Floodplain Analysis of the Missouri River for the Ameren Missouri Labadie Energy Center

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ABBREVIATIONS

BFE – Base Flood Elevation

cfs – cubic feet per second

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

FIS – Flood Insurance Study

HEC-RAS – Hydraulic Engineering Center River Analysis System

LFD – Letter of Final Determination

MSL – Mean Sea Level

NAD83 – North American Datum of 1983

NAVD88 – North American Vertical Datum of 1988

NGVD29 – National Geodetic Vertical Datum, 1929

NFIP – National Floodplain Insurance Program

SEMA – Missouri State Emergency Management Agency

USACE – United States Army Corps of Engineers

USGS – United States Geological Survey

GLOSSARY

CHECK-RAS – program designed to verify validity of parameters within HEC-RAS program.

FIRMette – Full Scale Section of a FEMA Flood Insurance Rate Map.

Floodplain Development Permit – Permit issued by the local regulatory agency which allows development within the regulatory floodway. [1]

River Miles – River miles stated in this report are miles upstream on the Missouri River from the confluence of the Missouri and Mississippi Rivers unless otherwise noted.

[1] This report assumes, for engineering discussion purposes only, that such ordinance applies to a utility waste landfill. The undersigned is not, however, an attorney or authorized or qualified to make any legal judgment or conclusion in such regard or as to any other matter provided herein, and we disclaim any intention to the contrary.

EXECUTIVE SUMMARY

The Ameren Missouri Labadie Energy Center, located on the south bank of the Missouri River, proposes to construct a waste disposal area in the form of a utility waste landfill (UWL) east of the existing ash pond. Preliminary design of this landfill began over one year ago and all preliminary designs were in accordance with the Federal Emergency Management Agency (FEMA) National Floodplain Insurance Program (NFIP) regulations in effect at that time. Based on the then-applicable requirements, the proposed landfill was located in an area designated as within the FEMA NFIP Missouri River regulatory floodplain, and outside of the regulatory floodway (in the floodway fringe).

FEMA has performed a new FEMA Flood Insurance Study (FIS) for the Missouri River and this preliminary FIS will become effective after October 18, 2011. The Preliminary Flood Insurance Rate Maps (FIRMs) that reflect the data in the Preliminary FIS will also become effective on that date. The Preliminary FIS would increase the regulatory base flood rate from 620,000 cfs to 674,000 cfs and significantly expands the boundary of the floodway. The Existing Conditions Model developed for this report incorporates the assumptions used to develop the Preliminary FIS and FIRMS and the expanded floodway boundary, which would now include the likely landfill area.[2]

Appendix H of the Franklin County Unified Land Use Regulations provides that "A floodplain development permit is required for all proposed construction or other development….in the areas described in Article H-2, Section A [to such Appendix]." The stated floodplain permit requirement would cover any development located within the "designated floodway". Certification would be required to show that the proposed development will not increase the water surface elevation during the regulatory base flood. This certification is known as a "no-rise" certificate. While the proposed development is not within the current regulatory floodway, the boundary revisions set forth in the Preliminary FIS and FIRM would result in the proposed landfill falling within the floodway. However, notwithstanding that regulatory change, the engineering assessment described herein reflects *that the proposed development will not result in any increase in the base (100-year) flood elevation and therefore meets the requirement of a "no-rise" condition even under the higher flow rate of 674,000 cfs in the Preliminary FIS.*

FEMA requires that certain development within the regulatory floodway result in "no-impact". "No-impact" occurs if the floodplain is able to manage the flow rate such that base flood elevations, regulatory floodway elevations, or regulatory floodway widths remain unchanged. Verification of this "no-impact" condition is documented on an Engineering "No-Rise" Certificate and the "no-impact" condition is typically referred to as a "no-rise" condition.

The results of the hydraulic analysis performed for this proposed development reflect that the proposed landfill will:

1) not impact the base flood elevations,
2) not impact the regulatory floodway, and
3) not impact the regulatory floodway width.

By satisfying all three of these conditions, this project successfully meets the requirements for a "no-rise" certification. The proposed development will meet all regulatory requirements currently in effect and as proposed in the Preliminary FIS and FIRMs.

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[2] CDG Engineers believes the revised preliminary floodway boundary is wider than required based on our engineering analysis and is inaccurate for this reach of the Missouri River.

1.0 OVERVIEW

The Ameren Missouri Labadie Energy Center is located along the southern bank of the Missouri River at approximate River Mile 58[3] in Franklin County, Missouri and is as located on Exhibit A.

This 4-unit power station is fueled by coal and has a rated capacity of 2,389 MW. The byproducts of coal combustion that are not beneficially used are managed on site in waste disposal areas. These waste disposal areas are nearing total capacity. To manage the anticipated volume of coal combustion waste, Ameren Missouri proposes to construct a new utility waste landfill located east of the existing station at approximate River Mile 57, as shown on Drawing C-101 – Site Map.

2.0 PURPOSE

The purpose of this submittal is to demonstrate that the issuance of a Floodplain Development Permit for the construction of a utility waste landfill in the Missouri River regulatory 100-year floodplain is appropriate and in accordance with regulatory requirements. The proposed landfill, according to the current Flood Insurance Rate Map, is located within the floodplain (floodway fringe) but not within the regulatory floodway. However, once the Preliminary FIRMs become effective on October 18, 2011, the proposed landfill will fall within the regulatory floodway. Accordingly, a Floodplain Development Permit for this project will require a "no-rise" analysis and technical data support for an Engineering "No-Rise" Certificate.

3.0 REGULATORY REFERENCES

The Floodplain Development Permit application and subsequent Engineering "No-Rise" Certificate were prepared according to the following standards and codes.

3.1 Current FEMA Data

FIS	Franklin County, Missouri, April 16, 1984
FIRM	2904930105B, October 16, 1984
Floodway Boundary and Floodway Map	290430105, October 16, 1984

Excerpts from the current Franklin County, Missouri FIS are included in Appendix A.

3.2 Preliminary FEMA Data

The National Flood Insurance Program has performed a new Flood Insurance Study and prepared new Flood Insurance Rate Maps. These new maps have not been published, but when published will be the regulatory data effective October 18, 2011. FEMA approved the Final Flood Elevation Determination on April 18, 2011. A copy of the LFD to Franklin County, Missouri is included in Appendix B.

[3] 58 miles upstream from the confluence of the Mississippi River.

The Preliminary Franklin County, Missouri FIS and FIRM panels applicable to this project include the following:

FIS	Franklin County, Missouri, to become effective October 18, 2011
FIRM	Map No. 29071C0180D, to become effective October 18, 2011 Map No. 29071C0185D, to become effective October 18, 2011 Map No. 29071C0190D, to become effective October 18, 2011 Map No. 29071C0195D, to become effective October 18, 2011

Excerpts from the Preliminary Franklin County, Missouri FIS and FIRMettes of the project area are included in Appendix C.

3.3 Franklin County, Missouri (SEMA) Floodplain Development Permit

The regulations pertaining to traditional, non-exempt floodplain development within Franklin County, Missouri are the Franklin County, Missouri Unified Land Use Regulations, Article 11 – Floodplain, Drainage and Erosion and Appendix H – Floodplain Management. Franklin County is a member of the FEMA National Flood Insurance Program (NFIP) and abides by the FEMA regulations. FEMA NFIP regulations state that certain proposed construction projects within the 100-year (1% occurrence) floodplain shall acquire a floodplain development permit. Franklin County has adopted this procedure; see Section E, Floodway, of the Unified Land Use Restrictions as noted below:

> *"2. The community shall prohibit any encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment* ***would not result in any increase in flood levels within the community during the base flood discharge****."*

Franklin County utilizes the Missouri State Emergency Management Agency's Floodplain Development Application Permit and Engineering "No-Rise" Certificate. The completed Missouri Floodplain Development Application Permit is included in Appendix D. The completed Missouri SEMA "No-Rise" Certificate is included in Appendix E.

4.0 HYDRAULIC ANALYSIS

4.1 "No-Rise" Methodology

FEMA requires that certain development within the regulatory floodway result in "no-impact" and that there is no measurable increase on base flood elevations, regulatory floodway elevations and regulatory floodway widths as explained below. Verification of this "no-impact" condition is documented on an Engineering "No-Rise" Certificate and the "no-impact" condition is typically referred to as a "no-rise" condition.

FEMA requires the development and analysis of four hydraulic models to evaluate proposed modifications within the floodway and to demonstrate that the "no-impact" requirements are met, thus demonstrating a "no-rise" condition. These models, in order of analysis are: the Currently Effective Model, the Duplicate Effective Model, the Existing Conditions Model, and the Proposed Conditions

Model. The following sections provide definitions of these four models and the procedures specific to each model necessary to prepare the technical data to support an Engineering "No-Rise" Certificate.

4.1.1. Currently Effective Model

The Currently Effective Model is the model that was developed by FEMA or their designated NFIP representative to define the current regulatory FIS and FIRM panels for a particular stream or river.

Step 1 Obtain the "Currently Effective Model" from the FEMA project library and/or the source designated by a FEMA NFIP representative.

Step 2 Obtain and review the FIS and FIRM panels that encompass the area of analysis.

4.1.2 Duplicate Effective Model

The Duplicate Effective Model is the Currently Effective Model as run by an engineer to verify that the model obtained from FEMA, or their NFIP representative, duplicates the data presented in the FIS and on the FIRM(s).

Step 3 Run the Duplicate Effective Model to reproduce (duplicate) the printed data in the FIS. Note the water surface elevations at the published cross-sections provided in the effective FIS.

Step 4 Compare the results of the Duplicate Effective Model with the printed data in the FIS. There should be no difference between the results of the Currently Effective Model and the Duplicate Effective Model. These two models should be consistent with the current FIS and FIRM panels.

4.1.3 Existing Conditions Model[4]

This model is the revised version of the Duplicate Effective Model as modified to reflect site-specific existing conditions. Additional cross-sections are incorporated to better define the river and the floodplain in the area of any proposed development. More cross-sections may then be added in the area of proposed development to define the existing conditions for specific areas that will be modified by the proposed development.

Step 5 Prepare a base map that incorporates data from the FIRM and other topographic data.

Step 6 Modify existing FIS cross-sections based on better topographic data in the project area.

Step 7 Identify and add additional cross-sections to further define the area of the proposed development.

Step 8 Manually set regulatory floodway limits at the new cross-sections by measuring the width of the regulatory floodway from the effective FIRM. See Section 4.2.1 of this report for an explanation of floodway.

[4] The Existing Conditions Model was previously known as the "Corrected Effective Model".

Step 9 Determine ineffective flow areas for the existing conditions. See Section 4.2.2 of this report for explanation of ineffective flow area.

Step 10 Run this model with the base flood flow rate as stated in the FIS. The calculated water surface elevations are established at all of the sections (new and existing) and are then noted and used for comparison purposes. Compare these water surface elevations of the regulatory cross-sections with the results from Step 3 above. These elevations should be essentially the same. Some slight differences may be noticed due to more accurate topographic data developed in the immediate area of a site. The elevations obtained from this model become the base elevations for later comparison to determine if a rise in water surface elevation occurs.

4.1.4 Proposed Conditions Model

This model incorporates all changes within the Existing Conditions Model and includes new information related to the proposed development.

Step 11 Modify the additional cross-sections added in Step 7 above to reflect the proposed development.

Step 12 Include these modified sections into the Existing Conditions Model.

Step 13 Modify ineffective areas based on the proposed development.

Step 14 Run the Proposed Conditions Model with the 100-year flow rate as presented in the effective FIS. Note water surface elevations.

Step 15 Compare the results from the Proposed Conditions Model at the 100-year flow rate with the results from the Existing Conditions Model, Step 10 above. Compare water surface elevations at all cross-sections, both published and site specific.

4.1.5 "No-Rise" Comparison

The difference in the water surface elevation between Steps 10 and 14 is considered the "rise" in the river that can be anticipated due to the proposed development. A rise of less than +0.01 foot is considered a "no-rise" condition.

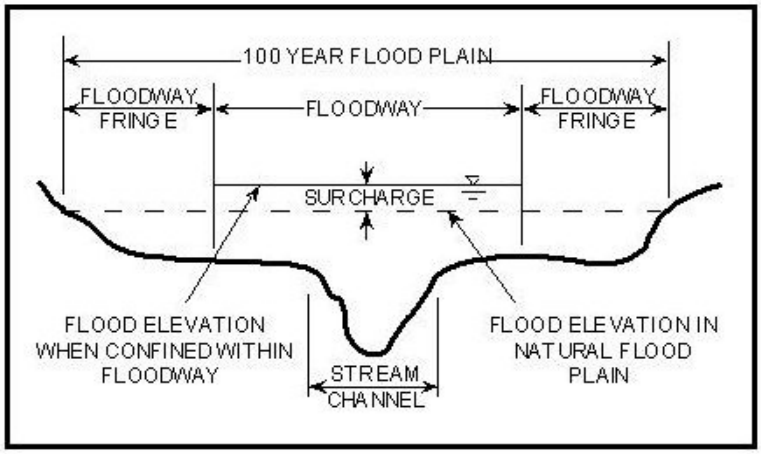
4.2 HEC-RAS

The USACE HEC-RAS software is a one-dimensional model used to perform steady or unsteady flow hydraulic analysis and can be used for the four models previously discussed. The steady flow analysis within HEC-RAS is designed for applications in the flood plain. This program has the specific capability to determine changes in water surface profiles due to improvements within a flood plain. During the development of the various models necessary to determine a "no-rise" condition, numerous parameters are evaluated and input into the model as described below. Further definition of the HEC-RAS program and the equations used within this system can be found in the HEC-RAS Hydraulic Reference Manual.

4.2.1 Floodway

A "regulatory floodway" is an area along a watercourse and the adjacent lands that is reserved in order to pass a regulatory flood without increasing the water surface elevation more than a set amount. Within

FEMA regulations, this set amount is 1 foot. To determine the floodway, first, determine the floodplain for a watercourse that indicates the lateral extent of the water surface profile during the regulatory flooding event. After that lateral extent is determined and the base flood elevation is set, move the extents of the area the river can flow through in towards the channel until the water surface elevation in the river reaches the base flood elevation plus the predetermined allowable increase. The width of this compressed flow path is considered the floodway. The area between the floodway and the extent of the floodplain is known as the floodway fringe. Theoretically, no adverse effect on the river will be realized during development anywhere within the floodway fringe. Development within the floodway can occur if it can be shown that the proposed development does not create a rise in the base flood elevation during the regulatory flooding event. A pictorial representation of the floodway is shown in the following sketch.[5]

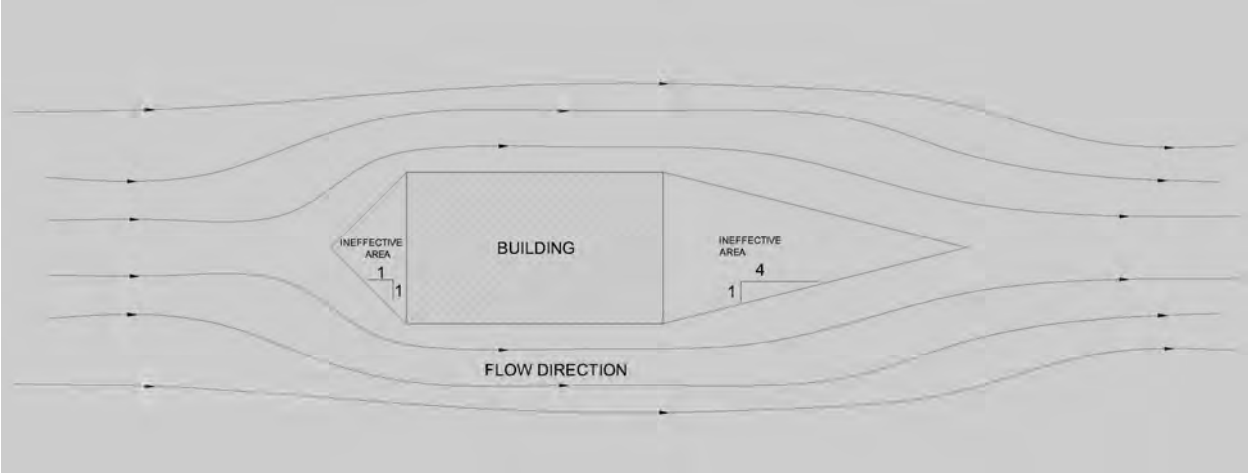


The HEC-RAS program can evaluate a watercourse with the floodway “on” or “off”. If the floodway is “on” in the program, this indicates the flow is confined to the floodway limits. If the floodway is “off” in the program, the flow is not confined and extends laterally to its natural width in the floodplain.

4.2.2 Ineffective Flow Area

Options within the HEC-RAS program allow for the restriction of flow within a so-called "ineffective" flow area of a cross-section. The term "ineffective" reflects a phenomenon where a flow area contains moving water but the velocity of that water in the downstream direction is close to zero. As a result, such an area does not convey flow in the direction of the main channel and therefore does not contribute to the actual flow area, therefore it is considered "ineffective." An ineffective flow area is created both downstream and upstream of an obstruction within the flow path. The area downstream of an obstruction is considered in a shadow, and the flow is effectively minimized. A large obstruction such as an area of raised elevation upstream may cast a shadow downstream; even a series of smaller obstructions may create a shadow between them, creating a reduced flow area. Small obstructions in the flow of a river such as a building will typically create an upstream shadow of 1:1 based on the face of the building perpendicular to the flow and a typical hydraulic shadow of 4:1 downstream. The following sketch illustrates this phenomenon.

[5] FEMA, National Flood Insurance Program (NFIP) Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials



Developments (buildings, fill area, etc.) constructed within an ineffective area tend to have no effect on the conveyance (ability to pass flow) of the stream and, therefore, will not create a rise in elevation (a "no-rise" condition). Due to the presence of the Labadie Energy Station and other physical obstructions, the proposed footprint of the landfill falls within such an ineffective area

4.2.3 Flow Rates

The previous notation of the 100-year discharge is now referred to as the 1-percent annual chance discharge. Under the Franklin County, Missouri, FIS to become effective October 18, 2011, flow rates report the 1-percent annual chance discharge for the Missouri River at the project site as 674,000 cfs. The current regulatory 1-percent flow rate is 620,000 cfs as stated in the Current FIS dated April 16, 1984. Relevant pages from this Franklin County, Missouri, Preliminary FIS are included in Appendix C of this report.

5.0 HYDRAULIC ANALYSIS OF PROJECT AREA

5.1 Site Description

The Ameren Missouri Labadie Energy Center, located at approximate River Mile 58 in Franklin County, currently includes a power plant, miscellaneous access roads, and numerous waste disposal areas. The average site elevation in the vicinity of the power plant buildings is 491 NGVD29. A portion of the site includes an existing ash pond surrounded by a protective levee to an average elevation of 492 NGVD29; typical ground surface elevation outside of this levee is 465 NGVD29. The location of the proposed landfill is directly east of the existing ash pond levee, between River Mile 57 and 58. An existing farm levee is located between River Miles 55.9 and 57.5, separating the Missouri River from the proposed landfill site. The elevation of this levee ranges from 474 to 480 NGVD29. An elevated access road is proposed connecting the landfill and the power plant. The site elements are shown on Drawing C-101.

5.2 Regulatory Data

The regulatory FEMA data in effect are the Current FIS and FIRM panels, dated April 16, 1984. The Franklin County, Missouri Preliminary FIS and FIRM panels to become effective October 18, 2011 were selected as the regulatory flood data for the purpose of this report. A detailed explanation about the selection process of the appropriate regulatory data is included in Section 8.0 of this report.

According to the Franklin County, Missouri Preliminary FIS, the 1-percent annual chance regulatory flow rate for the Missouri River in the vicinity of the proposed project is 674,000 cfs. The project site is located between the regulatory locations of Femme Osage River on the eastern boundary of Franklin County and Charrette Creek at Washington, Missouri. The 1-percent annual chance flow rate at both locations is 674,000 cfs as published in the Franklin County Preliminary FIS to become effective October 18, 2011 and was verified in the Currently Effective Model received from Greenhorne & O'Mara. Excerpts from the Franklin County Preliminary FIS to become effective October 18, 2011 are included in Appendix C of this report.

The Preliminary FIS includes two regulatory cross-sections in the immediate vicinity of the proposed project; Section F downstream of the proposed project and Section G upstream of the proposed project as shown on Drawing C-102. The BFE for the proposed project site averages El. 483' NAVD88.

The FEMA website now provides digital FIRMs that can be downloaded and inserted into CAD drawing files. The project site is located within portions of four Preliminary FIRM panels: #29071C0180D, #29071C0185D, #29071C0190D and #290071C0195D. These four Preliminary FIRM panels were combined. The footprint of the proposed landfill was included in this drawing and is included as Drawing C-102. The Preliminary FIRMs effective October 18, 2011 for this area indicate the proposed project will be located in the regulatory floodway. Specific Preliminary FIRMettes were created from the FEMA website for the project area and are included in Appendix C of this report.

5.3 Vertical Datum

The base elevation data was initially developed from the USGS Zone 15 Geological Survey, 7.5 minute series topographic map, Labadie, Missouri, 38090-E7-024 Quadrangle, NGVD29. Base survey data obtained from FEMA's engineering consultant was NGVD29. Current sounding data obtained from the River Engineering and Restoration Branch, U.S. Army Corps of Engineers, Kansas City, Missouri was in NAD83, UTM Zone 15N. Spot survey data collected for this project were in NAVD88.

All survey information from all sources was converted to NGVD29 format. All elevations presented in this report are in NGVD29 unless otherwise noted. NAD83 and NGVD88 refer to the same datum. NGVD29 is 0.13' higher than NAVD88.

5.4 Detailed Hydraulic Analysis

The following is a summary of the hydraulic analysis that was performed in accordance with Section 4.0 of this report. Detailed explanations of the results from these models will be presented in Section 6.0 of this report.

5.4.1 Currently Effective Model

Step 1 On May 11, 2011, CDG Engineers requested the official currently effective model (in effect after October 18, 2011) of the Missouri River from the FEMA authorized consultant, Greenhorne & O'Mara. CDG Engineers received an email from Greenhorne & O'Mara on May 23, 2011 that provided access to this model via an FTP website. This model includes the entire reach of the Missouri River, from the confluence with the Mississippi River upstream approximately 498 miles. A copy of this request and the response are included in Appendix F of this report.

The Currently Effective Model was prepared using the U.S. Army Corps of Engineers HEC-RAS software. Hydraulic modeling performed by CDG Engineers for the following steps used the same software.

Step 2 The Franklin County, Missouri Preliminary FIS report and applicable Franklin County, Missouri Preliminary FIRMs that will become effective after October 18, 2011, were downloaded from the FEMA map service center website, under Product Catalog, and in particular from the Future FIRMs section and the Future Flood Insurance Studies section. The Preliminary FIS and Preliminary FIRMs were reviewed and data was checked to verify the data in the Preliminary FIS and on the Preliminary FIRMs were consistent.

5.4.2 Duplicate Effective Model

Step 3 The Currently Effective Model (in effect after October 18, 2011) was run to create the Duplicate Effective Model using the preliminary regulatory flow rate of 674,000 cfs. The results from this model should duplicate the printed data for the published sections provided in the Preliminary FIS.

Step 4 The results from the Duplicate Effective Model were compared with the printed data in the Preliminary FIS. There was no difference between the Current Effective Model and the Duplicate Effective Model. The results from these two models match the data published in the Preliminary FIS and on the Preliminary FIRM panels, effective date October 18, 2011.

5.4.3 Existing Conditions Model

Step 5 A base topographic map was prepared that incorporates data from the Preliminary FIRM and other topographic data, Drawing C-103. This map combined several sources of topography including sounding data from the USACE. Limits of this sounding data are shown on Drawing C-104.

This base map is based on NGVD29 datum for elevations. Elevation data added to this map was converted to this datum. The Currently Effective Model (effective October 18, 2011) is based on NGVD29. The Preliminary FIS and Preliminary FIRM panels are referenced in NAVD88 elevations. Refer to Section 5.3 of this report to see the conversions between these referenced elevations.

As shown on Drawing C-103, the power plant site and railroad spur are built at a higher elevation than the surrounding bottom land. This elevation forms a plateau that remains above the base flood elevation during the regulatory flood event.

Step 6 The Existing Conditions Model includes three distinct types of cross-sections; 1) the regulatory cross-sections that are published in the Preliminary FIS and on the Preliminary FIRM panels, 2) cross-sections included in the currently effective model that are not published in the Preliminary FIS or on the Preliminary FIRM panels, and 3) cross-sections developed within the site at areas of major change in topography or at existing and proposed obstructions in the floodplain.

The preliminary regulatory cross-sections of the Missouri River in the project area are Sections E (River Mile 55.03), F (River Mile 56.15), G (River Mile 58.98) and H

(River Mile 60.4). CDG Engineers revised the preliminary existing cross-sections E, F, G and H to reflect more accurate topographic information. Current FIS and FIRM panels included five additional regulatory cross-sections in the project area. These cross-sections at River Miles 55.67, 56.61, 57.18, 57.85 and 59.73 are still included in the Currently Effective Model and have been maintained throughout this project. These five cross-sections included in the Currently Effective Model were modified based on the better topographic data in the project area. The regulatory cross-sections and the cross-sections included in the Currently Effective Model are shown on Drawing C-105.

Step 7 Fifteen additional cross-sections were developed and added to the Existing Conditions Model to further define the project area particularly in the area of the proposed development. All cross-sections, and the corresponding river miles, used in the Existing Conditions Model are shown on Drawing C-106 of this report.

Step 8 The floodway limits at the new sections were determined by measuring the width of the floodway from the Preliminary FIRM. Floodway limits are expressed as encroachment within HEC-RAS. Exhibit B presents encroachment data for all cross-sections within the models. The floodway as presented on the Preliminary FIRM dated October 18, 2011 is shown on Drawing C-107.

Step 9 The Currently Effective Model received from Greenhorne & O'Mara assumed all areas upstream and downstream of the existing power plant site as "effective" flow areas. In reality, the existing plant and the railroad spur located at the southwest corner of the power plant plateau form a peninsula into the Missouri River during times of high water.

This peninsula creates an area directly upstream and downstream that has ineffective flow. Options with the HEC-RAS program allow for the restriction of flow within an ineffective flow area of a cross-section. For clarification of ineffective flow area, refer to Section 4.2.2 of this report.

The preliminary Existing Conditions Model was originally run assuming that there were no ineffective areas (hydraulic shadows). The stream velocity results of this run are shown on Drawing C-108, Velocity Diagram 1% Flood Event. The results of this run show the velocity of the Missouri River at the 100-year base flow rate of 674,000 cfs. Velocity differences are represented by different colors. These velocities were determined by analyzing the velocity cross sections generated by HEC-RAS. Drawing C-109, Mean Velocity Calculations on HEC-RAS Velocity Gradient illustrates this procedure.

The ineffective areas upstream and downstream will have very low velocities. A review of Drawing C-108 reveals generally very low velocity directly downstream from the power plant. The velocities slowly increase downstream from the power plant as the effects of the hydraulic shadow tend to decrease with distance from the obstruction. The velocities directly south of the power plant (shown in deep blue) are slightly higher (1.40 fps) than the areas directly downstream of the plant (east) shown in green, yellow and orange (0.70 to 0.90). This is caused by swirling water, also referred to as an eddy.

The proposed ineffective area, as shown on Drawing C-108 (orange dotted lines) represents the areas of minimal velocity. Typically, ineffective areas are projected at 4:1 downstream and at 1:1 upstream. The ineffective area for this site is closer to a 3:1 downstream projection, a more conservative projection.

Drawing C-110, Ineffective Areas for Existing Conditions, shows the area modeled as "ineffective". The railroad spur located at the southwest corner of the power plant plateau effectively blocks the flow of the Missouri River. Areas downstream (east) do not convey flow.

Step 10 The Existing Conditions Model with the ineffective flow areas was run with a base flood flow rate of 674,000 cfs. The results are shown in blue on Exhibit C, columns 13, 14 and 15. The model was run in the natural condition (floodway "off") and with the floodway "on" as shown on the current FIRM (effective October 18, 2011). The HEC-RAS velocity sections for the Existing Conditions Model with the floodway "off" are included in Appendix G of this report. The HEC-RAS velocity sections for the Existing Conditions Model with the floodway "on" are included in Appendix H of this report.

Note that the calculated floodway surcharge is less than 1.0 foot and compares favorably with typical floodway tables where surcharge (increases) is one foot or less. These results indicate that the ineffective areas selected are appropriate.

The Existing Conditions Model was run through CHECK-RAS. The CHECK-RAS manual states,

> *"CHECK-RAS uses the data from the HEC-RAS geometric, steady flow, and output files to verify that the hydraulic estimates and assumptions made in the model appear to be justified, are in accordance with the applicable Federal Emergency Management Agency (FEMA) requirements, and are compatible with assumptions and limitations of the HEC-RAS program."*

The CHECK-RAS program analyzes data for Manning's "n", cross-sections, structures, floodway and profiles. The CHECK-RAS output did not indicate any areas of potential error.

CDG Engineers' Existing Conditions Model water surface elevations differ slightly from the Preliminary FIS. This variation is due to the more accurate Existing Conditions Model developed by CDG Engineers. The results of Exhibit C are also shown by a stream profile on Exhibit D, HEC-RAS Models Water Surface Elevation Profiles (Floodway Off).

5.4.4 Proposed Conditions Model

Step 11 Twelve cross-sections between River Miles 56.71 and 57.7 were modified to reflect the proposed development.

Step 12 The modifications to the cross-sections listed in Step 11 that reflect the addition of fill were included in the Proposed Conditions Model.

Step 13 Drawing C-111, Proposed Landfill Site with Sections, shows the proposed landfill footprint in green. This footprint was modified from the original design (reduced in size) and the proposed access road design was modified so as to be built within the ineffective flow area as determined in the Existing Conditions Model. Drawing C-112, Previous Landfill Site Footprint, shows the original design concept and the area that was removed. By locating the proposed landfill entirely within the existing conditions' ineffective flow area, the impact of the landfill on the floodway is null.

Step 14 The Proposed Conditions Model was run with the sections reflecting the modified landfill footprint, as shown on Drawing C-111, with a base flood flow (100-year) of 674,000 cfs. The calculated water surface elevations for all cross-sections are shown in Exhibit E, HEC-RAS Models Output Data Summary (red column). The Proposed Conditions Model was run in the natural condition (floodway "off") and with the floodway "on" as shown on the Preliminary FIRM (effective October 18, 2011). The HEC-RAS velocity sections for the Proposed Conditions Model with the floodway "off" are included in Appendix I of this report. The HEC-RAS velocity sections for the Proposed Conditions Model with the floodway "on" are included in Appendix J of this report.

Step 15 The calculated water surface elevations for all cross-sections in the Existing Conditions Model and Proposed Conditions Model were compared. The difference in elevation between the two calculated water surface elevations is considered the rise. A "no-rise" condition exists if the difference in elevations is less than +0.01 foot.

6.0 "NO-RISE" ANALYSIS

6.1 No Impact on Regulatory Floodway

As explained in Section 4.2 of this report, the floodway is the width within a floodplain that the river can be constricted to and still pass the regulatory flow without increasing the base flood elevation more than a predetermined amount. FEMA limits this increase to 1.0 foot. Each of the four models required within the "no-rise" analysis was run with the floodway "on" and with the floodway "off". Appendix K includes the first page of output from each of the models ran to determine the "no-rise" condition. The full HEC-RAS results are included on a disk accompanying this report.

Exhibits E and F present the regulatory base flood elevations from the Preliminary Franklin County, Missouri FIS without the floodway and with the floodway, respectively. The data presented in the Preliminary FIS is presented in NAVD 88; the elevations in relation to NGVD 29 are also included in this exhibit.

The Currently Effective Model was run with the regulatory sections and with the non-regulatory sections still included in the Preliminary FIS with the floodway and without the floodway (green data in Exhibits E & F). The increase due to the flow restricted to the floodway is shown. This data closely matches the Preliminary FIS data; there are minor differences in the increases at the regulatory cross-sections. This is attributed to the fact that the Existing Conditions Model is a more comprehensive and better defined model than the FIS and should be considered more accurate.

During the development of the Existing Conditions Model, an ineffective flow area was determined to be present upstream and downstream of the existing power plant, ash pond and railroad spur. To confirm the accuracy of the location of this ineffective flow area, the Existing Conditions Model was run with the floodway "on" and "off". The increase in base flood elevation with the floodway "on" was less than the

1.0 foot FEMA criteria and demonstrates that the location of the ineffective flow area is accurate. This also demonstrates that the width of the floodway would not be impacted due to the proposed development. These results are shown in blue on Exhibits E and F as Model Number 5.

The Proposed Conditions Model was run with the floodway "on" and "off" to confirm the proposed improvements did not adversely affect the floodway. These results are shown in red on Exhibits E and F as Model Number 6. The increase in the base flood elevation in the Proposed Conditions Model with the floodway "on" very closely correlates to the increase seen in the Existing Conditions Model, thus confirming the accuracy of the ineffective flow area as defined. The close correlation between these base flood elevation increases in the floodway confirms the proposed development does not impact the regulatory floodway.

6.2 No Impact on Base Flood Elevation

To determine if there would be any impact on the base flood elevation due to the proposed development, the Existing Conditions Model and the Proposed Conditions Model were run with the floodway "on" and "off". If the base flood elevations from the Proposed Conditions Model meet the 0.01 foot rise threshold, the proposed development is said to achieve a "no-rise" condition.

The results of these models with the floodway "off" show that the river flows to its natural lateral extent. These results are presented in Exhibit E. The difference in water surface elevations at all cross-sections when comparing the Proposed Conditions Model to the Existing Conditions Model is less than 0.01 foot of rise. Therefore, the proposed development creates no impact on the floodway with the floodway "off".

The Existing Conditions Model and the Proposed Conditions Model were run with the floodway "on" which constrains the flow within the regulatory floodway. The results of these models are presented on Exhibit F. When the models are run with the floodway on, the flow area is decreased and the top width is decreased. The roughness coefficient, Manning's "n", should remain the same. A summary of the variables within the two conditions (floodway "on" and floodway "off") is presented in Exhibit G.

The difference in water surface elevations at all cross-sections when comparing the Proposed Conditions Model to the Existing Conditions Model is less than 0.01 foot of rise. Therefore, the proposed development creates no impact to the floodway with the floodway "on".

6.3 "No-Rise" Determination

The determination of a "no-rise" conditions is based on three criteria; 1) no impact on the regulatory base flood elevation, 2) no impact on the regulatory floodway elevations; or 3) no impact on the regulatory floodway widths. Sections 6.1 and 6.2 confirm that there is no impact on any of these three requirements. Therefore, the proposed development meets the criteria for a "no-rise" condition.

7.0 SELECTION OF REGULATORY DATA AND FLOODWAY DISCUSSION

The preliminary design of the proposed landfill was in accordance with then effective FEMA NFIP regulations. Those regulations are in the process of being revised and this analysis incorporates those anticipated revisions including an increase of the 100-year base flow rate and an expansion in the area constituting the floodway.

During the development of the four required models in this hydraulic analysis, a request was made to the FEMA designated NFIP representative for the current regulatory model (Currently Effective Model) of the Missouri River. Upon receipt of this model, CDG Engineers ran this model to generate the Duplicate

Effective Model. In addition, CDG Engineers downloaded the current Franklin County, Missouri FIS and FIRM panels from the FEMA Map Service Center. The FEMA Map Service Center also includes a section for future FIS and FIRMs. CDG Engineers downloaded the documents listed under the future Franklin County, Missouri FIS and FIRMs section which were the DRAFT FIS and FIRMs, dated 2009.

During the time period of the preparation of this report, the Draft FIS and FIRMs were revised and are now available from the FEMA Map Service Center as the Preliminary FIS and FIRMs which will become effective after October 18, 2011. Since there are no regulatory cross-sections in the area of the proposed development, the closest regulatory cross-section was used for comparison.

The Current FIS (1984) presents a 100-year base flow rate of 620,000 cfs at Labadie. A new FEMA FIS has been performed for the Missouri River and this new hydraulic study is now supplied as the Currently Effective Model. The Currently Effective Model obtained from FEMA has a base flow rate of 674,000 cfs for the 100-year flood event. The data in the Currently Effective Model includes flows, topography and floodway definitions that do not match the Current FIS and FIRMs but do match the Preliminary FIS and FIRMs. Changes in the regulatory data are summarized in Table 1.

Table 1 – Regulatory Data Comparison, Current (1984) to Preliminary (2011)

	Current (1984)	**Preliminary (2011)**	**Currently Effective Model**
FIS Regulatory Flow Rate (100-year base flood)	620,000 cfs	674,000 cfs	674,000 cfs
FIS Regulatory Floodway Total Width	4768' Regulatory Cross-Section H RM 56	10,729' Regulatory Cross-Section F RM 56	10,729' RM 56.15
FIS Regulatory Floodway Width in Franklin County, Missouri	3,500' Regulatory Cross-Section H RM 56	10,030' Regulatory Cross-Section F RM 56	Not Available
FIRM Regulatory Floodway Width in Franklin County As Measured	3,500' Regulatory Cross-Section H RM 56	10,030' Regulatory Cross-Section F RM 56	Not Applicable

Since the data in the Currently Effective Model could be verified with the data presented in the Preliminary FIS and FIRMs to produce the Duplicate Effective Model, CDG performed the hydraulic analysis for this project based on the Preliminary FIS and FIRMs and with a 100-year base flood flow rate of 674,000 cfs.

Major changes to the Current FIS and FIRMs are proposed in these Preliminary FIS and FIRMs. The new FIS and FIRMs were developed by FEMA to reflect better topographic data and present a more defined hydraulic model; the Preliminary FIS increases the regulatory base flood rate from 620,000 cfs to 674,000 cfs. However, the Current (1984) FIS and FIRMs contain nine regulatory cross-sections between River Miles 54.03 and 60.4 and the Preliminary (2011) FIS and FIRMs contain only five regulatory cross-sections in the same reach. In particular, the regulatory cross-sections in the Preliminary FIS and FIRMs in the area of the proposed development are three miles apart and do not accurately define the project

area. The floodway boundary delineation is not specifically defined within this three mile reach within the Preliminary FIS and FIRMs. Even though we question this preliminary floodway boundary, CDG Engineers used this preliminary floodway boundary for all models within this report.

The Existing Conditions Model developed by CDG Engineers for this report better defines the floodplain in the project area. Engineering analysis indicates the regulatory floodway in the Preliminary FIS and FIRMs is wider than required. By definition, the floodway exists to allow the passage of the base flood flow without impedance. The floodway is the portion of the floodplain that transports the flow and is the area of high velocities. To define the floodway, the floodplain is reduced in width until it still transports the base flood flow but with a rise in the base flood elevation of 1 foot within the floodway width.

After collecting site specific topographic data in the project area, the Existing Conditions Model was created. An ineffective flow area was determined based on the hydraulic shadow of the existing ash pond as previously explained in this report. By definition, an area of ineffective flow does not convey flow and does not contribute to the actual flow area. The velocity in an ineffective flow area is close to zero. Reviewing the data presented in Exhibit C for the Currently Effective Model (green values) downstream of the project site, the increase in the water surface elevation with the floodway "on" (constraining the flow to just the floodway) shows an increase of from 0.81 feet to 0.89 feet. This indicates the floodway may possibly be set too broad and should be narrowed to reflect a 1.0 foot increase in base flood elevation.

Exhibit H is a flow visualization prepared to illustrate the hydraulic shadow phenomenon. The red arrows that are pointed directly downstream convey river water. The arrows that are in a swirling pattern (eddies) do not. These eddies can be observed in a river such as downstream of a bridge pier or a moored boat or barge. The exhibit shows the proposed landfill within the hydraulic shadow of the power station. The landfill would lie within the area where there is swirling water (an eddy) and, therefore, would not have any effect upon the conveyance of floodwater downstream.

Even though we question this preliminary floodway boundary, the hydraulic analysis of the proposed development using this floodway boundary and the data in the Preliminary FIS and FIRMs, reflects that construction of proposed landfill satisfies the requirements for a "no-rise" condition. Accordingly, the proposed development meets all eligibility requirements and for a floodplain permit, if required.

8.0 CONCLUSION

The Ameren Missouri Labadie Energy Center proposes to build a utility waste landfill east of an existing ash pond and railroad spur. The site is on the south bank of the Missouri River and the river flows from west to east. These two existing features block the flow of the Missouri River in this area and creates a hydraulic shadow downstream.

At present, the entire footprint of the proposed landfill lies within the current FEMA NFIP floodplain but outside of the current FEMA NFIP Missouri River floodway, in an area referred to as the floodway fringe. A new hydraulic study has been prepared for FEMA and the resulting Preliminary Franklin County, Missouri FIS and FIRM panels are set to become effective after October 18, 2011. The Preliminary Franklin County, Missouri FIS increases the 100-year base flood flow for this reach of the Missouri River from the current 620,000 cfs to 674,000 cfs. Based on the Preliminary Franklin County, Missouri FIRM panels, the proposed landfill will be within the FEMA NFIP regulatory Missouri River floodway after the adoption of the Preliminary Franklin County, Missouri FIS and these FIRM panels.

After extensive hydraulic analysis using detailed topographic data obtained for this project, CDG Engineers has concluded that the floodway width as defined in the Preliminary Franklin County, Missouri

FIS and FIRMs in the reach of the Missouri River downstream of the existing ash ponds is overly broad and a more accurate definition of this floodway is where the ineffective flow boundary line is shown on Drawing C-107.

The results of the hydraulic analysis of the proposed construction of the landfill as shown in Drawing C-111 will have no effect upon the 100-year base flood elevation of the Missouri River and meets all "no-rise" requirements when analyzed with the current Regulatory FEMA data and with the proposed Preliminary FEMA data. Therefore, the project meets the requirements of Franklin County's Floodplain Management Regulations and the regulations of FEMA's National Flood Insurance Program now and after the adoption of the Franklin County, Missouri Preliminary FIS and FIRMs and is eligible for a floodplain development permit, if legally required.

EXHIBITS

A Site with Image Background

B Encroachment Data

C HEC-RAS Models Output Data Comparison with and without Floodway

D HEC-RAS Models Water Surface Elevation Profiles (Floodway Off)

E HEC-RAS Models Output Data Summary without Floodway

F HEC-RAS Models Output Data Summary with Floodway

G HEC-RAS Sections Variable Summary with Floodway Off

H Flow Visualizations – Flood Conditions

T:\working\11042 – Ameren Labadie flood Plain Analysis\D – Calculations and Design Data\Civil\Hydro\CDG Dwgs\Site With Image Background.dwg
polovina 08/18/11–13:19

AMEREN SERVICES
LABADIE FLOOD PLAIN ANALYSIS
PROPOSED LANDFILL SITE
SITE WITH IMAGE BACKGROUND

REV.	DATE	DESCRIPTION	APPROVED

PROJECT NO. 11042
DRAWING NO. EXHIBIT A
DATE 08/18/11
SCALE SHOWN
CHECKED BY MWB
DRAWN BY KP

CDG ENGINEERS
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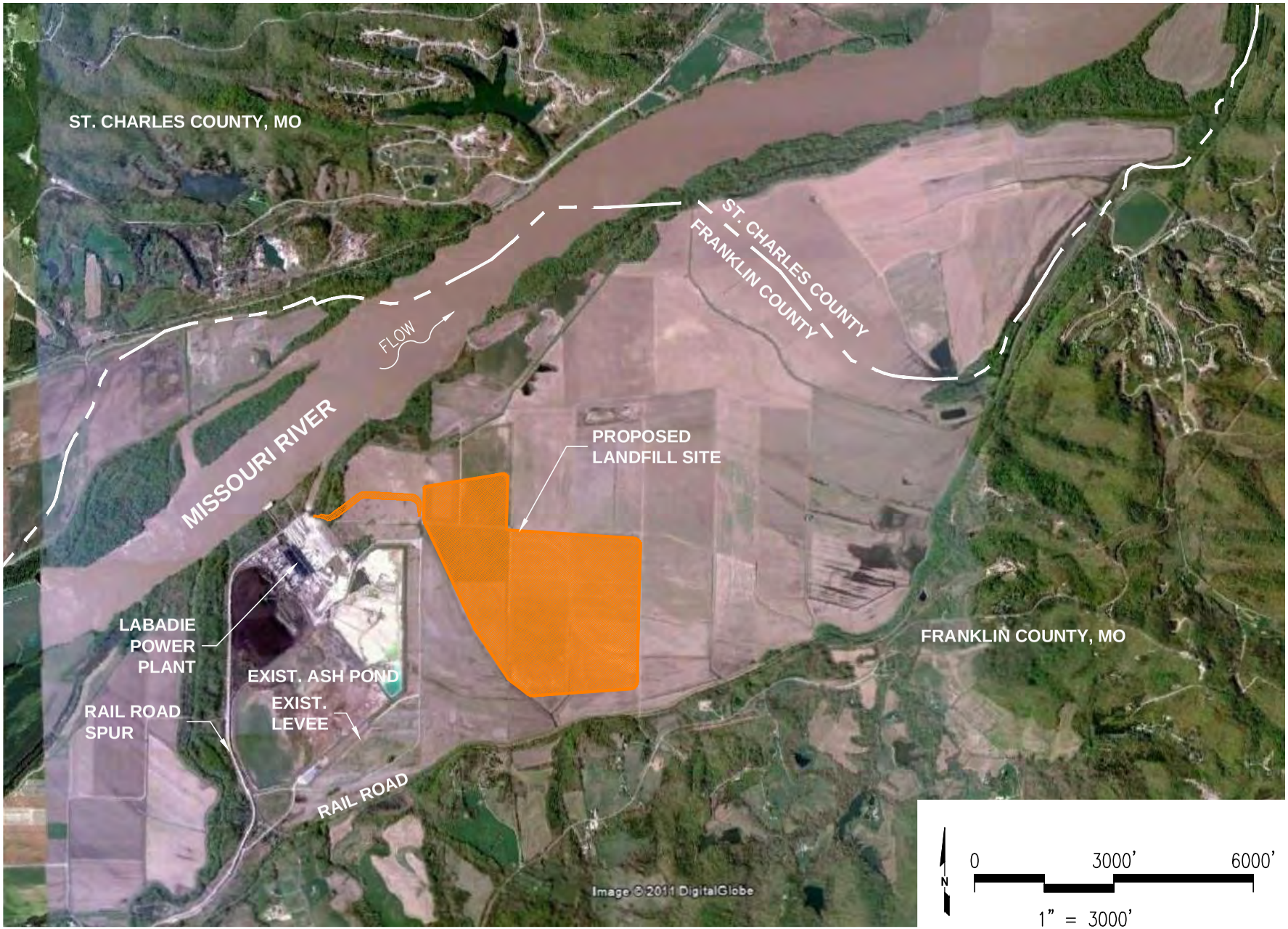
Ameren MISSOURI



AMEREN LABADIE POWER PLANT
FLOODPLAIN ANALYSIS FOR THE PROPOSED LANDFILL SITE
ENCROACHMENT DATA

CDG JOB #11042

SECTION NO	FIS CROSS SECTION	RIVER SECTION (HEC-RAS MODEL) APPROX. RIVER MILE	Enc Method[1]	Enc Sta L[2] (ft)	Enc Sta R[3] (ft)	COMMENTS About HEC-RAS Sections Location
1	H	60.4	1	1091	12293	Existing Section
2		59.73	1	1141	11428	Existing Section
3	G	58.98	1	908	11537	Revised Existing Section
4		58.65	1	484	11049[4]	New Section
5		58.41	1	689	11410	" " (Rail Toe of Slope)
6		58.4	1	647	11007	" " (Rail Top of Berm)
7		58.15	1	862	11508	New Section
8		57.85	1	1718	11542	Revised Existing Section
9		57.7	1	341	10894	New Section
10		57.61	1	396	10764	" "
11		57.54	1	422	10673	" "
12		57.52	1	427	10636	" "
13		57.38	1	502	10400	" "
14		57.32	1	514	10296	" "
15		57.18	1	1387	10494	Revised Existing Section
16		57.11	1	691	11099	New Section Prop. Landfill Site
17		57.01	1	619	10332	" "
18		56.93	1	549	10322	" "
19		56.79	1	459	10420	" "
20		56.71	1	428	10404	" "
21		56.61	1	530	10392	Revised Existing Section
22	F	56.15	1	971	11700	Revised Existing Section
23		55.67	1	530	10812	Existing Section
24	E	55.03	1	1841	11582	" "
25	D	54.03	1	1625	11698	" "

NOTES:

1. Encroachment Method 1 used by HEC-RAS Model
2. Encroachment Station Left
3. Encroachment Station Right
4. Stations Left and Right were measured from October 18, 2011 FIS

9/21/2011

EXHIBIT B