are present within the groundwater.

The proposed schedule for background water quality sampling at the Ameren Missouri Labadie Utility Waste Landfill is presented in Table 2. The intent of the schedule is to provide eight independent rounds of background data prior to the start of operations. The eight sets of data (from the four minimum sampling events required by the rule plus four additional sampling events) will better define the spatial variability of groundwater quality across the footprint of the disposal area. The degree of spatial variability will ultimately determine the statistical approach to be used in the evaluation of detection monitoring results.

Detection Monitoring will include analysis of the parameters listed in Appendix I of 10 CSR 80-11.010. Those parameters are listed for reference in Appendix 2.

6.0 FIELD SAMPLING EQUIPMENT - QA/QC PROCEDURES

All field personnel must read and familiarize themselves with the protocol established in this section. All personnel involved in the sampling process must wear Level D Protective clothing as defined by OSHA. This includes, but is not limited to, safety boots/shoes, safety glasses, and disposable gloves. No smoking is allowed during sampling. A first aid kit must be accessible to field personnel during each well sampling event.

The following equipment, at a minimum, will be available in the field during each sampling event: purging and sampling equipment, both dedicated and non-dedicated; an electronic water level measurement device; pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and turbidity meters; sample containers, and coolers.

The probes and attachments of each pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and turbidity meter will be hand washed in a laboratory grade, non-phosphate detergent, followed by a triple rinse in distilled water. The meters will then be calibrated in accordance with manufacturer's recommendations or as otherwise specified in the *Field Equipment Calibration Forms and Procedures* included in Appendix 3. Any malfunction will be corrected or the meter will be replaced.

Sample containers will be pre-cleaned by the contract laboratory by washing in a laboratory grade, non-phosphate detergent, triple rinsed in distilled water, and sufficiently dried to remove all moisture. The sample containers will be checked/inventoried for proper container volume, material, preservatives, labels and any observed defects (e.g., preservative leakage) at the time of receipt from the laboratory and documented on the *Groundwater Sampling Bottle Inventory* form (Appendix 4).

Prior to collecting a sample, the following decontamination procedures will be implemented.

1. Purging and Sampling Equipment will be handled and decontaminated as necessary to prevent contamination of the wells.

    a. If non-dedicated purging and sampling equipment is used, it will be thoroughly decontaminated and tested by collecting an equipment blank prior to use (see Section 7.4 Equipment Blank).
    b. If disposable bailers are used in the purging and sampling of the wells, they will be new, single-use bailers for each well and purging/sampling event. Used disposable bailers, even if decontaminated, are not acceptable.
    c. If dedicated pumps or bailers are used, care will be taken to prevent cross contamination.

2. Water level measuring device, including sensor probe and the entire length of graduated tape will be washed in laboratory grade, non-phosphate detergent followed by a triple rinse in distilled water.

    a. As the tape is reeled back onto the carrying spool, it will be wiped and dried using clean, dry paper towels.

3. During sampling, carefully lower the purging and sampling equipment into the well, handling it only with clean, disposable gloves. Do not drop any equipment into the well. The intake of the sampling equipment should be suspended above the base of the well to avoid churning of particulate matter within the sump.

4. After each well is sampled or during sampling events, as necessary, disposable gloves should be discarded, hands washed with soap and water, and fresh disposable gloves applied before the next sampling.

5. After use, the purging and sampling equipment will be washed in laboratory grade, non-phosphate detergent followed by a triple rinse with distilled water, prior to any further use.

6. Should purging and sampling equipment malfunction or not be available for use during the sampling event, substitute equipment or a bailer may be used.

7. All handling of the bailer will be with clean disposable gloves. Gloves must be changed as often as necessary, particularly if contact is made with other substances during the bailing process. The bailer must not be allowed to contact any foreign substance, in which case the bailer will be promptly replaced, regardless of condition.

8. Lightweight, high tensile strength line or a similar product used in conjunction with the disposable bailers or reel systems will be discarded and replaced each time a well is sampled.

If dedicated pumps are used, care should be taken to prevent any foreign objects from being part of the sample. The outside of the sample discharge tubing should be cleaned to prevent introduction of foreign objects into the sample container.

7.0 GROUNDWATER SAMPLES - QA/QC PROCEDURES

7.1 General

Precautions must be taken during both sampling and shipping procedures to ensure representative groundwater is obtained. Sample blanks and sample duplicates are therefore required to guard against and/or identify accidental, "induced" contamination from these sources. Sample blanks include trip blanks, field blanks, and equipment blanks. Sample duplicates are self-explanatory, but can include both matrix spike and matrix spike duplicates. Each of these quality control features is explained more fully as follows.

7.2 Trip Blanks

Trip blanks are prepared in the laboratory. They are designed to detect contamination resulting from improper or inadequately cleaned containers, sample coolers used for transport, or from chemical preservatives. A trip blank is prepared by filling an appropriately sized container with distilled water and any applicable chemical preservative. It is then shipped to the sample site and subsequently accompanies groundwater samples on the "trip" back to the laboratory. Trip blanks must be clearly identified as such along with the analyses to be performed on them. At a minimum, one trip blank per sampling event will be collected.

7.3 Field Blanks

Field blanks are prepared in the field. A field blank is prepared by directly filling an appropriately sized container with laboratory-supplied deionized water. Field blanks are used to detect contamination resulting from changed ambient air conditions. They also serve as a check against trip blanks. Field blanks should be clearly identified in the sampler's field notes and appropriately labeled to ensure its later identification in laboratory analytical results. One field blank will be collected per sampling event.

7.4 Equipment Blanks

Equipment blanks are prepared in the field when non-dedicated sampling equipment is used. They are used to ensure that non-dedicated equipment is properly decontaminated. This is accomplished by collecting a sample of distilled water passed through non-dedicated equipment after they have been decontaminated. Equipment blanks should also be collected anytime new, dedicated equipment is introduced into the water sampling process. Equipment blanks should be clearly identified in the sampler's field notes and appropriately labeled to ensure its later identification in laboratory analytical results. At a minimum, one equipment blank per sampling event will be collected.

7.5 Sample Duplicates

Sample duplicates are independent samples collected as close in time as possible as the original sample from any given well. They are stored and analyzed separately from the original sample and are a check on the precision of the sampling and analytical process.

Sample duplicates must immediately follow original sample collection of any given chemical parameter. Because they serve as a check on the reproducibility of data generated by the analytical laboratory, labeling should follow a format that does not overtly divulge the true identity of the sample on the sample labels or on the chain-of-custody sheet. It should be clearly identified in the sampler's field notes and appropriately labeled to ensure its later identification in laboratory analytical results. One sample duplicate will be collected for every 20 samples. At a minimum, one sample duplicate per sampling event will be collected.

7.6 Matrix Spikes

Matrix spikes are prepared in the laboratory by adding a known amount of target analyte to a sample prior to preparation and analysis. They are used to determine the bias of a method in a given sample matrix.

7.7 Matrix Spike Duplicates

Matrix spike duplicates are intra-laboratory split samples containing identical concentrations of target analytes. They are used to substantiate matrix spike samples.

8.0 FIELD SAMPLING PROCEDURES

8.1 General

Upon arrival at each monitoring well, its physical condition must be documented. Appendix 5 contains a *Monitoring Well Field Inspection* form that must be filled out for each well each time it is sampled. Any irregularities in the condition of the well must be immediately reported and corrective action implemented prior to the next sampling event.

8.2 Water Level Measurements

The next procedure is to obtain water level measurements. They must be obtained immediately prior to any attempt to purge the well. All water levels measuring equipment will be thoroughly decontaminated as previously described and checked for wear and abrasion prior to use. Clean, disposable gloves will be worn. All measurements must be recorded to $\pm$0.01 foot and should be based on a permanent reference point located at the top of the well, the elevation of which is established by a licensed surveyor.

Once the sample is collected, it is also necessary to measure the depth of the well. This is required to determine if the well screen is partially blocked by sediment, thus inhibiting recharge. If accumulated sediment obstructs more than twenty percent of the well screen height, it will be reported and arrangements made to redevelop the well prior to the next sampling event. Record all data gathered during water level measurements on the *Field Sampling Log* form provided in Appendix 6.

Ensure the well cap is clean prior to replacing after measurements are complete. Do not leave the well cap off for any reason, even for brief periods, unless purging immediately commences.

8.3 Purging

The next procedure is to purge the wells. There are two potential methods for purging the wells: Purge/Recover Sampling method; and Low-Flow Sampling method. Each method is acceptable, if the procedures are diligently followed. Each method is described separately below. All purge volumes must be documented on the *Volume Tracking Log* form provided in Appendix 6.

Purge/Recover Sampling: If using dedicated purge and sampling equipment, the following paragraph does not apply. If non-dedicated purge and sampling equipment is used, the wells should be purged in an order that precludes any potential cross-contamination. Typically, the upgradient wells are purged prior to the downgradient wells.

Purging must occur prior to any sampling, because water standing in the well may be unrepresentative due to physical and/or chemical alteration. Each well will be purged by removing at least three well volumes of water or until purge parameters stabilize. A well volume is considered the sum of the saturated portion of the well casing plus the saturated portion of the filter pack, which is roughly equivalent to an effective pore volume of 30 percent. The calculated volumes are based on the height of the water column above the established base of the well as measured immediately prior to purging. Filter pack heights must also be known. Well construction information for this facility will be placed in Appendix 1 following construction of the wells.

Wells will be purged using either dedicated bailers or other suitable purging and sampling equipment. All handling of purging equipment will be done wearing clean disposable gloves. Purge water will be poured into a graduated container sufficient to allow accurate measurement of the volume of water obtained. Once a well volume is obtained, temperature, specific conductivity, pH, oxidation-reduction potential (ORP) and turbidity will be recorded. Temperature must be measured first, followed by specific conductance ORP, pH, and lastly by turbidity. It is important to measure specific conductance and ORP prior to pH due to the potential presence of salts on the pH probe unit. All meters will be calibrated and checked for proper operation following manufacturer's recommendations or as otherwise outlined in Appendix 3. The clarity (turbidity) of the water will be noted. Cloudy, turbid water must be minimized.

<u>Low–Flow Sampling Method:</u> When using dedicated low flow pumps and automatic purge parameter sensors, such as the YSI 5083 Flow Cell, the following procedures will be followed to assess the stability of a water sample. At a minimum, all water will be purged from the line between the low-flow pump and the automatic sensors. This will be done by allowing a minimum of one volume within the connecting sampling tubing to flow from the well before assessing the stability of the water sample.

To be considered stable, the reading from each respective purge parameter sensor will be compared to the previous two values (collected at least one minute apart), and will be within the following limits:

- pH — +/- 0.2 S.U.
- Specific Conductance — +/- 20 umhos/cm
- Temperature — +/- 1 C
- Oxidation-Reduction Potential — +/- 20 millivolts
- Turbidity — +/- 1 NTU (optional)

or

- 10 percent for SC, temperature, ORP and turbidity and +/- 0.2 S.U. for pH

If one-quarter inch (¼") tubing is used to connect the low flow pump to the automatic sensor, it takes one minute to purge 26 feet of tubing at 250 ml/minute.

Once sampling is complete, properly dispose of all purge water. Record all purge data on the *Field Sampling Log* form provided in Appendix 6.

8.4 Sampling

The next procedure is the actual sampling of the well. As much as practical, sampling should take place within two hours of the final purge event. In some instances, the recharge characteristics of the screened interval may be such that the two-hour stipulation is not feasible. In that event, sampling should be performed no later than 24 hours after final purging. Wells should be sampled in the order that precludes as much, to the extent practical, any potential cross-contamination. Typically, the upgradient wells are purged prior to the downgradient wells. Samples from each well will be collected in the following order, based on their sensitivity to volatilization:

- TOX
- TOC
- TDS
- Metals
- Non-metals
- COD

Samples must be <u>carefully</u> decanted into the appropriate sample container. Agitation must be minimized to avoid altering the chemical makeup of the sample. If well pumps are being used, care should be taken to prevent any contaminant from the exterior of the sample tubing from contaminating the water sample. Field filtration of samples is not allowed under 10 CSR 80-11.010(11)(C)2.B. Consequently, sample clarity must be documented and efforts made to minimize increasing turbidity beyond what naturally occurs in the well environment. Once a sample is retrieved, it will be preserved according to the guideline provided in Appendix 4. Samples requiring storage at low temperature will be immediately placed in coolers packed with ice. The temperature of the storage coolers will be monitored to ensure appropriate temperatures are maintained. All sampling data will be documented on the *Field Sampling Log* form provided in Appendix 6.

9.0 SAMPLE TRANSPORT AND DELIVERY, CHAIN-OF-CUSTODY

A chain-of-custody procedure is necessary to ensure the integrity of samples from the time of collection through delivery and final analysis. A sample is considered in someone's custody if:

1. It is in that person's physical possession;
2. In view of that person once he/she has taken possession;
3. Has been secured by that person so as to prevent tampering, or;
4. Has been placed by that person in an area restricted to authorized personnel.

Any person with custody as defined above must comply with the procedures established herein.

Prior to transport, the person collecting the samples must properly label each sample container and complete a *Chain-of-Custody Field Record* form. An example chain-of-custody field record form is provided in Appendix 7. Each label must be secured to the container and the following information clearly described on the label in indelible marker or pen:

- Collector's name
- Date and time of sampling
- Monitoring Well ID
- Sample ID
- Preservative(s) used, if any
- Required analytical test(s)

If the sample cooler(s) used for transport is not tamper proof, each sample container must also have a tamper proof seal affixed by the collector across the lid. A chain-of-custody summarizing the samples to be transported is also required. This form should be prepared by the collector and completed upon final sampling. A copy of the form(s) should accompany the person responsible for transporting the samples so that it can be included with the final analytical report as support documentation. The sample collector also initializes the chain-of-custody record process. It is his/her responsibility to ensure that the record is maintained upon relinquishment of the samples for transport to the laboratory.

When samples are transported, the carrier assumes responsibility for the chain-of-custody record and for ensuring safe transport of the samples to the laboratory. The carrier must recognize the contents of the shipment, the potential hazards they entail, and demonstrate an understanding of the proper handling precautions to be used during transport. The carrier is responsible for ensuring that all samples are properly stored to avoid leakage or breakage. Sample coolers should be checked to ensure required temperatures are maintained and any additional ice is added as necessary. Do not use dry ice during transport. The carrier must also ensure that all relevant shipping manifests are properly and fully completed. Other individuals who might accompany the carrier must be advised of the nature of the shipment and must not be allowed direct contact with any of the samples.

Any transfer of samples from one carrier to another must be accompanied by the chain-of-custody record and the above process repeated prior to relinquishment of the samples. The carrier must deliver the samples to the laboratory as soon as practicable after sampling, generally no later than 48 hours. The carrier should ensure that the samples are delivered to the person in the laboratory qualified to receive samples prior to relinquishment of the chain-of-custody record to that individual.

The laboratory should assign a specific individual to be responsible for the samples. This individual should first inspect the condition of the sample containers and any seals, and then reconcile the information on sample labels with that listed on the chain-of-custody record prior to signing the record. This individual should then assign laboratory numbers to each sample, enter these numbers on the laboratory logbook and on each sample container label, and should store the samples in a secured storage area until ready for analysis. This individual is ultimately responsible for completion of the chain-of-custody record and for ensuring that it forms part of the final analytical report.

10.0 ANALYTICAL LABORATORY - REPORTING AND QA/QC PROCEDURES

The contract laboratory must have the ability to produce reliable quantitative results in accordance with established protocol. At a minimum, the laboratory must use analytical methods that will achieve the nominal target reporting limits for the MDNR Appendix I groundwater monitoring parameters listed in Appendix 2. Adequate levels of accuracy, precision, and completeness must be maintained.

10.1 Accuracy

Accuracy is defined as the degree of agreement between the measured amount of a species and the amount actually known to be present, expressed as a percentage. To achieve an adequate appraisal of accuracy, spikes and/or control samples should be made for one of every twenty samples analyzed. Minimum levels for accuracy should be listed in specific laboratory quality assurance plans.

10.2 Precision

Precision is a measure of the reproducibility of analytical results, generally expressed as a *Relative Percent Difference.* To achieve an adequate appraisal of precision, duplicate analyses should be performed for every one in twenty samples. Minimum levels for precision should be listed in specific laboratory quality assurance plans.

The relative standard deviation is a measure of the variability of the results from an analytical procedure. The relative standard deviation is calculated by taking the difference between a sample result, x, and the average of sample results from numerous laboratories, x_{bar}, for each analyte divided by x_{bar} [$(x-x_{bar})/x_{bar}$ expressed as a percentage].

The relative percent difference is the difference, by analyte, between the results of duplicate sample divided by the average value for those samples [$(x_1-x_2)/((x_1+x_2)/2)$ expressed as a percentage]. It is a measure of the variation in the results of an analyte for duplicate samples.

If the results for duplicate samples of an analyte for relative percent difference are within 2.5 times the percent relative standard deviation, the analytical data for the parameter may be accepted as being comparable results. If the results of an analyte for duplicate samples for relative percent difference are not within 2.5 times the percent relative standard deviation, the results of the analyte should be checked for comparability.

10.3 Completeness

Completeness is a comparison of the amount of valid data acquired to the amount of valid data planned to be obtained, expressed as a percentage. Should the percentage of completeness fall below 90 percent for the analytical results of any given sampling event, the laboratory should be prepared to present a corrective action narrative prior to receiving further groundwater samples.

10.4 Reporting Requirements

Minimum reporting requirements for the laboratory responsible for analytical results of groundwater monitoring well samples are as follows:

1. A table summary of all analytical test methods used in the analysis, including references for each to the method manual and test method number.

2. A summary of all analytical results. This must include use of appropriate units, reporting Practical Quantitation Limit (PQL), and appropriate signature on all data sheets. Units must be shown for each analyte. Data cannot be method blank corrected. Data must be appropriately flagged.

3. A complete chain-of-custody form(s). A complete form includes name and affiliation of sample collector, time and date of sampling, and all appropriate signatures denoting custody changes. The chain-of-custody form should be an original or a highly legible copy.

4. A completed copy of the field sampling log(s) contained in Appendix 6 of this Sampling and Analysis Plan.

5. Method detection limits must be established for all metals analysis. Method blank results are required.

6. All inorganic results will be accompanied by a Quality Assurance data form that includes minimum detection limits, method blanks, field or trip blanks, and lab replicate. If spiked samples are used, these data will also be included.

Supplemental laboratory data will include a summary that chronicles laboratory procedures, including date of sampling, sample receipt, preservation, preparation, analysis, and approval signature of the results.

Once laboratory analytical data are received, facility personnel must in turn submit the data to MDNR-SWMP in report form for review and comment within 90 days of the date of sampling. Information to be contained in the report should include the following:

1. Clearly state the purpose of the submittal (i.e. either detection or assessment monitoring).

2. Supply a copy of field notes, including all field data sheets.

3. Provide unaltered copies of the "raw" analytical data. A summary table is also recommended, but cannot take the place of the "raw" data.

4. Include the completed chain-of-custody form(s).

5. Summarize the data validation procedures.

6. Summarize groundwater flow direction and hydraulic gradient. Compare and contrast with previous data. Supply an updated water table (potentiometric) map prepared by a properly qualified individual.

7. Provide a statistical analysis summary using approved methods, including discussion of any statistically significant increase over established background values.

8. Note any deviations from the Sampling and Analysis Plan that may have taken place during the sampling event.

9. Provide electronic submission of groundwater data in a format and method prescribed by the MDNR-SWMP.

11.0 STATISTICAL ANALYSIS

The statistical analysis procedure(s) used for the Ameren Missouri Labadie Utility Waste Landfill (UWL) were selected to be consistent with the requirements of 10 CSR 80-11.010(11)(C)5. The statistical analysis plan below was developed for this facility and is submitted for review and approval.

This section contains a general discussion of the type of statistics chosen for the facility. The type of statistics chosen reflects the understanding that the site is located in a flood plain, and the shallow alluvial groundwater will be monitored.

11.1 Characterization of Well Network and Selection of Statistics

Upon installation of permanent groundwater monitoring wells, the Labadie Energy Center will follow the schedule for sampling shown in Table 2. After eight rounds of background sampling, a report will be prepared comparing the distribution of data for each parameter in both the upgradient and downgradient wells. Comparisons may include Box Plots for median, quartile and extreme values and Kruskal Wallis tests for comparison of populations at a 0.05 level of significance or other tests as appropriate. If downgradient well data are not comparable to upgradient well data, intra-well statistics will be considered for future comparisons. If data from one or more upgradient wells are comparable to the downgradient well(s) data, inter-well statistics will be considered for future comparisons.

11.2 Prediction Intervals or Other Statistical Tools

Parametric and non-parametric prediction intervals will be used as discussed below. The types of statistics to be used include parametric and non-parametric prediction intervals. For intra-well comparisons, the parametric and non-parametric prediction intervals will be defined by the data from previous samples collected at the well being reviewed. For inter-well comparisons, the parametric and non-parametric prediction intervals will be defined by the data from previous samples collected at the upgradient well(s).

Below is a specific discussion on the implementation for the statistics listed above. Prediction intervals for parametric and non-parametric distributions are recommended. Most computer statistical software programs include distribution testing with the appropriate selection of normal, log normal or non-parametric distribution. Some statistical software programs use the Ladder of Powers concept in an attempt to normalize data. Prediction intervals may include samples with results below detection limits by using either the Cohen or Aitchison approximations for a limited number of non-detects.

11.3 Choice of Statistical Test for Limited Data

The following restrictions apply to these statistical methods recommended in Section 11.2 depending on the number of samples that have been collected:

- Sample size < 4 – do not run statistics
- Sample size ≥ 4 but ≤ 8 – may use Poisson Prediction Limit Test or similar tests as a cursory review of parameter concentrations. Elevated parameters from this test are not Statistically Significant Increases (SSIs), but are parameters that will need to be looked at more closely when the sample size is greater than 12
- Sample size > 8 – use recommended Statistical methods

11.4 Non-Detects

There are limitations on the use of statistical procedures if analytical results do not detect a parameter. Examples are as follows:

- For non-detects ≥ 76 percent and < 100 percent, use a non-parametric inter-well prediction interval testing with the Upper Prediction Limit (UPL) = to the largest non-outlier value.
- For non-detects equal to 100 percent, use a non-parametric prediction interval testing with the Upper Prediction Limit (UPL) = the Practical Quantitation Limit (PQL). The analytical laboratory will maintain the lowest PQL practicable. Significant changes in PQL (± 25 percent) will be avoided as much as practicable.
- For non-detects < 25 percent, use PQL divided by two, or Cohen's Adjustment, and check for normality. The SWMP may approve use of a median PQL.
- For non-detects ≥ 25 percent and < 75 percent, use Cohen's Adjustment or a modified Aitchison's Adjustment (also known as the modified delta method), and check for normality.

11.5 Normality Testing

The purpose of normality testing is to determine whether the background data is normally distributed or if it can be normalized through transformation. Data that is normally distributed or that can be normalized will be evaluated using a parametric statistical tool. Data that is not normal will be evaluated using a non-parametric statistical tool. Examples of normality testing include:

- For sample population ≤ 50 – Shapiro-Wilk Test or equivalent
- For sample population > 50 – Shapiro-Francia Test or equivalent

Show normality testing on at least the original data, data residuals, and natural logarithmically transformed data or data transformed by the Ladder of Powers concept.

11.6 Outlier Testing

Since most of the software packages available use either the t-test or Dixon's method for determining outliers and neither of these methods can determine multiple outliers the SWMP has developed the following procedure to be used in determining outliers.

Screen data first by using Probability Plots and Time Series Plots. The Time Series Plot and the Probability Plots will aid in determining whether there are multiple possible outliers or a single possible outlier. The time Series Plot is used along with the Probability Plots to screen for possible outliers, a screening tool. The possible outliers are the points on the Probability Plots that appear out of alignment with the rest of the data. Care should be taken when using Probability Plots because non-normal data will also have points out of alignment as compared to the rest of the data. In addition, the Probability Plots will help determine if the numerical tests should be evaluated using log-transformations or transformed by the Ladder of Powers concept.

Determine the Median value for the Data to be processed. The median was chosen because the median value is not changed by either high or low values. This value is the *screening tool* to be used in the steps listed below:

- Use the screening tool to determine what values are possible outliers. The Time Series Plots could aid in the identification. If the number of possible outliers is equal to one, run the outlier test on that one value. If there are no possible outliers identified, do not screen for outliers. If there is more than one possible outlier proceed to the next step.

- Determine if one or more of the possible outliers could mask the other outliers. For example, for possible outlier values of 194, 290, 332, 838 and 1630, 1630 could mask 838 as an outlier. When masking can occur, each possible outlier should be tested with the other possible outliers not used in the calculations. In the example given, tag the value of 1630 and then run the outlier test on the value of 838. If the value 838 is an outlier then the value 1630 would also be an outlier and removed from the data set as confirmed outlier.

- If the outlier test would be run on the complete data set of 194, 290, 332, 838 and 1630, to determine if 1630 was an outlier, the value of 838 would not be an outlier if the value 1630 were not an outlier.

Also, when looking at the initial sample values, use the time series plots to determine if these initial values are within reasonable limits as compared to the other early samples. Some parameters have high readings the first few times a well is tested and these higher readings could mask a trend if they are not removed early in the monitoring program. Simply relying on a computer program to determine outliers without looking at the data through a visual means can give erroneous results.

There are different outlier tests depending on the number of samples:

- Use only Dixon's Test if the sample size is ≤ 25.

- Use Rosner's Test, if available, only if the sample size is ≥ 20. Rosner's Test is able to test for either single or for multiple outliers. Although Rosner's test avoids the problem of masking when multiple outliers are present in the same data set, it is not immune to the related problem of *swamping*. Swamping refers to a block of measurements all being labeled as outliers even though only some of the observations are actually outliers. This potential pitfall seems to be in properly identifying the total number of possible outliers. Following the screening procedure above should minimize the problem of *swamping*:

    - Outliers can only be excluded for the analytical event in which they are determined.

    - Previously determined outlier results will be re-checked when background is updated to confirm that these results are still outliers and not included in the background database.

    - Last date outliers of compliance well comparisons must not be excluded from current analysis.

    - Outlier screening will never be applied to the current (future values) monitoring data of control charts.

Other types of outlier test, besides those mentioned previously, may be used.

11.7 Prediction Interval Testing

When inter-well comparisons are being used, compare inter-well Upper Prediction Limit (UPL) to each downgradient well's last date value. Inter-well UPL is calculated from all dates of upgradient well background data.

When using intra-well comparisons, compare the UPL from previous sampling to the results by constituent of the current round of sampling results by constituent.

11.8 Procedures for Response to Future SSI's

This section contains a general discussion on the re-sampling strategy for any parametric or non-parametric inter-well prediction interval methods, re-sampling used to verify SSI's. An SSI is not proven:

- If the pooled background sample size (n) is ≤ 10, there is one resample out of two samples that does not show an SSI for the parameter; or

- If the pooled background sample size (n) is > 10, the single resample does not show an SSI for the parameter

This sampling strategy is identified in flow charts provided in Appendix 8.

If an SSI is confirmed, current (1997) Missouri Solid Waste Management Rules require the following procedures [Reference 10 CSR 80-11.010(11)(C)6].

"6. Response to statistical analysis.

A. *If the comparison for the upgradient wells shows a statistically significant increase (or pH change) over background, the owner/operator shall submit this information to the department.*
B. *If the comparisons for downgradient wells show a statistically significant increase (or pH change), resulting from the landfill, over background, the owner/operator shall within ninety (90) days of the last sampling event obtain additional groundwater samples from those downgradient wells where a statistically significant difference was detected, split the samples in two (2), and obtain analyses of all additional samples to determine whether the significant statistical difference was a result of laboratory error.*
C. *If the additional samples show a statistically significant increase (or pH change) over background, the owner/operator must demonstrate to the department within ninety (90) days that a source other than the utility waste landfill caused the contamination or that the statistically significant increase resulted from an error in sampling, analysis, statistical evaluation or natural variation. If the owner/operator cannot make this demonstration to the department, the owner/operator shall submit a plan to the department for a groundwater assessment monitoring program and implement the program as described in subparagraphs (11)(C)6.D. through H. of this rule. The plan shall specify the following:*
(I) The number, location and depth of wells;
(II) Sampling and analytical methods for the monitoring parameters listed in Appendix I of this rule on a quarterly basis;
(III) Evaluation procedures, including any use of previously gathered groundwater quality information;
(IV) The rate and extent of migration of the contaminant plume in the groundwater; and
(V) The concentrations of the contaminant plume in the groundwater.
D. *After obtaining the results from the initial or subsequent sampling events required in subparagraph (11)(C)6.B. the owner/operator shall -*
(I) Within fourteen (14) days, notify the department and place a notice in the operating record identifying the constituents that have been detected;

(II) Within ninety (90) days, and on a quarterly basis after that, resample all wells and conduct analysis for all constituents listed in Appendix I to this rule and notify the department of the constituent concentrations. A minimum of one (1) sample from each well sampled (background and downgradient) shall be collected and analyzed during these sampling events;

(III) Establish background concentrations for any new constituents detected during subsequent monitoring events; and

(IV) Establish groundwater protection standards for all new constituents detected during subsequent monitoring events.

E. *If the concentration of all constituents listed in Appendix I to this rule are shown to be at or below background levels as established in paragraph (11)(C)3. of this rule for two (2) consecutive sampling periods, the owner/operator may reinstate detection monitoring at the utility waste landfill as specified under subparagraph (11)(C)3.C. of this rule.*

F. *If the concentrations of any constituents listed in Appendix I of this rule are above background values, but all concentrations are below the groundwater protection standard established under subparagraph (11)(C)6.D. of this rule using the statistical procedures in paragraph (11)(C)5. of this rule, the owner/operator shall notify the department and the department may require the owner/operator to--*

(I) Continue assessment monitoring; or

(II) Develop a corrective measures assessment, or both.

G. *If one (1) or more constituents listed in Appendix I of this rule are detected at levels above the groundwater protection standard as established under subparagraph (11)(C)6.D., the owner/operator shall--*

(I) Provide the department with a report assessing potential corrective measures;

(II) Characterize the nature and extent of the release by installing additional monitoring wells as necessary; install at least one (1) additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with paragraph (11)(C)6. of this rule and, if required by the department, notify all persons who own the land or reside on the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site if indicated by sampling of wells; and

(III) Continue assessment monitoring as per the groundwater quality assessment plan, and implement the approved corrective action program specified in part (11)(C)6.G.(I) of this rule.

H. *The results of implementation of the assessment monitoring program shall be submitted to the department at the end of each year or an alternate time period approved by the department."*

Prior to implementing a response to a future SSI, it is recommended that the Missouri Code of State Regulations be reviewed to determine if the Solid Waste Management Rules regarding Response to Statistical Analysis have been revised.

11.9 Current MDNR Protocols

The following protocols are currently used by MDNR's Solid Waste Management Program in managing groundwater monitoring data for solid waste disposal areas and in evaluating that data for statistically significant increases (SSI's)

The SWMP has previously not allowed a verified SSI or its verification resample value(s) to be excluded as outliers from the database for control charts if the previously specified resample strategy shows that only the "future measurements" plot, including resample(s) measurement(s), does not exceed the "SCL - limit" line.

- Re-sampling SSI's must be conducted a minimum of one quarter later from the previous sampling event. MDNR's in-house laboratory or subcontractor will be given the option to split samples for each re-sampling event.

- If a subset of background data is to be excluded, or if a previous excluded subset of background data is to be re-included for statistical analysis, a request for modification to the approved statistical analysis plan must be submitted to and approved by the SWMP before implementation. This requirement does not include the data that would be temporarily excluded because of outlier testing during a single statistical analysis event.

- See Appendix 8, Attachment 1 for a flow diagram for implementing Prediction Intervals.

- See Appendix 8, Attachment 2 for a flow diagram for Non-Parametric Prediction Intervals for data that is non-normal or for data that cannot be normalized.

Prior to utilizing various MDNR protocols for statistical analysis of groundwater monitoring data, it is recommended that the SWMP be contacted to obtain updated recommendations on current protocols and/or policies.

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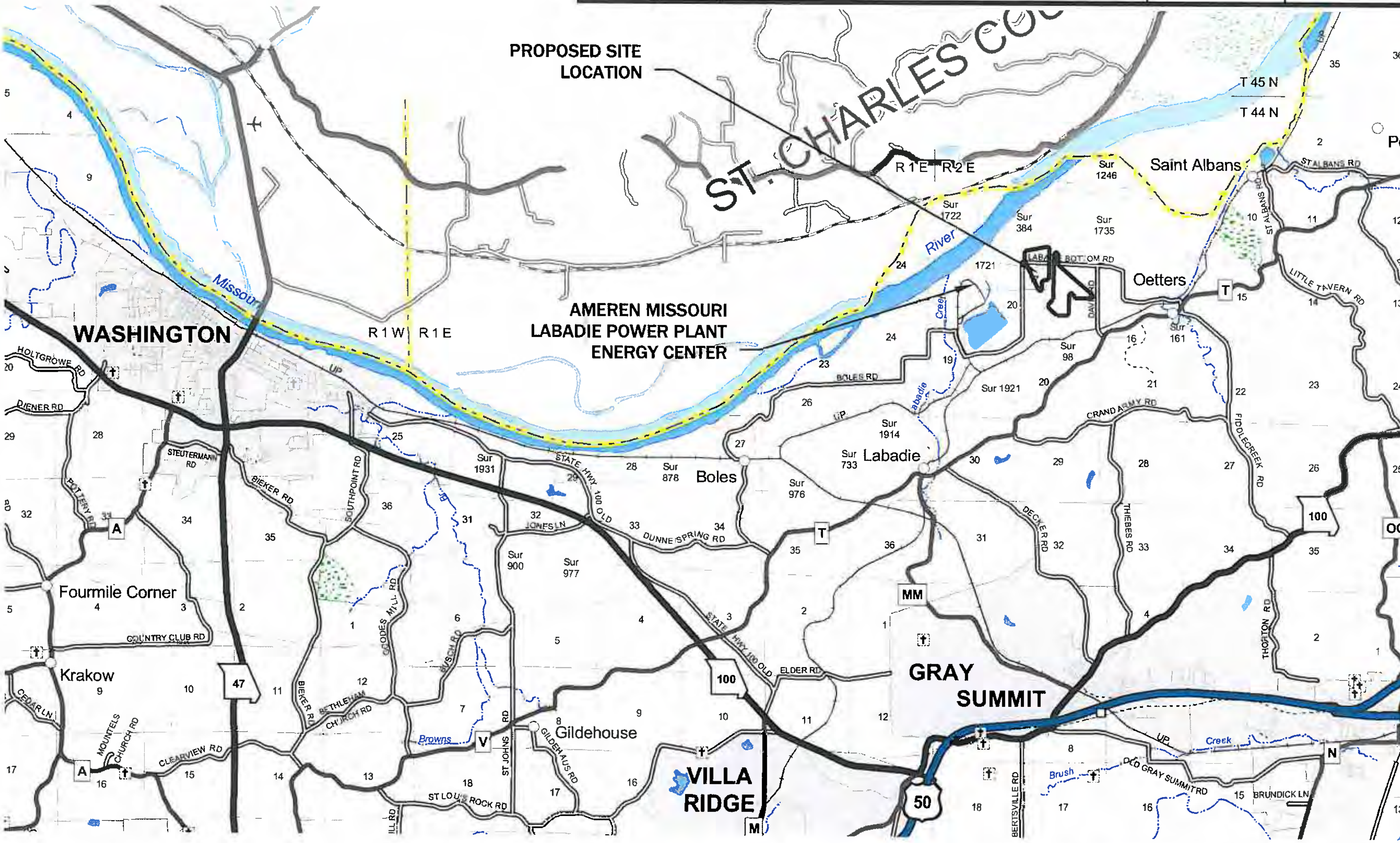
Figures

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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ENVIRONMENTAL ENGINEERING
LAND AIR WATER

PREPARED FOR Ameren MISSOURI

DRAWN W.J.A. (G.E.R.)	FIGURE 1, APPENDIX Q LABADIE ENERGY CENTER PROPOSED UTILITY WASTE LANDFILL SITE LOCATION MAP
CHKD. R.L.R. (G.E.R.)	
SUPV. T.R.G. (G.E.R.)	
APPD. T.R.G. (G.E.R.)	LOCATION 001009 · LABADIE ENERGY CENTER · CLASS 02010

Ameren MISSOURI ST. LOUIS, MISSOURI

REV.

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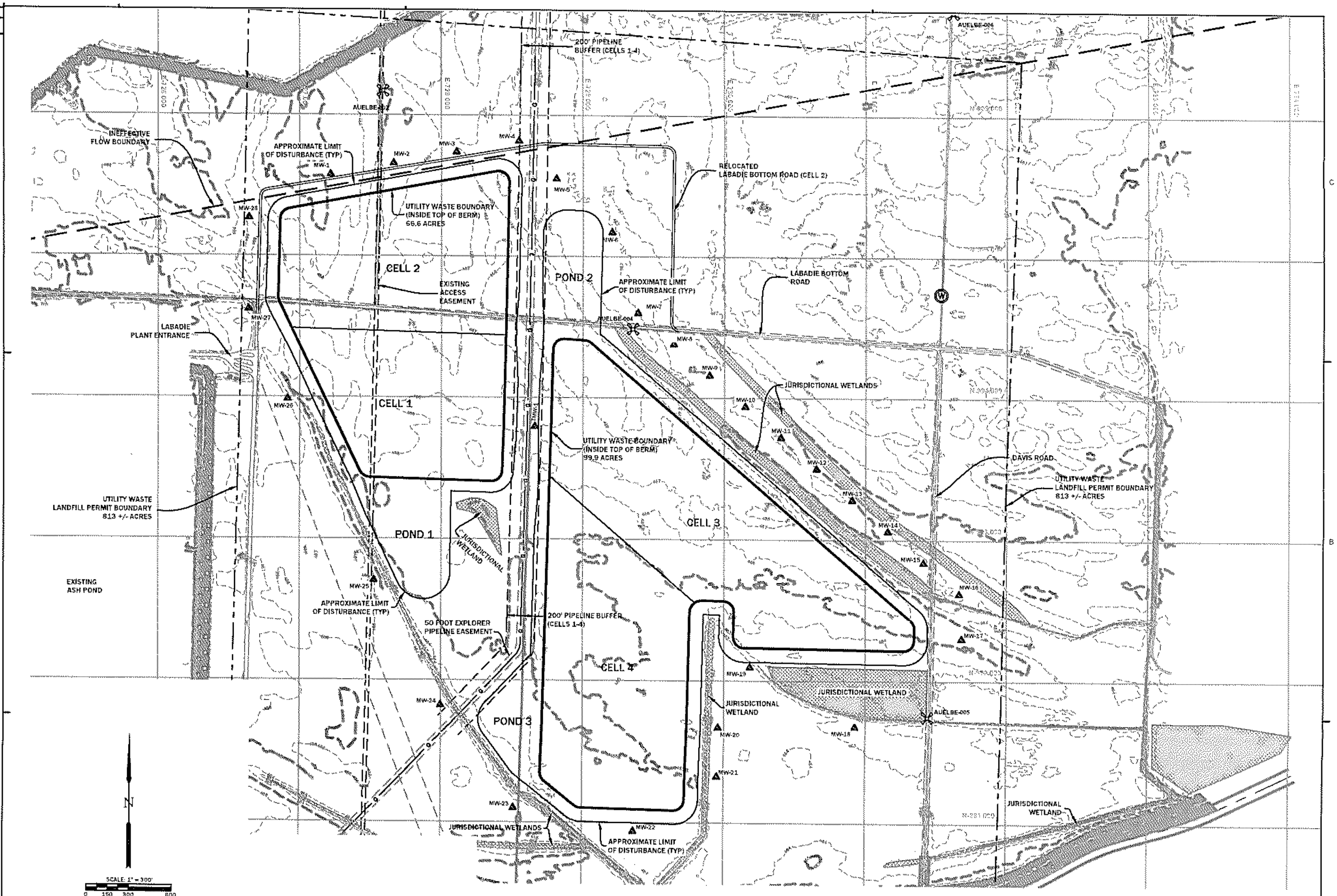

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996729.00	731621.70	467.67

Missouri State Plane Coordinate System Datum-
Horizontal Datum NAD 1983,
Vertical Datum NAVD 1988

NOTES TO THE CONTRACTOR:

UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS AND THEREFORE, THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS AT PRESENT NOT KNOWN. VERIFICATION OF THE LOCATIONS OF UNDERGROUND UTILITIES, SHOWN OR NOT SHOWN, WILL BE THE RESPONSIBILITY OF THE CONSTRUCTION CONTRACTOR.

THE CONTRACTOR SHALL MAKE SUITABLE AND TIMELY REQUESTS TO ALL UTILITY OWNERS, PIPELINE OWNERS, OR OTHER PARTIES AFFECTED TO HAVE ALL NECESSARY ADJUSTMENTS OF PUBLIC OR PRIVATE UTILITIES, PIPE LINES, OR OTHER APPURTENANCES WITHIN, OR ADJACENT TO THE LIMITS OF CONSTRUCTION, AS SOON AS PRACTICAL OR POSSIBLE.

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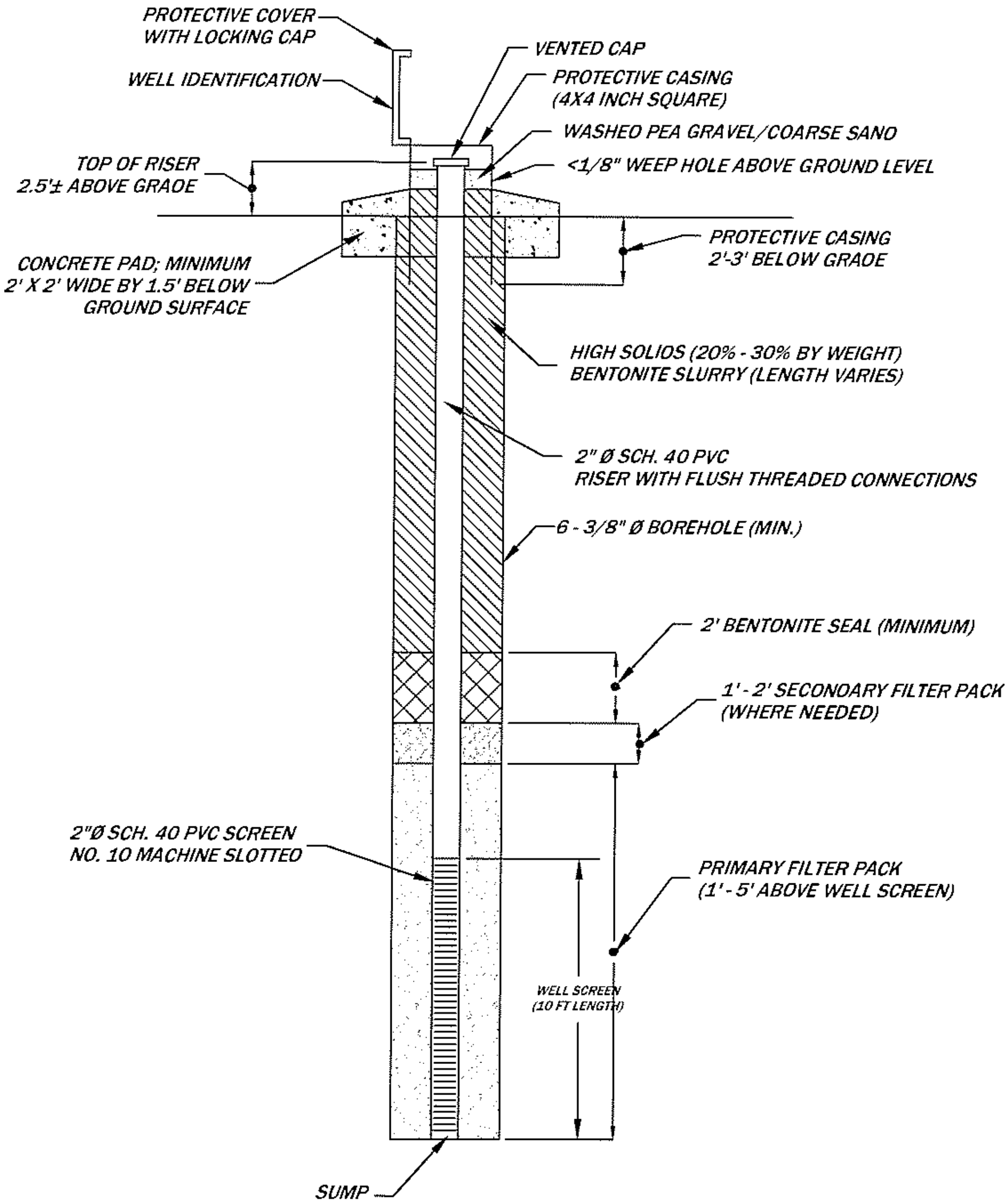
CHKD.	R.L.R. (G.E.R.)
SUPV.	T.R.G. (G.E.R.)
APPD.	T.R.G. (G.E.R.)

FIGURE 2, APPENDIX Q
PROPOSED UTILITY WASTE LANDFILL
MONITORING WELL LOCATION MAP

LOCATION 001009 | LABADIE ENERGY CENTER | CLASS 02010

Ameren Missouri | ST. LOUIS, MISSOURI | DECEMBER 18, 2012 | REV 0



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PREPARED FOR Ameren MISSOURI

DRAWN A.J.K. (G.E.R.)	FIGURE 3, APPENDIX Q PROPOSED UTILITY WASTE LANDFILL TYPICAL GROUNDWATER MONITORING WELL CONSTRUCTION DETAIL
CHKD. M.C.C. (G.E.R.)	
SUPV. M.C.C. (G.E.R.)	
APPD. T.R.G. (G.E.R.)	LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010
Ameren MISSOURI — ST. LOUIS, MISSOURI	DECEMBER 18, 2012 — REV.

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Tables

Construction Permit Application
Proposed Utility Waste Landill
Ameren Missouri Labadie Energy Center
Franklin County, Missouri

Groundwater Sampling and Analysis Plan
Groundwater Monitoring Well Summary
Table 1

Monitoring Well Designation	Upgradient or Downgradient	Northing	Easting	Ground Surface Elevation (approx.)	Well Depth (feet, bgs)	Screen Length (feet)	Top of Screen Interval Elevation (approx.)
MW-1	DG	995574	727216	470	25	10	455
MW-2	DG	995656	727662	469	23	10	456
MW-3	DG	995738	728106	468	22	10	456
MW-4	DG	995819	728547	468	21	10	457
MW-5	DG	995548	728812	468	21	10	457
MW-6	DG	995171	729206	467	20	10	457
MW-7	DG	994600	729389	467	19	10	458
MW-8	DG	994380	729642	466	18	10	458
MW-9	DG	994160	729895	465	17	10	458
MW-10	DG	993940	730147	466	18	10	458
MW-11	DG	993720	730400	466	18	10	458
MW-12	DG	993500	730653	465	17	10	458
MW-13	DG	993280	730905	465	17	10	458
MW-14	DG	993060	731158	464	16	10	458
MW-15	DG	992840	731410	464	15	10	459
MW-16	DG	992620	731663	464	15	10	459
MW-17	DG	992302	731681	465	16	10	459
MW-18	DG	991674	730925	462	13	10	459
MW-19	DG	992096	730184	463	15	10	458
MW-20	DG	991668	729958	463	14	10	459
MW-21	DG	991332	729953	463	14	10	459
MW-22	UG	990940	729361	464	15	10	459
MW-23	UG	991102	728514	465	17	10	458
MW-24	UG	991822	727995	465	17	10	458
MW-25	UG	992708	727524	466	18	10	458
MW-26	UG	993986	726913	467	20	10	457
MW-27	UG	994619	726637	468	22	10	456
MW-28	UG	995267	726640	469	24	10	455
TMW-1	DG	993795	728659	467	19	10	458

NOTES:

1. Refer to Figure 2 for proposed monitoring well locations.
2. TMW-1 is a temporary ("sentry") well located immediately east of initial cell construction area (Cell 1).
3. Basis for permanent well locations described in "Documentation of Groundwater Monitoring Well Design"; see Appendix X of Construction Permit Application.
4. Refer to Figure 3 for typical well construction details.
5. MW-1 through MW-21, and TMW-1, denote generally downgradient well positions. MW-22 through MW-28 denote generally upgradient well positions.

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Franklin County, Missouri

Groundwater Sampling and Analysis Plan
Groundwater Monitoring Schedule
Table 2

Time	Item to Be Completed	Reports to MDNR
27 or 28 months before initial UWL operation	Install and develop groundwater monitoring wells.	Monitoring well installation records to Wellhead Protection Program
26 months before initial UWL operation	Initial sampling event	Initial groundwater field sampling and laboratory data to Solid Waste Management Program (SWMP)
23 months before initial UWL operation	Second sampling event	Groundwater field sampling and laboratory data to SWMP
20 months before initial UWL operation	Third sampling event	Groundwater field sampling and laboratory data to SWMP
17 months before initial UWL operation	Fourth sampling event	Groundwater field sampling and laboratory data to SWMP
14 months before initial UWL operation	Fifth round of sampling	Groundwater field sampling and laboratory data to SWMP
11 months before initial UWL operation	Sixth round of sampling	Groundwater field sampling and laboratory data to SWMP
8 months before initial UWL operation	Seventh round of sampling	Groundwater field sampling and laboratory data to SWMP
5 months before initial UWL operation	Eighth round of sampling	Report on field sampling and analytical data distributions and choice of intra-well or inter-well statistics to SWMP. Includes groundwater sampling data.
2 months before initial UWL operation	Submit Request for Operating Permit to MDNR	MDNR-SWMP has 60 days to review the submittal and make a decision on the Operating Permit.
Initial UWL operations begin.	N/A	N/A
Continue monitoring once per six months during May and November	Semi-annual sampling for routine detection monitoring	Groundwater field sampling, laboratory data and statistical report within 90 days of each subsequent sampling event to SWMP

Appendices

Appendix 1

Driller's Logs and Monitoring Well Construction Details

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Information to be included following installation of groundwater monitoring wells.

Appendix 2

Missouri Solid Waste Management Rule Constituents for Detection Monitoring (10 CSR 80-11.010, Appendix I)

Ameren Missouri Labadie Energy Center
Groundwater Sampling and Analysis Plan

Constituents for Detection Monitoring
10 CSR 80-11.010 (Appendix I)

Chemical Constituent	Units	Method[1]	PQL[2]
Aluminum (Al)	ug/l	6010B	50
Antimony (Sb)	ug/l	7041	5
Arsenic (As)	ug/l	7060A	3
Barium (Ba)	ug/l	6010B	5
Beryllium (Be)	ug/l	6010B	1
Boron (B)	ug/l	6010B	20
Cadmium (Cd)	ug/l	6010B	2
Calcium (Ca)	mg/l	6010B	0.05
Chemical Oxygen Demand (COD)	mg/l	410.4	10
Chloride	mg/l	9251	1
Chromium (Cr)	ug/l	6010B	10
Cobalt (Co)	ug/l	6010B	10
Copper (Cu)	ug/l	6010B	10
Fluoride	mg/l	9214	0.10
Hardness	mg/l	2340C	NA
Iron (Fe)	mg/l	6010B	20
Lead (Pb)	ug/l	7421	2
Magnesium (Mg)	mg/l	6010B	0.010
Manganese (Mn)	ug/l	6010B	5
Mercury (Hg)	ug/l	7470A	0.2
Nickel (Ni)	mg/l	6010B	10
pH	S.U.	9040B	NA
Selenium (Se)	ug/l	6010B	50
Silver (Ag)	ug/l	6010B	10
Sodium (Na)	mg/l	6010B	0.05
Specific Conductance	umhos/cm	9050A	NA
Sulfate	mg/l	9036	50
Thallium (Tl)	ug/l	7841	2
Total Dissolved Solids (TDS)	mg/l	2540C	20
Total Organic Carbon (TOC)	mg/l	9060	1
Total Organic Halogens (TOX)	ug/l	9020B	20
Zinc (Zn)	ug/l	6010B	10
Ground Water Elevation	feet	NA	NA

1. Suggested Methods refer to analytical procedure numbers used in EPA Report SW-846 "Test Methods for Evaluating Solid Waste", third edition, November 1986, as revised, December 1987, or applicable updates.
2. Practical Quantitation Limits as established by the contract laboratory.

Appendix 3

Field Equipment Calibration Forms and Procedures

Field Instrumentation Calibration Log

Calibrated by: ______________________________

Field Instrument ________ ________

S/N # ________ ________ ________ ________

	Date	Time	pH Standards		pH Measurements	Specific Conductivity Standard (μs/cm)		Specific Conductivity Measurement (μs/cm)	Oxidation Reduction Potential Standard (mV)				Oxidation Reduction Potential Measurement (mV)	Turbidity Standards (NTU)		Turbidity Measurements (NTU)
Beginning of Day Calibration			4.00	=		1413	=		Temperature (°C)	=		=		0.02	=	
			7.00	=					Standard (mV)	=				10.0	=	
			10.00	=										1000	=	
End of Day Check			4.00	=		1413	=		Temperature (°C)	=		=		0.02	=	
			7.00	=					Standard (mV)	=				10.0	=	
			10.00	=										1000	=	

Notes: ______________________________

I certify that the aforementioned meters were calibrated within the manufactures specifications.

Date: ________ By: ______________________________

Prepared by GREDELL Engineering Resources, Inc.

ORP Interpolation Reference Table

Temperture °C	ORP mV	Temperture °C	ORP mV	Temperture °C	ORP mV	Temperture °C	ORP mV	Temperture °C	ORP mV	Temperture °C	ORP mV	Temperture °C	ORP mV
0.0	237.0	6.6	231.4	13.2	228.1	19.7	223.2	26.3	219.0	32.7	214.4	39.3	209.6
0.1	236.9	6.7	231.3	13.3	228.0	19.8	223.2	26.4	218.9	32.8	214.3	39.4	209.5
0.2	236.8	6.8	231.3	13.4	228.0	19.9	223.1	26.5	218.8	32.9	214.3	39.5	209.4
0.3	236.7	6.9	231.2	13.4	228.0	20.0	223.0	26.6	218.7	33.0	214.2	39.6	209.3
0.4	236.6	7.0	231.2	13.5	227.9	20.1	222.9	26.7	218.6	33.1	214.1	39.7	209.2
0.5	236.5	7.1	231.2	13.6	227.8	20.2	222.9	26.8	218.6	33.2	214.1	39.8	209.2
0.6	236.4	7.2	231.1	13.7	227.8	20.3	222.8	26.9	218.5	33.3	214.0	39.9	209.1
0.7	236.3	7.3	231.1	13.8	227.7	20.4	222.8	27.0	218.4	33.4	214.0	40.0	209.0
0.8	236.2	7.4	231.0	13.9	227.7	20.5	222.7	27.1	218.3	33.5	213.9	40.1	208.9
0.9	236.1	7.5	231.0	14.0	227.6	20.6	222.6	27.2	218.2	33.6	213.8	40.2	208.8
1.0	236.0	7.6	231.0	14.1	227.5	20.7	222.6	27.3	218.2	33.7	213.8	40.3	208.8
1.1	235.9	7.7	230.9	14.2	227.5	20.8	222.5	27.4	218.1	33.8	213.7	40.4	208.7
1.2	235.8	7.8	230.9	14.3	227.4	20.9	222.5	27.5	218.0	33.9	213.7	40.5	208.6
1.3	235.7	7.9	230.8	14.4	227.4	21.0	222.4	27.6	217.9	34.0	213.6	40.6	208.5
1.4	235.6	8.0	230.8	14.5	227.3	21.1	222.3	27.7	217.8	34.1	213.5	40.7	208.4
1.5	235.5	8.1	230.8	14.6	227.2	21.2	222.3	27.8	217.8	34.2	213.5	40.8	208.4
1.6	235.4	8.2	230.7	14.7	227.2	21.3	222.2	27.9	217.7	34.3	213.4	40.9	208.3
1.7	235.3	8.3	230.7	14.8	227.1	21.4	222.2	28.0	217.6	34.4	213.4	41.0	208.2
1.8	235.2	8.4	230.6	14.9	227.1	21.5	222.1	28.1	217.5	34.5	213.3	41.1	208.1
1.9	235.1	8.5	230.6	15.0	227.0	21.6	222.0	28.2	217.4	34.6	213.2	41.2	208.0
2.0	235.0	8.6	230.6	15.1	226.9	21.7	222.0	28.3	217.4	34.7	213.2	41.3	208.0
2.1	234.9	8.7	230.5	15.2	226.8	21.8	221.9	28.4	217.3	34.8	213.1	41.4	207.9
2.2	234.8	8.8	230.5	15.3	226.8	21.9	221.9	28.5	217.2	34.9	213.1	41.5	207.8
2.3	234.7	8.9	230.4	15.4	226.7	22.0	221.8	28.6	217.1	35.0	213.0	41.6	207.7
2.4	234.6	9.0	230.4	15.5	226.6	22.1	221.7	28.7	217.0	35.1	212.9	41.7	207.6
2.5	234.5	9.1	230.4	15.6	226.5	22.2	221.7	28.8	217.0	35.2	212.8	41.8	207.6
2.6	234.4	9.2	230.3	15.7	226.4	22.3	221.6	28.9	216.9	35.3	212.8	41.9	207.5
2.7	234.3	9.3	230.3	15.8	226.4	22.4	221.6	29.0	216.8	35.4	212.7	42.0	207.4
2.8	234.2	9.4	230.2	15.9	226.3	22.5	221.5	29.1	216.7	35.5	212.6	42.1	207.3
2.9	234.1	9.5	230.2	16.0	226.2	22.6	221.4	29.2	216.6	35.6	212.5	42.2	207.2
3.0	234.0	9.6	230.2	16.1	226.1	22.7	221.4	29.3	216.6	35.7	212.4	42.3	207.2
3.1	233.9	9.7	230.1	16.2	226.0	22.8	221.3	29.4	216.5	35.8	212.4	42.4	207.1
3.2	233.8	9.8	230.1	16.3	226.0	22.9	221.3	29.3	216.6	35.9	212.3	42.5	207.0
3.3	233.7	9.9	230.0	16.4	225.9	23.0	221.2	29.4	216.5	36.0	212.2	42.6	206.9
3.4	233.6	10.0	230.0	16.5	225.8	23.1	221.1	29.5	216.4	36.1	212.1	42.7	206.8
3.5	233.5	10.1	229.9	16.6	225.7	23.2	221.1	29.6	216.3	36.2	212.0	42.8	206.8
3.6	233.4	10.2	229.9	16.7	225.6	23.3	221.0	29.7	216.2	36.3	212.0	42.9	206.7
3.7	233.3	10.3	229.8	16.8	225.6	23.4	221.0	29.8	216.2	36.4	211.9	43.0	206.6
3.8	233.2	10.4	229.8	16.9	225.5	23.5	220.9	29.9	216.1	36.5	211.8	43.1	206.5
3.9	233.1	10.5	229.7	17.0	225.4	23.6	220.8	30.0	216.0	36.6	211.7	43.2	206.4
4.0	233.0	10.6	229.6	17.1	225.3	23.7	220.8	30.1	215.9	36.7	211.6	43.3	206.4
4.1	232.9	10.7	229.6	17.2	225.2	23.8	220.7	30.2	215.9	36.8	211.6	43.4	206.3
4.2	232.8	10.8	229.5	17.3	225.2	23.9	220.7	30.3	215.8	36.9	211.5	43.5	206.2
4.3	232.7	10.9	229.5	17.4	225.1	24.0	220.6	30.4	215.8	37.0	211.4	43.6	206.1
4.4	232.6	11.0	229.4	17.5	225.0	24.1	220.5	30.5	215.7	37.1	211.3	43.7	206.0
4.5	232.5	11.1	229.3	17.6	224.9	24.2	220.5	30.6	215.6	37.2	211.2	43.8	206.0
4.6	232.4	11.2	229.3	17.7	224.8	24.3	220.4	30.7	215.6	37.3	211.2	43.9	205.9
4.7	232.3	11.3	229.2	17.8	224.8	24.4	220.4	30.8	215.5	37.4	211.1	44.0	205.8
4.8	232.2	11.4	229.2	17.9	224.7	24.5	220.3	30.9	215.5	37.5	211.0	44.1	205.7
4.9	232.1	11.5	229.1	18.0	224.6	24.6	220.2	31.0	215.4	37.6	210.9	44.2	205.6
5.0	232.0	11.6	229.0	18.1	224.5	24.7	220.2	31.1	215.3	37.7	210.8	44.3	205.6
5.1	232.0	11.7	229.0	18.2	224.4	24.8	220.1	31.2	215.3	37.8	210.8	44.4	205.5
5.2	231.9	11.8	228.9	18.3	224.4	24.9	220.1	31.3	215.2	37.9	210.7	44.5	205.4
5.3	231.9	11.9	228.9	18.4	224.3	25.0	220.0	31.4	215.2	38.0	210.6	44.6	205.3
5.4	231.8	12.0	228.8	18.5	224.2	25.1	219.9	31.5	215.1	38.1	210.5	44.7	205.2
5.5	231.8	12.1	228.7	18.6	224.1	25.2	219.8	31.6	215.0	38.2	210.4	44.8	205.2
5.6	231.8	12.2	228.7	18.7	224.0	25.3	219.8	31.7	215.0	38.3	210.4	44.9	205.1
5.7	231.7	12.3	228.6	18.8	224.0	25.4	219.7	31.8	214.9	38.4	210.3	45.0	205.0
5.8	231.7	12.4	228.6	18.9	223.9	25.5	219.6	31.9	214.9	38.5	210.2		
5.9	231.6	12.5	228.5	19.0	223.8	25.6	219.5	32.0	214.8	38.6	210.1		
6.0	231.6	12.6	228.4	19.1	223.7	25.7	219.4	32.1	214.7	38.7	210.0		
6.1	231.6	12.7	228.4	19.2	223.6	25.8	219.4	32.2	214.7	38.8	210.0		
6.2	231.5	12.8	228.3	19.3	223.6	25.9	219.3	32.3	214.6	38.9	209.9		
6.3	231.5	12.9	228.3	19.4	223.5	26.0	219.2	32.4	214.6	39.0	209.8		
6.4	231.4	13.0	228.2	19.5	223.4	26.1	219.1	32.5	214.5	39.1	209.7		
6.5	231.4	13.1	228.1	19.6	223.3	26.2	219.0	32.6	214.4	39.2	209.6		

Note: Standard ORP measurements 0, 5, 10, 15, 20, 25, 30, 35, and 40 were provided by Geotech Environmental Equipment, Inc.
The rest of the standard ORP measurements were interpolated from Geotech Standard ORP measurements.

FIELD EQUIPMENT CALIBRATION PROCEDURES

Multi-meter pH, Temperature, Conductivity, Oxidation Reduction Potential (ORP)

pH Calibration/Operation Procedures

(Reference EPA Method 9040)

The field pH meter will be calibrated each day water samples are collected. Calibration results will be recorded on the Field Instrumentation Calibration Log in Appendix 3 of the Sampling and Analysis Plan.

pH Three-Buffer Calibration

This procedure is recommended for precise measurements.

1. Select three buffers which bracket the expected sample pH. The first should be near the electrode isopotential point (pH 7) and the second and third should bracket the expected sample pH (e.g. pH 4 and pH 10).
2. Rinse electrode first with distilled water and then with pH 7 buffer. Place the electrode in pH 7 buffer.
3. Wait for stable display. Set the meter to the pH value of the buffer at its measured temperature. (ATC @ 25°C = 7.00).
4. Rinse electrode first with distilled water and then with the second buffer. Place the electrode in the second buffer.
5. When the display is table, set the meter to the actual pH value of the buffer as described in the meter instruction manual.
6. Rinse electrode first with distilled water and then with the third buffer. Place the electrode in the third buffer.
7. When the display is table, set the meter to the actual pH value of the buffer as described in the meter instruction manual.
8. If all steps are performed correctly, and the slope is between 92 and 102%, proceed to pH Measurement.

For detailed calibration and temperature compensation procedures, consult meter instruction manual.

pH Measurement

1. Obtain a neat sample from collection device and place electrode directly into sample.
2. Allow reading to stabilize.
3. Record pH reading directly from meter and record on the Field Sampling Log.
4. Probes are to be decontaminated by multiple rinses with distilled water.

If the above procedures do not work, refer to Troubleshooting section of instrument instruction manual.

Measuring Hints

1. Always use fresh buffers for calibration. Choose buffers that are no more than 3 pH units apart.
2. Check electrode slope daily by performing a three-buffer calibration. Slope should be 92 to 102%.
3. Between measurements, rinse electrodes with distilled water and then with the next solution to be measured.
4. Stir all buffers and samples.
5. Avoid rubbing or wiping electrode bulb, to reduce chance of error due to polarization.

Interferences

Oil samples and salty samples may leave residues on the electrodes. The probe has to be rinsed thoroughly between all measurements using distilled water to remove salt residues. If oily residues need to be removed, rinse with acetone then distilled water. The electrodes need to be kept wet to ensure proper response.

FIELD EQUIPMENT CALIBRATION PROCEDURES

Conductivity/Temperature Calibration/ Operation Procedures

(Reference EPA Method 9050)

Calibration Procedures

Conductivity will be checked at a minimum of once per day using commercial traceable standards in the 1000 and 10,000 mmhos/cm range and recorded on the Field Instrumentation Calibration Log. Calibration checks outside of a ± 10% range are not acceptable and will require the sensor replacement and/or re-check of the standards. If calibration check standards are still outside ± 10% range, use alternate meter. Do not proceed with sample collection without acceptable calibration checks.

Temperature measurement is factory calibrated. Temperature will be checked for calibration by comparison with a laboratory thermometer within a ± 10% range prior to the sample event.

Temperature Measurement

Report all values on the Field Sampling Log in degrees Celsius (°C).

1. Immerse the temperature/conductivity sensor into the sample.
2. Record temperature reading directly from meter and record on the Field Sampling Log.

Conductivity Measurement

Report all values on the Field Sampling Log in umhos/cm (uS/cm).

1. Immerse the temperature/conductivity sensor into the sample.
2. Record conductivity reading directly from meter and record on the Field Sampling Log.
3. Sensors are to be decontaminated by multiple rinses with distilled water.

Most meters have a fixed temperature coefficient (TC) of 2.1% per °C and a fixed reference temperature of 25°C. These parameters are sufficient for the majority of "natural water" samples.

FIELD EQUIPMENT CALIBRATION PROCEDURES

Oxidation Reduction Potential (ORP) Calibration/ Operation Procedures

(Reference YSI Environmental)

ORP Calibration

Report all values on the Field Instrumentation Calibration Log in millivolts (mV).

1. Select ORP.
2. Immerse the sensor into the calibration solution.
3. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature (Refer to the Appendix 3 ORP Interpolation Reference Table in the Sampling and Analysis Plan).
4. Record ORP reading directly from meter and record on the Field Instrumentation Calibration Log.
5. Sensors are to be decontaminated by multiple rinses with distilled water.

ORP Measurement

Report all values on the Field Sampling Log in millivolts (mV).

1. Select ORP.
2. Immerse the sensor into the sample.
3. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature (Refer to the Appendix 3 ORP Interpolation Reference Table in the Sampling and Analysis Plan).
4. Record ORP reading directly from meter and record on the Field Sampling Log.
5. Sensors are to be decontaminated by multiple rinses with distilled water.

Low-Flow cell calibration

The manufacturer's recommended procedures shall be followed for low-flow cell calibration. A copy of these procedures is to be made a part of this sampling and analysis plan.

FIELD EQUIPMENT CALIBRATION PROCEDURES

Turbidimeter Calibration/ Operation Procedures

(Reference HF Scientific)

The Turbidimeter allows for the measurement of turbidity in the field. The instrument measures and reports the turbidity of a sample in nephelometric turbidity units (NTU's).

Turbidimeter Calibration

The instrument was calibrated and tested prior to leaving the factory. The instrument requires three (3) standards to be calibrated.

1. Select the calibration function of the instrument by pressing the CAL button once. The "CAL" block will be illuminated on the display with "1" indicating the standard required for this step of the calibration. This is the first standard that should be used in a full calibration.
2. Insert the 1000 NTU standard (CAL 1 in the figure above) into the sample well and press down until the cuvette snaps fully into the instrument. Align the indexing ring with the arrow on the instrument.
3. Wait for the reading to stabilize. Once the reading has stabilized press the enter button to indicate to the instrument that it should calibrate on this point.
4. When the instrument has completed calibration on this point, it prompts you to insert the next calibration standard into the sample well (CAL 2).
5. Repeat steps 2-4 for each calibration standard. When you calibrate on CAL 3 (turbidity free water), the instrument will automatically exit out of calibration returning back to the normal operating mode.

Turbidimeter Measurement

Turn on the instrument by pressing the ON/OFF button continuously for 1 second. Allow 75-second warm-up period while preparing for the turbidity measurement as described in the following steps:

1. Sample approximately 100 ml of your process, as you would normally do for turbidity measurement.
2. Obtain a clean and dry sample cuvette.
3. Rinse the cuvette with approximately 10 ml of the sample water (2/3 of cuvette volume), capping the cuvette with the black light shield (cuvette top) and inverting several times. Discard the used sample and repeat the rinsing procedure two more times.
4. Completely fill the rinsed cuvette (from step 3) with the remaining portion (approximately 15 ml) of the grab sample and then cap the cuvette with the supplied cap. Ensure that the outside of the cuvette is dry, clean and free from smudges.

5. Place the cuvette into the instrument and press it down until it snaps fully into the sample well. Index the cuvette by pressing and holding down the enter button while rotating the cuvette to identify the lowest reading (the displayed turbidity is continuously updated on the display). Once the cuvette is indexed, release the enter button to display the measured turbidity.

Appendix 4

Sample Container and Preservation Guidelines and Groundwater Sampling Bottle Inventory Form

Ameren Missouri LABADIE ENERGY CENTER
Groundwater Sampling and Analysis Plan

Sample Container and Preservation Guidelines

Measurement	Volume Req., (ml)	Container[a]	Preservative	Max. Holding Times	Reference
Specific Cond. (Field)	100	P, G	None	Det. on Site	1
pH (Field)	50	P, G	None	Det. on Site	1, 2
Temperature (Field)	1000	P,G	None	Det. on Site	1
Oxidation Reduction Potential	1000	P,G	None	Det. on Site	
Turbidity	1000	P,G	None	Det. on Site	
Inorganics, Non-Metallics					
Fluoride	300	P, G	HNO_3 to pH <2	28	1, 2
Total Organic Carbon	100	G_b	Cool, 4°C; HCl or H_2SO_4 to pH <2	28	1
Total Dissolved Solids	500	P, G	Cool, 4°C	7 Days	1,4
Chloride	500	P, G	Cool,4°C	28 Days	1, 2
Sulfate	200	P, G	Cool, 4°C	28 Days	1, 2,4
Total Organic Halides (TOX)	2000	G	Cool, 4°C; HCl or H_2SO_4 to pH <2	7 Days	4
COD	50	P, G	H_2SO_4 to pH <2	28 Days	1
Metals					
Total Recoverable	500	P, G	HNO_3 to pH <2	6 Mos	1, 2
Mercury	500	P, G	HNO_3 to pH <2	28 Days	1, 2

NOTES:

a. Plastic (P) or Glass (G). For metals, polyethylene with an all polypropylene cap is preferred.
b. Use Teflon© lined cap.
c. Silver requires an amber bottle

REFERENCES:

1. Methods for Chemical Analysis of Water and Wastes, March, 1983, USEPA, 600/4-79-020 and additions thereto.
2. Test Methods for Evaluating Solid Waste, Physical/Chemical Method, November, 1986, Third Edition, USEPA, SW-846 and additions thereto.
3. Guidelines Establishing Test Procedures for the Analysis of Pollutant Under the Clean Water Act", Environmental Protection Agency, Code of Federal Regulations (CFR), Title 40, Part 136.
4. MDNR-FSS-001, Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations, Randy Crawford, Trish Rielly, Water Quality Monitoring Section, MDNR ESP September 17, 2003

Groundwater Sampling Bottle Inventory

Well ID	Date Received	Bottles Received					
		Chloride, Sulfate, Fluoride, Hardness, and TDS 1,000 mL - 1 Total (pl - none)	Metals 500 mL (pl - HNO_3)	TOX 500 mL (gl - H_2SO_4)	TOC 125 mL Amber (gl - H_2SO_4)	COD 125 mL (pl - H_2SO_4)	Broken or Damaged Bottles
Extra # 1							
Extra # 2							
Duplicate # 1							
Duplicate # 2							
Field Blank							
Trip Blank							

Bottles delivered by: ______________________

H_2SO_4 = Sulfuric Acid

HNO_3 = Nitric Acid

Appendix 5

Monitoring Well Field Inspection Form

Monitoring Well Field Inspection

Facility: Ameren Missouri Labadie Energy Center Utility Waste Landfill

Monitoring Well ID: ____________________

Name (Field Sampler): ____________________________

Date: ____________

Access:

Accessibility: Good ___ Fair ___ Poor_____

Well clear of weeds and/or debris?: Yes ___ No ______

Well identification clearly visible?: Yes ___ No ______

Remarks:

Concrete Pad:

Condition of Concrete Pad: Good ___ Inadequate _____

Depressions or standing water around well?: Yes ___ No_____

Remarks:

Protective Outer Casing: Material =

Condition of Protective Casing: Good ___ Damaged_____

Condition of Locking Cap: Good ___ Damaged_____

Condition of Lock: Good ___ Damaged_____

Condition of Weep Hole: Good ___ Damaged_____

Remarks:

Well Riser: Material =

Condition of Riser: Good ___ Damaged_____

Condition of Riser Cap: Good ___ Damaged_____

Measurement Reference Point: Yes ___ No_____

Remarks:

Dedicated Purging/Sampling Device: Type -

Condition: Good ___ Damaged ___ Missing_____

Remarks:

Field Certification

Signed Title Date

Appendix 6

Field Sampling Log and
Volume Tracking Log Forms

Field Sampling Log

Facility: Ameren Missouri Labadie Energy Center UWL

Date: ____________________ Monitoring Well ID: ____________________

Name (Field Sampler): ____________________

Gas Detected Y / N

PURGE INFORMATION:

Method of Well Purge: ____________________ Dedicated? Y / N

Date/Time Initiated: ____________________ One (1) Well Volume (ml): ____________________

Initial Water Level (feet): ____________________ Total Volume Purged (ml): ____________________

GroundWater Elevation (NGVD): ____________________ Well Purged To Dryness? Y / N

Well Total Depth (feet): ____________________ Water Level after Purge (feet): ____________________

Casing Diameter (feet): ____________________ Date/Time Completed: ____________________

PURGE DATA:

Time	Purge Rate (ml/min)	Cumulative Volume (ml)	Temp (°C)	pH	Specific Conductivity (μS)	Oxidation Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Water Level	Notes

Field Sampling Log

Sampling Information: Date: ________ Monitoring Well ID: ________

Method of Sampling: low flow, peristaltic pump Dedicated: (Y) / N

Water Level @ Sampling, Feet: ________

Monitoring Event: Annual ( ) Semi-Annual ( ) Quarterly (x) Monthly ( ) Other ( )

Sampling Data:

Date/Time	Sample Rate ml/min	Temp (°C)	pH	Specific Conductivity (µS)	Oxidation Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)

Instrument Check Data:

pH Meter Serial #: 1* 4.0 std. = 1* 7.0 std. = 1* 10.0 std. 1*

Conduct. Meter Serial #: 1* standard = 1* µS reading = 1* µS

Turbidity Meter Serial #: 1* standard = 1* NTU reading = 1* NTU

* See instrument calibration log for daily calibration data.

General Information:

Weather Conditions @ time of sampling: ________

Sample Characteristics: ________

Sample Collection Order: Per SOP

Comments and Observations:

I certify that sampling procedures were in accordance with applicable EPA and State protocols.

Date: ________ By: ________ Title: ________

Prepared by GREDELL
Engineering Resources, Inc.

Volume Tracking Log

Facility Name: Ameren Missouri Labadie Energy Center UWL		
Well ID	**Tally notes**	**Total Volume (mL)**

Note: Each Tick mark is equal to 1000 mL or 1L.
Total volume based on a 1L graduated cylinder.

Appendix 7

Example Chain-of-Custody Field Record Form

Chain of Custody Record

Date: ____________ Page: _____ of _____

Plant Manager — Contact Name
314-992-8201 — Phone Number
314-992-8204 — Fax Number

Ameren Missouri Labadie Energy Center UWL — Company Name

Labadie Bottom Road — Street Address

Labadie, MO 63055 — City, State, Zip

Labadie Power Plant — Project Name
Utility Waste Landfill — Site Location

Sample ID	Date Collected	Time	Matrix	Lab ID	Preservation Code	Number of Containers	Rush	Container Size	Analysis Request							Comments

Preservation Code
1 = 4°C
2 = HNO_3
3 = HCl
4 = H_2SO_4
5 = NaOH
6 = Other

Special Instructions / Comments

Route Results Through:
Circle: Fax Email

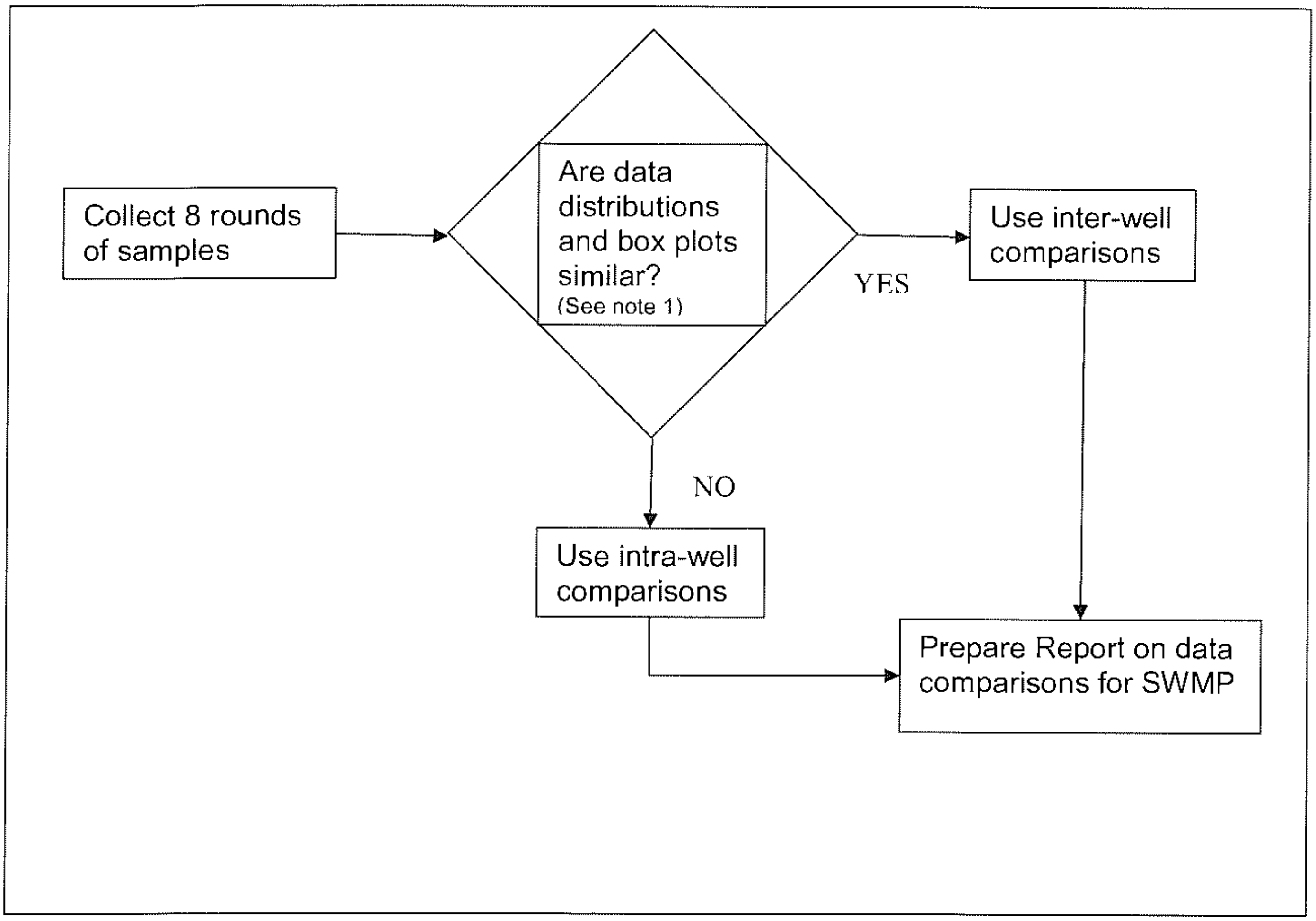
Email address:

(1) Relinquished By	(2) Relinquished By	Sampler Initials:
(1) Date / Time	(2) Date / Time	Method of Shipment
(1) Company	(2) Company	HAND CARRY USPS FEDX UPS
(1) Received By	(2) Received By	CoC
(1) Date / Time	(2) Date / Time	Seal Intact?
(1) Company	(2) Company	Yes No

Appendix 8

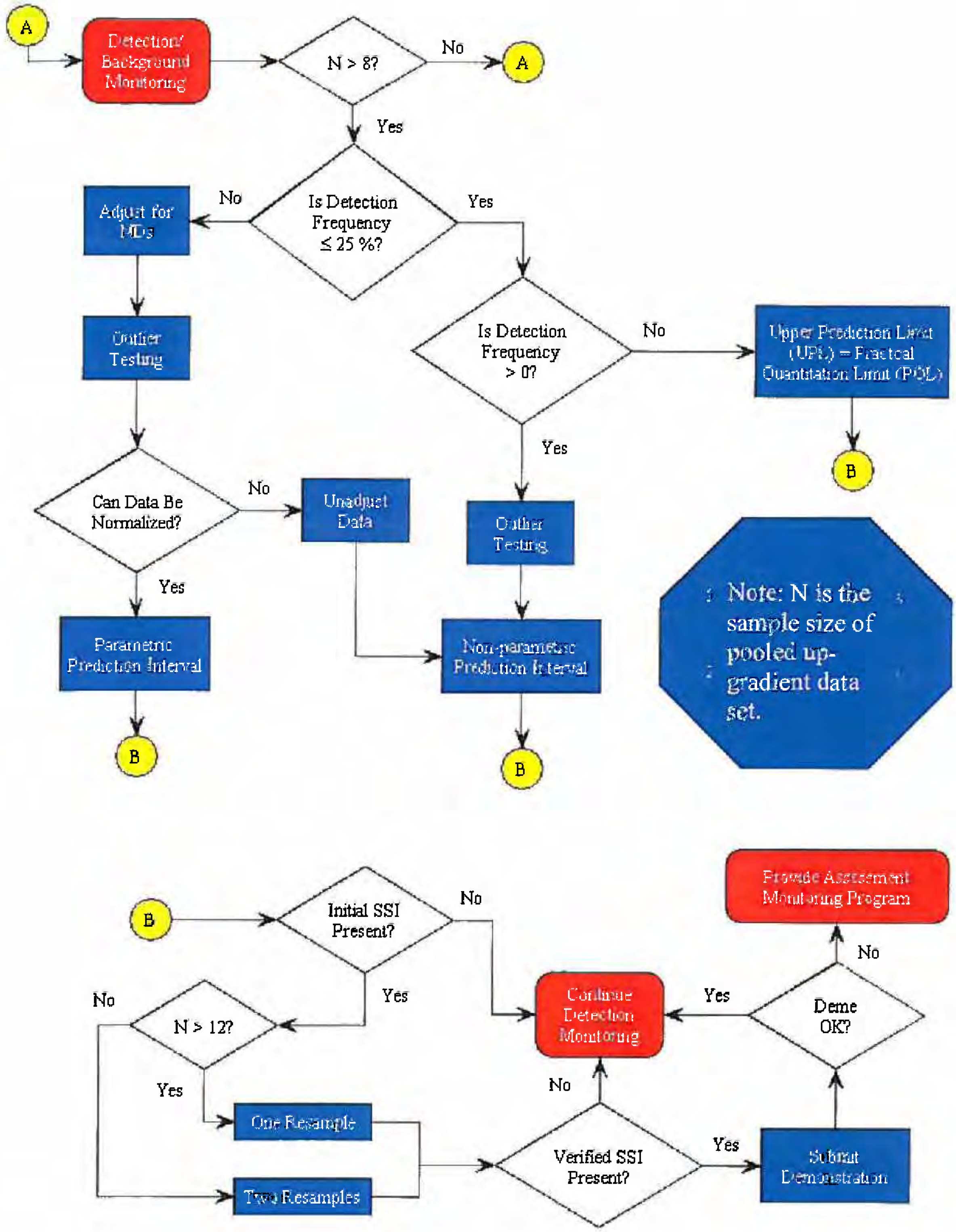
Decision Flow Charts

Selection of Statistical Procedure Based on Groundwater Background Data



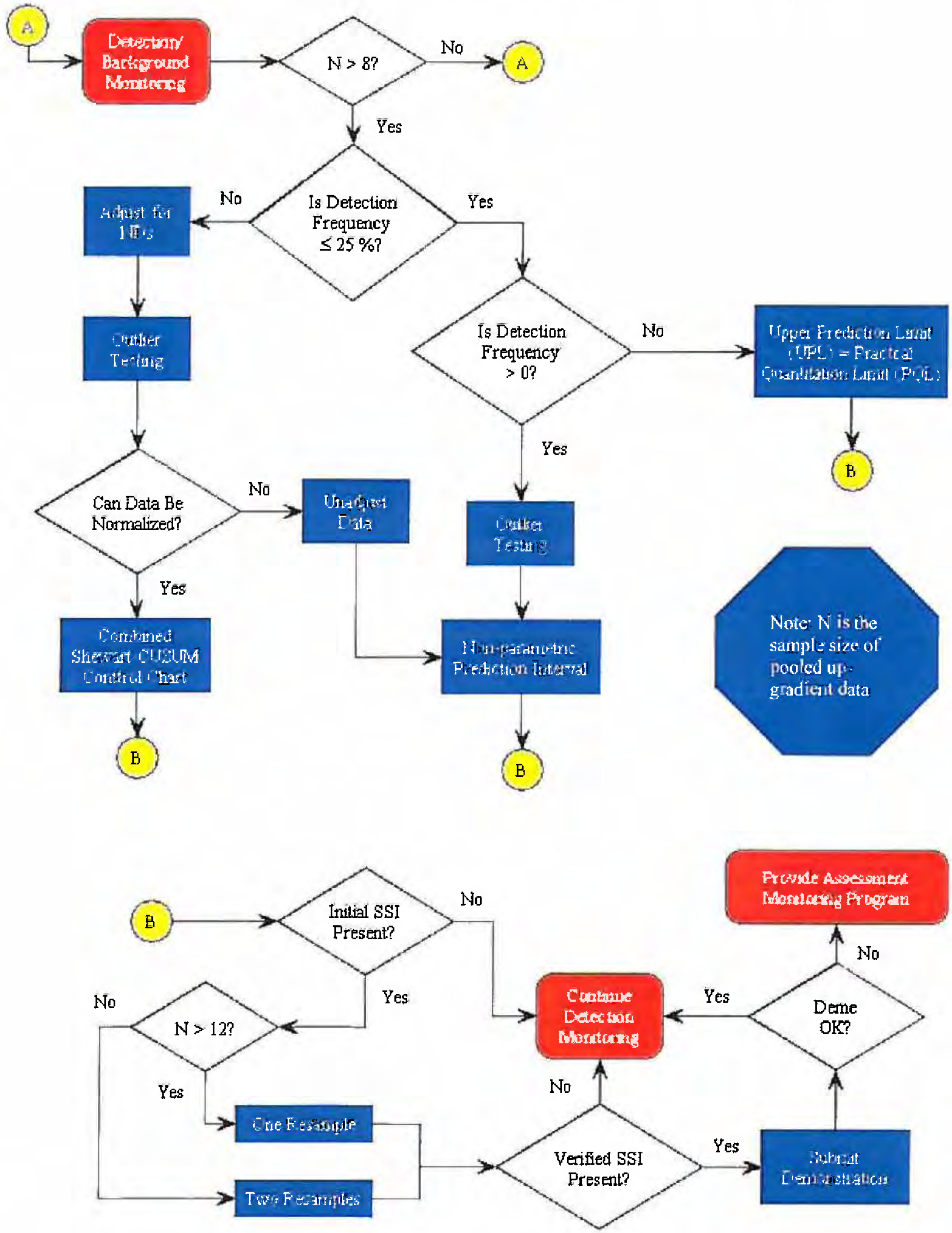
Note 1: This logic step is complex and will consist of various other steps. Exact steps are to be determined after data is available.

Attachment 1: Prediction Interval Test Strategy



Source: Missouri Department of Natural Resources Solid Waste Management Program DRAFT Technical Bulletin:"Statistical Analysis Plan Guidance", 4/26/01.

Attachment 2: Control Chart & Non-Parametric Prediction Interval Test Strategy



Source: Missouri Department of Natural Resources Solid Waste Management Program DRAFT Technical Bulletin:"Statistical Analysis Plan Guidance", 4/26/01.

Appendix R

Closure and Post-Closure Plan

Ameren Missouri Labadie Energy Center

Closure and Post-Closure Plan for a Proposed Utility Waste Landfill
Franklin County, Missouri

Ameren Missouri
Power Operation Services
3700 South Lindbergh Blvd.
St. Louis, Missouri 63127

December 2012

GREDELL Engineering Resources, Inc.
1505 East High Street
Jefferson City, Missouri 65101
Phone: (573) 659-9078
Fax: (573) 659-9079

Ameren Missouri Labadie Energy Center
Closure and Post-Closure Plan
Proposed Utility Waste Landfill
Franklin County, Missouri

December 2012

Table of Contents

List of Appendices

1.0 Introduction

This Closure and Post-Closure Plan provides the criteria necessary to properly close and maintain the Ameren Missouri Labadie Utility Waste Landfill (UWL), owned and operated by Ameren Missouri. This plan includes the methods and schedule anticipated to properly close the entire landfill during or at the end of its operating life. Following closure of any portion of the landfill, 20-year post-closure maintenance requirements will be initiated. Estimated costs for completing closure and post-closure activities described herein are included to provide a basis for assuring that sufficient funds are available to complete the necessary activities. According to 10 CSR 80-2.030 (4)(B)2.D, utility waste landfills are not required to provide a post-closure financial assurance instrument (FAI).

The following Missouri Department of Natural Resources (MDNR) Technical Bulletins were utilized to prepare the Closure and Post-Closure Plan and are included as Appendices 1 and 2:

- Landfill Closure Guidance, 6/2006
- Preparing Solid Waste Disposal Area Closure and Post-Closure Plans, 6/2006

2.0 Closure Plan

2.1 Closure Plan Sequencing

The Missouri Department of Natural Resources and Franklin County will be notified in writing at least 180 days prior to the anticipated last receipt of waste in a phase of the landfill. The owner will make provisions to begin closure within 30 days of receiving final waste and will complete closure within 180 days of beginning closure on the landfill. Table 1 details the construction sequence for the landfill, which will be completed in 4 phases.

TABLE 1

Phase Number	Cell Number	Disposal Acreage	Planned Use
Phase 1	Cell 1	31.4 ac	Utility Waste Disposal
Phase 2	Cell 2	35.2 ac	Utility Waste Disposal
Phase 3	Cell 3	57.1 ac	Utility Waste Disposal
Phase 4	Cell 4	42.8 ac	Utility Waste Disposal
Total		**166.5 ac**	

Prior to requesting authorization to operate, Ameren Missouri will execute an easement with MDNR that grants MDNR, its agents, or its contractors access to the permitted area to complete work specified in the closure plan, to monitor or maintain the utility waste disposal area, and/or to take remedial action during the post-closure period [10 CSR 80-2.020(2)(B)2.A]. Ameren Missouri will also submit evidence to MDNR that a notice and covenant running with the land has been recorded with the recorder of deeds in Franklin County. The notice and covenant will specify all items outlined in 10 CSR 80-2.020(2)(B)2.B(I)&(II). A copy of the Draft Agreements for Easement, Notice and Covenant Running with Land are provided in Appendix 3.

Following completion of closure activities, a letter and supporting documentation will be submitted to MDNR and Franklin County by an independent professional engineer registered in the State, verifying that closure activities have been completed in accordance with the closure plan and applicable laws and regulations. After MDNR and Franklin County approve closure of the landfill and the final survey plat, the survey plat identifying the boundaries and existence of the landfill will be recorded within 30 days with the Franklin County Recorder of Deeds. Two copies of the recorded plat will also be submitted to MDNR within 30 days of the filing with the Franklin County Recorder of Deeds.

2.2 Closure Activities

The required closure activities will consist of construction of the final cover, and construction of storm water control structures. Each of these closure activities will be completed according to the approved permit documents, including the Construction Permit Application and associated Plan Sheets and the Construction Quality Assurance Plan. The closure activities are discussed and detailed in the following sections of the Construction Permit Application and/or Plan Sheets:

1.) Landfill Final Cover	Section 3.12, Landfill Final Cover
	Section 4.9, Final Cover Material
	Plan Sheets 10, 11, 12, 13, 14 and 15
2.) Stormwater Runoff Controls	Section 3.7, Stormwater Management System
	Section 4.5.1, Stormwater Management
	Plan Sheets 16 and 21
	Appendix N

Ameren Missouri has the required quantity of soil suitable for construction of the final cap on their property. At closure, all soil will be obtained from on-site stockpiles or other areas within the permit boundary. The right of MDNR to utilize such soil for construction of the final cap and closure of the landfill will be provided through a binding, legal agreement between MDNR and Ameren Missouri, prior to issuance of the operating permit. The estimated average round trip distance from the soil borrow source to the landfill is less than 0.5 miles. A seed mixture compliant with MDNR's "Landfill Closure Guidance" (Appendix 1) will be used for vegetation on the final cover system.

2.3 Closure Cost Estimate

The purpose of closure cost assurance for landfills is to assure that sufficient funds are available to properly construct the final cover, establish vegetation, provide for erosion and drainage control and provide a pleasing appearance during the operating life of the landfill. The estimated costs for completing closure activities have been derived from the Closure and Post-Closure Cost Worksheet obtained from the MDNR Solid Waste Management Program website (http://www.dnr.mo.gov/forms/index.html). As indicated on the worksheet, the cost estimates or unit costs utilized in the calculations are in 2004 dollars. Costs are adjusted to third quarter 2012 dollars using the latest Implicit Price Deflators for Gross Domestic Product as determined by the U.S. Bureau of Economic Analysis.

Franklin County does not currently have closure and post-closure requirements for a UWL. For this reason, the requirements of 260.226 and 260.227 RSMo were used for the development of the plans and associated cost estimates.

The worksheets used to estimate the closure costs are included in Appendix 4. The closure cost estimate contained in Appendix 4A represents the maximum amount of closure financial assurance needed for the entire landfill. The cost of closing the entire 166.5-acre landfill is estimated to be $14,370,758. This cost represents the maximum amount of closure assurance needed if all cells of the landfill are open when the last volume of utility waste is deposited in the landfill.

Appendices 4B through 4E present the individual closure cost estimates for Phases 1, 2, 3, and 4. The individual phase cost estimates may be used to initially decrease the FAI and then incrementally increase the amount of the closure FAI throughout the operating life of the utility waste landfill.

3.0 Post-Closure Plan

3.1 Post-Closure Timeframe

This Post-Closure Plan includes the maintenance and monitoring activities to be performed at the landfill after closure. The post-closure maintenance period begins when MDNR agrees that the landfill, or a Phase of the landfill, has been properly closed. Post-closure maintenance will continue for 20 years from the date of final closure of the Phase or the landfill.

3.2 Post-Closure Activities

Post-closure care will include performance of the following activities:

1.) Maintenance of cover integrity, vegetative growth to protect the cover material, and the surface water control system

2.) Maintenance, sampling, testing and statistical analysis of the groundwater monitoring wells

Each of these post-closure activities will be completed according to the conditions of the permits and the approved permit documents. The post-closure activities are discussed and detailed in the following sections of the Construction Permit Application:

1.) Landfill Final Cover, Section 3.12 and Section 4.9, Final Cover Material
2.) Stormwater Management System, Section 3.7 and Section 4.5.1, Stormwater Management
3.) Groundwater Monitoring, Section 3.10 and Section 4.5.3, Groundwater Sampling and Analysis Plan

3.3 Post-Closure Cost Estimate

Per 10 CSR 80-2.030(4)(B)2.D, post-closure financial assurance is not required for utility waste landfills. However, Ameren Missouri has voluntarily agreed to provide a 20-year post-closure FAI for continued groundwater monitoring and evaluation during post-closure.

The purpose of the post-closure cost assurance for the Ameren Missouri Labadie Utility Waste Landfill is to assure that sufficient funds are available to maintain and test the groundwater monitoring system. The estimated cost for completing this post-closure care has been derived from the Closure and Post-Closure Cost Worksheet contained in the MDNR Solid Waste Management Program Technical Bulletin entitled "Preparing Solid Waste Disposal Area Closure and Post-Closure Plans", dated June 2006. The cost estimate or unit costs utilized in the calculations are in year 2004 dollars and adjusted to 2012 dollars.

Franklin County currently does not have a closure and post-closure requirements for a UWL. For this reason, the requirements of 260.226 and 260.227 RSMo were used for the development of the plans and associated cost estimate.

The worksheets used to estimate the closure and post-closure costs are included in Appendix 4. The post-closure cost estimate represents the maximum amount of post-closure financial assurance needed for the entire landfill. The cost of post-closure care for the entire 166.5-acre landfill is estimated to be $1,650,217.20. This cost represents the maximum amount of post-closure assurance needed for 20 years if all cells of the landfill are closed.

Appendix 4 also presents the individual closure and post-closure cost estimates for Phases 1, 2, 3, and 4. However, the cost for post-closure groundwater monitoring and evaluation are inseparable annual costs that will be fully funded prior to the operation of Phase 1.

3.4 Record Keeping

During the post-closure period, please contact Ameren Missouri, 1901 Chouteau Avenue, P.O. Box 66149, St. Louis, Missouri, 63166, (314) 554-2388, regarding any questions or issues with the landfill. Also during this period, all landfill records will be maintained by Ameren Missouri at the same address.

4.0 Remedial Action

If Ameren Missouri is required to develop a corrective action plan for the landfill during the life of the landfill or during the post-closure period, associated cost estimates will be prepared and a corresponding FAI will be secured.

5.0 Financial Assurance Instrument

Ameren Missouri may choose to provide financial assurance incrementally for closure and post-closure based on the closure and post-closure costs for each landfill construction phase as outlined below:

Closure:

Phase 1 (31.4 acres):	$2,710,161
Phase 2 (35.2 acres):	$3,038,142
Phase 3 (57.1 acres):	$4,928,350
Phase 4 (42.8 acres):	$3,694,105
Total Closure (166.5 acres):	$14,370,758

Post-Closure:

Total Post-Closure (166.5 acres for 20 years): $1,650,217 *

*Ameren Missouri has voluntarily agreed to provide a 20-year post-closure FAI for continued groundwater monitoring and evaluation during post-closure.

TOTAL Closure and Post-Closure:

Total Closure and Post-Closure (166.5 acres): FAI = $16,020,975

The closure and post-closure cost estimates presented above are adjusted to third quarter 2012 values, as calculated in Appendix 4. The cost estimate will be reviewed every year to adjust the estimate based on the previous year's inflation rate. The results of the annual review will be submitted to the MDNR along with any recommendation for revising the amount required for closure and post-closure financial assurance funding. If changes in the design or operation of the landfill are made at a future date, the closure and post-closure plan and cost estimate will be reviewed at that time. If modifications to the plan are necessary, the revised closure and/or post-closure plan will be submitted to the MDNR along with the revised FAI.

In accordance with Utility Waste Regulation 10 CSR 80-2.030(4)(D), a FAI for closure and post-closure care may be satisfied by one of the following alternatives: trust fund or escrow account, financial guarantee bond or performance bond, irrevocable letter of credit, insurance policy, or corporate guarantee. Ameren Missouri will provide a suitable FAI prior to obtaining the initial construction permit. The FAI will be adjusted annually for inflation.

APPENDICES

Appendix 1

MDNR "Landfill Closure Guidance" Technical Bulletin, dated 6/2006

Missouri Department of Natural Resources

Landfill Closure Guidance

Solid Waste Management Program technical bulletin 6/2006

The Missouri Department of Natural Resources' Solid Waste Management Program (SWMP) has developed this technical bulletin to provide assistance to landfill owners, operators and engineers in obtaining closure approval from the department. This bulletin was prepared to provide guidance for closure under Missouri Solid Waste Management law and rules.

All owners or operators applying for closure approval must have a department approved closure/post-closure plan. For further information regarding the preparation of closure/post-closure plans, see SWMP's technical bulletin entitled *Guidance For Preparing Solid Waste Disposal Area Closure and Post-Closure Plans* or contact SWMP at (573) 751-5401.

1. Closure Schedule

A. Notify the SWMP in writing of intentions to cease taking waste 180 days prior to anticipated closing date.
B. Implementation of closure must begin within 30 days of last receipt of waste.
C. Closure must be completed within 180 days of the initiation of closure activities. Time extensions may be granted by SWMP. To request an extension the owner or operator must submit a written request to SWMP within at least 30 days of the closure deadline and include a proposed schedule for completing closure. Extensions will only be granted on a case-by-case basis. However, the owner or operator must have made considerable efforts in previously closing the landfill.

2. Final Closure Guidance

As each phase of the landfill is completed, final cover must be applied. A good final cover will help minimize surface water infiltration and subsequent leachate production as well as minimize gas migration produced by decomposing waste. Following are descriptions of the various components of a final cover.

A. Landfills Without Composite Liners
  1. Two feet of compacted soil classified as CH, CL, ML, SC or MH as per ASTM method D-2487.
  2. One foot of vegetative soil.

B. Landfills With Composite Liners
  1. One foot of compacted soil classified as CH, CL, ML, SC or MH as per ASTM method D-2487.
  2. Geomembrane, equal to that of liner, at least 30 mil thick or 60 mil for HDPE liners.
  3. Lateral drainage layer must be constructed between the vegetative soil and the underlying geomembrane.
  4. Two feet of vegetative soil.

Note: All borrow area soil used for cover construction must be tested by a professional engineer or their agent to ensure the soil meets the approved standards as per 10 CSR 80-3.010.

3. Construction and Grading

When constructing the final cover a strict Quality Assurance/ Quality Control (QA/QC) plan must be followed to ensure the cover is not damaged in any way.

A. Final contours of the closed landfill shall not exceed the originally approved permitted final contours unless approval is granted by the department.
B. The compacted soil layer shall be constructed in 6 inch to 8 inch lifts until the desired thickness is achieved. The compacted soil must be covered so as to prevent damage from drying and cracking.
C. Side slopes shall not exceed permitted grade or 3:1 (horizontal: vertical), whichever is less. Those areas that require the placement of a geomembrane as a component of final cover must not be allowed to erode or cause slope failure. It is recommended in these cases that the slope be decreased.
D. Terracing and letdown structures shall be constructed to prevent erosion and to control stormwater, as called for in a department approved closure plan.

4. Vegetation

Once the cover has been applied, the top surface of the landfill must be vegetated. This is important for several reasons. A good healthy stand of vegetation helps control erosion of the topsoil from surface water runoff and wind as well as helps minimize the infiltration of stormwater into the landfill and subsequent leachate production. Following are some guidelines for establishing a good stand of vegetation.

A. Methods to establish vegetation:

1. The department recommends a hardy grass or legume mixture be used such as fescue (75 pounds/acre) and clover.
2. Soil testing of the vegetative layer for proper application of lime, fertilizer and other soil conditioning.
3. The application of mulch must be utilized during the time vegetation is to be established. Mulch is used to help prevent slope erosion, conserve soil moisture, prevent seed from being washed or blown away as well as prevent weed growth. Acceptable mulching materials include, but are not limited to, straw, hay or fiber. However, sawdust or chipped wood is not a suitable material for use as mulch.

B. The department considers that a good stand of healthy vegetation is one that controls and prevents erosion and provides vegetative cover of at least 80 percent of any square foot evaluated by department personnel. The department reserves the right to determine whether or not vegetation has been adequately established before closure is approved.

5. Submittals for Closure Approval

Before closure can be approved, three copies of the following documentation must be submitted.

A. Certification by a professional engineer registered in Missouri that closure has been completed in accordance with an approved closure plan. The certification must include

1. As-built drawings of the landfill. These drawings must include final contours of the landfill, vertical and horizontal limits of waste placement and any environmen tal control systems at the landfill. (The survey plat referenced below may be included on the as-built drawings, eliminating the need for two separate draw ings.)
2. Evidence that final cover components have been verified for depth and types of cover soils on 100 foot centers and identified on the as-built drawings.
3. Evidence that a dense stand of hardy vegetation has been established as per SWMP requirements, section 4. B. of this document.

B. A survey plat prepared by a licensed surveyor registered in Missouri must be submitted upon completion of closure. The plat must contain the following information at a minimum:

1. The name of the property owner as it appears on the property deed.
2. A survey and detailed legal description of the waste limits, the permitted area and the property boundary.
3. The general types, locations and depths of wastes within the property.
4. The location of any environmental control systems in place at the landfill and the length of time these systems and the landfill are to be maintained.
5. The location of all boundary markers and benchmarks located at the site.

Note: Filing of Survey Plat:

1. Within 30 days of department approval of the plat, the owner or operator shall file the plat with the county recorder of deeds.
2. Two copies of the recorded plat shall be submitted to the department within 30 days of the filing.

C. Owners or operators of solid waste disposal areas permitted prior to Jan. 1, 1987 and which close after Jan. 1, 1989 as part of closure must

1. Execute an easement with the department or its agents to enter the site to monitor, maintain, or take remedial action during the 30 year post-closure period.
2. Submit evidence to the department that a notice and covenant running with land has been filed with the county recorder of deeds. The notice and covenant shall specify the following:

   A. The property has been permitted as a sanitary landfill.
   B. That use of the land which interferes with the closure/post-closure plan is prohibited.

SWMP has created a standard form entitled *Agreement for Easement, Notice and Covenant Running With Land*, which must be submitted upon completion of closure. This form should be completed concurrently with the survey plat.

6. Closure Approval/Denial

Upon completion of the above closure activities, the permittee must request from the SWMP approval for final closure of the landfill and that closure funds be released.

A. SWMP will conduct a final closure inspection to verify that all the requirements for closure have been met.
B. SWMP will either approve or deny the request for closure approval. If the request is approved, closure funds will be released. If the request is denied, a letter will be sent to the permittee outlining the deficiencies for closure and time frames for compliance.

7. Recommended Guidance

A. Missouri Department of Natural Resources technical bulletin *Guidance For Preparing Solid Waste Disposal Area Closure and Post-Closure Plans.*
B. U.S. Environmental Protection Agency report *Standard Procedures For Planting Vegeta tion On Completed Sanitary Landfills.*
C. University of Missouri Extension Services document *How to Get A Good Soil Sample.*
D. University of Missouri Extension Services document *Using Your Soil Test Results.*

For more information call or write:

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
www.dnr.mo.gov/env/swmp Program Home Page

Appendix 2

MDNR "Preparing Solid Waste Disposal Area Closure and Post-Closure Plans" Technical Bulletin, dated 6/2006

Missouri Department of Natural Resources

Preparing Solid Waste Disposal Area Closure and Post-Closure Plans

Solid Waste Management Program Technical bulletin 6/2006

Introduction

The Missouri Department of Natural Resource's Solid Waste Management Program has developed this technical bulletin to help landfill owners prepare closure and post-closure plans. Closure and post-closure plans are intended to describe how a facility will be closed and maintained, and more importantly to provide a basis for calculating the amount of financial assurance required for the facility. Closure and post-closure plans must be prepared or approved by a Professional Engineer (P.E.) registered in the State of Missouri, and must be approved by the Solid Waste Management Program.

The Missouri Solid Waste Management Regulations contain the following requirements in regard to closure and post-closure plans:

- Owners of active sanitary landfills are required to provide closure plans and thirty-year post-closure plans.
- Owners of active demolition landfills, utility waste landfills and special waste landfills are required to provide closure plans.
- Owners of demolition landfills permitted after July 30, 1997, are also required to provide thirty-year post-closure plans.
- Owners of utility and special waste landfills permitted after July 30, 1997, are required to provide twenty-year post-closure plans.
- Owners of inactive landfills are required to provide closure and post-closure plans in accordance with the regulations in place at the time the facility ceased accepting waste.

This technical bulletin addresses two aspects of closure and post-closure plans: the text of the plan itself and the closure and post-closure cost estimates. These aspects apply to the following facilities:

Text of the plan

- Applies to facilities permitted after the date of this technical bulletin.
- Currently active facilities and permitted facilities that are not yet constructed will only be required to revise the text of their closure and post-closure plans to follow this new format when updating their closure and post-closure plans for any reason.
- Does not apply to inactive facilities (those that have ceased accepting waste).

Cost estimates

- Applies to facilities permitted after the date of this technical bulletin.
- Currently active facilities, and facilities that are permitted but not yet constructed will be required to revise their cost estimates with the next annual financial assurance update.
- Does not apply to inactive facilities.

The Solid Waste Management Program recommends that the closure and post-closure plans be a separate document rather than a section, or appendix, of the overall engineering report for the facility. It is important to make a distinction between the closure and post-closure plans and other aspects of the engineering design. The regulatory requirements are specific for final cover systems, gas control systems, surface water control systems, and environmental monitoring systems. The detailed aspects of design should be addressed in the appropriate section of the engineering report. The closure and post-closure plans address more general requirements.

Where possible, the closure and post-closure plans should refer to the approved design and the approved monitoring plans, but should not reiterate them in detail. Nor should changes to the closure and post-closure plans be submitted to modify the design of the final cover system, the surface water control system, the gas collection system, the gas-monitoring plan, or the ground-water monitoring plan. The closure and post-closure plan should focus on implementation of the design, the monitoring plans, and the maintenance activities.

Not only will eliminating redundancy decrease the chances for contradictions between the engineering design documents and the closure and post-closure plans, but in many cases it will allow the owner to modify some aspect of the design, or perhaps a monitoring plan, without having to make changes to the closure or post-closure plans.

This technical bulletin has been written to address the most detailed aspects of closure and post-closure. Many of the design features discussed here, such as geosynthetic caps and active gas collection systems, may not apply to demolition landfills, utility waste landfills, special waste landfills, or older areas of sanitary landfills. Only those portions applicable to the design and operation of your facility must be addressed.

Closure Plan

According to the regulations, closure plans must include a description of the methods and time schedules for closure of the permitted area. The plans may have distinctly different contents for older facilities as opposed to newer ones.

Methods

The engineering design should already address in detail the construction methods to be used for the final cap system and other systems that will be built during closure, such as the gas control system and the surface water control system. There is no need to repeat these construction methods in detail in the closure plan. However, the quality assurance/quality control (QA/QC) methods for these systems may not be clearly specified in the approved engineering design. QA/QC is an important part of closure since it forms the basis for the engineering certification that the facility was properly closed. It includes things such as laboratory and field testing of soils and membranes as well as survey control. It is essential to address this aspect of construction in one way or another. While more modern facilities usually have separate QA/QC plans, older facilities may not. If not, this aspect of closure must be addressed in the closure plan.

Schedule

Since the closure schedule depends on unpredictable factors, particularly waste flow, it would be futile to present a detailed closure schedule in the closure plan. This aspect of closure would more appropriately be termed a closure sequence. Again, for older facilities as opposed to newer ones, the closure plan may have a different focus in this regard.

Newer facilities are typically designed in phases. Current regulations require landfill owners to submit phase development drawings to show how the site will be developed. These drawings should be detailed enough to show the various stages of development of the landfill, from liner construction in new phases through closure of older phases, including construction of gas and surface water control systems. In other words, the closure sequence should already be laid out in sufficient detail in these phase development drawings. However, for older facilities, phase development drawings more than likely do not exist and should be included in the closure post-closure plan.

The closure plan must address the following:

- The plan must indicate the closure status of all areas within the permitted boundary that have received waste, regardless of when they were filled.
- The plan must indicate whether the facility will close in phases or all at one time.
- The plan must indicate the total size of the entire landfill footprint.
- For phased closure, the plan must also indicate the size of each phase.
- The plan must indicate that Missouri Department of Natural Resources will be notified in writing at least 180 days before the anticipated last receipt of waste in the landfill; or, for phased development, in any particular phase.
- The plan must indicate that closure will begin within 30 days of the last receipt of waste in the landfill or phase and will be completed within 180 days of beginning closure. The regulations allow the department to grant extensions to these time frames in certain situations, but any proposed deviations must be clearly indicated in the closure plan.
- The plan must indicate all the major steps necessary to close the landfill based on the approved engineering design and the conditions of the permit.
- For phased facilities with approved phase development drawings, the closure sequence should be summarized in the closure plan in enough detail to allow the department to determine when various landfill components will be constructed.
- For phased facilities without approved phase development drawings, the closure plan should include drawings clearly showing the planned closure sequence for the facility. The drawings should be correlated with the text of the plan to clearly indicate when various landfill components will be constructed.
- If you have an approved QA/QC plan for your facility that addresses the current regulatory requirements and construction verification procedures for the final cover system and other components to be installed or constructed as a part of closure, a simple reference to the QA/QC plan in the closure plan is sufficient.
- If you do not have an approved QA/QC plan, the closure plan must include a QA/QC plan for the final cover system and any component that will be installed as a part of closure. The QA/QC plan must address all field and laboratory procedures that will be used to verify the material properties and the construction methods for each component. The QA/QC plan must also address survey control.
- The plan must indicate that, upon completion of closure activities, a P.E. registered in the state of Missouri will certify that the facility or phase was properly closed.

Post-closure plans

According to the regulations, post-closure plans must address the maintenance and monitoring activities required during the post-closure period. However, most of the monitoring activities are performed in accordance with approved surface water, groundwater, and gas monitoring plans. There is no need to reiterate these monitoring plans in great detail in the post-closure plan. A simple reference is adequate. The plan should focus mostly on maintenance activities.

The post-closure plan must address the following:

- The plan must show that groundwater monitoring and gas monitoring will be done in accordance with the approved monitoring plans and the terms and conditions of the permit.
- The plan must show that surface water monitoring, if applicable, will be conducted in accordance with the terms and conditions of any permit(s) issued by the Missouri Clean Water Commission.
- The plan must show the activities necessary to maintain the integrity of the final cover system, the leachate collection system, the gas control system, the gas monitoring system, the surface water control system, the groundwater monitoring system, and any other system specified in the approved engineering design.
- The plan must show the location where landfill records will be kept during the post-closure period. A copy of these records must be made available to the appropriate department staff upon request.

Financial assurance and cost estimates

Current regulations require owners of sanitary, demolition, and utility waste landfills to provide a closure Financial Assurance Instrument (FAI). Sanitary landfill owners are also required to provide a post-closure FAI. FAIs are necessary to ensure that the department has sufficient funds to properly close and maintain the facility in the event the owner is unable to do so. The closure FAI may be returned if final closure has been approved in writing by the department. A portion of the post-closure FAI may be returned annually starting on the sixth anniversary of the beginning of the post-closure period, and the remainder may be refunded after completion of the post-closure period.

New facilities

The solid waste disposal area permitting process is separated into several distinct steps. In addition to the preliminary and detailed site investigation requirements, owners of new facilities, those applying for a construction permit after July 30, 1997, are now required to obtain a construction permit to build a landfill and an operating permit to begin receiving waste. For owners of new facilities, a closure FAI is due prior to obtaining the initial construction permit, and a post-closure FAI is due prior to obtaining the initial operating permit.

If the operations are phased, the initial closure FAI only needs to include the amount necessary to close the first phase of the landfill, while the initial post-closure FAI must include the separable post-closure costs for the first phase, plus the inseparable post-closure costs for the entire landfill. Separable costs are those which are common only to a particular phase, such as cover maintenance. Inseparable costs are those which are common to the entire landfill, such as annual inspections, gas monitoring, and groundwater monitoring. These inseparable activities will be required for the entire landfill for the duration of the post-closure period whether or not subsequent phases are developed. For subsequent phases of new facilities, both the closure FAI and separable post-closure FAIs are due when operation of the phase is requested.

Existing facilities

Owners of existing facilities must have a closure and post-closure FAI in place for any area of the landfill in which waste was placed after Jan. 1, 1987. For newly developed phases of existing facilities, as with new facilities, both the closure FAI and separable post-closure FAIs are due when operation of the phase is requested.

Worksheet

In order to determine the amount of funding required for financial assurance, it is necessary to do a cost estimate. The purpose of the closure cost estimate is to determine the funding required for the department to complete landfill closure. The purpose of the post-closure cost estimate is to determine the funding required for the department to maintain and monitor the facility for the duration of the post-closure period.

To simplify the cost estimation process, the department has developed the attached worksheet to be used in calculating the amount of financial assurance required for closure and post-closure. To understand the need for a simplified worksheet, you must first understand the scenario under which the department will be required to perform closure and post-closure activities. In this situation, there will either be no responsible party, or the responsible party will be unwilling or unable to perform closure or post-closure activities. There is no other reason for the department to assume these responsibilities. In this scenario, it is quite likely that the facility has been poorly managed, either operationally, financially, or both.

In a premature closure scenario, it is unlikely that the landfill will resemble what was depicted in the approved final contour drawings. Some areas of the landfill may be at the permitted final elevation while others may be significantly lower, or higher if the landfill was poorly managed. It is likely that extensive regrading will be required for cover construction; surface water may have to be routed differently than indicated in the approved design and some portions of the gas system may be installed while others are not. The department will likely hire a consultant to determine the most cost-effective method of closure. No one can anticipate all possible scenarios, nor is the FAI intended to provide funds for all possible scenarios. It is also difficult to accurately estimate the costs for complicated systems such as landfill gas collection systems even under ideal circumstances, much less during a premature closure scenario.

For this reason, the cost estimates are not intended to be extremely detailed or complicated. They are intended as a simple method of providing a reasonable amount of money to allow the department to evaluate the condition of the landfill and close it in accordance with the minimum requirements of the regulations and any special requirements imposed by the design engineer. The most important thing is that estimates be reasonably accurate and include costs for all major aspects of landfill closure and post-closure.

The attached worksheet must be completed in order to determine the closure and post-closure costs. Any critical feature(s) included in the design for which there is no line item on the worksheet must be accounted for as well. For these features, the department will allow the use of third party quotes or professional judgement on the part of the design engineer in preparing cost estimates. These estimates should be attached to the worksheet.

Please note that this worksheet only applies to facilities with Subtitle D (composite) caps or standard soil caps (two feet of compacted clay overlain with one foot of vegetative soil). Some demolition landfills, utility waste landfills, and special waste landfills are designed with other types of caps. The department will work with the owners of these facilities on a case by case basis to determine the amount of financial assurance required, using the principles and unit costs developed in this technical bulletin.

Due to variations in design, more than one worksheet may be necessary for your facility. For example, some older landfills have both Subtitle D areas and areas with soil caps. Some portions of the landfill may be required to have an active gas extraction system while others are not. In some cases, for example where a Subtitle D permit has superceded a previous permit, one worksheet can be completed to account for all areas within a permitted landfill. However, we suggest that you complete a separate worksheet for each distinct area. The worksheet is simple enough that this should not be difficult. In no case should areas with different permit numbers be combined on the same worksheet. The text of the plan should address each distinct area and explain the variations in design from one area to the next.

For a facility where all areas or phases are designed the same, such as a complete Subtitle D facility, as subsequent phases are opened you should submit a new worksheet that accounts for all phases of the landfill. For example, if you are submitting a request to open the fifth of ten phases, you should replace previously submitted worksheets with a new one that accounts for the total acreage for phases one through five.

The worksheet is based on unit closure costs for the following standardized aspects of design:

- Compacted clay cap
- Gas collection or venting system
- 40 mil low density polyethylene membrane
- Geocomposite drainage net, if applicable
- Vegetative soil
- Surface water controls
- Vegetation
- Borrow area reclamation
- Professional services

Owners of Subtitle D facilities must provide an FAI for either an active gas extraction system or a passive venting system. You must provide an FAI for an active system only if you are:

1. required to install the system by the department to control off-site gas migration,
2. required to install the system under the Federal New Source Performance Standards (NSPS), or,
3. required to install the system by some other regulatory agency.

If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide an FAI for a passive venting system. Owners of non-Subtitle D facilities (with soil caps) are not required to provide an FAI for a gas control system at all unless they meet at least one of the above conditions.

For simplicity, the worksheet costs are the same for active extraction wells and passive vents. Costs for wells or vents must be included in the cost estimate for the phase in which they will be physically located. However, costs for other components such as connecting piping, blowers, and flares, if required, only need to be included in the cost estimate at the point they are determined to be necessary by the design engineer. Again, this will depend entirely on the phase development and closure sequence discussed previously.

For example, assume that your landfill is large enough that you will eventually be required to install a gas extraction system under NSPS. The design engineer determines that the emissions will exceed the threshold limit when the fifth of ten phases are in place. In other words, if the landfill closes prematurely after only four phases are in place, the facility will be below the threshold limit and only a passive venting system will be required. The costs for the gas vents for each of the first four phases must be included in the FAI cost estimates for those phases because they will be required regardless of whether the fifth phase is ever constructed. You must at least vent Subtitle D landfills. You must use Form B, the Worksheet for Passive Gas System, through the first four phases. However, when you request to operate the fifth phase, since this will cause you to reach the threshold limit, you must now convert the passive vents to active extraction wells, install connecting piping, and the blower/flare station. To calculate your closure cost for this system, you must complete Form A, the Worksheet for Active Gas Systems.

The worksheet is based on unit post-closure costs for the following standardized maintenance and monitoring activities:

- Site inspections
- Erosion repair and revegetation of final cap
- Groundwater sampling and analysis
- Gas monitoring
- Leachate disposal
- Groundwater monitoring system maintenance and repair
- Gas monitoring system maintenance and repair
- Gas control system maintenance and repair (if applicable)
- Leachate management system maintenance and repair
- Professional services

Owners of facilities that voluntarily design and install an active gas system will be required to provide post-closure maintenance costs for the system once it is constructed. This is simply because, once the system has been built, the department will have to maintain it.

Worksheet unit costs

In the event the department is required to close a landfill, labor rates for the project will be in accordance with the prevailing wage rates in the county in which the landfill is located. Therefore, the unit costs in the worksheet are based primarily on R.S. Means publications because they reflect average national wage rates. A detailed analysis of the unit costs is available upon request.

You will note that the costs vary significantly depending on the round trip haul distance from the borrow area, and whether or not the landfill owner has granted an easement to the department for use of the borrow soils for closure. The higher costs due to increased haul distance should be apparent. Costs are also tied to the easement because, if the department is required to complete closure of a landfill or perform cover maintenance during the post-closure period, the costs will be much higher if we have to purchase the soil from an outside source. Therefore, unless you have executed an easement with the department that allows the use of borrow soil for closure and post-closure, we must make an assumption as to the availability of borrow soil. This assumption is that we will be able to locate and purchase the required quantity of suitable soils within five miles of the site. Therefore, for the purposes of cost estimating, we will assume a round trip haul distance of 10 miles.

Updating the cost estimate and FAI

One of the advantages of the simplified worksheet is that it minimizes the changes required to the cost estimate and the FAI. In order to understand this, you must understand the distinction between changes to the cost estimate and changes to the FAI.

The cost estimate is based on the major aspects of landfill design such as total acreage permitted for waste disposal (landfill footprint), the type of cover (subtitle D or non-subtitle D), the type of gas system (active or passive), and the number of groundwater monitoring wells. Once your cost estimate has been revised to match the figures in this technical bulletin, it must be updated only if some design aspect changes.

The FAI is a document ensuring that a reasonable amount of money is guaranteed to the department to complete closure and post-closure activities. It is based on the cost estimate. The amount of money must be updated annually for inflation, or if the cost estimate changes.

To illustrate this, we will use the following example:

Assume that, once your cost estimate is revised to match the figures in the technical bulletin, your closure cost estimate is $2 million and your post-closure cost estimate is $3 million. If you operate for twenty years and never modify any aspect of design, you will never need to change that cost estimate. You only need to increase the FAI annually for inflation, as outlined below. However, assume that at some point you are required by the department to install an-active gas system to control a gas migration, or add two groundwater-monitoring wells. You must submit a new worksheet accounting for the increased closure or post-closure cost for the modification. Once the modifications and new cost estimate are approved by the Solid Waste Management Program, you will be required at that time to update your FAI to match the new cost estimate. From that point on, the FAI must be increased annually for inflation, but no changes to the cost estimate will be necessary unless further design changes are approved.

It is important to note that using the worksheet to update a cost estimate will always result in an estimate in year 2000 dollars. This figure must then be updated for inflation to the current year.

Annual adjustments for inflation

Annual adjustments for inflation are determined by increasing the original dollar value using a multiplier. The multiplier is the latest percent change in the Implicit Price Deflator (IPD) for the Gross Domestic Product as determined by the U.S. Department of Commerce. The IPDs change every quarter depending on the current rate of inflation. You must always use the most recent IPD when updating a cost estimate or FAI. The most recent IPD can be obtained from the Solid Waste Management Program.

Forms Available Online

Closure and Post-Closure Cost Worksheet

www.dnr.mo.gov/forms/780-1882.pdf

Form A - Active Gas System Worksheet

www.dnr.mo.gov/forms/780-1881.pdf

Form B - Passive Gas System Worksheet

www.dnr.mo.gov/forms/780-1880.pdf

Table 1 - Cover Systems Construction and Repair Costs

www.dnr.mo.gov/forms/780-1879.pdf

For more information call or write:

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176
Jefferson City, MO 65102-0176
1-800-361-4827 or (573) 751-5401 office
(573) 526-3902 fax
www.dnr.mo.gov/env/swmp Program Home Page

Appendix 3

Agreement for Easement, Notice and Covenant Running with Land – Franklin County

Missouri Department of Natural Resources
Solid Waste Management Program

AGREEMENT FOR EASEMENT,
NOTICE AND COVENANT RUNNING WITH LAND
(Standard Form 4-11-96)

This Agreement made this DRAFT day of ______, 20___, between the Missouri Department of Natural Resources, hereinafter called Department and Ameren Missouri, hereinafter called Owner, to satisfy the requirements of the Missouri Solid Waste Management Law.

WITNESSETH.

Owner wishes to execute an Agreement for Easement, Notice and Covenant Running with Land for a solid waste disposal area (hereinafter called landfill) on property owned by owner in Franklin County, Missouri, and more fully described as follows:

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81

DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.

Owner has access to the above described landfill as follows:

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81 DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.

NOW, THEREFORE, in consideration of the mutual covenants of the parties and other valuable consideration, receipt of which is hereby acknowledged, the Department and Owner agree as follows:

1. The Department has issued Solid Waste Disposal Area Operating Permit No. ___

to Ameren Missouri, dated _______________, 20___, for the operation of a landfill by Owner in compliance with the provisions pursuant to the Missouri Solid Waste Management Law.

2. The owner hereby grants, bargains, sells and conveys to the Department, its agents, contractors, successors and assigns an easement in the landfill described above, together with an easement in the access property owned by landowner as described above, to enter the landfill as necessary to complete work specified in the closure plan, or to monitor or maintain the site if specified in a post-closure plan, or to take remedial action during the post-closure period. "Closure plan", "post-closure plan", and "post-closure period" are defined pursuant to the Missouri Solid Waste Management Law and for the purpose of this agreement are described in permit number ___________DRAFT_________. If the landfill is accessible only through property not owned by landowner, the owner/operator should obtain a separate easement from the access property's owner(s) in favor of the Department for appropriate access. The Department will provide assistance if this is necessary.

3. This agreement, when filed by the Owner with the Recorder of Deeds for Franklin County, Missouri, shall serve as notice that the property described herein has been permitted as a solid waste disposal area and, that use of the property in any manner which interferes with the closure and, where appropriate, post-closure plans filed with the Department is prohibited.

4. The owner, heirs, successors in title, personal representatives and assigns shall not use the herein described property in any manner which interferes with any closure and/or post-closure plans which are filed with the Department. Further, the use of the herein described property is subject to the Missouri Solid Waste Management Law and the rules promulgated thereunder.

5. Any restriction in this agreement on the use of the herein described property is a covenant running with the land.

IN WITNESS WHEREOF, the parties have hereunto set their hands the day and year first above written.

OWNER:	DEPARTMENT:
______________________________	______________________________
Ameren Missouri	Missouri Department of Natural Resources
Name: ______________________	Name: DRAFT
Title: ______________________	Title: Director

Notary for Owner:

STATE OF MISSOURI)
) ss
COUNTY OF)

On this ____________ day of ______, 20___, before me personally appeared (name), to me know to be the person described in and who executed the foregoing instrument, and acknowledged that they executed the same as their free act and deed.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

DRAFT ______________________________
Notary Public

Commission in __________________ County.

My Commission Expires: ________________.

Notary for Missouri Department of Natural Resources

STATE OF MISSOURI)
) ss
COUNTY OF COLE)

On this ______ day of ______ in the year 20___ before me, DRAFT , a Notary Public in and for the said state, personally appeared _____________ DRAFT _____________, ______________________________, Missouri Department of Natural Resources, known to me to be the person who executed the within document in behalf of the Department and acknowledged to me that he executed the same for the purposes therein stated.

DRAFT ______________________________
Notary Public

Commissioned in ________________ County.

My Commission Expires: ________________.

Appendix 4

Closure and Post-Closure Cost Worksheets

Appendix 4A

Closure and Post-Closure Cost Worksheet
Total, All Four (4) Phases: 166.5 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

CLOSURE AND POST-CLOSURE COST WORKSHEET

TOTAL ACREAGE-ALL PHASES

THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.

DATE	NAME OF FACILITY	PERMIT NUMBER
1/10/13	Ameren Missouri Labadie Utility Waste Landfill	

TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)		TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)		TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL	
SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D
166.5	0	0	0	0	0

1. How many acres is this financial assurance instrument intended for?

   acres for closure 166.5 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (TOTAL ACREAGE)

3. What is the approved final cover system design?

   ☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
   ☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
   (If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

   ☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

   ☐ Active extraction system ☐ Passive venting system ☒ No gas control system
   If you have an active extraction system, check the appropriate box.
   ☐a. Required to control gas migration
   ☐b. Required under NSPS
   ☐c. Required by other agency (city, county, etc.)
   ☐d. Specified only by design engineer
   If you check box "d", is any part of the active gas system constructed at this time?
   ☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
28 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

CLOSURE COSTS

Final Cover System

Subtitle D (Composite cover) 166.5 acres x $ 72,910 per acre = (From Table One) $ 12,139,515.00

Non – Subtitle D (soil cover) acres x $ per acre = (From Table One) $ 0.00

Gas Control System

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

Other Critical Design Features

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Closure Cost (sum of all lines) (2004 Dollars) **$** 12,139,515.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 12,139,515.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 14,370,757.86

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 / 97.874 = 0.1838
CURRENT IPD = 1.1838

POST-CLOSURE COSTS

Inseparable Annual Costs

Annual landfill inspection and reporting — $ ~~1,000~~

Gas monitoring and reporting — $ ~~4,450~~

Annual groundwater sampling and analysis cost. 28 wells x 2,000 = $ 56,000.00

Annual groundwater monitoring system maintenance and statistics cost. $ 13,700

☐ Leachate system maintenance $3,100 — $ 0.00
(Check if applicable and write this amount in the space provided.)

☐ Leachate testing $2,250 — $ 0.00
(Check if applicable and write this amount in the space provided.)

☐Active gas extraction system maintenance and utilities $17,600 — $ 0.00
(Check if applicable and write this amount in the space provided.)

☐ Passive gas system maintenance $1,600 — $ 0.00
(Check if applicable and write this amount in the space provided.)

Separable Annual Costs

Cap repair and maintenance — 0 acres x 0 (From Table One) = $ 0.00

☐ Leachate treatment (check if applicable) — 0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 = $ 0.00

☐ Leachate hauling (check if applicable) — 0 acres x 0 (Gal/Acre/Year) x $0.05 = $ 0.00

Annual Costs for Other Critical Design Features

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Annual Post- Closure Cost (2004 Dollars) $69,700.00

Adjust for Inflation
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 82,510.86
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

Total Post-Closure Cost
Annual post-closure costs x XX years 20 — $ 1,650,217.20

Appendix 4B

Closure and Post-Closure Cost Worksheet
Phase 1: 31.4 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

CLOSURE AND POST-CLOSURE COST WORKSHEET

Phase 1

THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.

DATE		NAME OF FACILITY		PERMIT NUMBER	
1/10/13		Ameren Missouri Labadie Utility Waste Landfill			
TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)		**TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)**		**TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL**	
SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D
166.5	0	0	0	0	0

1. How many acres is this financial assurance instrument intended for?

   acres for closure 31.4 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 1)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system

If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer

If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
28 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.0 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
(gal/acre/day) ☐ HELP model ☐ Other (please explain.)

OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Phase 1

CLOSURE COSTS

Final Cover System

Subtitle D (Composite cover) 31.4 acres x $ 72,910 per acre = $ 2,289,374.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

Gas Control System

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

Other Critical Design Features

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Closure Cost (sum of all lines) (2004 Dollars) $ 2,289,374.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 2,289,374.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 2,710,160.94

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 / 97.874 = 0.1838
CURRENT IPD = 1.1838

POST-CLOSURE COSTS

Inseparable Annual Costs

Annual landfill inspection and reporting		$ ~~1,000~~
Gas monitoring and reporting		$ ~~4,450~~
Annual groundwater sampling and analysis cost.	28 wells x 2,000 =	$ 56,000.00
Annual groundwater monitoring system maintenance and statistics cost.		$ 13,700
☐ Leachate system maintenance $3,100 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐ Leachate testing $2,250 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐ Active gas extraction system maintenance and utilities $17,600 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐ Passive gas system maintenance $1,600 (Check if applicable and write this amount in the space provided.)		$ 0.00

Separable Annual Costs

Cap repair and maintenance	0 acres x 0 (From Table One) =	$ 0.00
☐ Leachate treatment (check if applicable)	0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 =	$ 0.00
☐ Leachate hauling (check if applicable)	0 acres x 0 (Gal/Acre/Year) x $0.05 =	$ 0.00

Annual Costs for Other Critical Design Features

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Annual Post- Closure Cost (2004 Dollars) $69,700

Adjust for Inflation
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 82,510.86
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

Total Post-Closure Cost
Annual post-closure costs x ~~30~~ xx years 20 $ 1,650,217.20

Appendix 4C

Closure and Post-Closure Cost Worksheet
Phase 2: 35.2 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 2

THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.

DATE	NAME OF FACILITY	PERMIT NUMBER
1/10/13	Ameren Missouri Labadie Utility Waste Landfill	

TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)		TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)		TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL	
SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D
166.5	0	0	0	0	0

1. How many acres is this financial assurance instrument intended for?

   acres for closure 35.2 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 2)

3. What is the approved final cover system design?

   ☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
   ☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.

   (If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

   ☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

   ☐ Active extraction system ☐ Passive venting system ☒ No gas control system

   If you have an active extraction system, check the appropriate box.
   ☐ a. Required to control gas migration
   ☐ b. Required under NSPS
   ☐ c. Required by other agency (city, county, etc.)
   ☐ d. Specified only by design engineer

   If you check box "d", is any part of the active gas system constructed at this time?
   ☐ Yes ☐ No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 2

CLOSURE COSTS

Final Cover System

Subtitle D (Composite cover) 35.2 acres x $ 72910 per acre = $ 2,566,432.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

Gas Control System

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

Other Critical Design Features

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Closure Cost (sum of all lines) (2004 Dollars) **$** 2,566,432.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 2,566,432.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 3,038,142.20

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860

(115.860 - 97.874) divided by 97.874 = 17.9860 divided by 97.874 = 0.1838 (Current IPD = 1.1838)

PHASE 2

POST-CLOSURE COSTS		
Inseparable Annual Costs		
Annual landfill inspection and reporting		$ ~~1,000~~
Gas monitoring and reporting		$ ~~4,450~~
Annual groundwater sampling and analysis cost.	0 wells x 2,000 =	$ 0.00
Annual groundwater monitoring system maintenance and statistics cost.		$ ~~13,700~~
☐ Leachate system maintenance $3,100 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐ Leachate testing $2,250 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐Active gas extraction system maintenance and utilities $17,600 (Check if applicable and write this amount in the space provided.)		$ 0.00
☐ Passive gas system maintenance $1,600 (Check if applicable and write this amount in the space provided.)		$ 0.00
Separable Annual Costs		
Cap repair and maintenance	0 acres x 0 (From Table One) =	$ 0.00
☐ Leachate treatment (check if applicable)	0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 =	$ 0.00
☐ Leachate hauling (check if applicable)	0 acres x 0 (Gal/Acre/Year) x $0.05 =	$ 0.00
Annual Costs for Other Critical Design Features		
Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations.		$ 0.00
Total Annual Post- Closure Cost (2004 Dollars) $0.00		
Adjust for Inflation Adjust Amount for 2004 dollars to present value		
Annual closure cost 2004 Dollars $	x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD =	$
Sum of all annual post – closure costs (Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)		$ 0.00
Total Post-Closure Cost Annual post-closure costs xXX years 20		$ 0.00

Appendix 4D

Closure and Post-Closure Cost Worksheet
Phase 3: 57.1 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 3

THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.

DATE	NAME OF FACILITY	PERMIT NUMBER
1/10/13	Ameren Missouri Labadie Utility Waste Landfill	

TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)		TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)		TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL	
SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D
166.5	0	0	0	0	0

1. How many acres is this financial assurance instrument intended for?

   acres for closure 57.1 acres for post-closure 0

2. Description of area (cell number, etc.)

   Ameren Missouri Labadie Utility Waste Landfill (PHASE 3)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

   0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

   0 Clay (cubic yards)

   537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system

If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer

If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.00 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 3

CLOSURE COSTS

Final Cover System

Subtitle D (Composite cover) 57.1 acres x $ 72910. per acre = $ 4,163,161.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

Gas Control System

Active extraction system (Complete Form A and write the amount in the right column.)	$	0.00
Passive gas venting system (Complete Form B and write the amount in the right column.)	$	0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

Other Critical Design Features

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations.	$	0.00
Total Closure Cost (sum of all lines) (2004 Dollars)	$	4,163,161.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 4,163,161.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 4,928,349.99

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 divided by 97.874 = 0.1838
(CURRENT IPD = 1.1838)

POST-CLOSURE COSTS

Inseparable Annual Costs

Annual landfill inspection and reporting			$ ~~1,000~~
Gas monitoring and reporting			$ ~~4,450~~
Annual groundwater sampling and analysis cost.		0 wells x 2,000 =	$ 0.00
Annual groundwater monitoring system maintenance and statistics cost.			$ ~~13,700~~
☐ Leachate system maintenance (Check if applicable and write this amount in the space provided.)	$3,100		$ 0.00
☐ Leachate testing (Check if applicable and write this amount in the space provided.)	$2,250		$ 0.00
☐ Active gas extraction system maintenance and utilities (Check if applicable and write this amount in the space provided.)	$17,600		$ 0.00
☐ Passive gas system maintenance (Check if applicable and write this amount in the space provided.)	$1,600		$ 0.00

Separable Annual Costs

Cap repair and maintenance 0 acres x 0 (From Table One) = $ 0.00

☐ Leachate treatment (check if applicable) 0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 = $ 0.00

☐ Leachate hauling (check if applicable) 0 acres x 0 (Gal/Acre/Year) x $0.05 = $ 0.00

Annual Costs for Other Critical Design Features

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Annual Post- Closure Cost (2004 Dollars) $0.00

Adjust for Inflation

Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 0.00

(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

Total Post-Closure Cost

Annual post-closure costs x ~~30~~ years 20 $ 0.00

Appendix 4E

Closure and Post-Closure Cost Worksheet
Phase 4: 42.8 Acres

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

CLOSURE AND POST-CLOSURE COST WORKSHEET

PHASE 4

THIS WORKSHEET IS ONLY REQUIRED FOR THOSE FACILITIES THAT ACCEPT WASTE AFTER JAN. 1, 2004. OTHERS MAY USE THE WORKSHEET IF THEY CHOOSE.

DATE	NAME OF FACILITY	PERMIT NUMBER
1/10/13	Ameren Missouri Labadie Utility Waste Landfill	

TOTAL PERMITTED ACREAGE (INCLUDING UNDEVELOPED AREAS)		TOTAL ACREAGE WITH WASTE IN PLACE (INCLUDING OFFICIALLY CLOSED AREAS)		TOTAL ACREAGE WITH OFFICIAL CLOSURE APPROVAL	
SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D	SUBTITLE D	NON-SUBTITLE D
166.5	0	0	0	0	0

1. How many acres is this financial assurance instrument intended for?

acres for closure 42.8 acres for post-closure o

2. Description of area (cell number, etc.)

Ameren Missouri Labadie Utility Waste Landfill (PHASE 4)

3. What is the approved final cover system design?

☒ Subtitle D: one foot of compacted clay overlain with a geomembrane, a drainage layer and two feet of vegetative soil.
☐ Standard soil cover: two feet of compacted clay overlain with one foot of vegetative soil.
(If your facility has both subtitle D and non-subtitle D areas, separate worksheets are advisable for these areas to avoid confusion.)

4. Has an easement been granted to the Missouri Department of Natural Resources for access to and use of the borrow material for cap construction?

☒ Yes ☐ No

5. What is the average round-trip distance from the landfill (or phase) to the borrow area? Round trip distance should be to the nearest ½ mile if less than five miles. If more than five miles, round trip distance should be to the nearest mile. If the department does not have an easement to the borrow area, the round trip haul distance is assumed to be 10 miles.

0.5 miles

6. What is the approximate volume of soil remaining in the borrow area?

0 Clay (cubic yards)

537,200 Vegetative soil (cubic yards)

7. What is the approved gas control system design?

☐ Active extraction system ☐ Passive venting system ☒ No gas control system

If you have an active extraction system, check the appropriate box.
☐a. Required to control gas migration
☐b. Required under NSPS
☐c. Required by other agency (city, county, etc.)
☐d. Specified only by design engineer

If you check box "d", is any part of the active gas system constructed at this time?
☐Yes ☐No If yes, provide a general description of the portion(s) of the system installed.

Note: Owners of Subtitle D facilities must provide a closure financial assurance instrument for either an active extraction system or a passive venting system. You must provide a closure FAI for an active system only when you are: 1) Required to install the system by the department to control off-site gas migration, or 2) Required to install the system under the Federal New Source Performance Standards, or NSPS, or 3) Required to install the system by another regulatory agency (city, county, etc.).
If you own a Subtitle D facility and meet any of the conditions, complete Form A. If you own a Subtitle D facility and do not meet any of these conditions, you are only required to provide a closure FAI for a passive venting system. Complete Form B if you own a non-Subtitle D facility (with a soil cap), you are not required to provide a closure FAI for a gas control system at all unless you also meet at least one of the above conditions. If you have installed any portion of an active gas control system, you must provide post-closure maintenance funds for the portion of the system constructed. Do this by checking the appropriate box on the post-closure cost worksheet and adding that amount to the total.

8. How many ground water monitoring wells do you have?
0 wells

9. List the primary and secondary wastewater treatment plants used for leachate disposal, and the cost of disposal.
(Primary plant) $ 0.01 per gallon (Secondary Plant) $ per gallon.
☐ Check if the facility discharges directly to a wastewater treatment plant.

10. What is the estimated post-closure leachate generation rate and how was it derived?
0 (gal/acre/day) ☐ HELP model ☐ Other (please explain.)

OFFICIALLY CLOSED AREAS

11. If any areas of the landfill have been officially closed, list the following information.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

Area consisting of acres received official closure , years post-closure.

PHASE 4

CLOSURE COSTS

Final Cover System

Subtitle D (Composite cover) 42.8 acres x $ 72,910. per acre = $ 3,120,548.00
(From Table One)

Non – Subtitle D (soil cover) acres x $ per acre = $ 0.00
(From Table One)

Gas Control System

Active extraction system (Complete Form A and write the amount in the right column.) $ 0.00

Passive gas venting system (Complete Form B and write the amount in the right column.) $ 0.00

Note: Owners are not required to provide an FAI for an **active** gas system unless required to install the system for one of the reasons listed under section 7 of this worksheet. However, owners of Subtitle D landfills are required to provide an FAI for a **passive** gas system if they do not provide one for an active system.

Other Critical Design Features

Include total cost for construction of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Closure Cost (sum of all lines) (2004 Dollars) $ 3,120,548.00

*** Inflation Update**
Adjust amount from 2004 dollars to present value.

Total closure cost 2004 dollars $ 3,120,548.00 x current Implicit Price Deflator * /*Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD
$ 3,694,104.72

IPD 2004 4th Qtr = 97.874; IPD 2012 3rd Qtr = 115.860
(115.860 - 97.874) / 97.874 = 17.9860 divided by 97.874 = 0.1838
CURRENT IPD = 1.1838

POST-CLOSURE COSTS

Inseparable Annual Costs

Annual landfill inspection and reporting		$	~~1,000~~
Gas monitoring and reporting		$	~~4,450~~
Annual groundwater sampling and analysis cost.	0 wells x 2,000 =	$	
Annual groundwater monitoring system maintenance and statistics cost.		$	~~13,700~~
☐ Leachate system maintenance $3,100 (Check if applicable and write this amount in the space provided.)		$	0.00
☐ Leachate testing $2,250 (Check if applicable and write this amount in the space provided.)		$	0.00
☐ Active gas extraction system maintenance and utilities $17,600 (Check if applicable and write this amount in the space provided.)		$	0.00
☐ Passive gas system maintenance $1,600 (Check if applicable and write this amount in the space provided.)		$	0.00

Separable Annual Costs

Cap repair and maintenance	0 acres x 0 (From Table One) =	$	0.00
☐ Leachate treatment (check if applicable)	0 acres x 0 (Gal/Acre/Year) x (Cost per gallon) 0.00 =	$	0.00
☐ Leachate hauling (check if applicable)	0 acres x 0 (Gal/Acre/Year) x $0.05 =	$	0.00

Annual Costs for Other Critical Design Features

Include total annual cost for maintenance of other critical design features. Attach separate sheet(s) for cost calculations. $ 0.00

Total Annual Post- Closure Cost (2004 Dollars) $0.00

Adjust for Inflation
Adjust Amount for 2004 dollars to present value

Annual closure cost 2004 Dollars $ x current Implicit Price Deflator*/* Please contact the Solid Waste Management Program, 573-526-5401, for the current IPD = $

Sum of all annual post – closure costs $ 0.00
(Reduction. On the sixth anniversary of receiving official closure, a facility can reduce the post-closure FAI by one year's worth of fund.)

Total Post-Closure Cost
Annual post-closure costs x ~~30~~ years 20 $ 0.00

Appendix 4F

MDNR "Table 1 – Cover Systems Construction And Repair Costs," dated 11/2010

MISSOURI DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT PROGRAM

TABLE 1 – COVER SYSTEMS CONSTRUCTION AND REPAIR COSTS

HAUL DISTANCE (Miles)	SUBTITLE D COVER		STANDARD SOIL COVER		CAP REPAIR/ MAINTENANCE	
	1	2	3	4	5	6
	Easement	No Easement	Easement	No Easement	Easement	No easement
1/2	$72,910		$38,300		$256	
1	$74,910		$40,300		$265	
1.5	$76.000		$41,390		$269	
2	$78,200		$43,590		$278	
2.5	$79,100		$44,480		$281	
3	$81,140		$46,530		$290	
3.5	$82,190		$47,570		$294	
4	$83,730		$49,120		$300	
4.5	$87,720		$53,110		$316	
5	$91,710		$57,100		$332	
6	$93,550		$58,940		$340	
7	$95,400		$60,780		$347	
8	$97,240		$62,630		$355	
9	$99,090		$64,470		$362	
10	$100,930	$136,290	$66,320	$93,460	$370	$525
11	$102,580		$67,960		$376	
12	$104,170		$69,560		$383	
13	$105,820		$71,200		$390	
14	$107,410		$72,800		$396	
15	$109,010		$74,390		$402	
16	$110,650		$76,040		$409	
17	$112,300		$77,680		$416	
18	$113,890		$79,280		$422	
19	$115,540		$80,920		$429	
20	$117,130		$82,520		$435	

All costs are per acre costs.

Round trip distances should be to the nearest ½ mile when less than five miles. For distances greater than five miles, round trip distances should be to the nearest mile.

If an easement has been granted to the department for the borrow area, use the per acre cost from the "Easement" column corresponding to the haul distance. If no easement has been granted to the department, the round trip haul distance is assumed to be 10 miles. Enter the correct figure in the Closure Post-Closure Cost Worksheet.

Appendix S

Utility Waste Landfill Emergency Contacts

Ameren Missouri Labadie Energy Center

Utility Waste Landfill and Emergency Contacts

December 2012

Utility Waste Landfill Contact Persons:

Tom C See
Safety Supervisor
Ameren Missouri Labadie Energy Center
226 Labadie Power Plant Rd
Labadie, MO 63055
(314) 992-8246
(314) 540-3289 cell

David Strubberg
Plant Manager
Ameren Missouri Labadie Energy Center
226 Labadie Power Plant Rd
Labadie, MO 63055
(314) 992-8201
(314) 853-7584 cell

Paul R. Pike
Environmental Science Executive
Ameren Services
One Ameren Plaza
1901 Chouteau Avenue
P.O. Box 66149, MC 602
St. Louis, MO 63166-6149
314-554-2388
314-604-6905 cell
314-554-4182 fax

Emergency Contact Phone Numbers:

Labadie Utility Waste Landfill, after hours:	Operating Supervisor Ameren Missouri Labadie Energy Center 226 Labadie Power Plant Rd Labadie, MO 63055 314-992-8233
Highway Patrol/Troop C – (emergency)	9-1-1
(non-emergency)	(314) 340-4000
Hospital	9-1-1
Hospital Emergency Room (Ambulance Service)	9-1-1
St. Johns Mercy Hospital (non-emergency) 901 East 5th St., Washington, Missouri	(636) 239-8000
Labadie Fire Department – (emergency)	9-1-1
(non-emergency)	(636) 742-2515
Franklin County Sheriff's Department – (emergency)	9-1-1
(non-emergency)	(636) 583-2560
Franklin County Department of Health	(636) 583-7300

Appendix T

Recordkeeping and Reporting Forms

Ameren Missouri Labadie Energy Center Utility Waste Landfill
Utility Waste Landfill Operating Permit # ____________________
Franklin County, Missouri

DAILY REPORT- General Operations

Date: ____________________________

Weather Information: ____

____

____

Site Visitors: ____

____

____

DAILY REPORT- Utility Waste Landfill Operations

Coal Combustion Products Received:		Circle Appliable Units		Disposal Location:	
Fly Ash:	______________	TPD *	CY**	Cell 1:	☐
Bottom Ash:	______________	TPD	CY	Cell 2:	☐
FGD Material:	______________	TPD	CY	Cell 3:	☐
Total CCP:	______________	TPD	CY	Cell 4:	☐

* TPD = Tons Per Day **CY = Cubic Yards

Major Operational Problems, Complaints, or Difficulties:

____

____

____

____

Corrective Measures or Corrective Actions:

____

____

____

____

Dust Control Efforts: ____

____

____

____

Comments:

____

____

____

____

____

____

Landfill Manager or Designated Staff ____
(signature)

Monthly
Monitoring Well Field Inspection

Well ID: ____________ Date:

Access:

Accessibility: Good ___ Fair ___ Poor_____

Well clear of weeds and/or debris?: Yes ___ No ______

Well identification clearly visible?: Yes ___ No ______

Remarks:

Concrete Pad:

Condition of Concrete Pad: Good ___ Inadequate _____

Depressions or standing water around well?: Yes ___ No_____

Remarks:

Protective Outer Casing: Material =

Condition of Protective Casing: Good ___ Damaged_____

Condition of Locking Cap: Good ___ Damaged_____

Condition of Lock: Good ___ Damaged_____

Condition of Weep Hole: Good ___ Damaged_____

Remarks:

Well Riser: Material =

Condition of Riser: Good ___ Damaged_____

Condition of Riser Cap: Good ___ Damaged_____

Measurement Reference Point: Yes ___ No_____

Remarks:

Dedicated Purging/Sampling Device: Type -

Condition: Good ___ Damaged ___ Missing_____

Remarks:

Field Certification:

Signed Title Date

Appendix U

Draft FAI

March 29, 2013

LETTER FROM CHIEF FINANCIAL OFFICER

CERTIFIED MAIL: 7002 3150 0001 2354 9891

DIRECTOR
Missouri Department of Natural Resources
P. O. Box 176
Jefferson City, Missouri 65102

Dear Sir or Madam:

I am the chief financial officer of Union Electric Company, One Ameren Plaza, 1901 Chouteau Avenue, P. O. Box 66149, St. Louis, Missouri, 63166-6149. This letter is in support of the use of the financial test to demonstrate financial assurance, as specified in 10 CSR 80-2.030(4)(D)6. of the Missouri Solid Waste Management Rules ("SWMR") .

Solid Waste Operating Permit Number: 2005-121-LS
Sioux Power Plant Utility Waste Landfill
Sioux Plant, Union Electric Company
8501 N. State Route 94, P.O. Box 98
West Alton, MO 63386

Closure Cost Estimate: 2012 dollars $ 13,040,071
Post-Closure Care: 2012 dollars $ 951,910

Solid Waste Operating Permit Number: pending
Labadie Energy Center Utility Waste Landfill
Labadie Energy Center, Union Electric Company
226 Labadie Power Plant Rd., Labadie, MO 63055

Closure Cost Estimate: 2012 dollars $ 2,710,161
Post-Closure Care: 2012 dollars $ 1,650,217

1. This firm is the owner/operator of the following solid waste disposal areas for which financial assurance for closure care, post-closure care, or both, is demonstrated to the state of Missouri through the financial test pursuant to that specified in 10 CSR 80-2.030 (4)(D)6. of the SWMR. The current closure cost estimate, post-closure cost estimate, or both, covered by the test are shown for each disposal area:

   Sioux Power Plant Utility Waste Landfill
   Sioux Plant, Union Electric Company
   8501 N. State Route 94, P.O. Box 98
   West Alton, MO 63386

Closure Cost Estimate:	2012 dollars $13,040,071
Post-Closure Care:	2012 dollars $ 951,910

   Labadie Energy Center Utility Waste Landfill
   Labadie Energy Center, Union Electric Company
   226 Labadie Power Plant Rd., Labadie, MO 63055

Closure Cost Estimate:	2012 dollars $ 2,710,161
Post-Closure Care:	2012 dollars $ 1,650,217

2. This firm guarantees, through a corporate guarantee pursuant to that specified in 10 CSR 80-2.030(4)(D)6. of the SWMR, the closure care, post-closure care of the following solid waste disposal area(s) located in the state of Missouri owned or operated by subsidiaries of this firm. The current cost estimate for the closure care and/or post-closure care so guaranteed are shown for each disposal area(s): **NONE**

3. This firm is the owner/operator or guarantor of the following solid waste disposal areas for which financial assurance for closure and/or post-closure care is demonstrated through a financial test similar to that specified in 10 CSR 80-2.030(4)(D)6. of the SWMR. The current cost estimates for the closure and/or post-closure care covered by the test are shown for each disposal area: **NONE**

4. This firm is the owner/operator of the following solid waste disposal areas for which financial assurance for closure and/or post-closure care is demonstrated to a state through a financial test or other financial assurance instruments distinct from those specified in 10 CSR 80-2.030(4)(D)6. of the SWMR. The current closure and/or post-closure care cost estimates covered by such financial assurance are shown for each disposal area: **NONE**

   This firm is required to file a Form 10K with the Securities and Exchange Commission (SEC) for the latest fiscal year.

   The fiscal year of this firm ends on December 31. The figures for the following items marked with an asterisk are derived from this firm's independently audited, year-end financial statements for the latest completed fiscal year ended December 31, 2011 (in millions).

ALTERNATIVE II

1. Sum of current closure and post-closure cost estimates (total of all cost estimates shown in the four paragraphs above) $18.4
2. Current bond rating of most recent issuance of this firm and name of rating service: Moody's – A3 S&P – BBB+
3. Date of issuance of bond: March 20, 2009
4. Date of maturity of bond: March 15, 2039

*5. Tangible net worth: $ 4,030.

*6. Total assets in U.S. (required only if less than 90% of firm's assets are located in the U.S.): Not applicable

ANSWER YES OR NO:

7. Is line 5 at least 2 times line 1? Yes

*8. Are at least 90% of firm's assets located in the U.S.? Yes
If not, complete line 9.

9. Is line 6 at least 2 times line 1? Not applicable

"CERTIFICATION I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete.

I also hereby certify that the wording of this letter is identical to that specified in 10 CSR 80-2.030(4)(D)6.as such rules were constituted on the date shown immediately below."

Sincerely,

____

Signature

Martin J. Lyons, Jr.
Senior Vice President and
Chief Financial Officer
Date Signed: __________________

Appendix V

Survey Plat
Revised August 2013

Documents Included:

Explorer Pipeline Letter

Explorer Pipeline Email Correspondence

Survey Plat

explorer PIPELINE®

P. O. Box 2650
Tulsa, Oklahoma 74101
918-493-5172
Fax 918-493-5148
mailto:pnwakoby@expl.com

Patrick A. Nwakoby
Project Engineer

January 28, 2013

Ms. Barbara S. Skitt
Managing Supervisor, Real Estate
Ameren Services
PO Box 66149, MC 700
St. Louis, MO 63166-6149

Re: Proposed Waste Landfill; Explorer Pipeline Glenpool to Wood River 24" Line; Dwg. No. 421-AA-1199; Near MP 348, Tract #67 Franklin County, Missouri.

Dear Ms. Skitt,

Thank you for contacting Explorer Pipeline regarding the referenced project. It is our understanding that your company is working on the construction of several cells for waste landfill near your facility in Labadie, Missouri. The purpose of this letter is to express Explorer's interest in this project since it will traverse our 24-inch refined products pipeline easement.

From telephone conversations with you and others at Ameren, Explorer understands the impact on the pipeline will be minimal as follows:

The toe of the berms of the cells will be 100 feet from the centerline of the pipeline. Two gravel roads will be installed for use by Ameren traffic only to maneuver around the landfill area. These two roads will have no impact on the pipeline and shall be removed in the event of the need to access the pipeline. Ameren will install culverts to mitigate the potential of ponding water over the pipeline.

Explorer appreciates the early notification on this project and we look forward to assisting with this project to ensure its safe completion. If I can be of further assistance, please call me at (918) 493-5172.

Sincerely,

Patrick Nwakoby

From: Skitt, Barbara S
Sent: Thursday, November 15, 2012 5:39 PM
To: pnwakoby@expl.com
Cc: Reynolds, Renee M; Gerhardt, Kevin J
Subject: Ameren's Labadie Plant UWL Layout

Hi Patrick,

Thank you so much for your time again yesterday. Please find attached the revised layout of the Labadie UWL landfill. As we discussed the proposed landfill will no longer require a relocation of the pipe line. The new layout has the toe of the berms set back 100' off the centerline of the pipeline. The first 2 phases of the landfill will be west of the pipeline with no impact to the pipeline and phases 3 and 4 are east of the pipeline. Once phases 3 and 4 are constructed, 2 roads will be installed perpendicularly over the pipeline. These roads are for Ameren traffic only and are planned to only be gravel at a height of around 15'. These roads will be constructed in a way as not to impact the pipeline. These road will be able to be removed in short order if Explorer has a need to access their pipeline. Phases 1 and 2 have a life expectancy of 10-15 years after they go in service in 2015. Construction on phase 1 is scheduled for 2014. If you have any question feel free to call and discuss. **Please treat this email and attachment as confidential.**

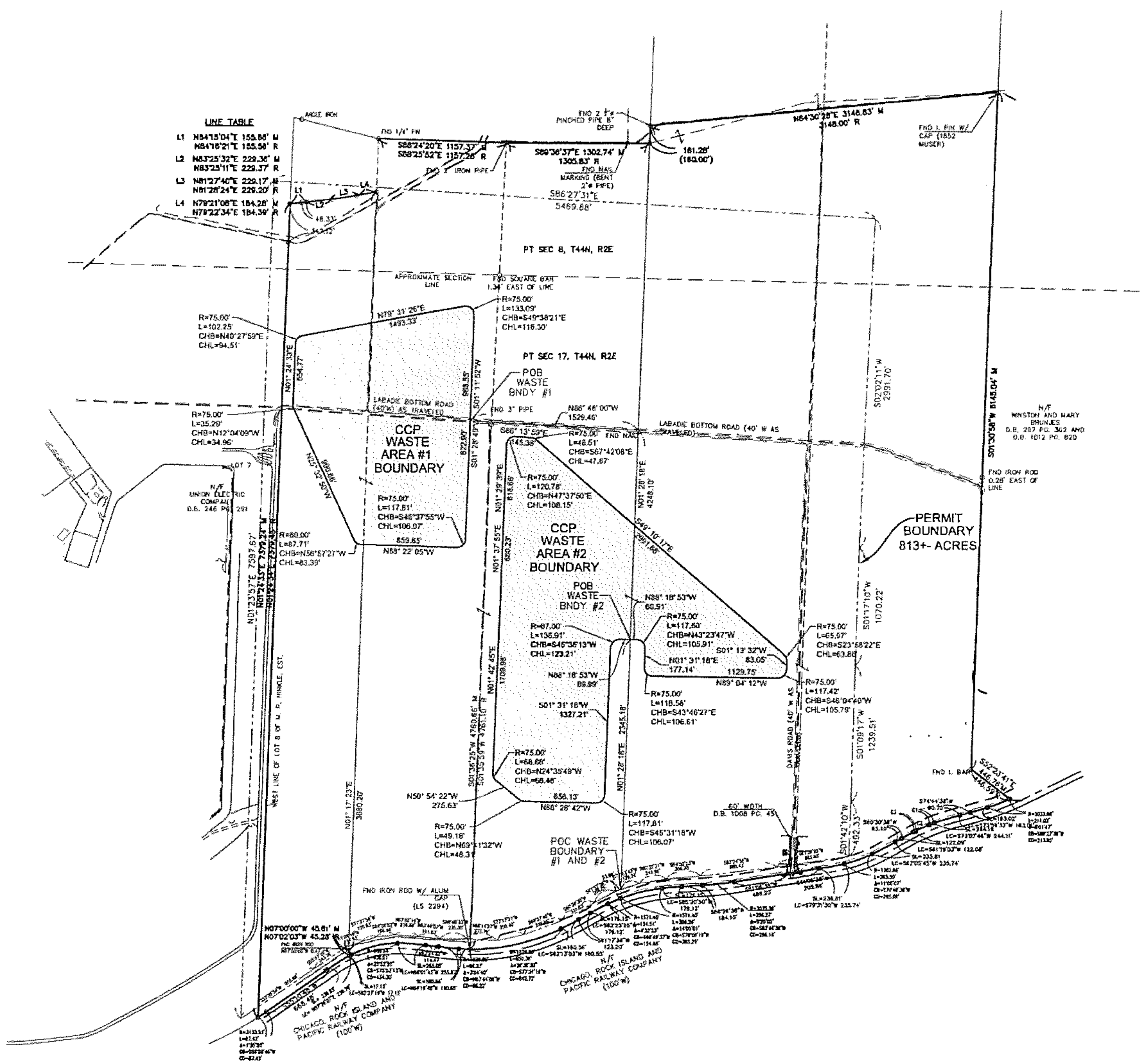
Have a good evening.

::::::::::::::::::::::::::::::
BARBARA S. SKITT
Managing Supervisor
Real Estate Department
T 314.554.2249
C 314.401.8674
F 314.554.2570
E bskitt@ameren.com
....

Ameren Services
1901 Chouteau Avenue
PO Box 66149, MC 700
St. Louis, MO 63166-6149
Ameren.com

CCP WASTE BOUNDARY AND PERMIT BOUNDARY EXHIBIT

TRACTS OF LAND IN PART OF SECTION 8 AND 17,
TOWNSHIP 44 NORTH, RANGE 2 EAST
OF THE FIFTH PRINCIPAL MERIDIAN
FRANKLIN COUNTY, MISSOURI



STATE OF MISSOURI
LS-2491
MICHAEL SAM HUBER
PROFESSIONAL LAND SURVEYOR

Michael S Huber 1-24-13

TRACTS OF LAND IN PART OF SECTION 8 AND 17,
TOWNSHIP 44 NORTH, RANGE 2 EAST
OF THE FIFTH PRINCIPAL MERIDIAN
FRANKLIN COUNTY, MISSOURI

CLIENT:
REITZ & JENS, INC.
1055 CORPORATE SQUARE DRIVE
ST. LOUIS, MO 63132
PHONE: (314) 993-4132

KdG
Kuhlmann *design* Group, Inc.
15 East Washington Street
Belleville, Illinois 62220-2149
Tel: 618.234.8898 Fax: 618.234.8959
St. Louis, MO • Belleville, IL

DISCLAIMER OF RESPONSIBILITY

NO.	DATE	

PROJECT NO. 120040	CONTRACT NO. 0002
DRAWN JPB	CHECKED MSH
DATE: 11-9-12	

S-1

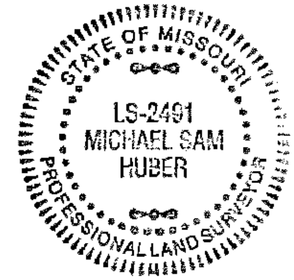
SHEET 1 OF 1

PROPERTY DESCRIPTION
Ameren Labadie Site
Permit Boundary

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

BEGINNING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORDS, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREES 28 MINUTES 18 SECONDS EAST, 80.58 FEET TO THE POINT OF BEGINNING OF THE TRACT HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 53.86 FEET; THENCE SOUTH 61 DEGREES 52 MINUTES 36 SECONDS WEST, 208.05 FEET; THENCE SOUTH 60 DEGREES 39 MINUTES 30 SECONDS WEST, 331.03 FEET; THENCE SOUTH 69 DEGREES 57 MINUTES 40 SECONDS WEST, 377.65 FEET; THENCE SOUTH 77 DEGREES 17 MINUTES 21 SECONDS WEST, 250.40 FEET; THENCE NORTH 86 DEGREES 14 MINUTES 27 SECONDS WEST, 273.79 FEET; THENCE 89 DEGREES 40 MINUTES 33 SECONDS WEST, 235.30 FEET; THENCE NORTH 83 DEGREES 46 MINUTES 07 SECONDS WEST, 191.63 FEET; THENCE NORTH 87 DEGREES 02 MINUTES 14 SECONDS WEST, 216.88 FEET; THENCE SOUTH 84 DEGREES 28 MINUTES 52 SECONDS WEST, 166.48 FEET; THENCE SOUTH 71 DEGREES 37 MINUTES 58 SECONDS WEST, 120.83 FEET; THENCE SOUTH 71 DEGREES 28 MINUTES 48 SECONDS WEST, 164.93 FEET; THENCE SOUTH 55 DEGREES 47 MINUTES 10 SECONDS WEST, 343.76 FEET; THENCE SOUTH 55 DEGREES 28 MINUTES 54 SECONDS WEST, 805.68 FEET; THENCE NORTH 01 DEGREES 23 MINUTES 57 SECONDS EAST, 7597.67 FEET; THENCE SOUTH 86 DEGREES 27 MINUTES 31 SECONDS EAST, 5469.88 FEET; THENCE SOUTH 02 DEGREES 02 MINUTES 11 SECONDS WEST, 2991.70 FEET; THENCE SOUTH 01 DEGREES 17 MINUTES 10 SECONDS WEST, 1070.22 FEET; THENCE SOUTH 01 DEGREES 09 MINUTES 17 SECONDS WEST, 1239.51 FEET; THENCE SOUTH 01 DEGREES 42 MINUTES 10 SECONDS WEST, 492.33 FEET; THENCE SOUTH 81 DEGREES 39 MINUTES 02 SECONDS WEST, 663.60 FEET; THENCE SOUTH 83 DEGREES 24 MINUTES 58 SECONDS WEST, 688.43 FEET; THENCE SOUTH 84 DEGREES 50 MINUTES 23 SECONDS WEST, 306.70 FEET; THENCE SOUTH 80 DEGREES 32 MINUTES 21 SECONDS WEST, 241.96 FEET; THENCE SOUTH 71 DEGREES 57 MINUTES 43 SECONDS WEST, 176.34 FEET TO THE POINT OF BEGINNING.

SAID TRACT BEING SITUATED IN FRANKLIN COUNTY, MISSOURI AND CONTAINING 35,422,418 SQUARE FEET OR 813.187 ACRES, MORE OR LESS.



Michael Huber 1·24·13

PROPERTY DESCRIPTION
Ameren Labadie Site
Waste Boundary

PART OF SECTIONS 8 AND 17 AND PART OF U.S. SURVEY 98 IN TOWNSHIP 44 NORTH, RANGE 2 EAST OF THE FIFTH PRINCIPAL MERIDIAN, FRANKLIN COUNTY, MISSOURI, DESCRIBED AS FOLLOWS:

CCP WASTE BOUNDARY AREA #1

COMMENCING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORD'S OFFICE, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREE 28 MINUTES 18 SECONDS EAST, 4,248.10 FEET TO THE CENTERLINE OF LABADIE ROAD; THENCE ALONG THE CENTER LINE OF LABADIE ROAD, NORTH 86 DEGREES 48 MINUTES 00 SECONDS WEST, 1,529.46 FEET TO THE POINT OF BEGINNING OF THE TRACT OF LAND HEREIN DESCRIBED; THENCE LEAVING SAID CENTERLINE, SOUTH 01 DEGREE 28 MINUTES 49 SECONDS WEST, 822.90 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.81 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 37 MINUTES 55 SECONDS WEST, A CHORD DISTANCE OF 106.07 FEET; THENCE NORTH 88 DEGREES 22 MINUTES 05 SECONDS WEST, 859.65 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 80.00 FEET, AN ARC DISTANCE OF 87.71 FEET, THE CHORD OF WHICH BEARS NORTH 56 DEGREES 57 MINUTES 27 SECONDS WEST, A CHORD DITANCE OF 83.39 FEET; THENCE NORTH 25 DEGREES 32 MINUTES 50 SECONDS WEST, 990.66 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 35.29 FEET, THE CHORD OF WHICH BEARS NORTH 12 DEGREES 04 MINUTES 09 SECONDS WEST, A CHORD DISTANCE OF 34.96 FEET; THENCE NORTH 01 DEGREE 24 MINUTES 33 SECONDS EAST, 554.77 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 102.25 FEET, THE CHORD OF WHICH BEARS NORTH 40 DEGREES 27 MINUTES 59 SECONDS EAST, A CHORD DISTANCE OF 94.51 FEET; THENCE NORTH 79 DEGREES 31 MINUTES 26 SECONDS EAST, 1,493.33 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 133.09 FEET, THE CHORD OF WHICH BEARS SOUTH 49 DEGREES 38 MINUTES 21 SECONDS EAST, A CHORD DISTANCE OF 116.30 FEET; THENCE SOUTH 01 DEGREE 11 MINUTES 52 SECONDS WEST, 968.55 FEET TO THE POINT OF BEGINNING.

Michael S Huber
1-24-13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

SAID TRACT (AREA #1) OF LAND BEING SITUATED IN FRANKLIN COUNTY MISSOURI AND CONTAINING 2,900,779 SQUARE FEET OR 66.593 ACRES MORE OR LESS.

CCP WASTE BOUNDARY AREA #2

COMMENCING AT THE SOUTHWEST CORNER OF LOT 1 OF "WORTHINGTON HEIRS SUBDIVISION" AS RECORDED IN PLAT BOOK C, PAGE 25 IN THE FRANKLIN COUNTY RECORD'S OFFICE, SAID SOUTHWEST CORNER BEING ON THE NORTHERLY RIGHT OF WAY LINE OF THE CHICAGO (100' W) ROCK ISLAND AND PACIFIC RAILWAY COMPANY; THENCE DEPARTING SAID NORTHERLY LINE AND ALONG THE WESTERLY LINE OF SAID "WORTHINGTON HEIRS SUBDIVISION" NORTH 01 DEGREE 28 MINUTES 18 SECONDS EAST, 2,345.18 FEET TO THE POINT OF BEGINNING OF THE TRACT OF LAND HEREIN DESCRIBED; THENCE DEPARTING SAID WESTERLY LINE NORTH 88 DEGREES 18 MINUTES 53 SECONDS WEST, 89.99 FEET; THENCE ALONG A CURVE TO THE LEFT, HAVING A RADIUS OF 87.00 FEET, AN ARC DISTANC OF 136.91 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 36 MINUTES 13 SECONDS WEST, A CHORD DISTANCE OF 123.21 FEET; THENCE SOUTH 01 DEGREE 31 MINUTES 18 SECONDS WEST 1,327.21 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE 117.81 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 31 MINUTES 18 SECONDS WEST, A CHORD DISTANCE OF 106.07 FEET; THENCE NORTH 88 DEGREES 28 MINUTES 42 SECONDS WEST, 656.13 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 49.18 FEET, THE CHORD OF WHICH BEARS NORTH 69 DEGREES 41 MINUTES 32 SECONDS WEST, A CHORD DISTANCE OF 48.31 FEET; THENCE NORTH 50 DEGREES 54 MINUTES 22 SECONDS WEST, 275.63 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75 .00 FEET, AN ARC DISTANCE 68.88 FEET, THE CHORD OF WHICH BEARS NORTH 24 DEGREES 35 MINUTES 49 SECONDS WEST, A CHORD DISTANCE OF 66.48 FEET; THENCE NORTH 01 DEGREE 42 MINUTES 45 SECONDS EAST, 1,709.98 FEET; THENCE NORTH 01 DEGREES 37 MINUTES 55 SECONDS EAST, 660.23 FEET; THENCE NORTH 01 DEGREES 29 MINUTES 39 SECONDS EAST, 618.66 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 120.78 FEET, THE CHORD OF WHICH BEARS NORTH 47 DEGREES 37 MINUTES 50 SECONDS EAST, A CHORD DISTANCE OF 108.15 FEET; THENCE SOUTH 86 DEGREES 13 MINUTES 59 SECONDS EAST, 145.38 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 48.51 FEET, THE CHORD OF WHICH BEARS SOUTH 67 DEGREES 42 MINUTES 08 SECONDS EAST, A CHORD DISTANCE OF 47.67 FEET; THENCE SOUTH 49 DEGREES 10 MINUTES 17 SECONDS EAST, 2991.68 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 65.97

Michael S Huber
1.24.13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

FEET, THE CHORD OF WHICH BEARS SOUTH 23 DEGREES 58 MINUTES 22 SECONDS EAST, A CHORD DISTANCE OF 63.86 FEET; THENCE SOUTH 01 DEGREE 13 MINUTES 32 SECONDS WEST, 83.05 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.42 FEET, THE CHORD OF WHICH BEARS SOUTH 46 DEGREES 04 MINUTES 40 SECONDS WEST, A CHORD DISTANCE OF 105.79 FEET; THENCE NORTH 89 DEGREES 04 MINUTES 12 SECONDS WEST, 1,129.75 FEET; THENCE ALONG A CURVE TO THE RIGHT, HAVING A RADIUS 75.00 OF FEET, AN ARC DISTANCE OF 118.58 FEET, THE CHORD OF WHICH BEARS NORTH 43 DEGREES 46 MINUTES 27 SECONDS EAST, A CHORD DISTANCE OF 106.61 FEET; THENCE NORTH 01 DEGREE 31 MINUTES 18 SECONDS EAST, 177.14 FEET; THENCE ALONG A CURVE TO THE LEFT, HAVING A RADIUS OF 75.00 FEET, AN ARC DISTANCE OF 117.60 FEET, THE CHORD OF WHICH BEARS NORTH 43 DEGREES 23 MINUTES 47 SECONDS WEST, A CHORD DISTANCE OF 105.91 FEET; THENCE NORTH 88 DEGREES 18 MINUTES 53 SECONDS WEST, 60.91 FEET TO THE POINT OF BEGINNING.
SAID TRACT (AREA #2) OF LAND BEING SITUATION BEING SITUATED IN FRANKLIN COUNTY MISSOURI AND CONTAINING 4,351,083 SQUARE FEET OR 99.887 ACRES MORE OR LESS.

Michael S Huber
1-24-13

STATE OF MISSOURI
LS-2491
MICHAEL SAM
HUBER
PROFESSIONAL LAND SURVEYOR

Appendix W

Groundwater Hydraulic Data

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

Appendix W
Groundwater Hydraulic Data Summary

December 2012

INTRODUCTION

Appendix W contains a summary description and graphical representations of surface water and groundwater data acquired from the Ameren Missouri Labadie Energy Center proposed Utility Waste Landfill site during completion of the Detailed Site Investigation (DSI) in 2009-2010. The surface water and groundwater data have been evaluated to identify and describe the factors that influence the direction and flow rate of the uppermost aquifer beneath the proposed Utility Waste Landfill. Additional details on the data used for this evaluation can be found in the DSI report for this site on file with the Missouri Department of Natural Resources, Division of Geology and Land Survey in Rolla, Missouri and referenced at the end of this report.

The Ameren Missouri Labadie Energy Center is located near Missouri River Mile 57. Missouri River elevations obtained from the Labadie Energy Center gauging station, which is at the same approximate river mile, are provided for comparison to the groundwater data due to the significant influence river levels have on the groundwater potentiometric surface across the site.

DISCUSSION OF DATA

Groundwater elevation readings were taken on a monthly basis for twelve consecutive months from all one hundred (100) piezometers installed at the site for the DSI. These readings were taken from December 2009 through November 2010. Seven additional sets of readings from select piezometers were obtained between late April and June 2010 to better evaluate what short term impacts rising Missouri River elevations have on the groundwater elevations and gradients beneath the proposed site. The DSI report also investigated what impact precipitation has on groundwater elevations. Following approval of the DSI report, 90 of the piezometers were properly plugged and abandoned in April 2011. The remaining 10 piezometers were properly plugged and abandoned in early September 2011.

During the year-long DSI monitoring period, it was determined that the direction of groundwater flow varied in response to Missouri River elevation. During periods of relatively low river elevations (November-February) the prevailing direction of groundwater flow was north-northwest toward the river. During periods of relatively high river elevations (March-October) the prevailing direction of groundwater flow shifted eastward. These changes in flow direction can be quite rapid. For example, from the "routine" monthly measurements made on May 11, 2010 to the supplemental measurements made on May 18, 2010, as the Missouri River rose 12 feet, groundwater flow shifted approximately 90 degrees from a northeasterly to a southeasterly direction. This shift was accompanied by site-wide increases in groundwater levels of between 1.5 and 7.25 feet and a corresponding increase in hydraulic gradient.

The behavior of groundwater elevations in response to changes in Missouri River stage as described in the DSI report indicated that at the beginning of the monitoring period (December 2009), river elevation was below the water table surface. It remained more or less below the local water table throughout the succeeding three months (January to March 2010) except for relatively short-term periods (4 to 9 days). Average water table elevation remained slightly above 459 feet during this period and overall groundwater flow direction was northward, toward the Missouri River. However, beginning in mid-March 2010, river level surged above 460 feet and generally remained above that elevation through late August 2010. During that same time period, average water table elevation also rose above 460 feet, where it remained throughout the five-month time span. Water table maps for this time period (March-August 2010) show overall groundwater flow direction with a strong easterly component. Northeasterly trends for the months of March and May 2010 coincided with relatively "low" average water table elevations (460.41 to 461.98 feet) and a southeasterly trend during July 2010 coincided with a relatively high and sustained water table exceeding 463 feet. By November 2010, as both the water table and river levels dropped below 460 feet, overall groundwater flow direction "reverted" to the northwest, essentially mirroring groundwater behavior observed during the first three months of monitoring.

Comparison of groundwater levels in the southeastern part of the site (farthest from the river) to groundwater levels in the northwestern part of the site (closest to the river) suggests that the reversal in groundwater flow occurs when the Missouri River level attains a more or less sustained elevation of between 461 and 463 feet.

As recorded in the DSI report, calculated groundwater velocities range from extremes of 0.1 to 584 feet per year (ft/yr). This wide range is chiefly attributable to both calculated hydraulic gradient and effective porosity values. Hydraulic conductivity values are relatively uniform across the site due to the homogeneous nature of the sandy soils comprising the alluvial aquifer. The DSI report indicated that the lower ranges in hydraulic gradient were believed more representative of prevailing groundwater movement at the site, which results in velocities ranging from 0.1 to 10 ft/yr. However, the report also noted the possibility of higher groundwater velocity values in the northwestern part of the site, where hydraulic gradient increases in response to changes in Missouri River elevation.

Figure 1 is a graphical representation of the relationship between groundwater and river elevations at the Ameren Missouri Labadie Energy Center proposed landfill site from the period December 2009 to November 2010. It is based on Figure 31 of the DSI Report. In addition, Figure 2 provides a summary of groundwater movement for the twelve-month monitoring period

(December 2009 to November 2010) during the DSI investigation. The figure is based on Figures 18-29 of the DSI Report.

SUMMARY AND CONCLUSIONS

The variable direction of groundwater movement at the Ameren Missouri Labadie Energy Center proposed landfill site appears intrinsically related to Missouri River elevation. When river elevations are relatively high, it acts as a recharge source to the alluvial aquifer and groundwater movement is generally toward the east and southeast. Conversely, when river elevations are relatively low, the local water table appears to "unwater" toward the river and groundwater movement is generally toward the north and northwest. Based on the data presented in the DSI report, this change in flow direction occurs when the Missouri River reaches an elevation of between 461 and 463 feet. Comparison of the river gauge data acquired during the 12-month monitoring period to gauge data for the preceding ten years suggests that river levels were unseasonably high in 2010, relative to the years 2000-2009. Thus, "unwatering" of the local water table toward the Missouri River may be more prevalent than what was suggested by the DSI data. Regardless, groundwater movement throughout much of the site is along a shallow hydraulic gradient. Calculated groundwater velocities believed to be representative of this shallow gradient range from 0.1 to 10 ft/yr, but could be as high as 584 ft/yr. Higher velocities to the northwest are suggested, where hydraulic gradient increases.

REFERENCES

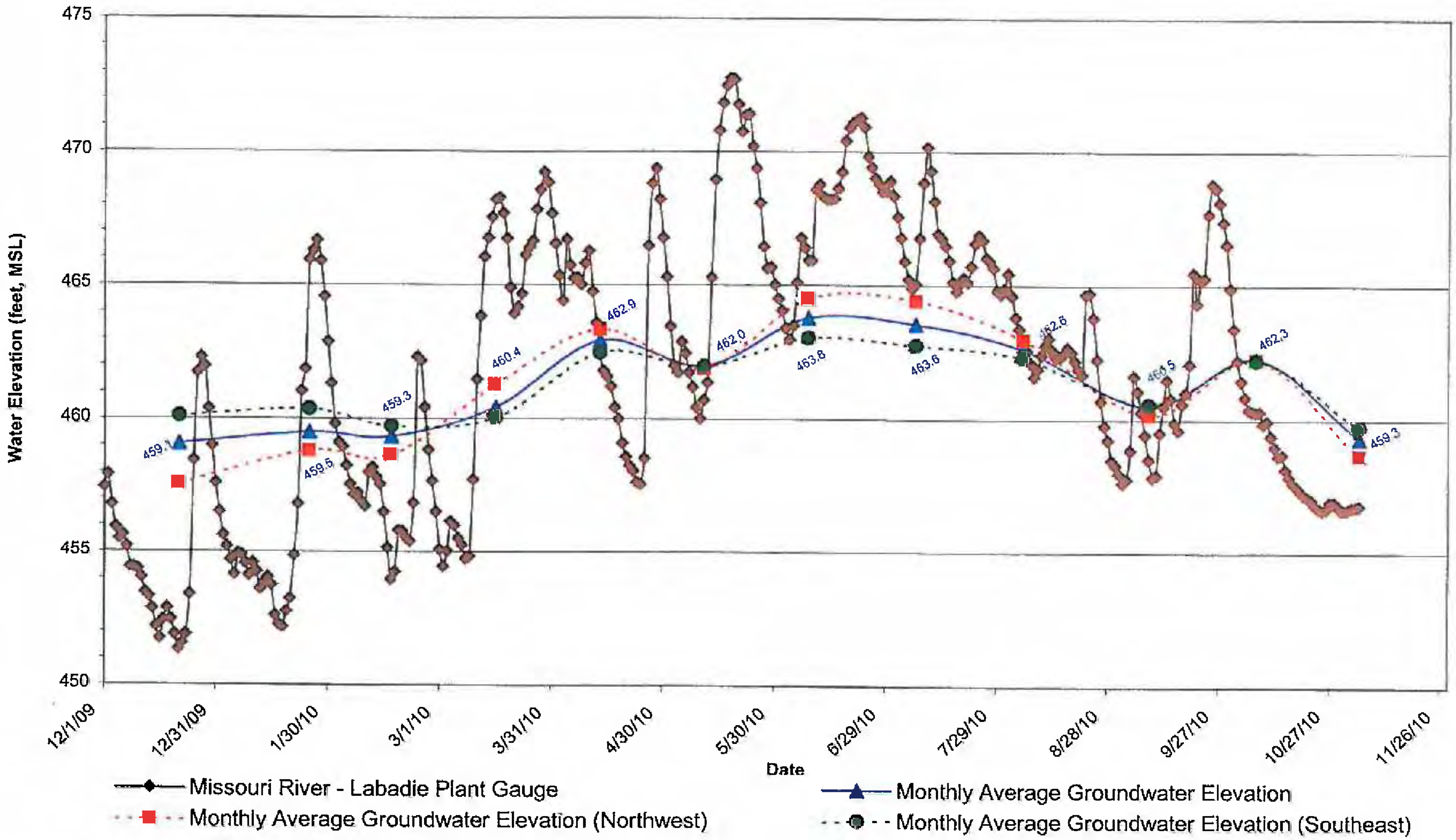
1. *Detailed Site Investigation Report For Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011 by GREDELL Engineering Resources, Inc. and Reitz & Jens, Inc.

FIGURES

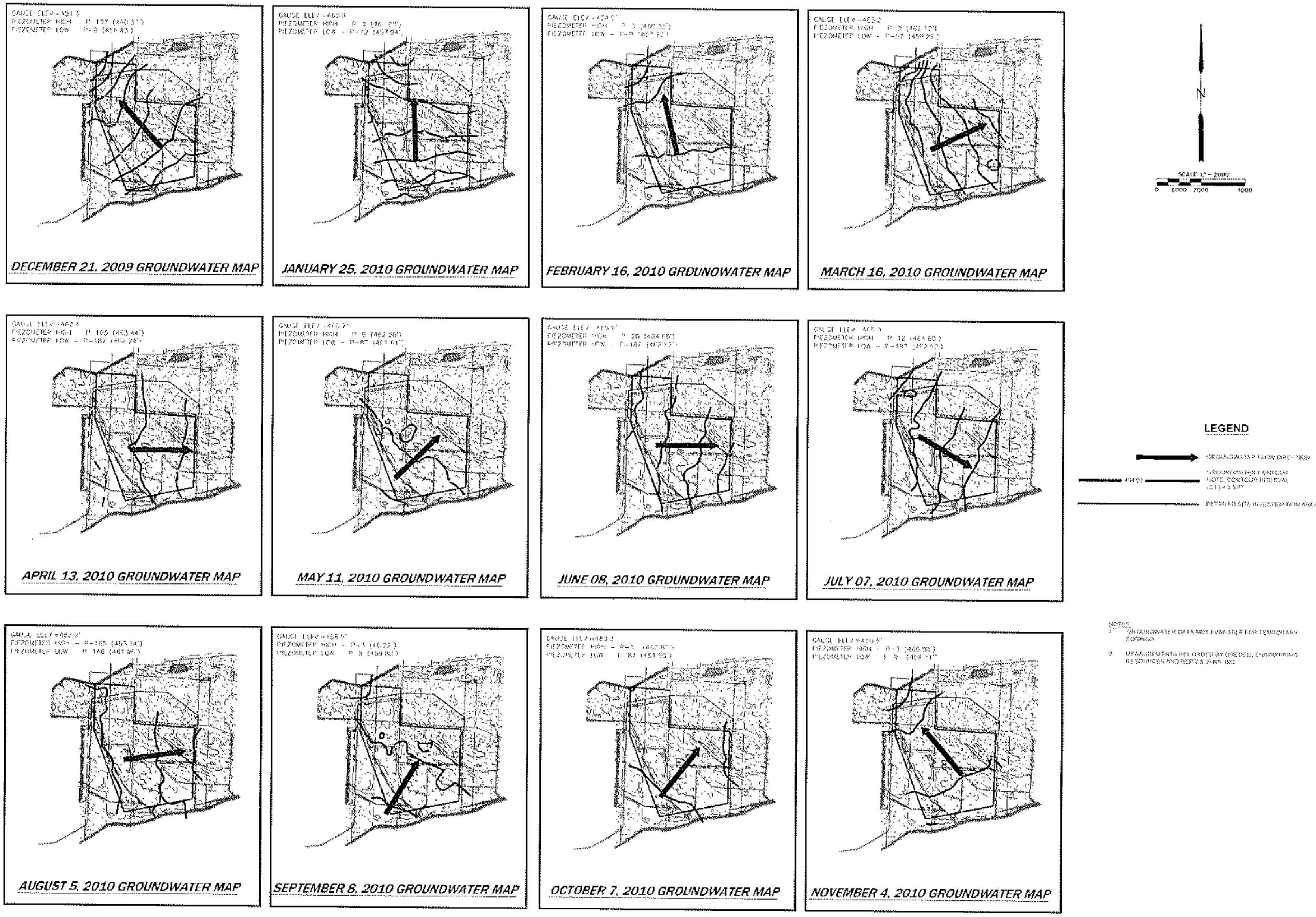
AMEREN MISSOURI LABADIE POWER PLANT
GROUNDWATER HYDRAULIC DATA SUMMARY
APPENDIX W

Monthly Average Water Table Elevation vs Missouri River Elevation

FIGURE 1*



*From Figure 31 of the Detailed Site Investigation Report



NOTES:

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS
2. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ & JENS INC.

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PREPARED FOR Ameren

DRAWN W.J.A. (GER)	FIGURE 2 APPENDIX W GENERALIZED GROUNDWATER SUMMARY DECEMBER 2009 THROUGH NOVEMBER 2010
CHKD M.C.C. (GER)	
SUPV M.C.C. (GER)	
APPD M.C.C. (GER)	LOCATION 001004 — LABADIE PLANT — CLASS 02010

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Appendix X

Documentation of Groundwater Monitoring System Design

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri

Appendix X
Documentation of Groundwater Monitoring System Design

December 2012

INTRODUCTION

This document provides the methodology used to determine the number, location, spacing, and overall design of the proposed groundwater monitoring system for the proposed Ameren Missouri Labadie Utility Waste Landfill (UWL) at the Labadie Energy Center in Franklin County, Missouri. It is provided in support of the Solid Waste Disposal Area Construction Permit application submitted to MDNR-SWMP.

This evaluation is based on the results of the Detailed Site Investigation (DSI) undertaken in 2009-2010 and detailed in a report entitled, *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri,* dated February 4, 2011 and revised March 30, 2011. Data from that report were utilized as baseline parameters for the development of a dispersion model that provided insight into the spacing of wells needed to provide a system of downgradient monitoring wells that would detect potential leakage from the UWL. The results of this analysis have been used to propose the number and location of the permanent groundwater monitoring wells for inclusion in the Solid Waste Disposal Area Construction Permit Application. Screen interval depths necessary to ensure full immersion during seasonal groundwater fluctuations were also assessed using the data from the DSI report. They are described at the end of this report.

BASELINE HYDROLOGIC DATA

Review of the hydrologic data contained in the DSI Report indicate that a notable feature concerning groundwater movement is the large temporal fluctuation in overall flow direction in response to the rise and fall of Missouri River elevation (refer also to Appendix W). Examination of the monthly groundwater maps contained in that report (December 2009 through November 2010) demonstrate that the prevailing direction of flow describes a wide arc approaching 180° as it moves roughly from north-northwest during periods of low river stage to east-southeast during periods of high river stage. These temporal changes can be quite rapid. For example, between May 11, 2010 and May 18, 2010, during which period of time the Missouri River rose 12 feet, the prevailing direction of groundwater movement shifted approximately 90 degrees from northeast to southeast. This shift was accompanied by site-wide increases in groundwater levels of between 1.5 and 7.25 feet and a corresponding increase in hydraulic gradient. As a result, much of the proposed disposal area perimeter exhibits both hydraulically upgradient and downgradient conditions with respect to waste disposal limits dependent on river stage. Further, areas of the proposed UWL closer to the Missouri River appear to exhibit a more vigorous response to changing river elevations than those areas more remote from the river proper.

For those reasons, it was determined that baseline hydrologic data used should be specific with respect to proposed landfill development nearest the river relative to proposed landfill development farther from the river. Consequently, for the proposed Cell 1 and Cell 2 construction areas, hydrologic data pertaining to piezometers installed during the DSI in the western and northwestern parts of the site were considered (reference Sheet 3 of Construction Permit Application Plans for site layout). Similarly, those data pertaining to the southern and southeastern parts of the site were considered for the Cell 3 and Cell 4 construction areas. This approach allows for the recognition of variations in hydrologic conditions across the site and accounts for them in the development of a model for long-term detection monitoring at the site.

The baseline data used for the proposed cell construction areas included an assessment of principal flow direction during each of the twelve successive months of water level monitoring, calculated hydraulic gradients, and hydraulic conductivity data as presented in the DSI report. These data are provided for review as Attachment 1 to this appendix. For both the Cell 1-2 and Cell 3-4 areas, average values for hydraulic gradient and hydraulic conductivity were obtained and those values were then used to calculate a range in groundwater velocity, as summarized in Table 1. Examination of Table 1 shows that subtle variations exist in the hydrologic data for each of these areas.

These baseline data were then input into the groundwater model to determine the direction and extent of plume dispersion over a given period of time in order to develop spacing criteria and the total number of long-term groundwater monitoring wells believed required along the perimeter of proposed waste disposal boundaries.

GROUNDWATER MODEL DESCRIPTION

The two-dimensional model chosen for use is called PLUME and is available in the Monitoring Network Design Package, MAP, authored by Golder Associates, Inc. (1992) and available through the International Ground Water Modeling Center at the Colorado School of Mines. This model was chosen because it provides a reasonable and readily available model for estimating groundwater plume dispersion independent of linear flow direction.

Mathematically stated it is:

$$C(x,y,t) = (C_o/4)\, e[(xv/2D_x)[1-(1+4kD_x/v^2)^{1/2}]]\, \mathrm{erfc}[[x-vt(1+4kD_x/v^2)^{1/2}]/2(D_xt)^{1/2}]$$
$$[\mathrm{erf}[(y+Y/2)/2(D_Yx/v)^{1/2}]-\mathrm{erf}[(y-Y/2)/2(D_Yx/v)^{1/2}]]$$

Where,

- $C(x,y,t)$ = target downgradient contaminant concentration. The value used was set at one-one thousandth (0.001) of the concentration at the point of release.

- C_o = the concentration of the contaminant at the point of release. This value is 1000x the downgradient contaminant concentration. For example, if an initial chloride concentration of 3,000 mg/l is used, then the target downgradient concentration is equal to 3 mg/l, which is within generally accepted laboratory PQLs.
- k = the first-order radioactive decay constant. A conservative value of zero was used in the analysis because no diminution of the source is assumed.
- erfc = complimentary error function
- x = distance downgradient from the release. This value is generated by the software to determine the shape and dimensions of the plume.
- v = average contaminant velocity. The contaminant velocity is calculated as the groundwater velocity divided by the retardation factor (R). Generally, mobile tracers like chloride will flow at the same rate as groundwater and will not be retarded. Therefore, a conservative value of one (1) was used for R and average contaminant velocity equals groundwater velocity. The averaged annual groundwater velocity is taken as the sum of the twelve monthly displacements, which then defines the major components of the resultant vector used to determine the dispersion coefficients. For Cells 1 and 2, an average yearly velocity of 14.54 feet (1.21 feet per month) was determined (Table 2a). For Cells 3 and 4, an average yearly velocity of 12.16 feet (1.0 foot per month) was determined (Table 2b).
- D_x = longitudinal dispersion coefficient. This is a constant used to model spreading of the wave front in the direction of flow. It is derived by using a coefficient times the average monthly velocity in the principal direction of flow for each of the twelve months of data collection. By projecting each monthly change in velocity and principal flow direction as a resultant vector, an estimate of the longitudinal dispersion is determined using one standard deviation divided by the average monthly velocity along the primary direction of flow. Tables 2a and 2b summarizes these calculations for both the Cell 1-2 and Cell 3-4 areas.
- t = time (in months) of continuous leakage from the defect. A value of 528 months or 44 years was used. This time period is roughly equivalent to the life expectancy of the UWL plus a 20-year closure-post closure time period.
- erf = error function
- y = transverse distance from the defect. This value is generated by the software to determine the shape and dimensions of the plume.
- Y = the width of the source. A value of one hundred feet was used because it anticipates a seam failure in the geomembrane liner.
- D_y = transverse dispersion coefficient. This is the constant used to model spreading of the wave front at right angles to the direction of flow for this two dimensional model. The model uses a coefficient times the average velocity in the primary direction of flow to provide a variation in the velocity. By projecting each monthly vector as the velocity at right angles to the resultant vector for the twelve months of data collection, an estimate of the transverse dispersion factor is calculated as the standard deviation of those twelve projections divided by

the average monthly velocity at right angles the direction of flow. Tables 2a and 2b summarizes these calculations for both the Cell 1-2 and Cell 3-4 areas.

The illustration provided below is intended as an aide to envision how leakages will fan out (disperse) from a discrete failure point. As the contaminants move with the groundwater downgradient (X-axis), the concentration at the leading edge of the plume gets broader (Y-axis).

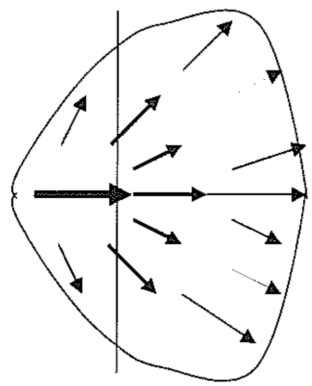


Illustration: Visualization of leak dispersion as it moves downgradient with groundwater flow.

Further documentation for the Plume model can be found in a paper authored by Wilson et al. (ref. Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO); GROUNDWATER, v.30, No. 6, Nov.-Dec. 1992). This reference provides a specific equation for modeling the longitudinal and transverse dispersion of a nonreactive constituent in a homogeneous medium. A copy of the reference is provided for review as Attachment 2 to this appendix.

CRITERIA FOR MODEL

As applied to the Labadie UWL, the model assumptions used were:

- Leakage from the UWL is through an imperfection in the geomembrane liner with a length of 100 feet.
- The liner failure allows leakage to move vertically until the contaminant encounters the top of the groundwater table.
- Each release is modeled as a set of particles that move within groundwater and the particles essentially serve as mathematical markers for estimating the extent of the plume.
- The contaminants stay suspended in the water column without creating density gradients, which could influence the direction of contaminant transport.

- Contaminants move by advective and dispersive components of flow, but will not diffuse due to chemical gradients.
- The vertical component of dispersion is not considered as significant as the horizontal component because contaminant concentrations are assumed to be preferentially moving parallel with groundwater flow direction. Moreover, the intended function of the well system is as a detection monitoring network and therefore the wells will be screened in the upper portion of the alluvial aquifer to ensure early detection in the event of a contaminant release, as described at the end of this report.
- The detection limit for the contaminant is sensitive enough to be reported as it moves near a given well point. This limit is set at one-one thousandth (0.001) of the actual concentration at the point of release.
- The prevailing direction of groundwater movement is equivalent to the average of the twelve monthly directional vectors noted for each area in Attachment 1.
- The model uses no loss or gain of the solute mass due to geochemical reactions following a release, including organic reactions. Therefore, both the first order decay constant and the chemical diffusion constant were set at zero.
- The modeling uses a period of diffusion of 528 months (44 years). This time period is roughly equivalent to the life expectancy of the UWL plus a 20-year closure-post closure time period.

MODEL APPLICATION AND WELL SPACING

The application of the PLUME model to determine an appropriate spacing for the groundwater monitoring network required input values for velocity, transverse dispersivity, longitudinal dispersivity, and time (Tables 2a and 2b). The PLUME software then uses these data to generate a scaled, 2-dimensional plot for each of the four phases showing three contours representing concentrations of one-tenth (0.1), one-hundredth (0.01), and one-one thousandth (0.001) of the concentration at the point of entry into the groundwater (Attachment 3). The innermost contour around the source represents the highest concentration (10 percent of source concentration), the middle contour represents one percent of the source concentration, and the outermost contour represents one-tenth of a percent of the source concentration.

Once the plots were developed, a series of overlays were made and superimposed on a map of the site and oriented along the primary axis of flow as determined from the average of the monthly longitudinal flow vectors presented in Tables 2a and 2b. The origin of the plots (i.e. release point) was established as close to the edge of proposed waste boundaries as practicable. The overlays were then manipulated so that points of intersection were attained at the 0.001 contour interval. Those points of intersection along the downgradient sides of the proposed UWL were then considered the minimum spacing whereupon early detection of a release could be determined. The modeling effort resulted in the identification of 21 downgradient well locations (Figure 2). Beginning at the northwestern corner of the site, well spacing along the northern edge of Cell 2 is approximately

450 feet (well ID #'s MW-1 through MW-4). Well spacing between MW-5 and MW-7 is wider since these wells are farther from the waste disposal limits of Cell 2 due to the location of Pond 2. Well spacing along the eastern perimeter of Cell 3 is approximately 330 feet (well ID #'s MW-7 through MW-17). The spacing was increased along the southern edge of Cell 3 to avoid well placement impacting jurisdictional areas (well ID # MW-18). Well spacing along the eastern perimeter of Cell 4 is between approximately 330 and 500 feet (well ID #'s MW-19 through MW-21). Table 3 summarizes location information for the proposed downgradient wells. The table also describes a temporary monitoring well (TMW-1) that will serve as a "sentry" for the initial operations within Cell 1. It will be located immediately east (downgradient) of Cell 1 within the utility pipeline corridor (Figure 2) and used to supplement water quality data derived from the permanent downgradient wells located along the eastern perimeter of Cell 3. TMW-1 will be removed as soon as Cell 3 becomes operational.

For those areas considered hydraulically upgradient of proposed waste boundaries, which includes the western and southwestern perimeter of the site, seven additional wells are proposed to complete the groundwater monitoring network. These wells are identified as MW-22 through MW-28 on Figure 2. Spacing is greater for these wells than it is for the downgradient wells. It is widest along the west-central perimeter of the site (1,400 feet) but systematically decreases to less than 1,000 feet toward the northwestern and southeastern parts of the site (i.e. where downgradient conditions begin). Table 3 summarizes location information for the proposed upgradient wells.

WELL SCREEN PLACEMENT

A determination of well screen placement is primarily dependent upon two inter-related factors. One, the well screen should be placed at a level that ensures to the extent practicable that the entire screen interval remains fully saturated, even during periods of low river stage of the Missouri River. Two, the top of the well screen should be placed at a depth as shallow as practicable to provide early detection of contaminants that may disperse within the upper part of the water table. Lithologic composition and monitoring well construction constraints also have to be considered in the positioning of well screen depth.

As documented in the DSI Report for this facility, the chief control on water table elevations is the Missouri River. As the Missouri River stage increases, it is accompanied by a corresponding, progressive rise in groundwater levels in a northwest to southeast direction. Conversely, as the Missouri River stage decreases, it is accompanied by a progressive drop in groundwater levels that, if sustained, eventually reverses the overall direction of groundwater movement back to the northwest. While these fluctuations were apparent throughout the site, they become more pronounced to the northwest, as the Missouri River is approached. Piezometric data from that area document fluctuations in excess of eight feet whereas fluctuations in the southeastern part of the site are between three and four feet. In light of these data, a single elevation for the placement of well screens cannot be used. Rather, well screen elevations vary and become progressively deeper in a northwesterly direction.

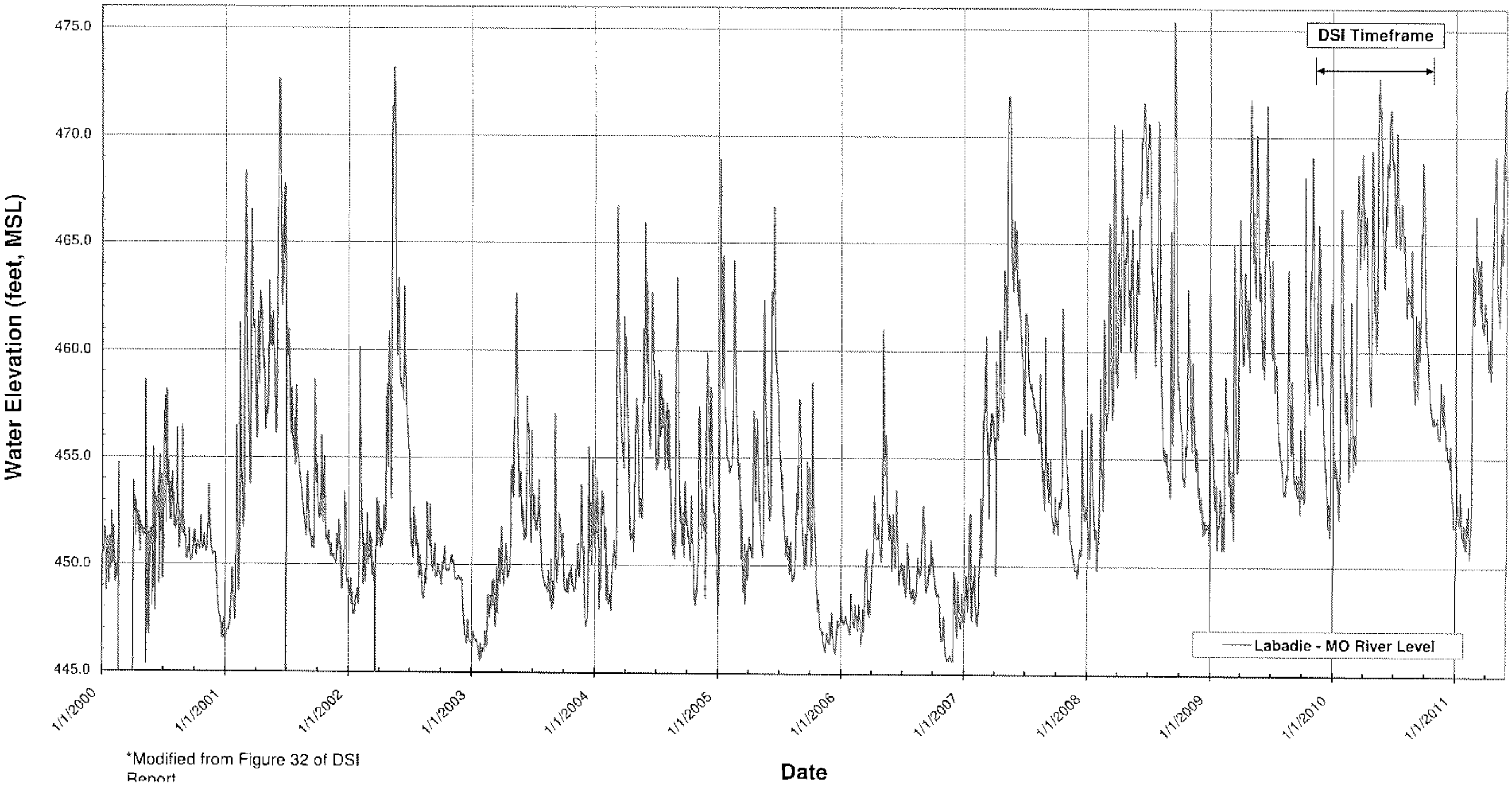
Review of the Missouri River data presented in the DSI report suggests that the 12-month timeframe during which piezometric monitoring was in effect at the site (December 2009 to November 2010) coincided with a period of relatively high Missouri River elevations (between 451 and 473 feet). Consequently, it was necessary to examine the historical data presented in that report to determine a low river elevation. Inspection of that data, which is included here for reference (Figure 1), indicates that 445 feet approximates the lowest recorded river elevation during the preceding ten-year timeframe.

Using this documented low river elevation as a point of intersection, linear regression plots were made showing the projected height of the water table surface at select points centered along the primary northwest-southeast axis of flow beneath the proposed UWL facility. Monthly water level data from a total of 14 piezometers installed during the DSI were used in the analysis (Attachment 4). The results show that the water table surface would be expected to drop to 454.5 feet in the extreme northwestern part of the facility near the location of former piezometer P-9 (Figure 2). Thus, a monitoring well in that area would need to have its well screen set at an elevation no higher than approximately 454 feet to ensure full saturation during low river stage. As the primary axis of flow is traced southeastward, the projected point of intersection of the water table surface with low river stage (445 feet) gradually increases and lines drawn perpendicular to the primary axis of flow in one-foot increments define the maximum well screen elevation throughout the remainder of the facility. Note that these incremental boundaries define regions where projected water table elevations remain approximately 0.5 feet above the maximum well screen height. Based on this analysis, anticipated well depths (assuming 10-ft well screens) for the proposed groundwater monitoring well system layout are summarized in Table 3.

Figures

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Construction Permit Application

Missouri River Historical Data (2000-2011)
Figure 1*



*Modified from Figure 32 of DSI Report

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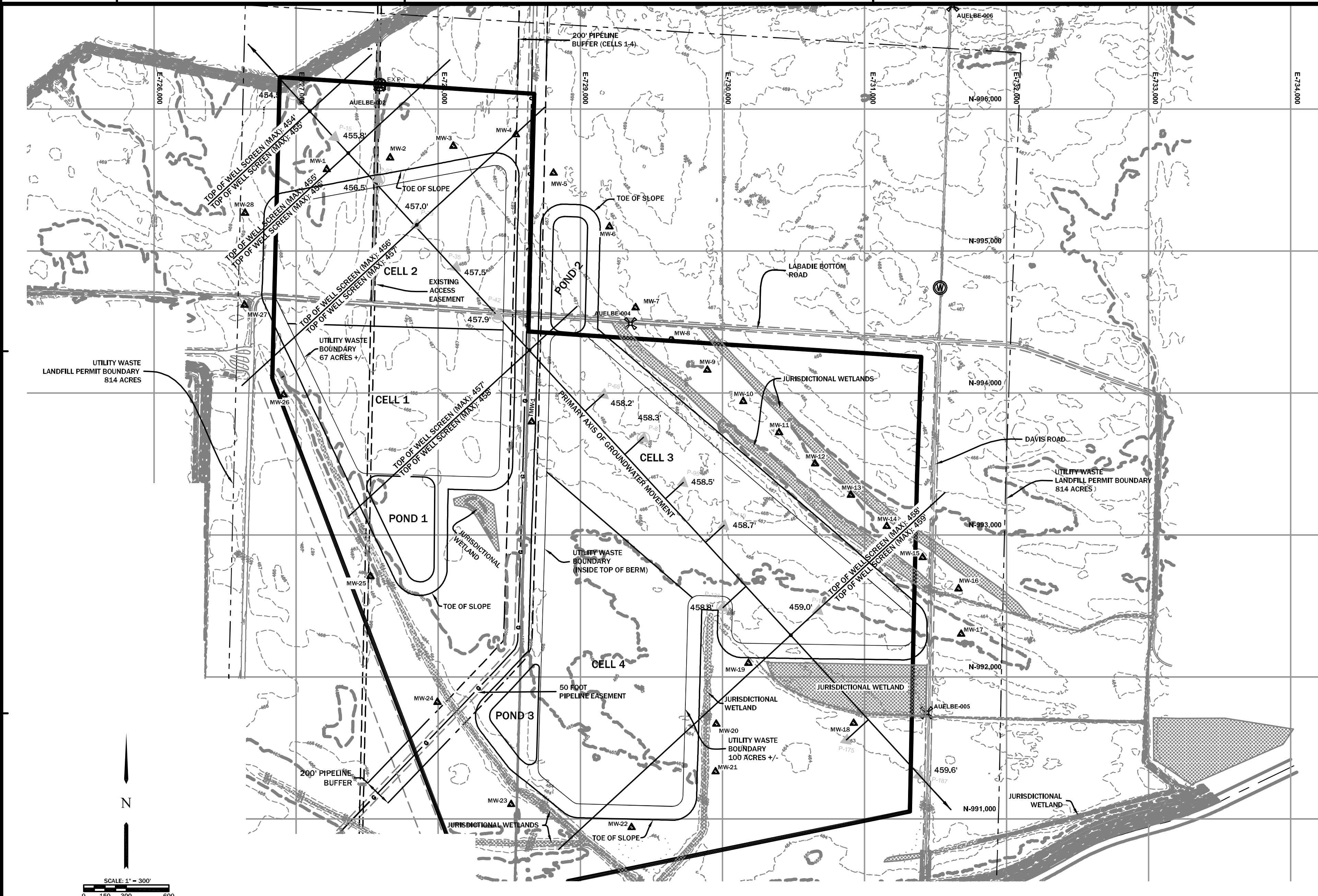

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996729.00	731621.70	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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LAND AIR WATER

PREPARED FOR Ameren MISSOURI

DRAWN W.J.A. (G.E.R.)	FIGURE 2, APPENDIX X PROPOSED UTILITY LANDFILL WELL SCREEN ELEVATION SUMMARY
CHKD. R.L.R. (G.E.R.)	
SUPV. T.R.G. (G.E.R.)	
APPD. T.R.G. (G.E.R.)	LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010
Ameren MISSOURI — ST. LOUIS, MISSOURI	DECEMBER 18, 2012 — REV.

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Tables

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Franklin County, Missouri

Calculated Groundwater Velocities by Month
Table 1

Cells 1 and 2			
December 21, 2009			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0007 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	61	53	46
January 25, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0008 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	70	60	53
February 16, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0003 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	26	23	20
March 16, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0008 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	70	60	53
April 13, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0002 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	18	15	13
May 11, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	9	8	7
June 8, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0004 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	35	30	26
July 7, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0004 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	35	30	26
August 5, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0002 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	18	15	13
September 8, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	9	8	7
October 7, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	9	8	7
November 4, 2010			
Hydraulic Conductivity (K)	Cells 1 & 2 Site K_{avg} = 5.002 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0003 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	26	23	20

Cells 3 and 4			
December 21, 2009			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0003 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	41	35	31
January 25, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0004 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	54	47	41
February 16, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	14	12	10
March 16, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0005 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	68	58	51
April 13, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0003 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	41	35	31
May 11, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0002 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	27	23	20
June 8, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0004 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	54	47	41
July 7, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0004 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	54	47	41
August 5, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0003 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	41	35	31
September 8, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	14	12	10
October 7, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0002 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	27	23	20
November 4, 2010			
Hydraulic Conductivity (K)	Cells 3 & 4 Site K_{avg} = 5.567 x 10^{-2} ft/min		
Hydraulic Gradient (*i*)	i = 0.0001 ft/ft		
Effective Porosity (n)	0.30	0.35	0.40
Velocity (=Ki/n) (ft/yr)	14	12	10

Notes

1. Hydraulic gradient values derived using 3-point methods for 12 month monitoring period 12/09-11/10.

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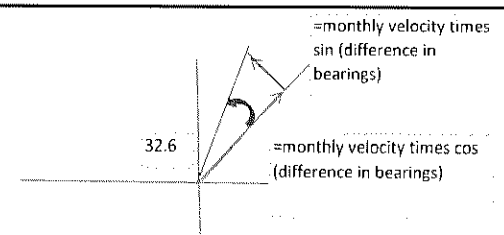
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Franklin County, Missouri

Plume Definition for Cells 1 and 2
Table 2a

Cells 1 & 2	Month/Year	Azimuth	Hydraulic Gradient	Velocity (ft/yr)	Velocity (ft/month)	East Component =x	North Component= y	Resultant East Vector	Resultant North Vector		Hydraulic Conductivity, *.01 ft/yr		delta angle	Cos (delta angle)	Sin (delta angle)	Monthly Velocity *Cos(delta angle)	Monthly Velocity *Sin(delta angle)
	Dec-09	-74	0.0007	53	4.38	-4.21	1.21	-4.21	1.21		4.642		-106.65	-0.286	-0.958	-1.255	-4.198
	January-10	20	0.0008	60	5.01	1.71	4.71	-2.50	5.91		6.324		-12.65	0.976	-0.219	4.886	-1.097
	February-10	-51	0.0003	23	1.88	-1.46	1.18	-3.96	7.10		4.482		-83.65	0.111	-0.994	0.208	-1.866
	March-10	63	0.0008	60	5.01	4.46	2.27	0.50	9.37		4.561		30.35	0.863	0.505	4.322	2.531
	April-10	94	0.0002	15	1.25	1.25	-0.09	1.75	9.28		5.00225	Average	61.35	0.479	0.878	0.600	1.099
	May-10	17	0.0001	8	0.63	0.18	0.60	1.94	9.88		Effective		-15.65	0.963	-0.270	0.603	-0.169
	June-10	102	0.0004	30	2.50	2.45	-0.52	4.38	9.36		Porosity (n) =	0.35	69.35	0.353	0.936	0.883	2.343
	July-10	115	0.0004	30	2.50	2.27	-1.06	6.65	8.30				82.35	0.133	0.991	0.333	2.482
	August-10	94	0.0002	15	1.25	1.25	-0.09	7.90	8.21				61.35	0.479	0.878	0.600	1.099
	September-10	-22	0.0001	8	0.63	-0.23	0.58	7.67	8.79				-54.65	0.579	-0.816	0.362	-0.511
	October-10	48	0.0001	8	0.63	0.47	0.42	8.13	9.21				15.35	0.964	0.265	0.604	0.166
	November-10	-57	0.0003	23	1.88	-1.58	1.02	6.56	10.24				-89.65	0.006	-1.000	0.012	-1.878
						Average velocity, ft/yr =		12.16	57.35								
	Average	38.5	0.00037			Bearing, Northeast=			32.65						Average monthly velocity	1.013	0.000
	Standard Deviation	61.9	0.00026												Standard Deviation in monthly velocity	1.767	2.059
	Error in Mean	17.9	0.00008	0.1572432													
															Average yearly velocity	12.157	0.000
															Alpha	1.744	2.032
																Longitudinal	Transverse



Construction Permit Application
Proposed Utility Waste Landfill
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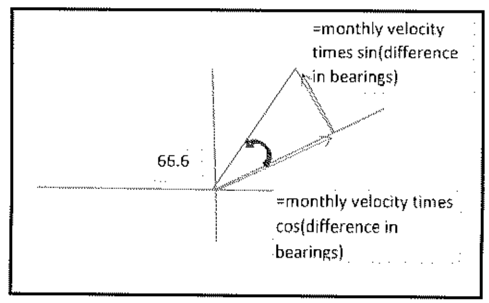
Franklin County, Missouri

Plume Definition for Cells 3 and 4
Table 2b

Cells 3 & 4	Month/Year	Azimuth	Hydaulic Gradient	Velocity (ft/yr)	Velocity (ft/month)	East Component= x	North Component= y	Resultant East Vector	Resultant North Vector		Hydraulic Conductivity, *.01 ft/yr		delta angle	Cos (delta angle)	Sin (della angle)	Monthly Velocity *Cos(delta angle)	Monthly Velocity *Sin(delta angle)
	Dec-09	-70	0.0003	25	2.08	-1.96	0.71	-1.96	0.71		4.642		-136.58	-0.726	-0.687	-1.513	-1.432
	January-10	3	0.0004	33	2.75	0.14	2.75	-1.81	3.46		6.324		-63.58	0.445	-0 896	1.224	-2.463
	February-10	-11	0.0001	8	0.67	-0.13	0.65	-1.94	4.11		4.482		-77.58	0.215	-0 977	0.143	-0.651
	March-10	63	0.0005	42	3.50	3.12	1.59	1.18	5.70		4.561		-3.58	0.998	-0.062	3.493	-0.219
	April-10	84	0.0003	25	2.08	2.07	0.22	3.25	5.92		5.00225	Average	17.42	0.954	0.299	1.988	0.624
	May-10	70	0.0002	17	1.42	1.33	0.48	4.58	6.40				3.42	0.998	0.060	1.414	0.084
	June-10	105	0.0004	33	2.75	2.66	-0.71	7.24	5.69		Effective		38.42	0.784	0.621	2.155	1.709
	July-10	109	0.0004	33	2.75	2.60	-0.90	9.84	4.80		Porosity (n)=	0.35	42.42	0.738	0.675	2.030	1.855
	August-10	95	0.0003	25	2.08	2.08	-0.18	11.91	4.62				28.42	0.880	0.476	1.832	0.991
	September-10	47	0.0001	8	0.67	0.49	0.45	12.40	5.07				-19.58	0.942	-0.335	0.628	-0.223
	October-10	81	0.0002	17	1.42	1.40	0.22	13.80	5.29				14.42	0.969	0.249	1.372	0.353
	November-10	-43	0.0001	8	0.67	-0.45	0.49	13.34	5.78				-109.58	-0.335	-0.942	-0.223	-0.628
						Average velocity, ft/yr =		14.54	23.42								
						Bearing, Northeast=		66.58									

Average	54.8	0.00028	
Standard Deviation	50.5	0.00014	
Error in Mean	14.6	0.00004	0.1280281

Average monthly velocity	1.212	0.000
Standard Deviation in monthly velocity	1.307	1.239
Average yearly velocity	14.543	0.000
Alpha	1.078	1.023
	Longitudinal	Transverse



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Franklin County, Missouri

Groundwater Monitoring Well Summary
Table 3

Monitoring Well Designation	Upgradient or Downgradient	Northing	Easting	Ground Surface Elevation (approx.)	Well Depth (feet, bgs)	Screen Length (feet)	Top of Screen Interval Elevation (approx.)
MW-1	DG	995574	727216	470	25	10	455
MW-2	DG	995656	727662	469	23	10	456
MW-3	DG	995738	728106	468	22	10	456
MW-4	DG	995819	728547	468	21	10	457
MW-5	DG	995548	728812	468	21	10	457
MW-6	DG	995171	729206	467	20	10	457
MW-7	DG	994600	729389	467	19	10	458
MW-8	DG	994380	729642	466	18	10	458
MW-9	DG	994160	729895	465	17	10	458
MW-10	DG	993940	730147	466	18	10	458
MW-11	DG	993720	730400	466	18	10	458
MW-12	DG	993500	730653	465	17	10	458
MW-13	DG	993280	730905	465	17	10	458
MW-14	DG	993060	731158	464	16	10	458
MW-15	DG	992840	731410	464	15	10	459
MW-16	DG	992620	731663	464	15	10	459
MW-17	DG	992302	731681	465	16	10	459
MW-18	DG	991674	730925	462	13	10	459
MW-19	DG	992096	730184	463	15	10	458
MW-20	DG	991668	729958	463	14	10	459
MW-21	DG	991332	729953	463	14	10	459
MW-22	UG	990940	729361	464	15	10	459
MW-23	UG	991102	728514	465	17	10	458
MW-24	UG	991822	727995	465	17	10	458
MW-25	UG	992708	727524	466	18	10	458
MW-26	UG	993986	726913	467	20	10	457
MW-27	UG	994619	726637	468	22	10	456
MW-28	UG	995267	726640	469	24	10	455
TMW-1	DG	993795	728659	467	19	10	458

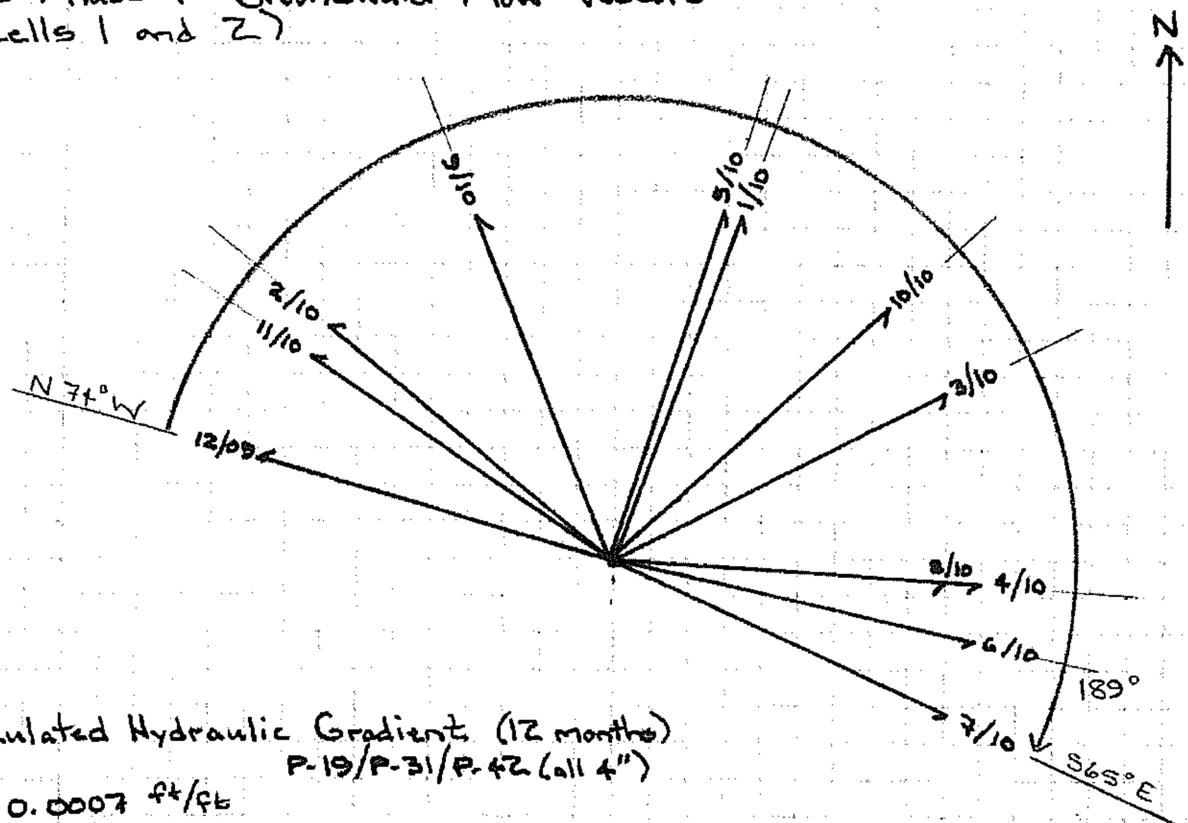
Attachment 1

Baseline Hydrologic Data Notes

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING — LAND - AIR - WATER
Telephone (573) 659-9078

Date: 5-25-12		Page No: 1 of 1	
Client: Reitz & Jens			
Prepared By: M.C. Carlson	Checked By: MCC	Project: Labadie Construction Permit	
Subject: Groundwater Monitoring System			

1. "Old Phase 4" Groundwater Flow Vectors
   (Cells 1 and 2)



2. Calculated Hydraulic Gradient (12 months)
   P-19/P-31/P-42 (all 4")

12/09	1.	0.0007 ft/ft
1/10	2.	0.0008
2/10	3.	0.0003
3/10	4.	0.0008
4/10	5.	0.0002
5/10	6.	0.0001
6/10	7.	0.0004
7/10	8.	0.0004
8/10	9.	0.0002
9/10	10.	0.0001
10/10	11.	0.0001
11/10	12.	0.0003

Avg: 0.00037 ft/ft

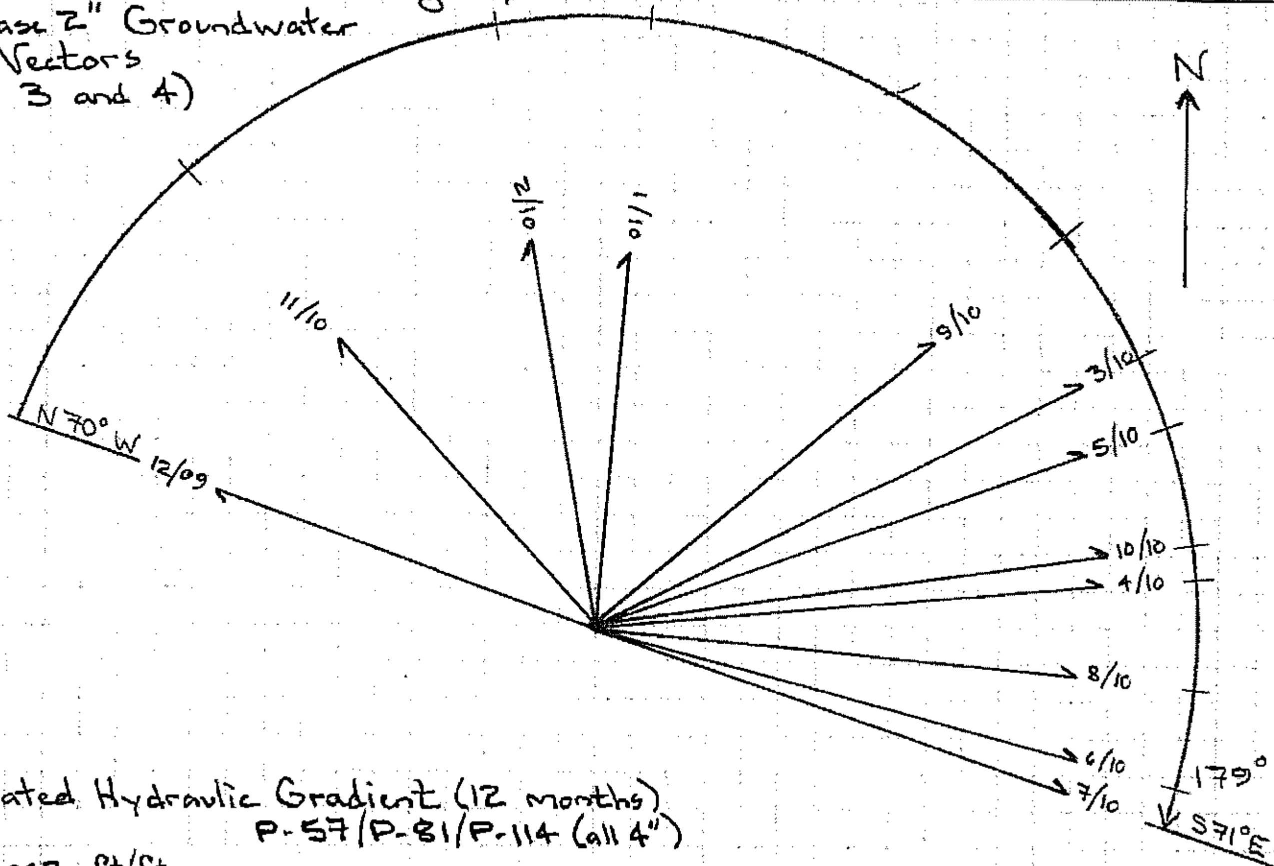
3. Calculated K values from w/in Old Phase 4 realignment area (from DSI)
   1. P-19: 4.642×10^{-2} ft/min
   2. P-22: 6.324×10^{-2} "
   3. P-31: 4.482×10^{-2} "
   4. P-42: 4.561×10^{-2} "

   Avg: 5.002×10^{-2} ft/min

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING — LAND - AIR - WATER
Telephone (573) 659-9078

Date: 5-25-12	Page No: 1 of 1
Client: Reitz + Jens	
Prepared By: M.C. Carlson — Checked By: MCC	Project: Labadie Construction Permit
Subject: Groundwater Monitoring System	

1. "Old Phase 2" Groundwater Flow Vectors (Cells 3 and 4)



2. Calculated Hydraulic Gradient (12 months) P-57/P-81/P-114 (all 4")

1. 0.0003 ft/ft
2. 0.0004
3. 0.0001
4. 0.0005
5. 0.0003
6. 0.0002
7. 0.0004
8. 0.0004
9. 0.0003
10. 0.0001
11. 0.0002
12. 0.0001

Avg: 0.00028 ft/ft

3. Calculated K values from w/in Old Phase 2 (Cells 3 and 4) Area (from DSI):
   1. P-53: 2.444×10^{-2} ft/min
   2. P-57: 4.737×10^{-2} ft/min
   3. P-81: 7.184×10^{-2} ft/min
   4. P-85: 7.744×10^{-2} ft/min
   5. P-114: 5.724×10^{-2} ft/min

   Avg: 5.567×10^{-2} ft/min

Printed on Recycled Paper

Attachment 2

Wilson, C.R., Einberger, C.M., Jackson, R.L., and Mercer, R.B. (1992) "*Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO)*"; *GROUNDWATER*, V. 30, No. 6, Nov.-Dec.

GROUND WATER

Computer Notes

Design of Ground-Water Monitoring Networks Using the Monitoring Efficiency Model (MEMO)

by Charles R. Wilson[a], Carl M. Einberger[a], Ronald L. Jackson[b], and Richard B. Mercer[b]

Abstract

An analytical Monitoring Efficiency Model (MEMO) has been developed to assist in the design of monitoring well networks. The method simulates the migration of hypothetical contaminant plumes from a site and quantifies the efficiency of alternative well network designs in detecting the plumes. The computed detection efficiency provides a basis for optimizing the design. Maps of the site showing areas from which releases would or would not be detected by a given well network are produced, providing insight into the benefits of adding, deleting, or moving specific wells.

Introduction

Ground-water monitoring is generally required by regulatory agencies at hazardous waste sites, solid waste landfills, and other sites where the potential release of chemicals to the sursurface is a concern. The goals of ground-water monitoring include verifying regulatory compliance and providing early warning of a chemical release. Although the intent of such monitoring is to protect human health and the environment, a clear approach for measuring the degree of protection offered by a monitoring system has not been well established. A Monitoring Efficiency Model (MEMO) presented in this paper provides a method for quantifying the efficiency of a given monitoring well network in detecting a potential chemical release, and graphically depicting areas where releases would not be detected. The method is an extension and refinement of a physical design approach suggested by Massmann, Freeze and others (Massmann and Freeze, 1987; Freeze et al., 1990) and Meyer and Brill (1988). It provides an easily understood way to adjust and optimize the network design to site and waste conditions, and to quantify the degree of protection for public and regulatory review.

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Discussion open until May 1, 1993.

General Approach

The technique developed in this paper quantifies the monitoring efficiency of a given monitoring well network by determining areas within a potential chemical source area where a chemical release would or would not be detected by the monitoring well network. Monitoring efficiency is defined as the ratio of the area of detection to the total area of the site. For example, a determined efficiency of 90 percent predicts that releases occurring over 90 percent of the site would be detected by the monitoring wells, and releases occurring over 10 percent of the site would not be detected.

The monitoring efficiency solution is determined in the following manner. A grid of potential chemical source points is defined within the potential source area. At each potential source point, a contaminant plume is generated using an analytical contaminant transport solution. If the plume is intersected by a monitoring well before it migrates beyond a specified boundary, the source point is considered to be detected. After checking each grid point to determine whether the plume released from that point is detected or not detected, the monitoring efficiency is calculated, and a map showing areas from which chemical releases would not be detected is produced.

An illustration of the application of MEMO is shown in Figure 1. Critical geometric elements are the potential source area(s), a grid of potential source points, the buffer zone boundary, and monitoring well locations. The buffer zone boundary is defined as the limit to which a plume can migrate before it should be detected, and serves as the plume migration limit for "early warning" detection of a contami-

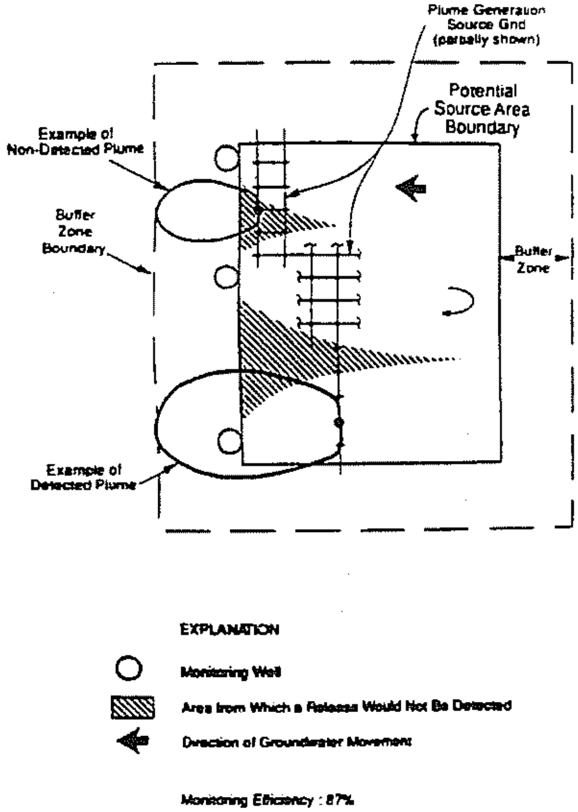

Fig. 1. Illustration of MEMO results.

nant release. A plume that moves beyond this limit without detection by a monitoring well is considered to be undetected. Figure 1 shows examples of detected and nondetected plumes and two distinct nondetected regions defined by source grid points from which generated plumes were not detected by monitoring wells prior to passing the buffer zone boundary.

Ground-water flow and contaminant transport parameters are required to determine the plume dimensions and configuration. Specific flow and transport input requirements will depend upon the plume generation routine used in the analysis. MEMO currently uses a two-dimensional plume generation routine based on the two-dimensional analytical solution of Domenico and Robbins (1985), but the methodology incorporated into MEMO can be applied with other analytical contaminant transport solutions.

MEMO is applied using available site-specific and/or literature-based information. Multiple simulations can be performed to analyze the sensitivity of a specific problem domain to input parameters. Because MEMO is based upon a simulation of physical processes, evaluations of the adequacy of the design are determined from the physical parameters and processes governing contaminant migration, rather than upon qualitative judgments of how many wells are enough.

Plume Generation

MEMO uses a plume generation routine to compute the sizes and shapes of the plumes from each grid point. The plume generation routine currently incorporated into MEMO is based upon the two-dimensional analytical transport model presented in Domenico and Robbins (1985) and modified in Domenico (1987). This model assumes that solute is released along a continuous line source in a uniform aquifer, and predicts the concentrations that would be observed at points downstream of that source. The governing equation is:

$$C(x, y, t) = (C_o/4) \exp\{(xv/2D_x)[1 - (1 + 4kD_x/v^2)^{1/2}]\}$$
$$\mathrm{erfc}\{[x - vt(1 + 4kD_x/v^2)^{1/2}]/2(D_x t)^{1/2}\}$$
$$\{\mathrm{erf}[(y + Y/2)/2(D_y x/v)^{1/2}] - \mathrm{erf}[(y - Y/2)/2(D_y x/v)^{1/2}]\}$$

where $C(x, y, t)$ = concentration at x, y, t; C_o = source concentration; x = distance downstream from the source; y = transverse distance from the source; k = first-order radioactive decay constant; Y = width of the source in the ground water; v = average contaminant velocity; D_x = longitudinal dispersion coefficient; D_y = transverse dispersion coefficient; and t = time.

The average contaminant velocity is computed as:

$$v = Ki/Rn$$

where K = hydraulic conductivity; i = hydraulic gradient; R = retardation factor; and n = effective porosity.

The dispersion coefficients are functions of the contaminant velocity, the dispersivities, the retardation factor, and the diffusion coefficient for the contaminant of interest.

$$D_x = \alpha_x v + D_m/R$$
$$D_y = \alpha_y v + D_m/R$$

where α_x = longitudinal dispersivity; α_y = transverse dispersivity; and D_m = effective molecular diffusion coefficient for the contaminant of interest.

MEMO is solved using a specified dilution contour, defined as:

$$C_{dil} = C_{ds}/C_o$$

where C_{ds} is the detection standard selected as the limiting concentration to be detected by a monitoring well, and C_o, as defined above, is the source concentration.

Assumptions of the plume generation routine include negligible vertical ground-water flow and vertical chemical transport, a uniform ground-water flow field, and a continuous line source. The assumption of a uniform flow field implies constant hydrologic and transport properties and a uniform hydraulic gradient over the length of the plume.

Significant judgment is required prior to performing MEMO simulations for a site. An evaluation of the suitability of the model assumptions presented in the previous section must be performed on a case-by-case basis. For example, it should be recognized that the plume shape predicted by the model is idealized for uniform aquifer conditions, and the heterogeneities present at field sites may cause plumes to assume irregular shapes. As with any model, care must be taken that erroneous conclusions are not made based on inadequate assumptions about the problem domain.

Required Input Parameters

The principal input parameters required for MEMO are the geometry and discretization of the problem domain, potential source width, the contaminant transport parameters, and the dilution contour to be measured in the monitoring wells. Parameters that are not known from site-specific field data must be conservatively estimated. Sensitivity analyses may be performed to identify critical parameters affecting monitoring efficiency predictions.

Geometry of Problem Domain

Key geometric elements of the problem domain are the potential source area(s), monitoring wells to be investigated, and the location of the buffer zone boundary. Geometric data are input using a standard coordinate system, and a uniform source grid spacing must also be specified. The sensitivity of an efficiency analysis to the source grid spacing should be evaluated, since grid spacing can influence the accuracy of the solution.

Monitoring wells are located between the potential source area(s) and the buffer zone boundary. Plumes that are not detected by a monitoring well prior to contacting the buffer zone boundary are considered to be "not detected" in the monitoring efficiency estimate. However, it should not be inferred that plumes considered "not detected" for purposes of network design will never be detected. Plumes will continue to expand until steady state is reached, and may eventually be detected prior to reaching steady state. Identification of a buffer zone is necessary because unless the center line of a plume directly contacts a monitoring well, the leading edge of the plume will migrate beyond the monitoring well prior to plume detection.

Although a smaller buffer zone width is more conservative because it will generate a lower apparent monitoring efficiency, our sensitivity analyses have indicated that MEMO efficiency predictions are not particularly sensitive to buffer zone widths greater than several hundred feet. The appropriate width for the buffer zone will depend on site-specific and regulatory conditions. General criteria for establishing buffer zone widths include distances to property boundaries and neighboring dwellings, distances to ground-water supply wells or surface-water bodies, the velocity of ground-water movement, and the relative costs and benefits of providing early detection of a release. Buffer zone widths established for hazardous waste facilities in current regulations vary, but are on the order of hundreds to thousands of feet. We have used a conservative width of 500 feet for remote sites.

Potential Source Width

Vertical migration of contaminants through the unsaturated zone to the water table is assumed to create a source of contamination in the ground water that generates the contaminant plume. The width of the source in the ground water will depend upon the dimensions of the release at the waste site and the subsequent dispersion in the unsaturated zone. The size and strength of this source may be estimated from field measurements if releases have occurred at the site, or from the size, type of contaminants, and transport mechanisms of a hypothetical release from the site.

The data needed to support a rigorous analysis of the potential source width are often lacking, requiring that this parameter be conservatively estimated. Smaller source widths are more conservative because they are more difficult to detect. The source width estimate should take into account the dimensions of the release at the waste site and the effects of migration through the unsaturated zone. The dimensions of the release at the waste site may be, for example, the dimensions of a typical waste container at an unlined site, or may be the dimensions of a potential liner leak at a lined site. Migration through the unsaturated zone is usually accompanied by lateral spreading. The source width may be increased for larger release dimensions and larger unsaturated zone thicknesses, but the estimated mass flux of contaminants entering the ground water should be held constant by adjusting the source concentration used to calculate the dilution contour.

Contaminant Transport Parameters

Contaminant transport parameters required for plume generation are the direction of ground-water movement, the average contaminant velocity, and the longitudinal and transverse dispersivities. Optional contaminant transport parameters are the molecular diffusion coefficient and the first-order radioactive decay constant.

If ground-water level data are available for a site, they can be used to estimate the direction of ground-water movement. If no water-level data are available, the direction of ground-water movement may be estimated from regional hydrogeologic data or from site topography. The sensitivity of the monitoring efficiency estimate to variations in ground-water flow direction should be considered, particularly when no field data are available. The efficiency of a particular monitoring well network can be significantly changed by a change in the ground-water flow direction.

The average contaminant velocity can be approximated from estimates of the average hydraulic conductivity, hydraulic gradient, retardation factor, and effective porosity at the site. With the Domenico and Robbins plume generation routine, for a plume of a given length the shape of the generated plume is independent of the time required to develop the plume, if decay and molecular diffusion are negligible. For example, a plume that traveled 500 feet in five years would be predicted to have the same shape as one that traveled 500 feet in 50 years. Because of this independence, for cases where decay and diffusion are negligible, the monitoring efficiency solution is not dependent on the hydraulic parameters governing the average contaminant velocity, and is not sensitive to the choice of average contaminant velocity.

Site-specific dispersivities are rarely available, and must usually be estimated from available literature values for similar geologic media. Gelhar et al. (1985) provide a source for such information. Dispersivity values have been reported to increase as the length of the plume increases, although the most reliable measured values are the lower estimates. The selection of values is complicated by the fact that considerably more data are available for longitudinal than transverse dispersivities; thus the uncertainty is higher for the transverse dispersivity. If the data base for transverse dispersivity cannot support a direct estimate, it can be estimated as a fraction of the longitudinal value ($\alpha_y / \alpha_x = 0.1$ is commonly used). The width of the plume is quite sensitive to the transverse dispersivity (α_y) and is relatively insensitive to the longitudinal dispersivity (α_x). Longer, thinner plumes are harder to detect, and therefore larger values of longitudinal and smaller values of transverse dispersivity are more conservative. For application to a site with unconsolidated silts, sands, and gravels, the best direct estimate values for transverse and longitudinal dispersivities were 8 and 28 feet, respectively, using a scale of interest of about 1,000 feet. The relatively high transverse to longitudinal ratio of about 0.3 was supported by limited site-specific data. For conservatism, the monitoring network design was based upon a transverse dispersivity of 5 feet and a longitudinal dispersivity of 35 feet.

For most field situations, the diffusion coefficient is quite small compared to the adjective velocity and can be neglected. For sites with very low adjective velocities, the effect of molecular diffusion can be evaluated in a sensitivity analysis. Radioactive or chemical decay can be incorporated into the monitoring efficiency study by specifying a first-order decay constant.

Dilution Contour

The dilution contour (C_{dl}), defined as the ratio of the detection standard (C_{ds}) to the concentration at the source of the plume in the ground water (C_o), identifies the boundary of the plume used in the monitoring efficiency determination. The monitoring efficiency is affected by the dilution contour, because plumes of a given length are slightly wider for a lower dilution contour than for a higher dilution contour. The wider plumes would be easier to detect and fewer monitoring wells would be required to achieve a target monitoring efficiency. To provide adequate early warning of a release, the design should be based upon a dilution contour for the more mobile potential contaminants at the site.

To determine an appropriate dilution contour, the source strength and detection standard must be estimated. The source strength is the contaminant concentration at the plume source within the aquifer. The potential source strength may be estimated through analysis of ground-water samples from an identified source area where a release has already occurred, through analysis of the physical conditions of the waste and the site, or through identifying a threshold source strength that would be of regulatory concern. The first of these approaches is not typically possible, because monitoring well network designs are generally prepared for sites where releases have not yet occurred or have not been established. In estimating source strength using the other approaches, release of contaminants from the potential source area(s) is considered to be continuous and governed by long-term average hydrologic conditions.

If the mass flux rate of contaminants released from the site is assumed to be constant, the strength and width of the source in the ground water become inversely related. If the width of the source increases, such as from a higher estimated dispersion in the unsaturated zone, the strength of the source must decrease, because the total mass flux of contaminant entering the ground water remains constant. Although the network design is sensitive to changes in either source strength or source width when taken independently, it becomes relatively insensitive when the inverse relationship between these parameters is considered.

Estimates of source strength based upon the physical conditions of the waste and the site may be made considering the amounts and physical states of potential contaminants in the waste, the probable mobilization and release mechanisms into the unsaturated zone, the dispersive effects occurring in the unsaturated zone, and the rate of ground-water movement in the underlying aquifer. Factors which should be considered are whether the waste is in solid or liquid form, and its potential mobility given the conditions of release or disposal. The data necessary to rigorously address the processes of release and subsequent migration to the ground water are often unavailable, and conservative estimates must be made.

Estimates of source strength may also be based upon threshold values that would be of regulatory concern. This approach is useful when the contaminant of concern has an assigned regulatory standard such as a maximum contaminant level (MCL), but its concentration at the point of release at the waste site is difficult to estimate, for example, because of a lack of solubility information. This approach has been particularly useful for metals and radionuclides. The threshold strength of concern is generally considered to be the regulatory standard, and the contaminant concentration at the source in the ground water would be set to approximately equal that standard. This would be more conservative than estimates based on solubility limits if the regulatory standard is less than the estimated source concentration. However, if the estimated source concentration is less than the regulatory standard, it is recommended that the regulatory standard be used as the source concentration to avoid an overly conservative design.

Example Application

MEMO has been employed to design monitoring networks for eight waste management areas on the U.S. Department of Energy's Hanford Site in eastern Washington. Before applying MEMO at a location, the relevant hydrogeologic data and information on waste characteristics are assembled and reviewed to develop alternative conceptual models of the directions and stability of ground-water movement and the unsaturated zone transport conditions associated with alternative release scenarios. Uncertainties in parameter values are analyzed in MEMO sensitivity studies, and uncertainties in the validity of the assumptions used in MEMO are identified. Higher design monitoring efficiencies may be used at sites with greater parameter uncertainties.

The data base parameters for MEMO were developed

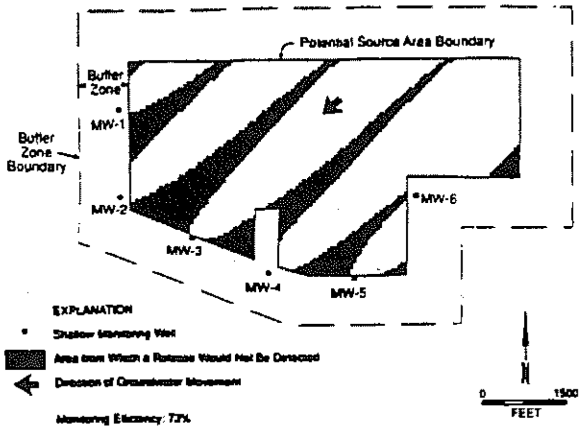

Fig. 2. Example MEMO results for a network of six wells.

by applying the logic described above. The results of example applications are shown in Figures 2 and 3 for a waste site of irregular geometry. The direction of ground-water flow was assumed to be the same throughout the site. The following data base was used in this example:

Source Width	20 feet
Buffer Zone Width	500 feet
Longitudinal Dispersivity	35 feet
Transverse Dispersivity	5 feet
C_{dil}	0.001

Contaminant decay and molecular diffusion were considered negligible in this example.

Figure 2 shows the MEMO results for a relatively sparse downgradient network of six wells. The shaded areas on the figure indicate locations where a release is not predicted to be detected. The influence of the approximately 1,500-foot gaps between the monitoring wells can be seen in the sizes of the shaded areas. The efficiency of this network is about 73 percent, and is less the minimum target of 90 percent adopted for this example. Efficiencies may be improved by adding or adjusting locations of monitoring wells in the vicinity of the larger shaded areas.

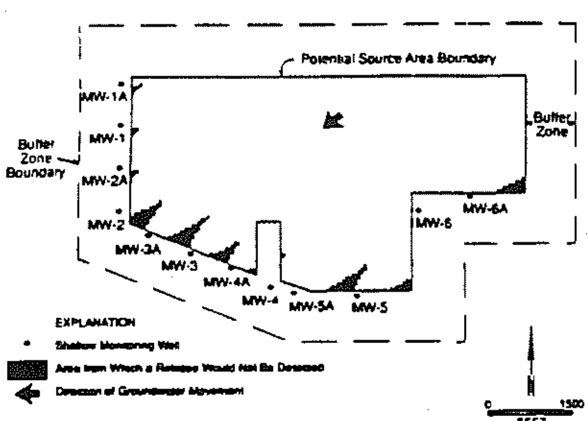

Fig. 3. Example MEMO results for a network of 12 wells.

Figure 3 shows the MEMO results for the site shown in Figure 2, but with a network of 12 wells. This network greatly reduces the shaded areas and increases the monitoring efficiency to 96 percent. This efficiency may be unnecessarily high for the site, particularly if the direction of ground-water flow is stable. Monitoring wells can be moved, added, or deleted until a satisfactory network is achieved. The sensitivity of the final network to uncertainties in ground-water flow directions or in any of the other input parameters can also be evaluated.

Future Model Development

The monitoring efficiency concept of MEMO can be developed with other assumptions and applications. Some examples of areas for future model development are discussed in this section.

MEMO currently provides a deterministic solution for the monitoring efficiency. A probabilistic model incorporating a Monte Carlo approach has been considered, with user-specified probabilistic functions for each of the field or literature-derived input parameters. Rather than producing a single monitoring efficiency, a range of values would be produced. Graphical output could present contours of the frequency of detection of each potential source point, rather than shading nondetected potential source points.

A three-dimensional analytical solution can be incorporated into MEMO to allow evaluations of nested monitoring well networks. The user would specify well locations and screen intervals for each well. Plume migration would be limited by a planar buffer zone limit. MEMO can also be developed with a two-dimensional or three-dimensional finite-difference or finite-element contaminant transport module, to allow application to sites where available data and site complexity suggest that the simplifying assumptions of the current analytical solution are inappropriate.

As an alternative to using the buffer zone concept, plumes can be limited by migration time or allowed to reach steady state, prior to checking for detection in a monitoring well. However, if this approach is used, the downgradient limit of each generated plume will vary with the geometry of the source area. At sites where ground-water contamination is of concern, early warning of contamination is typically desired to allow corrective action to be taken. The buffer zone boundary serves as the limit for plume migration before early warning should occur. For this reason, the buffer zone concept is our preferred configuration for the model.

Conclusions

MEMO is a method for monitoring well network design that is quantitative and produces easily understood graphical output. The computed detection efficiency provides data for optimization of a monitoring network design based upon physical processes. The model requires significant judgment because of the need to obtain or estimate the input parameters. The benefits obtained from adding, deleting, or moving wells can be readily demonstrated using multiple simulations. The model has been found to be of significant value in justifying a network design to both regulatory agencies and site owners. The approach can be readily adapted or enhanced to address alternative problems. For example, the model can be modified for use with three-dimensional plume generation techniques if required for a particular site. It also can be developed on a probabilistic basis, to quantify the uncertainty in the design, as an alternative to the deterministic and conservative approach described here. The expanded use of MEMO and other similar design approaches is expected to promote reduction in the uncertainties inherent in monitoring well network design.

Availability of Model

MEMO software and a User's Manual can be obtained from the authors.

Acknowledgments

MEMO was developed at the request of Westinghouse Hanford Company, Richland, Washington, for the U.S. Department of Energy. The authors would like to acknowledge the support and insightful comments received on the MEMO concept from many colleagues. Particular thanks go to Ian Miller, Rick Kossik, and George Evans for their valuable insights into the basic modeling concepts, and to Scott Kindred, John Velimesis, and Scott Warner for their help in brainstorming ideas, verifying the code, polishing the text, and working through many manual applications.

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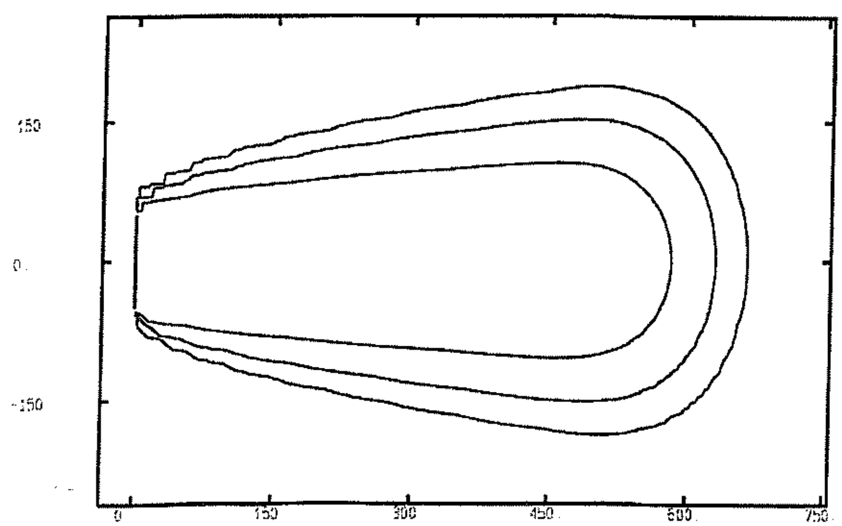
Attachment 3

PLUME Model Outputs

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center
Cells 1 and 2
Plume Model Output for 44 Years

MAP ver 1.1 PLUME Simulation Golder Associates Inc.



Contours at: .00100, .01000, .10000
Advection time = 528.00
Average contaminant velocity = 1.0130
Width of line source = 100.00

Longitudinal dispersivity = 1.74
Transverse dispersivity = 2.03
First-order decay constant = .000E+00
Diffusion coefficient = .000E+00

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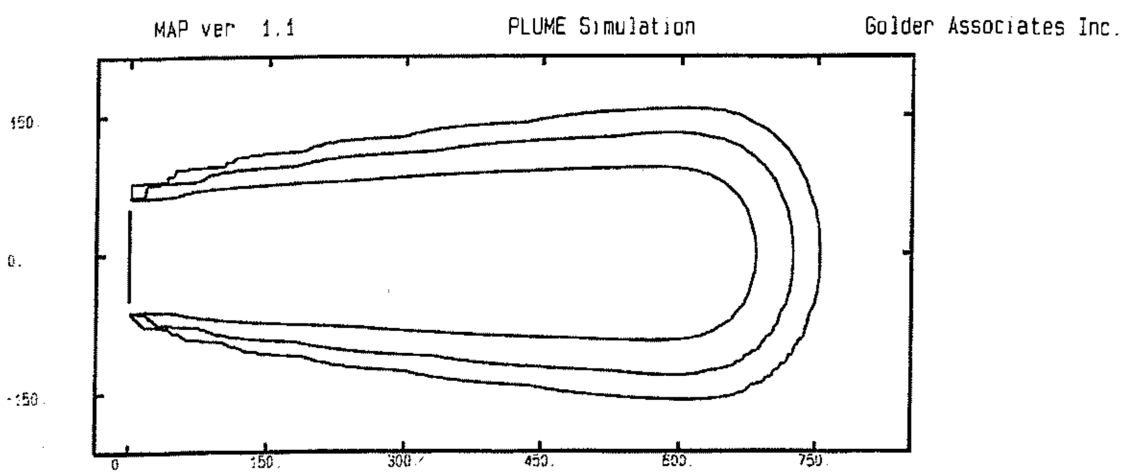
Ameren Missouri Labadie Energy Center
Cells 3 and 4
Plume Model Output for 44 Years



Contours at: .00100, .01000, .10000
Advection time = 528.00
Average contaminant velocity = 1.2120
Width of line source = 100.00

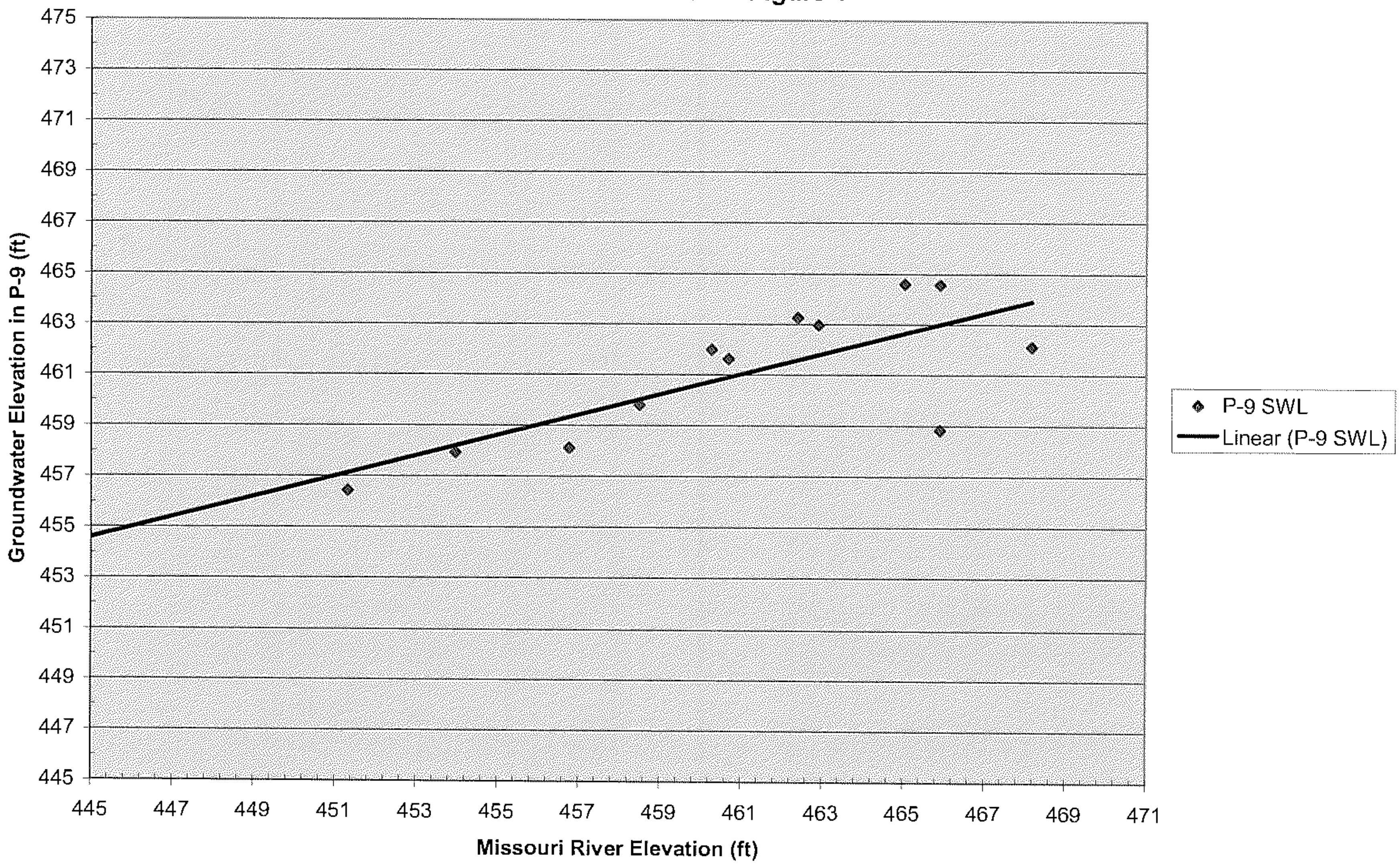
Longitudinal dispersivity = 1.07
Transverse dispersivity = 1.02
First-order decay constant = .000E+00
Diffusion coefficient = .000E+00

Attachment 4

Linear Regression Plots
Missouri River Elevation vs
Top of Water Table

Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-9)
Attachment 4 - Figure 1



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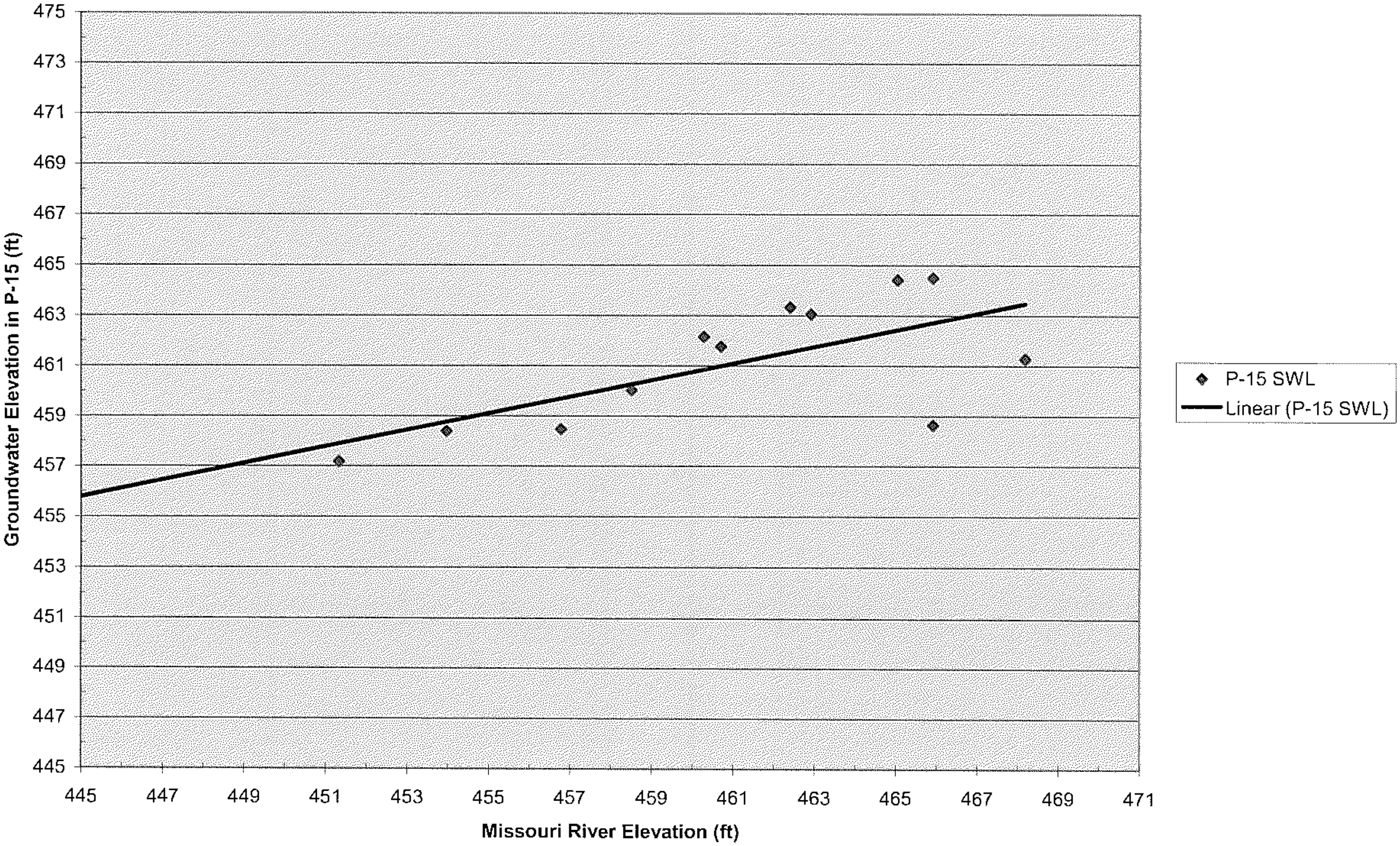
Missouri River Elevation vs Top of Water Table (P-15)
Attachment 4 - Figure 2



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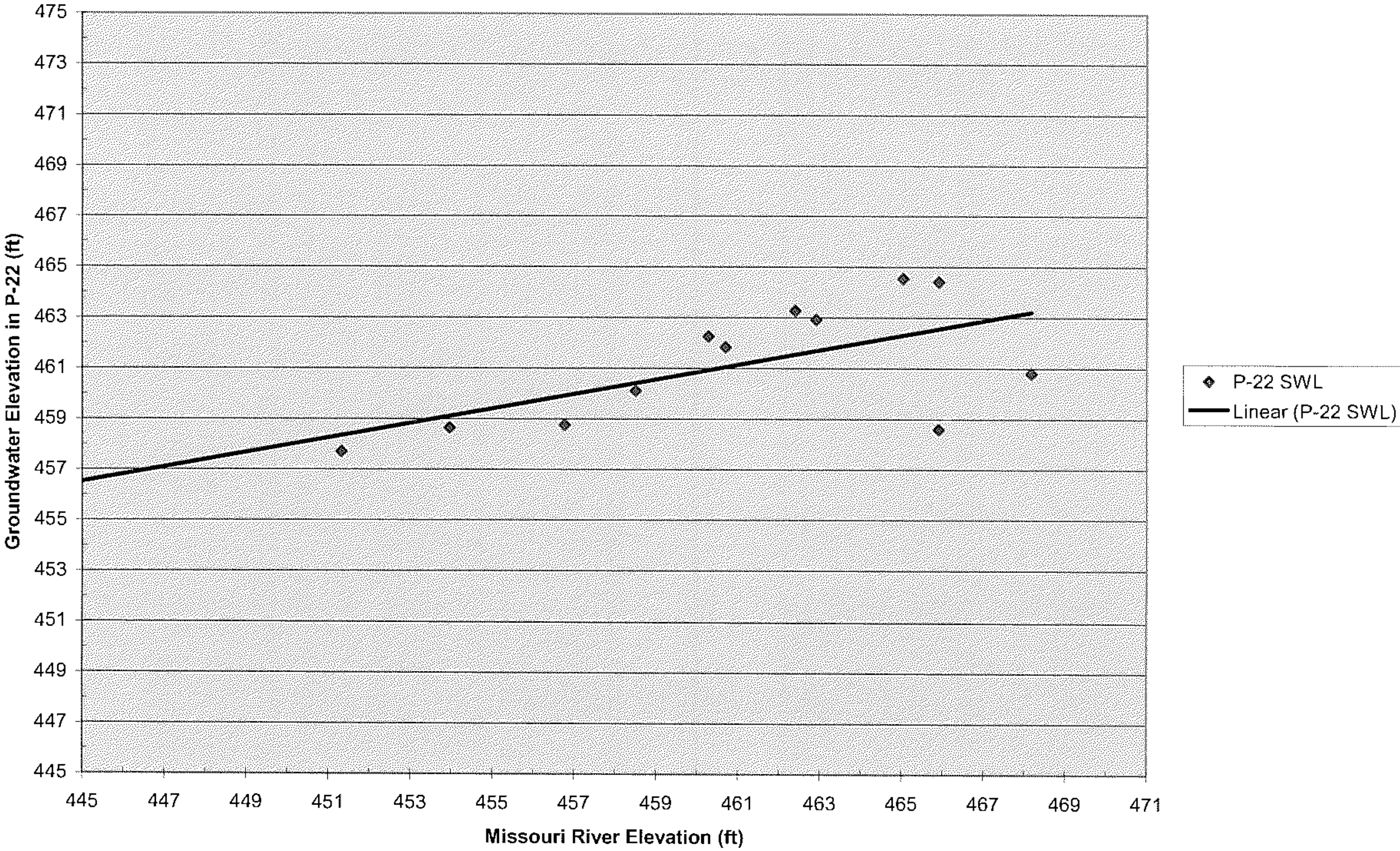
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-22)
Attachment 4 - Figure 3



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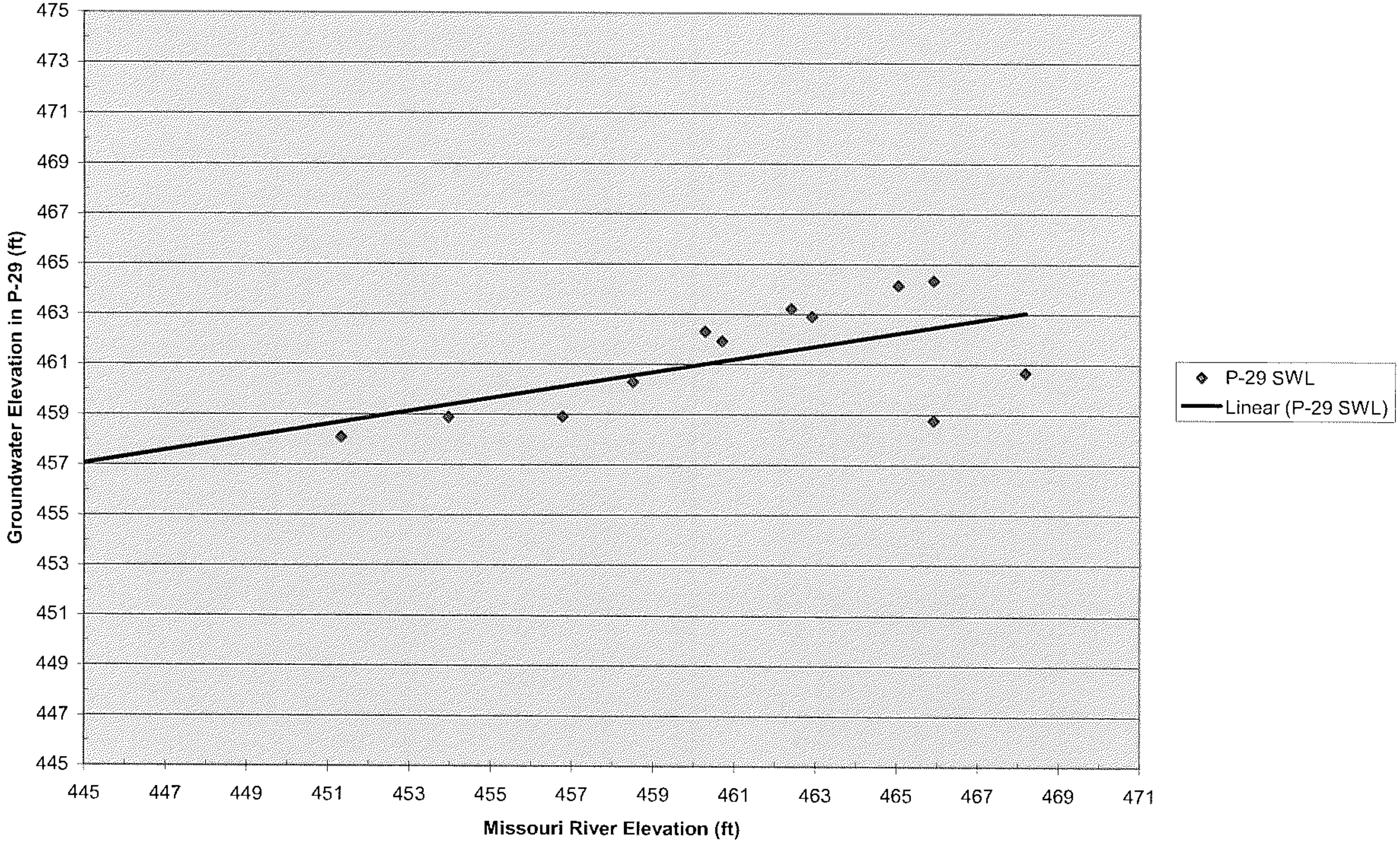
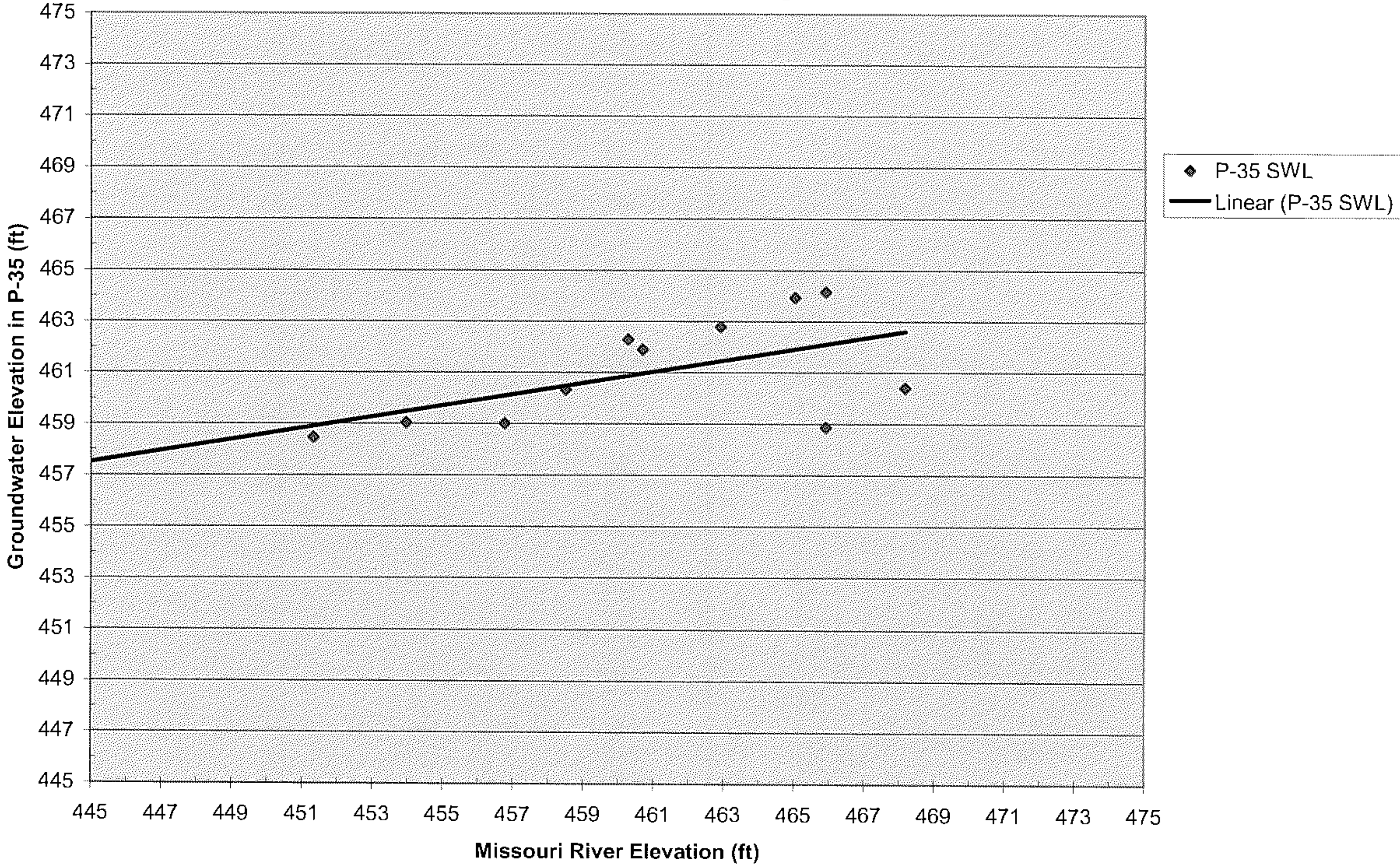
Missouri River Elevation vs Top of Water Table (P-29)
Attachment 4 - Figure 4



Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-35)
Attachment 4 - Figure 5



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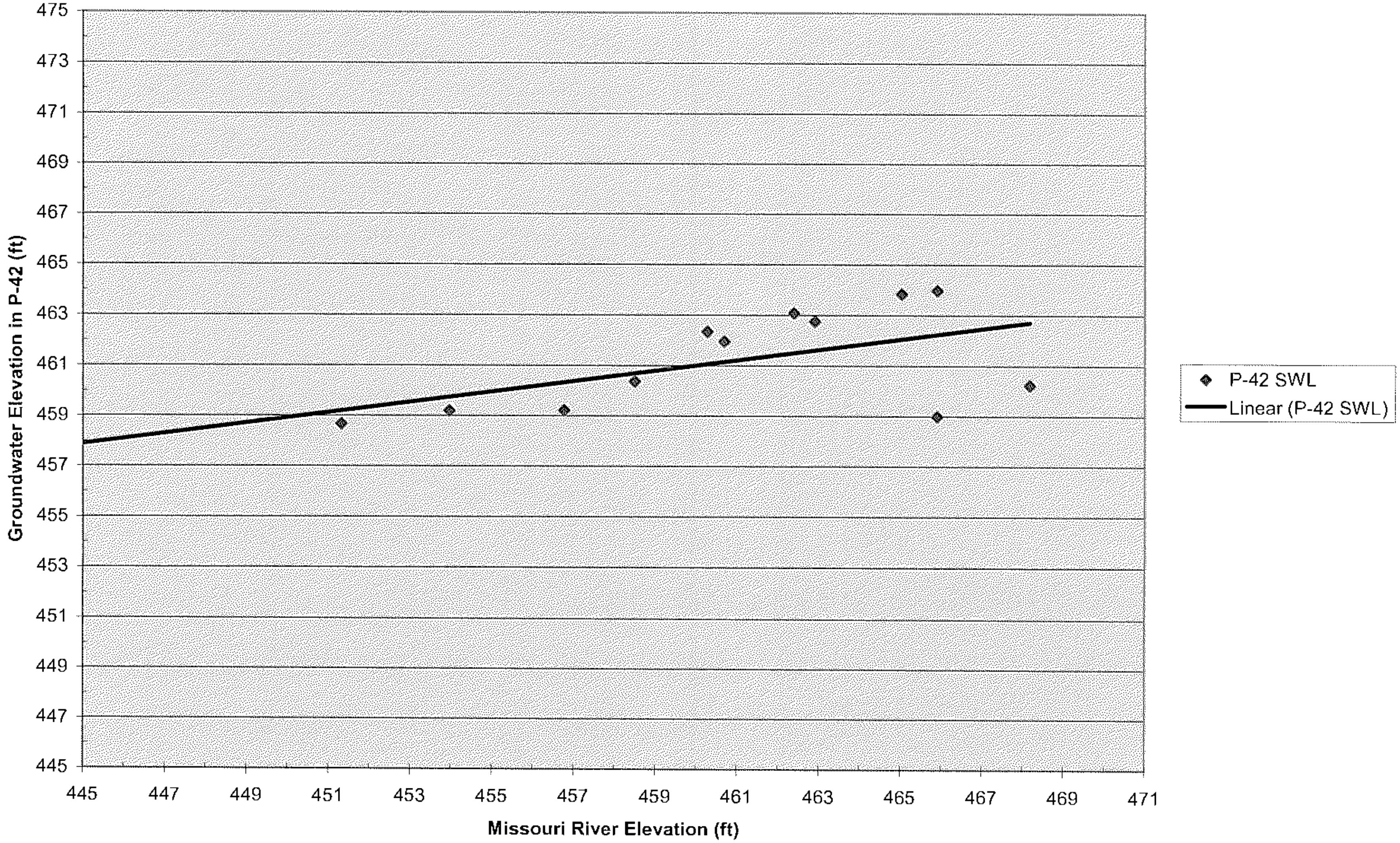
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-42)
Attachment 4 - Figure 6



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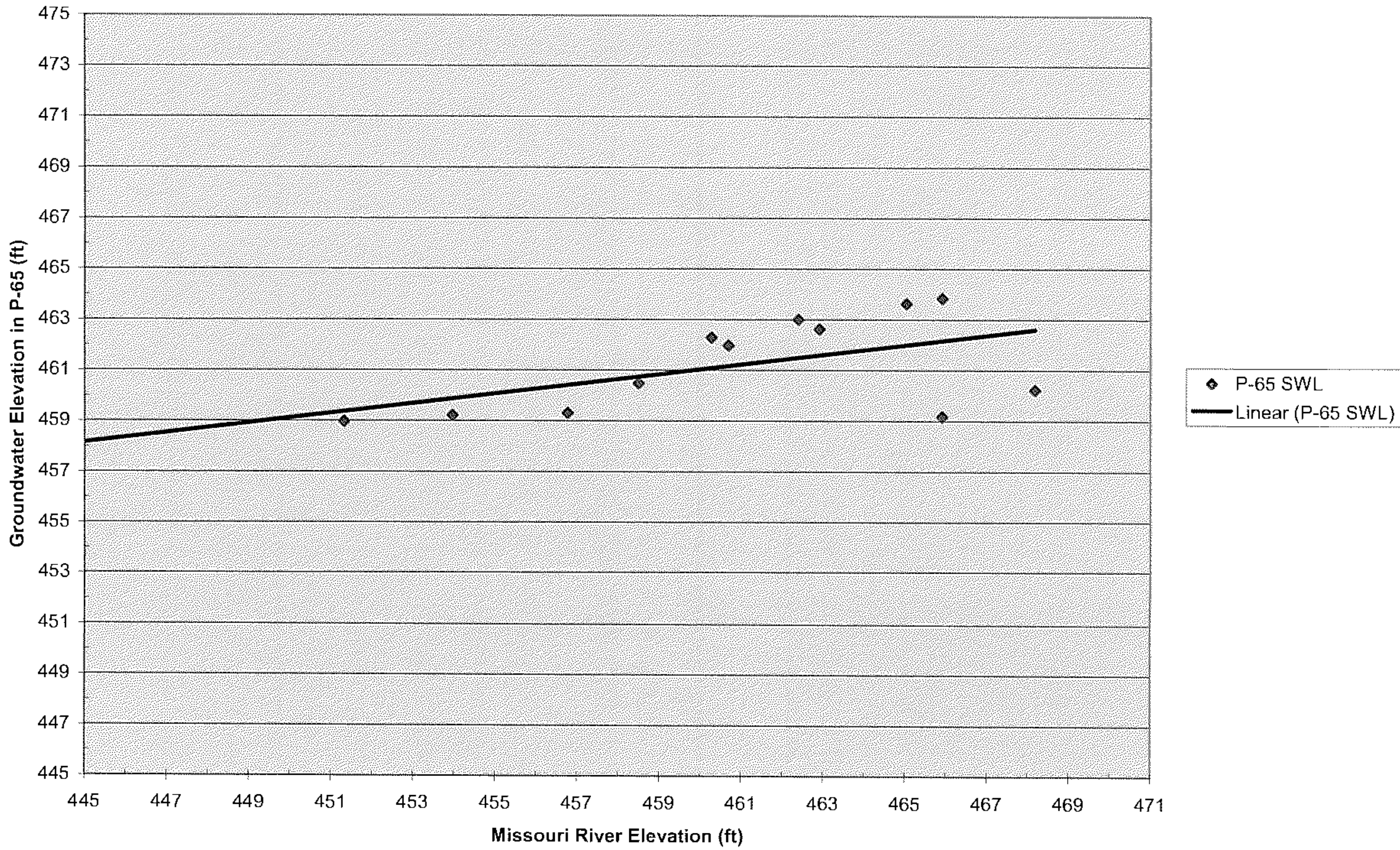
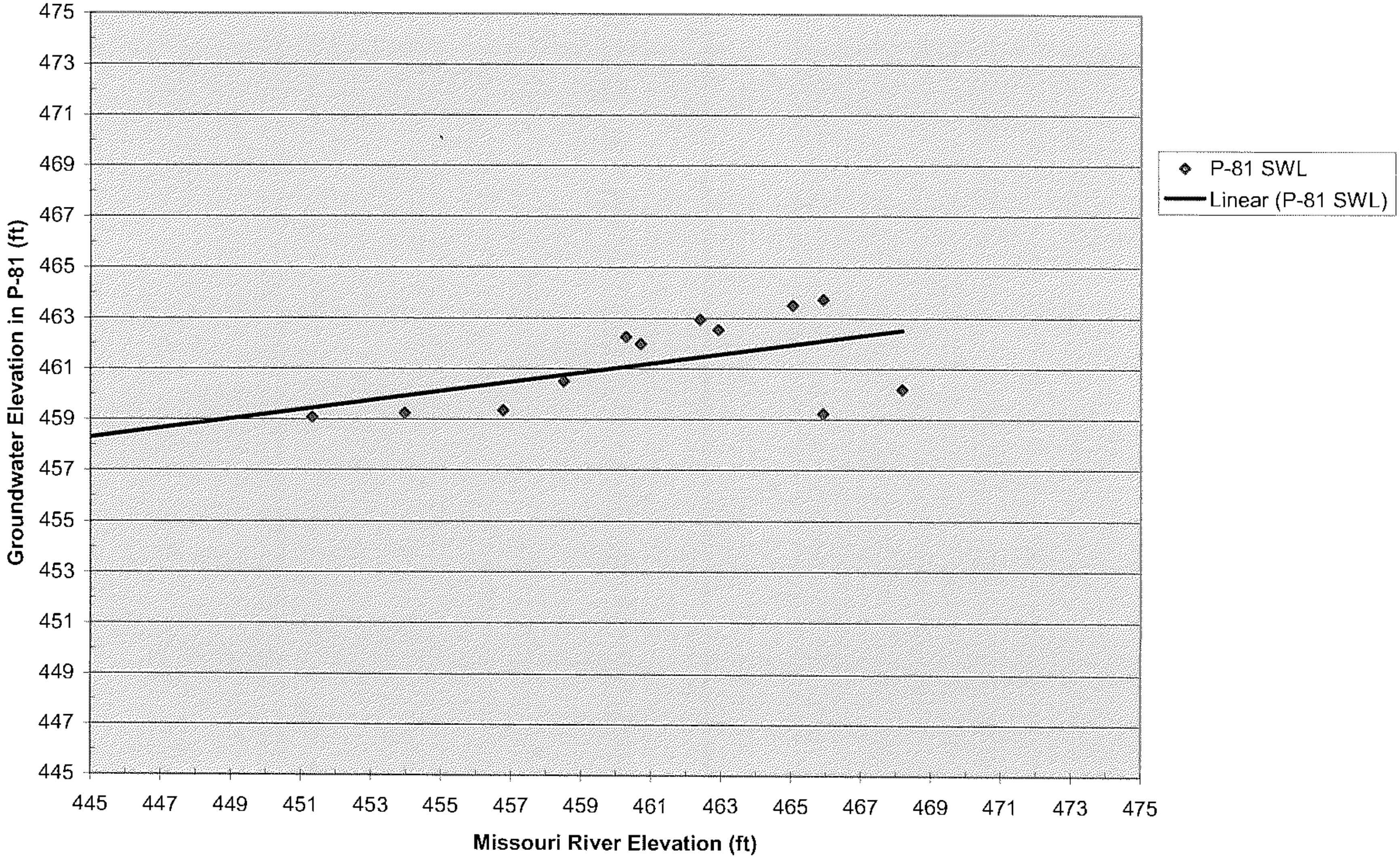
Missouri River Elevation vs Top of Water Table (P-65)
Attachment 4 - Figure 7



Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-81)
Attachment 4 - Figure 8



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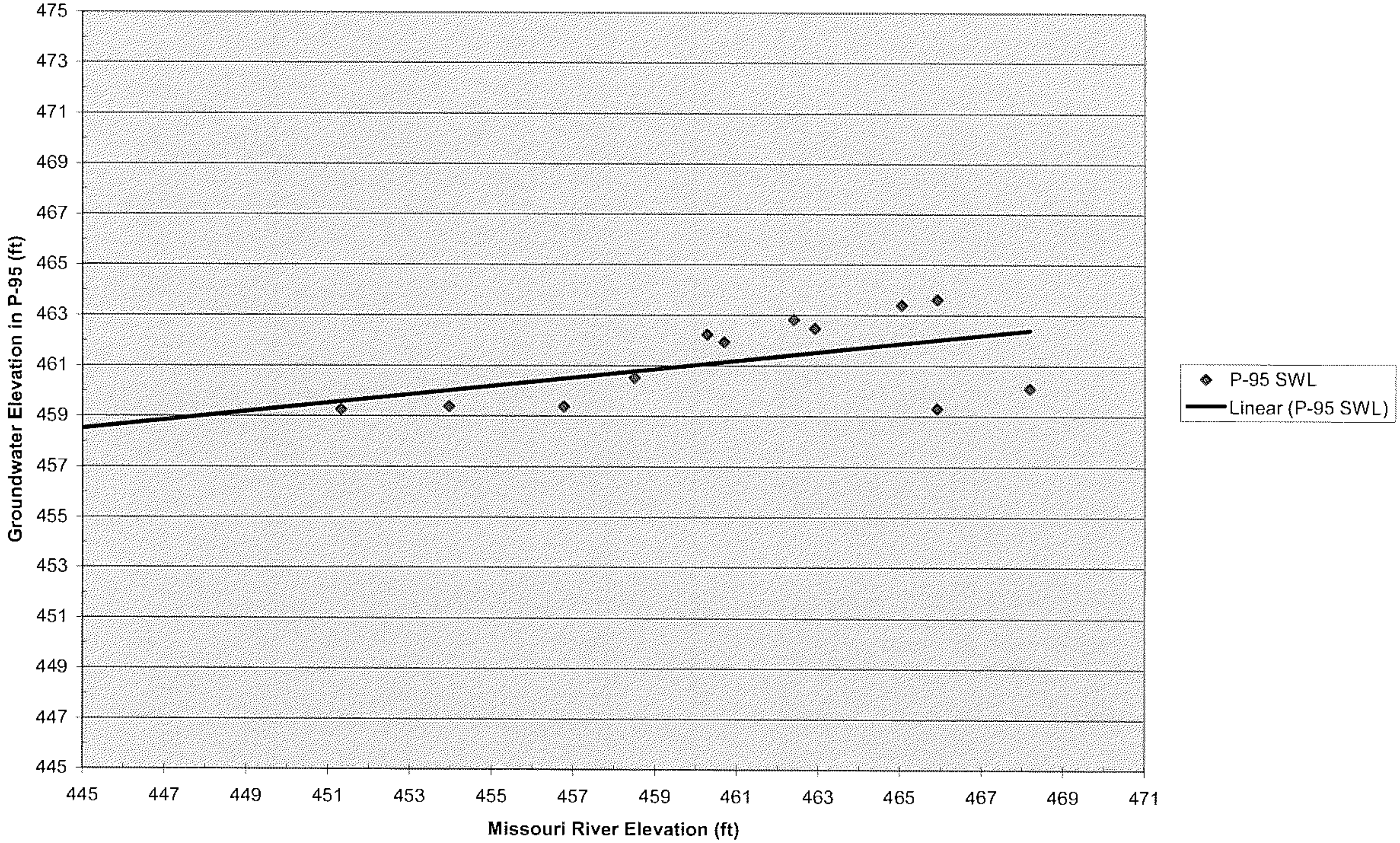
Missouri River Elevation vs Top of Water Table (P-95)
Attachment 4 - Figure 9



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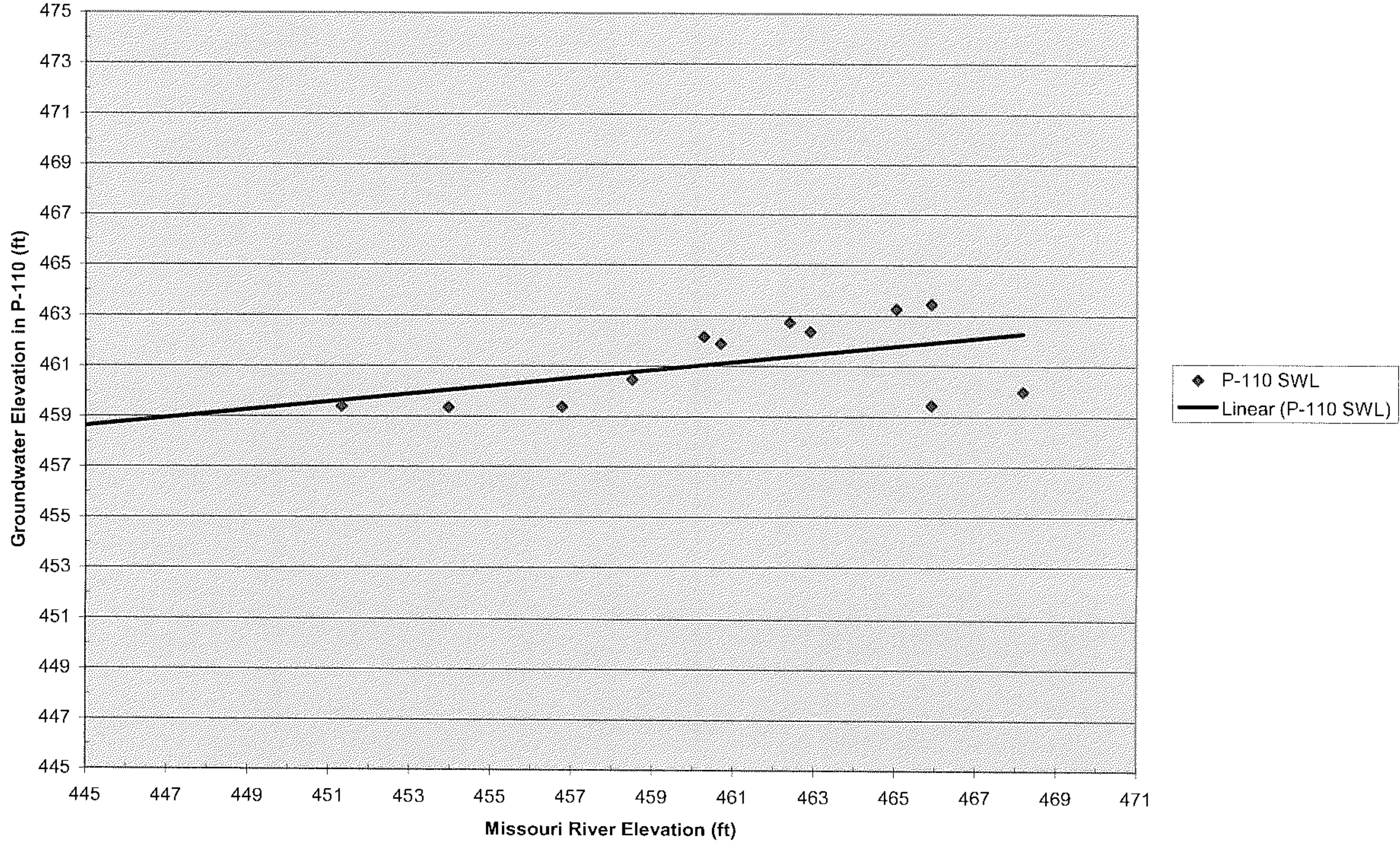
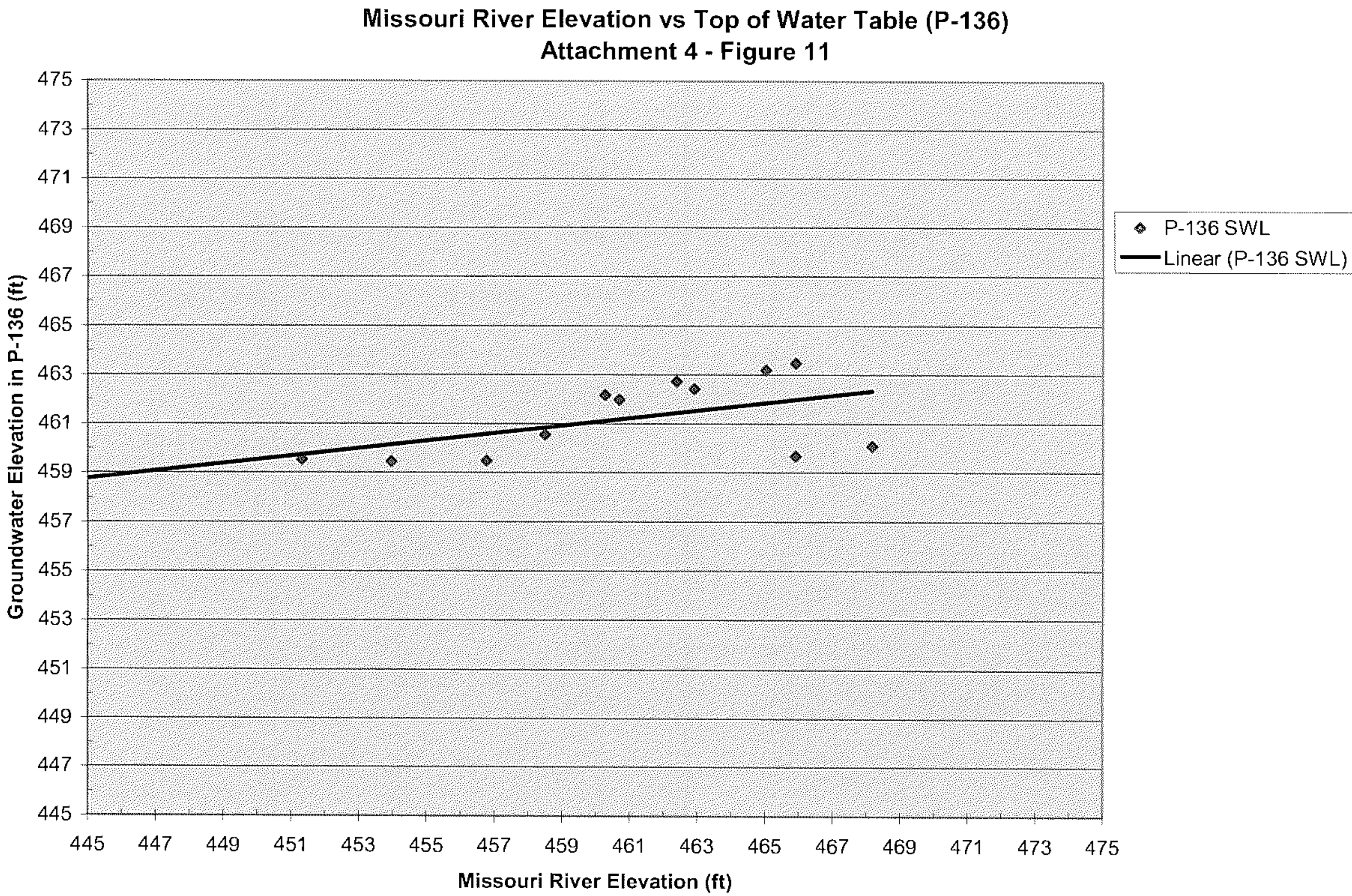
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-110)
Attachment 4 - Figure 10

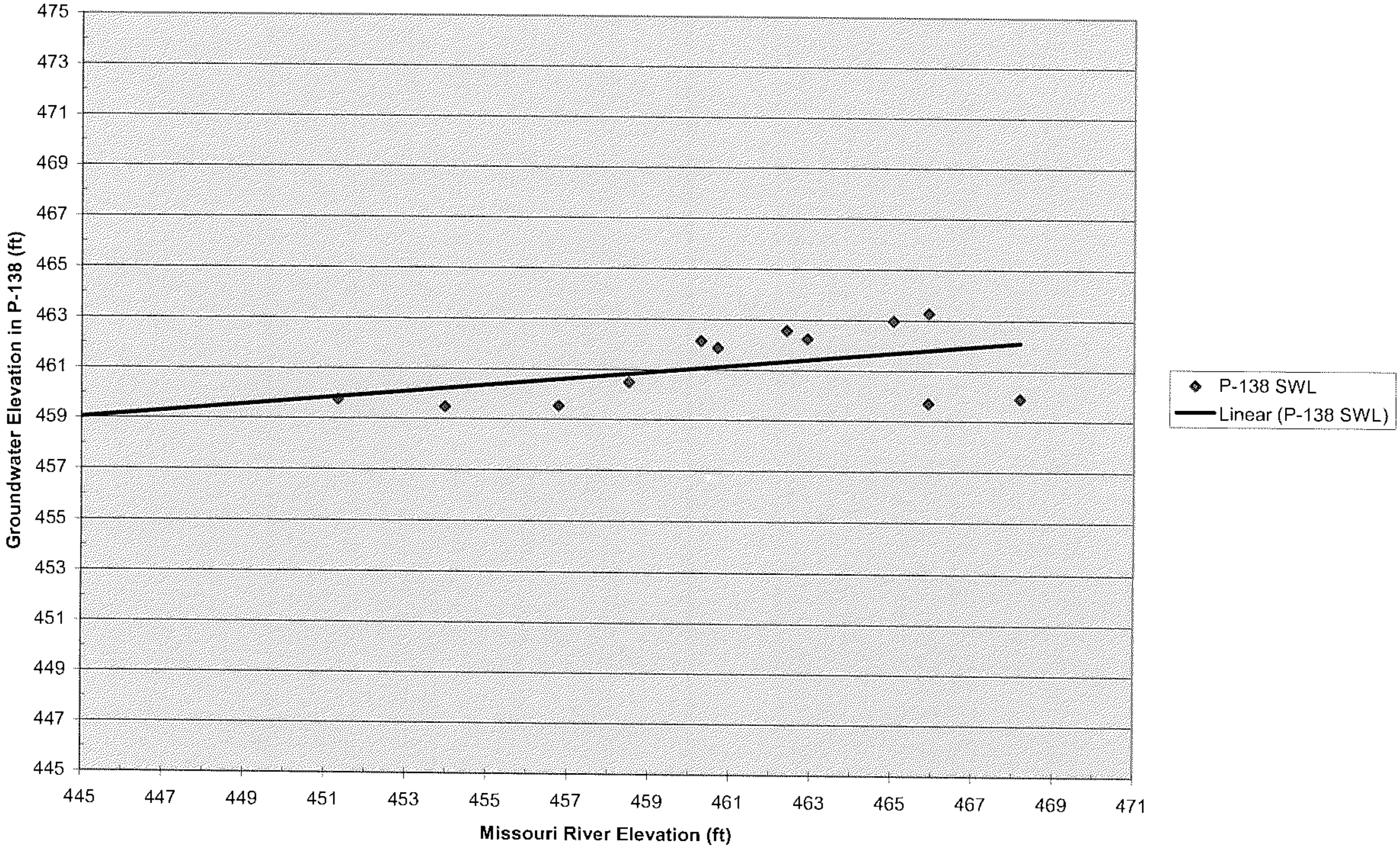


Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center



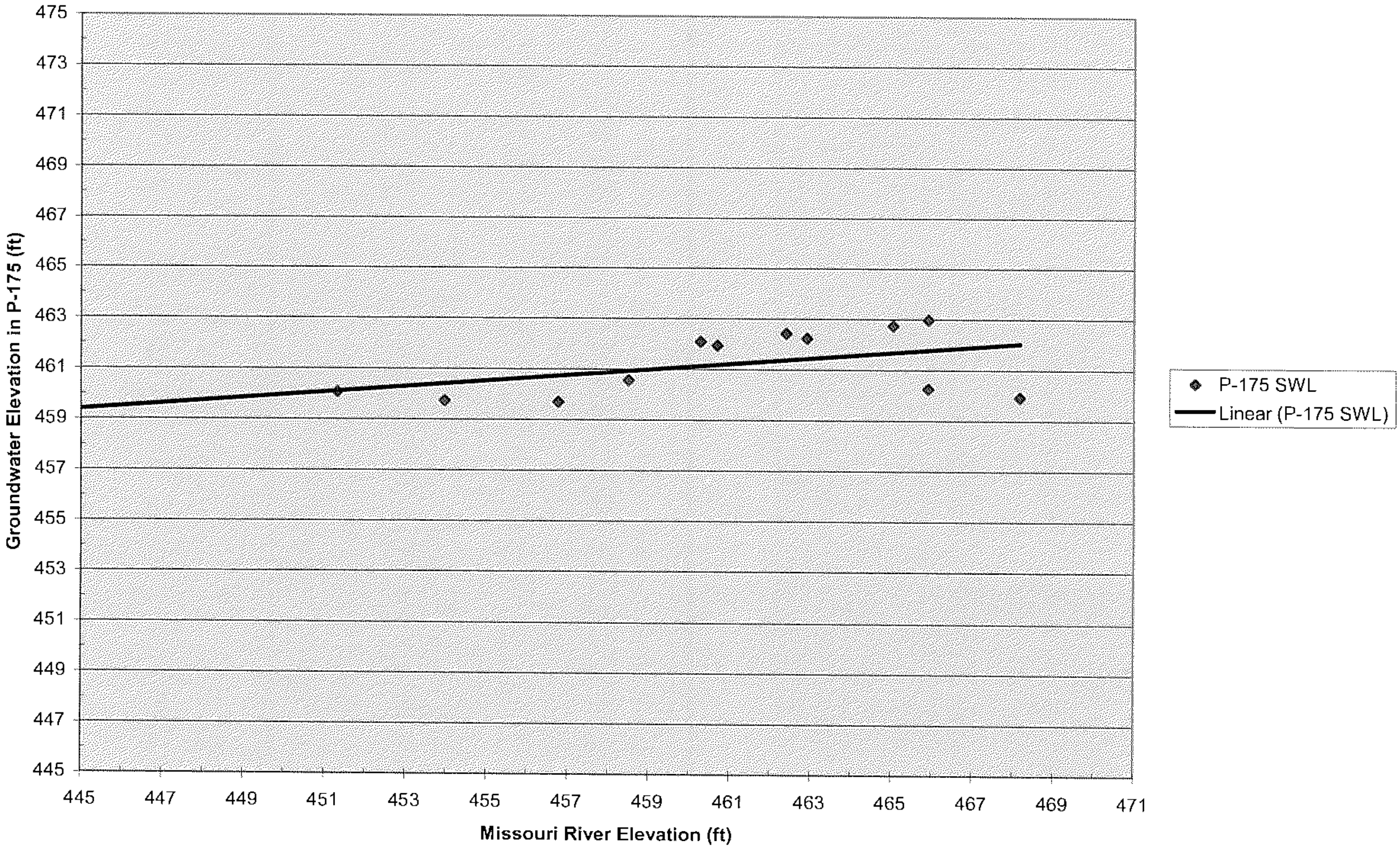
Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-138)
Attachment 4 - Figure 12



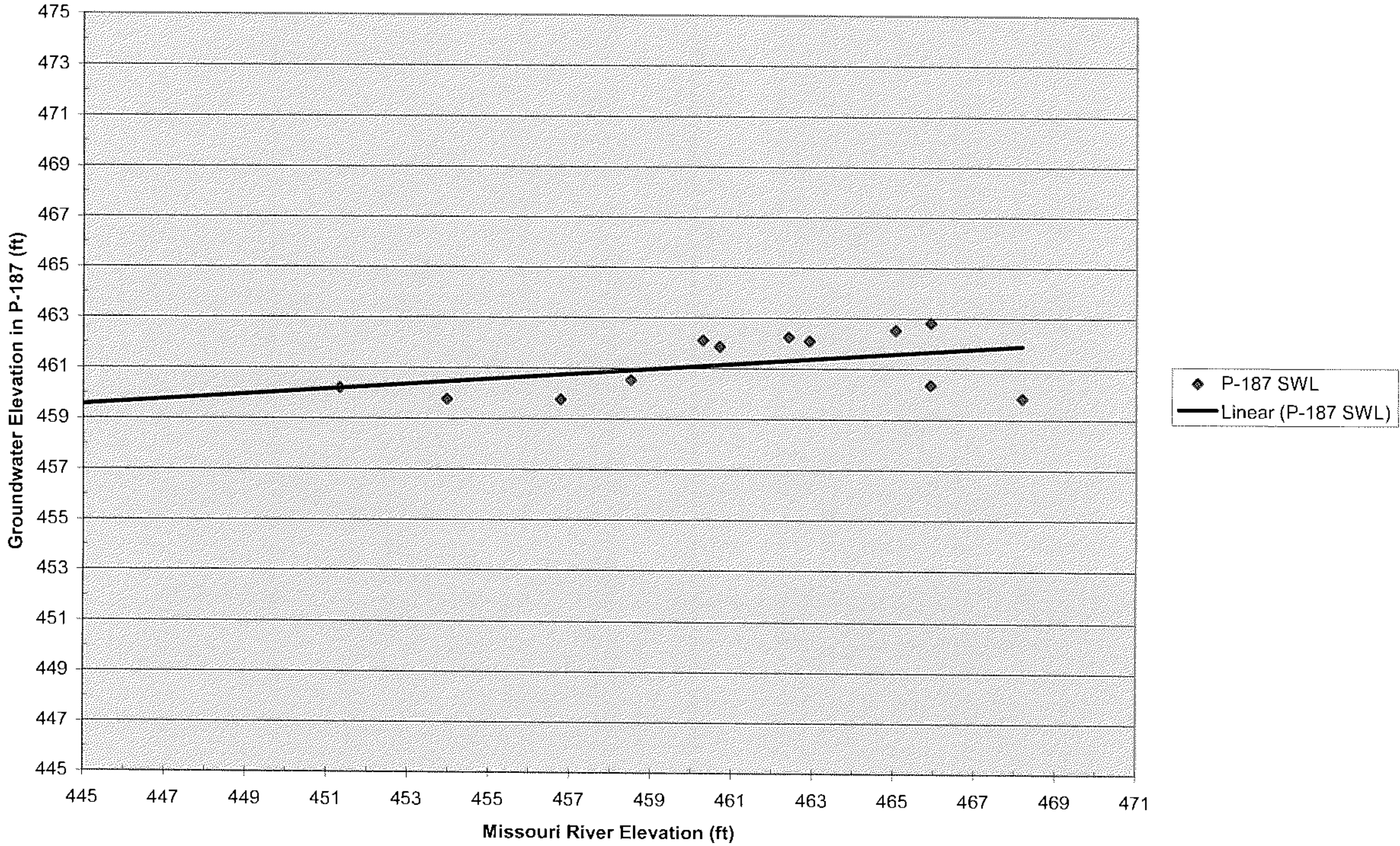
Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-175)
Attachment 4 - Figure 13



Construction Permit Application
Proposed Utility Waste Landfill
Ameren Missouri Labadie Energy Center

Missouri River Elevation vs Top of Water Table (P-187)
Attachment 4 - Figure 14



Appendix Y

Miscellaneous Engineering Calculations
Revised August 2013

Documents Included:

Y(a) Leachate Pipe and Pump Calculations
Revised August 2013

Y(b) Estimated Maximum Settlements Leachate Collection Pipe Profile

Y(c) Water Management Calculations

Y(d) Flood Mitigation Calculations
Revised August 2013

Y(e) Geosynthetics Design Calculations

Appendix Y(a)

Leachate Pipe and Pump Calculations

Ameren Missouri Labadie Energy Center
Leachate Pipe and Pump Calculations
Proposed Utility Waste Landfill
Franklin County, Missouri

January 2013, Revised August 2013

Table of Contents

Supplemental Information for Appendix Y(a)

Prepared by GREDELL Engineering Resources, Inc.

1.0 Introduction

Piping proposed for use at the Ameren Missouri Labadie Utility Waste Landfill (UWL) was reviewed for capacity and resistance to crushing and buckling under various conditions. First, capacity for leachate collection piping in the cells and the leachate force mains is estimated. Second, several scenarios representing a pipe element of the leachate collection system at some phase of the UWL development was checked for resistance to crushing and buckling. Sketches of each scenario are included in Section 3.5.

2.0 Pipe Capacity

2.1 Leachate Force Main

Leachate will be pumped to storage or treatment. Leachate pump and pipe requirements are estimated in this appendix.

Assumptions:

- The worst case flow of 13.4 gpm is in the 31.4-ac Cell 1 (see Appendix O, Table O-1, Sub Appendix O-11). Prorating this over the 166.5 acres, the flow is 71 gpm.
- The longest run of pipe is anticipated to be 2500 ft (the length of the furthest Cell 3 sump in southeast corner from Pond 2).
- Leachate will be pumped to a 12-ft diameter, horizontal tank on top of the perimeter berm and a 3-ft saddle. The elevation difference will be from the bottom of the sump to 15 ft above the top of berm:

  488 elevation + 15 ft - 464.2 elevation = 38.8 ft.

The head loss is estimated using the Hazen-Williams formula

$$H_f = [(0.00208 \times L) / (D_I^{4.8655})] \times (100 \times Q / C)^{1.85}$$

Where:
h_f is the head loss (ft),
L is the length (2500 ft),
D_I is the inside diameter of the pipe (in),
Q is the rate of flow (71 gpm), and
C is the friction factor (150 for HDPE).

The inside diameter 4-in nominal diameter DR17 pipe is 3.939 in. The head loss is

$$H_f = 0.00208 \times 2500 / 3.939^{4.8655} \times (100 \times 71/150)^{1.85} = 8.3 \text{ ft}$$

The total head is: 8.3 ft + 38.8 ft = 47.1 ft

There are 2 sumps in Cell 1, so the typical pump would only need to handle a rate of 13.4 gpm / 2 = 6.7 gpm (the sumps in the other cells have smaller drainage areas, and, therefore, will have smaller flows per sump). A review of leachate pump manufacturer's literature revealed that leachate pump models are available that can produce 10 gpm or more of flow at 50 ft of head (e.g., EPG SERIES 8 Surepump™).

2.2 Leachate Collection Pipe

The leachate collection pipes in each cell are intentionally oversized. The following calculations estimate the full-flow capacity of a nominal 6-in DR 11 HDPE pipe at a 0.5 percent slope using Manning's equation.

$$Q = 1.49 / n \times A \times R^{2/3} \times S^{1/2}$$

Where:
Q is the flow (cfs),
n is Manning's n (0.009 for HDPE),
A is the cross-sectional area of the pipe (sq ft),
R is the wetted perimeter (ft), and
S is the slope (0.5 percent or 0.005 ft/ft).
$A = \pi \times d^2 / 4$

Where d is the inside diameter. For a nominal 6-in HOPE DR 11 pipe, the inside diameter is 5.348 in or 0.446 ft.

$A = \pi \times (0.4457 \text{ ft})^2 / 4 = 0.156$ sq ft

$P = \pi \times d = \pi \times 0.446$ ft = 1.4 ft

R = A / P = 0.156 sq ft / 1.4 ft = 0.111 ft

$Q = (1.49 / 0.009) \times 0.156 \times 0.111^{2/3} \times 0.005^{1/2} = 0.42$ cfs

0.42 cfs x 7.48 gal/cfs x 60 s/min = **190 gpm**

As previously estimated, the maximum flow in a sump is approximately 7 gpm, but the use of the lowest flow leachate pump capacity at 11.1 gpm, actual flow is significantly less than the capacity of the proposed pipe.

3.0 Crushing and Buckling Scenarios

The methods used to estimate resistance to crushing and buckling follow those published by the Plastics Pipe Institute (PPI) in its Handbook for PE Pipe (2nd Edition). A conservative CCP unit weight, 120 pounds per cubic foot (95% compaction of the Standard Proctor), was used for all crushing and buckling calculations. This unit weight is higher than reported in the typical cell material profile provided in Scenario 2 (below) because 95% compaction of the CCP is not anticipated. Therefore, the calculations and reported factors of safety are conservative.

3.1 Scenario 1

Scenario 1 represents a leachate collection pipe (DR 11) placed in a trench with rock bedding, a minimum 12 inches of aggregate protective cover, and live loads. An H20 truck, which is a 20 ton truck with properties defined by The American Association of State Highway and Transportation Officials (AASHTO), is used for modeling live loads over the pipe.

<u>Determine Total Vertical Load</u>

1. **Earth Load - Vertical prism loads**

   Earth Load (P_E)= $w_{cover}H_{cover} + w_{bedding}H_{bedding}$ = *(120 pcf *1.0 ft) + (125 pcf *1.5 ft)*
   = *308 psf*

   Where:
   w_{waste} = Density of Aggregate Cover = 120 pcf
   H_{waste} = Depth of Aggregate Cover = 1.0 ft
   $w_{bedding}$ = Density of Bedding = 125 pcf
   $H_{bedding}$ = Depth of Bedding = 1.5 ft

2. **Live Load - Determine loading for an H20 truck using Timoshenko's Equation for a load directly above the pipe and the Boussinesq Equation for a load straddling the pipe. Use the greater load to be conservative**.

   Timoshenko's Equation

   $$\text{Llve Load } (P_L) = \frac{I_f W_w}{A_c}\left(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}\right) = \frac{3*16{,}000lb}{1.39\,ft^2}\left(1-\frac{(2.5\,ft)^3}{[(0.665\,ft)^2+(2.5\,ft)^2]^{1.5}}\right)$$
   = *3,366 psf*

   Where:
   H = Total Depth of Cover = 2.5 ft
   I_f = Impact Factor = 3 (Typical for unpaved surface)
   W_w = Wheel Load = 16,000 Ib (Typical value for H20 truck

A_c = Contact Area = 1.39 ft^2 (Typical value for H20 truck)

r_γ = Equivalent Radius = $\sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{1.39\,ft^2}{\pi}}$ = 0.665 ft

Boussinesq Equation

Live Load (P_L) = $\frac{3I_f W_W H^3}{2\pi r^2} = \frac{3*3*16{,}000lb*(2.5\,ft)^3}{2\pi(5.6\,ft)^2}$ *= 65.0 psf*

The live load is 130 psf to account for two wheels.

Where:
H = Total Depth of Cover = 2.5 feet
I_f = Impact Fator =3 (For an unpaved surface)
W_w = Wheel Load = 16,000 Ibs (Typical value for H20 Truck)
x = Horizontal distance from wheel to center of pipe = 5 ft. (assuming truck is 10 ft wide and centered over pipe)
r = Diagonal distance from wheel to center of pipe = $\sqrt{x^2 + H^2} = \sqrt{(5\,ft)^2 + (2.5\,ft)^2}$ = 5.6 ft

3. Total Vertical Load

Total Vertical Pressure (P_{Total}) = P_E + P_L = 308 psf + 3,366 psf = 3,700 psf

<u>Calculate Ring Deflection</u>

1. **Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.**

Ring Deflection = $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$= \frac{1}{144}\left(\frac{(0.1*1.5*308\,psf) + (0.1-3{,}366\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{11-1}\right)^3 + (0.061*0.85*3{,}000\,psi)}\right)$ *= 0.016 or 1.6%*

1.6 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
K_{BED} = Bedding Factor = 0.1 (Typical Value)
L_{DL} = Deflection Lag Factor = 1.5 (Typical Value)
P_E = 308 psf (Greater Value Calculated Above)
P_L = 3,366 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 3,000 psi (Assume compacted crushed rock)
F_s = Soil Support Factor = 0.85 (When: $\frac{E_N^{'}}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 3)
DR = Dimension Ratio = 11

Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

Compressive Stress (S) = $\frac{P_{Total} * DR}{288} = \frac{3{,}700\,psf * 11}{288}$ = *141 psi*

141 psi < 800 psi, the compressive stress value is within the acceptable range.

Where:
P_{Total} = 3,700 psf (Previously calculated)
DR = Dimension Ratio = 11

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than P_{TOTAL} (3,700 psf) using Luscher's Equation.**

Constrained Buckling Pressure (P_{WC}) = $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{0.80*0.227*3{,}000\,psi*\frac{21{,}000\,psi}{12(11-1)^3}}$ = *87.2 psi = 12,550 psf*

12,550 psf > 3,700 psf, the buckling pressure is within the acceptable range

Where:
N = Safety Factor = 2

R = Buoyancy Reduction Factor = 1 - 0.33 $\frac{H_{GW}}{H}$ = 1 – 0.33 $\frac{1.5\,ft}{2.5\,ft}$ = 0.80

H_{GW} = Groudwater Height Above Pipe = 1.5 ft assuming a maximum 1 ft allowed on liner plus an addition 0.5 ft.
H = Cover Above Pipe = 2.5 ft

B' = Soil Support Factor = $\frac{1}{1+4e^{-0.065H}}$ = $\frac{1}{1+4e^{-0.065*2.5}}$ = 0.227

E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reduction = 3,000 psi (Assuming compacted crushed rock)

3.2 Scenario 2

Scenario 2 represents a leachate collection pipe as in Scenario 1, except under the loading conditions of the UWL at full capacity.

<u>Determine Total Vertical Load</u>

1. **Earth load - Vertical prism loads**

Earth Load (P_E)= $w_{waste}H_{waste} + w_{soil}H_{soil} + w_{bedding}H_{bedding}$

$$= (120\,pcf * 98\,ft) + (120\,pcf * 2\,ft) + (125\,pcf * 1.5\,ft) = 12{,}188\,psf$$

Where:
w_{waste} = Density of Waste = 120 pcf
H_{waste} = Depth of Waste = 98 ft
W_{soil} = Density of Waste = 120 pcf
H_{soil} = Depth of Waste = 2.0 ft
$w_{bedding}$ = Density of Bedding = 125 pcf
$H_{bedding}$ = Depth of Bedding = 1.5 ft

2. **Live Load – No Live Load Exists**

$P_L = 0\ psf$

3. **Total Vertical Load**

Total Vertical Pressure (P_T) = P_L + P_E = 0 psf + 12,188 psf = 12,188 psf

Calculate Ring Deflection

1. **Rigidity Factor – Use the Watkins- Gaube Method to find Rigidity Factorm Deformation Factor, and Soil Stress. From this, Ring Deflection can be found and should be less than the allowable 5%.**

   Rigidity Factor (R_f) = $\frac{12E_s(DR-1)^3}{E} = \frac{12*3{,}491psi*(11-1)^3}{21{,}000psi}$ = *1,995*

   Where:

   E_s = Secant Modulus of Soil = $M_s \frac{(1+\mu)(1-2\mu)}{(1-\mu)} = 4{,}700\,psi\frac{(1+0.3)(1-2*0.3)}{(1-0.3)}$

   = 3,491 psi

   Assuming, M_s = 4,700 psi and μ = 0.3, based on typical values.

   DR = Dimension Ratio = 11

   E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

2. **Deformation Factor – For Rigidity Factor of 1,995**

   Deformation Factor (DF) = 1.5

3. **Soil Strain**

   Soil Strain (ε_s) = $\frac{P_E}{144E_s} = \frac{12{,}188psi}{144*3{,}491psi}$ = *0.024 or 2.4 %*

   Where:
   P_E = 12,188 psi (previously calculated)
   E_s = 3,491 psi (previously calculated)

4. **Ring Deflection – Determine whether Ring Deflection is less than the allowable 5%.**

   Ring Deflection $\left(\frac{\Delta X}{D_M}\right)$ = *ε_s(%)*DF = 2.4% * 1.5 = 3.6%*

   Since 3.6% < 9%, the ring deflection is within acceptable range.

Calculate Hoop Stress

1. **Hoop Thrust Stiffness Ratio –**

Hoop Stress Stiffness Ratio (S_A) = $\frac{1.43 M_S r_{cent}}{EA}$ = $\frac{1.43 * 4{,}700\, psi * 3.095 in}{21{,}000\, psi * 0.60 in}$ = *1.65*

Where:
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
A = Pipe Thickness = 0.60 in
M_S = 4,700 psi (Typical Value, From Table 3.12)
r_{cent} = radius to pipe centroid = 3.095 in

2. **Vertical Arching Factor –**

Vertical Arching Factor (VAF) = $0.88 - 0.71\left(\frac{S_A - 1}{S_A + 2.5}\right)$ = $0.88 - 0.71\left(\frac{1.65 - 1}{1.65 + 2.5}\right)$ = *0.769*

3. **Hoop Stress – Determine if Hoop Stress is less than the allowable 800 psi using the radial directed earth pressure (P_{RD})**

Radial Directed Earth Pressure (P_{RD}) = $VAF * P_E$ = $0.769 * 12{,}188\, psf$ = *9,373 psf*

Where:
P_E = Vertical Earth Load = 11,403 psf (calculated above)

Hoop Stress (S) = $\frac{(P_{RD} + P_L)DR}{288}$ = $\frac{(9{,}373\, psf + 0\, psf) * 11}{288}$ = *358 psi*

358 psi < 800 psi, therefore the hoop stress is within the acceptable range

Where:
P_L = 0 psf (No live load)
DR = Dimension Ratio = 11

3.3 Scenario 3

Scenario 3 represents a sump riser (DR 17) on the side slope, bedded in a trench, and under a live load. Loads were treated as if they were normal to the pipe. This is a larger pipe that contains the sump and pump discharge pipe.

Determine Total Vertical Load

1. Earth Load - Vertical prism loads

*Earth Load (P_E)= $w_{cover}H_{cover}$ + $w_{bedding}H_{bedding}$ = (120 pcf *1.0 ft) + (125 pcf *1.0 ft)*
= 245 psf

Where:
w_{waste} = Density of Aggregate Protective Cover = 120 pcf
H_{waste} = Depth of Aggregate Protective Cover = 1.0 ft
$w_{bedding}$ = Density of Bedding = 125 pcf
$H_{bedding}$ = Depth of Bedding = 1.0 ft

2. Live Load - Determine loading for a 6,000 lb (3-ton) skid steer directly above the pipe using Timoshenko's Equation. According to the PPI Handbook, the load of a wheel directly over the pipe will be greater than two wheels straddling the pipe when there is less than 4ft of cover.

Timoshenko's Equation

$$\text{Llve Load } (P_L) = \frac{I_f W_w}{A_c}\left(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}\right) = \frac{3*1{,}500 lb}{0.89\, ft^2}\left(1-\frac{(2.0\, ft)^3}{[(0.53\, ft)^2+(2.0\, ft)^2]^{1.5}}\right)$$

= 489 psf

Where:
H = Total Depth of Cover = 2.0 ft
I_f = Impact Factor = 3 (Typical for unpaved surface)
W_w = Wheel Load = 6,000 lb/ 4 tires = 1,500 Ib
A_c = Contact Area = 0.66 ft * 1.33 ft = 0.89 ft^2

$$r_\gamma = \text{Equivalent Radius} = \sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{0.89\, ft^2}{\pi}} = 0.53 \text{ ft}$$

3. Total Vertical Load

Total Vertical Pressure (P_T) = P_L + P_E = 489 psf + 245 psf = 734 psf

Calculate Ring Deflection

1. Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.

Ring Deflection = $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$= \frac{1}{144}\left(\frac{(0.1*1.5*245\,psf)+(0.1-489\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{17-1}\right)^3 + (0.061*0.3*3{,}000\,psi)}\right)$ *= 0.010 or 1.0%*

1.0 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
K_{BED} = Bedding Factor = 0.1 (Typical Value)
L_{DL} = Deflection Lag Factor = 1.5 (Typical Value)
P_E = 245 psf (Calculated Above)
P_L = 489 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 3,000 psi (Assume compacted crushed rock)
F_s = Soil Support Factor = 0.3 (When: $\frac{E_N^{'}}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 1.5)
DR = Dimension Ratio = 17

Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

   Compressive Stress (S) = $\frac{P_{Total} * DR}{288} = \frac{734\,psf * 17}{288}$ *= 43 psi*

   43 psi < 800 psi, the compressive stress value is within the acceptable range.

   Where:
   P_{Total} = 734 psf (Previously calculated)
   DR = Dimension Ratio = 17

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than P_{TOTAL} (734 psf) using Luscher's Equation.**

Constrained Buckling Pressure (P_{WC}) = $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{1.0*0.222*3{,}000\,psi*\frac{21{,}000\,psi}{12(17-1)^3}}$ *= 47.7 psi = 6,869 psf*

6,869 psf > 734 psf, the buckling pressure is within the acceptable range

Where:
N = Safety Factor = 2
R = Buoyancy Reduction Factor = 1 - 0.33$\frac{H_{GW}}{H}$ = 1 – 0.33$\frac{0\,ft}{2.0\,ft}$ = 1.0

H_{GW} = Groudwater Height Above Pipe = 0 ft because there will be no standing water on the slope
H = Cover Above Pipe = 2.0 ft

B' = Soil Support Factor = $\frac{1}{1+4e^{-0.065H}}$ = $\frac{1}{1+4e^{-0.065*2.0}}$ = 0.222
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

E' = Modulus of Soil Reduction = 3,000 psi (Assuming compacted crushed rock)

Calculate Allowable Live Load Pressure

1. **Allowable Live Load Pressure – Calculate live load pressure for a shallow cover situation. The pressure calculated should be less than the live load.**

Allowable Live Load Pressure (P_{LA}) = $\frac{12w(KH)^2}{ND_o}+\frac{7387.2(I)}{ND_o{}^2C}\left(S-\frac{wD_oH}{288A}\right)$

= $\frac{12*120\,pcf\,(2.46*2\,ft)^2}{2*18in}+\frac{7387.2*0.094}{2*(18in)^2*0.53in}\left(3{,}000\,psi-\frac{120\,pcf\,*18in*2\,ft}{288*1.06in}\right)$

= 7,006 psf

734 psf < 7,006 psf, the allowable live load is in the acceptable range

Where:
w = Average Density of Cover Material = 120 pcf
H = Depth of Cover = 2 ft

K = Passive Earth Pressure Coefficient = $\frac{1+\sin\phi}{1-\sin\phi}$ = $\frac{1+\sin(25)}{1-\sin(25)}$ = 2.46

ϕ = 25° for a loose silty material

N = Safety Factor = 2

D_o = Outside Diameter of Pipe = 18 in

A = Pipe Wall Thickness = 1.06 in (Based in DR of 17)

C = Outer Fiber Wall of Centroid = 0.5t = 0.5*1.06 in = 0.53 in

S = Material Yield Strength = 3,000 psi

I = Pipe Wall Moment of Inertia = $\frac{t^2}{12}$ = $\frac{(1.06in)^2}{12}$ = 0.094

3.4 Scenario 4

Scenario 4 represents a pipe (DR 17) in the perimeter berm for carrying leachate to a holding tank.

Determine Total Vertical Load

1. **Earth Load – Vertical prism loads**

*Earth Load (P_E)= $w_{soil}H_{soil}$ = (120 pcf *4.0 ft) = 480 psf*

Where:
w_{soil} = Density of Soil = 120 pcf
H_{soil} = Depth of Soil Cover = 4.0 ft

2. **Live Load - Determine loading for an H20 truck using Timoshenko's Equation for a load directly above the pipe and the Boussinesq Equation for a load straddling the pipe. Use the greater load to be conservative**.

Timoshenko's Equation

Llve Load (P_L) $= \frac{I_f W_w}{A_c}(1-\frac{H^3}{(r_\gamma^2+H^2)^{1.5}}) = \frac{3*16{,}000lb}{1.39\,ft^2}(1-\frac{(4.0\,ft)^3}{[(0.665\,ft)^2+(4.0\,ft)^2]^{1.5}})$

= 1,384 psf

Where:
H = Total Depth of Cover = 4.0 ft
I_f = Impact Factor = 3 (Typical for unpaved surface)
W_w = Wheel Load = 16,000 Ib (Typical value for H20 truck
A_c = Contact Area = 1.39 ft^2 (Typical value for H20 truck)

r_γ = Equivalent Radius = $\sqrt{\frac{A_c}{\pi}} = \sqrt{\frac{1.39\,ft^2}{\pi}}$ = 0.665 ft

Boussinesq Equation

Live Load (P_L) = $\frac{3I_f W_W H^3}{2\pi r^2} = \frac{3*3*16{,}000lb*(4.0\,ft)^3}{2\pi(6.4\,ft)^2}$ *= 137.0 psf*

The live load is 274 psf to account for two wheels.

Where:
H = Total Depth of Cover = 4.0 feet
I_f = Impact Fator =3 (For an unpaved surface)
W_w = Wheel Load = 16,000 Ibs (Typical value for H20 Truck)
x = Horizontal distance from wheel to center of pipe = 5 ft. (assuming truck is 10 ft wide and centered over pipe)
r = Diagonal distance from wheel to center of pipe = $\sqrt{x^2 + H^2}$ = $\sqrt{(5\,ft)^2 + (4.0\,ft)^2}$ = 6.4 ft

3. **Total Vertical Load**

Total Vertical Pressure (P_{Total}) = P_E + P_L = 480 psf + 1,384 psf = 1,864 psf

Calculate Ring Deflection

1. **Ring Deflection – Determine whether the ring deflection is less than the allowable 5% using Spangler's Modified Iowa Formula.**

Ring Deflection = $\left(\frac{\Delta X}{D_M}\right) = \frac{1}{144}\left(\frac{K_{BED}L_{DL}P_E + K_{BED}P_L}{\frac{2E}{3}\left(\frac{1}{DR-1}\right)^3 + 0.061F_S E'}\right)$

$= \frac{1}{144}\left(\frac{(0.1*1.5*480\,psf) + (0.1-1{,}384\,psf)}{\left(\frac{2*21{,}000}{3}\right)*\left(\frac{1}{17-1}\right)^3 + (0.061*0.85*2{,}000\,psi)}\right)$ *= 0.013 or 1.3%*

1.3 % < 5 %, therefore the ring deflection is within the acceptable range.

Where:
K_{BED} = Bedding Factor = 0.1 (Typical Value)
L_{DL} = Deflection Lag Factor = 1.5 (Typical Value)
P_E = 480 psf (Greater Value Calculated Above)
P_L = 1,384 psf (Calculated Above)
E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)
E' = Modulus of Soil Reaction = 2,000 psi (Assume compacted coarse grained soil)
F_s = Soil Support Factor = 0.85 (When: $\frac{E'_N}{E'}$ = 0.2 and $\frac{B_d}{D_O}$ = 3)
DR = Dimension Ratio = 17

Crushing and Buckling Forces

1. **Compressive Stress - Determine whether the compressive stress is less than the allowable 800 psi.**

Compressive Stress (S) = $\frac{P_{Total} * DR}{288} = \frac{1{,}864\,psf * 17}{288}$ = *110 psi*

110 psi < 800 psi, the compressive stress value is within the acceptable range.

Where:
P_{Total} = 1,864 psf (Previously calculated)
DR = Dimension Ratio = 17

2. **Allowable Constrained Buckling Pressure - Determine if the buckling pressure is greater than P_{TOTAL} (1,864 psf) using Luscher's Equation.**

Constrained Buckling Pressure (P_{WC}) = $\frac{5.65}{N}\sqrt{RB'E'*\frac{E}{12(DR-1)^3}}$

= $\frac{5.65}{2}\sqrt{1.0*0.245*2{,}000\,psi*\frac{21{,}000\,psi}{12(17-1)^3}}$ = *40.9 psi = 5,890 psf*

5,890 psf > 1,864 psf, the buckling pressure is within the acceptable range

Where:
N = Safety Factor = 2
R = Buoyancy Reduction Factor = 1 - 0.33$\frac{H_{GW}}{H}$ = 1 – 0.33$\frac{0\,ft}{4.0\,ft}$ = 1.0

H_{GW} = Groudwater Height Above Pipe = 0 ft because there will be no standing

water on the slope
H = Cover Above Pipe = 4.0 ft

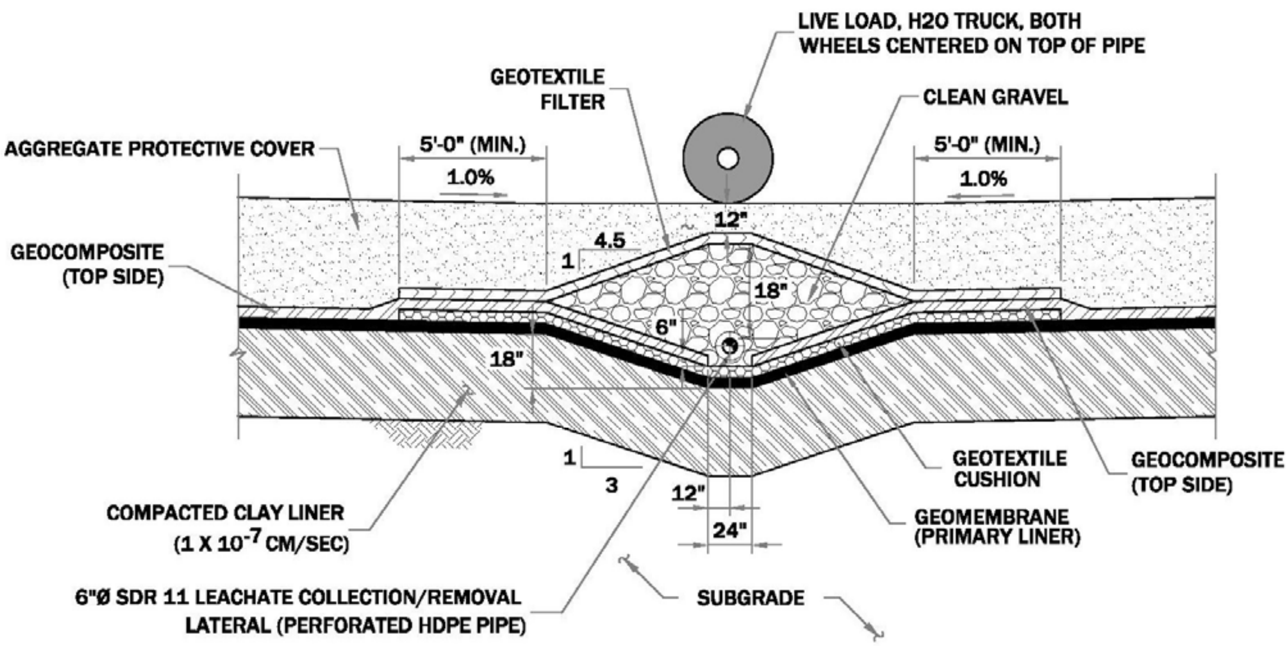
B' = Soil Support Factor = $\dfrac{1}{1+4e^{-0.065H}} = \dfrac{1}{1+4e^{-0.065*4.0}} = 0.245$

E = Apparent Modulus of Elasticity of Pipe Material = 21,000 psi (Assume 100 yrs, 73°F)

E' = Modulus of Soil Reduction = 2,000 psi (Assuming compacted coarse grained soil)

3.5 Scenario Sketches

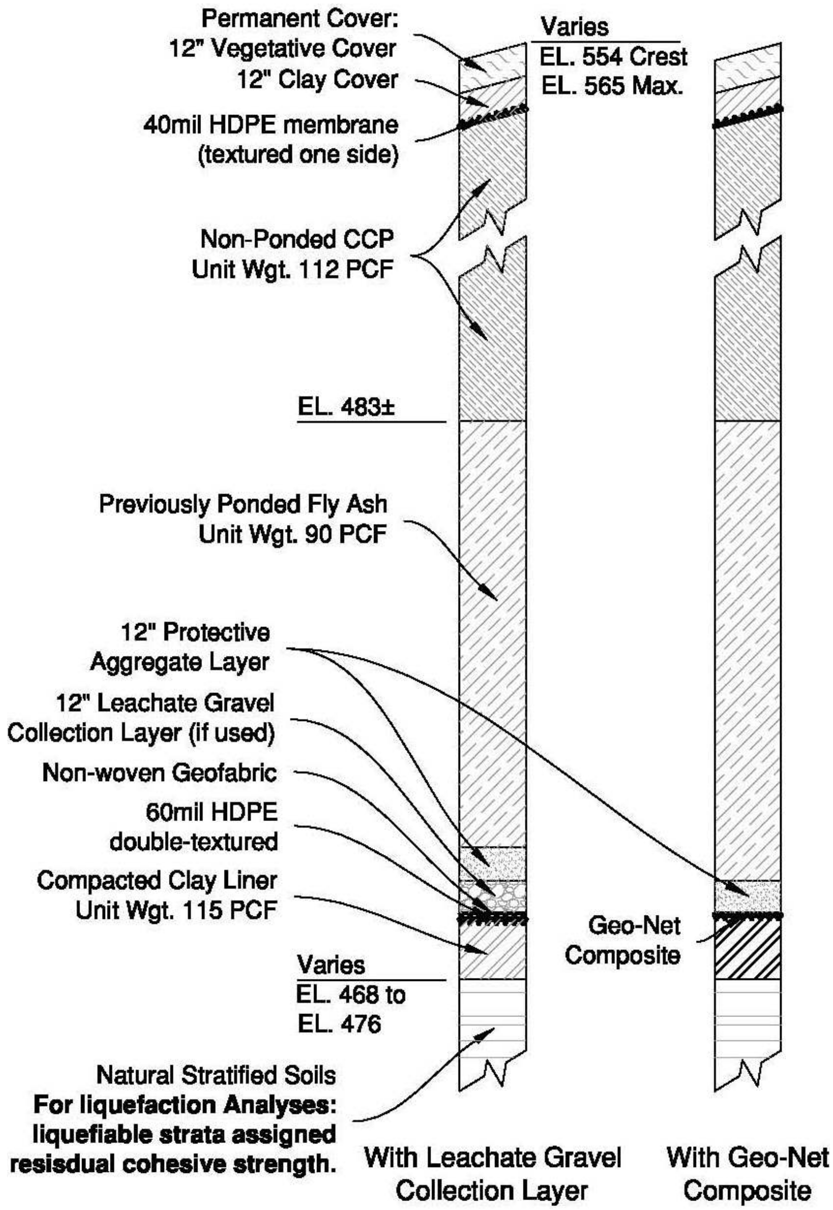
Scenario 1



LEACHATE COLLECTION LATERAL TRENCH (ALTERNATE)

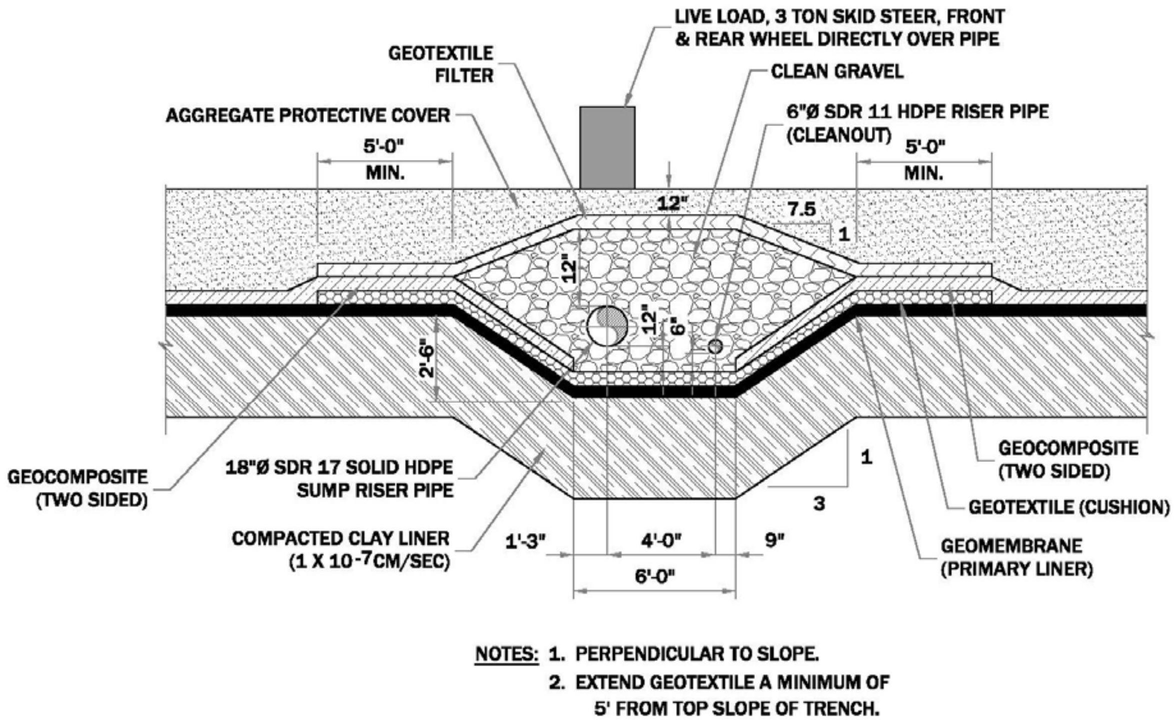
N.T.S.

Scenario 2



Typical Cell Material Profile
NOT TO SCALE

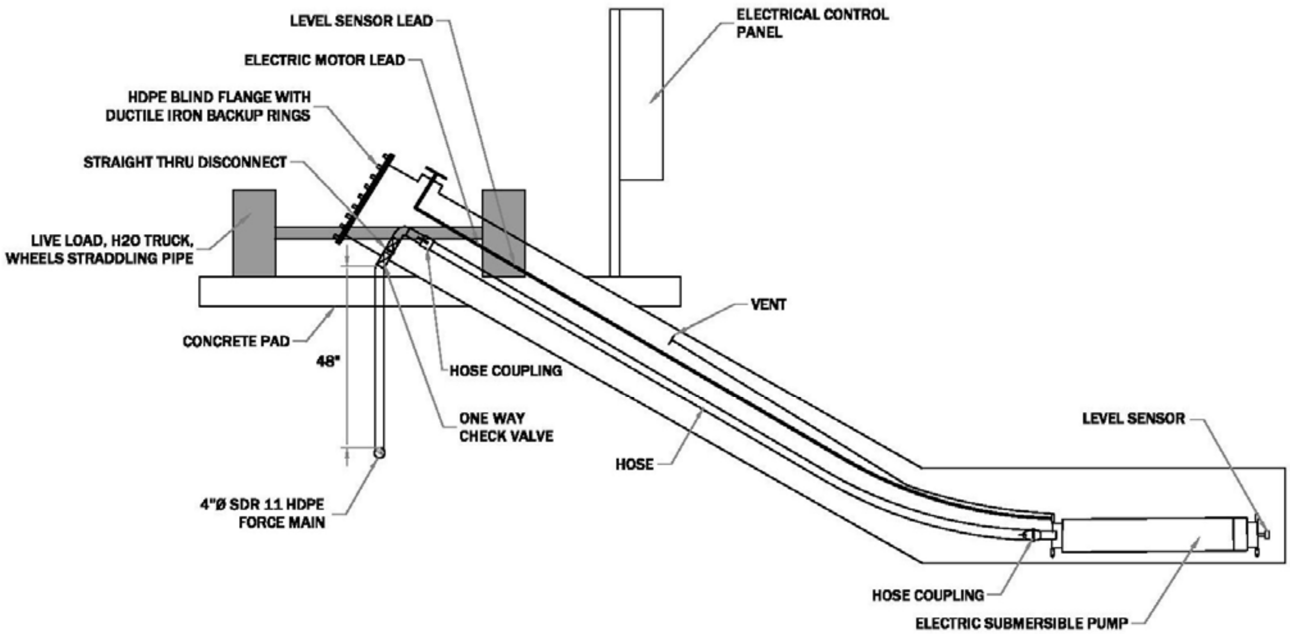
Scenario 3



SECTION: SUMP RISER TRENCH

N.T.S.

Scenario 4



TYPICAL LEACHATE PUMP STATION WITH LEACHATE FORCE MAIN

N.T.S.

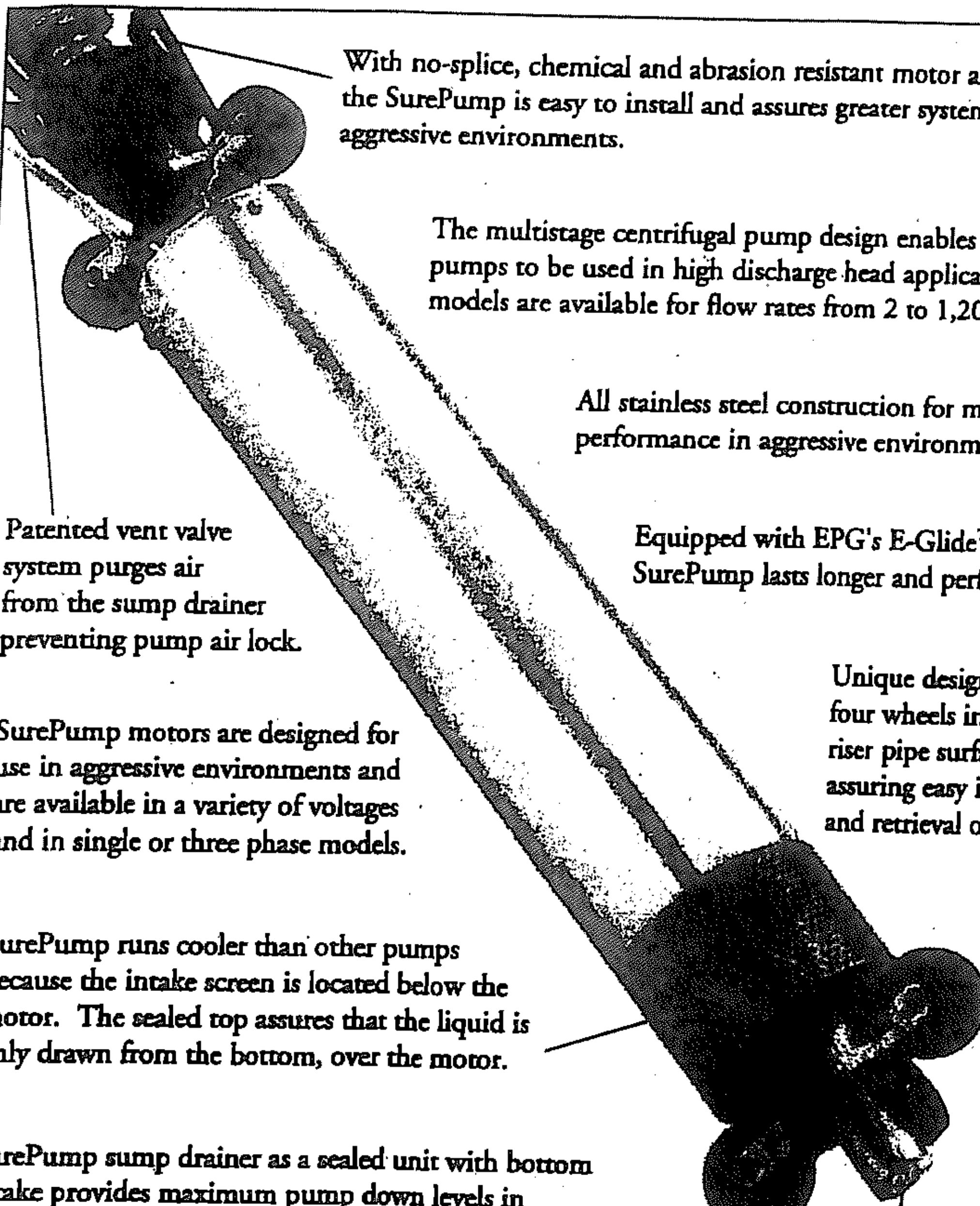
Supplemental Information for Appendix Y(a)

Pipe and Pump Calculations

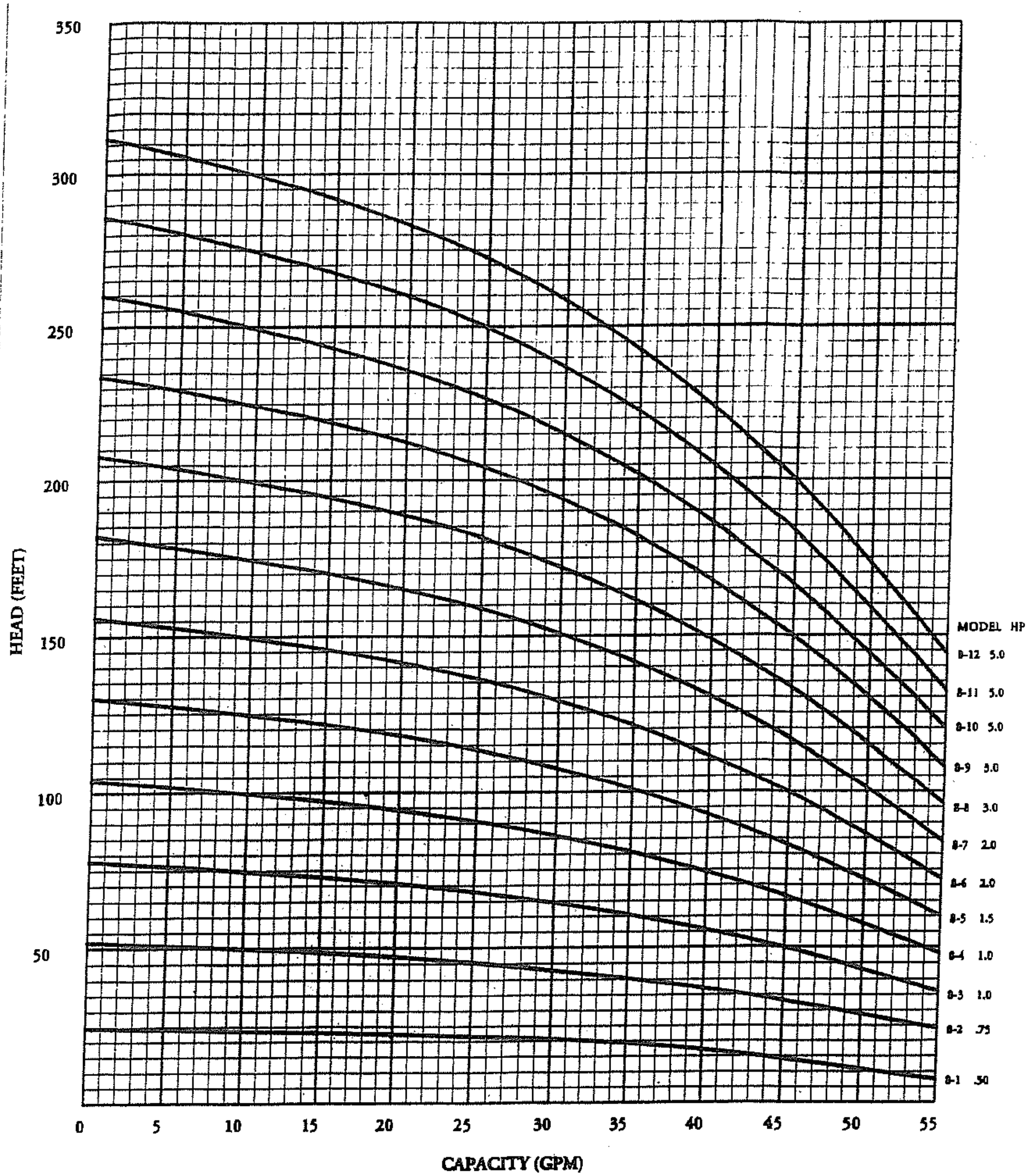
From Sioux Const. Permit Mod. Report Feb 2012

Horizontal Wheeled Sump Drainer

More details at www.epgco.com



SERIES 8 SurePump™
Flow Range 20-50 GPM
60 Hz



DATA SUBJECT TO CHANGE WITHOUT NOTICE

Pump Capacities

If the following curves do not meet your needs, please call us at 800-443-7426 and ask for an application specialist. Custom pumps in additional sizes, flow rates and head are available.

SurePump™

Curve	Model	Flow Range
05714-0000	SERIES 1	1 to 7 [illegible]
05770-0000	SERIES 1.5	3 to 10 GPM
05771-0000	SERIES 2	4 to 14 GPM
05772-0000	SERIES 3	10 to 20 GPM
05773-0000	SERIES 5	15 to [illegible] GPM
05774-0000	SERIES 8	20 to 50 GPM
05775-0000	SERIES 12	35 to 75 GPM
05776-0000	SERIES 15	45 to 95 GPM

Curve	Model	Flow Range
[illegible]	SERIES 17	[illegible] GPM
05778-0000	SERIES 30	50 to 200 GPM
[illegible]	SERIES [illegible]	75 to [illegible] GPM
05780-0000	SERIES 60	50 to 400 GPM
[illegible]	[illegible] 77	75 to [illegible] GPM
05782-0000	SERIES 95	95 to 680 GPM
[illegible]	SERIES 125	125 to [illegible] GPM

The SurePumps are available in the following configurations:

WSDPT: Wheeled Sump Drainer with integral level sensor for side slope riser applications

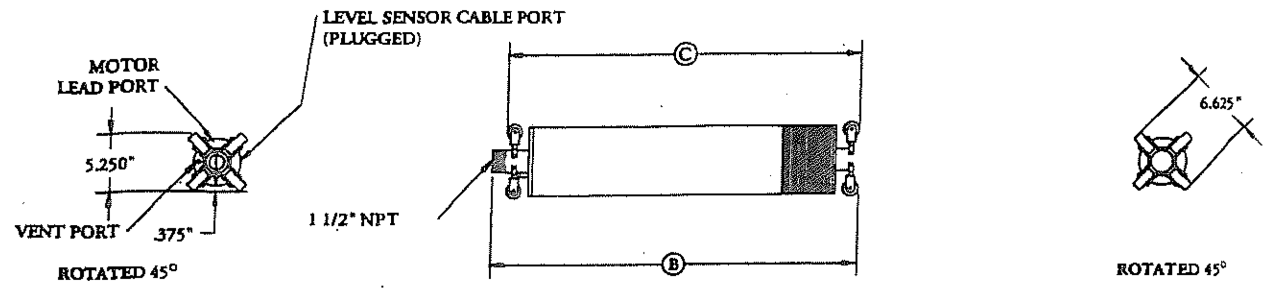
WSD: Wheeled Sump Drainer without integral level sensor for side slope riser applications

VSDPT: Vertical Sump Drainer with integral level sensor

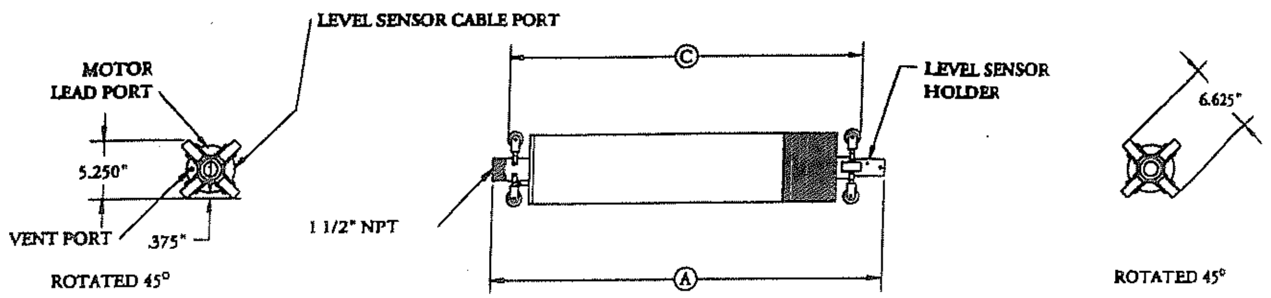
VSD: Vertical Sump Drainer with no level sensor

TSP: Submersible Pump

SERIES 8 SIZE 4 WHEELED SUMP DRAINER



WSD



WSDPT

MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT WSD	*APPROX. SHIPPING WEIGHT WSDPT
8-1	0.50	1	32.72	31.60	30.85	62.79	67.79
8-1	0.50	3	32.72	31.60	30.85	62.79	67.79
8-2	0.75	1	35.50	34.38	33.63	68.95	68.95
8-2	0.75	3	35.50	34.38	33.63	68.95	68.95
8-3	1.00	1	38.24	37.12	36.37	75.08	80.08
8-3	1.00	3	38.24	37.12	36.37	75.08	80.08
8-4	1.00	1	39.89	38.77	38.02	77.36	82.36
8-4	1.00	3	39.89	38.77	38.02	77.36	82.36
8-5	1.50	1	43.41	42.29	41.54	86.09	91.09
8-5	1.50	3	41.54	40.42	39.67	79.64	84.64
8-6	2.00	1	46.56	45.44	44.69	92.53	97.53
8-6	2.00	3	45.06	43.94	43.19	88.37	93.37

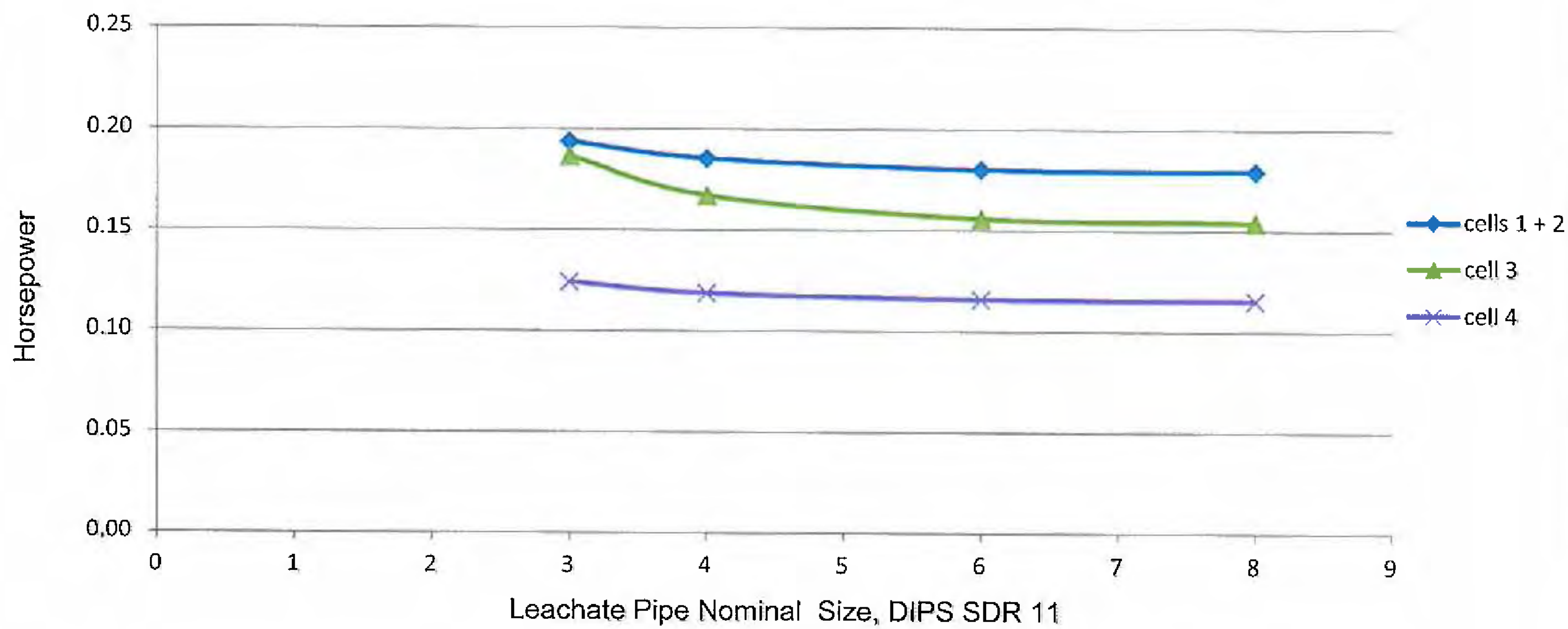
MODEL	HP	PHASE	A	B	C	*APPROX. SHIPPING WEIGHT WSD	*APPROX. SHIPPING WEIGHT WSDPT
8-7	2.00	1	48.21	47.09	46.34	94.81	99.81
8-7	2.00	3	46.71	45.59	44.84	90.65	95.65
8-8	3.00	1	58.36	57.24	56.49	126.69	131.69
8-8	3.00	3	55.36	54.24	53.49	113.36	118.36
8-9	3.00	1	60.01	58.89	58.14	128.97	133.97
8-9	3.00	3	57.01	55.89	55.14	115.64	120.64
8-10	5.00	1	67.66	66.54	65.79	150.91	155.91
8-10	5.00	3	61.66	60.54	59.79	131.25	136.25
8-11	5.00	1	69.31	68.19	67.44	153.19	158.19
8-11	5.00	3	63.31	62.19	61.44	133.53	138.53
8-12	5.00	1	70.96	69.84	69.09	155.47	160.47
8-12	5.00	3	64.96	63.84	63.09	135.81	140.81

NOTE: ALL DIMENSIONS ARE IN INCHES.

*SHIPPING WEIGHT INCLUDES
WSD: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE.
WSDPT: CRATE, 50' OF 14-4 MOTOR LEAD, 50' OF 1/8" SS CABLE, LEVEL SENSOR AND CABLE.

Ameren Missouri Labadie UWL
Leachate Pump Calculation

Pump Horsepower for leachate lines for cells to leachate holding at Pond 1



Prepared byGREDELL Engineering Resoruces, Inc.

January 2013

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING LAND - AIR - WATER
Telephone (573) 659-9078

Date: 11/6/2012	Page No: 1 of 2		
Client: Reitz & Jens			
Prepared By: FP	Checked By:	Project: Ameren MO Labadie CCPLF	
Subject: Check Calculations of Pipe Size and Pump Power for Leachate Collection			

Area of Cell 1 31.4 Ac

Measured	Sf	Ac		Ac Corrected
680, 1370, 0.5	465800	14.98 Sump 2	31.4 / 30.38	= 15.5
140, (1370 + 1300)/2	186900			
390, (1300 + 1130)/2	413100	15.4 Sump 1	31.4 / 30.38	15.9
520, 990, 0.5	257400			
		30.38		31.4

Flow from HELP Model OGE3 R003

Peak 612.5 gpad → 0.00095 cfs/Ac

Annual 209.8 gpad → 0.00032 cfs/Ac

	Ac	cfs/sump	Total flow
Sump 1	15.9 × 0.00095	.0151	0.0632
Sump 2	15.5	.0147	0.0481
Add Cell 2		.0334	

4" SDR 11 DIPS Effective Diameter = 3.89" = 0.32' ISCO

$$Area = \frac{\pi d^2}{4} = 0.082\ sf$$

$$Velocity = Q/A = 0.0632/0.082 = 0.77\ fps$$

$$Reynold's\ No = \frac{V d}{V_K}$$ where V_K = Kinematic Viscosity $= 0.00001217\ ft^2/sec$ at 60° Vennard Fluid mechanics

$$R_E = \frac{(0.77)(0.32)}{1.217 \times 10^{-5}} = 20400$$

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ENVIRONMENTAL ENGINEERING — LAND - AIR - WATER
Telephone (573) 659-9078

Date:	11/6/2012	Page No:	2 of 2
Client:	Reitz & Jens		
Prepared By: FD	Checked By:	Project:	Ameren MO Labadie CCP LF
Subject:	Check Calculations of Pipe Size and Pump Power for Leachate Collection		

Velocity and friction head

e = roughness = 7×10^{-5} ft

d = 0.32 ft

$e/d = \frac{7\times10^{-5}}{3.2\times10^{-1}} = 2.2\times10^{-4} = 0.000202$

entering Moody's Diagram for $R_e = 20,400$ and $e/d = 0.0002$ $f = 0.025$

$$\left(1 + f\frac{L}{d}\right)\frac{v^2}{2g} = \left(1 + \frac{0.025\,(140)}{0.32}\right)\frac{(0.77)^2}{2(32.2)} =$$

g = gravity constant 32.2 ft/sec²

$$= \frac{(1 + 10.8)(0.59)}{64.4} = 0.11 \text{ ft}$$

$$= \left(1 + \frac{0.028\,(140)}{0.324}\right)\frac{(0.765)^2}{64.4}$$

$$(1 + 12.2)\frac{0.585}{64.4} = 0.12 \text{ ft}$$

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Pipe Type:	DIPS
Pipe Diameter:	3
Pipe SDR:	SDR 11
Flow Rate:(GPM)	28.3
Pipe Length:(ft)	140

Pipe I. D.:(in)	3.21	
Wall Thickness:(in)	0.360	
Pressure Rating:	160	
Flow Velocity:(ft/sec)	1.12	$= (q^{0.408709}/d^2)$
Head loss: (ft/100 feet)	0.164	$= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$
System Pressure loss: (psi)	0.10	

Calculate Reset Print Form

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Pipe Type:	DIPS
Pipe Diameter:	4
Pipe SDR:	SDR 11
Flow Rate:(GPM)	28.3
Pipe Length:(ft)	140

ISCO INDUSTRIES

Pipe I. D.:(in)	3.89	
Wall Thickness:(in)	0.436	
Pressure Rating:	160	
Flow Velocity:(ft/sec)	0.76	$= (q^{0.408709}/d^2)$
Head loss: (ft/100 feet)	0.065	$= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$
System Pressure loss: (psi)	0.04	

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Pipe Type:	DIPS
Pipe Diameter:	6
Pipe SDR:	SDR 11
Flow Rate:(GPM)	28.3
Pipe Length:(ft)	140

Pipe I. D.:(in)	5.60	
Wall Thickness:(in)	0.627	
Pressure Rating:	160	
Flow Velocity:(ft/sec)	0.37	$= (q^{0.408709}/d^2)$
Head loss: (ft/100 feet)	0.011	$= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$
System Pressure loss: (psi)	0.01	

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ISCO INDUSTRIES

Pipe Type:	DIPS
Pipe Diameter:	8
Pipe SDR:	SDR 11
Flow Rate:(GPM)	28.3
Pipe Length:(ft)	140

Pipe I. D.:(in)	7.34	
Wall Thickness:(in)	0.823	
Pressure Rating:	160	
Flow Velocity:(ft/sec)	0.21	$= (q^{0.408709}/d^2)$
Head loss: (ft/100 feet)	0.003	$= .2083(100/C)^{1.852} x (q^{1.852}/d^{4.8655})$
System Pressure loss: (psi)	0.00	

Calculate | Reset | Print Form

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Ameren MO Labadie Energy Center
Computer Worksheet
Leachate Pumping to Holding Tank(s)

e, roughness= 0.00007 ft. — Technical literature from Chevron Petroleum Company

Flow pre acre 0.0009 cfs/acre — From HELP Model for Operational Condition, run OGE3R003

Gallon / acre / d	612.5	209.8
cfs/acre	0.000947743	0.000324631
Flow condition	peak	average
Sample	OGE3R003	OGE3R003

Tank on saddles 10,000
length 30
height 4

DIPS SDR 11

	3	4	6	8
Diameter in inches	3.21	3.89	5.6	7.34
Diameter in feet	0.27	0.32	0.47	0.611666667
Area in square feet	0.056	0.083	0.171	0.294

	Area for sump		Distances to tanks		Flow of leachate		
	Measured	Corrected	Total Distance	Incremental distance			
	Acres		feet		Flow/ sump , cfs	Total flow at sump,cfs	Total flow at sump,gpm
cell 1	31.4		.				
1	15.4	15.9	140	140	0.02	0.06	28.33
2	15	15.5	630	490	0.01	0.05	21.56
cell 2	35.2						
1	11.1	10.9	2300	1670	0.01	0.03	14.97
2	11.6	11.4	2800	500	0.01	0.02	10.32
3	13.1	12.9	3200	400	0.01	0.01	5.48
		35.2					
cell 3	57.1						
1	8.7	8.9	2850	2850	0.01	0.05	24.29
2	10.3	10.6	3350	500	0.01	0.05	20.49
3	10.3	10.6	3840	490	0.01	0.04	15.99
4	10.0	10.2	4330	490	0.01	0.03	11.48
5	10.2	10.4	4820	490	0.01	0.02	7.15
6	6.3	6.4	5310	490	0.01	0.01	2.72
		57.1					
cell 4	42.8						
1	8.8	8.4	1650	1650	0.01	0.04	18.20
2	9.7	9.3	2150	500	0.01	0.03	14.61
3	11.8	11.4	2660	510	0.01	0.02	10.64
4	14.2	13.7	3160	500	0.01	0.01	5.81

	3.21	3.89	5.6	7.34	Reynolds's Number 3.21	3.89	5.6	7.34
cell 1								
1	1.12	0.76	0.37	0.21	25,000	20,000	14,000	11,000
2	0.85	0.58	0.28	0.16	19,000	16,000	11,000	8,000
cell 2					-	-	-	-
1	0.59	0.40	0.20	0.11	13,000	11,000	7,000	6,000
2	0.41	0.28	0.13	0.08	9,000	7,000	5,000	4,000
3	0.22	0.15	0.07	0.04	5,000	4,000	3,000	2,000
cell 3								
1	0.96	0.66	0.32	0.18	21,000	17,000	12,000	9,000
2	0.81	0.55	0.27	0.16	18,000	15,000	10,000	8,000
3	0.63	0.43	0.21	0.12	14,000	11,000	8,000	6,000
4	0.46	0.31	0.15	0.09	10,000	8,000	6,000	4,000
5	0.28	0.19	0.09	0.05	6,000	5,000	4,000	3,000
6	0.11	0.07	0.04	0.02	2,000	2,000	1,000	1,000
cell 4								
1	0.72	0.49	0.24	0.14	16,000	13,000	9,000	7,000
2	0.58	0.39	0.19	0.11	13,000	11,000	7,000	6,000
3	0.42	0.29	0.14	0.08	9,000	8,000	5,000	4,000
4	0.23	0.16	0.08	0.04	5,000	4,000	3,000	2,000

	e/D 3.21	3.89	5.6	7.34	Friction factor 3.21	3.89	5.6	7.34
cell 1								
1	0.000261682	0.000215938	0.00015	0.00011444	0.026	0.028	0.028	0.028
2	0.000261682	0.000215938	0.00015	0.00011444	0.027	0.031	0.032	0.033
cell 2								
1	0.000261682	0.000215938	0.00015	0.00011444	0.029	0.033	0.034	0.035
2	0.000261682	0.000215938	0.00015	0.00011444	0.032	0.038	0.037	0.037
3	0.000261682	0.000215938	0.00015	0.00011444	0.036	0.042	0.042	0.042
cell 3								
1	0.000261682	0.000215938	0.00015	0.00011444	0.027	0.029	0.03	0.032
2	0.000261682	0.000215938	0.00015	0.00011444	0.029	0.03	0.03	0.032
3	0.000261682	0.000215938	0.00015	0.00011444	0.03	0.032	0.032	0.038
4	0.000261682	0.000215938	0.00015	0.00011444	0.032	0.034	0.038	0.04
5	0.000261682	0.000215938	0.00015	0.00011444	0.038	0.038	0.044	0.044
6	0.000261682	0.000215938	0.00015	0.00011444	0.05	0.05	0.065	0.065
cell 4								
1	0.000261682	0.000215938	0.00015	0.00011444	0.028	0.028	0.032	0.034
2	0.000261682	0.000215938	0.00015	0.00011444	0.031	0.031	0.032	0.035
3	0.000261682	0.000215938	0.00015	0.00011444	0.032	0.034	0.035	0.04
4	0.000261682	0.000215938	0.00015	0.00011444	0.038	0.04	0.065	0.065

	Incremental head loss for velocity and friction 3.21	3.89	5.6	7.34	Total head including elevation head with diameter of tank and 1 foot for tank saddle 3.21	3.89	5.6	7.34	Horsepower 3.21 (3)	3.89 (4)	5.6 (6)	7.34 (8)
cell 1												
1	0.29	0.12	0.02	0.01	27.05	25.89	25.15	25.04	0.19	0.19	0.18	0.18
2	0.57	0.25	0.04	0.01	26.77	25.78	25.13	25.03				
cell 2												
1	1.00	0.43	0.07	0.02	26.19	25.52	25.09	25.02				
2	0.16	0.07	0.01	0.00	25.20	25.09	25.01	25.00				
3	0.04	0.02	0.00	0.00	25.04	25.02	25.00	25.00				
cell 3												
1	4.16	1.71	0.29	0.08	30.37	27.19	25.37	25.10	0.19	0.17	0.16	0.15
2	0.57	0.22	0.04	0.01	26.21	25.49	25.08	25.02				
3	0.35	0.14	0.02	0.01	25.65	25.26	25.05	25.01				
4	0.19	0.08	0.01	0.00	25.30	25.12	25.02	25.01				
5	0.09	0.03	0.01	0.00	25.10	25.04	25.01	25.00				
6	0.02	0.01	0.00	0.00	25.02	25.01	25.00	25.00				
cell 4												
1	1.41	0.54	0.10	0.03	26.94	25.75	25.14	25.04	0.12	0.12	0.12	0.12
2	0.31	0.12	0.02	0.01	25.54	25.21	25.04	25.01				
3	0.17	0.07	0.01	0.00	25.23	25.09	25.02	25.01				
4	0.06	0.02	0.01	0.00	25.06	25.02	25.01	25.00				

CIVIL ENGINEERING HANDBOOK

LEONARD CHURCH URQUHART, C.E., Editor-in-Chief

Consulting Engineer, Porter, Urquhart, McCreary & O'Brien
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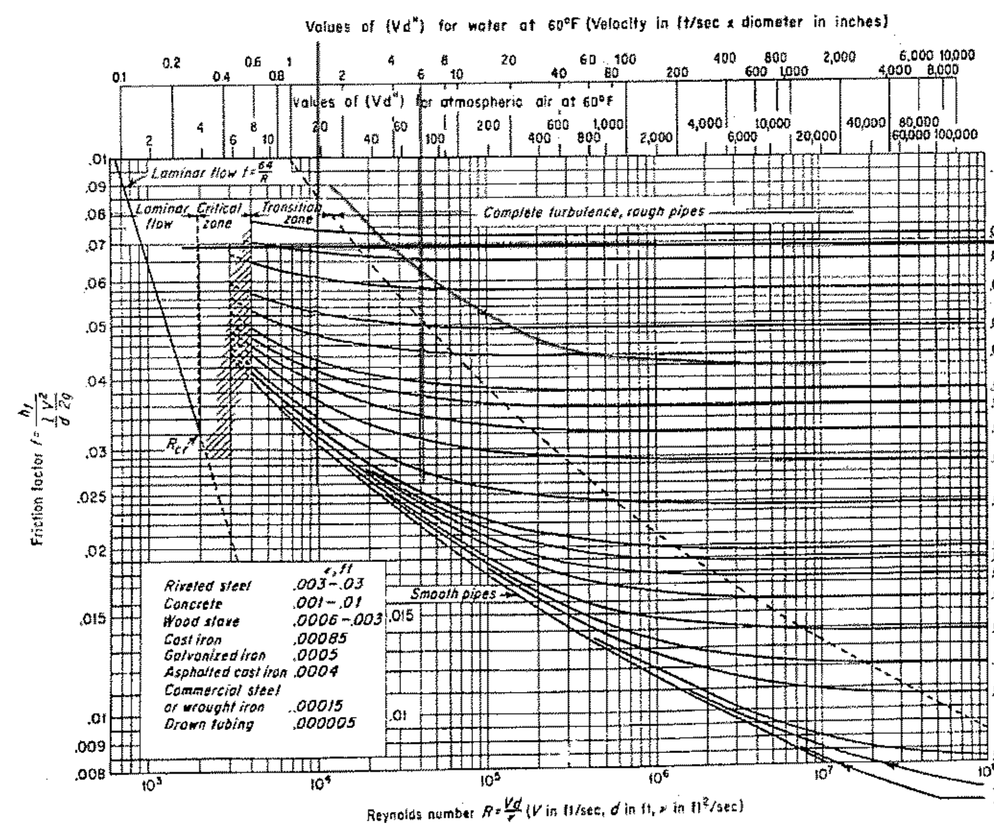

FIG. 61. Pipe friction coefficients.

Moody's chart. It is taken from the reference below.
ed to find friction factors for water in long pipes.

Appendix Y(b)

Estimated Maximum Settlements
Leachate Collection Pipe Profile

Ameren Missouri Labadie Energy Center
Utility Waste Landfill
Franklin County, MO
January 2013

Estimated Maximum Settlements for Leachate Collection Pipe Profile Appendix Y(b)

A graphical analysis of the effect of long-term settlement due to the weight of utility waste on the leachate collection pipe is shown on the following page and detail number 1 on sheet 18 of the drawings. Analysis indicated that long-term settlement would cause a negative pipe slope within the approximately 180 feet of pipe length upstream of the leachate collection sump. The negative slope occurs because the maximum long-term settlement is estimated to be approximately 2.2 feet on the interior of the landfill, while it is estimated to be approximately 0.8 feet at the leachate collection sump. If the pipe were installed with a 0.5% slope running all the way to the sump, future settlement could reduce the final pipe slope to about -0.2%.

To mitigate this risk, it is proposed to slightly steepen the design slope of the leachate collection trenches from the head of the collection pipe to the sumps in order to provide a minimum post-construction, post-settlement pipe grade of 0.5%. The proposed design trench bottom grades are elevation 465.0 at the sump low point and elevation 467.0 at an inflection point 200 feet upstream from the sump low point. Laying out the trenches and sumps for excavation to these fixed elevations will provide a maximum installed leachate collection line slope of 0.6% from the head of the line to the inflection point, and a slope of 1.0% from the inflection point to the sumps.

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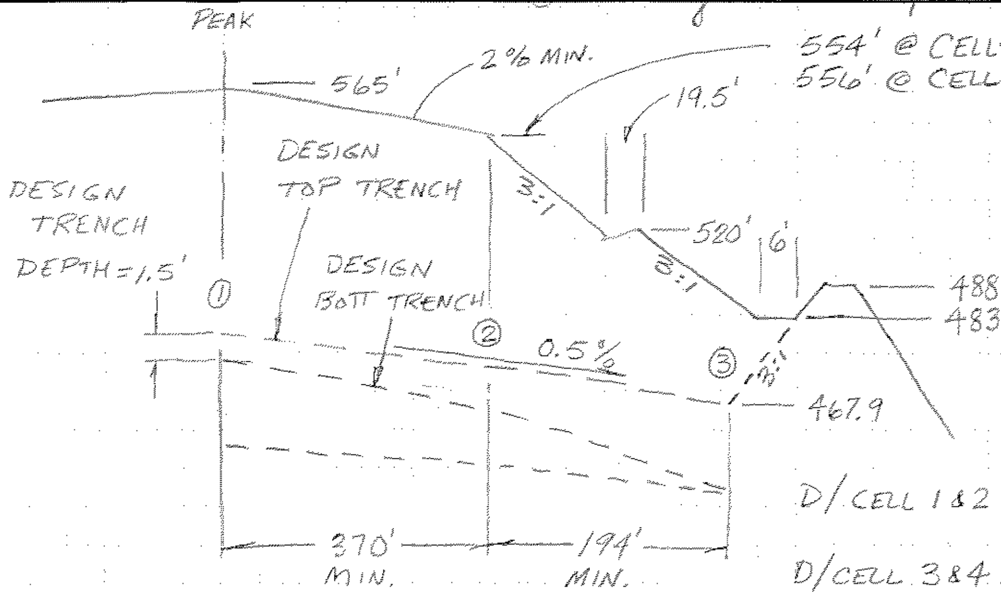
Date: 11/15/12		Page No: 1 of 1
		Client: Reitz & Jens
Prepared By: BD	Checked By:	Project: Labadie UWL

Subject: Leachate Trench Grading to Compensate UWL Settlement



See Appendix J for Settlement Estimates

D/CELL 1 & 2: (554 - 483) 3 + 19.5 + 6 - (483 - 46.8) 3 = 193.5'

D/CELL 3 & 4: (556 - 483) 3 + 19.5 + 6 - (483 - 468) 3 = 199.5'

LOCATION →	①		②		③	
TOP TRENCH PRE-S EL.	470.72		468.87		467.90	
BOTT TRENCH PRE-S EL.	469.22		467.37		466.40	(BASED ON 0.5% INITIAL SLOPE ON BOTT TRENCH)
MAX. EST. S	2.17		2.17		1.42	
MIN. EST. S	1.67		1.50		0.83	
BOTT TRENCH MAX. POST-S EL.*	467.55		465.87		465.57	* w/o DESIGN GRADE COMPENSATION
SLOPE, %		0.45		0.15 ← UNACCEPTABLE		
BOTT TRENCH MIN. POST-S EL.*	467.05		465.20		464.98	* w/o DESIGN GRADE COMPENSATION
SLOPE, %		0.50		0.11 ← UNACCEPTABLE		
MAX ΔS PER X-SECTS		0.42'		0.83'		

PROP. BOTT TRENCH PER MAX ΔS	469.22		466.95		465.04
		0.61%		0.96%	

THEOR. POST-S EL. PER MAX ΔS	467.05		465.20		464.21
		0.50%		0.50%	

FOR DETAIL 1/18:
SET DESIGN BOTT TR @ ② = 467.0'
" " " " @ ③ = 465.0'
REPORT SLOPE ① → ② @ 0.6% (design)
REPORT SLOPE ② → ③ @ 1.0%

Appendix Y(c)

Water Management Calculations

Ameren Missouri Labadie Energy Center
Utility Waste Landfill
Franklin County, MO
January 2013

Appendix Y(c)
Water Management Calculations

Leachate and stormwater are planned to be managed on site. The following calculations describe the capacity needed for water storage and pumping.

1. Leachate Flow

Cell 1 HELP Model results for leachate flow:

- Operational condition is worst case (Appendix O, Sub Appendix O -11).
- For the Operational condition for Cell 1:
    - Geocomposite drainage layer on the bottom and side slope:
        - Peak Daily Volume is: 13.4 gpm or 19,296 gpd.
        - Average Annual Volume is: 321,394 cu. ft./yr or 2,404,000 gallons per year.
    - Aggregate material drainage layer on the bottom and a geocomposite layer on the side slope:
        - Peak daily leachate flow is: 11.7 gpm or 16,848 gpd.
        - Average Annual Volume is: 320,708 cu. ft./yr or 2,399,000 gallons per year.

For Cell 3 at 57.1 acres; estimate the leachate volumes by pro-rating maximum peak daily flows using the ratio of the size of Cell 3 (57.1 acres) to Cell 1 (31.4 acres) or 1.819 (rounded).

- Peak daily leachate flow is: 21.3 gpm or 30,672 gpd.
- Average Annual Volume is: 584,616 cu. ft./yr or 4,367,000 gallons per year.

2. Stormwater Flow

Cell 1 HELP Model results for stormwater flow:

- Peak daily stormwater runoff is: 1,683,913 gpd

Estimating the maximum daily stormwater runoff using the ratio of Cell 3 to Cell 1:

- Peak daily stormwater runoff is: 3,063,000 gpd.

3. Estimate the Volume of Onsite Reuse of Leachate and/or Stormwater Runoff

Onsite water (leachate or stormwater runoff) usage:

- Reuse for CCP Moisture Conditioning Estimate:
  - The daily CCP generation rate for the first five years: 2,300,000 CY. The ratio of fly ash to bottom ash is 70% to 30%.
  - Therefore, the annual volume of fly ash generation is:
  - (2,300,000 CY / 5) x 0.70 = 322,000 CY/ year:
  - At 22% moisture by volume for conditioning, the water usage is 70,840 CY per year or 1,912,680 cubic feet (cf) or 14,306,846 gallons per year for CCP moisture conditioning.
  - This equates to an average daily water demand of 39,200 gpd, or an average flow rate of 27 gpm.

- Usage for Dust Control on Haul Roads:
  - Onsite water usage for dust control on onsite haul roads:
  - Assume an application rate of 0.25 inches (depth) per hour applied 6 hours per day or 1.5 inches per day.
  - Assume a road width of 12 feet and a ¼ mile of onsite haul road.
  - Volume is 12' x 1320' x0.25"/hr x 6 hr/day/(12"/1') = 1,980 cf per day
  - Volume is 1,980 cf/day x 7.48 gallons/cf = 14,810 gpd for dust control
  - Volume is 14,810 gpd x 5 days/wk x 52 weeks/yr = 3,850,600 gallons per year for dust control.
  - This equates to an average daily water demand of 10,550 gpd, or an average flow rate of 7.3 gpm.

Estimated Total Volume of Potential Onsite Reuse: 18,157,446 gallons per year or approximately 34.3 gpm.

4. Leachate Storage

The estimated required onsite leachate tank storage volume is calculated for the average annual volume from the HELP model results:

- Cell 1 Initial = 4.2 gpm x 1440 = 6,048 gpd = 2,207,520 gallons per year
- Cell 3 Initial = 6,048 x 57 ac/31 ac = 10,998 gpd = 4,014,312 gallons per year
- Cell 1 Operational = 4.6 gpm x 1440 = 6,624 gpd = 2,417,760 gallons per year
- Cell 3 Operational = 6,624 x 57 ac/ 31 ac = 12,180 gpd = 4,445,559 gallons per year

Therefore, a 10,000 gallon onsite storage tank will provide for an average of 0.8 days storage of the average annual leachate flow for Cell 3. One (1), 10,000 gallon horizontal tank would be 12 feet in diameter by 30 feet long. One or more tanks can be utilized based on the actual leachate flow and the demand for onsite reuse.

Backup leachate management will be at an off site POTW.

Backup stormwater management will be through the Labadie Energy Center's plant stormwater management system, which will be dependent on current NPDES operating permit requirements.

Appendix Y(d)

Flood Mitigation
Calculations

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Franklin County, Missouri
January 2013, Revised August 2013

Appendix Y(d)
Flood Mitigation Calculations

Pumping Rates for Flood Water Protection – Cell 3

Known:

Average Area of Cell 3 between floor and 480 ft. elev. = 49 ac

Average Bottom Elevation of Cell 3 from CADD surface = 471.2 ft

100-year Flood Elevation = 484 ft

Depth of water is estimated using the method described in Figure 7 of Appendix J. The density of water is substituted for the density of CCP to estimate the water fill depth need to protect against uplift during a flood. The inside toe of the slopes where the gravel drainage layer terminates is considered the critical location in the liner system that is most sensitive to hydrostatic uplift. The end-of-construction ballast against uplift at this location is equal to 2-feet of clay liner and 1-foot of protective cover. With estimated densities of 115 pounds per cubic foot (pcf) and 125 pcf, respectively, the ballast of 355 pounds per square foot (psf) at this location is the lowest at any point on the liner. Required elevations are determined by adding “H” values plus liner and cover thickness to elevation 466 feet.

$$H_{\text{Inside Cell}} = (H_{\text{Outside Cell}} \text{ x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 62.4 \text{ pcf}$$

$$H_{\text{Outside Cell}} = 484 \text{ ft} – 466 \text{ ft (lowest bottom of liner elevation)} = 18 \text{ ft}$$

$$H_{\text{Inside Cell}} = (18 \text{ ft x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 62.4 \text{ pcf} = 14.1 \text{ ft (elev. } 483.1 \text{ ft)}$$

49 ac x 43,560 sf/ac x (483.1 - 471.2 ft) = 25,399,836 cf

25,399,836 cf x 7.48 gal/cf = 189,990,773 gal

Assume pumping will occur for 10 days, 24 hours per day:

10 days x 1,440 min/day = 14,400 min

Pumping rate = 189,990,773 gal / 14,400 min = 13,194 gpm

A pumping rate of 13,194 gpm, pumping 24 hours per day, is required to fill Cell 3 in 10 days for 100-year flood protection. High capacity pumps and power equipment necessary for pumping are readily available from equipment dealers and contractors within the St. Louis metropolitan area in the event of a major flood.

Fill Volume for Flood Mitigation

For each cell of the UWL, when there is an impending flood event that creates floodwater levels that exceed the minimum elevation of CCPs inside the active cell, CCPs will be placed at an accelerated rate in the active cell until it reaches an elevation sufficient to counterbalance uplift pressure during a flood. Again using the method described in Figure 7 of Appendix J, the minimum elevation of CCP's is determined as follows:

$$H_{CCP} = (H_{Outside\ Cell} \text{ x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 93.0 \text{ pcf}$$

$$H_{Outside\ Cell} = 484 \text{ ft} – 466 \text{ ft (lowest bottom of liner elevation)} = 18 \text{ ft}$$

$$H_{CCP} = (18 \text{ ft x } 62.4 \text{ pcf x } 1.1 – 355 \text{ psf}) / 93.0 \text{ pcf} = 9.5 \text{ ft (elev. 478.5 ft)}$$

A fill elevation of 478.5 feet provides sufficient ballast to resist the uplift pressure on the clay liner created by 100-year flood elevation of 484 feet, with a factor-of-safety of 1.1.

Fill volumes for each cell are estimated in the attached Table. Cell 3 has the largest estimated fill volume of 578,000 CY at elevation 478.5 ft. At a rate of 10,000 CY/day, it would take 58 days to fill to elevation 478.5 ft.

Flood Mitigation Culvert Design for Stormwater Ponds

The maximum anticipated rate of floodwater rise is estimated at 5-feet in 24-hours at the proposed site. To mitigate this flood risk, it is proposed to install pipe culverts with the capacity to intake water at a rate that will raise the pond levels at least 5-feet in 24 hours while limiting excess uplift head on the liner to less than 3-feet. The proposed pipe culverts were modeled with their flowline at elevation 472 feet, and a maximum headwater at the inlet of 2-feet.

The maximum volume in any 5-foot elevation interval in the stormwater ponds occurs in Pond 2. From elevation 478 feet to 483 feet, the volume is 19.8 acre-feet (see Table N-8, Appendix N). Based on a water elevation rise of 5 feet per day, the required inflow rate through a culvert in cubic feet per second (cfs) is:

$$(19.8 \text{ acre-feet/day})*(43{,}560 \text{ ft}^2\text{/acre})*(1 \text{ day/24 hours})*(1 \text{ hour/3600 sec}) = 10.0 \text{ cfs}$$

Based on the assumption of 2 feet of headwater on the pipe inlet at all times and an inflow discharge value of 10.0 cfs, the proposed diameter for a HDPE pipe culvert is 24 inches. Based on a pond berm design with a 12-foot top width at 488 elevation, 3:1 side slopes, and a culvert pipe at 472 elevation, the culvert pipe will be approximately 110 feet in length. A "duckbill" elastomeric valve is proposed to be installed on the culvert outlet to prevent backflow and subsequent loss of water. Additionally, a mechanical check valve is proposed to be installed in the pipe to control flow into the stormwater pond and to provide redundant backflow protection.

Solution of culvert design is by determination of flow under given headwater and tailwater conditions. The two critical conditions of flow through the proposed culvert are full pipe flow and partial pipe flow. These two conditions can be analyzed by their controlling element; inlet and/or outlet control.

Full pipe flow is a critical condition with submerged inlet and free fall outlet. This condition can be defined through a capacity equation given by:

$$q = a\sqrt{2gH} / \sqrt{1 + Ke + Kdv + KcL}$$

Where:

q=flow capacity (cfs)
a=conduit cross-sectional area (ft^2)
H=head causing flow (ft.) = 2' – 0.6*pipe diameter = 0.8'
Ke=entrance loss coefficient
Kc=friction loss coefficient from pipe
Kdv= duckbill valve friction loss coefficient
L=length of conduit (ft.)
g=acceleration due to gravity (32 ft/s^2)

$$q= \pi (1)^2 * \sqrt{2*32*.8})/\sqrt{1+.78+1.0+(0.0165*110})$$

q=10.50 cfs

Friction loss due to the mechanical check valve does exist, however the loss values are negligible. Under the conditions of full pipe flow, a 24-inch diameter design culvert is acceptable since the pipe discharge, q (10.5 cfs) is greater than the calculated minimum pond inflow requirement of 10.0 cfs.

Under submerged inlet and submerged outlet conditions, H=2 ft. and the outlet flow capacity using the above equation is 16.6 cfs, which exceeds the 10 cfs minimum pond inflow requirement.

The second critical flow condition is orifice controlled partial flow. This condition is illustrated by a submerged inlet and a free fall outlet. This condition can be defined by a capacity equation given as:

$$q=aC\sqrt{2gh}$$

Where:

q=flow capacity (cfs)
a=conduit cross-sectional area (ft^2)
C=coefficient for a sharp-edged orifice (0.6)
g=acceleration due to gravity (32 ft/s^2)
h= head to the center of the orifice (ft.)

$$q= \pi (1)^2 * 0.6 * \sqrt{2*32*1}$$

q=15.1 cfs

Under the conditions of orifice controlled partial flow, a 24-inch diameter culvert is acceptable since $q_{outflow}$ (15.1 cfs) is greater than the required q_{inflow} (10.0 cfs). The value of h=1 foot is the minimum value for a 24" culvert under the specified condition. As h increases, the outflow capacity increases, which continues to satisfy the condition of outflow capacity > inflow capacity.

Ameren Missouri Labadie Energy Center
Proposed Utility Waste Landfill
Flood Elevation vs. Fill Volumes

Appendix Y(d)
January 2013

Cell	100-yr Flood Elevation (ft)	Required CCP Elevation (ft)	Mean EL. Cell Floor	Floor Area (acres)	Area at 480 EL. (acres)	Volume to Fill Cell (cy)	Time to Fill with Varying Daily Disposal Rates (days)				
							1,000 CY/day	2,000 CY/day	4,000 CY/day	8,000 CY/day	10,000 CY/day
1	484	478.5	471.1	24.9	27.0	311,000	311	156	78	39	32
2	484	478.5	471.5	31.2	33.8	368,000	368	184	92	46	37
3	484	478.5	471.2	46.9	51.3	578,000	578	289	145	73	58
4	484	478.5	471.5	37.7	40.8	444,000	444	222	111	56	45

Notes
Volumes are estimates only, based on:
- Areas from permit drawings.
- The mean cell floor elevations were determined from CADD surfaces.
- Cell fill volumes were estimated using the average-end-area method.
- For the purposes of this table, it was estimated that the minimum CCP elevation to prevent hydrostatic uplift of the liner is 478.5 ft.
- For the purposes of this table, the cell areas at 478.5 ft and 480 ft are considered equivalent.

Appendix Y(e)

Geosynthetic Design Calculations

Ameren Missouri Labadie Power Plant
Utility Waste Landfill
Franklin County, Missouri
January 2013

Appendix Y(e)
Geosynthetics Design Calculations

The following anchor trench and slope stability design is based on three-foot horizontal to one-foot vertical slope utilizing a 60-mil HDPE textured geomembrane, a 250-mil Geocomposite with double sided 6 ounce per square yard non-woven needlepunched geotextile, and a 40-mil geomembrane. The calculations were performed through use of the equations provided in the book "Designing with Geosynthetics". Three conditions were analyzed: bottom liner slope stability, anchor trench design for the utility waste landfill's bottom liner and internal tensile stress within the bottom liner side slope layers.

Reference:

1. Koerner, R.M., Designing with Geosynthetics, 5th Edition, Prentice Hall, Upper Saddle River, New Jersey, 2005
2. Koerner, R.M., Designing with Geosynthetics, 2nd Edition, Prentice Hall, Upper Saddle River, New Jersey, 1990
3. Coduto, D.P., Geotechnical Engineering Principles and Practices, Prentice Hall, Upper Saddle River, New Jersey, 1999
4. Held, R.J., Soil Survery of Franklin County, Missouri, United States Department of Agriculture: Soil Conservation Service, 1989
5. *GSE HD Smooth Geomembrane*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 5MAR2012.
6. *GSE HD Textured Geomembrane*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 09APR2012.
7. *GSE FabriNet HF Geocomposite*; Product Data Sheet; GSE Lining Technology, LLC: Houston, TX, REV 01MAY2012.

Prepared by:
GREDELL Engineering Resources, Inc.

January 2013

Appendix Y(e) Notes

Slope Stability of Liner, Anchor Trench Pullout, and Liner Layer Stress Calculation

Calculations Required:

1. Failure due to sliding of leachate collection protective cover.
2. Failure due to anchor trench pullout of geomembrane and geocomposite.
3. Failure due to tensile stress in liner layers.

1. Side Slope Cover Material Stability on 3(H):1(V) Slope

From Koerner (5th Edition) the stability of the system is achieved if all interface friction angles (δ) are greater than the slope angle (β). The Factor of Safety (F.S.) will be determined by the use of Equation 5.22 (pg. 492, 5th Ed.) where δ is the lowest numerical interface friction angle. Interface friction angles are taken from Table 5.6, Koerner, 2nd Edition, and Table 5.7, Koerner, 5th Edition.

$\beta = \tan^{-1}(\frac{1}{3}) = 18.43^\circ$

$F.S. = \frac{\tan\delta}{\tan\beta}$

$\delta_{clay\text{-}geomembrane} = 26^\circ > 18.43^\circ$

$\delta_{geomembrane\text{-}geotextile} = 32^\circ > 18.43^\circ$

$\delta_{geotextile\text{-}protectivecover} = 30^\circ > 18.43^\circ$

$F.S. = \frac{\tan 26^\circ}{\tan 18.43^\circ} = 1.5$

The slope is stable with a F.S. of 1.5.

2. Anchor Trench Depth and Runout Calculations

Check design detail to determine if proposed runout and anchor trench depth provides adequate F.S.

Koerner gives detailed equations for calculating required depth and runout on pgs. 500-506 (5th Ed.). Rearranging Eq. 5.26, one can solve for runout length (L_{RO}), anchor trench depth (d_{AT}), or allowable stress (T_{allow}). The allowable stress was solved for and input to a spreadsheet to expedite calculations. The equation was used as follows:

$$T_{allow} = \frac{d^{AT}[0.5 * \gamma_{AT}(K_P - K_A)] + d_{AT}[\sigma(K_P - K_A)] + L_{RO}[\sigma_n(\tan\delta_u + \tan\delta_L)]}{[\cos\beta - \sin\beta\tan\delta_L]}$$

Attached to these calculations are printouts of the inputs and results for this calculation.

In order to determine certain friction angles some assumptions were made about the material to be used for berm construction which affects the anchor trench soil as well as the cover soil on top of the liner runout. It was assumed that stock piled soil from the top 18 inches of onsite soil would be used.

Onsite soils are predominately Blake-Waldron Complex classification as determined using the cares website. USDA soil survey of Franklin County, Missouri (1989) defines Blake-Waldron as CL, CL-CH soil with plasticity indices ranging from 10-45 within the top 24", giving an average of approximately 26.0. For calculation purposes P_I was chosen to be 30.0. Using Fig. 13.17 from Coduto (pg. 489), this gives an effective friction angle of approximately 27°. This soil will also have a compacted unit weight of approximately 115 lb/ft^3.

The interface friction angle between the geomembrane and the material directly above and below it must be taken from published data until more site specific data are known. δ_L for the geomembrane-CCL inferface will be selected from Table 5.6 from Koener 2nd Edition. Detail 5/17 on Sheet 17 shows the geometry of the designed anchor trench and runout.

To determine if the liner or geocomposite will pullout of the anchor trench the calculated T_{allow} was compared to the T_{Design} obtained from the manufacturer's specifications. If $T_{allow} > T_{Design}$ the liner (or composite) will yield before anchor trench pullout occurs.

For 60 mil textured HDPE Geomembrane:

$$T_{Design} = 22 \text{ kN/m}$$
$$T_{allow} = 44.88 \text{ kN/m}$$
$$T_{allow} > T_{Design}, \text{ therefore no pullout}$$

$$\text{F.S.} = \frac{T_{allow}}{T_{Design}} = 2.0$$

For 250 mil Geocomposite with 6 oz/sq yd non-woven, needle-punched Geotextile:

$$T_{Design} = 9.60 \text{ kN/m}$$
$$T_{allow} = 49.31 \text{ kN/m}$$
$$T_{allow} > T_{Design}, \text{ therefore no pullout}$$

$$\text{F.S.} = \frac{T_{allow}}{T_{Design}} = 5.1$$

3. <u>Tensile Stress Calculations within Liner Layers</u>

$N = W\cos(\beta)$
$W = W_C - T_C$
$\beta = slopeangle = \tan^{-1}(1/3) = 18.43°$

$H_C = HeightofCover = 2.0'$

$L_S = LengthofSlope = 53.8'$

$\gamma_c = 130 pcf$

$\phi = 26°$

$W_C = H_c L_s \gamma_c$

Tc= $\sigma_H \tan\phi H_C = K_0 \sigma_U (\tan\phi) H_C$

Tc = (1-sin(26))(2')(130 pcf)(2')(tan(26))= 142 lb/ft
Wc = (2')(53.8')(130 pcf) = 14,000 lb/ft

W = 14,000 – 142 = 13,858 lb/ft
N = 13,858*cos(18.43) = 13,147 lb/ft

a.) Shear Forces in Geocomposite

$$F_{above} = N * \tan(\delta_u)$$

$$F_{below} = N * \tan(\delta_L)$$

$$F_a = (13{,}147)\tan 25 = 6130.5 lb/ft$$

$$F_b = (13{,}147)\tan 32 = 8215.2 lb/ft$$

Therefore Geocomposite is not in tension

b.) Shear Forces in Geomembrane

$$F_{above} = F_{belowfromcomposite} = 8215.2 lb/ft$$

$$F_{below} = N \tan\delta_u = (13{,}147)\tan 26 = 6412.2 lb/ft$$

$$F_{above} > F_{below}$$

Therefore the Geomembrane is in tension

$$\sigma_{n,\max} = (\gamma_{ccp})(H_{ccp}) = (134 pcf)(100') = 13{,}400 psf = 93.1 psi$$

$$\sigma_{all,membrane} = \frac{131 lb/in}{0.06 in} = 2138 psi$$

$$F.S. = \frac{\sigma_{all}}{\sigma_{\max}} = \frac{2183}{93.1} = 23.4$$

Therefore the geomembrane is acceptable.

THESE CALCULATIONS FOR THE GEOSYNTHETICS IN THE COVER ARE SUPPLEMENTAL TO THOSE FOR THE LINER. THEY APPLY THE SAME METHODS.

① SIDE SLOPE COVER MATERIAL STABILITY

THE PREVIOUSLY CALCULATED SLOPE ANGLE IS $18.43°$.

THE CCP IS ASSUMED TO BE SIMILAR TO SAND FOR THE PURPOSE OF ESTIMATING THE FRICTION ANGLE BETWEEN IT AND THE GEOMEMBRANE.

$$\delta_{GEOMEMBRANE-CCP} = 22° > 18.43°$$ (SAND FRICTION ANGLE ~ 30°)

$$F.S. = \frac{\tan 22°}{\tan 18.43°} = 1.2$$

$$\frac{\tan 30°}{\tan 18.43°} = 1.7$$

② ANCHOR TRENCH DEPTH AND RUNOUT

ANCHOR TRENCH AND RUNOUT CALCULATIONS WERE PREVIOUSLY CONDUCTED FOR 60-MIL HDPE. THE SAME METHODS WERE APPLIED TO THE 40-MIL GEOMEMBRANE [SEE ATTACHED PRINTOUT]

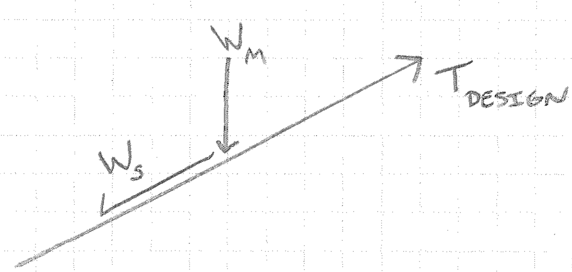
$$T_{ALLOW} = 24.72 \text{ kN/m}$$

$$T_{DESIGN} = 15 \text{ kN/m}$$

$$T_{ALLOW} > T_{DESIGN}$$

$$F.S. = \frac{24.72 \text{ kN/m}}{15 \text{ kN/m}} = 1.6$$

THE LENGTH OF THE GEOMEMBRANE MUST BE SHORT ENOUGH SO ITS WEIGHT DOES NOT PULL OUT OF THE TRENCH



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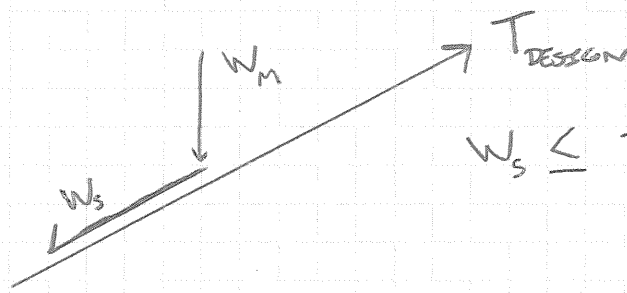
Date: JAN 2013		Page No: 2 of 2	
Client: REITZ AND JENS			
Prepared By: ML	Checked By: BD	Project: AMEREN MISSOURI LABADIE	
Subject: SLOPE STABILITY OF COVER, ANCHOR TRENCH PULLOUT & COVER STRESS			



$W_S \le T_{DESIGN}$

$W_S = W_M \sin 18.43^\circ$

$W_M = \gamma t L$

$\approx 59 \text{ pcf} (40 \text{ mil}) \left(\frac{1 \text{ ft}}{12{,}000 \text{ mil}} \right) = (0.2 \text{ psf}) L$

$W_S = (0.2 \text{ psf}) L (\sin 18.43^\circ) = (0.06 \text{ psf}) L$

$T_{DESIGN} = 15{,}000 \text{ N/m} \left(\frac{1 \text{ lb}}{4.448222 \text{ N}} \right) \left(\frac{0.3048 \text{ m}}{\text{ft}} \right)$

$T_{DESIGN} = 1028 \text{ lb/ft}$

$(0.06 \text{ psf}) L \le 1028 \text{ lb/ft}$

$\boxed{L \le 17{,}133 \text{ ft}}$

Ameren Missouri
Labadie Energy Center UWL
Anchor Trench & Runout Calculations for 40 mil Geomembrane

Design Data & Material Properties	
Allowable Stress in Geosynthetic (kPa), σ_{ALLOW}	14,763.8
Thickness of Geosynthetic (m), t_g	0.0010
Side Slope Ratio (V:H), 1:	3.00
Side Slope Angle (degrees), β	18.43
Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), δ_L	22.00
Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), δ_U	0.00
Unit Weight of Runout Cover Material (kN/m^3), γ_{CM}	18.07
Thickness of Runout Cover Material (m), t_{CM}	0.61
Applied Normal Stress from Cover Material (kPa), σ_n	11.02
Unit Weight of Soil in Anchor Trench (kN/m^3), γ_{AT}	18.07
Angle of Shearing Resistance of Fill Soil in Trench (degrees), Φ_A (Typically the same as Φ_P)	22.00
Angle of Shearing Resistance of Soil in Trench Wall (degrees), Φ_P (Typically the same as Φ_A)	22.00
Allowable Force in Geosynthetic (kN/m), T_{DESIGN}	15.00
Active Earth Pressure from Trench Fill, K_A	0.45
Passive Earth Pressure from Trench Wall, K_P	2.20

Calculate Length of Runout (L_{RO}) for Given Depth of Anchor Trench (d_{AT})	
Depth of Anchor Trench (m), d_{AT}	
Length of Geosynthetic Runout Required (m), L_{RO}	0.00

Calculate Depth of Anchor Trench (d_{AT}) for Given Length of Runout (L_{RO})	
Length of Geosynthetic Runout (m), L_{RO}	
Depth of Anchor Trench Required (m), d_{AT}	0.00

Calculate Allowable Force in Geosynthetic and Factor of Safety	
Length of Geosynthetic Runout (m), L_{RO}	0.61
Depth of Anchor Trench (m), d_{AT}	0.61
Allowable Force in Geosynthetic (kN/m), T_{ALLOW}	24.72
Factor of Safety, F.S.	1.6

Ameren Missouri
Labadie Energy Center UWL
Anchor Trench & Runout Calculations for 60 mil Geomembrane

Design Data & Material Properties	
Allowable Stress in Geosynthetic (kPa), σ_{ALLOW}	15,333.3
Thickness of Geosynthetic (m), t_g	0.0015
Side Slope Ratio (V:H), 1:	3.00
Side Slope Angle (degrees), β	18.43
Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), δ_L	26.00
Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), δ_U	0.00
Unit Weight of Runout Cover Material (kN/m^3), γ_{CM}	18.07
Thickness of Runout Cover Material (m), t_{CM}	0.91
Applied Normal Stress from Cover Material (kPa), σ_n	16.52
Unit Weight of Soil in Anchor Trench (kN/m^3), γ_{AT}	18.07
Angle of Shearing Resistance of Fill Soil in Trench (degrees), Φ_A (Typically the same as Φ_P)	27.00
Angle of Shearing Resistance of Soil in Trench Wall (degrees), Φ_P (Typically the same as Φ_A)	27.00
Allowable Force in Geosynthetic (kN/m), T_{DESIGN}	23.00
Active Earth Pressure from Trench Fill, K_A	0.38
Passive Earth Pressure from Trench Wall, K_P	2.66

Calculate Length of Runout (L_{RO}) for Given Depth of Anchor Trench (d_{AT})	
Depth of Anchor Trench (m), d_{AT}	
Length of Geosynthetic Runout Required (m), L_{RO}	0.00

Calculate Depth of Anchor Trench (d_{AT}) for Given Length of Runout (L_{RO})	
Length of Geosynthetic Runout (m), L_{RO}	
Depth of Anchor Trench Required (m), d_{AT}	0.00

Calculate Allowable Force in Geosynthetic and Factor of Safety	
Length of Geosynthetic Runout (m), L_{RO}	0.61
Depth of Anchor Trench (m), d_{AT}	0.61
Allowable Force in Geosynthetic (kN/m), T_{ALLOW}	44.88
Factor of Safety, F.S.	2.0

Ameren Missouri
Labadie Energy Center UWL
Anchor Trench & Runout Calculations for 250 mil Geocomposite

Design Data & Material Properties	
Allowable Stress in Geosynthetic (kPa), σ_{ALLOW}	1,523.8
Thickness of Geosynthetic (m), t_g	0.0063
Side Slope Ratio (V:H), 1:	3.00
Side Slope Angle (degrees), β	18.43
Angle of Shearing Resistance between Geosynthetic & adjacent material BELOW Geosynthetic (degrees), δ_L	32.00
Angle of Shearing Resistance between Geosynthetic & adjacent material ABOVE Geosynthetic (degrees), δ_U	0.00
Unit Weight of Runout Cover Material (kN/m^3), γ_{CM}	18.07
Thickness of Runout Cover Material (m), t_{CM}	0.91
Applied Normal Stress from Cover Material (kPa), σ_n	16.52
Unit Weight of Soil in Anchor Trench (kN/m^3), γ_{AT}	18.07
Angle of Shearing Resistance of Fill Soil in Trench (degrees), Φ_A (Typically the same as Φ_P)	27.00
Angle of Shearing Resistance of Soil in Trench Wall (degrees), Φ_P (Typically the same as Φ_A)	27.00
Allowable Force in Geosynthetic (kN/m), T_{DESIGN}	9.60
Active Earth Pressure from Trench Fill, K_A	0.38
Passive Earth Pressure from Trench Wall, K_P	2.66

Calculate Length of Runout (L_{RO}) for Given Depth of Anchor Trench (d_{AT})	
Depth of Anchor Trench (m), d_{AT}	
Length of Geosynthetic Runout Required (m), L_{RO}	0.00

Calculate Depth of Anchor Trench (d_{AT}) for Given Length of Runout (L_{RO})	
Length of Geosynthetic Runout (m), L_{RO}	
Depth of Anchor Trench Required (m), d_{AT}	0.00

Calculate Allowable Force in Geosynthetic and Factor of Safety	
Length of Geosynthetic Runout (m), L_{RO}	0.61
Depth of Anchor Trench (m), d_{AT}	0.61
Allowable Force in Geosynthetic (kN/m), T_{ALLOW}	49.31
Factor of Safety, F.S.	5.1

PRODUCT DATA SHEET

GSE HD Smooth Geomembrane

METRIC

GSE HD is a smooth high density polyethylene (HDPE) geomembrane manufactured with the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require excellent chemical resistance and endurance properties.

[*]

AT THE CORE:
An HDPE geomembrane used in applications that require excellent chemical resistance and endurance properties.

Product Specifications

These product specifications meet GRI GM 13

Tested Property	Test Method	Frequency	Minimum Average Value				
			0.75 mm	1.00 mm	1.50 mm	2.00 mm	2.50 mm
Thickness, (minimum average), mm Lowest individual reading	ASTM D 5199	every roll	0.750 0.675	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm^3	ASTM D 1505	90,000 kg	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, N/mm Strength at Yield, N/mm Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm G.L. 33 mm	9,000 kg	 20 11 700 12	 27 15 700 12	 40 22 700 12	 53 29 700 12	 67 37 700 12
Tear Resistance, N	ASTM D 1004	20,000 kg	93	125	187	249	311
Puncture Resistance, N	ASTM D 4833	20,000 kg	240	320	480	640	800
Carbon Black Content, % (Range)	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Notch Constant Tensile Load, hr	ASTM D 5397, Appendix	90,000 kg	300	300	300	300	300
Oxidative Induction Time, min	ASTM D 3895, 200°C; O_2, 1 atm	90,000 kg	>100	>100	>100	>100	>100
TYPICAL ROLL DIMENSIONS							
Roll Length(2), m			341	265	171	131	104
Roll Width(2), m			6.86	6.86	6.86	6.86	6.86
Roll Area, m^2			2,341	1,819	1,171	899	711

NOTES:
- (1)Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)Roll lengths and widths have a tolerance of ±1%.
- GSE HD Smooth is available in rolls weighing approximately 1,800 kg.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

GSE ENVIRONMENTAL™

PRODUCT DATA SHEET

GSE HD Textured Geomembrane

METRIC

GSE HD Textured is a co-extruded textured high density polyethylene (HDPE) geomembrane available on one or both sides. It is manufactured from the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require increased frictional resistance, excellent chemical resistance and endurance properties.

[*]

AT THE CORE:
An HDPE geomembrane used in applications that require increased frictional resistance, excellent chemical resistance and endurance properties.

Product Specifications

These product specifications meet GRI GM13

Tested Property	Test Method	Frequency	Minimum Average Value				
			0.75 mm	1.00 mm	1.50 mm	2.00 mm	2.50 mm
Thickness, (minimum average), mm Lowest individual reading	ASTM D 5994	every roll	0.750 0.675	1.00 0.90	1.50 1.35	2.00 1.80	2.50 2.25
Density, g/cm³ , (min.)	ASTM D 1505	90,000 kg	0.940	0.940	0.940	0.940	0.940
Tensile Properties (each direction) Strength at Break, N/mm Strength at Yield, N/mm Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 50 mm/min G.L. 50 mm G.L. 33 mm	9,000 kg	 8 11 100 12	 10 15 100 12	 16 22 100 12	 21 29 100 12	 26 37 100 12
Tear Resistance, N	ASTM D 1004	20,000 kg	93	125	187	249	311
Puncture Resistance, N	ASTM D 4833	20,000 kg	200	267	400	534	667
Carbon Black Content, % (Range)	ASTM D 1603*/4218	9,000 kg	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	20,000 kg	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Asperity Height, mm	ASTM D 7466	second roll	0.40	0.45	0.45	0.45	0.45
Notch Constant Tensile Load(2), hr	ASTM D 5397, Appendix	90,000 kg	300	300	300	300	300
Oxidative Induction Time, min	ASTM D 3895, 200°C; O_2, 1 atm	90,000 kg	>100	>100	>100	>100	>100
TYPICAL ROLL DIMENSIONS							
Roll Length(3), m	Double-Sided Textured Single-Sided Textured		253 308	213 238	158 165	122 125	101 101
Roll Width(3), m			6.86	6.86	6.86	6.86	6.86
Roll Area, m²	Double-Sided Textured Single-Sided Textured		1,736 2,113	1,461 1,633	1,084 1,132	837 858	693 693

NOTES:
- (1)Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)NCTL for GSE HD Textured is conducted on representative smooth geomembrane samples.
- (3)Roll lengths and widths have a tolerance of ±1%.
- GSE HD Textured is available in rolls weighing approximately 1,800 kg.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77° C when tested according to ASTM D 746.
- *Modified.

PRODUCT DATA SHEET

GSE FabriNet HF Geocomposite

METRIC

GSE FabriNet HF geocomposite consists of a 6.3 mm thick GSE HyperNet HF geonet heat-laminated on one or both sides with a GSE nonwoven needle-punched geotextile. The geotextile is available in mass per unit area range of 200 g/m² to 540 g/m². The geocomposite is designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions.

[*]

AT THE CORE:

A 6.3 mm thick GSE HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needle-punched geotextile.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value		
Geocomposite			200 g/m²	270 g/m²	335 g/m²
Transmissivity(2), m²/sec Double-Sided Composite Single-Sided Composite	ASTM D 4716	1/50,000 m²	5×10^{-4} 1.5×10^{-3}	5×10^{-4} 1.5×10^{-3}	3×10^{-4} 1×10^{-3}
Ply Adhesion, g/cm	ASTM D 7005	1/4,600 m²	178	178	178
Geonet Core(3) – GSE HyperNet HF					
Transmissivity(2), m²/sec	ASTM D 4716		3×10^{-3}	3×10^{-3}	3×10^{-3}
Density, g/cm³	ASTM D 1505	1/4,600 m²	0.94	0.94	0.94
Tensile Strength (MD), N/mm	ASTM D 5035/7179	1/4,600 m²	9.6	9.6	9.6
Carbon Black Content, %	ASTM D 1603(6)/4218	1/4,600 m²	2.0	2.0	2.0
Geotextile(3,4)					
Mass per Unit Area, g/m²	ASTM D 5261	1/8,300 m²	200	270	335
Grab Tensile, N	ASTM D 4632	1/8,300 m²	710	975	1,155
Puncture Strength, N	ASTM D 4833	1/8,300 m²	395	525	725
AOS, US sieve(1) (mm)	ASTM D 4751	1/50,000 m²	0.212	0.180	0.150
Permittivity, (sec⁻¹)	ASTM D 4491	1/50,000 m²	1.5	1.3	1.0
Flow Rate, lpm/m²	ASTM D 4491	1/50,000 m²	4,480	3,865	3,050
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70
NOMINAL ROLL DIMENSIONS					
Geonet Core Thickness, mm	ASTM D 5199	1/4,600 m²	6.3	6.3	6.3
Roll Width(5), m			4.5	4.5	4.5
Roll Length(5), m	Double-Sided Composite Single-Sided Composite		70.1 79.2	64.0 79.2	64.0 76.2
Roll Area, m²	Double-Sided Composite Single-Sided Composite		321 362	293 362	293 348

[Product specifications continued on back]

PRODUCT DATA SHEET

[*]

AT THE CORE:
A 250 mil thick HyperNet HF geonet heat-laminated on one or both sides with a nonwoven needlepunched geotextile.

Product Specifications [continued]

NOTES:

- [1]AOS in mm is a maximum average roll value.
- [2]Gradient of 0.1, normal load of 10,000 psf, water at 70˚F between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- [3]Component properties prior to lamination.
- [4]Refer to geotextile product data sheet for additional specifications.
- [5]Roll widths and lengths have a tolerance of \1%.
- [6]Modified.

Appendix Z

Groundwater Demonstration

REPORT
2008012455

AMEREN MISSOURI LABADIE ENERGY CENTER
UTILITY WASTE LANDFILL (UWL)
SOLID WASTE DISPOSAL AREA
FRANKLIN COUNTY, MISSOURI

APPENDIX Z
DEMONSTRATION: BASE OF UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

Prepared for

Ameren MISSOURI

Prepared by

REITZ & JENS, INC.
CONSULTING ENGINEERS

STATE OF MISSOURI
JEFFREY LYNN FOUSE
NUMBER E-21043
REGISTERED PROFESSIONAL ENGINEER

11/21/2012

November 2012

The Professional whose signature and personal seal appear hereon assumes responsibility only for what appears in the attached report and disclaims (pursuant to Section 327.411 RSMo) any responsibility for all other plans, estimates, specifications, reports, or other documents or instruments not sealed by the undersigned Professional relating to or intended to be used for any part or parts of the project to which this report refers.

APPENDIX Z
DEMONSTRATION: BASE OF UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

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DEMONSTRATION: BASE OF A UTILITY WASTE LANDFILL LINER IN INTERMITTENT CONTACT WITH GROUND WATER

1.0 INTRODUCTION

The Missouri Solid Waste Management Rules for utility waste disposal (reference Chapter 11, Utility Waste Landfill) were effective on July 30, 1997, in response to statutory changes to the Missouri Solid Waste Management Law. The statutory changes were intended to distinguish the physical and chemical characteristics of utility waste from the sanitary and demolition wastes that were the focus of the original solid waste management Rules (reference Chapter 3, Sanitary Landfill, and Chapter 4, Demolition Landfill), as well as to address other unique issues of the electric power generation industry. Chapter 11 is patterned after Chapter 3 and Chapter 4, which were originally created in 1973 in response to the new Missouri Solid Waste Management Law.

10 CSR 80-11.010(1) General Provisions, states the overall intent of the rule, stating in part:

> This rule is intended to provide for utility waste landfill operations that will have minimal impact on the environment. The rule sets forth requirements and the method of satisfactory compliance to ensure that the design, construction and operation of utility waste landfills will protect the public health, prevent nuisances and meet applicable environmental standards. *The requirement subsections contained in this rule delineate minimum levels of performance required of any utility waste landfill operation. The satisfactory compliance subsections are presented as the authorized methods by which the objectives of the requirements can be realized. The satisfactory compliance subsections are based on the practice of landfilling utility waste. If techniques other than those listed as satisfactory compliance in design or operation are used, it is the obligation of the utility waste landfill owner/operator to demonstrate to the department in advance that the techniques to be employed will satisfy the requirements.* Procedures for the techniques shall be submitted to the department in writing and approved by the department in writing prior to being employed. [*emphasis added*]

Ameren Missouri recognizes that, if they choose to "...utilize techniques other than those listed as satisfactory compliance in the design and operation..." of the utility waste landfill, they must "...demonstrate to the department in advance that the techniques to be employed will satisfy the requirements..."

The Missouri Department of Natural Resources' rules for utility waste landfills (UWL) stipulate in 10 CSR 80-11.010(4)(B)6 that:

> If the base of the landfill liner will be in contact with ground water, the applicant shall demonstrate to the department's satisfaction that the ground water will not adversely impact the liner.

In addition, 10 CSR 80-11.010(8)(B)1.C requires that the plans shall include:

> Ground water elevation and proposed separation between the lowest point of the lowest cell and the predicted maximum water table elevation;

The lowest point of the base of the clay liner for the cells will be at el. 466, which is 2 feet above the "natural water table" as defined in the following section. The bottom of the clay liner in the lowest sumps will probably be in intermittent contact with the ground water. In accordance with 10 CSR 80-11.010(1), this document has been prepared to demonstrate that the ground water intermittent contact will not adversely impact the compacted clay liner in the sumps, per 10 CSR 80-11.010(4)(B)6, based upon the interpretation that this regulation is applicable to the sumps because they are integral with the cells.

It is the objective of this report to provide the technical and regulatory basis for:

- demonstrating the impacts of an intermittent high ground water table on the composite bottom liner (specifically the bottom compacted clay liner and the HDPE membrane liner on top of the compacted clay liner) are negligible;
- evaluating the environmental impact of this site condition on the projected use of the UWL; and
- demonstrating that the characteristics of the compacted clay liner and the proper design of the UWL will continue to function as designed in compliance with the intent of the 10 CSR 80-11.010 to minimize environmental hazards and comply with applicable ground water and surface water quality standards and requirements throughout the life and post-closure of the UWL.

Section 2.0 of this report provides a summary discussion of the technical basis of the structural and hydraulic engineering properties of compacted clay liners (CCLs) and the potential impact to CCLs from intermittent contact with ground water in the protection of surface water and ground water quality. Section 3.0 provides an overview of the impact to the environmental protections provided to surface water and ground water by the utility waste landfill's CCL under intermittent contact with the unconfined ground water. Finally, Section 4.0 identifies the specific requirements of 10 CSR 80-11.010 that potentially require demonstration of satisfactory compliance with the requirements of the Utility Waste Landfill design and operational standards.

1.1 Brief Project Description

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Energy Center is situated, on the right descending (south) overbank area of the Missouri River between River Miles 56.88 and 57.38. The existing ground surface ranges from about el. 471 to el. 465[1] below the current footprint of the UWL. The areas of lower ground surface elevations (below about el. 464) located in the southeast region of the site have been excluded from the proposed developed area of the UWL.

The proposed UWL is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project[2] the ground water levels are strongly influenced by

[1] Elevations herein refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM). NAVD88 corrects many of the problems with the earlier NGVD of 1929.
[2] *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resources, Division of Geology and Land Survey on April 8, 2011.

the Missouri River (see Appendix W or page 39 of DSI Report). Because the Missouri River is an "open river," that is not controlled by a dam in the vicinity of the Labadie Energy Center, the level of the Missouri River and hence the natural water table at the site are constantly changing. Therefore, the Natural Water Table is never under static hydrologic conditions.

The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Energy Center itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of 483.98 at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be 487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6.

The Labadie UWL will be divided into four distinct internal drainage zones or cells. The lowest point of each drainage area is designed to be el. 468 (top of composite liner), while the highest point of each cell bottom will be el. 474 to 476 (top of composite liner). The majority of the UWL bottom is designed to have a minimum 1% slope and will have a "blanket drain" as a part of the leachate collection system. In addition to the blanket drain, each cell will have a 6-inch diameter collection pipe running generally perpendicular to the outside edge of the landfill at an approximate 0.5% slope.

Each collection pipe will discharge into a small leachate sump (approximate size 15 feet by 20 feet). The bottom of the composite clay liner in the sumps is designed to be at el. 463.0. With settlement, the bottom of the clay of the composite liner in the sumps is estimated to be at el. 462.2. The 15 sumps represent less than 0.15% of the entire UWL acreage. Additionally, the sumps will be gravel filled and are expected to have one to three feet of water in them under normal operating conditions.

2.0 TECHNICAL BASIS

In the 1980's through the mid-1990's, compacted clay liners and composite liners were the subject of significant research and technical discussion due to increasing regulatory requirements on industrial and municipal landfills. The base of knowledge regarding compacted clay liner was established on a national level and the technical requirements were widely adopted as 'state of the art' Missouri's current utility waste landfill requirements were adopted in the mid-1990's and closely follow the prevailing technical basis for compacted clay liners. The Labadie UWL utilizes a two-foot thick composite liner system (compacted clay liner overlain by a flexible membrane liner). An intermittent high ground water table will first come in contact with the bottom of the compacted clay liner in the sumps. Therefore, the focus of the technical discussion is on the lower compacted clay liner, not the upper flexible membrane liner.

2.1 Requirements of Compacted Clay Liner

The compacted clay liner must have the following characteristics (10 CSR 80-11.010(6)(B)):

1) For a composite liner, includes a lower component that consists of at least a 2-foot layer of compacted soil with a hydraulic conductivity (k) of no more than $1x10^{-5}$ cm/sec., and compacted to 95% of standard Proctor (ASTM D699) maximum dry unit weight ($\gamma_{d,max}$)

with the moisture content at the time of compaction between optimum moisture content (w_{opt}) and 4% above w_{opt}, or within other ranges of density and moisture such that are shown to provide for the liner to have a $k \leq 1x10^{-5}$ cm/sec.

2) The soils used for the compacted clay liner shall have the following minimum specifications:
   A. Be classified as low plastic clay (CL), high plastic clay (CH) or sandy clay (SC).
   B. Have more than 30% particle sizes by weight passing U.S. #200 sieve (0.075mm).
   C. Have an Atterberg liquid limit (LL) $\geq$ 20%
   D. Have an Atterberg plasticity index (PI) $\geq$ 10%.

Daniel and Koerner (1993) reported that the degree of saturation of clay liners placed with this criteria ranges from 71% to 98%, and averages 85%. That is, the voids in the soil matrix may still contain some air as well as water. The technical questions in regard to the clay liner are: 1) If the GWT is above the bottom liner for a long enough time, could the compacted clay liner become saturated; and 2) what are the potential ramifications of the compacted clay liner becoming saturated? Frank et al (2005) reported that a compacted clay liner which had been under 0.31m of water for 14 years did not become fully saturated. The report theorized that this is due to the very high capillary stresses in the matrix of the compacted clay which could not be overcome by high external hydrostatic pressure. Therefore, the internal shear strength and hydraulic properties of the compacted clay liner were not affected.

The proposed design of the cells for the Labadie UWL will use a clay liner with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec, which provides an additional factor of safety that the hydraulic conductivity will not exceed the required maximum even if changes to the clay liner should occur. This report will demonstrate that the initial permeability of the clay liner, even at the more stringent than required $1x10^{-7}$ cm/sec permeability, will not be impacted by intermittent contact with groundwater.

2.2 Definition of Natural Ground Water Table at Labadie UWL Site

This section was submitted to the Missouri Department of Natural Resources and Franklin County as a separate report titled "Design Basis for Ground Water Level," dated April 9, 2012, to present a rational definition of the "Natural Water Table" as it applies to this site, as a basis for the design of the Labadie UWL.

The daily average levels of the Missouri River at the Labadie Energy Center from December 3, 1999, through November 9, 2010, were used in the analyses of the hydrogeology of the site for the DSI because these are the only Missouri River readings close to the site. The 3973 readings are plotted in Figure 32 (attached) from the DSI Report. The graph of the data demonstrates the highly variable nature of the Missouri River level at the site. The highest level in the data is el. 475.4 which occurred on September 16, 2008. The lowest statistically significant level in the data with multiple occurrences is el. 445.3. Below is a table of the frequencies of the Missouri River levels in 2-foot intervals from these data:

Frequencies of Missouri River Levels at Labadie Energy Center (2000-2010)

Range	No.	%	% Greater
474-475.4	3	0.08%	
472-473	12	0.30%	0.38%
470-471	52	1.31%	1.69%
468-469	75	1.89%	3.57%
466-467	77	1.94%	5.51%
464-465	132	3.32%	8.83%
462-463	187	4.71%	13.54%
460-461	225	5.66%	19.20%
458-459	263	6.62%	25.82%
456-457	348	8.76%	34.58%
454-455	365	9.19%	43.77%
452-453	518	13.04%	56.81%
450-451	801	20.16%	76.97%
448-449	577	14.52%	91.49%
393-448	338	8.51%	100.00%

The ground water levels at the site were monitored monthly for the DSI from December 2009 through November 2010. These findings are summarized in Appendix W. The data show that the alluvial aquifer discharges toward the Missouri River during periods of relatively low flow, during which time the ground water levels below the site will be 1 to 3 feet above the Missouri River level. However, when the Missouri River is above approximate el. 461 for a sustained period, the ground water flow reverses and the ground water levels approach the level of the Missouri River near the river (in the northwest portion of the site) and about 5 feet or more below the river level over the majority of the site.

This is demonstrated in the graph of the average water table elevations versus the Missouri River elevation in Figure 1 of Appendix W. From June 5, 2010, through July 5, 2010, the Missouri River elevation at the plant was above el. 465.1, and reached a maximum of el. 471.3. During this period, the average ground water table below the site rose to el. 464, with the average ground water table approaching el. 465 in the northwest portion of the site. The level of the Missouri River at the plant also was above el. 465 between May 13 and May 30, 2010, with a maximum level of el. 472.8. During this shorter duration of sustained high river levels (18 days compared to 30 days in June and July), the average ground water table beneath the site rose from el. 462.0 to el. 463.0. It can be concluded from these data that the ground water table beneath the site will rise to about el. 464 when the Missouri River at the plant is above el. 465 for about 30 days and reaches a maximum level above el. 471 during that period. The question then becomes "How often do such sustained high Missouri River levels occur at the site?"

From the above table, the Missouri River was at or above el. 465 about 9% of the days from December 1999 through November 2010, and was at or above el. 470 about 1.7% of the days. There were 12 intervals in this decade during which the Missouri River at the plant was above el. 465 for more than 5 days and peaked above el. 470. However, the Missouri River level was above el. 465 for more than 13 days during only 5 of these 12 intervals:

Periods of Sustained High Missouri River Levels at Labadie Energy Center (2000-2010)

Period	No. Days	Maximum River Elev.
June 3 – July 8, 2008	36	471.6
June 5 – July 5, 2010	30	471.3
May 2 – May 20, 2002	19	473.2
May 13 – May 30, 2010	18	472.8
May 9 – May 21, 2007	13	471.9

As stated above, the data from the 12 months of ground water level monitoring at the site indicate that the maximum average ground water level of about el. 464 will occur when the sustained high Missouri River level at the Labadie Energy Center exceeds el. 465 for more than 18 days, and probably approaching 30 days, with a peak river level above el. 471. While the level of the Missouri River at the site has exceeded el. 470 about 1.7% of the 3973 days from December 1999 through November 2010, an interval of sustained high river levels adequate to create a high average ground water level of el. 464 has occurred only twice. **Therefore, defining el. 464 as the average "Natural Water Table" or ground water level at the site would appear to be conservative, in that it occurs for a relatively short duration only about two times in a 10-year period. This Natural Water Table elevation can also be considered the 'average high groundwater table' at the Labadie UWL site.**

2.3 Potential Technical Impacts of a High Ground Water Table

The potential impacts of a ground water table (GWT) that is above the bottom compacted clay liner are:

1. potential swelling of the compacted clay liner, particularly if the clay is high plastic (CH) as defined by ASTM D2487,
2. hydrostatic uplift against the bottom of the compacted clay liner,
3. potential loss of shear strength of the compacted clay liner,
4. potential decrease in the stability of exterior or interior slopes,
5. constructability of a compacted clay liner in a high ground water table, and
6. long-term performance of the composite liner system.

2.3.1 Potential Swelling

High plastic clay (i.e. "CH" with a LL above 50%) has a tendency to swell when the clay is at low moisture content. When relatively dry, expansive clay is exposed to free water, then the clay will swell if it is not confined by a large pressure. The weight of the CCP in the UWL (particularly in the sumps which are at the lowest elevations) confines the clay liner and therefore reduces this swell potential. Swelling would increase the void ratio of the clay and could result in a larger hydraulic conductivity. The clay for the liner will be imported to the site. Part of the laboratory testing to qualify the clay liner material will include grain size and Atterberg limits to determine the swell potential of the clay soils.

Composite samples of the clay liner material will be compacted in a qualified soil laboratory for hydraulic conductivity tests for the approval of the clay material. The first step in the hydraulic conductivity test is to saturate the sample at a low confining pressure (ASTM D5084). Thus, any swelling that may occur would do so in the test cell, and the hydraulic conductivity that is subsequently measured would already be affected by any swelling. Therefore, laboratory testing on the clay liner material will take into account any swell potential.

2.3.2 Hydrostatic Uplift

Water levels approaching the 100-year flood elevation around the UWL perimeter berms will create a hydrostatic uplift pressure on the base of the composite liner. Operational procedures to counteract this potential uplift concern are discussed in Section 3.3.2.2 and Appendix J of the Construction Permit Application. Dry cells will be filled with CCPs upon completion to counter any hydrostatic uplift that might occur.

2.3.3 Loss of Shear Strength

The shear strength of a soil has 2 components: the effective cohesion (c') and the effective internal friction angle (ø'). Unless there is some cementation in the soil matrix, the cohesive shear strength is actually very small at very low confining pressures (Terzaghi, Peck, Mesri, 1996). Saturation of a soil will reduce its shear strength, primarily due to the loss of negative pore pressures, and the impact of the increase in pore pressure during shearing. Therefore, ø' is the critical shear strength property. However, the area of a sump is very small compared to the extents of the perimeter berm, so the loss of shear strength of the clay liner in the sump, if it could occur, will have an insignificant impact on the stability of the exterior slopes of the UWL. Consolidated-undrained (C-U) triaxial compression tests with pore pressure measurements will be run on representative composite clay liner samples. The first step in the C-U test is to ensure that the sample is saturated (ASTM D4767). Thus, the impact of potential saturation is already incorporated in the measurement of ø'. Therefore, the possible impact of saturation of the compacted clay liner, if it could occur, is not an issue because the saturated properties used in the analyses for the UWL will be verified by the laboratory testing of the clay liner material before it is approved for construction.

2.3.4 Stability of Slopes

A ground water level that is at the ground surface results in the minimum factor of safety for the global stability of any slope because of the reduction in effective confining stress in the natural soils beneath and beyond the toe of the berm. The internal stability of the waste is not affected by the external ground water level because the waste is isolated from the ground water by the liner. Some of the cases of global stability of the waste slope and perimeter berm that were analyzed used measured long-term shear strength properties (c' and ø') and an assumed exterior water level at ground surface. So, the issue of high ground water levels, or flooding, has been considered in the stability analyses reported in the Construction Permit Application, including under seismic load and liquefaction potential.

2.3.5 Constructability of Clay Liner in a High Ground water Table

A high ground water table could interfere with the excavation to final subgrade of the bottom liner and with the compaction of the clay liner. If this condition occurs, the subgrade will be soft and will tend to pump and rut, making it difficult to properly compact the clay liner. Once the ground water level is about 2 or 3 feet below the subgrade, then it is possible to construct the bottom liner in accordance with the project specifications. So, a high ground-water could adversely affect the construction schedule and costs, which will be addressed at the time of construction. But the quality and performance of the properly constructed bottom liner will not be impacted for the reasons presented in the preceding sections.

2.3.6 Long-term Performance of Composite Liner System

The types of clays used in construction of the liner and the methods of construction will preclude potential negative impacts of infrequent high ground water levels on the long-term performance of the composite liner system. Also, the long-term properties which were used in the analyses for the UWL, and the various extreme conditions which were considered (i.e., flooding or earthquake) take into consideration extreme adverse conditions which may occur during the operating life and post closure performance. Only one potential impact of an intermittent, high GWT on the bottom liner in the sumps could not be mitigated by the design and construction of the UWL – the hydrostatic uplift pressure. Therefore, this impact will be addressed through operational requirements of the UWL.

3.0 ENVIRONMENTAL PROTECTION OF A UTILITY WASTE LANDFILL

As stated in 10 CSR 80-11.010 (1) General Provisions, "The rule sets forth requirements and the method of satisfactory compliance to ensure that the design, construction and operation of utility waste landfills will protect the public health, prevent nuisances and meet applicable environmental standards...". The individual subsections 10 CSR 80-11.010 imply that the Missouri Solid Waste Management Law and Rules, as they relate to utility waste, are promulgated primarily to prevent the construction and operation of solid waste disposal areas from negatively impacting the surface waters, ground water and air, in particular, typically monitored within a specific zone of impact surrounding the solid waste disposal area. The following sections discuss the environmental protections provided by the Labadie UWL design and operation. The focus of this section is on the protection of ground water quality and surface water quality, because the performance of the CCL does not have a direct impact on air quality.

3.1 Ground Water Quality Protection

Protection of ground water quality is a primary objective of regulatory design and operating requirements for utility waste disposal areas. Liners, leachate collection systems, and final cover systems all focus on: keeping the waste materials relatively dry; minimizing the quantity of leachate formed by the disposal area; containing the leachate within the disposal area; and collecting and removing the leachate from the disposal area for further treatment and ultimate disposal outside of the disposal area environment. With regard to ground water in intermittent contact with the utility waste landfill liner, the critical issues are: the continued structural integrity of the liner, both as the base of the landfill and as a component of the composite liner; and the hydraulic performance of the CCL component of the composite liner to serve its intended function of containing the leachate within the disposal area. The discussion of specific, potential technical impacts to the landfill design in Section 2.0 demonstrate that the structural integrity and the hydraulic performance of the CCL component are not impacted by ground water in intermittent contact with the utility waste landfill liner. Therefore, the CCL component's functions of providing a structural base for the landfill and of containing leachate within the disposal area are not diminished.

3.2 Surface Water Quality Protection

Regarding ground water in intermittent contact with the utility waste landfill liner, the continued structural integrity and hydraulic performance of the CCL component of the composite liner to serve its intended function of containing the leachate within the disposal area indirectly relates to the protection of surface water quality at the Labadie UWL. The design and construction of berms around the perimeter of each disposal cell to prevent inundation of the utility waste during future Missouri River flood events are the primary design protection of surface water quality at the Labadie UWL. The proposed operational plan to contain all stormwater runoff generated inside of the perimeter berms provides the primary operational protection of surface water quality. The design and operation of the primary stormwater management systems are not directly impacted by ground water in intermittent contact with the utility waste landfill liner.

4.0 DEMONSTRATION OF COMPLIANCE WITH 10 CSR 80-11.010

The 'dry tomb' landfill concept seeks to avoid permanent placement of waste below the natural ground water table, in part, to avoid a direct connection to ground water through a liner leak and to avoid the long-term infiltration of ground water into the landfill that would require additional post closure care in the form of increased leachate removal and disposal. The design of the Labadie UWL does not propose to permanently place waste below the ground water table. This statement is supported by the original Detailed Site Investigation for the UWL. In addition, the technical discussions in Section 2.0 of this report support Ameren Missouri's position that the intermittent contact of the CCL with ground water does not impact the ability of the CCL to satisfactorily meet the requirements of 10 CSR 80-11.010 (Chapter 11, Utility Waste Landfill). This results in Ameren Missouri proposing the use of techniques other than those listed in 10 CSR 80-11.010 as satisfactory compliance in the design and operation of the utility waste disposal area. As previously stated, this report provides a demonstration to the Missouri Department of Natural Resources Solid Waste Management Program that the site conditions at the Labadie UWL, coupled with the engineering design and operational details, are acceptable from both a technical and regulatory perspective.

The rule format for Chapter 11 generally includes one section for each specific topic, each followed by three subsections [(A) Requirement; (B) Satisfactory Compliance – Design; and (C) Satisfactory Compliance – Operations]. Section 4.1 identifies the design and/or operational methods proposed for the Labadie UWL that require demonstration that the overall requirements of Chapter 11, Utility Waste Landfill, are met for the site conditions and design of the Labadie UWL.

4.1 Design/Operational Considerations Relative to Unique Labadie UWL Site Conditions

The following sections of the Missouri Solid Waste Management Rules have been identified for specific summary discussion as a conclusion to the demonstration that the Labadie UWL meets the minimum requirements of the Missouri Solid Waste Management Rules. The design and/or operational issues identified are listed below, followed by the regulatory REQUIREMENT [emphasis added] as identified in the appropriate rule section or subsections and the specific design and/or operational methods specified by Chapter 11. Finally, reference is made to the specific technical issues provided in Section 2.0 that support the proposed deviation from the specified design and/or operational method. In review, the critical points of Section 2.0 are summarized below:

- Studies have shown that clay liners do not become saturated even when continuously submerged for years due to the very high internal capillary stresses. Therefore the internal properties of the clay liner are unlikely to be affected by intermittent contact with ground water;
- The compacted clay liner for the Labadie UWL is designed to have a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec, which provides an added safety factor that the maximum hydraulic conductivity of $1x10^{-5}$ cm/sec required by regulation will not be exceeded. Furthermore, the initial installed hydraulic conductivity of the CCL will not be impacted by intermittent contact with groundwater;
- The laboratory measurement of hydraulic conductivity of the clay liner allows for any potential swelling at low confining pressures;
- The remote threat of adverse hydrostatic uplift will be addressed through operational procedures of the UWL;
- The minimum internal and interface shear strength properties assumed for the compacted clay liner for the design of the UWL will be specified (see Appendix J) and verified for the offsite clay liner material; and
- The structural stability analyses of the perimeter berms and exterior slopes of the UWL considered the worst-case condition of a ground water table at the ground surface. Therefore, this condition is considered in the current design.

4.1.1 INTERMITTENT GROUND WATER CONTACT WITH LANDFILL LINER.

Regulatory Citation and Requirement:

10 CSR 80-11.010(4) Site Selection.
(A) Requirement. Site selection and utilization shall include a study and evaluation of geologic and hydrologic conditions and soils at the proposed utility waste landfill and an evaluation of the environmental effect upon the projected use of the completed utility waste landfill. Applications for utility waste landfill construction permits received on or after the effective date of this rule shall document compliance with all applicable siting restriction requirements contained in paragraphs (4)(B)1. through 5. of this rule.

Regulatory Design and/or Operational Techniques:

(B)6. If the base of the landfill liner will be in contact with ground water, the applicant shall demonstrate to the department's satisfaction that the ground water will not adversely impact the liner.

(B)7. Owners/operators of proposed utility waste landfills shall demonstrate how adverse geologic and hydrologic conditions may be altered or compensated for via surface water drainage diversion, underdrains, sumps, and other structural components. All alterations of the site shall be detailed in the plans. Precipitation, evapotranspiration and climatological conditions shall be considered in site selection and design.

(B)8. The results of the detailed site investigation report will be the basis to determine if a secondary liner, such as a geomembrane, or a leachate collection system is mandatory to ensure that there is no environmental impact from the landfill. Owner/operators of proposed utility waste landfills shall make a demonstration based on the following:

A. An evaluation of the physical and/or chemical characteristics of the waste; and

B. Documentation through modeling, testing, or other research data proving that the quality of ground water underlying the proposed site will not be affected and that there is no potential for migration of fluids from the utility waste landfill.

Discussion of Alternative Design:

This report provides specific discussion of technical information indirectly required by this regulation relative to the intermittent contact of the CCL component of the composite liner. As outlined in the details of Section 2.0, the design of the utility waste landfill for the Labadie Energy Center anticipates the potential for saturated clays and saturated insitu base conditions, as well as the potential impact of high ground water table conditions intermittently caused by fluctuating Missouri River levels. No additional design alternatives or changes are considered necessary, as supported by the information in the report.

Compliance with Regulatory Requirement:

The CPA for the Labadie UWL addresses the site selection and utilization requirements, including a study and evaluation of geologic and hydrologic conditions and soils at the proposed utility waste landfill and an evaluation of the environmental effect upon the projected use of the completed utility waste landfill. The technical discussion in Section 2.0 provides additional "demonstration" relative to the site-specific design with regard to the intermittent contact of the CCL component of the composite liner.

Based on the conclusions of this report, no additional design or operational changes are necessary to demonstrate that the geologic and hydrologic conditions referenced in 10 CSR 80-11.010(4), Site Selection, (specifically, the intermittent contact of small portions of the bottom of the landfill liner) are necessary to demonstrate that the quality of ground water underlying the proposed site will not be affected and that there is no increased potential for migration of fluids from the Labadie UWL. The liner and leachate collection requirements are further discussed in previous and subsequent portions of this report.

4.1.2. IMPACT OF DSI RESULTS ON LINER AND LEACHATE COLLECTION SYSTEM DESIGN.

Regulatory Citation and Requirement:

10 CSR 80-11.010(5) Design

(A) Requirement. Plans, addendums, as-built drawings, or other documents which describe the design, construction, operation, or closure of a utility waste landfill or which request an operating permit modification for the utility waste landfill shall be prepared or approved by a professional

engineer. These documents shall be stamped or sealed by the professional engineer and submitted to the department for review and approval.

Regulatory Design Requirements:

(A)3. Owners/operators of utility waste landfills shall demonstrate how adverse geologic and hydrologic conditions may be altered or compensated for via surface water drainage diversion, underdrains, sumps, and other structural components. All alterations of the site shall be detailed in the plans.

A. Precipitation, evapotranspiration and climatological conditions shall be considered in site selection and design.

B. Engineering plans and specifications that have computer model attached to them shall list the limitations and assumptions of each model used in the application.

(A)4. Plans for stability analyses for all stages of construction shall include:

A. Settlement and bearing capacity analyses shall be performed on the in-place foundation material beneath the disposal area. The effect of foundation material settlement on the liner and leachate collection shall be evaluated;

B. Stability analyses shall be performed on all liner and leachate system components;

C. Leachate collection pipe material and drainage media shall be analyzed to demonstrate that these components possess structural strength to support maximum loads imposed by overlying waste materials and equipment;

D. Waste mass stability analyses shall be performed on the disposal area at final waste grade conditions and at intermediate slope conditions; and

E. Stability analyses shall be performed on all final cover system components, including an evaluation of the effect of waste settlement on the final cover system components, side slope liner system components, surface water management system components and gas migration system components.

Discussion of Alternative Design:

The Detailed Site Investigation (DSI) required by 10 CSR 80-2.015 addressed the precipitation, evapotranspiration and climatological conditions considered in original site selection and design. This included ground water table elevations and the relationship of the Missouri River levels to the ground water table. This report provides additional technical discussion of this information. In addition, the models and calculations submitted with the CPA address all stages of construction and operation of the Labadie UWL.

This report provides additional technical discussion relative to the intermittent contact of the CCL component of the composite liner. As outlined in detail in Section 2.0, the proposed design and operation of the utility waste landfill for the Labadie Energy Center anticipates the potential for saturated clays and saturated insitu base conditions, as well as the potential impact of high ground water table conditions intermittently caused by fluctuating Missouri River levels. No additional design alternatives or changes are believed necessary to address 10 CSR 80-11.010 (5).

Compliance with Regulatory Requirement:

In compliance with 10 CSR 80-11.010 (5), Design, this demonstration report has been prepared by professional engineers, has been reviewed and approved by a professional engineer and bears the signature and seal of the principal design engineer.

4.1.3. LANDFILL LINER SEPARATION FROM GROUND WATER.

Regulatory Citation and Requirement:

10 CSR 80-11.010(8) Water Quality.
(A) Requirement. The location, design, construction and operation of the utility waste landfill shall minimize environmental hazards and shall conform to applicable ground and surface water quality standards and requirements. Applicable standards are federal, state or local standards and requirements that are legally enforceable.

Regulatory Design Requirements:

(B)1. Plans shall include

C. Ground water elevation and proposed separation between the lowest point of the lowest cell and the predicted maximum water table elevation;

Discussion of Alternative Design:

This report provides information relative to the proposed separation between the lowest point of the lowest cell and the predicted normal water table elevation. In addition, it further evaluates the potential impact of the intermittent contact of the CCL component of the composite liner. No additional design alternatives or changes are believed necessary to address 10 CSR 80-11.010 (8).

Compliance with Regulatory Requirement:

The content of this demonstration report support the conclusion that the regulatory requirement is met. The proposed design, construction and operation of the utility waste landfill shall minimize environmental hazards and shall conform to applicable ground and surface water quality standards and requirements.

4.1.4. DESIGN AND OPERATION OF LINER SYSTEM.

Regulatory Citation and Requirement:

10 CSR 80-11.010(10) Liner Systems.

(A) Requirement. A liner shall be placed on all surfaces to minimize the migration of leachate from the utility waste landfill.

Regulatory Design Requirements:

(B)1. For a composite liner a lower component that consists of at least a two-foot (2') layer of compacted soil with a hydraulic conductivity of no more than 1 x 10^{-5} cm/sec. A compacted soil liner at a minimum shall be constructed of six to eight-inch (6-8") lifts, compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, or within other ranges of density and moisture such that are shown to provide for the liner to have a hydraulic conductivity no more than 1 x 10^{-5} cm/sec. For a single compacted clay liner a component that consists of at least a two-foot (2') layer of compacted soil with a hydraulic conductivity of no more than 1 x 10^{-7} cm/sec. A compacted soil liner at a minimum shall be constructed of six to eight-inch (6-8") lifts, compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, or within other ranges of density and moisture such that are shown to provide for the liner to have a hydraulic conductivity of no more than 1 x 10^{-7} cm/sec. The design shall include a detailed explanation of the construction techniques and equipment necessary to achieve ninety-five percent (95%) of the standard Proctor density under field conditions. The design also shall include QA/QC procedures to be followed during construction of the liner. The composite liner and the compacted clay liner shall be protected from the adverse effects of desiccation or freeze/thaw cycles after construction, but prior to placement of waste. Traffic shall be routed so as to minimize the detrimental impact on the constructed liner prior to placement of waste. The soils used for this purpose shall meet the following minimum specifications:

A. Be classified under the Unified Soil Classification Systems as CL, CH, or SC (ASTM Test D2487-85);
B. Allow more than thirty percent (30%) passage through a No. 200 sieve (ASTM Test D1140);
C. Have a liquid limit equal to or greater than twenty (20) (ASTM Test D4318-84);
D. Have a plasticity index equal to or greater than ten (10) (ASTM Test D4318-84); and
E. Have a coefficient of permeability equal to or less than 1 x 10^{-7} cm/sec for the compacted clay liner and 1 x 10^{-5} cm/sec for the composite liner when compacted to ninety-five percent (95%) of standard Proctor density with the moisture content between optimum moisture content and four percent (4%) above the optimum moisture content, when tested by using a flexible wall permeameter (ASTM D-5084) or other procedures approved by the department;

Alternative Design:

The proposed utility waste disposal area will utilize a composite liner that will consist of a 60-mil HDPE geomembrane liner underlain by two feet of compacted clay liner with a hydraulic conductivity equal to or less than 1 x 10^{-7} cm/sec. This proposed design significantly exceeded the performance of the minimum design standards and performance of the two liner options prescribed in 10 CSR 80-11.010 (10). Ameren Missouri proactively chose this design to minimize the migration of leachate from the utility waste disposal area and to provide a UWL that will address anticipated future regulatory revisions.

Compliance with Regulatory Requirement:

The regulatory requirement is met and exceeded by the Labadie UWL proposed composite liner design. This report demonstrates that the intermittent contact of ground water with the CCL component of the composite liner will not impact the CCL's design, function or performance.

4.2 Impact on the Construction Permit Application

Following the review and acceptance of this demonstration by MDNR, this demonstration will be incorporated into the approved engineering report and plans required to be maintained throughout the operating life and post closure care as required by the Solid Waste Disposal Area Operating Permit.

5.0 REFERENCES

ASTM D4767, "Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils."

ASTM D5084, "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter."

Daniel, David E. and Robert M. Koerner (1993) Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resources, Division of Geology and Land Survey on April 8, 2011.

Reitz & Jens, Inc. (2012) "Design Basis for Ground Water Level, Ameren Missouri Labadie Power Station Utility Waste Landfill," prepared for Ameren Missouri in compliance with Franklin County's amended Unified Land Use Regulations, Article 10, Section 238.

Timothy E. Frank, Ivan G. Krapac, Timothy D. Stark and Geoffrey D. Strack (2005), "Long-Term Behavior of Water Content and Density in an Earthen Liner," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 131, No. 6, June.

Mitchell, James K. (1976). Fundamentals of Soil Behavior. John Wiley & Sons, New York, 386 p.

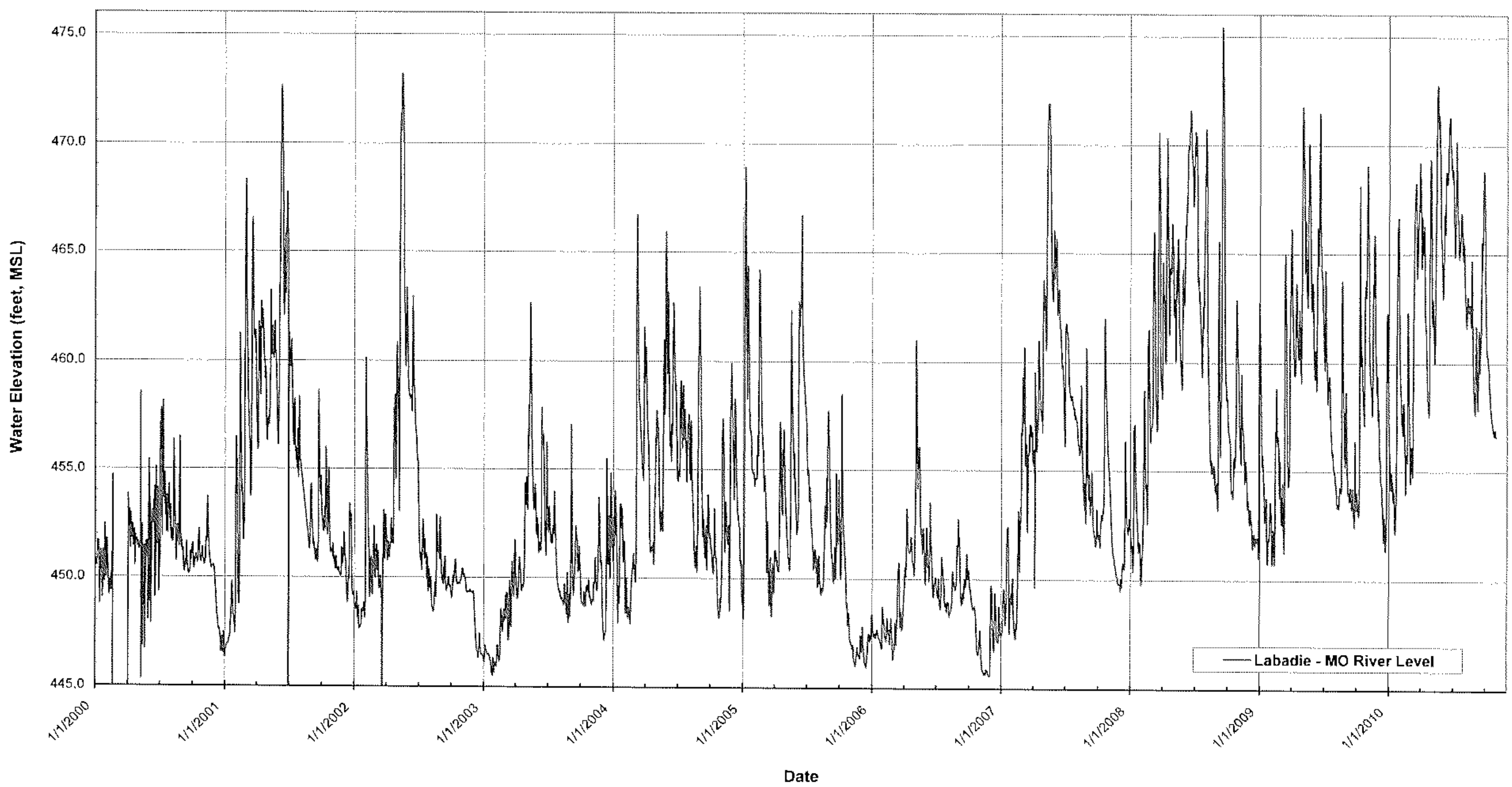
MDNR and Stark, Timothy D. (1997). Draft Technical Guidance Document on Static and Seismic Slope Stability for Solid Waste Containment Facilities. Solid Waste Management Program, Division of Environmental Quality, Missouri Department of Natural Resources, Jefferson City, MO, 96 p.

Terzaghi, Karl, Ralph B. Peck, Gholamreza Mesri (1996). Soil Mechanics in Engineering Practice, 3rd Edition. John Wiley & Sons, New York, 549 p.

Detailed Site Investigation
Proposed Utility Waste Disposal
Ameren Missouri Labadie Power Plant

Missouri River 10-Year Historical Data (2000-2010)

FIGURE 32



<u>CONFIDENTIAL BUSINESS INFORMATION</u>

Ameren Missouri Labadie Power Station
Utility Waste Landfill
<u>DESIGN BASIS FOR GROUND WATER LEVEL</u>

April 9, 2012

<u>Introduction and Purpose</u>

The County Commission amended the County's Unified Land Use Regulations on October 25, 2011 to add regulations concerning Non-Utility Waste and Utility Waste Landfills (UWL) in Franklin County, Missouri. Article 10, Section 238(C)(3) of these amended regulations requires in part that:

c.) The clay or composite soil component at the base of the Utility Waste Landfill shall be at least two (2) feet above the Natural Water Table in the site area.

Section 238(A)(11) defines "Groundwater" as "*Water below the land surface in the zone of saturation.*"

Section 238(A)(19) defines "Natural Water Table" as:

> *The level at which water stands in a fully saturated unconfined aquifer as measured by shallow piezometers or wells. The natural water table is under static hydrologic conditions and uninfluenced by groundwater pumping or other engineered activities.*

The site of the proposed UWL at Ameren Missouri's Labadie Power Station is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project[1] the ground water levels are strongly influenced by the Missouri River (page 39 of DSI Report). Because the Missouri River is an "open river," that is not controlled by a dam in the vicinity of the Labadie Power Station, the level of the Missouri River and hence the natural water table at the site are constantly changing. Therefore, the Natural Water Table is never "under static hydrologic conditions."

The amended County Unified Land Use Regulations allow the Independent Registered Professional Engineer to review and approve certain UWL requirements after evaluation of a specific UWL site and consultation with the UWL owner and engineer. This paper presents a rational definition of the "Natural Water Table" as it applies to the site of the proposed UWL at Ameren Missouri's Labadie Power Station, as a basis for design of the UWL. This report was prepared at the request of Ameren Missouri by Reitz & Jens, Inc., the Designer of Record for the Labadie UWL.

<u>Brief Project Description</u>

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Power Station is situated, on the right descending (south) overbank area of the

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[1] *Detailed Site Investigation Report for Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area, Franklin County, Missouri*, dated February 4, 2011, revised March 30, 2011. Approved by Missouri Department of Natural Resoures, Division of Geology and Land Survey on April 8, 2011.

Missouri River between River Miles 56.71 and 57.38. The existing ground surface ranges from about el. 471 to el. 465[2] below the current design of the UWL. The areas of lower ground surface elevations (below about el. 464) located in the southeast region of the site are in potential wetlands and therefore have been excluded from the proposed developed area of the UWL.

The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Power Station itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of 483.98 at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be 487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6. The planned top of the constructed perimeter berms of the Labadie UWL will be at el. 488.

Ground Water Levels and Missouri River Data

The daily average levels of the Missouri River at the Labadie Power Station from December 3, 1999, through November 9, 2010, were used in the analyses of the hydrogeology of the site for the DSI because these are the only Missouri River readings close to the site. The 3973 readings are plotted in Figure 32 (attached) from the DSI Report. The graph of the data demonstrates the highly variable nature of the Missouri River level at the site. The highest level in the data is el. 475.4 which occurred on September 16, 2008. The lowest level in the data is el. 393.0 which occurred on June 29, 2001. Below is a table of the frequencies of the Missouri River levels in 2-foot intervals from these data:

Frequencies of Missouri River Levels at Labadie Power Station (2000-2010)

Range	No.	%	% Greater
474-475.4	3	0.08%	
472-473	12	0.30%	0.38%
470-471	52	1.31%	1.69%
468-469	75	1.89%	3.57%
466-467	77	1.94%	5.51%
464-465	132	3.32%	8.83%
462-463	187	4.71%	13.54%
460-461	225	5.66%	19.20%
458-459	263	6.62%	25.82%
456-457	348	8.76%	34.58%
454-455	365	9.19%	43.77%
452-453	518	13.04%	56.81%
450-451	801	20.16%	76.97%
448-449	577	14.52%	91.49%
393-448	338	8.51%	100.00%

[2] Elevations herein refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM). NAVD88 corrects many of the problems with the earlier NGVD of 1929.

The ground water levels at the site were monitored monthly for the DSI from December 2009 through November 2010. The data show that the alluvial aquifer discharges toward the Missouri River during periods of relatively low flow, during which time the ground water levels below the site will be 1 to 3 feet above the Missouri River level. However, when the Missouri River is above about el. 461 for a sustained period, the ground water flow reverses and the ground water levels approach the level of the Missouri River near the river (in the northwest portion of the site) and about 5 feet or more below the river level over the majority of the site.

This is demonstrated in the graph of the average water table elevations versus the Missouri River elevation in Figure 31 from the DSI Report. From June 5, 2010, through July 5, 2010, the Missouri River elevation at the plant was above el. 465.1, and reached a maximum of el. 471.3. During this period, the average ground water table below the site rose to el. 464, with the average ground water table approaching el. 465 in the northwest portion of the site. The level of the Missouri River at the plant also was above el. 465 between May 13 and May 30, 2010, with a maximum level of el. 472.8. During this shorter duration of sustained high river levels (18 days compared to 30 days in June and July), the average ground water table beneath the site rose from el. 462.0 to el. 463.0. Therefore, it appears from these data that the ground water table beneath the site will rise to about el. 464 when the Missouri River at the plant is above el. 465 for about 30 days and reaches a maximum level above el. 471 during that period. How often do such sustained high Missouri River levels occur at the site?

From the above table, the Missouri River was at or above el. 465 about 9% of the days from December 1999 through November 2010, and was at or above el. 470 about 1.7% of the days. There were 12 intervals during this decade during which the Missouri River at the plant was above el. 465 for more than 5 days and during which time the river level exceeded el. 470. However, the Missouri River level was above el. 465 for more than 13 days during only 5 of these intervals:

Periods of Sustained High Missouri River Levels at Labadie Power Station (2000-2010)

Period	No. Days	Maximum River Elev.
June 3 – July 8, 2008	36	471.6
June 5 – July 5, 2010	30	471.3
May 2 – May 20, 2002	19	473.2
May 13 – May 30, 2010	18	472.8
May 9 – May 21, 2007	13	471.9

As stated above, the data from the 12 months of ground water level monitoring at the site indicate that the maximum average ground water level of about el. 464 may occur when the sustained high Missouri River level at the Labadie Power Station exceeds el. 465 for more than 18 days, and probably approaching 30 days, with a peak river level above el. 471. While the level of the Missouri River at the site has exceeded el. 470 about 1.7% of the 3973 days from December 1999 through November 2010, an interval of sustained high river levels adequate to create a high average ground water level of el. 464 has occurred only twice. **Therefore, the definition of el. 464 as the average "Natural Water Table" at the site would appear to be an extreme event that occurs for a relatively short duration only about two times in a 10-year period.**

Requirements for "Beneficial Use"

The Missouri Department of Natural Resources (MDNR) has previously permitted the use of CCR as fill for "beneficial use" without a clay liner if the fill was above the normal annual high ground water level. Adoption of el. 464 at the proposed site of the Labadie UWL would satisfy this requirement.

Summary

The current Franklin County Land Use regulations for Utility Waste Landfills require that the clay or composite soil component at the base of the Utility Waste Landfill shall be at least two (2) feet above the Natural Water Table in the site area, and that the definition of "Natural Water Table" is the "static hydrologic conditions uninfluenced by groundwater pumping or other engineered activities."

The site of the proposed UWL at Ameren Missouri's Labadie Power Station is located in the alluvial deposits adjacent to the Missouri River. As demonstrated in the Detailed Site Investigation (DSI) for this project, the ground water levels are strongly influenced by the Missouri River. Because the Missouri River is an "open river," the level of the Missouri River and hence the natural water table at the site is never under truly "static hydrologic conditions." Based upon the 12 months of monitoring of ground water levels at the site and almost 11 years of daily Missouri River level readings at the Labadie Power Station, the definition of el. 464 as the average "Natural Water Table" at the site would appear to be an extreme event that occurs for a relatively short duration only about two times in a 10-year period, and therefore would satisfy the intent of the Franklin County Land Use regulations.

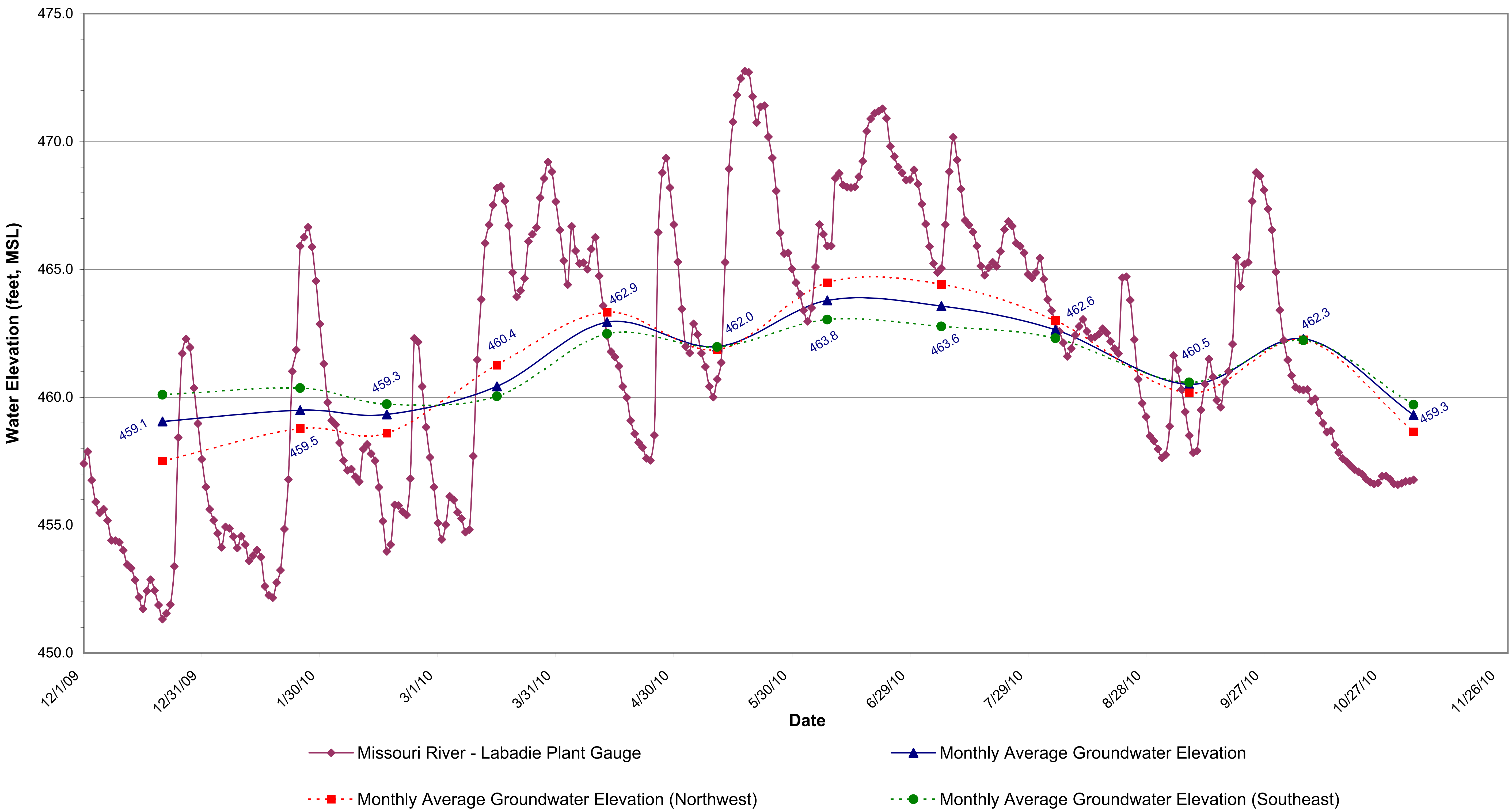
Attachments

Figure 31 from DSI Report, "Monthly Average Water Table Elevation VS Missouri River Elevation"
Figure 32 from DSI Report, "Missouri River 10-Year Historical Data (2000-2010)"

Detailed Site Investigation
Proposed Utility Waste Disposal
Ameren Missouri Labadie Power Plant

Monthly Average Water Table Elevation vs Missouri River Elevation

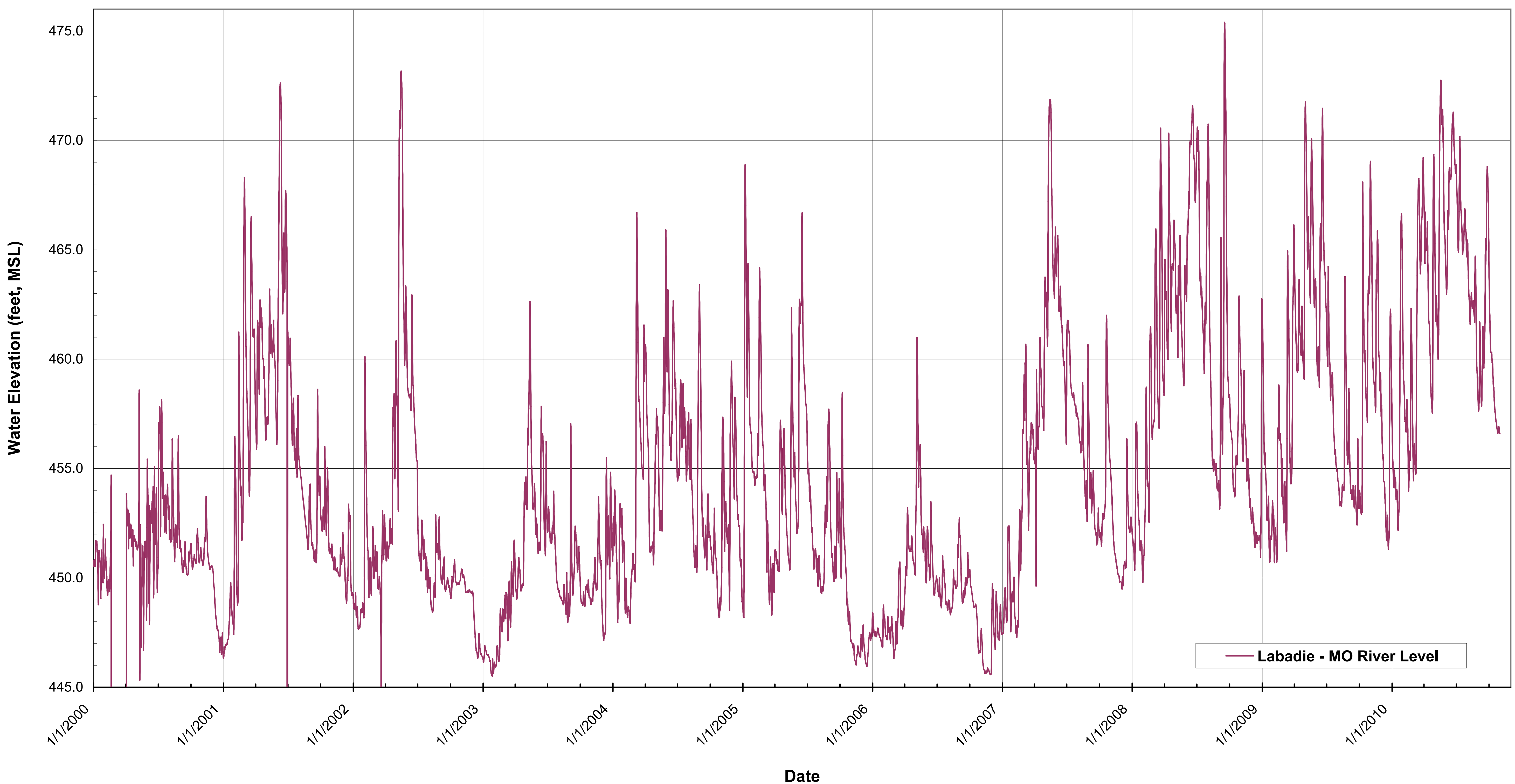
FIGURE 31



Detailed Site Investigation
Proposed Utility Waste Disposal
Ameren Missouri Labadie Power Plant

Missouri River 10-Year Historical Data (2000-2010)

FIGURE 32



Ameren Missouri Labadie Power Station
Utility Waste Landfill
DESIGN BASIS FOR EXTERIOR BERMS

April 10, 2012

Introduction and Purpose

The County Commission amended the County's Unified Land Use Regulations on October 25, 2011 to add regulations concerning Non-Utility Waste and Utility Waste Landfills (UWL) in Franklin County, Missouri. Article 10, Section 238(C)(3) of these amended regulations requires in part that:

d.) All "cells" shall be designed and constructed so that they shall be protected by an exterior berm meeting the following criteria:

i.) The top of the berm at a minimum shall be equal to the five hundred (500) year flood level in the area of the proposed Utility Waste Landfill.

ii) … All berms shall be constructed of concrete or cement-based material sufficiently thick for the purpose intended and approved by the Independent Registered Professional Engineer.

The amended County Unified Land Use Regulations allow the Independent Registered Professional Engineer to review and approve certain UWL requirements after evaluation of a specific UWL site and consultation with the UWL owner and engineer. This paper will help define the "purpose intended" as it applies to the exterior berms for the proposed UWL at Ameren Missouri's Labadie Power Station and present a recommended design. This report was prepared at the request of Ameren Missouri by Reitz & Jens, Inc., the Designer of Record for the Labadie UWL.

Brief Project Description

The Labadie UWL will be developed on property contiguous with the boundary of property upon which the Labadie Power Station is situated, on the right descending (south) overbank area of the Missouri River between River Miles 56.71 and 57.38. The UWL site is currently protected from regular Missouri River flooding by the Labadie Bottom Levee District agricultural levee with heights at or near the 100-year flood elevation. In the unlikely event that the agricultural levee is overtopped or breached, the UWL site is further protected from direct Missouri River flood currents by the Labadie Power Station itself which is upstream and higher than the 500-year flood elevation, creating a low velocity shadow, or ineffective flow area, over the entire UWL site. The regulatory 100-year base flood elevation (BFE) of el. 483.98[1] at the upstream end of the UWL site became effective on October 18, 2011. The 500-year flood elevation at this river station is reported by FEMA to be el.

[1] All elevations refer to the North American Vertical Datum of 1988 (NAVD88) which is the datum used in FEMA's new Flood Insurance Rate Maps (FIRM).

487.55. By comparison, the flood crest at this location in August 1993 was about el. 483.6. The planned top of the constructed perimeter berms of the Labadie UWL will be at el. 488.
The total area of the UWL when completed will be approximately 280 acres. The UWL will be constructed in cells, as defined by the Franklin County land use regulations, with each cell designed to contain a minimum of 5 years of the coal combustion residuals (CCRs) produced by the Labadie Plant. As planned prior to adoption of the new Land Use regulations in October 2011, each cell will be fully surrounded by a perimeter berm. The primary purpose intended for these berms is to separate the CCRs in the UWL from coming in contact with floodwater. The internal angle of friction of the CCRs that will be deposited in each cell will be sufficiently high so as to create a stable fill that does not require the perimeter berms for stability.

Two types of perimeter berms will be built. Exterior berms are those that will form the perimeter of the fully developed 280-acre UWL. Interior berms are those that initially will form a portion of each cell's perimeter, but will ultimately be covered with CCRs as future cells are developed. Some exterior berms infrequently may be in contact with a flow of flood water of the Missouri River, but only when the Labadie Bottom Levee District levee is overtopped or breached. The interior berms may also infrequently come in contact with flood water, but the water velocities will be too low to cause erosion. In both instances a vegetated cover alone would provide sufficient erosion protection, as with standard levee design. Because the CCR mass and perimeter berms are inherently stable, concrete and/or cement-based material will be used only to prevent possible erosion of the exposed slopes of perimeter berms that may be subject to the flow of flood water.

The general height and geometry of the exterior and interior berms will be as shown in Figure 1. The exterior berms will be constructed with compacted soil and the inside slope will be covered with a composite liner in accordance with the Missouri Department of Natural Resources (MDNR) regulations. The outside slope of the exterior berms will have a concrete or cement-based layer to protect against erosion from flood water (the "purpose intended"). Interior berms will be constructed with a core of CCRs and a compacted clay cap and vegetated cover on their outside slope. The composite liner will extend under the interior berm and tie into the exterior slope's clay cap to encapsulate the CCRs in accordance with MDNR regulations and allow extension of the composite liner beneath the next cell. Both side slopes of the perimeter berms will be 3 horizontal to 1 vertical (3:1). The top of the perimeter berms will be constructed to el. 488.0, that is 0.45 feet above the 500-year flood level, as required by the Franklin County Land Use regulations. The height of the berms above existing ground surface will vary but average about 23 feet.

Berm Design Basis Using Concrete or Cement-Based Materials

Reitz & Jens has researched and evaluated alternatives for using concrete or cement-based materials for erosion protection of the exposed slopes of exterior berms at the Labadie UWL. Our

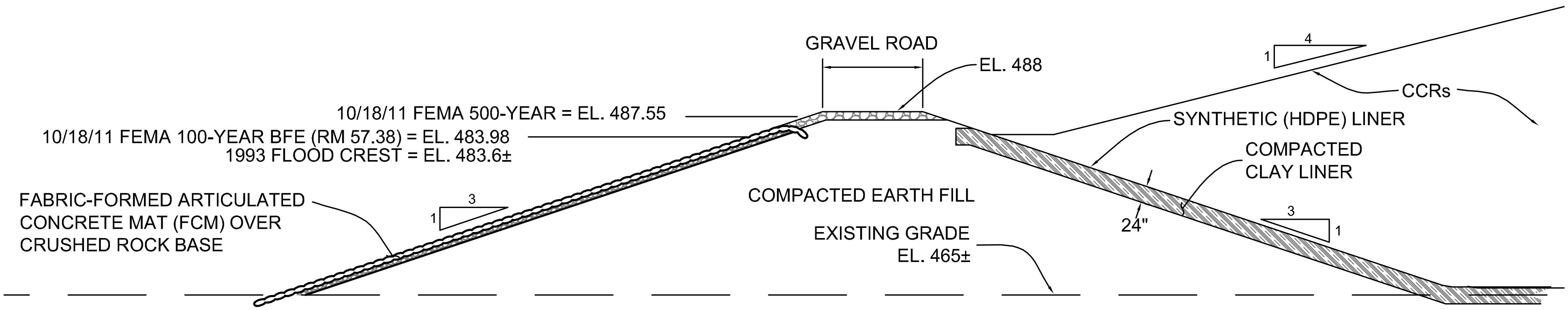
recommendation is to incorporate fabric-formed concrete mats (FCM) constructed using manufactured fabric forms and cast-in-place concrete (example shown in photo below). Evenly-spaced sewn filter "windows" or inserted plastic weep holes prevent excess hydrostatic pressures beneath the FCM as floodwater that may be present from time to time recedes. Some options include windows in the FCM to permit growing a vegetative cover. The forms are typically available in 4-, 6- or 8-inch thicknesses. The required thickness will be determined based on the hydraulic conditions. The ducts between the block compartments are limited to 10% of the maximum thickness of the blocks to achieve flexibility and articulation of the finished FCM, to accommodate differential settlement. Reinforcing cables may be inserted through the block compartments to provide additional strength, if necessary for severe applications or for slopes up to 2:1. The design of the FCM will be based upon hydraulic analyses of the maximum flow that may result from overtopping or a breach of the Labadie Bottom levee at the worst case location for each section of the exterior berms. The FCM will be placed on geotextile filter or crushed rock base to prevent loss of soil.

Summary

The current Franklin County Land Use regulations for Utility Waste Landfills require that all exterior berms be constructed of concrete or cement-based material sufficiently thick for the purpose intended. As explained above, the primary purpose intended for these berms is to separate the coal combustion residuals in the UWL from coming in contact with flood water. To comply with these regulations, the UWL design includes building the exterior berms with a soil core and fabric-formed concrete mat surface to protect the exterior slopes from floodwater that could result from a breach or overtopping of the existing Labadie Bottom Levee District levee along the Missouri River. The FCM has the following advantages:

- construction uses pre-manufactured fabric forms,
- erosion-resistant concrete face,
- weep holes or "windows" to relieve excess hydrostatic pressure,
- exposed exterior concrete for visual inspection,
- can be installed without heavy construction equipment (disturbing surrounding areas),
- articulated to compensate for differential settlement, and
- does not create rigidity within berms that could cause cracking and piping.

CONFIDENTIAL BUSINESS INFORMATION



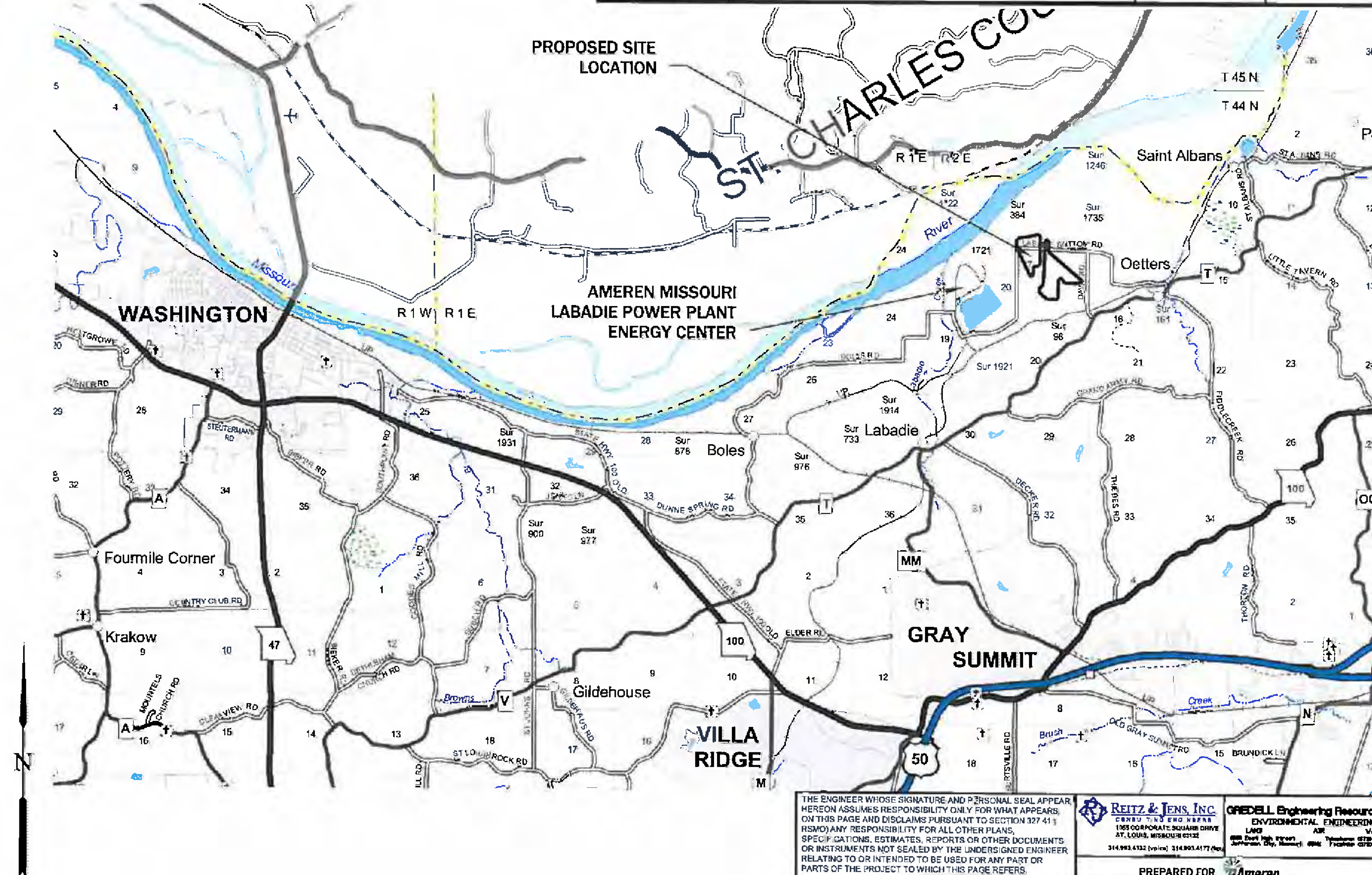
Ameren Labadie UWL
RECOMMENDED DESIGN FOR
EXTERIOR BERMS

Reitz & Jens, Inc.

Figure 1

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\FIG 1 ENGR REPT.dwg, Cover Sheet, 1/23/2013 2:39:22 PM

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



SCALE: 1" = 10000'

0 5000 10000

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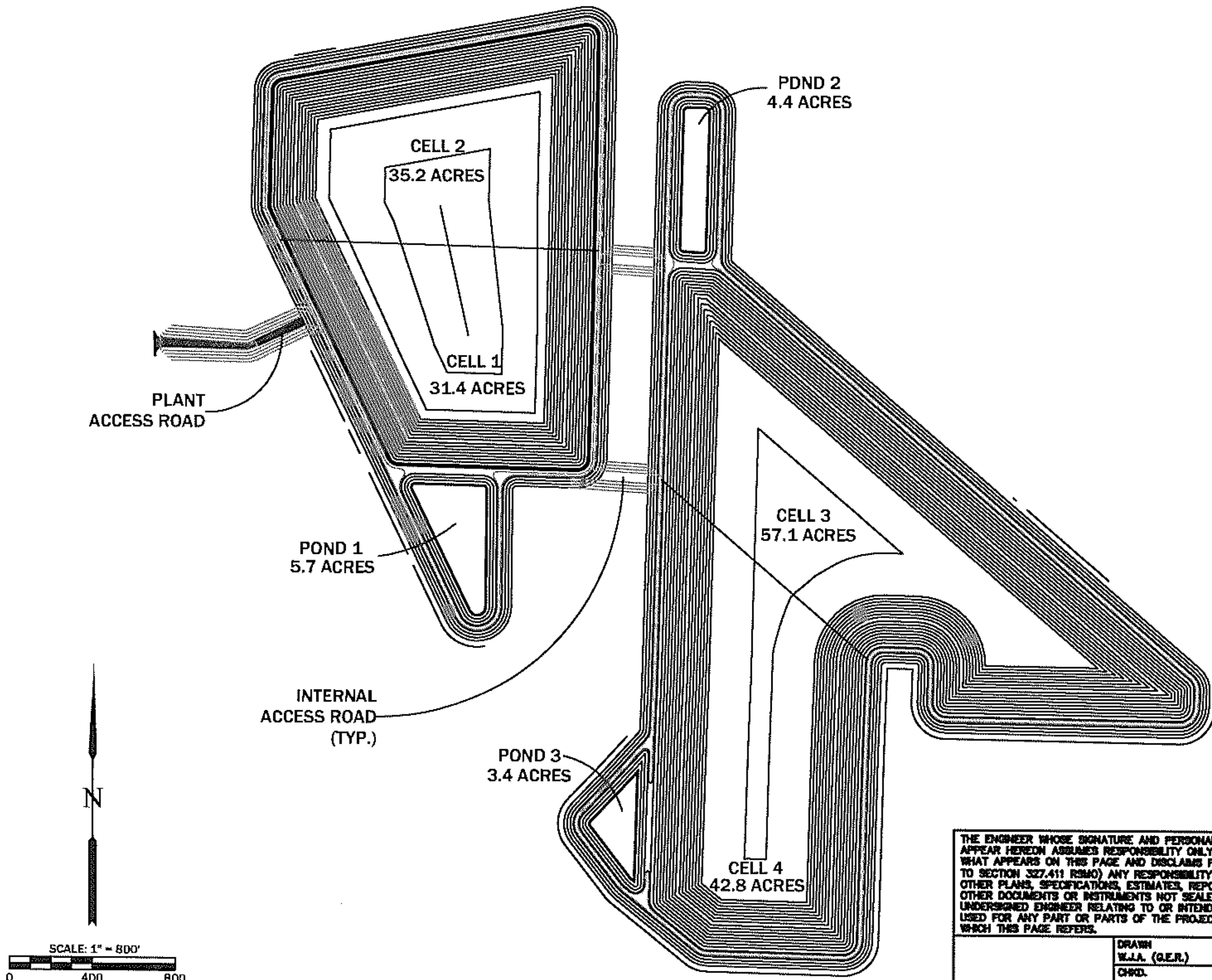
GREDELL Engineering Resources, Inc. ENVIRONMENTAL ENGINEERING — LAND AIR WATER

PREPARED FOR Ameren

DRAWN W.J.A. (G.E.R.)	FIGURE 1 LABADIE ENERGY CENTER PROPOSED UTILITY WASTE LANDFILL SITE LOCATION MAP
CHKD R.L.R. (G.E.R.)	
SUPV T.R.G. (G.E.R.)	
APPD T.R.G. (G.E.R.)	LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010
Ameren MISSOURI — ST. LOUIS, MISSOURI	JANUARY 2013 — REV

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



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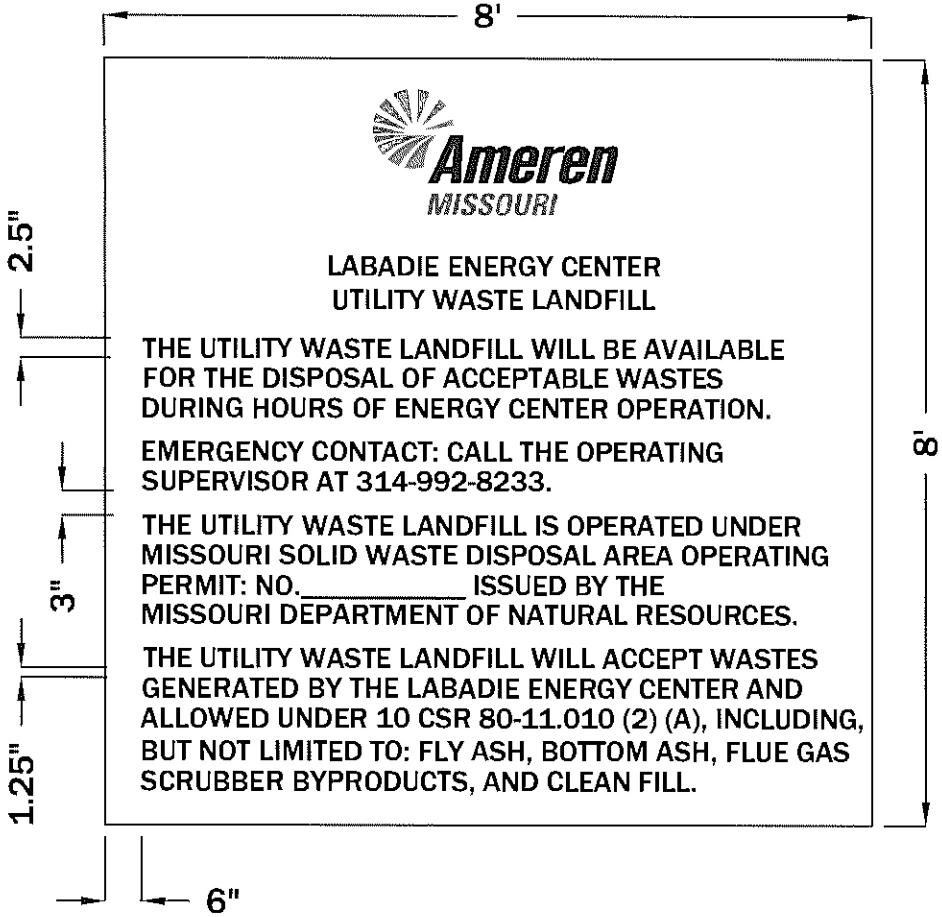
SUPV. T.R.G. (G.E.R.)
APPD. T.R.G. (G.E.R.)

FIGURE 2
LABADIE ENERGY CENTER
PROPOSED UTILITY WASTE LANDFILL
SEQUENCE OF CELL CONSTRUCTION

LOCATION		CLASS
001009	LABADIE ENERGY CENTER	02010

Ameren MISSOURI — ST. LOUIS, MISSOURI — JANUARY 2013 — REV.



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CHKD	R.L.R. (G.E.R.)
SUPV.	T.R.G. (G.E.R.)
APPD.	T.R.G. (G.E.R.)

FIGURE 3
LABADIE ENERGY CENTER
PROPOSED UTILITY WASTE LANDFILL
ENTRANCE SIGN DETAIL

LOCATION 001009 — LABADIE ENERGY CENTER — CLASS 02010

Ameren MISSOURI — ST. LOUIS, MISSOURI — JANUARY 2013 — REV.

M:\Share\CADDFiles\AMEREN-UE\LABADIE\CONSTRUCTION PERMIT\2012 DRAWINGS\FIG 3 ENGR REPT.dwg, Cover Sheet, 1/23/2013 2:42:30 PM

TABLES

Ameren Missouri Labadie Energy Center
Construction Permit Application for a Proposed Utility Waste Landfill
Franklin County, Missouri

Applicable Regulatory References
Sorted by Table of Contents
Table 1A

TITLE	REFERENCE (10 CSR 80-)
Construction Permit Application Form	2.020(2)(A)2.A
Construction Permit Application Fee-MDNR ($2,000)	2.020(2)(A)2.G; 2.020(2)(A)5

1.0	**INTRODUCTION**	
1.1	Site Background	11.010(4)(A)
1.2	Proposed Facility	2.020(2)(A)
1.3	Landfill Owner and Operator	2.020(2)(A); 2.010(67); 2.010(68)
1.4	Applicant Violation History	2.020(2)(A)2.I; 2.070
1.5	Request for Recommendation from East Central Solid Waste Management District, Region I	260.205.7 (MO Statute)
2.0	**SITE SELECTION**	11.010(4)
2.1	Site Location	2.020
2.2	Legal Description of the Property	2.020(2)(A)
2.3	Site Access	11.010 (4)(C)1; 11.010(16)(B)1; 11.010(16)(C)2
2.4	Zoning and Land Use	11.010(4)(B)5.B
2.5	Surrounding Land Use	11.010(4)(B)5.B; 2.020(9)(B)8.C
2.6	Site Topography	11.010(4)(B)5.A
2.7	Utilities	11.010(4)(B)5.B
2.8	Site Selection Location Restrictions	11.010(4)
2.8.1	Preliminary Site Investigation (PSI)	2.015(1)(A); 260.205.2 (MO Statutue);11.010
2.8.2	Detailed Site Investigation (DSI)	2.015(1)(D)
2.8.3	Floodplains	11.010(4)(B)1
2.8.4	Wetlands	11.010(4)(B)2
2.8.5	Seismic Impact Zone	11.010(4)(B)3; 2.010(96); 2.010(57)
2.8.7	Unstable Areas	11.010(4)(B)4; 2.010(114); 2.010(77);2.010(6); 2.010(49), 3.010
2.9	Geotechnical Investigations	11.010(4)(B)5.D
2.9.1	Soils	11.010(4)(B)5.D
2.9.2	Bedrock	11.010(4)(B)4.A
2.9.3	Groundwater Occurrence	11.010(8)(B)1.C; 11.010(8)(B)1.D; 2.010(5)
2.10	Survey Control	11.010(7)
2.10.1	Boundary Survey	11.010(7)(B)1

TITLE		REFERENCE (10 CSR 80-)
2.10.2	Permanent Survey Control Points	11.010(7)
3.0	**LANDFILL DESIGN**	11.010(5)
3.1	Description of the Landfill Design	11.010(5)
3.1.1	Project Background Summary	11.010(4)(5)
3.1.2	Technical Background Summary	11.010(4)(5)
3.1.3	Environmental Protection	11.010(1)
3.1.4	Compliance with 10 CSR 80-11.010	11.010; 2.010(11); 2.010(118)
3.2	Volume of the Proposed Landfill	11.010(5)(B); 11.010(17)(C)1.D
3.2.1	Landfill Life Expectancy	11.010(17)(C)1.D
3.2.2	Soil Material Volume	11.010(10)(B)1; 11.010(14)(B)1
3.3	Construction Sequence	11.010(5)(B)1
3.3.1	UWL Construction Sequence	11.010(5)(B)3
3.3.2	UWL Disposal Area Construction Sequence	11.010(5)(B)3
3.3.2.1	Phase Construction Sequence	11.010(5)(B)3
3.3.2.2	Flood Impact Mitigation Plan	11.010(5)(B)3
3.3.2.3	Franklin County Requirement - Erosion Protection	Article 10 Section 238 C,3d.)
3.3.3	Phased Development	11.010(5)(B)3; 2.010(74)
3.3.4	Excavaton to Proposed Subgrade	11.010(5)(B)3
3.3.5	Miscellaneous Construction	11.010(5)(B)3
3.4	Final Contours	11.010(4)(B)5.A
3.5	Solid Waste Accepted	11.010(2)(A); 11.010(2)(B); 2.010(118)
3.6	Solid Waste Excluded	11.010(3)(A); 11.010(3)(B)
3.7	Stormwater Management System	11.010(8)(B)1.F; 11.010(8)(C)1
3.7.1	Stormwater Runoff Controls	11.010(8)(B)1.F; 11.010(8)(C)1
3.7.2	Water Quality Permits	2.020(2)(A)2.J
3.8	Landfill Liner	11.010(10)(B)
3.8.1	Grading Plan	11.010(10)(B)4
3.8.2	Materials and Construction	11.010(10)(C)
3.8.2.1	Soil Component	11.010(10)(B)1
3.8.2.2	Geomembrane Component	11.010(10)(B)2
3.9	Leachate Management System	11.010(9)(B)
3.9.1	Leachate Generation Rate	11.010(9)(B)
3.9.1.1	Pre-Closure Generation Rate	11.010(9)(B)
3.9.1.2	Post-Closure Generation Rate	11.010(9)(B)
3.9.2	Water Storage and Disposal	11.010(9)(B)
3.10	Groundwater Monitoring	11.010(11)
3.10.1	Groundwater Quality	11.010(11)(C)3
3.10.2	Groundwater Monitoring System	11.010(11)
3.10.3	Corrective Action	11.010(11)(C)6

TITLE		REFERENCE (10 CSR 80-)
3.11	Cover Material	11.010(14)(C)1
3.11.1	Soil Cover Sources	11.010(14)(B)1
3.12	Landfill Final Cover	11.010(14)
3.12.1	Materials and Construction	11.010(14)(C); 11.010(14)(B)
3.12.1.1	Soil Component	11.010(14)(C)1; 11.010(14)(C)3; 11.010(14)(C)10
3.12.2	Vegetation	11.010(14)(C)7
3.13	Air Quality	11.010(12)
3.14	General Maintenance of Landfill Systems	11.010(4)(B)5.C
3.15	Closure and Post-Closure	11.010(14)(B); 2.030(4)(B)2.0
4.0	**LANDFILL OPERATION**	11.010(5)(B)
4.1	Construction and Development	11.010(5)(B)1.2
4.1.1	Phased Development	11.010(5)(B)3
4.1.2	Sequence of Phase Construction	11.010(5)(B)
4.1.3	Construction Quality Assurance (CQA)	11.010(6)(B)
4.1.4	Survey Control	11.010(7)
4.2	Operational Description	11.010(4)(B)5.C
4.2.1	UWL Disposal Operation Description	11.010(4)(B)5.C
4.2.2	Flood Impact Mitigation Plan	11.010(4)(B)5.C
4.3	Solid Waste Accepted	11.010(2)
4.4	Solid Waste Excluded	11.010(3)
4.5	Water Quality	11.010(8); 11.010(9)
4.5.1	Stormwater Management	11.010(8)(C)
4.5.2	Leachate Management in the UWL	11.010(9)(C)
4.5.3	Groundwater Sampling and Analysis Plan	11.010(11)(C)2
4.6	Air Quality	11.010(12)
4.6.1	Dust Control	11.010(12)(B)
4.7	Aesthetics	11.010(13)
4.7.1	General Aesthetics	11.010(13)
4.7.2	Mining for Beneficial Reuse	11.010(13)(C)3
4.8	Equipment and Staffing	11.010(15)
4.8.1	Primary Equipment	11.010(15)(C)1
4.8.2	Equipment Maintenance	11.010(15)(B)1
4.8.3	Back-Up Equipment	11.010(15)(B)1
4.8.4	Staffing	11.010(15)(C)
4.9	Final Cover Material	11.010(14)
4.10	Compaction	11.010(15)
4.11	Safety	11.010(16)
4.12	Records	11.010(17);11.010(9); 11.010(11); 11.010(3)(B); 2.030(4)(A) (B) (C)

LIST OF APPENDICES

	TITLE	REFERENCE (10 CSR 80-)
	LIST OF PLAN SHEETS	
1	Cover Sheet	11.010(4)(B)5
2	Existing Site Conditions	11.010(4)(B)5
3	Project Overview	11.010(4)(B)5
4	Land Use and Zoning within 1/4 mile	11.010(4)(B)5
5	Overall Bottom Grading Plan (Top of Liner)	11.010(4)(B)5
6	Cell 1 Grading Plan (Top of Liner)	11.010(4)(B)5
7	Cell 2 Grading Plan (Top of Liner)	11.010(4)(B)5
8	Cell 3 Grading Plan (Top of Liner)	11.010(4)(B)5
9	Cell 4 Grading Plan (Top of Liner)	11.010(4)(B)5
10	Overall Final Grading Plan	11.010(4)(B)5
11	Phase 1 Final Grading Plan	11.010(4)(B)5
12	Phase 2 Final Grading Plan	11.010(4)(B)5
13	Phase 3 Final Grading Plan	11.010(4)(B)5
14	Phase 4 Final Grading Plan	11.010(4)(B)5
15	Geomembrane and Cover Details	11.010(10)(B)2.(14)(A)
16	Stormwater Pond Storage and Transfer Details	11.010(5)
17	Liner Details	11.010(5)
18	Miscellaneous Details 1	11.010(5)
19	Miscellaneous Details 2	11.010(5)
20	Leachate Collection System Details	11.010(5)
21	Stormwater Drainage Details	11.010(5)
22	Cross Sections A-A' and B-B'	11.010(5)
23	Cross Sections C-C' and D-D'	11.010(5)

Ameren Missouri Labadie Energy Center
Construction Permit Application for a Proposed Utility Waste Landfill
Franklin County, Missouri

Applicable Regulatory References
Sorted by Regulatory Citation
Table 1B

STATE OF MISSOURI REVISED STATUTES (RSMo)

RSMo	REPORT SECTION	TITLE
260.205.2	2.8.1	Preliminary Site Investigation (PSI)
260.205.7	Appendix E	Request for Recommendation from East Central Solid Waste Management District, Region I
260.205.7	1.5	Request for Recommendation from East Central Solid Waste Management District, Region I

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-2 RULES

10 CSR 80-	REPORT SECTION	TITLE
2,11	Table 1A	Applicable Regulatory Reference Sorted by Table of Contents
2,11	Table 1B	Applicable Regulatory Reference Sorted by Regulatory Citation
2.020(1)(2)(A)(B)	Appendix B	Articles of Organization
2.020(1)(2)(A)(B)	Appendix C	Good Standing Certificate
2.010(5)	2.9.3	Groundwater Occurrence
2.010(6)	2.8.7	Unstable Areas
2.010(11)	3.1.4	Compliance with 10 CSR 80-11.010
2.010(49)	2.8.7	Unstable Areas
2.010(57)	2.8.6	Seismic Impact Zone
2.010(67)	1.3	Landfill Owner and Operator
2.010(68)	1.3	Landfill Owner and Operator
2.010(74)	3.3.3	Phased Development
2.010(77)	2.8.7	Unstable Areas
2.010(96)	2.8.6	Seismic Impact Zone
2.010(114)	2.8.7	Unstable Areas
2.010(118)	3.1.4	Compliance with 10 CSR 80-11.010
2.010(118)	3.1.4	Compliance with 10 CSR 80-11.010
2.015(1)(A)	2.8.1	Preliminary Site Investigation (PSI)
2.015(1)(D)	2.8.2	Detailed Site Investigation (DSI)
2.020	2.1	Site Location

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-2 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
2.020(2)(A)	1.2	Proposed Facility
2.020(2)(A)	1.3	Landfill Owner and Operator
2.020(2)(A)	2.2	Legal Description of the Property
2.020(2)(A)2.A	N/A	Construction Permit Application Form
2.020(2)(A)2.C	Appendix U	Draft FAI
2.020(2)(A)2.D	Appendix R	Closure and Post-Closure Plan
2.020(2)(A)2.F	Appendix G	Adjacent Landowners or Landowners within 1000 ft
2.020(2)(A)2.G	N/A	Construction Permit Application Fee - MDNR ($2,000)
2.020(2)(A)2.I	1.4	Applicant Violation History
2.020(2)(A)2.J	3.7.2	Water Quality Permits
2.020(2)(A)5	N/A	Construction Permit Application Fee - MDNR ($2,000)
2.020(6)	Appendix F	Franklin County Requirements
2.020(7)	Appendix U	Draft FAI
2.020(8)	Appendix D	Habitual Violator Disclosure Form
2.020(9)(B)8.C	2.5	Surrounding Land Use
2.020(9)(B)8.H	Appendix S	Utility Waste Landfill Emergency Contacts
2.030(4)	Appendix R	Closure and Post-Closure Plan
2.070	1.4	Applicant Violation History
3.010	2.8.7	Unstable Areas

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES

10 CSR 80-	REPORT SECTION	TITLE
11.010	2.8.7	Preliminary Site Investigation (PSI)
11.010	3.1	Description of the Landfill Design
11.010	3.1.1	Project Background Summary
11.010	3.1.2	Technical Background Summary
11.010	3.1.4	Compliance with 10 CSR 80-11.010
11.010	Appendix Y	Miscellaneous Engineering Calculations
11.010(1)	3.1.3	Environmental Protection
11.010(1)	Appendix Z	Groundwater Demonstration and Design Basis Memoranda
11.010(2)	4.3	Solid Waste Accepted

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
11.010(2)(A)	3.5	Solid Waste Accepted
11.010(2)(B)	3.5	Solid Waste Accepted
11.010(2)(3)(16)	Figure 3	Entrance Sign Detail
11.010(3)	4.4	Solid Waste Excluded
11.010(3)(A)	3.6	Solid Waste Excluded
11.010(3)(B)	3.6	Solid Waste Excluded
11.010(4)	2.0	Site Selection
11.010(4)	2.8	Site Selection Location Restrictions
11.010(4)(A)	1.1	Site Background
11.010(4)(5)	3.1.1	Project Background Summary
11.010(4)(5)	3.1.2	Technical Background Summary
11.010(4)(B)1	2.8.3	Floodplains
11.010(4)(B)1	Appendix H	Floodplain Documentation
11.010(4)(B)2	2.8.4	Wetlands
11.010(4)(B)2	Appendix I	Wetland Assessment
11.010(4)(B)3	2.8.6	Seismic Impact Zone
11.010(4)(B)4	2.8.7	Unstable Areas
11.010(4)(B)4.A	2.9.2	Bedrock
11.010(4)(B)5	Plan Sheet 1	Cover Sheet
11.010(4)(B)5	Plan Sheet 2	Existing Site Conditions
11.010(4)(B)5	Plan Sheet 3	Project Overview
11.010(4)(B)5	Plan Sheet 4	Land Use and Zoning Within 1/4 Mile
11.010(4)(B)5	Plan Sheet 5	Overall Bottom Grading Plan (Top of Liner)
11.010(4)(B)5	Plan Sheet 6	Cell 1 Grading Plan (Top of Liner)
11.010(4)(B)5	Plan Sheet 7	Cell 2 Grading Plan (Top of Liner)
11.010(4)(B)5	Plan Sheet 8	Cell 3 Grading Plan (Top of Liner)
11.010(4)(B)5	Plan Sheet 9	Cell 4 Grading Plan (Top of Liner)
11.010(4)(B)5	Plan Sheet 10	Overall Final Grading Plan
11.010(4)(B)5	Plan Sheet 11	Phase 1 Final Grading Plan
11.010(4)(B)5	Plan Sheet 12	Phase 2 Final Grading Plan
11.010(4)(B)5	Plan Sheet 13	Phase 3 Final Grading Plan
11.010(4)(B)5	Plan Sheet 14	Phase 4 Final Grading Plan

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
11.010(4)(B)5	Figure 2	Sequence of Cell Construction
11.010(4)(B)5.A	2.6	Site Topography
11.010(4)(B)5.A	3.4	Final Contours
11.010(4)(B)5.B	2.4	Zoning and Land Use
11.010(4)(B)5.B	2.5	Surrounding Land Use
11.010(4)(B)5.B	2.7	Utilities
11.010(4)(B)5.C	3.14	General Maintenance of Landfill Systems
11.010(4)(B)5.C	4.2	Operational Description
11.010(4)(B)5.C	4.2.1	UWL Disposal Operation Operational Description
11.010(4)(B)5.C	4.2.2	Flood Impact Mitigation Plan
11.010(4)(B)5.D	2.9	Geotechnical Investigations
11.010(4)(B)5.D	2.9.1	Soils
11.010(4)(B)5.D	Appendix J	Geotechnical Investigation for Construction Permit Application by Reitz & Jens, dated June 2011
11.010(4)(B)5.D	Appendix K	Soil Material Volume and Balance Calculations
11.010(4)(B)(6)	Appendix Z	Groundwater Demonstration and Design Basis Memoranda
11.010(4)(C)1	2.3	Site Access
11.010(5)	Plan Sheet 16	Stormwater Pond Storage and Transfer Details
11.010(5)	Plan Sheet 17	Liner Details
11.010(5)	Plan Sheet 18	Miscellaneous Details 1
11.010(5)	Plan Sheet 19	Miscellaneous Details 2
11.010(5)	Plan Sheet 20	Leachate Collection System Details
11.010(5)	Plan Sheet 21	Stormwater Drainage Details
11.010(5)	Plan Sheet 22	Cross Sections A-A' and B-B'
11.010(5)	Plan Sheet 23	Cross Sections C-C' and D-D'
11.010(5)	Figure 1	Site Location Map
11.010(5)	3.0	Landfill Design
11.010(5)	3.1	Description of the Landfill Design
11.010(5)(A)4	Appendix J	Report Titled "Geotechnical Engineering Report for Construction Permit Application" by Reitz & Jens, dated November 2012
11.010(5)(B)	3.2	Volume of the Proposed Landfill
11.010(5)(B)	4.0	Landfill Operation
11.010(5)(B)1	3.3	Construction Sequence

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
11.010(5)(B)1.2	4.1	Construction and Development
11.010(5)(B)	4.1.2	Sequence of Phase Construction
11.010(5)(B)3	3.3.1	UWL Construction Sequence
11.010(5)(B)3	3.3.2	UWL Disposal Area Construction Sequence
11.010(5)(B)3	3.3.2.1	Phase Construction Sequence
11.010(5)(B)3	3.3.2.2	Flood Mitigation Plan
11.010(5)(B)3	3.3.3	Phased Development
11.010(5)(B)3	4.1.1	Phased Development
11.010(6)(B)	Appendix P	Construction Quality Assurance Plan
11.010(6)(B)	4.1.3	Construction Quality Assurance (CQA)
11.010(7)	2.10	Survey Control
11.010(7)	2.10.2	Permanent Survey Control Points
11.010(7)	4.1.4	Survey Control
11.010(7)(B)	Appendix V	Survey Plat
11.010(7)(B)1	2.10.1	Boundary Survey
11.010(8)	4.5	Water Quality
11.010(8)(A)(B)	Appendix W	Groundwater Hydraulic Data
11.010(8)(B)1.C	2.9.3	Groundwater Occurrence
11.010(8)(B)1.C	Appendix Z	Groundwater Demonstration and Design Basis Memoranda
11.010(8)(B)1.D	2.9.3	Groundwater Occurrence
11.010(8)(B)1.F	3.7	Stormwater Management System
11.010(8)(B)1.F	3.7.1	Stormwater Runoff Controls
11.010(8)(B)1.F	Appendix M	Erosion Calculations
11.010(8)(B)1.F	Appendix N	Stormwater Calculations
11.010(8)(B)1.F	Appendix O	H.E.L.P Model Results
11.010(8)(C)	Appendix N	Stormwater Calculations

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
11.010(8)(C)	Appendix O	H.E.L.P Model Results
11.010(8)(C)	4.5.1	Stormwater Management
11.010(8)(C)1	3.7	Stormwater Management System
11.010(8)(C)1	3.7.1	Stormwater Runoff Controls
11.010(9)	4.5	Water Quality
11.010(9)(B)	3.9	Leachate Management System
11.010(9)(B)	3.9.1	Leachate Generation Rate
11.010(9)(B)	3.9.1.1	Pre-Closure Generation Rate
11.010(9)(B)	3.9.1.2	Post-Closure Generation Rate
11.010(9)(B)	3.9.2	Water Storage and Disposal
11.010(9)(C)	4.5.2	Leachate Management in the UWL
11.010(10)(B)	3.8	Landfill Liner
11.010(10)(B)1	3.2.2	Soil Material Volume
11.010(10)(B)1	3.8.2.1	Soil Component
11.010(10)(B)2	3.8.2.2	Geomembrane Component
11.010(10)(B)2.(14)(A)	Plan Sheet 15	Geomembrane and Cover Details
11.010(10)(B)4	3.8.1	Grading Plan
11.010(10)(C)	3.8.2	Materials and Construction
11.010(11)	3.10	Groundwater Monitoring
11.010(11)	3.10.2	Groundwater Monitoring System
11.010(11)(A)(B)	Appendix X	Documentation of Groundwater Monitoring Well Design
11.010(11)(C)2	Appendix Q	Groundwater Sampling and Analysis Plan
11.010(11)(C)2	4.5.3	Groundwater Sampling and Analysis Plan
11.010(11)(C)3	3.10.1	Groundwater Quality
11.010(11)(C)6	3.10.3	Corrective Action
11.010(12)	3.13	Air Quality
11.010(12)	4.6	Air Quality
11.010(12)(B)	4.6.1	Dust Control
11.010(13)	4.7	Aesthetics

STATE OF MISSOURI DEPARTMENT OF NATURAL RESOURCES
MISSOURI SOLID WASTE MANAGEMENT
10 CSR 80-11 RULES (continued)

10 CSR 80-	REPORT SECTION	TITLE
11.010(13)	4.7.1	General Aesthetics
11.010(13)(C)3	4.7.2	Mining for Beneficial Reuse
11.010(14)	3.12	Landfill Final Cover
11.010(14)	4.9	Final Cover Material
11.010(14)(B)	Appendix R	Closure and Post-Closure Plan
11.010(14)(B)	3.15	Closure and Post-Closure
11.010(14)(B)	3.12.1	Materials and Construction
11.010(14)(B)1	3.2.2	Soil Material Volume
11.010(14)(B)1	3.11.1	Soil Cover Sources
11.010(14)(C)	3.12.1	Materials and Construction
11.010(14)(C)	3.12.1.1	Soil Component
11.010(14)(C)1	3.11	Cover Material
11.010(14)(C)3	3.12.1.1	Soil Component
11.010(14)(C)7	3.12.2	Vegetation
11.010(14)(C)10	3.12.1.1	Soil Component
11.010(15)	4.8	Equipment and Staffing
11.010(15)	4.10	Compaction
11.010(15)(B)1	4.8.2	Equipment Maintenance
11.010(15)(B)1	4.8.3	Back-Up Equipment
11.010(15)(C)	4.8.4	Staffing
11.010(15)(C)1	4.8.1	Primary Equipment
11.010(16)	4.11	Safety
11.010(16)(B)1	2.3	Site Access
11.010(16)(B)1	4.0	Landfill Operation
11.010(16)(C)2	2.3	Site Access
11.010(17)	4.12	Records
11.010(17)	Appendix T	Recordkeeping and Reporting Forms
11.010(17)(C)2.A(I)	Appendix A	Property Deeds
11.010(17)(C)1.D	Appendix L	Landfill Life Estimate
11.010(17)(C)1.D	3.2	Volume of the Proposed Landfill
11.010(17)(C)1.D	3.2.1	Landfill Life Expectancy

NOTE: Franklin County Requirement for Erosion Protection, Article 10 Section 238 C 3d is referenced in 3.3.2.3.

From: Skitt, Barbara S
Sent: Thursday, November 15, 2012 5:39 PM
To: pnwakoby@expl.com
Cc: Reynolds, Renee M; Gerhardt, Kevin J
Subject: Ameren's Labadie Plant UWL Layout

Hi Patrick,

Thank you so much for your time again yesterday. Please find attached the revised layout of the Labadie UWL landfill. As we discussed the proposed landfill will no longer require a relocation of the pipe line. The new layout has the toe of the berms set back 100' off the centerline of the pipeline. The first 2 phases of the landfill will be west of the pipeline with no impact to the pipeline and phases 3 and 4 are east of the pipeline. Once phases 3 and 4 are constructed, 2 roads will be installed perpendicularly over the pipeline. These roads are for Ameren traffic only and are planned to only be gravel at a height of around 15'. These roads will be constructed in a way as not to impact the pipeline. These road will be able to be removed in short order if Explorer has a need to access their pipeline. Phases 1 and 2 have a life expectancy of 10-15 years after they go in service in 2015. Construction on phase 1 is scheduled for 2014. If you have any question feel free to call and discuss. **Please treat this email and attachment as confidential.**

Have a good evening.

::::::::::::::::::::::::::::::
BARBARA S. SKITT
Managing Supervisor
Real Estate Department
T 314.554.2249
C 314.401.8674
F 314.554.2570
E bskitt@ameren.com
....

Ameren Services
1901 Chouteau Avenue
PO Box 66149, MC 700
St. Louis, MO 63166-6149
Ameren.com

RECEIVED

MAR 18 2013

FRANKLIN COUNTY MO
PLANNING & ZONING DEPT

FLOODPLAIN DEVELOPMENT PERMIT/APPLICATION

Application No. 120219 Date: ____

TO THE ADMINISTRATOR: The undersigned hereby makes application for a permit to develop in a floodplain. The work to be performed, including flood protection works, is as described below and in attachments hereto. The undersigned agrees that all such work shall be in accordance with the requirements of the Floodplain Management Ordinance and with all other applicable county/city ordinances, federal programs, and the laws and regulations of the State of Missouri.

AMEREN MISSOURI — Owner or Agent; Date: ____
NOT DETERMINED — Builder; Date: ____

Address: 10 LABADIE POWER PLANT RD. LABADIE, MO 63055
Address: ____

Phone: (314) 554-2249
Phone: ____

SITE DATA

1. Location: — 1/4; — 1/4; Section 17, 20 ; Township 44N ; Range 2E
   Street Address 10 LABADIE POWER PLANT RD. LABADIE, MO 63055
2. Type of Development: Filling X Grading ____ Excavation ____ Minimum Improvement ____
   Routine Maintenance ____ Substantial Improvement ____ New Construction X Other ____
3. Description of Development: CONSTRUCTION OF UTILITY WASTE LANDFILL
4. Premises: Structure Size N/A ft. By N/A ft. Area of Site 10,092,852 Sq Ft
   Principal Use UTILITY WASTE STORAGE Accessory Uses (storage, parking, etc.) —
5. Value of Improvement (fair market) $ 14,000,000 * Pre-Improvement/Assessed Value of Structure $ 0
6. Property Located in a Designated FLOODWAY? Yes ✓ No ____
   * COST ESTIMATE FOR FIRST PHASE

   IF ANSWERED YES, CERTIFICATION MUST BE PROVIDED PRIOR TO THE ISSUANCE OF A PERMIT TO DEVELOP, THAT THE PROPOSED DEVELOPMENT WILL RESULT IN NO INCREASE IN THE BASE (100-YEAR) FLOOD ELEVATIONS.

7. Property Located in a Designated Floodplain FRINGE? Yes ✓ No ____
8. Elevation of the 100-Year Flood (ID source) 482.5 - 483.5 FRANKLIN CO FIS, OCT 18, 2011 NAVD88 NGVD/NAVD
9. Elevation of the Proposed Development Site 465 NGVD29 GROUND ELEVATION. HIGHEST POINT 564. NGVD29 NGVD/NAVD
10. Local Ordinance Elevation/Floodproofing Requirement N/A NGVD/NAVD
11. Other Floodplain Elevation Information (ID and describe source) N/A
12. Other Permits Required?

	Yes	No	Provided
Corps of Engineer 404 Permit:		✓	
State Department of Natural Resources 401 Permit:		✓	
Environmental Protection Agency NPDES Permit:		✓	

All Provisions of Ordinance Number ____, the "Floodplain Management Ordinance", shall be in Compliance.

PERMIT APPROVAL/DENIAL

Plans and Specifications Approved/~~Denied~~ this 19th Day of MARCH, 2013

[signature] Signature of Developer/Owner
[signature] Authorizing Official

BARBARA SKITT, MANAGING SUPERVISOR, REAL ESTATE — Print Name and Title
TORI KARIM FLOODPLAIN MANAGER — Print Name and Title

OFFICE OF ZONING ENFORCEMENT
Franklin County Courthouse
Union, MO 63084

THIS PERMIT IS ISSUED WITH THE CONDITION THAT THE LOWEST FLOOR (INCLUDING BASEMENT FLOOR) OF ANY NEW OR SUBSTANITALLY IMPROVED RESIDENTIAL BUILDING WILL BE ELEVATED 2 FOOT/FEET ABOVE THE BASE FLOOD ELEVATION. IF THE PROPOSED DEVELOPMENT IS A NON-RESIDENTIAL BUILDING, THIS PERMIT IS ISSUED WITH THE CONDITION THAT THE LOWEST FLOOR (INCLUDING BASEMENT) OF A NEW OR SUBSTANITALLY IMPROVED NON-RESIDENTIAL BUILDING WILL BE ELEVATED OR FLOODPROOFED 2 FOOT/FEET ABOVE THE BASE FLOOD ELEVATION.

THIS PERMIT IS USED WITH THE CONDTION THAT THE DEVELOPER/OWNER WILL PROVIDE CERTIFICATION BY A REGISTERED ENGINEER, ARCHITECT, OR LAND SURVEYOR OF THE "AS-BUILT" LOWEST FLOOR (INCLUDING BASEMENT) ELEVATION OF ANY NEW OR SUBSTANTIALLY IMPROVED BUILDING COVERED BY THIS PERMIT.

II. THIS PERMIT IS CONTINGENT UPON AMEREN UE MISSOURI OBTAINING A "CONSTRUCTION PERMIT" FROM THE DEPARTMENT OF NATURAL RESOURCES. WITHOUT THE DNR PERMIT, THIS APPROVAL WILL BECOME NULL AND VOID

FRANKLIN COUNTY

Franklin County Highway Department
Eva Gadcke, Highway Administrator

400 EAST LOCUST STREET
ROOM 003A
UNION, MO 63084
MAIN LINE (636) 583-6361
FAX (636)584-0902
www.franklinmo.org

July 24, 2013

Craig Giesmann, PE, PMP
Managing Supervisor
Ameren – Power Operations Service
3700 S. Lindbergh Blvd., MC F-604
St. Louis, MO 63127

RE: Labadie Bottom Road Relocation

Dear Mr. Giesmann,

As part of the proposed landfill plans Labadie Bottom Road, a county road, will need to be relocated and an overpass from the plant to the landfill will need to be installed. I have been in contact with your engineer, Reitz & Jens, to review the county design requirements for these improvements. The traffic on this county road is mainly Ameren employees on the asphalted west end, and agricultural traffic on the graveled east end. We have not worked through final details of the roadway design or determined the extent of hard surfacing and gravel roadway. Our intent is to work with Reitz & Jens to come up with final plans for the roadway and submit them to the County Commission for approval.

Conceptually, the proposed relocation and overpass is accepted. The county reserves the right to approve the final plan details before construction can begin. Please let me know if you need additional information on this subject.

Sincerely,

Joe Feldmann
Franklin County Highway Dept.
County Engineer

CC: Mark Vincent
Paul Reitz, Reitz & Jens