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

TABLE OF CONTENTS

Section

Page

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 1×10^{-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.

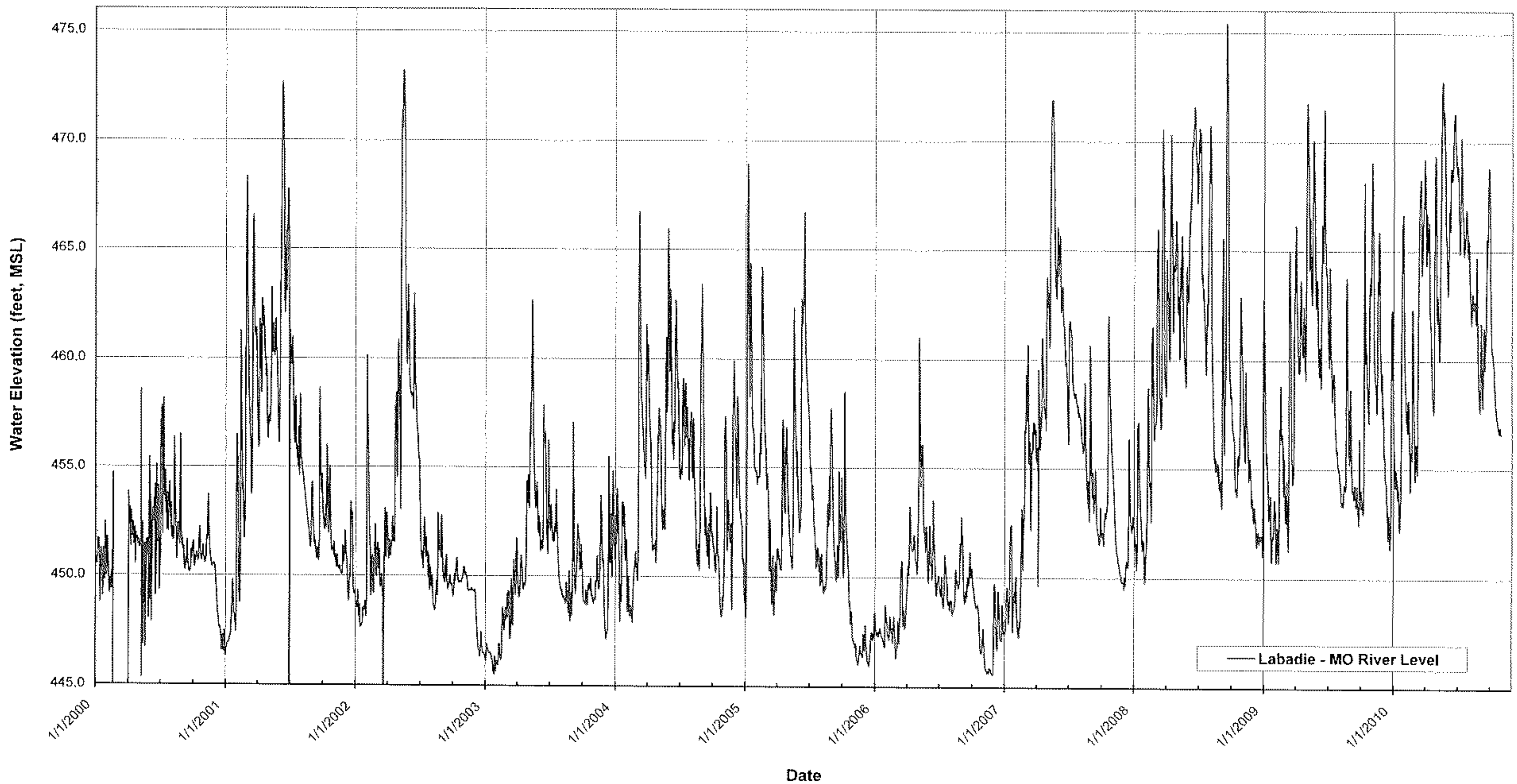
MDNR and Stark, Timothy D. (1997). Draft Technical Guidance Document on Static and Seismic Slope Stability for Solid Waste Containment Facilities. Solid Waste Management Program, Division of Environmental Quality, Missouri Department of Natural Resources, Jefferson City, MO, 96 p.

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
DESIGN BASIS FOR GROUND WATER LEVEL

April 9, 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:

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.

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

[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.

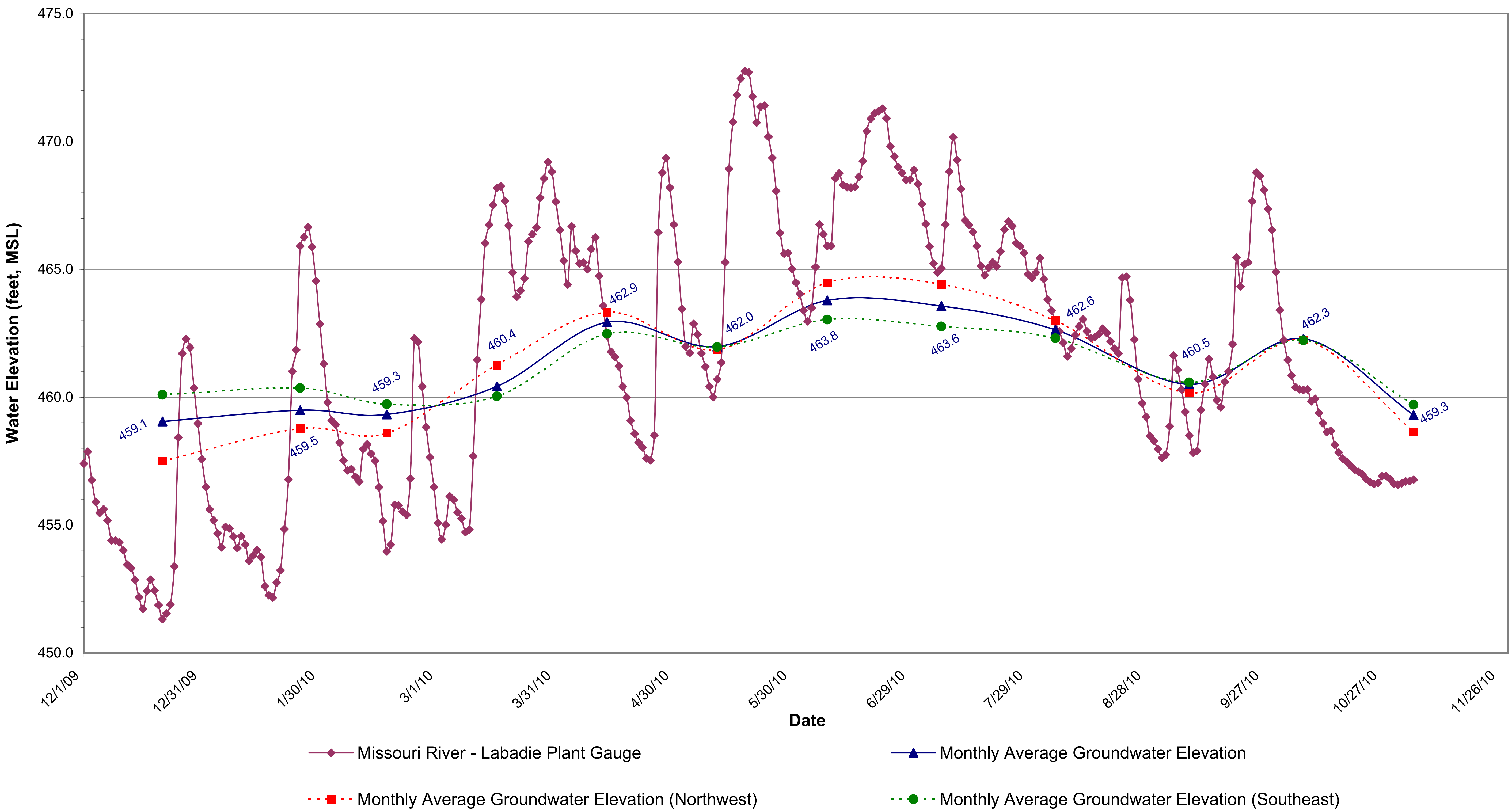
Attachments

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

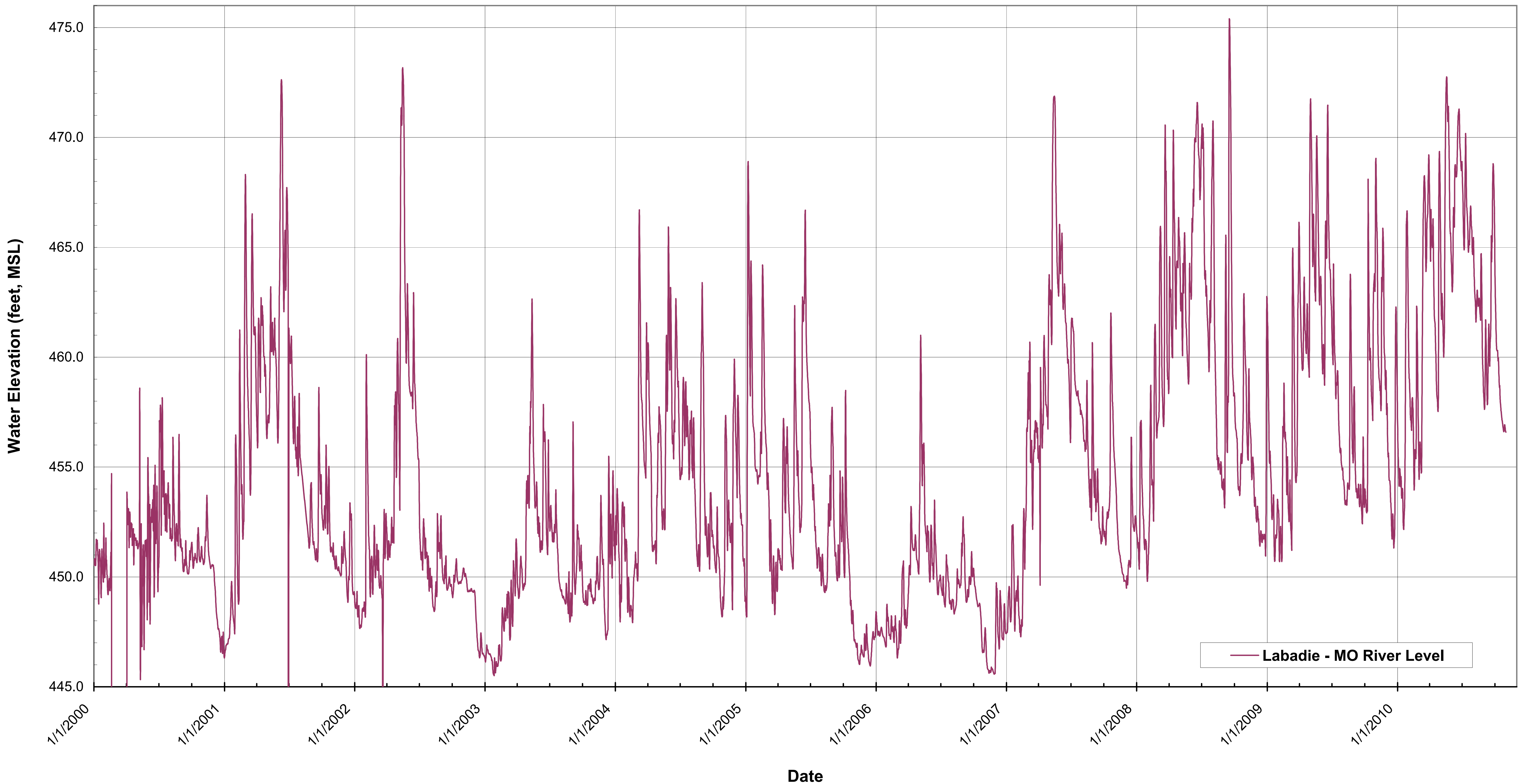
FIGURE 31



Detailed Site Investigation
Proposed Utility Waste Disposal
Ameren Missouri Labadie Power Plant

Missouri River 10-Year Historical Data (2000-2010)

FIGURE 32



<u>CONFIDENTIAL BUSINESS INFORMATION</u>

Ameren Missouri Labadie Power Station
Utility Waste Landfill
<u>DESIGN BASIS FOR EXTERIOR BERMS</u>
April 10, 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:

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.

<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 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

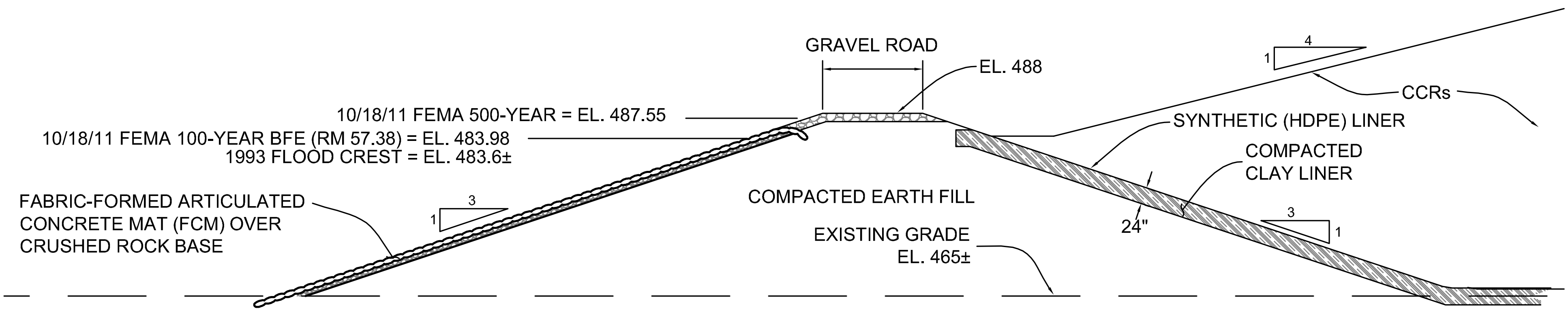
recommendation is to incorporate fabric-formed concrete mats (FCM) constructed using manufactured fabric forms and cast-in-place concrete (example shown in photo below). Evenly-spaced sewn filter “windows” or inserted plastic weep holes prevent excess hydrostatic pressures beneath the FCM as floodwater 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