MEMORANDUM

SUBJECT: EPA Comments on "Assessment of Dam Safety of Coal Combustion Surface Impoundments: City Utilities of Springfield, John Twitter Energy Center (formerly Southwest Power Station), Springfield, Missouri"

DATE: January 16, 2014

On Thursday, January 9, EPA held a call with City Utilities of Springfield, MO regarding the utility's comments on the draft report for the John Twitty Energy Center. The below comment responses correspond to the utility's submitted comment document and are EPA's proposed revisions to the draft report subsequent to the utility's comments.

II. Specific Comments

1.1

A. Although the language is stock, EPA may want to consider adding a sentence stating, roughly:

> "The operation of the John Twitty Energy Center and the findings of this report are separate and distinct from any operations or findings that may have taken place at other facilities that have been assessed as part of this effort."

B. EPA clarified to JTEC that the POOR rating was based on lack of documentation. EPA may consider adding language that states, roughly:

> "Although the visual assessment, operation, and maintenance plans of this facility appear to be adequate, the lack of structural stability analysis documentation merits a POOR rating due to lack of information."

1.3

A. EPA will inform JTEC of an allowed extension to perform stability analyses in an appropriate time frame and forward to EPA. This information will be included in the final report.
B. JTEC will be allowed to provide the documentation.
C. JTEC has provided this documentation and will be included in the final report.
D. No response
E. JTEC will provide a description of the monitoring and surveillance program and provide EPA with documentation speaking to that effect.
F. JTEC will be allowed to provide the documentation.

1.4

A. EPA has asked for documentation of a basic H/H analysis which JTEC will be afforded the opportunity to supply.
B. EPA will rectify this language to ensure it accurately reflects state of Missouri requirements, while JTEC has committed to submitting any EAP plans available for incorporation in the final report. This is a requirement of the report that is independent of state regulation and provides information on the over operation of the unit.
C. No response
D. JTEC has committed to submitting updated monitoring well information including location and monitoring well plan

2.1

A. EPA will make change

2.2

A. EPA is willing to amend the language to "clear supernatant."

B. EPA is willing to clarify the waste handling of FGD and boiler slag at the plant, as explained by JTEC. JTEC may submit language explicitly defining this management of wastes.

2.3

A. No response

B. EPA will amend report to reflect clarification

2.4

A. EPA agrees with JTEC and will recommend the appropriate volumetric calculations are reflected in the final report

B. No response

2.5

A. No response

B. EPA will make the clarifying changes to the final report regarding the outlet structures

2.6.

A. No response

3.1

A. EPA will reflect this information with the submittal of sample monitoring checklists by JTEC

3.2

A. No response

3.3

A. EPA will reflect this information with the submittal of sample monitoring and surveillance checklists by JTEC

4.1

A. No response

B. EPA will make the clarifying changes to the final report regarding the outlet structures

C. EPA will make the clarifying changes to the final report regarding the outlet structures

4.2

A. EPA will reflect clarification in final report

B. JTEC will submit language regarding Missouri DNR instructing the removal of emergency spillways.

5.1

A. Clarification will be reflected in final report

B. EPA will insert language clarifying the specific guidelines from FEMA being used

C. EPA will clarify

5.2

A. No response
B. EPA will clarify

5.3

A. No response
B. EPA will clarify

Additional EPA Comments:

DATE: August 12, 2013

1. Please remove the blank page following the cover page.
2. On pages 2-1 and 2-2, Sections 2.2.3 and 2.2.4, please add a statement in each subsection as to how the waste is being handled. Also, in section 2.2.4, in the first line following "stored" add "in".
3. On page 4-1, Section 4.1.1, first paragraph, first line, replace "JETC" with "JTEC".
4. In Section 4.1.1 (page 4-2) the report states that "The common dividing embankment construction plans also show a 12-inch thick pond liner (liner), comprised of compacted lime and fly ash". In Appendix B, under liner, on "page 3", the report indicates "clay". Please rectify this inconsistency.

CITY UTILITIES

Bringing Power Home.℠

December 12, 2013

Submitted Electronically

Jana Englander
United States Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, D.C. 20460

Subject: ***Draft Assessment of Dam Safety of Coal Combustion Surface Impoundment; John Twitty Energy Center***

Ms. Englander:

City Utilities of Springfield, Missouri (CU) is pleased to submit the attached comments concerning the referenced draft report. Generally, we are grateful for the complimentary remarks regarding the operation, and maintenance of our coal combustion residuals impoundment. However, we are very concerned about certain factual inaccuracies regarding the design and regulatory status of the impoundments and puzzled concerning the overall characterization of the future suitability of the structure for its intended use. In light of these inaccuracies and disconnections described in the attached comments, we strongly suggest that the contractors who prepared the draft report contact us to discuss these concerns in detail. We are available by telephone (417.831.8778) or would be willing to travel to meet and discuss these issues at your convenience.

Respectfully,

David M. Fraley, Ph.D.
Director, Environmental Affairs
Dave.Fraley@cityutilities.net

Comments of City Utilities of Springfield, Missouri on "Assessment of Dam Safety of Coal Combustion Surface Impoundments – Draft Report"

Report Prepared for USEPA by CDM Smith, July, 2013 (Revision 1)
Comments prepared by City Utilities staff, November 2013

I. General Overview

The draft report describes the results of inspection occurring on August 27 and 28 by CDM Smith, accompanied by City Utilities (CU) personnel. The report states that the inspection revealed adequate operational procedures, adequate maintenance procedures, and no structural defects in the ash holding ponds at John Twitty Energy Center (JTEC). Yet the inspectors inexplicably rated the holding ponds at as "poor" with respect to continued safe and reliable operation in the future. As explained in the comments below, City Utilities adamantly disagrees with this unfounded characterization and welcomes the opportunity to correct the record of inspection.

CDM Smith, acting as contractor for USEPA, appears to have based their inaccurate ranking, despite empirical observations to the contrary, on certain documentation they claim was not provided by CU, certain Missouri safety regulations, and certain design flaws. In short, the records in question were not provided because they were not requested by CDM Smith, the regulations they cite do not apply to ponds as small as those at JTEC, and the design appears to be misrepresented, and possibly misperceived, by the report's authors. These and other shortcomings of the report are described in the section-by-section review below. CU feels that it would be virtually impossible to correct all of the inaccuracies of the draft report in one editorial effort. At a minimum, the inspectors should return to the site for additional information or, at a minimum, afford CU the opportunity for a conference meeting or call to address these errors.

The report also characterizes the JTEC ponds as having a "low" hazard potential rating with respect to downstream impacts. CU agrees with this straightforward assessment, since any impacts from the unlikely event of an impoundment failure of these small ponds would undoubtedly remain confined to the plant grounds.

II. Specific Comments

Section 1 – Conclusions and Recommendations

1.1. Introduction

a. The opening stock language concerning the unfortunate 2008 event at TVA's Kingston plant appears to convey the notion that the JTEC ponds are similar in size and function. Although this inaccurate depiction is ameliorated somewhat in the hazard assessment finding, this does not appear until late in the third paragraph. This should appear earlier and specifically denote that the finding makes a Kingston-style incident veritably unlikely.

b. The third paragraph includes the opinion that the JTEC ponds are "poor" for continued safe and reliable operation. For the reasons delineated below, CU strongly disagrees with that opinion.

1.2. Purpose and Scope

No comments

1.3. Conclusions

a. Paragraph 1.3.1 reveals that the ponds appear to be structurally sound, a finding which should carry great weight in the overall findings. This, in short, was the primary reason that the inspectors spent two days on site rather than conducting the survey by telephone or e-mail. Unfortunately, this positive finding does not appear to inform or influence the general conclusions of the report. Instead the paragraph appears to fault JTEC staff for not providing technical support documentation on pond stability. According to follow-up discussions with the personnel involved in the inspection, CDM Smith did not ask for this documentation, either during the inspection or at any time thereafter. CU questions how this lack of response to an unposed question can form the basis for the negative tone of the report, when actual field observations would appear to militate otherwise.

b. Paragraphs 1.32 and 1.3.2 suffer from the same deficiency as noted above. The documentation referenced was not provided because it was not requested. These paragraphs appear to have written themselves.

c. Again, paragraph 1.3.4 refers to documents not requested. The final design drawings are included as **Attachment 1** to these comments.

d. Paragraphs 1.3.5 and 1.3.6 chronicle the good condition of the impoundments, the outfall structure, the operability, the apparent historical integrity, and the adequacy of operating and maintenance procedures. All of these observations are affirmed by CU, but they appear to have no bearing on the report's conclusions.

e. Paragraph 1.3.7 inaccurately states that there is no monitoring or surveillance program in place. In fact the ponds are visually inspected daily by plant personnel and the dikes are inspected on a quarterly basis.

f. Paragraph 1.3.8 again refers to acceptable design and operations but concludes with a projection of "poor" future operability due solely to a lack of documentation – documentation which was not requested during the inspection.

1.4. Recommendations

a. CU believes the impoundments are capable of continued safe and reliable operation without the need for extensive hydrologic/hydraulic evaluation referenced in Paragraph 1.4.1. We would be willing to discuss alternatives with CDM Smith and EPA at your convenience.

b. Paragraph 1.4.3 states that the State of Missouri requires an Emergency Action Plan for coal combustion waste (CCW) impoundments. We find no state regulation that specifically requires an EAP for CCW impoundments in general. Although state dam safety rules do make reference to EAP requirements, the small ponds at JTEC are not subject to those regulations. Accordingly, CDM Smith should remove this wording from the report.
c. CU agrees that there were minor areas of vegetation on the inside slopes that might benefit from trimming. While these do not constitute a structural safety hazard, they may impede routine inspections. CU will consider reviewing our ongoing vegetation management program accordingly.
d. As discussed below, JTEC has installed a series of monitoring wells in the vicinity of the ponds since the time of the inspection. These wells will provide the data and surveillance recommended in paragraph 1.4.4.

1.5. Participants and Acknowledgments

No comments

Section 2 - Description of the Coal Combustion Waste Management Unit

There is a typographical error in the heading to this section

2.1. Location and description

a. The description of the plant physical location is generally correct except the zip code should read "65619." The zip code shown is for our Post Office box.

2.2. Waste handling

a. CU generally agrees with the description of fly and bottom ash in paragraphs 2.2.1 and 2.2.2. However, the characterization of bottom ash effluent from the three cascading settling basins upstream of the ponds as "slurry" is somewhat misleading. According to online technical dictionaries, the term "slurry" is reserved for mixtures containing more than 5,000 parts per million (0.5%) solids by weight. Following three successive sedimentation steps, the basin effluent registers far below this value and should be referred to as "clear supernatant." JTEC management has implemented measures over the past twenty years to minimize the amount of coal combustion residuals that ultimately reach the ponds.
b. JTEC is a pulverized coal plant, so does not produce boiler slag as a general rule, as would a cyclone or slag tap furnace. Any slag produced incidentally (e.g., from temporary variations in coal mineral chemistry) is handled and co-disposed with bottom ash. Similarly, JTEC does not and has no future plans to produce waste FGD slurry. The only FGD waste is from a dry lime process that is handled and co-disposed with fly ash. As

such, Paragraphs 2.2.3 and 2.2.4 are irrelevant as written and convey misleading information regarding the design and operation of the plant.

2.3. Size and hazard class

a. CU agrees with the recommended size and hazard class ratings shown in Table 2.3. These are small impoundments with a vanishingly small potential for downstream impacts.
b. A point of clarification is required in discussing Missouri Department of Natural Resources (MDNR) regulation of the ash ponds. MDNR does regulate the quality of ash pond *effluent* through its Division of Environmental Quality. However, MDNR does not regulate the *structural* or operational aspects of the ponds through its Dam and Reservoir Safety Council (MDNR is an umbrella agency. In addition to environmental quality, it also oversees dam safety, state parks and historic sites, land reclamation, geology and mineralogy, etc.).

2.4. Amount and type of residuals stored

a. The volumetric calculations appear to assume that the two ash ponds are cylindrical in shape (e.g., 3.36 acre area x 12 foot normal pool depth = 40 acre-feet volume). Actually, both ponds have tapered to conical bottoms, resulting in volumes one-third to one-half of the values calculated.
b. CU agrees with the description of the sources of solids introduced to the ponds.

2.5. Principal project structures

a. CU agrees with the description of the embankment and earthworks.
b. The outlet structure description in paragraph 2.5.2 is incorrect in one important respect. The east and west ponds do share a common outlet structure, but the outlet is by gravity rather than pumped drainage. The pumps located in the outlet building are used only to recycle clear water back to the plant for boiler seals and bottom ash conveyance. This design feature is important to the discussion at paragraphs 4.1, 5.4, and 7.1. In addition, the overflow pipes noted in this paragraph are important to the discussion in paragraphs 4.2 and 5.4.

2.6. Critical infrastructure downstream

We generally agree that an unplanned discharge from the ash ponds would not impact critical infrastructure downstream. We would also add that the entire volume would likely be contained within the plant grounds. A series of onsite berms constructed to control storm water sediment loading would make onsite containment even more likely.

Section 3 – Summary of Relevant Reports, Incidents, and Permits

3.1. Summary of reports on safety

JTEC personnel were correct in their assessment that there have been no structural problems, accidental releases, or similar safety incidents associated with the ash pond embankments. The plant has been operational for less than forty years and numerous employees, past and present, can attest to this safety record.

3.2. Summary of local, state, and federal environmental permits

Permit information is correct as described. It should again be noted that the MDNR permit is an effluent discharge authorization and does not fall under the purview of MDNR's Dam and Reservoir Safety Council.

3.3. Summary of spill/release incidents

JTEC personnel were correct in their assessment that there have been no accidental spills or releases associated with the ash pond embankments. DDM Smith indicates they cannot prove this because no performance records were produced by plant personnel. As noted above, JTEC personnel do maintain records of daily visual inspections and quarterly embankment inspections. Undoubtedly, any accidental discharge or breach would have been noted by plant personnel, duly recorded, reported to MDNR, and the resulting report provided to the inspectors on request.

Section 4 – Summary of History of Construction and Operation

4.1. Summary of construction history

a. CU generally agrees with the contents of paragraph 4.1.1 regarding original construction, except that the third paragraph related to the divider rock berms should be moved to 4.1.2. As indicated on the original Burns and McDonnell drawings in Appendix C of the report, these dividing berms were added at a later date. This occurred in the mid-1990s.
b. The last paragraph of 4.1.1 repeats the erroneous description of the outfall as a pumped discharge. See comments to paragraph 2.5.
c. This same paragraph includes a description of the overflow pipes. These were added in 1986 and their description should also be moved to paragraph 4.1.2.

4.2 Summary of operational procedures

a. This section requires the same corrections noted for 4.1.1. The divider rock berm was not part of the original operation. Rather, ash was allowed to accumulate in the entire volume of each pond and cleaned out periodically. As a result of the over-excavation and liner damage noted in paragraph 4.1.3, plant management elected to design and install the divider berms to limit the amount of pond volume used for sedimentation. This in turn reduced the need to entirely drain the pond during cleaning and reduced the possibility for future liner damage. This change should be noted in paragraph 4.2.2.

b. The other change indicated in our comments to paragraph 4.1 should also be added to 4.2.2. The 12” overflow pipes serving each pond were added in 1986 to replace the original overflow spillways (as shown in detail on the original drawing, Appendix C). This change was required by Missouri Department of Natural Resources to ensure that any overflow discharge would be directed to the measurement weir and reported in discharge monitoring reports. To date, there has never been a discharge through these overflow pipes.

Section 5 – Field Observations

5.1. Project overview and significant findings

a. In the second paragraph Ted Salveter, P.E. is identified as JTEC personnel. Mr. Salveter actually works for our corporate Environmental Affairs Department and is not directly connected to JTEC.

b. The report references Federal Guidelines for Dam Safety published by FEMA (April 2004). FEMA applies this title to an entire suite of publications; the report should indicate which specific guideline document(s) are germane.

c. The report should also indicate that FEMA guidance is, in fact, only guidance. Dam safety regulations are the responsibility of the states and, as noted, Missouri regulations exempt small impoundments like the JTEC ponds.

5.2. West impoundment

a. CU agrees with the findings that the west impoundment is in good condition with no evidence of seeps, cracks, burrowing, or other potential problems.

b. We technically disagree with the term “dam” to describe the impoundment face. Under the Missouri dam safety statute, the term “dam” is reserved for retaining structures 35 feet or more in height. We would suggest the alternate term “embankment,” as is used elsewhere in the report.

5.3. East impoundment

a. CU agrees with the findings that the east impoundment is in good condition with no evidence of seeps, cracks, burrowing, or other potential problems.

b. We technically disagree with the term “dam” to describe the impoundment face. Under the Missouri dam safety statute, the term “dam” is reserved for retaining structures 35 feet or more in height.

5.4. Outlet structures

a. Paragraph 5.4.2 describes the outlet system as having an integral pump. The pump station actually serves to recycle water to the plant and is not integral to the pond outlet. Water is discharged from the pond by gravity drainage through the piping and weir identified in this paragraph.

b. Paragraph 5.4.3 indicates no emergency spillway, which is technically incorrect. As shown in the original drawings (Appendix C of the report and **Attachment 1** to this response), each pond was originally designed and constructed with an emergency overflow and spillway system. In 1986 MDNR required CU to replace the free-flowing spillways with the overflow piping system shown in photograph 5.9 and indicated in paragraph 5.4.2. As noted above, this was to ensure that any emergency overflow would pass through the measurement weir for recording and reporting. JTEC has never experienced an emergency overflow on either pond.

Section 6 – Hydrologic/Hydraulic Safety

6.1. Supporting technical documentation

a. Plant personnel are correct in their observation that the ponds have never experienced flooding. Accordingly, there is no record of such an event.
b. Paragraph 6.1.2 again references the discharge capacity of the pumping station. The pumping station is designed to return flows to the plant, not to discharge water from the ponds.
c. We agree with the general assessment in paragraph 6.1.2 that overtopping of the pond is unlikely. This observation stems from the fact that it has never occurred despite 24-hour rainfalls as great as 6.8 inches (September 1-2, 2010; see **Attachment 2a**), a figure very near the 100-year storm of 7.58 inches (**Attachment 2b**).
d. Plant personnel are unable to determine the origin of the 9.6 MGD allowable discharge rate included in the NPDES permit and referenced in paragraph 6.1.3. This value appears to have been carried over from historic permit application data and is not reflective of current hydraulic flows. A plant water balance diagram submitted for the latest permit renewal (**Appendix C, Document 04 of the CDM Smith report**) shows total peak inflows to the ponds to be 8.56 MGD. However, this value includes 4.0 MGD for ash sluice water, which originates from the pond itself (shown as Flow line 13 in the diagram), leaving a net maximum inflow of 4.56 MGD. This figure includes a 3.7 MGD peak storm water contribution. CU would be happy to discuss further the hydraulic capacities of the outfall structure and emergency overflows at your convenience.
e. CU generally agrees that no significant property or infrastructure damage would result from a downstream flood. However, we question whether an unlikely breach in an ash pond embankment would result in any downstream impact at all.

6.2. Adequacy of supporting technical documentation

a. Paragraph 6.2 again references the discharge capacity of the pumping station. The pumping station is designed to return flows to the plant, not to discharge water from the ponds.

b. As indicated, JTEC personnel would be pleased to provide information and documentation regarding precipitation and design features of the outfall if requested.

6.3. Assessment of hydrologic/hydraulic safety

a. CU agrees with the general observation that the design and operation of the impoundments are consistent with the indication of no past overtopping of the embankments.
b. If additional consultation and documentation are required to buttress these observations, CU would be happy to discuss these needs with the reviewers.

Section 7 – Structural Stability

7.1. Supporting technical documentation

a. Paragraph 7.1.1 correctly states that these impoundments are exempt from Missouri dam safety laws and regulations but asserts that this is merely due to their age and "grandfathered" status. In fact the embankments are exempt owing to their small size. The Missouri statute applies only to dams greater than 35 feet and height and impounding over fifteen acres of surface water. Smaller ponds, such as those at JTEC, are recognized as presenting far less hazard and are not required to perform stability analyses. Accordingly, the entire discussion of paragraph 7.1.1 is out of order to the extent that it references any requirement of state statute or regulations.
b. Paragraph 7.1.2 states that CDM Smith did not receive information on design parameters for fill materials used in embankment construction. This information would have been provided if requested. The construction drawing provided by JTEC and included in Appendix C of the report includes written specifications for embankment materials. This drawing accompanied written specifications in Contract 343, which includes additional specifications on construction materials, as shown in **Attachment 3**.
c. Paragraph 7.1.3 indicates there are no groundwater piezometers installed at JTEC at the time of inspection. We would first observe that JTEC, unlike most power stations reviewed by EPA, is in an upland location where groundwater fluctuation is unlikely to disrupt the integrity of the ponds or liners. In addition, there is now a network of nine piezometers in the general area of the landfill as shown in the map included as **Attachment 4**. This attachment also includes piezometer data taken to date, which indicate adequate separation between the lowest pond elevation and the phreatic surface.
d. CU agrees that JTEC is located in a low seismic hazard area. A recent analysis conducted for CU by Anderson Engineering, Inc. supports this finding and is included as **Attachment 5**.

7.2. Adequacy of supporting technical documentation

CU provided all of the data requested by CDM Smith and is providing additional documentation herewith. The conclusion that adequate documentation does not exist is therefore unfounded.

7.3. Assessment of structural stability

JTEC staff would be pleased to discuss the nature of the data and documentation necessary for CDM Smith to complete the assessment of structural stability of the embankments.

Section 8 – Adequacy of maintenance and Methods of Operation

8.1. Operating procedures

JTEC has not reduced pond operating procedures to a written manual. CU agrees that such a document might be helpful to a better understanding of the system under inspection.

8.2. Maintenance of the dam and project facilities

JTEC has not reduced pond operating procedures to a written manual.

8.3. Assessment of maintenance and methods of operations

JTEC agrees with the finding that the operational and maintenance procedures for the impoundment appear to be adequate. CU will take under advisement the recommendation to implement written procedures.

Section 9 – Adequacy of Surveillance and Monitoring Program

9.1. Surveillance procedures

JTEC maintains historical records of impoundment inspections in the administrative office at the plant. These could readily be provided to CDM Smith for review on request.

9.2. Instrumentation monitoring

Since the time of the inspection, JTEC has installed a network of nine piezometers in the general area of the onsite landfill. Two of these are located near the east ash pond but are not installed in the embankment structure itself. In-bank piezometers are typically deployed as an investigative tool when visual inspection indicates potential structural problems. The JTEC embankments have never evidenced any problems requiring such follow-up.

9.3. Assessment of surveillance and monitoring program

a. JTEC agrees with the finding that the inspection program for the impoundment is adequate. As noted above, the records recommended in paragraph 9.3.1 are already retained at the plant.

b. Monitoring wells recommended in paragraph 9.3.2 have already been installed in conjunction with another project. These wells would serve the purpose suggested in this finding.

III. Summary and Conclusion

The draft report is accurate in many respects regarding observations of the current condition and past practices associated with the subject impoundments. However, there are numerous errors demanding correction regarding, for example, facility personnel, pond outlet design, emergency outlet features, regulatory status, and other respects. These corrections, together with the additional technical information submitted herewith, necessitate a reevaluation of the future operational integrity of the JTEC ponds.

The report describes a supernatant ponding system that is well designed, operated, and maintained. Aside from a small area of vegetative overgrowth, no unsatisfactory features were elicited during the two days of inspection. Even this vegetation was found only to constitute a hindrance to inspections, not a threat to structural integrity. Operating and maintenance procedures were found to be satisfactory, although they might benefit from being reduced to writing. The structure has proven to be hydraulically and structurally capable of withstanding rainfall events of historic magnitude. Seismic disturbance is not an issue, and newly installed monitoring wells indicate groundwater forces are similarly of no concern. The only remaining review feature appears to be a stability analysis, which is not required for these ponds owing to their unregulated status under Missouri statute.

Accordingly, the report's conclusion that the future operability of these ponds for their intended function falls into the "poor" category appears to accrue squarely from the mere fact that the ponds are unregulated. In our view the report should highlight the fact that JTEC staff admirably continues to operate the ponds in a safe and prudent fashion *despite* the lack of a regulatory impetus. Instead the report leaves an impression that no pond is safe unless it is regulated, and that no facility is too small to escape that net. We hope our perception on this point is in error and that the report's authors will work with us to correct the report and its findings at the earliest practicable convenience.

Attachments

Attachment 1. Final drawings from Contract 343

Attachment 2a. 24-Hour Rainfall Peaks Recorded at JTEC

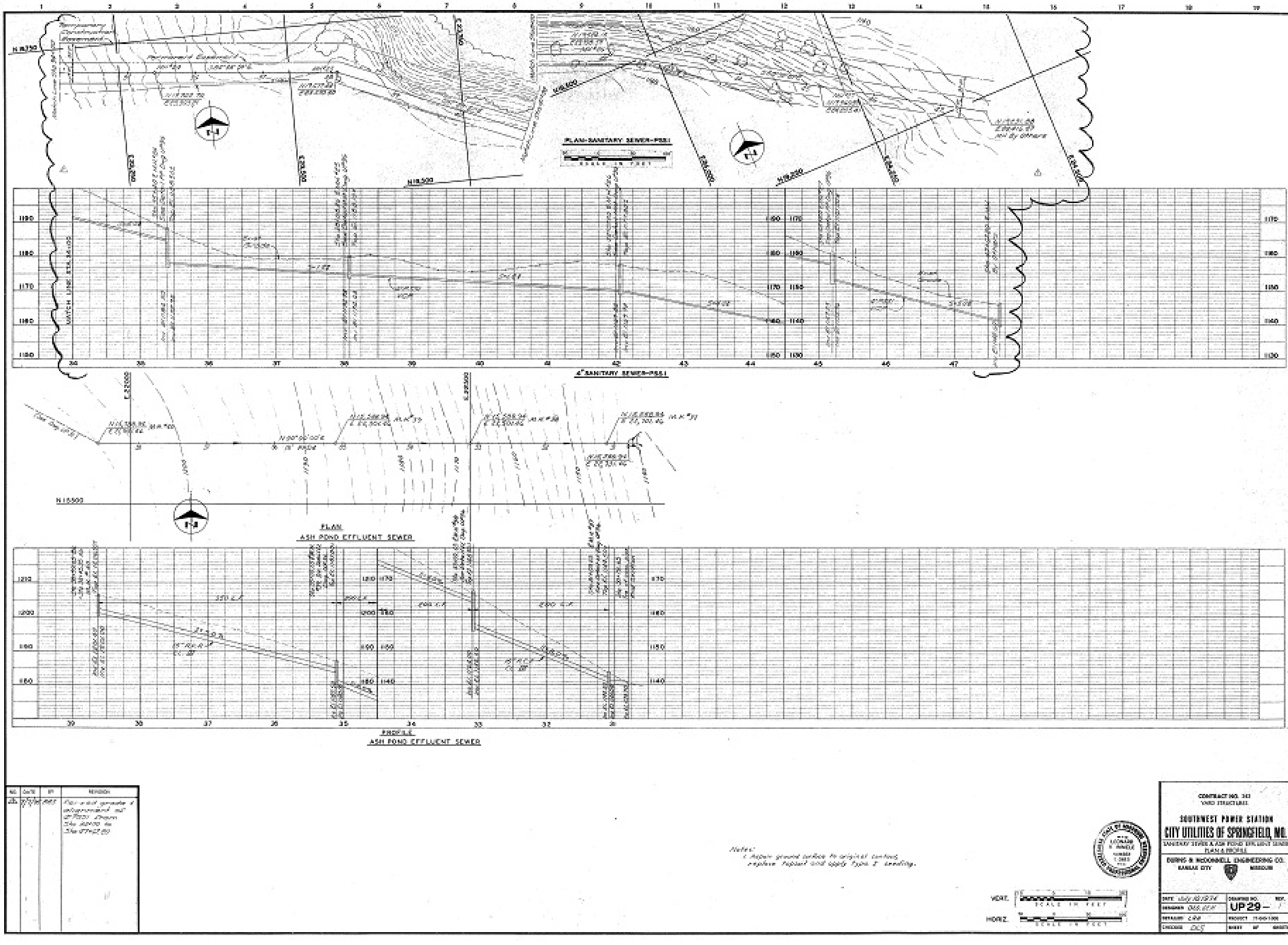
Attachment 2b. National Weather Service Storm Frequency Matrix for Springfield, MO

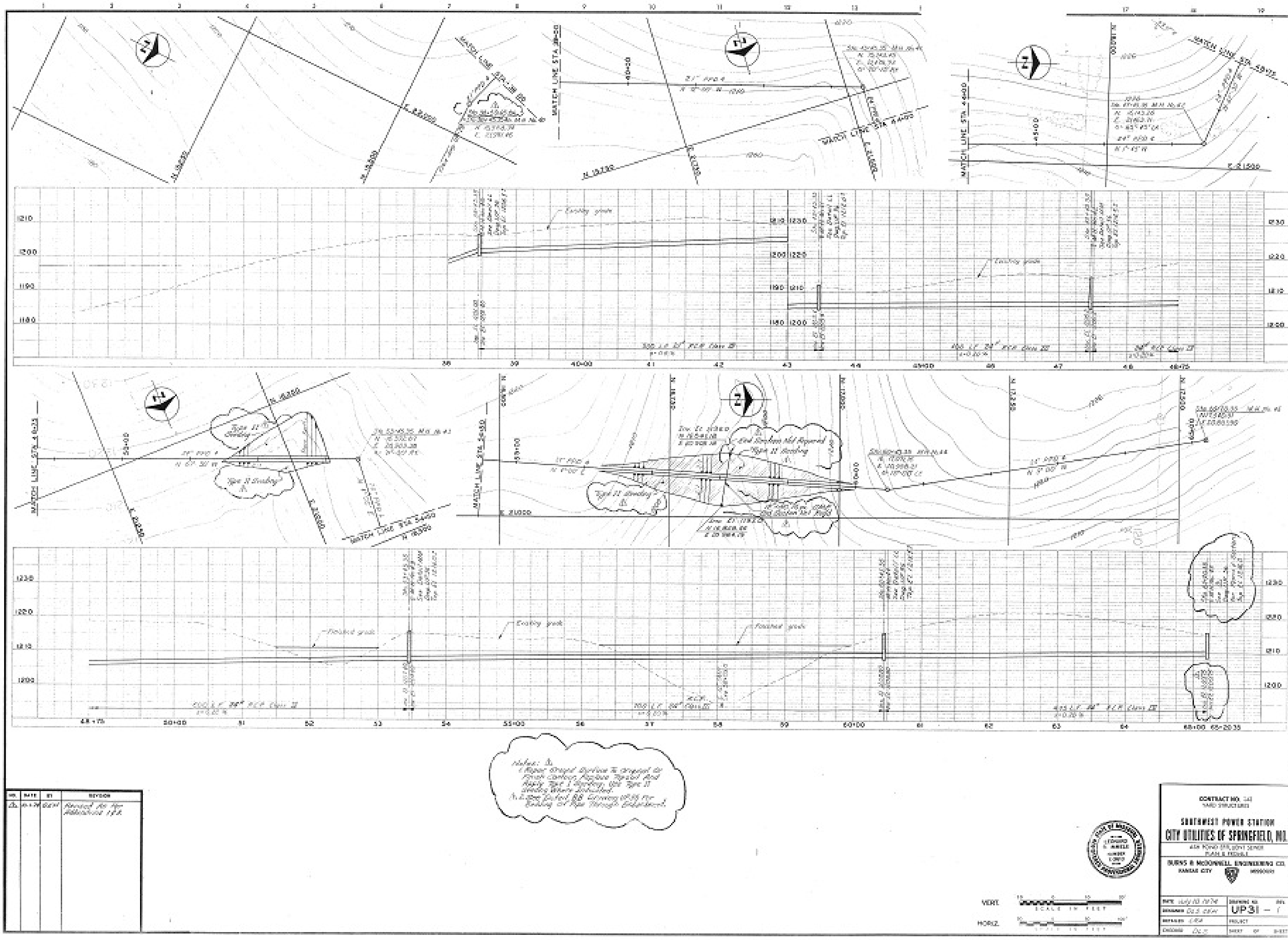
Attachment 3. Embankment Fill Material Specifications from Contract 343 – Power Station Yard Structures

Attachment 4. 2013 Piezometer Study

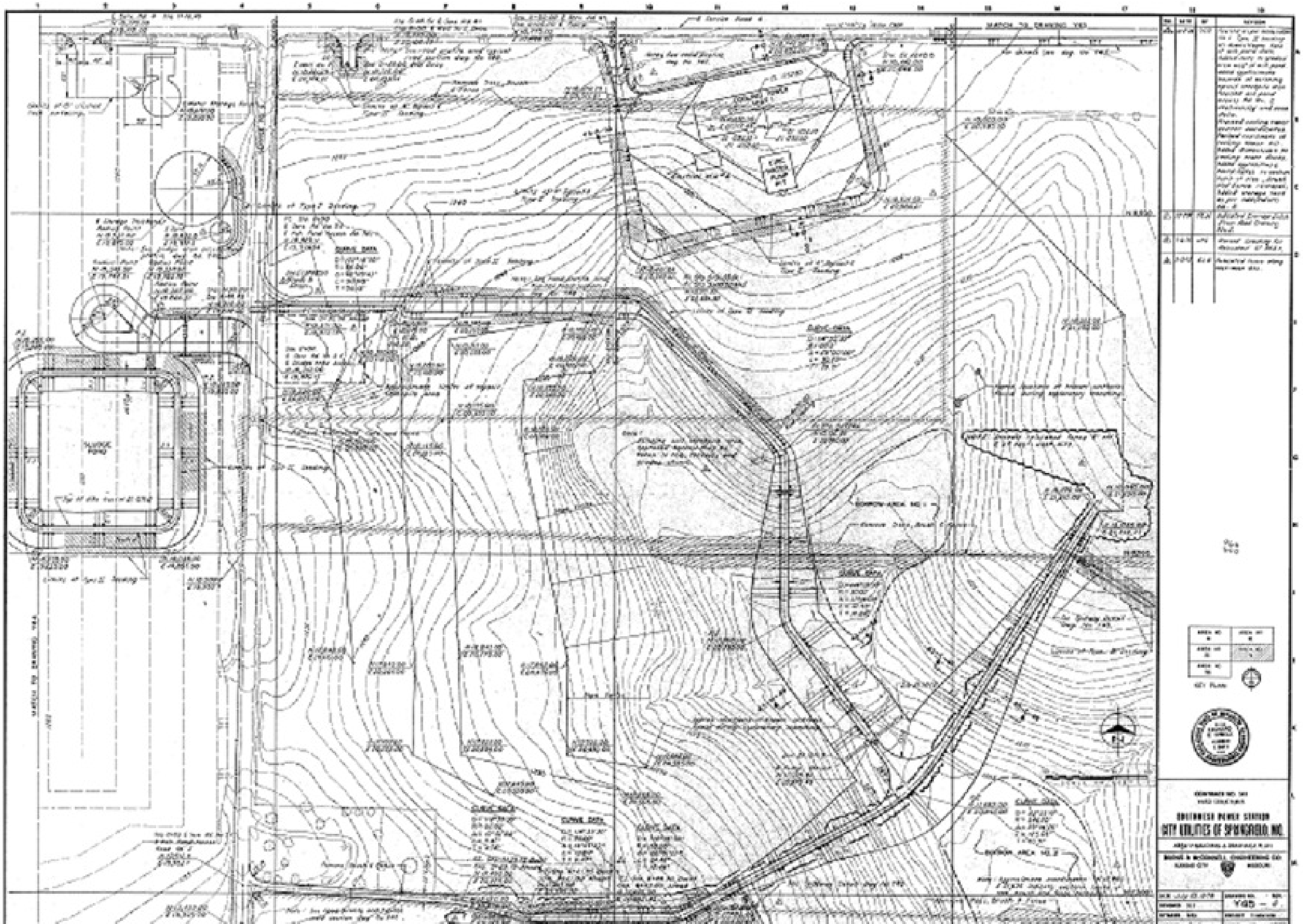
Attachment 5. JTEC Seismic Study, Anderson Engineering, 2011

Attachment 1. Final drawings from Contract 343


PLAN-SANITARY SEWER-PSS.1
SCALE IN FEET
MATCH LINE STA. 34+00
4" SANITARY SEWER-PSS.1
PLAN
ASH POND EFFLUENT SEWER
PROFILE
ASH POND EFFLUENT SEWER
VERT.
SCALE IN FEET
HORIZ.
SCALE IN FEET
Notes:
1. Repair ground surface to original contour, replace topsoil and apply Type I seeding.
CONTRACT NO. 313
YARD STRUCTURES
SOUTHWEST POWER STATION
CITY UTILITIES OF SPRINGFIELD, MO.
SANITARY SEWER & ASH POND EFFLUENT SEWER
PLAN & PROFILE
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY
MISSOURI
DATE July 12, 1974
DRAWING NO.
REV.
UP29-
DESIGNER
DETAILER
PROJECT
CHECKER
SHEET
OF
SHEETS
NO.
DATE
BY
REVISION



Existing grade
Finished grade
MATCH LINE STA. 44+00
CONTRACT NO.
SOUTHWEST POWER STATION
CITY UTILITIES OF SPRINGFIELD, MO.
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY MISSOURI
UP31 - 1
VERT.
HORIZ.
SCALE IN FEET


CITY UTILITIES OF SPRINGFIELD, MO.
BURNS & McDONNELL ENGINEERING CO.
KANSAS CITY
MISSOURI

Attachment 2a. 24-Hour Rainfall Peaks Recorded at JTEC

JTEC Notable Rain Events				
Date	Rain (Inches)	Corresponding Dates	Add'l Rain (Inches)	Total Rain (Inches)
5/30/2013	3.1	5/31/2013	0.9	4
9/15/2012	4.6	9/14/2013	0.3	4.9
4/25/2011	3.5	4/24/2011	2.6	6.1
9/1/2010	5.4	9/2/2010	1.4	6.8
5/1/2009	1	30-Apr	0.6	1.6
4/13/2008	6	N/A		6
6/11/2007	1	6/12/2007	0.75	1.75
6/27/2007	3.5	6/27/2007	0.7	4.2
9/17/2006	1.75	N/A		1.75
7/30/2004	0.65	7/29/2004	2	2.65

Attachment 2b. National Weather Service Storm Frequency Matrix for Springfield, MO

Wettest Days Report - Springfield, MO

Precipitation	Year	Month	Day
6.27	1987	11	24
5.83	1909	7	7
5.48	1949	10	21
5.20	1932	6	26
5.03	1993	9	24
4.96	1895	12	18
4.82	1975	6	9
4.66	1905	7	26
4.64	1897	1	2
4.62	2010	9	1

NOAA Atlas 14, Volume 8, Version 2
Location name: Springfield, Missouri, US*
Coordinates: 37.1894, -93.2719
Elevation: 1314 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.375 (0.321-0.444)	0.432 (0.369-0.512)	0.527 (0.448-0.625)	0.606 (0.513-0.722)	0.718 (0.587-0.879)	0.805 (0.643-0.997)	0.893 (0.690-1.13)	0.984 (0.729-1.28)	1.11 (0.789-1.47)	1.20 (0.834-1.61)
10-min	0.550 (0.469-0.650)	0.633 (0.540-0.749)	0.772 (0.656-0.915)	0.888 (0.751-1.06)	1.05 (0.859-1.29)	1.18 (0.942-1.46)	1.31 (1.01-1.66)	1.44 (1.07-1.87)	1.62 (1.16-2.15)	1.76 (1.22-2.36)
15-min	0.670 (0.572-0.793)	0.772 (0.659-0.914)	0.941 (0.800-1.12)	1.08 (0.915-1.29)	1.28 (1.05-1.57)	1.44 (1.15-1.78)	1.60 (1.23-2.02)	1.76 (1.30-2.28)	1.98 (1.41-2.62)	2.14 (1.49-2.88)
30-min	0.982 (0.838-1.16)	1.13 (0.967-1.34)	1.38 (1.18-1.64)	1.59 (1.35-1.90)	1.88 (1.54-2.30)	2.11 (1.68-2.61)	2.33 (1.80-2.95)	2.57 (1.90-3.32)	2.87 (2.05-3.81)	3.11 (2.16-4.18)
60-min	1.29 (1.10-1.52)	1.49 (1.27-1.77)	1.84 (1.56-2.18)	2.13 (1.80-2.53)	2.54 (2.08-3.11)	2.86 (2.29-3.55)	3.19 (2.46-4.04)	3.53 (2.62-4.58)	4.00 (2.85-5.31)	4.36 (3.03-5.86)
2-hr	1.59 (1.37-1.87)	1.85 (1.59-2.17)	2.29 (1.96-2.69)	2.66 (2.26-3.14)	3.19 (2.63-3.89)	3.61 (2.91-4.45)	4.05 (3.15-5.10)	4.50 (3.36-5.80)	5.12 (3.68-6.76)	5.60 (3.92-7.49)
3-hr	1.79 (1.54-2.09)	2.07 (1.79-2.42)	2.56 (2.20-3.00)	2.99 (2.55-3.52)	3.61 (2.99-4.39)	4.11 (3.33-5.06)	4.63 (3.62-5.82)	5.18 (3.89-6.67)	5.94 (4.29-7.83)	6.54 (4.59-8.71)
6-hr	2.18 (1.89-2.53)	2.50 (2.17-2.90)	3.07 (2.65-3.57)	3.58 (3.07-4.17)	4.32 (3.62-5.24)	4.94 (4.03-6.05)	5.59 (4.41-7.00)	6.29 (4.76-8.06)	7.27 (5.29-9.54)	8.06 (5.70-10.7)
12-hr	2.66 (2.33-3.06)	3.02 (2.63-3.47)	3.64 (3.17-4.20)	4.20 (3.63-4.86)	5.04 (4.25-6.07)	5.74 (4.72-6.99)	6.49 (5.16-8.07)	7.30 (5.56-9.28)	8.43 (6.19-11.0)	9.35 (6.66-12.3)
24-hr	3.16 (2.78-3.61)	3.60 (3.16-4.10)	4.35 (3.80-4.97)	5.00 (4.36-5.75)	5.97 (5.05-7.10)	6.75 (5.58-8.13)	7.58 (6.06-9.33)	8.46 (6.48-10.7)	9.68 (7.14-12.5)	10.7 (7.64-13.9)
2-day	3.65 (3.24-4.13)	4.23 (3.74-4.79)	5.19 (4.57-5.89)	6.00 (5.26-6.84)	7.14 (6.06-8.38)	8.03 (6.66-9.54)	8.94 (7.17-10.9)	9.87 (7.60-12.3)	11.1 (8.25-14.2)	12.1 (8.74-15.7)
3-day	4.01 (3.57-4.52)	4.63 (4.11-5.22)	5.65 (5.00-6.38)	6.50 (5.72-7.38)	7.70 (6.56-8.99)	8.63 (7.19-10.2)	9.58 (7.71-11.6)	10.6 (8.15-13.1)	11.9 (8.82-15.1)	12.9 (9.32-16.6)
4-day	4.32 (3.85-4.85)	4.95 (4.40-5.56)	5.99 (5.31-6.74)	6.87 (6.06-7.76)	8.09 (6.92-9.42)	9.06 (7.56-10.7)	10.0 (8.10-12.1)	11.0 (8.56-13.7)	12.4 (9.25-15.7)	13.4 (9.77-17.3)
7-day	5.07 (4.54-5.65)	5.74 (5.14-6.40)	6.85 (6.12-7.67)	7.80 (6.92-8.76)	9.13 (7.84-10.6)	10.2 (8.54-11.9)	11.2 (9.13-13.5)	12.3 (9.62-15.2)	13.8 (10.4-17.4)	15.0 (10.9-19.2)
10-day	5.74 (5.16-6.37)	6.46 (5.81-7.18)	7.67 (6.86-8.54)	8.68 (7.73-9.71)	10.1 (8.72-11.6)	11.2 (9.46-13.1)	12.4 (10.1-14.8)	13.5 (10.6-16.6)	15.1 (11.4-19.0)	16.3 (12.0-20.8)
20-day	7.70 (6.97-8.48)	8.62 (7.80-9.50)	10.1 (9.13-11.2)	11.4 (10.2-12.6)	13.1 (11.3-14.9)	14.4 (12.2-16.6)	15.6 (12.8-18.5)	16.9 (13.3-20.5)	18.6 (14.1-23.2)	19.9 (14.7-25.2)
30-day	9.33 (8.48-10.2)	10.4 (9.48-11.4)	12.2 (11.0-13.4)	13.6 (12.3-15.0)	15.5 (13.5-17.5)	16.9 (14.4-19.4)	18.3 (15.0-21.5)	19.6 (15.5-23.6)	21.3 (16.2-26.4)	22.6 (16.8-28.5)
45-day	11.4 (10.4-12.4)	12.7 (11.6-13.9)	14.8 (13.4-16.2)	16.4 (14.8-18.0)	18.5 (16.1-20.8)	20.1 (17.1-22.8)	21.5 (17.7-25.1)	22.9 (18.1-27.4)	24.5 (18.7-30.2)	25.7 (19.2-32.3)
60-day	13.1 (12.0-14.3)	14.6 (13.4-15.9)	17.0 (15.5-18.5)	18.8 (17.0-20.6)	21.1 (18.4-23.5)	22.7 (19.4-25.7)	24.2 (20.0-28.0)	25.5 (20.3-30.4)	27.1 (20.7-33.2)	28.1 (21.1-35.3)

Attachment 3. Embankment Fill Material Specifications from Contract 343 – Power Station Yard Structures

DIVISION 2 - SITE WORK

2A - SITE PREPARATION AND EARTHWORK:

1. Extent of Work: The work required under this section consists of site preparation activities and certain items of earthwork common to other related work as necessary to complete the Work.

2. Applicable Standards:
   a. American Association of State Highway Officials Standard Method of Test (AASHO):
      (1) T99 - The Moisture-Density Relations of Soils Using a 5.5-Pound Rammer and a 12-Inch Drop.
      (2) T104 - Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Test.
   b. American Society for Testing and Materials (ASTM): D2049 - Relative Density of Cohesionless Soils.

3. Clearing and Grubbing:
   a. Extent of Work: Perform clearing and grubbing:
      (1) As indicated or as necessary to perform excavation, trenching, embankment, borrow and other work required.
      (2) Where desired by Contractor for subsidiary purposes subject to approval.
   b. Clearing:
      (1) Clearing includes felling and disposal of trees, brush, other vegetation, and organic soils.
      (2) Remove existing fence within the limits of clearing and waste or store as indicated.
      (3) Conduct work in a manner to prevent damage to property and to provide for the safety of employees and others.
      (4) Keep operations within property lines as indicated.
   c. Grubbing:
      (1) Remove and dispose of tree stumps and roots larger than 3 inches in diameter to a depth of at least 18 inches below existing grade elevation.
      (2) Backfill all excavated depressions with approved material and grade to drain.

4. Debris:
   a. Dispose of debris from clearing, grubbing and demolition by burying in areas designated by the Engineer.
   b. Debris buried on the site shall be placed a minimum of 5 feet below finished grade in areas designated by the Engineer. Locations of buried debris shall be indicated on Contractor-furnished construction records.
   c. Contractor may claim and salvage any timber which he may consider of value, but shall not delay in any manner either this contract or other work with salvaging operations.

5. Materials Encountered:
   a. Suitable materials include material that is free of debris, roots, organic matter, frozen matter and which is free of rock with any dimension greater than one-half the specified loose layer thickness.

b. Unsuitable materials include all material that contains debris, roots, organic matter, frozen matter, rock (with any dimension greater than one-half the loose layer thickness) or other materials that are determined by Engineer as too wet or otherwise unsuitable for providing a stable subgrade or stable foundation for structures.
c. Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands exclusive of clayey and silty material - materials which are free-draining and for which impact compaction will not produce a well-defined moisture-density relationship curve and for which the maximum density by impact methods will generally be less than by vibratory methods.
d. Cohesive materials include silts and clays generally exclusive of sands and gravel - materials for which impact compaction will produce a well-defined moisture-density relationship curve.
e. All materials encountered, regardless of type, character, composition and condition thereof shall be unclassified. Estimate quantity of various materials included prior to submitting Bid Form. Rock encountered shall be handled at no additional cost to Owner.

6. Explosives:
   a. Handling: Store and use explosives to conform to local, state and federal regulations.
   b. Blasting:
      (1) Blasting shall be performed only under the direction of an employee of Contractor who is qualified, competent, and thoroughly experienced in the use of explosives for rock excavation.
      (2) Persons handling explosives shall be licensed or otherwise authorized to use explosives.
      (3) Locate charge holes properly and drill to correct depth for charges used.
      (4) Limit charges in size to minimum required for reasonable removal of material by excavating equipment.
      (5) Avoid excessive overbreak or damage to adjacent structures, equipment, utilities, or buried pipeline and conduit as follows:
         (a) With properly designed pattern.
         (b) By use of approved explosion mats.
      (6) Blasting near utilities shall be subject to approval of owning agency.
   c. Insurance: Before delivery of any explosives at jobsite, Contractor must have obtained a blasting endorsement on his public liability and property damage insurance policy.

7. Dewatering:
   a. Control grading around excavations to prevent surface water from flowing into excavation areas of structures.
   b. Drain or pump as required to continually maintain all excavations and trenches, including cutoff trench for embankment, free of water or mud from any source, and discharge to approved drains or channels. Commence when water first appears and continue until work is complete to the extent that no damage will result from hydrostatic pressure, flotation, or other causes.

c. Use pumps of adequate capacity to insure rapid drainage of area, and construct and use drainage channels and subdrains with sumps as required.
d. Remove subgrade materials rendered unsuitable by excessive wetting and replace with approved backfill material.

8. Stockpiling:
a. Stockpile in amounts sufficient for and in a manner to segregate materials suitable for the following:
(1) Topsoiling.
(2) Constructing embankments and fills.
(3) Backfilling.
(4) Waste only.
b. Do not obstruct or prevent access to:
(1) Roads and driveways.
(2) Utility control devices.
(3) Ditches or natural drainage channels.
c. Perform in a manner to avoid endangering the work. stability of banks or structures, or health of trees and shrubs to be saved.
d. Maintain safe distance between toe of stockpile and edge of excavation or trench.
e. Stockpile in other areas or off site when adjacent structures, easement limitations, or other restrictions prohibit sufficient storage adjacent to the Work. Off-site areas shall be arranged for by Contractor at no additional cost to Owner.

9. Waste Materials:
a. Includes excess usable materials and materials unsuitable for use in the Work.
b. Remove unsuitable materials from Work area as excavated.
c. Deposit such materials in locations and within areas designated by Engineer and as indicated.
d. Place excavated rock in the interior of waste area fills so that it will not be exposed to view.
e. Grade waste areas and leave them free draining and with an orderly and neat appearance.

10. Borrow Materials:
a. Refers to all fill materials and topsoil obtained from approved locations on the jobsite.
b. Borrow shall include all excavating, handling, and final disposal of materials as specified.
c. Borrow areas shall be as indicated and as designated by the Engineer.
d. Material removed from borrow areas shall be as approved.
e. Leave borrow areas graded to drain and to present a neat appearance.

11. Compaction:
a. Compact subgrades, fills, embankments and backfills using a tamping roller or rubber-tired roller unless specified otherwise. Tamping roller shall consist of one (1) or more units. Each unit shall consist of a watertight cylindrical drum not less than forty-eight (48) inches in length and shall be surmounted by metal studs with tamping feet

projecting not less than seven (7) inches from the surface of the drum and spaced not less than six (6) inches nor more than ten (10) inches measured diagonally from center to center. The area of each tamper foot shall be not less than seven (7) square inches nor more than twelve (12) square inches. Each unit shall be provided with a suitable tamper foot cleaning device. Where more than one rolling unit is used, the rolling units shall be pivoted on the main frame in a manner which will permit the rolling units to adapt themselves to uneven ground surfaces, and to rotate independently so that each unit shall maintain even bearing for its full width. When fully loaded, it shall exert not less than 500 pounds per square inch on the tamping feet. Tamping rollers shall be crawler tractor drawn or self-propelled type. Rubber-tired rollers shall be of two types and will be used where specified. Type I shall have a total weight ranging from 10 to 15 tons and minimum roller pressure of 300 to 325 pounds per inch of contact roller width. Type II shall have a total weight ranging from 30 to 35 tons with minimum load per wheel of 6000 to 8000 pounds. Contact pressure under each wheel shall not be less than 80 psi. Each lift shall be compacted by the number of passes specified for the tamping roller or rubber-tired roller.

b. All backfill compaction for piping and structures shall be performed by other approved methods to specified densities to prevent damage to piping and structures.

c. Actual number of passes of specified compaction equipment required, within the range specified, shall be determined by the Engineer.

12. Stripping: Remove topsoil from areas within limits of excavation, trenching and borrow areas and areas designated to receive embankment and compacted fill as follows:

a. Scrape areas clean of all brush, grass, weeds, roots and other materials.

b. Strip to depth of approximately 4 inches or to a maximum depth of 18 inches to remove excessive roots in heavy vegetation or brush areas and as required to segregate topsoil.

c. Stockpile topsoil in areas designated where it will not interfere with construction operations or existing facilities. Stockpiled topsoil shall be reasonably free of subsoil, debris, and stones larger than 2-inch diameter.

d. Remove waste from the work area and deposit in areas indicated and/or designated by the Engineer.

13. Subgrade Preparation:

a. Extent of Work:

(1) Excavate or backfill as required to construct subgrades to the elevations and grades indicated.

(2) Remove all unsuitable material and replace with approved fill material, and perform all wetting, drying, shaping, and compacting required to prepare a suitable subgrade.

b. Subgrade for Fills and Embankments:

(1) After stripping areas as specified in this Section, scarify top 12 inches and wet or dry as required to insure bonding of fill or embankment material with subgrade.

(2) Compact subgrade by making 3 to 5 complete coverages with specified tamping roller. (Engineer shall determine number of passes required based on field observation).

(3) Moisture content at time of compaction shall not be less than optimum nor more than optimum plus 6 percent based on that portion of material which passes a No. 4 sieve.

c. Subgrade for Roadways, Drives, Parking Areas:

(1) Extend subgrade the full width of the roadbed plus one foot outside.

(2) Compact subgrade embankments by making 3 to 5 passes with specified tamping roller. Moisture content at time of compaction shall be not less than optimum nor more than optimum plus 6 percent for that portion of material passing a No. 4 sieve.

(3) Compact the top six inches of subgrades for traffic areas in excavation by making 3 to 5 passes with specified tamping roller Moisture content shall be between optimum and optimum plus 6 percent for that portion of material passing a No. 4 sieve.

d. Subgrades for Concrete Slabs on Grade:

(1) Compact subgrade in embankment areas and in the top six inches in excavation areas by 3-6 passes with specified tamping roller. Moisture content shall be between optimum and optimum plus 6 percent for that portion of material passing a No. 4 sieve.

14. Embankment:

a. Material:

(1) Construct embankments to the contours and elevations indicated, using suitable approved material from excavations and borrow areas.

(2) Material shall be free of roots or other organic matter, refuse, ashes, cinders, frozen earth or other unsuitable material.

(3) Use material from designated borrow areas.

(4) Do not use material containing gravel, stones, or shale particles greater in dimension than one-half the depth of the layer to be compacted.

(5) Moisture content shall be held between optimum and optimum plus 6 percent for that portion of material passing a No. 4 sieve.

b. Placement:

(1) Place fill material in 4-inch to 8-inch layers in areas requiring a high degree of compaction and in 8-inch to 12-inch layers in other embankment areas.

(2) Place embankment only on subgrades approved by Engineer.

(3) Do not place snow, ice or frozen earth in fill and do not place fill on a frozen surface.

c. Compaction: Compact each lift with 3 to 5 passes of the specified tamping roller equipment.

15. Site Grading:

a. Extent of Work: Excavate, fill, compact fill, and rough grade to bring project area outside of buildings to subgrades as follows:

(1) For surfaced areas, to underside of respective surfacing or base course.

(2) For lawn and planted areas, to 4 inches below finished grade where top soil is indicated.

b. Rock:
  (1) When encountered in grading areas outside of buildings, the provisions contained herein shall apply.
  (2) Backfill to grade, with earth compacted in place after removing rock to depths as follows:
    (a) Under surfaced areas, to 6 inches below the top of respective subgrades for such areas.
    (b) Under lawn and planted areas to 24 inches below finished grade.

c. Fill:
  (1) Fill as required to raise existing grades outside of building areas to the new grades as indicated.
  (2) Such fill shall be performed as specified in "Embankment," this Section.
  (3) Remove all debris subject to termite attack, rot, or corrosion, from areas to be filled.

d. Rough Grading:
  (1) All areas within the project, including excavated and filled sections, and adjacent transition areas shall be reasonably smooth, compacted, and free from irregular surface changes.
  (2) Degree of finish shall be that ordinarily obtained from blade grader or scraper operations, except as otherwise specified.
  (3) Finished rough grades shall generally be not more than 0.25 feet above or below established grade or approved cross sections with due allowance for topsoil.
  (4) Tolerance for areas within 10 feet of building and areas to be paved shall not exceed 0.15 feet above or below established subgrade.
  (5) Finish all ditches, swales, and gutters to drain readily.
  (6) Unless otherwise indicated, slope the subgrade evenly to provide drainage away from building walls in all directions at a grade not less than ¼-inch per foot.
  (7) Provide roundings at top and bottom of banks and at other breaks in grade.

16. Riprap:

a. Material:
  (1) Riprap material may be obtained from structure and area excavations, and from on-site stockpiles.
  (2) Maximum dimension of riprap shall be 18 inches with no more than 10 percent by weight passing the No. 4 sieve.

b. Foundation Preparation:
  (1) Trim and dress areas requiring riprap to conform with lines as indicated within an allowable tolerance of 6 inches from the theoretical slope lines and grades.
  (2) Fill areas below tolerance limit with suitable material and compact.
  (3) Do not place riprap until the embankment or subgrade has been approved.

c. Placement:
  (1) Place stones to full course thickness in one operation and in a manner to avoid displacing the underlying material.
  (2) Place stone on the embankment slopes or subgrade to produce a reasonably well graded mass of stone in close contact and with a minimum of voids.

2D - ASH POND CONSTRUCTION:

Perform as specified in Section 2A, 2B, 2C and as follows:

1. Extent of Work: The work under this section consists of repair of inspection trenches, sinkhole repair, pond base stabilization, cutoff trench construction and embankments and spillway construction.

2. Site Preparation:
   a. Perform all clearing, grubbing and stripping as specified in Section 2A of this division, except as noted.

3. Inspection Trench Repair:
   a. Trench walls shall be sloped to stand unbraced, and to allow back-filling and compaction with specified equipment.
   b. Backfill material may be that which was excavated from the trench or from designated borrow areas.
   c. Backfill trenches without compaction to within 4 feet of existing grade. Then compact in 12-inch lifts the remaining 4 feet of fill.

4. Sinkhole Repair:
   a. Sinkholes known to exist in the pond area are indicated. Sinkholes shall be repaired as indicated.
   b. Sinkholes encountered during construction shall be repaired in the same manner.
   c. Fill material shall be approved material from excavation or designated borrow material.
   d. Top 4 feet shall be placed and compacted in lifts as specified for "Embankment" Section 2A.

5. Pond Base Stabilization:
   a. The pond base is defined as the pond area below finish contour elevation 1232.0 and as indicated.
   b. Grubbing and stripping shall be performed as specified in Section 2A.
   c. The upper 12-inch layer of material below the top soil shall be removed from the pond base area and stockpiled.
   d. Scarify the next 12 inches of soil and recompact with the specified Type II rubber-tired roller, by making 3 to 5 passes. Perform at a moisture content between optimum and optimum plus 6%. Moisture content shall be based on that portion of the material passing a No. 4 sieve.
   e. The stockpiled soil of 5c above or designated borrow material shall be placed and mixed with 10 percent by weight of flyash and 3 percent by weight of pebble lime as manufactured by the Ash Grove Lime Company or acceptable alternate. The lime and flyash shall be thoroughly mixed with the soil to insure uniform distribution throughout the lift thickness. The finished stabilized base shall be 12 inches thick. The mixing shall be accomplished by blading and scarifying or by other approved methods. The Contractor shall obtain the flyash from the Owner's James River Power Station located approximately 10 miles southeast of the construction site. The flyash must be reclaimed from an ash waste pond. The flyash shall be the ash material from the waste pond which passes a No. 100 sieve. The Contractor

May have to re-roll

Soil 95#/cf Determine quantities Lime 2.85#/cf Flyash 9.5#/cf

Ref Det. unit dry wt of material in place (soil) and moisture content (opt +6%)

Determine Dry wt soil #/ft^3
Use to determine lime & fly ash contents
Place fly ash and determine moisture content -
must be up to +6% before lime is added.
add 1½% lime to previously mixed material with lime
init. ~~OT~~ This material is then to be placed
immediately on dyke sides, compacted in 12" lifts
and top lift sealed off each day. (also exposed face)

shall inspect the site where the flyash is to be reclaimed to determine accessibility and equipment requirements for reclaiming and transporting the flyash from the waste pond to the construction site.

f. The stabilized soil shall be compacted in one 12-inch lift with the specified Type I rubber-tired roller, and number of passes. Moisture content of the stabilized soil at time of compaction shall range from optimum to 6% above optimum. The finished compacted surface shall be free of surface irregularities such as ruts in excess of one inch created by compaction equipment, or areas showing segregation of materials resulting in pockets or seams of essentially granular material.

g. Apply RS-2 asphalt emulsion seal on final compacted stabilized lift at the rate of 0.6 ± 0.15 gallons of asphalt/square yard within 6 hours of placement to avoid loss of moisture and damage by the elements.

6. Cutoff Trench Construction:
   a. Excavate cutoff trench as shown on the cross section of embankment drawing from east spillway to west spillway.
   b. The base of the excavation shall be 8 feet wide, minimum, and shall be carried to a maximum depth of 7 feet below existing grade or to top of rock, whichever occurs first.
   c. Trench walls shall be sloped to stand unbraced, and to allow backfilling and compaction with equipment as specified.
   d. The base of the excavation shall be free of loose material and water prior to backfilling.
   e. Backfill material shall be approved excavated material or designated borrow material. Moisture content shall be between optimum and optimum plus 6%. Moisture content shall be based on the material passing a No. 4 sieve.

7. Embankments and Spillways:
   a. Grubbing and stripping shall be performed as specified in Section 2A except a 10-foot wide area under the upstream toe of the east-west embankment which is a part of the pond base stabilization.
   b. Scarify and recompact the next 12-inch layer except as indicated in 7a. above using the specified tamping roller.
   c. Construct embankments with material from designated borrow areas in maximum lifts of 12 inches and compacted with the specified tamping roller. Maximum size of rock shall be no greater than one half the lift thickness except where indicated. Rock 6 inches and greater can be placed in the downstream face of the east-west embankment as indicated. Larger size rock shall be placed in the bottom portion of the downstream riprap.
   d. Moisture content of all material to be compacted shall be above standard optimum moisture content for material passing a No. 4 sieve but not greater than 6% above optimum.
   e. Spillways shall be located as shown on the drawings.
   f. Riprap shall be placed on the faces of the embankments as indicated. Riprap material and placement shall be as specified in Section 2A.

8. Borrow Areas:
   a. Obtain borrow from borrow areas, Numbers 1 and 2 as indicated, any additional borrow required shall be obtained from approved on-site areas south of the pond.
   b. Maximum depth of excavation shall be as indicated on the drawings or to a depth approved by the Engineer.
   c. Where borrow areas are adjacent to embankments side slopes shall be the same as for the embankments.
   d. Waste material from pond areas may be disposed of in borrow area No. 2 after borrow excavation is complete.

Add #1 #3
   e. APPROVED BORROW MATERIAL MAY BE TAKEN FROM THE AREA IMMEDIATELY WEST OF THE ASH POND TO THE CONTOURS SHOWN.

9. Compaction Requirements:

Operation	Equipment	Lift Thickness	Compaction Req.
1. Inspection Trench Repair	Tamping Rollers	12 inches	3-5 passes
2. Sinkhole Repair	Tamping Roller	12 inches	3-5 passes
3. Pond Base Stabilization	Rubber-Tired Rollers	12 inches	3-5 passes
4. Cutoff Trench	Tamping Roller	12 inches	3-5 passes
5. Embankment	Tamping Roller	12 inches	3-5 passes

* * * * *

Burns & McDonnell / Engineers – Architects – Consultants

POST OFFICE BOX 173
KANSAS CITY, MISSOURI 64141

TEL: 816-333-4375 TWX: 910-771-3059
4600 EAST 63rd STREET

April 10, 1975

Martin K. Eby Construction Company
P. O. Box 1679
Wichita, Kansas 67201

Attention: Mr. Dan Phelan

Re: City Utilities of Springfield, Missouri
Southwest Power Station
Contract 343 - Yard Structures
Project 71-040-1

Gentlemen:

Enclosed are two prints each of Sketches SK107 and SK108 indicating changes to the ash pond dam construction.

We request two separate proposals for deleting the rip-rap across the top of each dam and secondly, for deleting the rip-rap on the downstream face of the east-west dam.

The rip-rap across the top of the north-south dike would be replaced with material as specified for embankment - Section 2D; the rip-rap across the top of the east-west dam and its downstream face would be replaced with native fill material taken from stockpile or borrow areas.

Please review these changes and submit your proposals to us. Contact me if you have any questions.

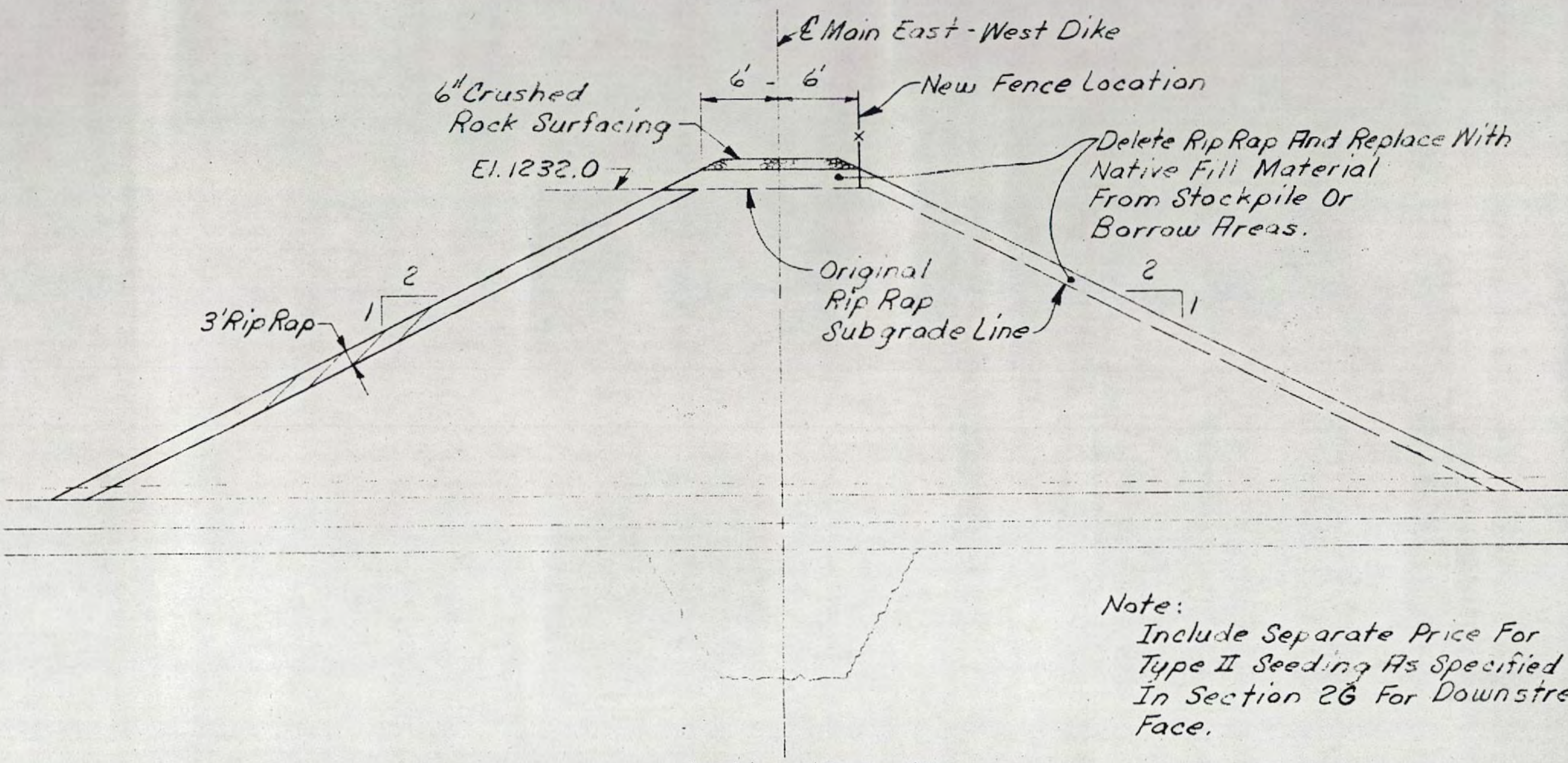
Very truly yours,

D. L. Sheridan, P. E.

DLS/jj

Enclosures
cc: Mr. M. T. Graham w/prints
Mr. Oliver Davis w/prints

2671 S. W. 27th AVENUE, MIAMI, FLORIDA 33133
TWO PENNSYLVANIA PLAZA, NEW YORK, NEW YORK 10001
7000 N. E. AIRPORT WAY, PORTLAND, OREGON 97218

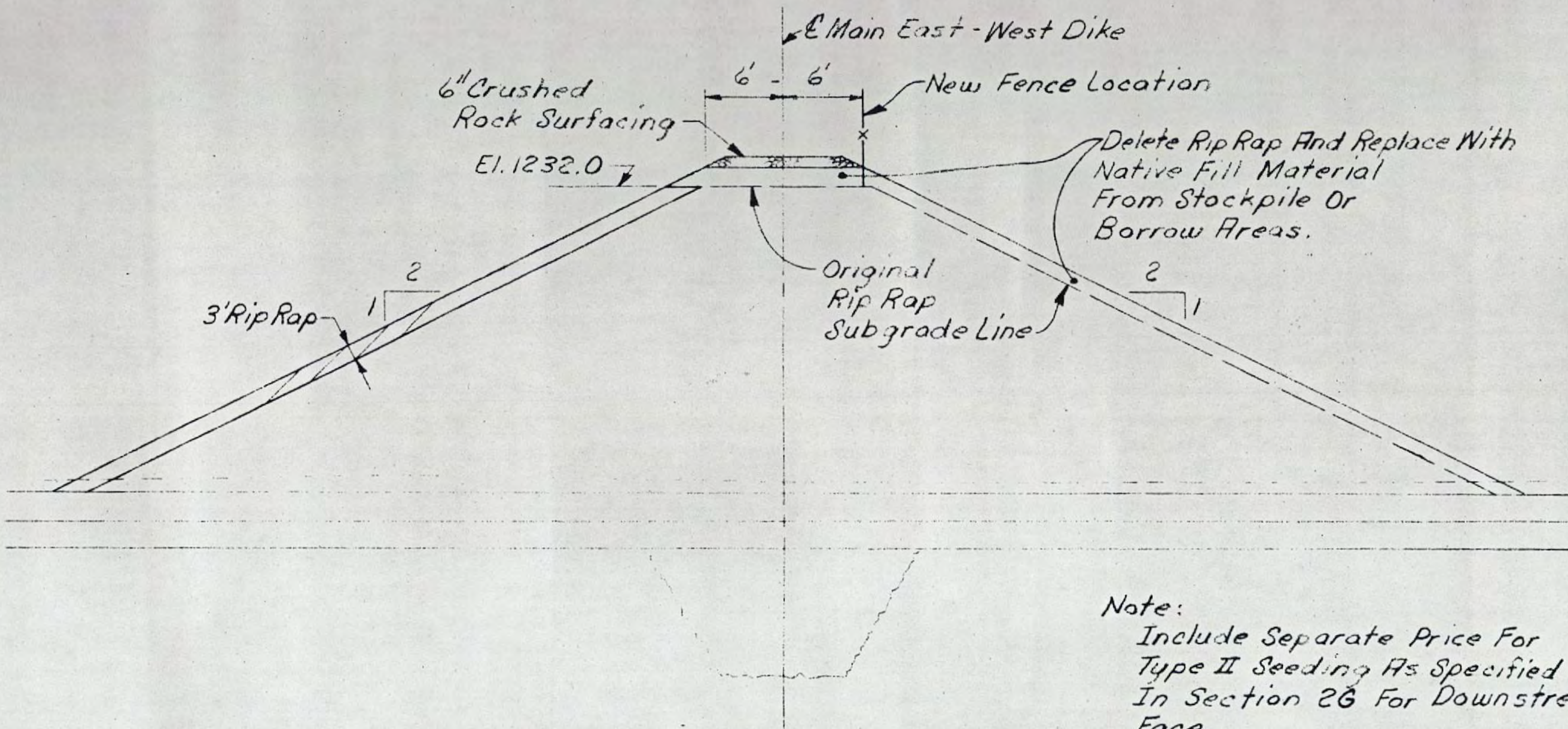


Section 45-E-49
Proposed Revision

Note:
Include Separate Price For Type II Seeding As Specified In Section 2G For Downstrea Face.

Springfield, Missou
Southwest Power Sta
Contract 343 Yard Structu
SK 107 71-040-1
Burns & McDonnell
L.R.A. 4-10-75

Sketch 107



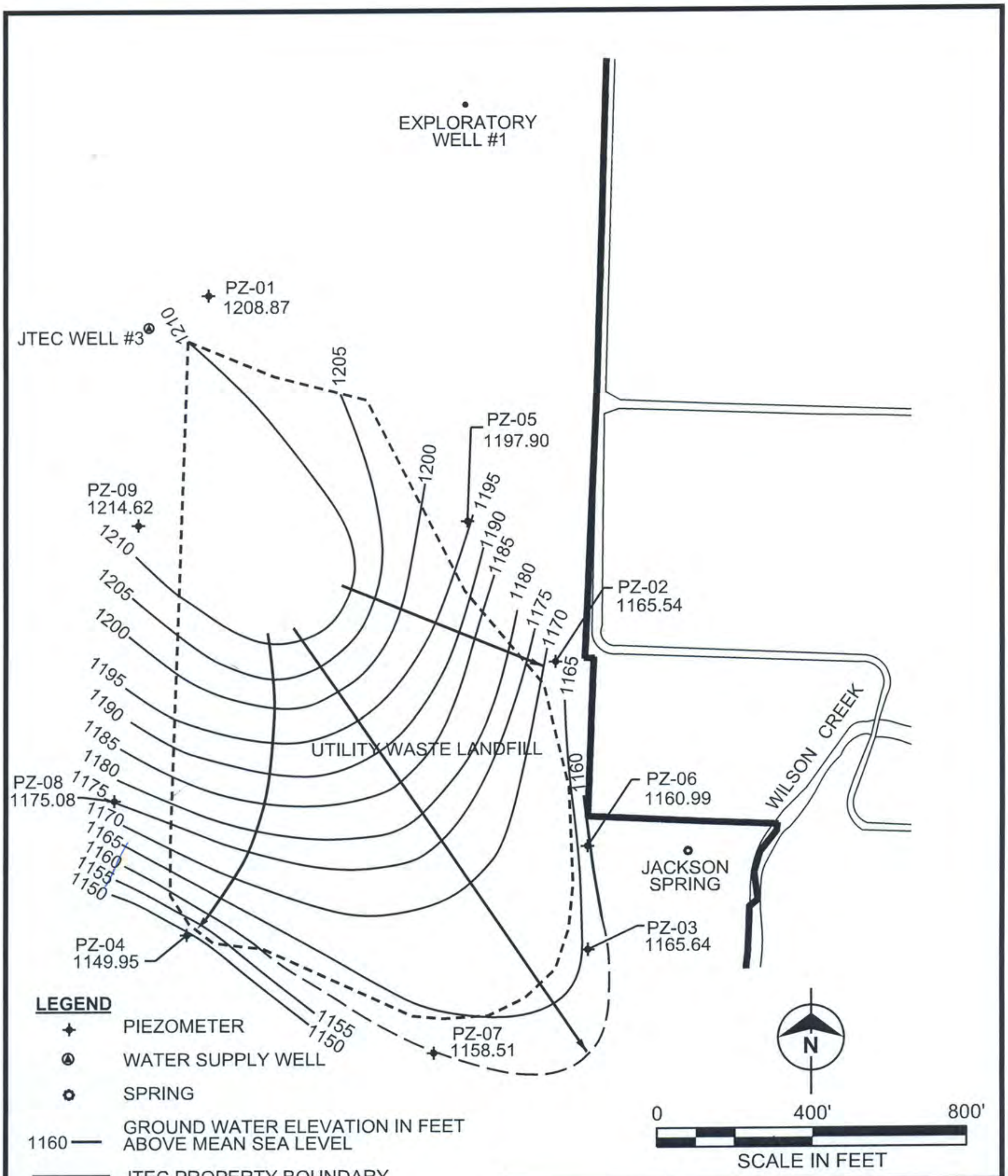
Section 45-E-49

Proposed Revision

Note:
Include Separate Price For Type II Seeding As Specified In Section 26 For Downstream Face.

Springfield, Missouri
Southwest Power Static
Contract 343 Yard Structure
SK 107 71-040-1
Burns & McDonnell
L.R.A. 4-10-75

Attachment 4. 2013 Piezometer Study



Burns & McDonnell SINCE 1898

Figure 3-15
GROUND WATER PIEZOMETER MAP (NOVEMBER 15, 2012)
JOHN TWITTY ENERGY CENTER
SPRINGFIELD, MISSOURI

K:\ENV\SPRINGFIELD MISSOURI\Site\62848\Cad\JTEC PLANT\NOVEMBER 2012\Fig3-15_GW_Piezometer_NOV 15_2012_Springfield_MO.dgn

Attachment 5. JTEC Seismic Study, Anderson Engineering, 2011

GEOTECHNICAL INVESTIGATION REPORT

John Twitty Energy Center (JTEC) Utility Waste Landfill
Springfield, Greene County, Missouri

PREPARED FOR
CITY UTILITIES OF SPRINGFIELD (CU)
P.O. Box 551
Springfield, Missouri 65801

December 9, 2011

PREPARED BY:
ANDERSON ENGINEERING, INC.
2045 WEST WOODLAND
SPRINGFIELD, MISOURI 65807
417-866-2741

811 EAST THIRD STREET
JOPLIN, MISSOURI 64801
417-782-7399

Anderson Engineering Work Order # 70045-11

STATE OF MISSOURI
JOHN TONY SNIDER
NUMBER
PE-2008034893
PROFESSIONAL ENGINEER

12/9/2011

John T. Snider, P.E.
Senior Geotechnical Engineer

STATE OF MISSOURI
STEVE L. BRADY
NUMBER
E-14938
PROFESSIONAL ENGINEER

Steven L. Brady, P.E.
CEO/Senior Geotechnical Engineer

12/9/2011

ANDERSON ENGINEERING, INC
EMPLOYEE OWNED

December 9, 2011

Mr. Ted Salveter, P.E.
CITY UTILITIES OF SPRINGFIELD (CU)
P.O. Box 551
Springfield, Mo. 65801

Re: Geotechnical Exploration Report
Slope Stability Analysis with Additional Engineering Analysis,
Including Erosion Control -
For Proposed Vertical Expansion
John Twitty Energy Center (JTEC), Ash Landfill
Springfield, Greene County, Missouri
Anderson Engineering Work Order # 70045-11

Dear Ted;

Attached is the slope stability report performed at the above referenced site for your use.

Should you have any questions regarding the report, please give me or John Snider a call. Thank you for the opportunity to be of service.

Sincerely,

ANDERSON ENGINEERING, INC.
by

John T. Snider, P.E.
Senior Geotechnical Engineer

Steven L. Brady, P.E.
CEO/Senior Geotechnical Engineer

Enclosures

811 E. THIRD STREET JOPLIN, MO 64801 PH: 417.782.7399 FX: 417.782.7398 WWW.AEINCMO.COM E-MAIL: AEINC@AEINCMO.COM
ENGINEERS • SURVEYORS • LABORATORIES • DRILLING

rocky or cherty.

SEISMIC RISK:

The site is located approximately 250 miles west/northwest of the New Madrid Fault Zone in southeast Missouri. In past years this fault has produced large magnitude earthquakes (Richter Magnitude 8+). Numerous small earthquakes (Richter Magnitude 2 to 4) occur along the New Madrid Fault each year.

The determination of seismic risk or hazard for this site was performed by reviewing the most recent, 2008 Update of the United States National Seismic Hazard Maps and data files produced by the United States Geologic Survey (USGS). The USGS periodically publishes national seismic hazards maps. The previous map was produced in 2002. The USGS's National Seismic Hazard Maps are the basis for seismic design provisions in building codes, insurance rates structures, and land-use planning. The use of these hazard maps into design allows structures to withstand designated earthquake shaking without collapse. By determining the likely shaking for a given area, the hazard maps also help avoid over-design for unlikely levels of ground motion

The National Seismic Hazard Map (NSHM) models a variety of geologic earthquake conditions to produce hazard maps which are calculated at several peak horizontal ground accelerations (PGA) for various probabilities of occurrence. The PGA results are reported as a percentage of gravity, g. These results are published in a rectangular girded format over the United States in 0.05 degree increments in longitude and latitude (which is a rectangular grid network of approximately every 3 miles for this site).

The hazard curves produced are for 10-percent, 5-percent, and 2-percent probability of exceedance in 50 years. Many state and federal agencies use a threshold of 2-percent probability that 0.1 g will be exceeded in 50 years as an initial threshold of seismic impact or hazard zone that should be regulated. The 2-percent probability of exceedance in 50 years is based on Poisson (time-independent) event occurrence and corresponds with an annual rate of exceedance of 0.00040 or 1 in 2500.

As discussed above, the hazard at 2-percent probability of exceedance in 50 years in the Central United States is dominated by the New Madrid seismic zone. A review of the USGS grid points surrounding the JTEC ash landfill shows a PGA of 0.09 g at 2-percent probability of exceedance in 50 years. This is less than 0.1 g PGA at 2-percent probability of exceedance in 50 years that is often used as an initial regulatory threshold for seismic risk management. See attached seismic map and table in Appendix IV

GENERAL SITE CONDITIONS:

An inspection of the landfill surface for indications of slope instability was performed by the Project Engineer. . Checks were made for: tension cracks, fissures, slumping, toe cracks, active seepage, excessive settlements, and other signs of instability. No significant signs of instability were observed. A small slump was observed on the upper face of the landfill just above the working face to the north east. Although this area was topsoiled and turfed, it is a temporary face and appeared to be compacted to less effort than the final capped parts of the Phase I landfill.

Several erosion rills were also observed on the non-turfed parts of the working slope faces of the landfill. Depth of erosion rills ranged from a few inches to about two feet. Due to the silty to fine sand nature of the ash fill this should be expected on exposed, non-turfed ash slopes. These erosion rills otherwise appeared stable. A minor amount of standing

APPENDIX IV

SEISMIC MAP RESULTS

W	N	g							
-93.450	37.200	0.088		JTS, 12-29-09		38319			
-93.400	37.200	0.090							
-93.350	37.200	0.092		N	37	8	47.4		
-93.300	37.200	0.094					0.790		
-93.250	37.200	0.096				8.790			
-93.200	37.200	0.098				0.147			
-93.450	37.150	0.089		37.147					
-93.400	37.150	0.091							
-93.350	37.150	0.093		W	93	22	51.3		
-93.300	37.150	0.095					0.855		
-93.250	37.150	0.097				22.855			
-93.200	37.150	0.099				0.381			
-93.450	37.100	0.090		93.381					
-93.400	37.100	0.092							
-93.350	37.100	0.094							
-93.300	37.100	0.096							
-93.250	37.100	0.098							
-93.200	37.100	0.101							

(Header cell above columns E–G: SW Power Plant, Springfield, MO)

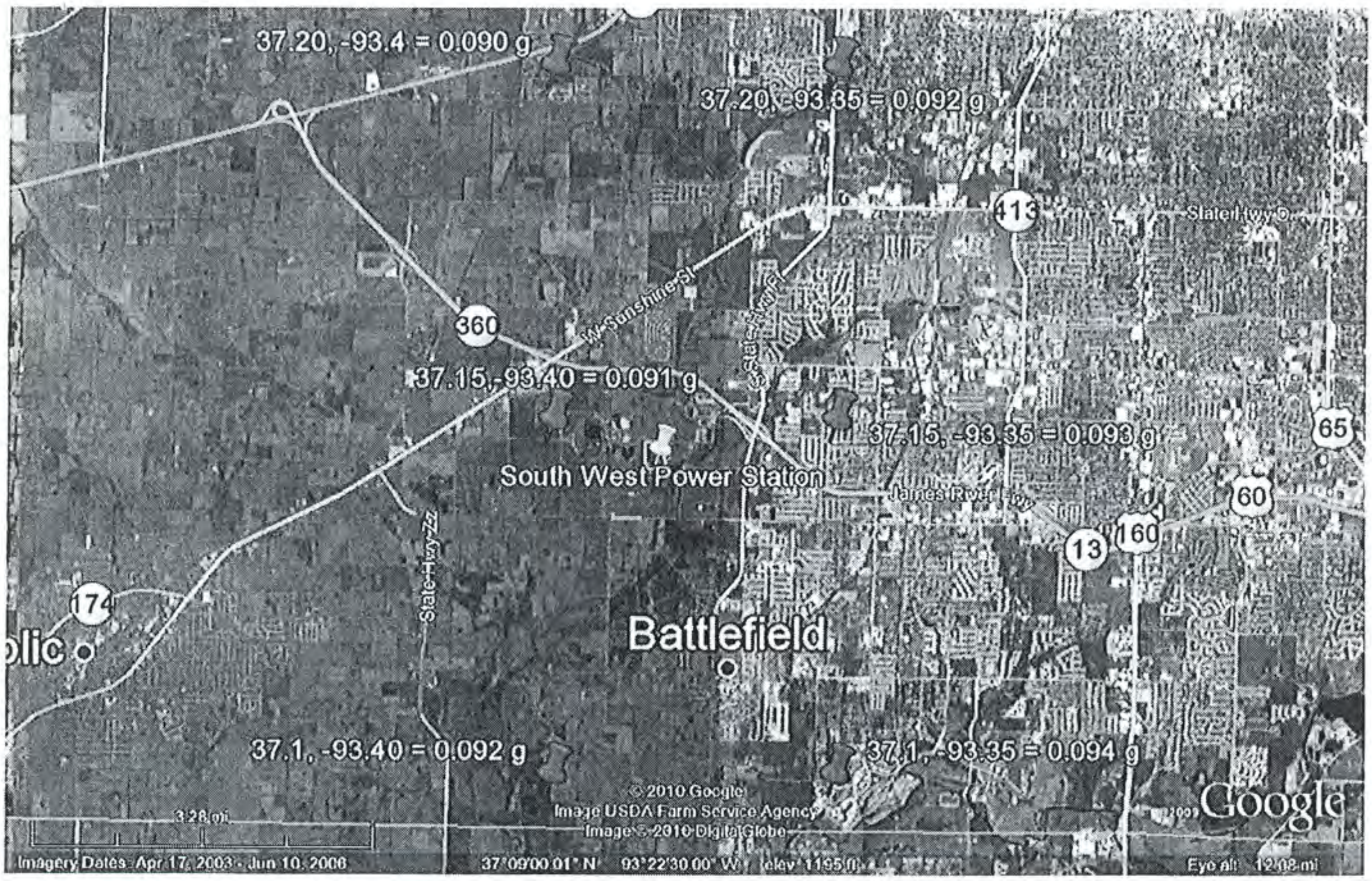
Gridded Hazard Map, Peak Ground Acceleration, 2% in 50 Years, Text (3 Mb)

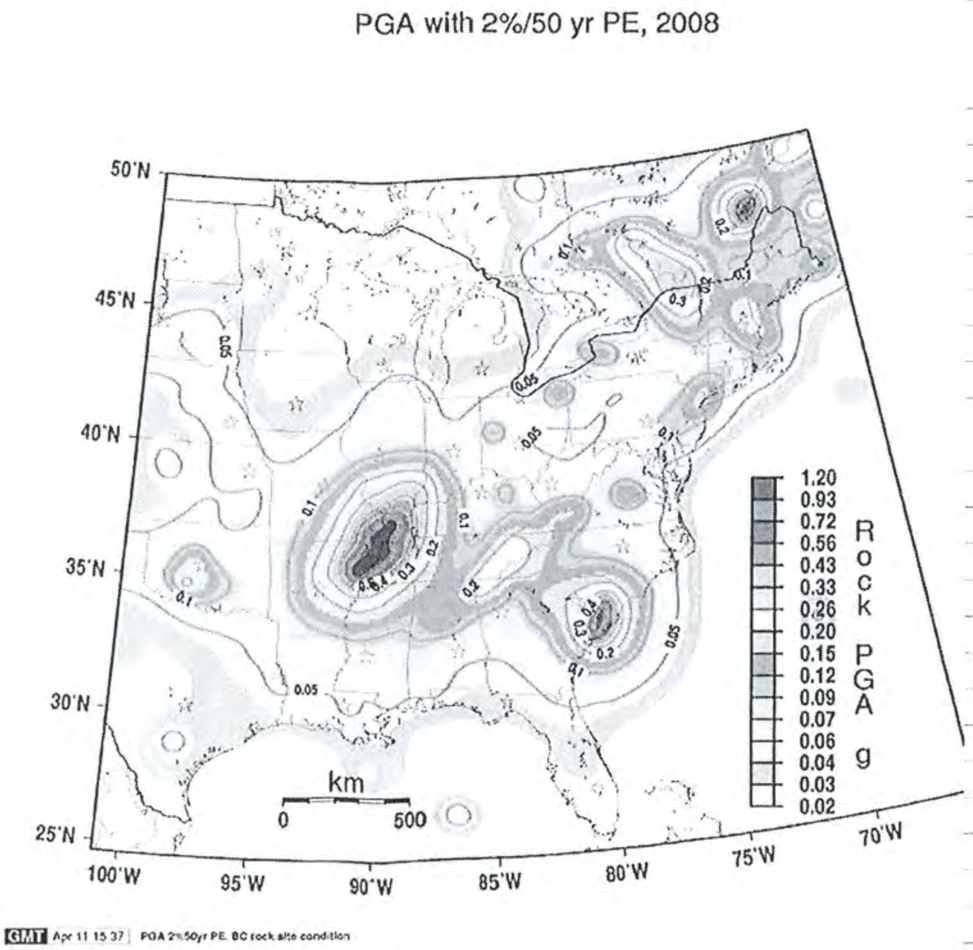
http://earthquake.usgs.gov/hazards/products/conterminous/2008/data/

2008 NSHM Gridded Data

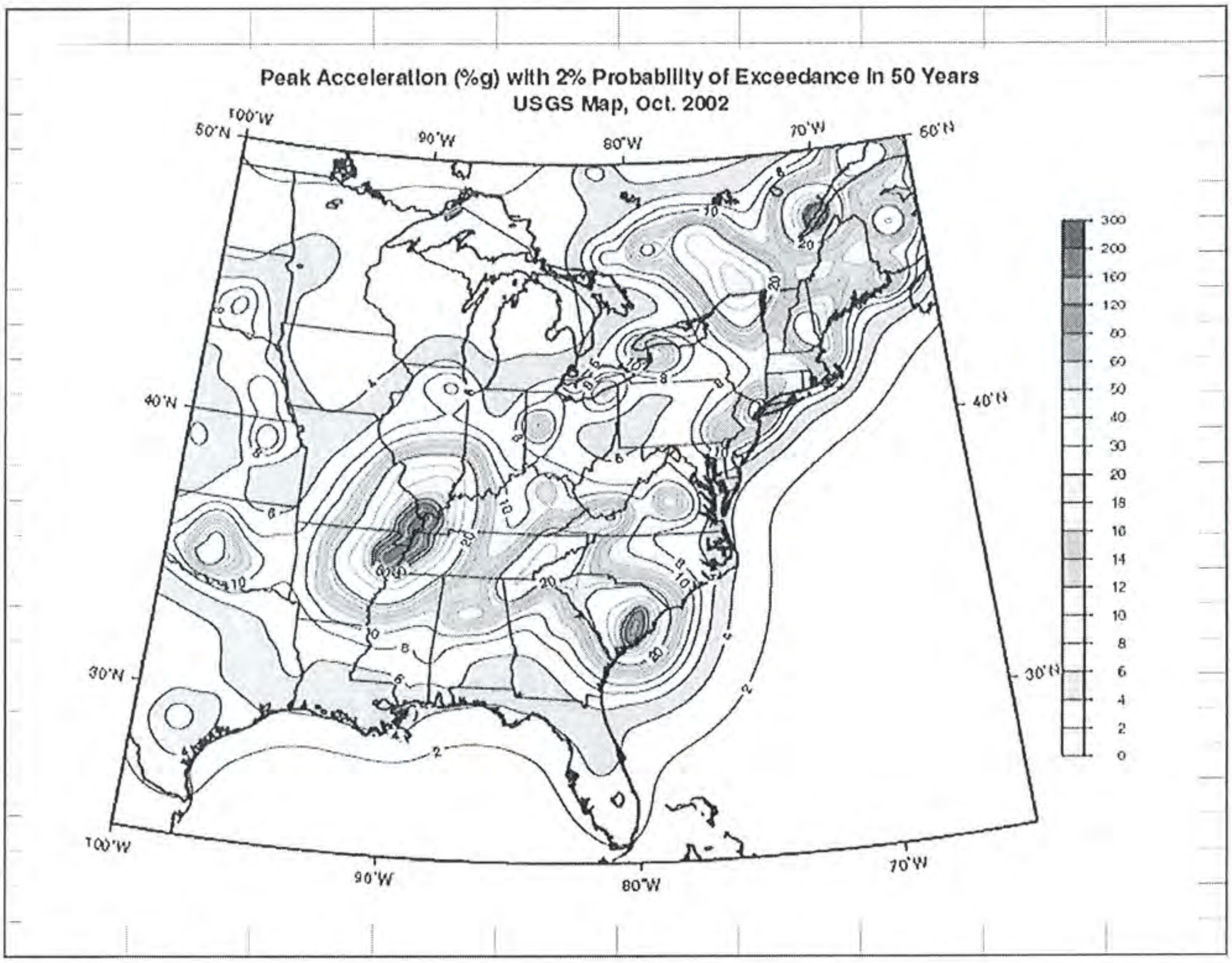
These files contain space-delimited, rectangular gridded data over the Conterminous 48 States in 0.05 degree increments in longitude (x-value) and latitude (y-value)

These files contain ground motion values for the gridded geographic points as described above. The ground motion units are in g where 1g = 980.5 cm/s/s and are defined for the B/C boundary (Vs30 = 760 m/s). Data contained in these files specify a single geographic point per line starting with longitude and latitude values (respectively), with the third and final value of each line specifying the ground motion for that geographic point.


37.20, -93.4 = 0.090 g
37.20, -93.35 = 0.092 g
413
State Hwy D
360
W Sunshine St
37.15,-93.40 = 0.091 g
37.15, -93.35 = 0.093 g
65
South West Power Station
James River Fwy
60
13
160
State Hwy ZZ
174
Battlefield
37.1, -93.40 = 0.092 g
37.1, -93.35 = 0.094 g
© 2010 Google
Image USDA Farm Service Agency
Image © 2010 DigitalGlobe
Google
3.28 mi
Imagery Dates: Apr 17, 2003 - Jun 10, 2006
37°09'00.01" N 93°22'30.00" W elev 1195 ft
Eye alt 12.08 mi



PGA with 2%/50 yr PE, 2008
50°N
45°N
40°N
35°N
30°N
25°N
100°W
95°W
90°W
85°W
80°W
75°W
70°W
km
0
500
1.20
0.93
0.72
0.56
0.43
0.33
0.26
0.20
0.15
0.12
0.09
0.07
0.06
0.04
0.03
0.02
Rock PGA g



C:\Work_Projects\38319 SW PS Ash Landfill, City Utilities - Seismic Determination\SW plant area, Springfield, MO, UShazard.20081229.pga.2pc50.xls, Sheet1

From:	Dave Fraley
To:	Englander, Jana
Cc:	Hoffman, Stephen; Dufficy, Craig; Kelly, PatrickM; Mark Haden
Subject:	RE: Draft report response John Twitty Energy Center
Date:	Friday, December 13, 2013 12:04:40 PM

Jana,

Sorry, we should have clarified. The slope stability analysis report was performed for the landfill located a bit east of the ponds rather than on the ponds themselves. We only included the seismic risk portion figuring it would apply equally to both structures.

Thanks!
Dave

From: Englander, Jana [Englander.Jana@epa.gov]
Sent: Friday, December 13, 2013 10:34 AM
To: Dave Fraley
Cc: Hoffman, Stephen; Dufficy, Craig; Kelly, PatrickM; Englander, Jana; Mark Haden
Subject: FW: Draft report response John Twitty Energy Center

Dave,

We are in receipt of your comments on the DRAFT report regarding the Coal Ash Site Assessment at the John Twitty Energy Center. We would be happy to set up a conference call regarding your comments, once we have had a chance to properly review them. From a cursory look, is there a reason why attachment 5, slope stability analyses was not provided as a complete report?
I will be back in touch with you sometime next week to schedule a conference call.

Regards,

Jana

Jana Englander
Office of Resource Conservation and Recovery,
Materials Recovery Waste Management Division
Energy Recovery and Waste Disposal Branch
U.S. Environmental Protection Agency
703-308-8711

From: Dave Fraley <Dave.Fraley@cityutilities.net>
Sent: Thursday, December 12, 2013 4:55 PM
To: Englander, Jana
Cc: Mark Haden
Subject: RE: Draft report response John Twitty Energy Center

Ms. Englander,

Please accept the attached comments. As you will note, we would definitely appreciate a chance to discuss the report with CDM again before finalizing. Sorry for the delay, please advise if we can provide any other info or assistance.

Dave Fraley

From: Englander, Jana [Englander.Jana@epa.gov]
Sent: Monday, December 09, 2013 9:14 AM
To: Dave Fraley
Subject: RE: Draft report response John Twitty Energy Center

Hi Dave,

Thanks for your message. I look forward to receiving your comment package this week.

Regards,

Jana

Jana Englander
Office of Resource Conservation and Recovery,
Materials Recovery Waste Management Division
Energy Recovery and Waste Disposal Branch
U.S. Environmental Protection Agency
703-308-8711

From: Dave Fraley [mailto:Dave.Fraley@cityutilities.net]
Sent: Friday, December 06, 2013 5:03 PM
To: Englander, Jana
Subject: Draft report response John Twitty Energy Center

Ms. Englander,

Sorry I missed your phone call yesterday and was unable to get back with you this afternoon. Our response is complete but for one attachment I am expecting from the power plant. I will be out again on Monday but will contact you Tuesday and hope to have the report ready to submit electronically by then.

Thanks!
Dave Fraley
417.831.8778

Are you connected? Follow us!

Are you connected? Follow us!

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE:		DATE INSPECTED:	02-11-2013
COUNTY:	GREENE	WEATHER:	Sunny & Warm
		TEMPERATURE:	45° F.
TYPE OF DIKE:	EARTH EMBANKMENT	PERSON MAKING INSPECTION:	W. Painter

ITEM	YES	NO	
1. CREST	**YES**	**NO**	
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓	✓	001 Outfall / East & West Ash Ponds
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?			
F. ADEQUATE RIP-RAP PROTECTION?			
G. ANY STONE DETERIORATION?	✓		East Ash Pond Dividing Rip Rap not Sufficient
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		001 Outfall / East & West Ash Ponds
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?		✓	
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: 001, 002, 004
COUNTY: GREENE
TYPE OF DIKE: EARTH EMBANKMENT

DATE INSPECTED: 11/15/12
WEATHER: Clear
TEMPERATURE: 50°
PERSON MAKING INSPECTION: [illegible]

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		001, 002, 004
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?	✓		The Roads 001, 002, 004
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		001, 002, 004
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: ______

COUNTY: GREENE

TYPE OF DIKE: EARTH EMBANKMENT

DATE INSPECTED: 10-13-12

WEATHER: CLOUDY

TEMPERATURE: 72°

PERSON MAKING INSPECTION: WESTER

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE:	001, 002, 003, 004	DATE INSPECTED:	9/24/12
COUNTY:	GREENE	WEATHER:	Sunny
		TEMPERATURE:	58°
TYPE OF DIKE:	EARTH EMBANKMENT	PERSON MAKING INSPECTION:	Shane Williams

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		002 004
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?	✓		004 Erosion SE Corner Truck Tracks
C. ARE TREES GROWING ON SLOPE?	✓		002
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: 002
COUNTY: GREENE
DATE INSPECTED: 8-4-12
WEATHER: Sunny / Dry
TEMPERATURE: 100°

TYPE OF DIKE: EARTH EMBANKMENT
PERSON MAKING INSPECTION: Shane Williams

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		East Pond
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		Some Small Tree's starting to grow
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE:		DATE INSPECTED:	6-12-12
COUNTY:	GREENE	WEATHER:	FAIR
		TEMPERATURE:	82
TYPE OF DIKE:	EARTH EMBANKMENT	PERSON MAKING INSPECTION:	TIM SMITH, JON INGERSON, GARY KLEEMAN

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: 001/002/003/004
COUNTY: GREENE
TYPE OF DIKE: EARTH EMBANKMENT

DATE INSPECTED: 05/13/12
WEATHER: Clear
TEMPERATURE: 76
PERSON MAKING INSPECTION: [illegible]

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		002, 004
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		001, 002
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE:		DATE INSPECTED:	23 Apr 12
COUNTY:	GREENE	WEATHER:	Clear
		TEMPERATURE:	53°
TYPE OF DIKE:	EARTH EMBANKMENT	PERSON MAKING INSPECTION:	T Hardy

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?	✓		East pond
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?		✓	outfall 001 is dry. The outfall on the Southeast of the property is draining.
I. IS SEEPAGE PRESENT?	✓		
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: Ash Pond III (?)
COUNTY: GREENE
DATE INSPECTED: 3/18/12 (?)
WEATHER: Cloudy (?)
TEMPERATURE: 75 (?)
TYPE OF DIKE: EARTH EMBANKMENT
PERSON MAKING INSPECTION: [illegible]

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		✓	
B. MISALIGNMENTS		✓	
C. CRACKING?		✓	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. ADEQUATE RIP-RAP PROTECTION?	✓		
G. ANY STONE DETERIORATION?		✓	
H. VISUAL DEPRESSIONS OR BULGES?		✓	
I. VISUAL SETTLEMENTS?		✓	
J. DEBRIS OR TRASH PRESENT?		✓	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	✓		
B. ANY EROSION?		✓	
C. ARE TREES GROWING ON SLOPE?		✓	
D. LONGITUDINAL CRACKS?		✓	
E. TRANSVERSE CRACKS?		✓	
F. VISUAL DEPRESSIONS OR BULGES?		✓	
G. VISUAL SETTLEMENTS?		✓	
H. IS TOE DRAIN DRY?	✓		
I. IS SEEPAGE PRESENT?		✓	
J. SOFT OR SPONGY ZONES PRESENT?		✓	

SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE: East Ash Pond Dam
DATE INSPECTED: 12-5-11
COUNTY: GREENE
WEATHER: Overcast
TEMPERATURE: 34°

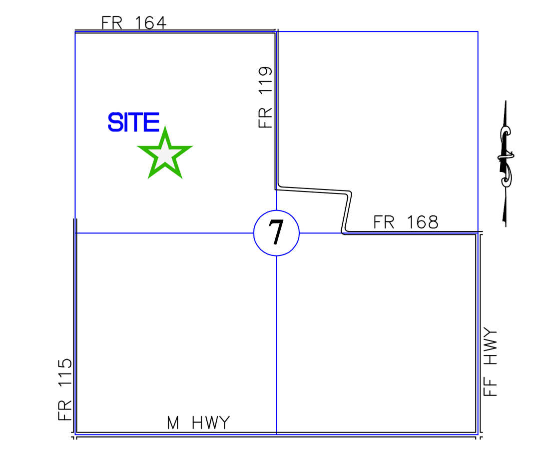
TYPE OF DIKE: EARTH EMBANKMENT
PERSON MAKING INSPECTION: K. King

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		X	
B. MISALIGNMENTS		X	
C. CRACKING?		X	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	X		
B. ANY EROSION?		X	
C. ARE TREES GROWING ON SLOPE?		X	
D. LONGITUDINAL CRACKS?		X	
E. TRANSVERSE CRACKS?		X	
F. ADEQUATE RIP-RAP PROTECTION?	X		
G. ANY STONE DETERIORATION?		X	
H. VISUAL DEPRESSIONS OR BULGES?		X	
I. VISUAL SETTLEMENTS?		X	
J. DEBRIS OR TRASH PRESENT?		X	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	X		
B. ANY EROSION?		X	
C. ARE TREES GROWING ON SLOPE?		X	
D. LONGITUDINAL CRACKS?		X	
E. TRANSVERSE CRACKS?		X	
F. VISUAL DEPRESSIONS OR BULGES?		X	
G. VISUAL SETTLEMENTS?		X	
H. IS TOE DRAIN DRY?			
I. IS SEEPAGE PRESENT?		X	
J. SOFT OR SPONGY ZONES PRESENT?		X	

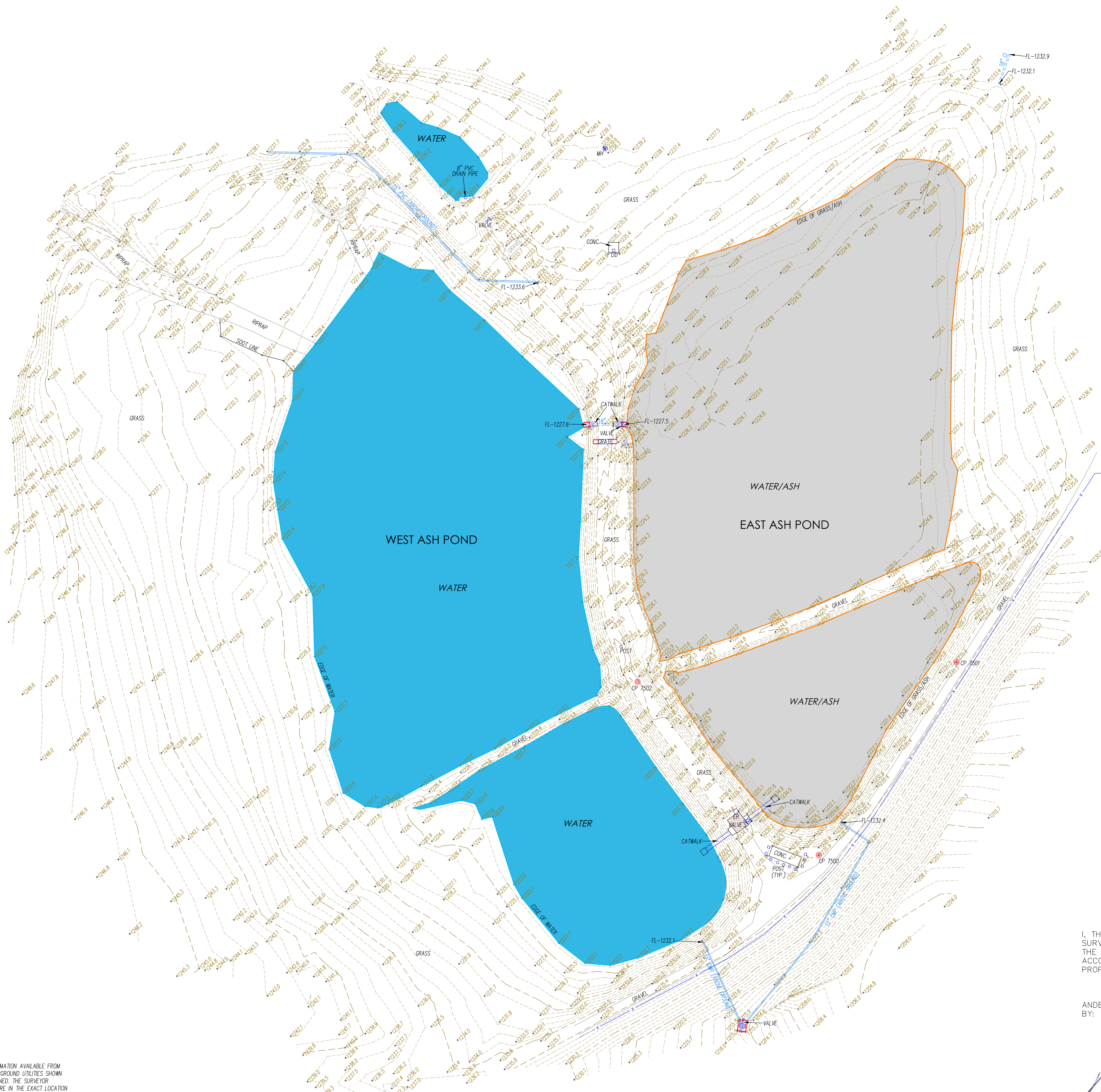
SWPS DIKE INSPECTION CHECKLIST

NAME OF DIKE:	West Bottom Ash Pond	DATE INSPECTED:	12-5-11
COUNTY:	GREENE	WEATHER:	overcast
		TEMPERATURE:	34°
TYPE OF DIKE:	EARTH EMBANKMENT	PERSON MAKING INSPECTION:	K. King

ITEM	YES	NO	
1. CREST			
A. ANY VISUAL SETTLEMENT?		X	
B. MISALIGNMENTS		X	
C. CRACKING?		X	
2. UPSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	X		
B. ANY EROSION?		X	
C. ARE TREES GROWING ON SLOPE?		X	
D. LONGITUDINAL CRACKS?		X	
E. TRANSVERSE CRACKS?		X	
F. ADEQUATE RIP-RAP PROTECTION?	X		
G. ANY STONE DETERIORATION?		X	
H. VISUAL DEPRESSIONS OR BULGES?		X	
I. VISUAL SETTLEMENTS?		X	
J. DEBRIS OR TRASH PRESENT?		X	
3. DOWNSTREAM SLOPE			
A. ADEQUATE GRASS COVER?	X		
B. ANY EROSION?		X	
C. ARE TREES GROWING ON SLOPE?		X	
D. LONGITUDINAL CRACKS?		X	
E. TRANSVERSE CRACKS?		X	
F. VISUAL DEPRESSIONS OR BULGES?		X	
G. VISUAL SETTLEMENTS?		X	
H. IS TOE DRAIN DRY?			
I. IS SEEPAGE PRESENT?		X	
J. SOFT OR SPONGY ZONES PRESENT?		X	



LOCATION SKETCH
SEC 7, T28N, R22W
SCALE: 1"=2000'



GRID

GRAPHIC SCALE

50 0 25 50 100 200

(IN FEET)
1 inch = 50 ft.

LEGEND

CP	CONTROL POINT
IP	FOUND IRON PIN
IP	SET IRON PIN
RWM	RIGHT-OF-WAY MARKER
PP GY	POWER POLE W/ GUY
MH	MANHOLE
SCO	SEWER CLEANOUT
GM	GAS METER
LP	LIGHT POLE
	SIGN
WM	WATER METER
WV	WATER VALVE
GV	GAS VALVE
FH	FIRE HYDRANT
TR	TELEPHONE RISER
	BUMPER POST
	GRATE INLET
	TREELINE
	BUSH
ER	ELECTRICAL RISER
TS	TRAFFIC SIGNAL BOX
MB	MAIL BOX
PROPERTY LINE	
SANITARY SEWER	SS
STORM SEWER	SW
TELEPHONE LINE	T
UNDERGROUND TELEPHONE	UT
GAS LINE	G
WATER LINE	W
ELECTRIC LINE	E
UNDERGROUND ELECTRIC	UE
FENCE LINE	x
RETAINING WALL	
LINE LABELS	MEASURED 100' M / DEED 100' D

UTILITY NOTE:
THIS SURVEY REFLECTS ABOVE GROUND INDICATIONS OF UTILITIES AND INFORMATION AVAILABLE FROM UTILITY COMPANIES. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANTY THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED, ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

POND VOLUME ABOVE NORMAL
POOL ELEVATION 1227 TO 1234

EAST ASH POND = 46,564 CUBIC YARDS
WEST ASH POND = 60,631 CUBIC YARDS

SURVEYOR'S DECLARATION

I, THE UNDERSIGNED, DO HEREBY DECLARE THAT THE TOPOGRAPHIC SURVEY SHOWN HEREON WAS MADE UNDER MY SUPERVISION AND TO THE BEST OF MY KNOWLEDGE THE INFORMATION IS AS SHOWN AND IN ACCORDANCE WITH THE CURRENT MINIMUM STANDARDS FOR URBAN PROPERTY SURVEYS. DATE OF LAST REVISION JANUARY 17, 2014.

ANDERSON ENGINEERING, INC. LC 62
BY:

STATE OF MISSOURI
KEVIN L. LAMBETH
NUMBER LS-2695
PROFESSIONAL LAND SURVEYOR

KEVIN L. LAMBETH, P.L.S. 2695

1-17-2014
DATE

DATE OF FIELD SURVEY JANUARY 2014

ANDERSON ENGINEERING, INC
ENGINEERS • SURVEYORS • LABORATORIES • DRILLING
2045 W. WOODLAND • SPRINGFIELD, MISSOURI 65807 • PHONE (417) 866-2741
COA # 000062

NO.	REVISIONS DESCRIPTION	BY	DATE

DRAWING INFO.	
FIELD BY:	BH
DRAWN BY:	BAC
CHECK BY:	KLL
DATE:	1-17-2014
FIELD BOOK:	
JOB NUMBER:	30007-14

CITY UTILITIES OF SPRINGFIELD

EAST AND WEST ASH POND 1227 TO 1234 CONTOUR VOLUME SURVEY

JTEC
SPRINGFIELD, MISSOURI

DRAWING NO.
WB 109-940
SHEET NUMBER
1
OF 1

CAPACITY OF ASH PONDS TO CONTAIN DESIGN RAINFALL EVENT

Purpose:

Document that ash ponds have adequate capacity above the normal pool elevation to store a 100-year, 24-hour rainfall event and maintain adequate freeboard.

Assumptions

- Total precipitation from a 100-year, 24-hour rainfall event is **8.18 inches**. (Source: City of Springfield Drainage Design Manual)
- Normal pool elevation of both east and west ponds is 1226 to 1227 feet (use 1227 feet)
- Low point along top of embankment (both ponds) is 1235 feet
- East pond storage volume (1227 to 1234 feet) is **46,564 cubic yards** (2014 Anderson survey)
- West pond storage volume (1227 to 1234 feet) is **60,631 cubic yards** (2014 Anderson survey)
- Drainage area for east pond is 30.4 acres
- Drainage area for west pond is 36.6 acres

Calculate total rainfall volume from design storm event in E. and W. pond drainage areas

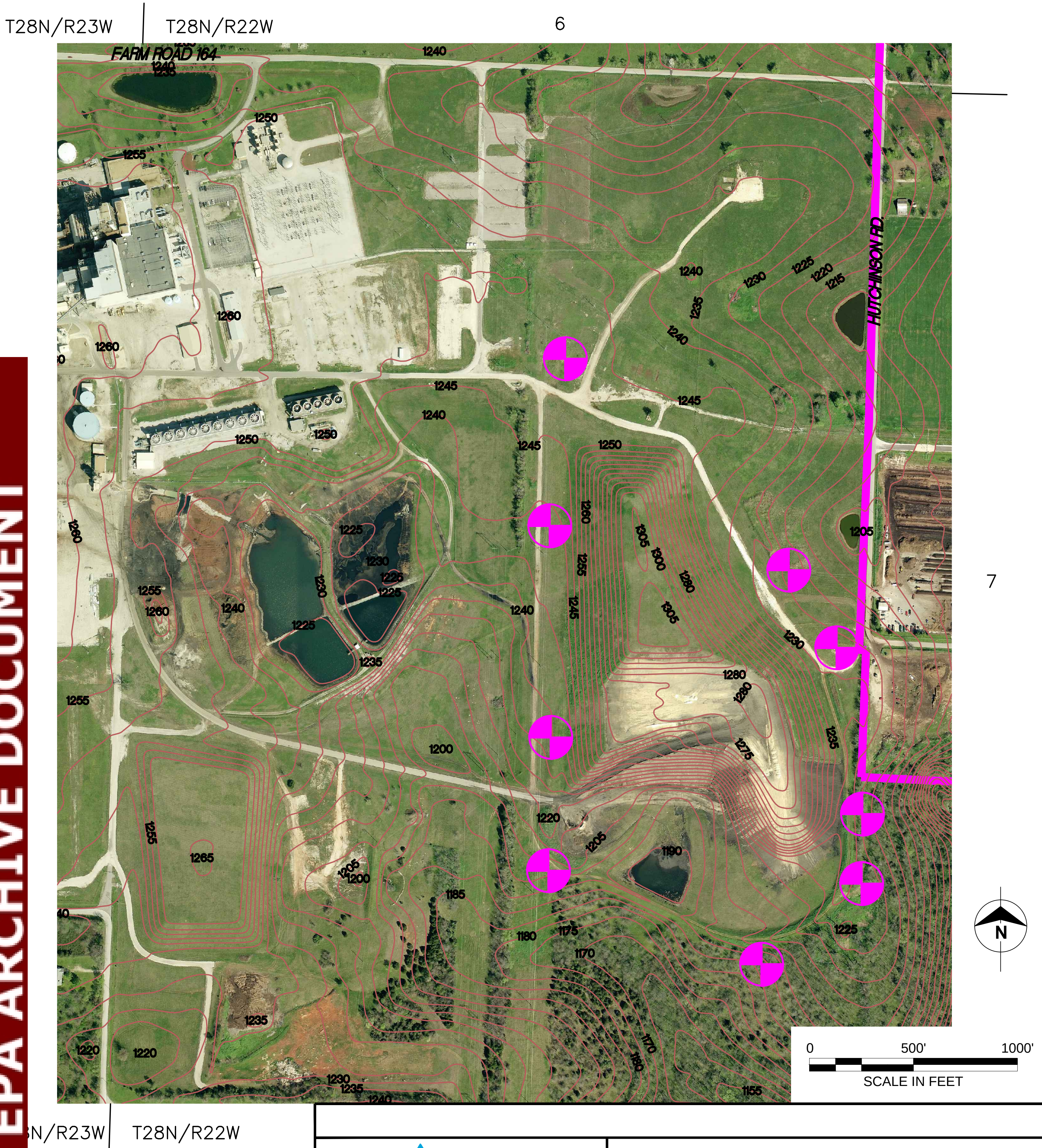
East Pond: [30.4 acres] [43,560 sq. ft/acre] [8.18 in.] [1 ft/12 in.] [cubic yard/27 cubic ft.] = **33,432 yd3**

West pond: [36.6 ac.] [43,560 sq. ft./ac.] [8.18 in.] [1 ft./12 in.] [cubic yard/27 cubic ft.] = **40,251 yd3**

Conclusion

Both the east and west ponds will contain a 100-year, 24-hour rainfall event and maintain a freeboard greater than one foot. This is a very conservative estimate in that it:

1. Assumes that the total rainfall produced in the drainage areas actually drains to the pond (i.e no infiltration).
2. Does not account for the additional routing capacity of the two 12" diameter corrugated spillway overflow pipes which have a discharge capacity of 2 to 3 cfs each.
3. Does not account for the maximum routing capacity of the ponds outlet structure which is capable of discharging approximately 6.5 million gallons per day (mgd) and which could be utilized in the event of major storm event. For reference the average pond discharge is 0.2 mgd.



LEGEND:

LANDFILL MONITORING WELLS

CITY UTILITIES JTEC PROPERTY BOUNDARY(TOTAL ACRES: 980±)

CONTOURS ARE LIDAR DATA, GREENE COUNTY, FEB 2011 AND ARE ON 5-FT INTERVALS

AERIAL PHOTOGRAPH TAKEN FEBRUARY 2012

CITY UTILITIES

Bringing Power Home.

JOHN TWITTY ENERGY CENTER SITE PLAN

ENGINEERED BY: TCS	APPROVED BY: TCS	DATE: 8/26/2013	DATE ISSUED:	MAP NO.:
DRAWN BY: JET	AGENCY NO.:		PLOT DATE/TIME: 1/15/2014	SCALE: 1" = 500'
APPLICATION NO.:	PERMIT NO.:		SHEET OF	DRAWING NO.: JTPSI02

Project Number: 62848
Project Name: Springfield City Utilities, JTEC
Monitoring Well No: PZ-05
Well Location: JTEC
Installation Start (Date/Time): 9/11/2012
Completion (Date/Time): 9/13/2012

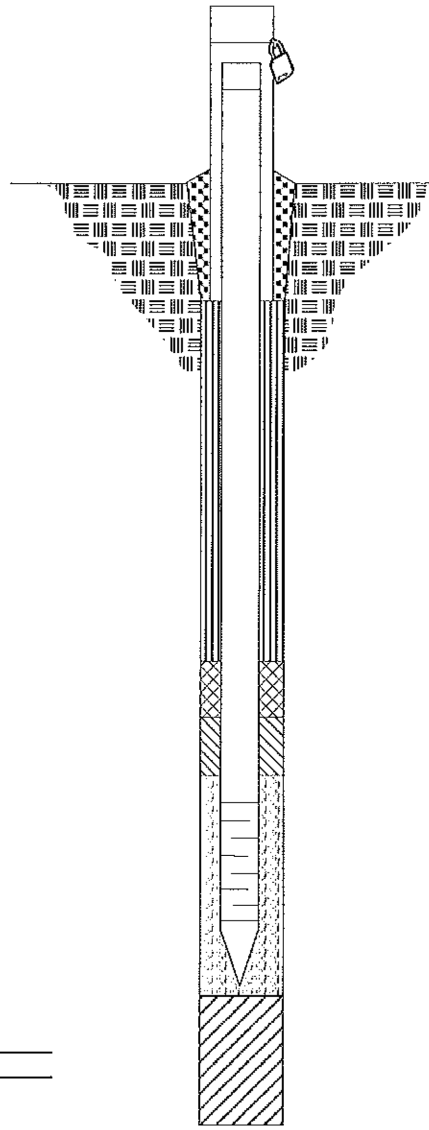
Well casing, top elevation 1235.64 ft. msl

Land surface elevation 1232.56 ft. msl

Top View

Side View

Sketch of Surface Completion



Annular seal, top 2.0 ft bgs

Bentonite seal, top 41.0 ft bgs

Fine sand, top na ft bgs

Filter pack, top 46.3 ft bgs

Screen joint, top 53.0 ft bTOC

Bottom of end cap 63.3 ft bTOC

Filter pack, bottom 60.5 ft bgs

Borehole, bottom 85.0 ft bgs

Development:
Method: Surge and Bail
Date: 9/26/12

Static water level >24hr. after development

Date	Time	Level below TOC

1. Cap and Lock? ☒Yes ☐No
2. Protective cover:
   a. Inside Diameter 4 in.
   b. Length 5.0 ft.
   c. Material Metal
   d. Weep hole location/size: 1 inch above pad
   e. Add. protection? ☒Yes ☐No
3. Pad type/dimensions: 3'x3'x2' Concrete
4. Surface Seal: ☒ Concrete ☒ ____
5. Material between well casing and protective cover: Concrete, Sand
6. Annular seal: ☐ Granular bentonite ☒ Bentonite slurry ☐ Bentonite-cement ☐ Other ____
7. Bentonite seal: ☐ Granular bentonite ☐ Bentonite pellets ____ inch ☒ Bentonite chips 3/4 inch ☐ Other ____
8. Fine sand: Manufacturer, name, & size ____
   Volume added ____ lbs.
9. Filter pack: Manufacturer, name, & size Filter Sil, 20/40 Filter Sand
   Volume added 200 lbs
10. Well casing:
    Type Schedule 40 pvc
    Manufacturer ____
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
11. Screen material:
    Type Schedule 40 PVC Slotted
    Manufacturer ____
    Slot size 0.010 in.
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
12. Backfill material (below filter pack): ☐ None ☒ Other Bentonite chips
13. Centralizers: ☐ No ☒ Yes
    If yes, Type/material Stainless
    Number 2
    Depth(s) 45.0', 25.0'

Comments ____

Driler: E. Wentzel (REDI)
Inspector: S. Woodland (BMcD)
Discrepancies:
Checked by: ____ **Date:** ____

Project Number: 62848

Project Name: Springfield City Utilities, JTEC

Monitoring Well No: PZ-06

Well Location: JTEC

Installation Start (Date/Time): 9/25/2012

Completion (Date/Time): 9/26/2012

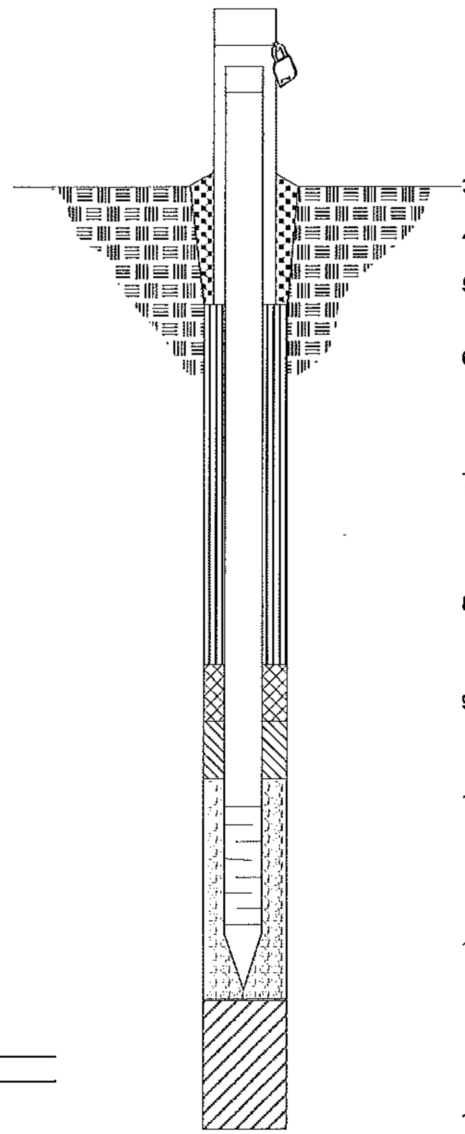
Well casing, top elevation 1221.12 ft. msl

Land surface elevation 1218.05 ft. msl

Top View

Side View

Sketch of Surface Completion



Annular seal, top 2.0 ft bgs

Bentonite seal, top 55.0 ft bgs

Fine sand, top na ft bgs

Filter pack, top 58.8 ft bgs

Screen joint, top 62.72 ft bTOC

Bottom of end cap 73.02 ft bTOC

Filter pack, bottom 72.0 ft bgs

Borehole, bottom 85.0 ft bgs

Development:
Method: Surge and Bail
Date: 9/27/12

Static water level >24hr. after development

Date	Time	Level below TOC

1. Cap and Lock? ☒Yes ☐No
2. Protective cover:
   a. Inside Diameter 4 in.
   b. Length 5.0 ft.
   c. Material Metal
   d. Weep hole location/size: 1 inch above pad
   e. Add. protection? ☒Yes ☐No
3. Pad type/dimensions: 3'x3'x2' Concrete
4. Surface Seal: ☒ Concrete ☒ ____
5. Material between well casing and protective cover: Concrete, Sand
6. Annular seal: ☐ Granular bentonite ☒ Bentonite slurry ☐ Bentonite-cement ☐ Other ____
7. Bentonite seal: ☐ Granular bentonite ☐ Bentonite pellets ____ inch ☒ Bentonite chips 3/4 inch ☐ Other ____
8. Fine sand: Manufacturer, name, & size ____
   Volume added ____ lbs.
9. Filter pack: Manufacturer, name, & size Filter Sil, 20/40 Filter Sand
   Volume added 200 lbs
10. Well casing:
    Type Schedule 40 pvc
    Manufacturer ____
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
11. Screen material:
    Type Schedule 40 PVC Slotted
    Manufacturer ____
    Slot size 0.010 in.
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
12. Backfill material (below filter pack): ☐ None ☒ Other Bentonite chips
13. Centralizers: ☐ No ☒ Yes
    If yes, Type/material Stainless
    Number 2
    Depth(s) 55.0', 25.0'

Comments ____

Driller: E. Wentzel (REDI)

Inspector: S. Woodland (BMcD)

Discrepancies: ____

Checked by: ____ **Date:** ____

Project Number: 62848
Monitoring Well No: PZ-07
Installation Start (Date/Time): 9/18/2012

Project Name: Springfield City Utilities, JTEC
Well Location: JTEC
Completion (Date/Time): 9/20/2012

Well casing, top elevation 1193.42 ft. msl

Land surface elevation 1190.60 ft. msl

Top View

Side View

Sketch of Surface Completion

Annular seal, top 2.0 ft bgs

Bentonite seal, top 43.0 ft bgs

Fine sand, top na ft bgs

Filter pack, top 48.0 ft bgs

Screen joint, top 54.65 ft bTOC

Bottom of end cap 64.95 ft bTOC

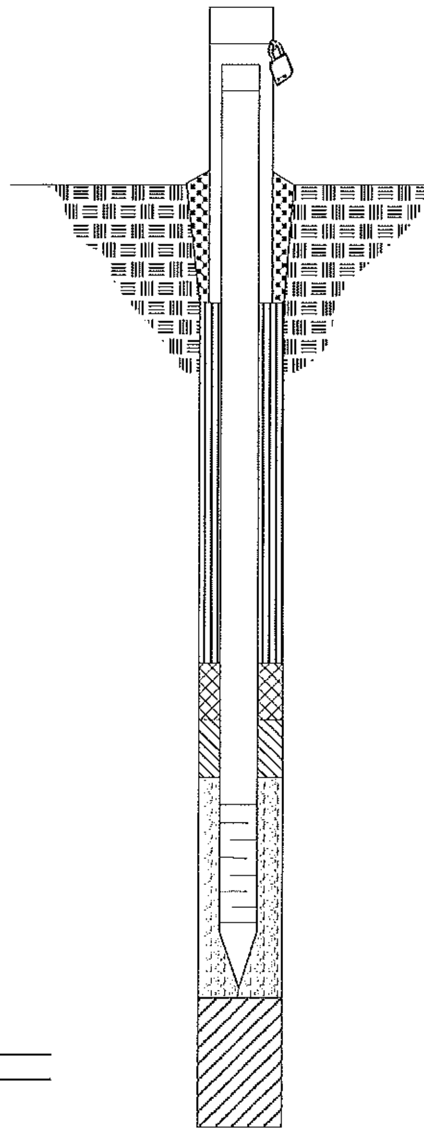
Filter pack, bottom 62.0 ft bgs

Borehole, bottom 62.0 ft bgs

Development:
Method: Surge and Bail
Date: 9/26/12

Static water level >24hr. after development

Date	Time	Level below TOC



1. Cap and Lock? ☒Yes ☐No
2. Protective cover:
   a. Inside Diameter 4 in.
   b. Length 5.0 ft.
   c. Material Metal
   d. Weep hole location/size: 1 inch above pad
   e. Add. protection? ☒Yes ☐No
3. Pad type/dimensions: 3'x3'x2' Concrete
4. Surface Seal: ☒ Concrete ☒ ____
5. Material between well casing and protective cover: Concrete, Sand
6. Annular seal: ☐ Granular bentonite ☒ Bentonite slurry ☐ Bentonite-cement ☐ Other ____
7. Bentonite seal: ☐ Granular bentonite ☐ Bentonite pellets ____ inch ☒ Bentonite chips 3/4 inch ☐ Other ____
8. Fine sand: Manufacturer, name, & size ____
   Volume added ____ lbs.
9. Filter pack: Manufacturer, name, & size Filter Sil, 20/40 Filter Sand
   Volume added 200 lbs
10. Well casing:
    Type Schedule 40 pvc
    Manufacturer ____
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
11. Screen material:
    Type Schedule 40 PVC Slotted
    Manufacturer ____
    Slot size 0.010 in.
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
12. Backfill material (below filter pack): ☐ None ☒ Other Bentonite chips
13. Centralizers: ☐ No ☒ Yes
    If yes, Type/material Stainless
    Number 2
    Depth(s) 47.0', 25.0'

Comments ____

Driller: E. Wentzel (REDI)
Inspector: S. Woodland (BMcD)
Discrepancies: ____
Checked by: ____ **Date:** ____

Project Number: 62848
Monitoring Well No: PZ-08
Installation Start (Date/Time): 9/25/2012

Project Name: Springfield City Utilities, JTEC
Well Location: JTEC
Completion (Date/Time): 9/26/2012

Well casing, top elevation 1226.91 ft. msl

Land surface elevation 1223.87 ft. msl

Top View

Side View

Sketch of Surface Completion

Annular seal, top 2.0 ft bgs

Bentonite seal, top 60.1 ft bgs

Fine sand, top na ft bgs

Filter pack, top 65.0 ft bgs

Screen joint, top 69.9 ft bTOC

Bottom of end cap 80.2 ft bTOC

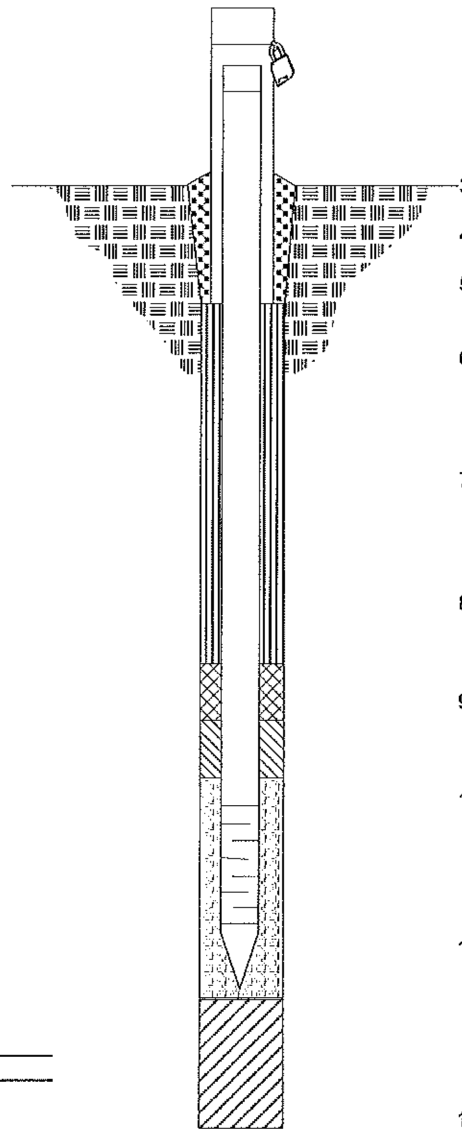
Filter pack, bottom 77.0 ft bgs

Borehole, bottom 77.0 ft bgs

Development:
Method: Surge and Bail
Date: 9/27/12

Static water level >24hr. after development

Date	Time	Level below TOC



1. Cap and Lock? ☒ Yes ☐ No
2. Protective cover:
   a. Inside Diameter 4 in.
   b. Length 5.0 ft.
   c. Material Metal
   d. Weep hole location/size: 1 inch above pad
   e. Add. protection? ☒ Yes ☐ No
3. Pad type/dimensions: 3'x3'x2' Concrete
4. Surface Seal: ☒ Concrete ☒ ____
5. Material between well casing and protective cover: Concrete, Sand
6. Annular seal: ☐ Granular bentonite ☒ Bentonite slurry ☐ Bentonite-cement ☐ Other ____
7. Bentonite seal: ☐ Granular bentonite ☐ Bentonite pellets ____ inch ☒ Bentonite chips 3/4 inch ☐ Other ____
8. Fine sand: Manufacturer, name, & size ____
   Volume added ____ lbs.
9. Filter pack: Manufacturer, name, & size
   Filter Sil, 20/40 Filter Sand
   Volume added 200 lbs
10. Well casing:
    Type Schedule 40 pvc
    Manufacturer ____
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
11. Screen material:
    Type Schedule 40 PVC Slotted
    Manufacturer ____
    Slot size 0.010 in.
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
12. Backfill material (below filter pack): ☐ None ☒ Other Bentonite chips
13. Centralizers: ☐ No ☒ Yes
    If yes, Type/material Stainless
    Number 2
    Depth(s) 62.0', 25.0'

Comments ____

Driller: E. Wentzel (REDI)
Inspector: S. Woodland (BMcD)

Discrepancies: ____
Checked by: ____ **Date:** ____

Project Number: 62848
Project Name: Springfield City Utilities, JTEC
Monitoring Well No: PZ-09
Well Location: JTEC
Installation Start (Date/Time): 9/14/2012
Completion (Date/Time): 9/17/2012

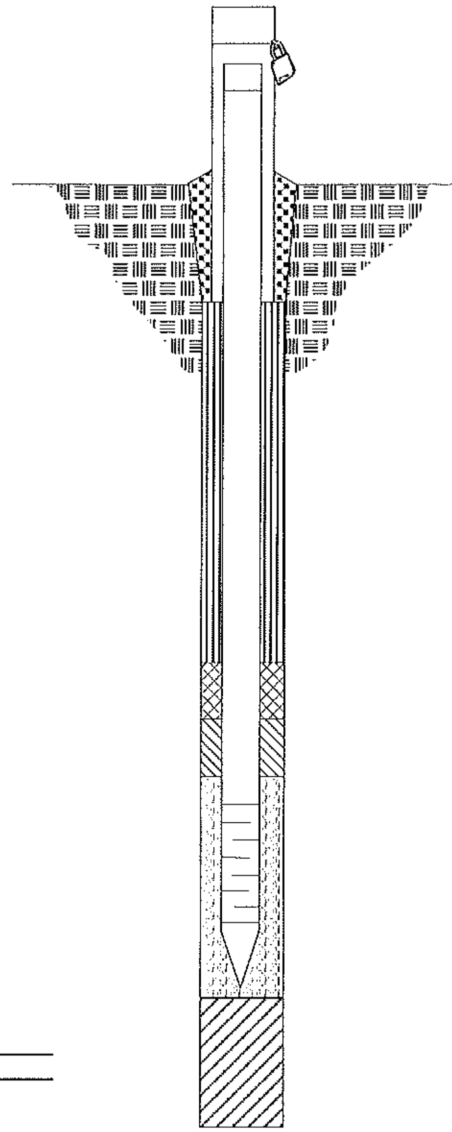
Well casing, top elevation 1239.39 ft. msl

Land surface elevation 1236.59 ft. msl

Top View

Side View

Sketch of Surface Completion



Annular seal, top 2.0 ft bgs

Bentonite seal, top 50.0 ft bgs

Fine sand, top na ft bgs

Filter pack, top 53.0 ft bgs

Screen joint, top 58.71 ft bTOC

Bottom of end cap 69.01 ft bTOC

Filter pack, bottom 66.0 ft bgs

Borehole, bottom 66.0 ft bgs

Development:
Method: Surge and Bail
Date: 9/26/12

Static water level >24hr. after development

Date	Time	Level below TOC

1. Cap and Lock? ☒Yes ☐No
2. Protective cover:
   a. Inside Diameter 4 in.
   b. Length 5.0 ft.
   c. Material Metal
   d. Weep hole location/size: 1 inch above pad
   e. Add. protection? ☒Yes ☐No
3. Pad type/dimensions: 3'x3'x2' Concrete
4. Surface Seal: ☒ Concrete ☒ ____
5. Material between well casing and protective cover: Concrete, Sand
6. Annular seal: ☐ Granular bentonite ☒ Bentonite slurry ☐ Bentonite-cement ☐ Other ____
7. Bentonite seal: ☐ Granular bentonite ☐ Bentonite pellets ____ inch ☒ Bentonite chips 3/4 inch ☐ Other ____
8. Fine sand: Manufacturer, name, & size ____
   Volume added ____ lbs.
9. Filter pack: Manufacturer, name, & size Filter Sil, 20/40 Filter Sand
   Volume added 200 lbs
10. Well casing:
    Type Schedule 40 pvc
    Manufacturer ____
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
11. Screen material:
    Type Schedule 40 PVC Slotted
    Manufacturer ____
    Slot size 0.010 in.
    Outside diameter 2.375 in.
    Inside diameter 2.215 in.
12. Backfill material (below filter pack): ☐ None ☒ Other Bentonite chips
13. Centralizers: ☐ No ☒ Yes
    If yes, Type/material Stainless
    Number 2
    Depth(s) 50.0', 25.0'

Comments ____

Driler: E. Wentzel (REDI)
Inspector: S. Woodland (BMcD)
Discrepancies:
Checked by: ____ **Date:** ____

January 22, 2014

Mr. Ted C. Salveter, P.E.
Environmental Affairs
City Utilities
P.O. Box 551
Springfield, Missouri 65801-0551

Email: Ted.Salveter@cityutilities.net

RE: Preliminary Opinion and Proposed Scope of Services
Coal Combustion Waste Impoundments
City Utilities of Springfield – John Twitty Energy Center
Springfield, Missouri
PPI Project Number: 219892

Dear Mr. Salveter:

Palmerton & Parrish, Inc. (PPI) has been retained by the City Utilities of Springfield (CU) to assist CU with a response to the Draft Report issued by CDM Smith regarding the structural stability and hydrologic / hydraulic safety of the coal combustion waste impoundments at CU's John Twitty Energy Center (JTEC) in Springfield, Missouri.

This letter presents:

1. PPI's Preliminary Opinion regarding the structural stability and hydrologic / hydraulic safety of the coal combustion waste impoundments;
2. An Itemized Scope of Services intended to address the questions raised in CDM Smith's Draft Report; and
3. An anticipated Timeline for Completion of the Scope of Services.

F

CDM Smith was one of several Engineering Consultants (Contractors) retained by the United States Environmental Protection Agency (EPA) to perform Site Structural Assessments of the structural stability and hydrologic / hydraulic safety of selected coal combustion waste (CCW) impoundments located across the United States. CDM Smith visited CU's John Twitty Energy Center (JTEC) on August 27 and 28, 2012, and completed a site reconnaissance and interviews with CU Staff. CDM Smith issued a Draft Report in July 2013.

CDM Smith's Draft Report is entitled "Assessment of Dam Safety of Coal Combustion Surface Impoundments – Draft Report; City Utilities of Springfield; John Twitty Energy Center; Springfield, Missouri". The Report is referred to as the "CDM Smith Draft Report" throughout this letter. The CDM Smith Draft Report discusses two (2) CCW Impoundments at JTEC, identified as the West CCW Impoundment and the East CCW Impoundment.

Discussion throughout the CDM Smith Draft Report gives the impression that the structural stability, hydrologic / hydraulic safety, and operating procedures of the CCW Impoundments are generally adequate. The list below summarizes statements of that nature that are included in the CDM Smith Draft Report.

1. The CCW Impoundments have a ñLowò Hazard Rating, based upon their total height, storage capacity, and the extent of downstream development.
2. The CCW Impoundment embankments were observed to be in overall good condition at the time of CDM Smithôs Site Visit.
3. The CCW Impoundments appear to have adequate capacity with regard to hydrologic / hydraulic safety.
4. CUôs Operating and Maintenance Procedures appear to be generally adequate.

However, the CDM Smith Draft Report ultimately rates the CCW Impoundments as POOR due to a lack of specific documentation of the structural stability, hydrologic and hydraulic safety, and operating and maintenance procedures. The CDM Smith Draft Report outlines the need for documentation of several Studies, Operating and Maintenance Procedures, and Surveillance and Monitoring Plans before they will change the POOR rating.

’S S S

An engineer from PPIôs staff, Ms. Rachel Goeke, P.E., visited the JTEC CCW Impoundment Site with Mr. Ted Salveter, P.E., CU Environmental Affairs, on Monday, January 13, 2014. Mr. Salveter and Ms. Goeke walked and/or drove around the perimeter of the CCW Impoundments. Mr. Salveter described the typical operating procedures of the Impoundments. A survey crew from Anderson Engineering, Inc. (AE) was on-site at the same time, completing a current topographic survey of the CCW Impoundments and surrounding areas.

S

CU provided the documents listed below to PPI via email during the period from January 13, 2014 through January 16, 2014. It is anticipated that CU will be able to provide additional documents to support completion of PPIôs Scope of Services upon request.

- CDM Smith; July 1, 2013; ñAssessment of Dam Safety of Coal Combustion Surface Impoundments ï Draft Report; City Utilities of Springfield; John Twitty Energy Center; Springfield, Missouriò, prepared for the United States Environmental Protection Agency
- Burns & McDonnell Engineering Company, Inc.; July 10, 1974; ñSheet Y49, Rev. 2; Contract No. 343: Yard Structures; Ash Pond Grading Detailsò
- Burns & McDonnell Engineering Company, Inc.; July 10, 1974; ñSheet Y45, Rev. 4, Contract No. 343: Yard Structures; Area V Grading and Drainage Planò
- Burns & McDonnell Engineering Company, Inc.; Excerpt from the Project Specifications: Contract No. 343: Division 2: Site Work
- Burns & McDonnell Engineering Company, Inc.; April 10, 1975; Letter Correspondence to Martin K. Eby Construction Company, Revised Design Cross Sections
- Anderson Engineering, Inc.; December 15, 2005, ñCity Utilities of Springfield, Ash Pond Topographic Survey, Southwest Power Station, Springfield, Missouriò
- Anderson Engineering, Inc.; December 9, 2011, Excerpts from ñAEWO#70045-11: Ash Landfill Slope Stability and Engineering Analyses; John Twitty Energy Center, Springfield, MOò
- Anderson Engineering, Inc.; January 15, 2014; ñCity Utilities of Springfield, East and West Ash Pond Topographic Survey, JTEC, Springfield, Missouriò

F S

The CCW Impoundments were originally constructed in 1976. The Impoundments are identified as the West CCW Impoundment (approximately 3.89 acres) and the East CCW Impoundment (approximately 3.36 acres). Based upon information provided on the original Design Drawings and Supplemental Cross Sections prepared by Burns & McDonnell Engineering Company, Inc., the Impoundment embankments were originally constructed with controlled earth fill and 2 Horizontal to 1 Vertical (2H:1V) side slopes. A cutoff trench was constructed out of select fill material beneath the center of the embankments.

The exterior levees and water handling system remain basically unchanged from original construction. CU has added an interior dike in the approximate north-south center of both Impoundments. The dike allows for additional sedimentation and filtering before water reaches the downstream portion of the channel.

Flow through the Impoundments generally trends North to South. Bottom ash is transported to the Impoundments in slurry form via pipeline. Prior to reaching the Impoundments, the bottom ash slurry passes through a series of three (3) tiered concrete detention basins. A large portion of the bottom ash settles out, and is periodically dredged and stockpiled prior to eventual disposal at the JTEC Landfill.

The bottom ash slurry that reaches the Impoundments is retained in the northern portion of the Impoundment, north of the interior dikes added by CU. Additional bottom ash settles out in the northern portion of the Impoundments. CU periodically schedules maintenance of the Impoundments to remove the accumulated bottom ash, and reworks the clay bottom liner as necessary to maintain an approximate 2-foot thickness of well-compacted clay.

In addition to the bottom ash slurry, the Impoundments receive water from the cooling tower blowdown, boiler blowdown, Plant drain water, and storm water from the pondsôapproximately 67 acre drainage area around the Plant. The East and West CCW Impoundments share a common Recycle Pump House and Outlet Structure located near the southern end of the interior embankment that divides the Impoundments. A large portion of the water that enters the Impoundments is recirculated back to the Power Plant for reuse as bottom ash sluice water. Water that is discharged downstream exits the Outlet Structure via a 24-inch diameter corrugated metal outlet pipe to a weir south of the Impoundments. The discharged water is tested and routed to eventual discharge under CUõs NPDES Operating Permit MO-0089940.

Each Impoundment has a high water outlet pipe near the top of the embankment, consisting of a 12-inch diameter corrugated metal pipe. The pipe invert elevations on the upstream, interior embankment slope are 1232.1 feet and 1232.4 feet for the West and East CCW Impoundments, respectively. Based upon information provided by CU, the water elevation in the Impoundments has never approached the high water outlet pipe invert elevation, and the pipes have never been utilized.

During normal operations, only one (1) of the CCW Impoundments is in service at any given time. The normal operating water elevation is maintained near the top elevation of the interior dikes, at approximate elevation 1227 feet. Only the West CCW Impoundment was in service on January 13, 2014 during PPIõs Site Visit and completion of Anderson Engineeringõs topographic survey. The water elevation in the northern portion of the West CCW Impoundment was approximately 1227.3 feet, while the water elevation in the southern portion was a couple feet below normal pool elevation at approximate elevation 1223.7 feet.

The maximum embankment cross section occurs on the south side of the Impoundments. At its approximate lowest point, the top elevation of the embankment is 1235.3 feet. The embankment crest width is a minimum of approximately 10 feet, and more typically on the order of 12 to 15 feet. The maximum cross section height is approximately 31 feet, with a corresponding toe of slope elevation of 1204 feet.

On a preliminary basis only, PPI's initial opinion is that the CCW Impoundment embankments at JTEC will most likely meet the required minimum Factors of Safety for Slope Stability, and that the existing hydrologic / hydraulic system is most likely sufficient.

Completion of detailed slope stability and hydrologic / hydraulic studies is planned to address the lack of documentation cited in the CDM Smith Draft Report. Anticipated studies are discussed in greater detail in a later section of this letter.

S S For the purposes of this letter, PPI completed preliminary slope stability analysis on the approximate maximum cross section, which occurs on the south side of the East CCW Impoundment. PPI utilized the topographic survey data collected by Anderson Engineering during the week of January 13, 2014 to determine the cross section geometry. Assumptions regarding the approximate bottom elevation of the East CCW Impoundment were made using data from the original Design Drawings.

Soil stratigraphy was assumed based upon information shown on the original Design Drawings, and data provided on boring logs from the nearby JTEC Landfill Site. For the purposes of this preliminary analysis, only maximum pool, steady state seepage conditions were analyzed. The water level on the embankment interior was assumed at elevation 1232.4 feet. Soil strength parameters were assumed using effective stress conditions.

Slope stability analysis was performed using the computer program SlopeW, part of the GeoStudio 2012 software package. Spencer's method was selected as the finite difference analysis method, since it achieves both moment and force equilibrium. The grid and radius method was utilized to search for the critical slope failure surface.

The required minimum Factor of Safety for steady state seepage conditions required by various United States Army Corps of Engineers, Federal Emergency Management Association, and Missouri Department of Natural Resources guidelines is 1.5. PPI completed five (5) different preliminary slope stability analysis runs, assuming different combinations of soil strength parameters and groundwater conditions. Computed Factors of Safety ranged from 1.05 (worst case combination of low shear strength parameters and a shallow piezometric surface through the embankment) to 1.89 (moderately high to high shear strength parameters and a normal groundwater gradient through the embankment). Copies of the slope stability analysis output are included with this letter as Attachment A.

In PPI's opinion, the final computed Factor of Safety for the maximum cross section, during maximum pool, steady state seepage conditions, will most likely be on the order of 1.5 to 1.9. Assuming that field studies confirm and/or exceed the shear strength parameters and groundwater conditions that were assumed in the "passing cases" of the preliminary analysis, PPI anticipates that the final slope stability analysis will show that the existing CCW Impoundment embankments meet or exceed the required Factors of Safety for global slope stability.

PALMERTON & PARRISH, INC.

S F S S

PPI proposes completion of the Task Items outlined below in order to meet the questions raised in the CDM Smith Draft Report regarding slope stability and hydrologic / hydraulic analysis. It is anticipated that PPI will complete the Task Items related to the Subsurface Investigation, Slope Stability Analysis, and Piezometer Installation. PPI is available to assist CU with completion of the hydrologic / hydraulic analysis, or that work may be completed by CU or Others.

S S

1. PPI will review existing data provided by CU.
2. A field subsurface investigation will be performed to investigate the nature of the existing embankment and underlying residual soils. PPI anticipates drilling a minimum of four (4) subsurface borings in two (2) sets of two (2) borings (one at the slope crest and one at the slope toe), in order to develop two (2) geologic cross sections. The two (2) cross sections will be sited at the approximate maximum cross sections through the East and West CCW Impoundment embankments, respectively.
3. Soil sampling during completion of the field subsurface investigation will include collection of relatively undisturbed thin-walled Shelby tube samples in general accordance with ASTM D 1587, disturbed split spoon samples collected during performance of the Standard Penetration Test in general accordance with ASTM D 1586.
4. Shelby tube samples will be extruded in PPI's laboratory. Selected samples will be tested for shear strength parameters via completion of drained direct shear testing, consolidated undrained triaxial testing, and unconfined compressive strength testing. Classification testing will also be performed and may include determination of in situ moisture contents, Atterberg Limits, and grain size analysis.
5. PPI plans to install temporary piezometers in all four (4) borings, and monitor them daily for a minimum of two (2) days. PPI does not anticipate the presence of a shallow piezometric surface through the embankments, based upon the past operational performance of the Impoundments, and the fact that seepage has not been observed through the embankments.

   Provided that the piezometers confirm that there is not a shallow piezometric surface through the CCW Impoundment embankments, the piezometers will be drilled out and closed by grouting full depth via tremie after a minimum of two (2) days of monitoring.
6. Geologic cross sections will be developed using data from the field and laboratory investigation, and groundwater level readings obtained from the temporary piezometers.
7. Slope stability analysis will be performed on all required loading cases. In accordance with the regulatory guidelines, PPI anticipates analyzing the following cases:

   (1) Steady state seepage, normal pool (effective stress conditions), downstream slope;

   (2) Steady state seepage, maximum pool (effective stress conditions), downstream slope;

   (3) Steady state seepage, normal pool, earthquake loading (total stress conditions), downstream slope; and

   (4) Rapid drawdown (total stress conditions), upstream slope.

   The slope stability analysis will be accompanied by a discussion of assumptions made, and the relative applicability of each loading case.

8. Results of the studies will be summarized in a Formal Geotechnical Engineering Report, including recommendations for modification if required.

1. Existing data will be reviewed, including information about typical operating procedures, water elevations, and past performance of the CCW Impoundments.
2. CUõs operating procedures will be researched and documented in order to gain a good understanding of how CUõs operating procedures affect ñnormalò pool elevations.
3. The available ñfree boardò of the CCW Impoundment System for normal pool conditions will be computed.
4. The ability of the CCW Impoundments to contain and/or pass the 24-hour, 100-year storm event will be evaluated.
5. Results of the hydrologic / hydraulic analysis will be summarized in a Formal Engineering Report, including recommendations for modification if required.

F

PPI anticipates that the Slope Stability and Hydrologic / Hydraulic Studies outlined in this letter can be completed within approximately 6 weeks from the time field drilling commences. A breakdown of PPIõs anticipated schedule is summarized in the table below. PPIõs anticipated schedule is subject to weather conditions, encountered subsurface conditions, and other factors beyond our control that could impact the overall scope and schedule for the Project.

Field Subsurface Investigation Groundwater Level Monitoring Temporary Piezometer Closure	3 Days 2 Days 1 Day
Laboratory Testing Program	15 Days
Slope Stability Analysis	3 Days
Hydrologic / Hydraulic Analysis	3 Days
Draft Report Preparation	3 Days
Incorporation of Review Comments	2 Days
Final Report Preparation	2 Days
	3 .

S

PPI appreciates the opportunity to work with CU on this Project. Please don't hesitate to contact our Springfield office at (417) 864-6000 if you have any questions regarding this letter.

PALMERTON & PARRISH, INC.
By:

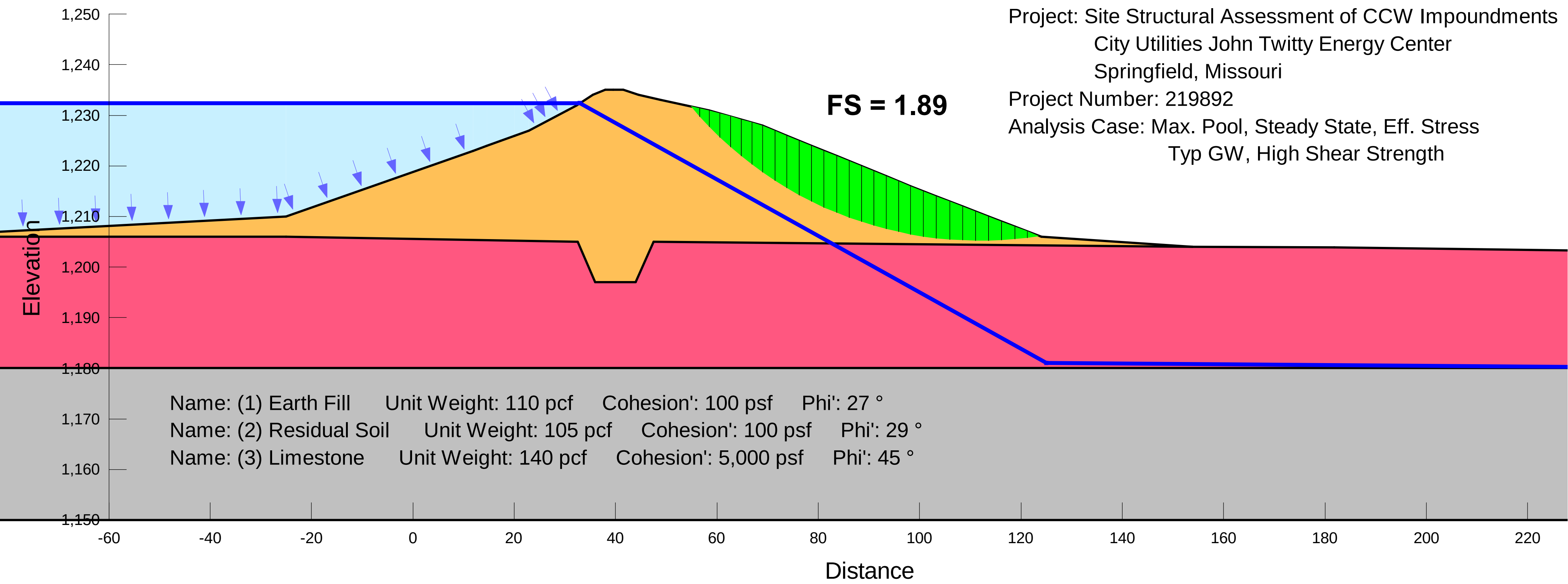
Rachel J. Goeke, P.E.
Geotechnical Engineer

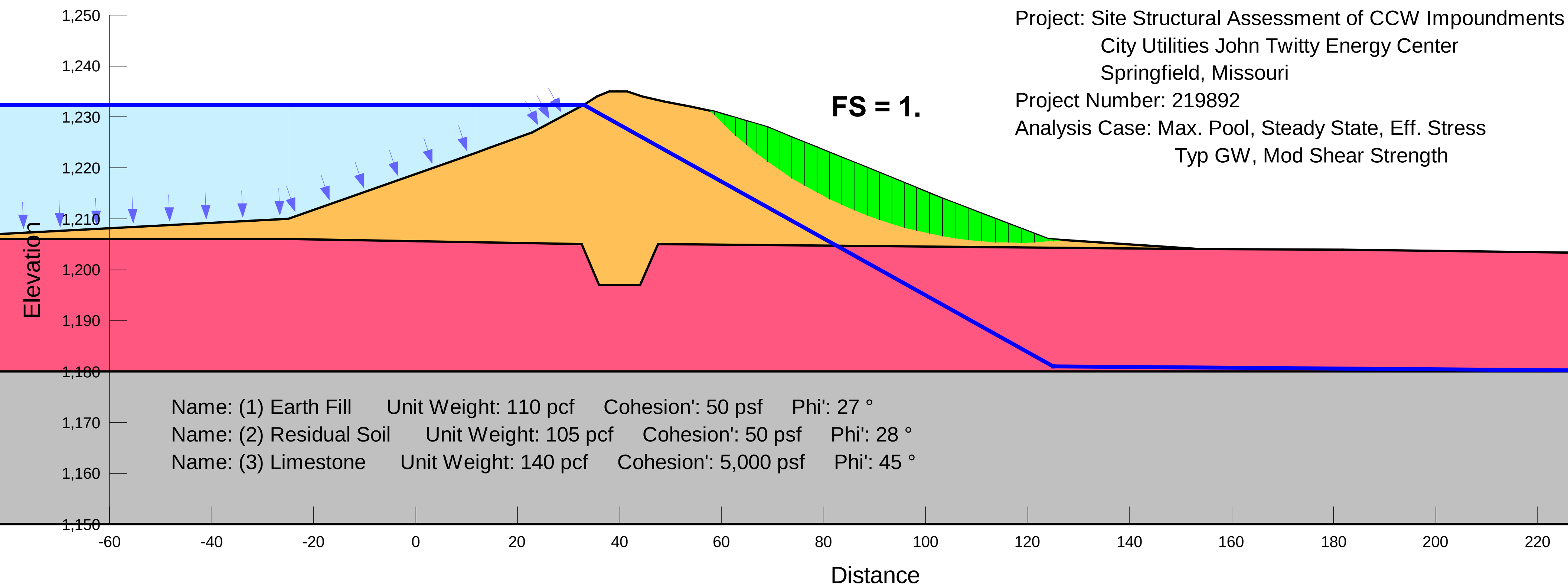
Attachment: Attachment A: Slope Stability Analysis Results

Submitted: 1 Electronic (.pdf) Copy via Email (ted.salveter@cityutilities.net)

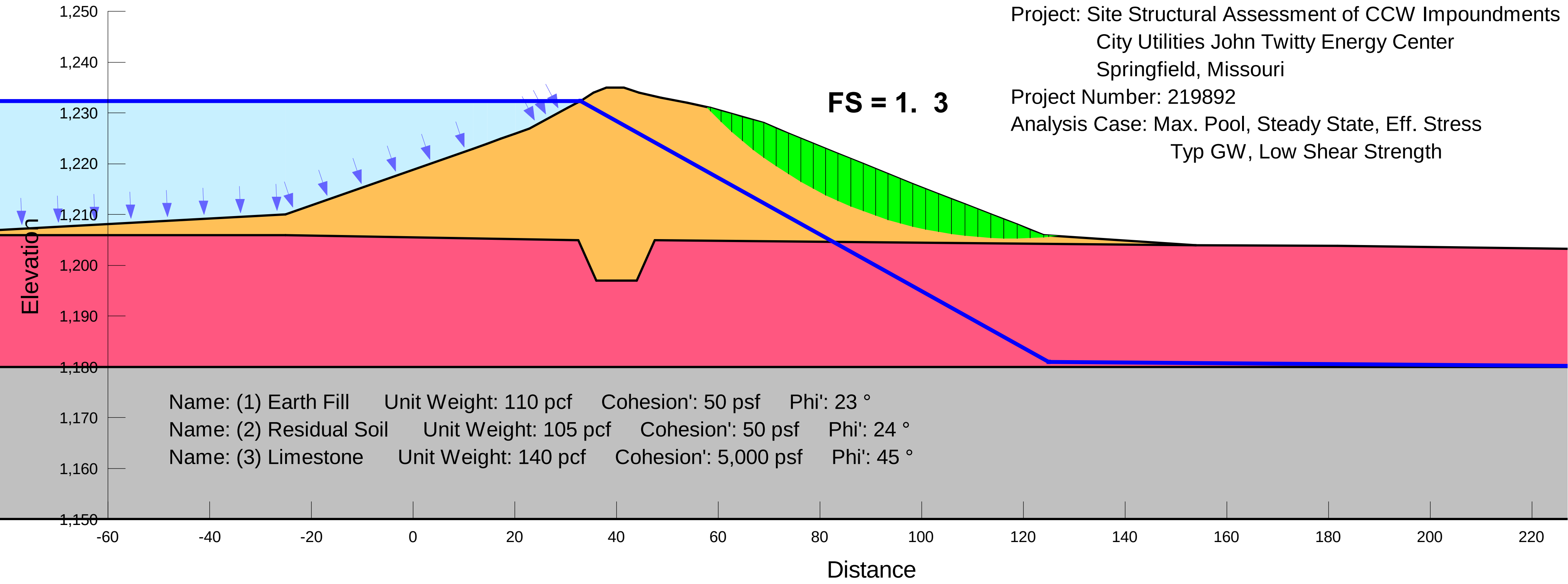
BRP:RJG/rjg

S S S S S S

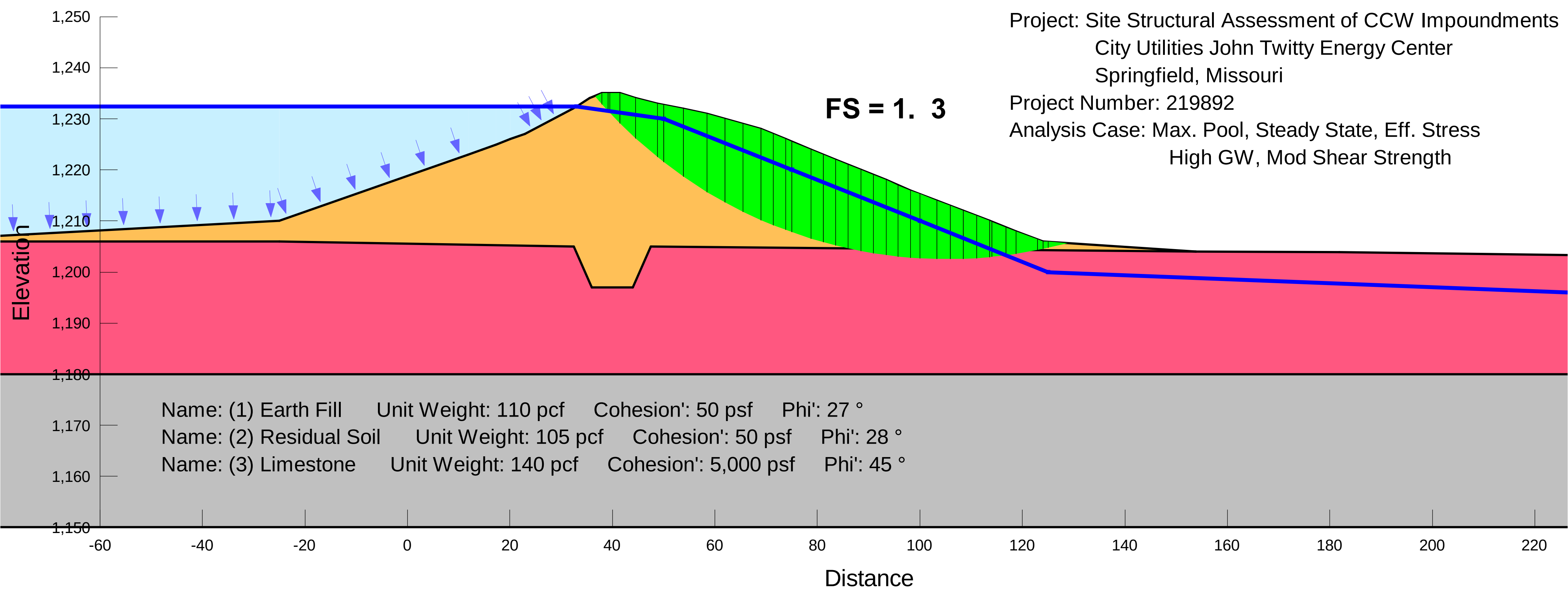

Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
Typ GW, High Shear Strength
FS = 1.89
Name: (1) Earth Fill Unit Weight: 110 pcf Cohesion': 100 psf Phi': 27 °
Name: (2) Residual Soil Unit Weight: 105 pcf Cohesion': 100 psf Phi': 29 °
Name: (3) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °
Elevation
1,250
1,240
1,230
1,220
1,210
1,200
1,190
1,180
1,170
1,160
1,150
Distance
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220

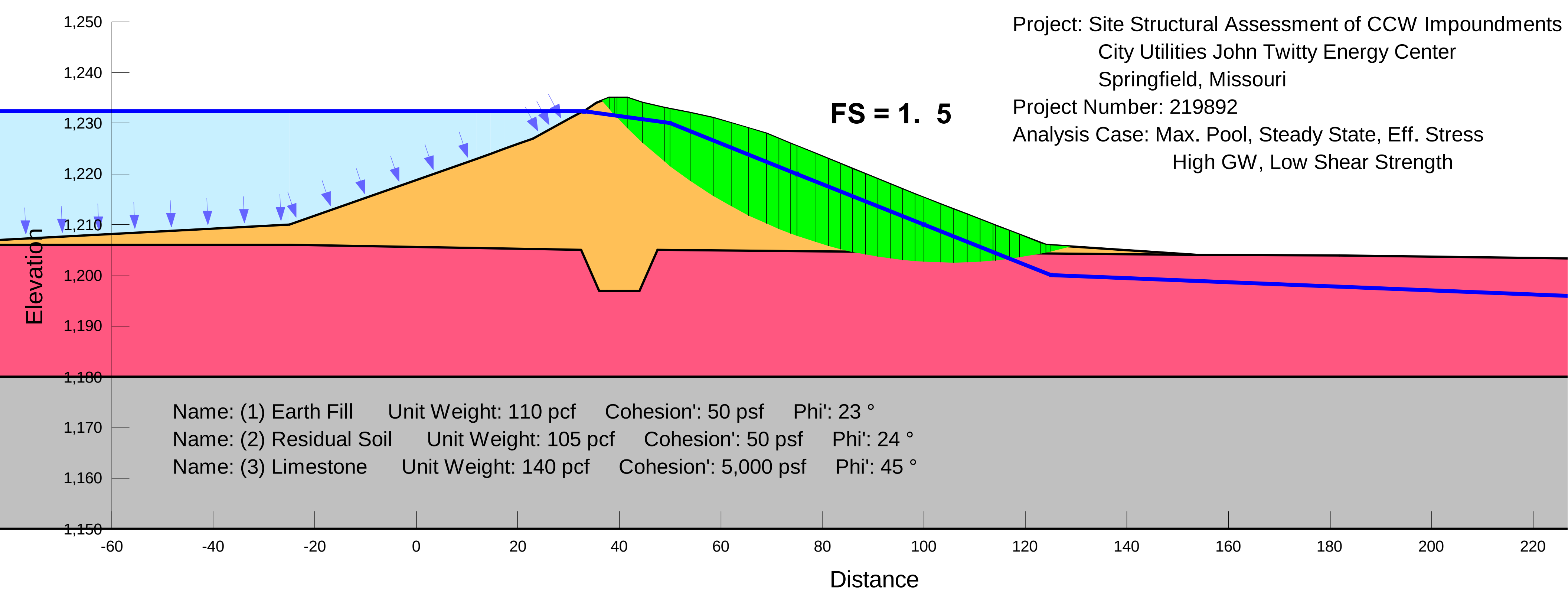


Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
Typ GW, Mod Shear Strength
FS = 1.
Name: (1) Earth Fill Unit Weight: 110 pcf Cohesion': 50 psf Phi': 27 °
Name: (2) Residual Soil Unit Weight: 105 pcf Cohesion': 50 psf Phi': 28 °
Name: (3) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °
Elevation
1,250
1,240
1,230
1,220
1,210
1,200
1,190
1,180
1,170
1,160
1,150
Distance
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220



Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
Typ GW, Low Shear Strength
FS = 1. 3
Name: (1) Earth Fill Unit Weight: 110 pcf Cohesion': 50 psf Phi': 23 °
Name: (2) Residual Soil Unit Weight: 105 pcf Cohesion': 50 psf Phi': 24 °
Name: (3) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °
Elevation
1,250
1,240
1,230
1,220
1,210
1,200
1,190
1,180
1,170
1,160
1,150
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
Distance


Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
High GW, Mod Shear Strength
FS = 1. 3
Name: (1) Earth Fill Unit Weight: 110 pcf Cohesion': 50 psf Phi': 27 °
Name: (2) Residual Soil Unit Weight: 105 pcf Cohesion': 50 psf Phi': 28 °
Name: (3) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °
Elevation
1,250
1,240
1,230
1,220
1,210
1,200
1,190
1,180
1,170
1,160
1,150
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
Distance


Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
High GW, Low Shear Strength
FS = 1. 5
Name: (1) Earth Fill Unit Weight: 110 pcf Cohesion': 50 psf Phi': 23 °
Name: (2) Residual Soil Unit Weight: 105 pcf Cohesion': 50 psf Phi': 24 °
Name: (3) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °
Elevation
1,250
1,240
1,230
1,220
1,210
1,200
1,190
1,180
1,170
1,160
1,150
Distance
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220

Clarification on JTEC ash pond overflow modifications, 1985

In 1985 the Missouri Department of Natural Resources performed an inspection of the JTEC (then Southwest Power Station, SWPS) ash ponds and concluded that they required modification of the overflow system. As originally designed, each pond was constructed with an overflow pipe directed to a riprap spillway channel. The state agency was concerned that any overflow through such a structure would not be captured in the permitted discharge stream of Outfall 002.

To remedy this, the SWPS Plant Engineer designed an overflow modification that replaced the open channel spillways with closed piping to divert overflow to the common discharge weir at the base of the ash pond embankment. At this point it could be measured and sampled with the ordinary underflow discharge stream. To reduce piping costs and introduce slope to the new structure, the original overflow inlets were abandoned in favor of new inlets located closer to the centerline separating the two ponds. These changes are shown in plan view on the accompanying drawing entitled "Modification Details."

In addition, Mr. Wehrly performed calculations to ensure that the modified overflow structure would perform as adequately as the original design. These hand calculations are included in two separate files as "Modification Study." It should be noted that the hydraulic calculations in that study are overly conservative compared to current conditions. In this original study it appears that the slope of the new discharge lines, a limiting hydraulic factor, assumed that the inlet structures would remain in their original spread locations. Moving them laterally toward the discharge point increased the respective slopes dramatically. In addition, rainfall runoff tributary to the ash pond was calculated assuming a contribution from the coal pile storage area to the west. Several years after these modifications, the plant modified its discharge permit by diverting all coal pile runoff away from Outfall 002 and directing it to dedicated storm water Outfall 001.

FORM 1047.

CU

JOB NO. PAGE NO. 1

COMPUTED BY MRW DATE 11/21/85

CHECKED BY DATE

REVIEWED BY DATE

APPROVED BY DATE

SUBJECT

SHEET NO. OF

INVESTIGATION

ASH POND OVERFLOW MODIFICATIONS

FORM 1047.

CU

JOB NO. PAGE NO. 2

SUBJECT

COMPUTED BY DATE
CHECKED BY DATE
REVIEWED BY DATE
APPROVED BY DATE

SHEET NO. OF

ASH POND OVERFLOW MODIFICATIONS

PURPOSE: TO MODIFY THE EXISTING ASH PONDS OVERFLOW SYSTEM SUCH THAT ALL OVERFLOW IS CAPTURERED AND ROUTED THROUGH THE EXISTING OUTFALL WEIR STRUCTURE (M.H. 45). IF NOT DONE, MISSOURI DNR WILL REQUIRE THAT THE OVERFLOW DISCHARGE BE PERMITTED AND MONITORED. THE DISCHARGE FROM M.H. 45 IS ALREADY PERMITTED.

OPTIONS:

I - TIE INTO THE EXISTING OVERFLOW PIPES AND ROUTE NEW PIPES FROM THERE TO M.H. 45. ROUTING WOULD BE ABOVE GROUND AND GENERALLY WOULD FOLLOW THE TOE OF THE DAM.

II - PLUG OR REMOVE THE EXISTING OVERFLOW PIPES AND INSTALL NEW OVERFLOW PIPES AND ROUTE THESE NEW PIPES DIRECTLY TO M.H. 45. ROUTING WOULD BE THROUGH THE DAM AND DOWN THE BACKSIDE OF THE DAM.

PIPING OPTIONS TO INVESTIGATE:

A. REINFORCED CONCRETE PIPE (RCP)
B. CORRUGATED METAL PIPE (CMP)
  a. GALVANIZED ONLY
  b. POLYMER COATED INSIDE & OUTSIDE.
C. DUCTILE IRON PIPE (D.I.)

FORM 1047.

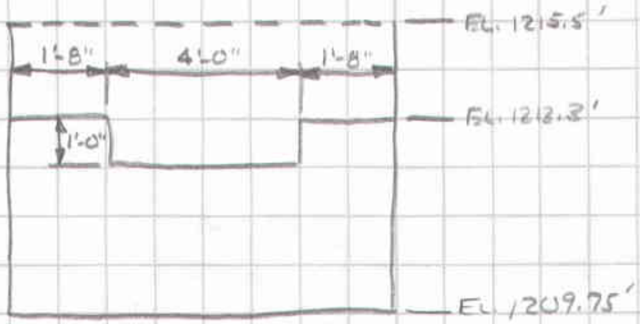
JOB NO. ______ PAGE NO. 3

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

CHECK CAPACITY OF EXISTING WEIR:



REHBOCK FORMULA:

$$Q = \tfrac{2}{3}\sqrt{2g}\, L H^{3/2}\left(0.605 + \frac{1}{320H - 3} + \frac{0.05H}{P}\right)$$

$L = L' - 0.1NH$ BELOW EL. 1213.3 $L = 4 - 0.1(2)(1) = 3.8'$

ABOVE EL. 1213.3 $L = 7.33'$

H - BELOW EL 1213.3 = 1'

ABOVE EL. 1213.3 = 2.2'

P - BELOW EL 1213.3 = 2.55'

ABOVE EL 1213.3 = 3.55'

$$Q_{BELOW\ 1213.3} = \tfrac{2}{3}\sqrt{2(32.2)}\,(3.8)(1)^{3/2}\left(0.605 + \frac{1}{320(1) - 3} + \frac{0.05(1)}{2.55}\right)$$

= 13.00 ft³/sec = 5834.4 GPM = 8.4 MGD

$$Q_{ABOVE\ 1213.3} = \tfrac{2}{3}\sqrt{2(32.2)}\,(7.33)(2.2)^{3/2}\left(0.605 + \frac{1}{320(2.2) - 3} + \frac{0.05(2.2)}{3.55}\right)$$

= 83.95 ft³/sec = 37676.8 GPM = 54.3 MGD

$Q_{TOTAL\ FOR\ WEIR\ STRUCTURE}$ = 13 + 83.95 = 96.95 ft³/sec

= 43,511.2 GPM = 62.7 MGD

CHECK CAPACITY OF DOWNSTREAM PIPE:

PIPE IS 24" RCP, CLASS IV, SLOPE = 0.2%

MANNING FORMULA:

$$Q = \frac{1.486}{n}\, a\, r^{2/3} S^{1/2}$$

FORM 1047.

JOB NO. ______ PAGE NO. 4

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

$n = 0.013$ FOR CONCRETE PIPE

$a = \frac{\pi d^2}{4} = \pi \frac{(24/12)^2}{4} = 3.14 \text{ ft}^2$

$r = a/p = 3.14 / \pi(24/12) = 0.5 \text{ ft}$

$S = 0.2\% = 0.002 \text{ ft/ft}$

$Q = \frac{1.486}{0.013}(3.14)(0.5)^{2/3}(0.002)^{1/2}$

$= 10.11 \text{ ft}^3/\text{SEC}$

THE DOWNSTREAM PIPE IS THE LIMITING FACTOR

CALCULATE RAINFALL RUNOFF

USE 10 YEAR, 24 HOUR STORM - FOR SPRINGFIELD AREA
THIS GIVES 5.57 INCHES OF WATER OVER ENTIRE AREA
IN A 24 HOUR PERIOD.

RATIONAL FORMULA: $Q = CIA$

C = RUNOFF COEFFICIENT = 0.20 FOR GENERAL PLANT AREA
= 0.90 FOR COAL PILE AREA

I = INTENSITY = $5.57/24 = 0.232$ IN/HR

A = AREA IN ACRES - FROM OVERALL PLAN VIEW - ESTIMATED:

EAST CELL $A = 1{,}350{,}000 \text{ ft}^2 / 43560 \text{ ft}^2/\text{acre} = 30.99$ SAY 32 ACRES
WEST CELL $A = 840{,}000 \text{ ft}^2 = 19.28$ SAY 20 ACRES
COAL PILE $A = 900{,}000 \text{ ft}^2 = 20.66$ SAY 21 ACRES

$Q_{EAST} = (0.2)(0.232)(32) = 1.485 \text{ ft}^3/\text{SEC}$
$Q_{WEST} = (0.2)(0.232)(20) = 0.928 \text{ ft}^3/\text{SEC}$
$Q_{COAL\ PILE} = (0.9)(0.232)(21) = 4.385 \text{ ft}^3/\text{SEC}$

WORST CASE IS EAST CELL WITH COAL PILE RUNOFF
$Q_{TOTAL} = 1.485 + 4.385 = 5.87 \text{ ft}^3/\text{SEC}$

FORM 1047

CU JOB NO. PAGE NO. 5

SUBJECT

COMPUTED BY DATE

CHECKED BY DATE

REVIEWED BY DATE

APPROVED BY DATE

SHEET NO. OF

CHECK CAPACITY OF EXISTING OVERFLOWS

EACH OVERFLOW HAS 2 - 29"x18", 14GA, CMP.

MANNING FORMULA:

$Q = \frac{1.486}{n} a r^{2/3} s^{1/2}$

$n = 0.024$ FOR CMP

$a = \pi a b = \pi \left(\frac{29/2}{12}\right)\left(\frac{18/2}{12}\right) = 2.847 \text{ ft}^2$

$r = a/p = 2.847/\pi(a+b)k \quad k = 1.0144$

$= 0.456$ ft

$S = \frac{1232 - 1231.8}{35} = 0.0057$ ft/ft

$Q = \frac{1.486}{0.024}(2.847)(0.456)^{2/3}(0.0057)^{1/2}$

$= 7.88 \text{ ft}^3/\text{sec}$ PER PIPE

$= 15.76 \text{ ft}^3/\text{sec}$ TOTAL FOR EACH POND

FORM 1047.

CU JOB NO. PAGE NO. 6

SUBJECT

COMPUTED BY DATE

CHECKED BY DATE

REVIEWED BY DATE

APPROVED BY DATE

SHEET NO. OF

CAPACITY OF NEW OVERFLOW PIPE:

THE PIPE DOWNSTREAM OF THE WEIR IS THE LIMITING FACTOR WITH A MAXIMUM FLOW OF 10.11 ft^3/SEC. THE OVERFLOW PIPE CAN BE SIZED IN TWO DIFFERENT WAYS. THE FIRST WAY TO SIZE THE PIPE WOULD BE TO ASSUME THE TOTAL MAXIMUM CAPACITY OF THE INLET PIPES SHOULD NOT EXCEED THE MAXIMUM DOWNSTREAM FLOW. THE SECOND WAY TO SIZE THE PIPE WOULD BE TO ASSUME A NORMAL FLOW THROUGH THE EXISTING INLET PIPE AND SIZE THE OVERFLOW FOR THE CAPACITY UP TO THE MAXIMUM DOWNSTREAM FLOW.

I. CHECK THE CAPACITY OF THE EXISTING INLET PIPE:

PIPE IS 21" CMP, 12 GAUGE.

SLOPE: VERTICAL DROP - 1211.0' − 1209.75' = 1.25'

HORIZONTAL DISTANCE - 196'

$S = 1.25/196 = 0.0064$

MANNINGS FORMULA:

$$Q = \frac{1.486}{n} a r^{2/3} s^{1/2}$$

$$= \frac{1.486}{0.024} \left(\frac{\pi (\frac{21}{12})^2}{4}\right)\left(\frac{21/12}{4}\right)^{2/3} (0.0064)^{1/2}$$

$$= 6.87 \text{ ft}^3/\text{sec}$$

DIFFERENCE = 10.11 − 6.87 = 3.24 ft^3/sec

SIZE NEW OVERFLOW PIPE BASED ON MAXIMUM FLOW OF 3.24 ft^3/sec.

SLOPE OF NEW PIPE THROUGH DIKE IS LIMITING FACTOR

$S = 0.0057$

MANNINGS FORMULA:

$$3.24 = \frac{1.486}{n} \left(\frac{\pi d^2}{4}\right)\left(\frac{d}{4}\right)^{2/3} (0.0057)^{1/2}$$

$$3.24 = \frac{d^{2\,2/3}}{n} 0.035$$

$$\frac{d^{2\,2/3}}{n} = 92.57$$

FORM 1047

JOB NO. ______ PAGE NO. 7

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

FOR RCP $n = 0.013$ $d = 1.072' = 12.86''$ use 12"
FOR CMP (HELICAL) $n = 0.011$ $d = 1.007' = 12.08''$ use 12"
FOR D.I. $n = 0.012$ $d = 1.040' = 12.48''$ use 12"

II. "NORMAL" FLOW THROUGH THE EXISTING INLET PIPE IS 692,000 GAL/DAY = 1.07 ft³/sec

DIFFERENCE = 10.11 − 1.07 = 9.04 ft³/sec

SIZE NEW OVERFLOW PIPES BASED ON MAXIMUM FLOW OF 9.04 ft³/sec

SLOPE OF NEW PIPE THROUGH DAM IS LIMITING FACTOR

$S = 0.0057$

MANNINGS FORMULA:

$$9.04 = \frac{1.486}{n}\left(\frac{\pi d^2}{4}\right)\left(\frac{d}{4}\right)^{2/3}(0.0057)^{1/2}$$

$$9.04 = \frac{d^{2\frac{2}{3}}}{n}\,0.035$$

$$\frac{d^{2\frac{2}{3}}}{n} = 258.29$$

FOR RCP $n = 0.013$ $d = 1.575' = 18.90''$ use 18"
FOR CMP (HELICAL) $n = 0.013$ $d = 1.575' = 18.90''$ use 18"
FOR D.I. $n = 0.012$ $d = 1.528' = 18.34''$ use 18"

CAPACITY OF POND

WITH EITHER OF THE ABOVE SOLUTIONS, WE WILL BE LIMITING THE OVERFLOW CAPACITY TO A MUCH LOWER VALUE THAN WE HAVE (AND/ALL) HAD AVAILABLE IN THE PAST. A CHECK OF THE POND CAPACITY IS NEEDED.

THE MAIN ITEM TO CHECK AGAINST THE OVERFLOW CAPACITY IS THE RAINFALL RUNOFF. THE NORMAL FLOW OUT OF THE POND WOULD NOT GENERALLY BE CHANGED DUE ONLY TO A RAINFALL, SO THE OVERFLOW WOULD HANDLE RUNOFF ONLY.

FORM 1047.

JOB NO. ______ PAGE NO. 8

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

THE TOTAL FLOW INTO THE POND DUE TO RUNOFF IS 5.87 ft^3/sec BASED ON THE EAST POND INCLUDING COAL PILE RUNOFF. THIS IS BASED ON A 10 YEAR, 24 HOUR STORM.

ACTUAL OVERFLOW CAPACITIES:

CASE I: 12" RCP $Q = \frac{1.486}{0.03}\left(\frac{\pi}{4}\right)\left(\frac{1}{4}\right)^{2/3}(0.0057)^{1/2} = 2.69\ ft^3/sec$

12" CMP $Q = \frac{1.486}{0.011}\left(\frac{\pi}{4}\right)\left(\frac{1}{4}\right)^{2/3}(0.0057)^{1/2} = 2.64\ ft^3/sec$

12" D.I. $Q = \frac{1.486}{0.012}\left(\frac{\pi}{4}\right)\left(\frac{1}{4}\right)^{2/3}(0.0057)^{1/2} = 2.91\ ft^3/sec$

CASE II: 18" RCP $Q = 7.93\ ft^3/sec$

18" CMP $Q = 7.93\ ft^3/sec$

18" D.I. $Q = 8.59\ ft^3/sec$

} ALL VALUES FOR CASE II ARE HIGHER THAN RUNOFF RATE.

WORST CASE IS FOR 12" CMP WITH A DIFFERENCE OF $5.87 - 2.64 = 3.23\ ft^3/sec$

SURFACE AREA OF POND AT EL. 1232'-0" IS APPROXIMATELY 160,000 ft^2:

$$\frac{160,000}{3.23} = 49536\ sec/ft = 13.75\ HRS/ft.$$

VERY CONSERVATIVELY - IT WOULD TAKE APPROXIMATELY 14 HOURS TO RAISE THE LEVEL OF THE POND 1 FOOT WITH THE 10 YEAR, 24 HOUR STORM. THE NEW OVERFLOW CAPACITY IS ADEQUATE IN EITHER CASE.

FORM 1047

JOB NO. ______ PAGE NO. 9

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

PIPE SELECTION

FOR ALL PIPE, THE MAXIMUM STRENGTH REQUIRED WILL BE IN OPTION II WHERE THE NEW OVERFLOW PIPE WILL BE BURIED UNDER THE EXISTING ROADWAY AND WILL NEED TO SUPPORT THE LOADS IMPOSED BY ACID TRUCKS FOR DELIVERIES.

ASSUME FOR ALL PIPE THAT THE TRENCH BACKFILL WILL BE COMPACTED (90% OR BETTER) GRANULAR MATERIAL AND THE TOP OF THE PIPE WILL BE BURIED 2 FEET UNDER THE SURFACE. LOADING WILL BE ON AN ELASTIC ROADWAY SURFACE AND SHALL CONFORM TO H20/S16 LOADING.

I. REINFORCED CONCRETE PIPE (RCP)

A. 12" SIZE, ASSUME 2" WALL (CALCULATIONS BASED ON AMERON ENGINEERING INFO)

$B_c = 1 + 2(2/12) = 1.333'$

$B_d = 1.333 + 2 = 3.333'$

$\frac{H}{B_d} = \frac{2}{3.33} = 0.60$

$C_d = 0.555$

$W_d = C_d\, w\, B_d^2 = (0.555)(120)(3.333)^2 = 739\ lbs.$

$W_t = \frac{1}{A} I_c C_t T$

$m = \frac{A/2}{H} = \frac{3/2}{2} = 0.75$

$n = \frac{B_c/2}{H} = \frac{1.333/2}{2} = 0.33$

$C_t = 0.075 \times 4 = 0.30$

$W_t = \frac{1}{3}(1.2)(0.30)(16000) = 1920\ lb$

$D = \left[\frac{DL}{DL_f} + \frac{LL}{LL_f}\right]\left(\frac{FS}{ID}\right)$

$= \left[\frac{739}{1.1} + \frac{1920}{1.5}\right]\left(\frac{1.0}{1}\right)$

$= 1952\ lb$

NEED 12", CLASS IV, WALL B, RCP $D_{0.01} = 2000$

FORM 1047

JOB NO. ______ PAGE NO. 10

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

B. 18" SIZE, ASSUME 2½" WALL

$B_c = 1.5 + 2(2^{1/2}/12) = 1.92'$

$B_d = 1.92 + 2 = 3.92'$

$\frac{H}{B_d} = \frac{2}{3.92} = 0.51$

$C_d = 0.469$

$W_d = C_d\, w\, B_d^2 = (0.469)(120)(3.92)^2 = 865\ lb$

$W_t = \frac{1}{A} I_c C_t T$

$m = \frac{A/2}{H} = \frac{3/2}{2} = 0.75$

$n = \frac{B_c/2}{H} = \frac{1.92/2}{2} = 0.48$

$C_t = 0.105 \times 4 = 0.42$

$W_t = \frac{1}{3}(1.2)(0.42)(16000) = 2688\ lb$

$D = \left[\frac{DL}{DL_f} + \frac{LL}{LL_f}\right]\left(\frac{FS}{ID}\right)$

$= \left[\frac{865}{1.1} + \frac{2688}{1.5}\right]\left(\frac{1.0}{1.5}\right)$

$= 1719\ lb$

NEED 18", CLASS IV, WALL B, RCP $D_{0.01} = 2000$

II. CORRUGATED METAL PIPE (CMP)

A. 12" SIZE, FIND WALL THICKNESS & TYPE OF CORRUGATIONS

PER TOM BARON - THOMPSON CULVERT COMPANY - THE STANDARD CMP IN THIS SIZE IS 16 GUAGE, 2⅔" x ½" CORRUGATIONS. ALL CALCULATIONS BASED ON "HANDBOOK OF STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS".

DESIGN PRESSURE: $P_v = DL + LL$

$DL = H \times w = 2 \times 120 = 240\ lb/ft^2$

LL (H20), 2' COVER, $= 800\ lb/ft^2$

$P_v = 240 + 800 = 1040\ lb/ft^2$

FORM 1047

CU

JOB NO. ______ PAGE NO. 11

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

RING COMPRESSION : $C = P_V \times S/2$

$= 1040 \times \frac{12/12}{2} = 520 \text{ lb/ft}^2$

ALLOWABLE WALL STRESS

$f_c = 19{,}200 \text{ lb/in}^2$ FOR $2\frac{2}{3}" \times \frac{1}{2}"$ CORRUGATIONS

WALL CROSSECTIONAL AREA

$A = C/f_c = 520/19{,}200 = 0.027 \text{ in}^2/\text{ft}$ REQUIRED

FOR $2\frac{2}{3}" \times \frac{1}{2}"$, 16 GUAGE - $A = 0.775 \text{ in}^2/\text{ft}$ - OK.

HANDLING STIFFNESS

$FF = \frac{D^2}{EI}$

$D = 12"$

$E = 30 \times 10^6$

$I = 0.0227 \text{ in}^4/\text{ft}$ FOR $2\frac{2}{3}" \times \frac{1}{2}"$, 16 GUAGE

$FF = 12^2/(30 \times 10^6)(0.0227) = 0.00021$

$0.0021 < 0.0433 \Rightarrow$ O.K.

NEED 12", $2\frac{2}{3}" \times \frac{1}{2}"$, 16 GUAGE GALVANIZED CMP
LOOK AT POLYMER COATED AS AN OPTION

B. 18" SIZE, FIND WALL THICKNESS AND TYPE OF CORRUGATION

DESIGN PRESSURE : $P_V = 1040 \text{ lb/ft}^2$

RING COMPRESSION : $C = P_V \times S/2$

$= 1040 \times \frac{18/12}{2} = 780 \text{ lb/ft}^2$

ALLOWABLE WALL STRESS:

$f_c = 19{,}200 \text{ lb/in}^2$ FOR $2\frac{2}{3}" \times \frac{1}{2}"$ CORRUGATIONS

FORM 1047

CU

JOB NO. ______ PAGE NO. 12

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

WALL CROSSECTIONAL AREA

$A = C/f_c = 780/19{,}200 = 0.041 \text{ in}^2/\text{ft}$ REQUIRED

FOR 2 2/3" x 1/2", 16 GUAGE - CROSSECTIONAL AREA = $0.775 \text{ in}^2/\text{ft}$

OK

HANDLING STIFFNESS

$FF = D^2/EI$

$D = 21''$

$E = 30 \times 10^6$

$I = 0.0227 \text{ in}^4/\text{ft}$ FOR 2 2/3" x 1/2", 16 GUAGE

$FF = \dfrac{21^2}{(30 \times 10^6)(0.0227)} = 0.00065$

$0.00065 < 0.0433$ OK

NEED 18", 2 2/3" x 1/2", 16 GUAGE GALVANIZED CMP

LOOK AT POLYMER COATED AS AN OPTION

III. DUCTILE IRON PIPE

ALL CALCULATIONS ARE BASED ON "U.S. PIPE - DUCTILE IRON PIPE DESIGN, 4" THROUGH 48"".

A. 12" SIZE

LAYING CONDITION 5 - 90% COMPACTED GRANULAR BACKFILL

TABLE 3 - THICKNESS FOR EARTH LOAD PLUS TRUCK LOAD

12", 2 1/2' COVER, TYPE 5 LAYING CONDITION

TOTAL CALCULATED THICKNESS = 0.18" => USE CLASS 50

TABLE 4 - THICKNESS FOR INTERNAL PRESSURE

12", 150 PSI WORKING PRESSURE

TOTAL CALCULATED THICKNESS = 0.22" => USE CLASS 50

NEED 12", CLASS 50 DUCTILE IRON PIPE

FORM 1047

CU

JOB NO. PAGE NO. 13

SUBJECT

COMPUTED BY DATE

CHECKED BY DATE

REVIEWED BY DATE

APPROVED BY DATE

SHEET NO. OF

B. 18" SIZE

LAYING CONDITION 5 - 90% COMPACTED GRANULAR BACKFILL

TABLE 3 - THICKNESS FOR EARTH LOAD PLUS TRUCK LOAD

18", 2½' COVER, TYPE 5 LAYING CONDITION

TOTAL CALCULATED THICKNESS = 0.20" => USE CLASS 50

TABLE 4 - THICKNESS FOR INTERNAL PRESSURE

18", 150 PSI WORKING PRESSURE

TOTAL CALCULATED THICKNESS = 0.27" => USE CLASS 50

NEED 18", CLASS 50, DUCTILE IRON PIPE

FORM 1047

CU JOB NO. ________ PAGE NO. 14

SUBJECT ________

COMPUTED BY ________ DATE ________
CHECKED BY ________ DATE ________
REVIEWED BY ________ DATE ________
APPROVED BY ________ DATE ________

SHEET NO. ________ OF ________

ESTIMATED COSTS

PIPE & FITTINGS

REINFORCED CONCRETE PIPE

FROM ROSE CON: 12", CLASS IV, WALL B - 7.25 $/ft.
18", CLASS IV, WALL B - 11.05 $/ft.
FITTINGS - 12 x $/ft.

FROM RICHARDSONS (INSTALLATION): 12" RCP - 3.00 $/ft.
18" RCP - 3.75 $/ft.
FOR FITTINGS - ESTIMATE - 10 x $/ft (INST)

CORRUGATED METAL PIPE

FROM THOMPSON CULVERT: 12", 2 2/3" x 1/2", 16 GA - 8.79 $/ft, 11.51 $/ft COATED
18", 2 2/3" x 1/2", 16 GA - 11.82 $/ft, 16.28 $/ft COATED
12" FITTINGS - $65.65 LABOR + 4' MATERIAL
18" FITTINGS - $93.77 LABOR + 4' MATERIAL

FROM RICHARDSONS (INSTALLATION): 12" CMP - 1.10 $/ft.
18" CMP - 2.75 $/ft.
FOR FITTINGS - ESTIMATE - 10 x $/ft (INST)

DUCTILE IRON PIPE

FROM STOREROOM: 12", CLASS 50 - 8.88 $/ft.
FITTINGS AVG - 125 $/EA

FROM HARRY CONNORS: 18" CLASS 50 - 22 $/ft.
FITTINGS AVG. - 175 $/EA

FROM RICHARDSONS (INSTALLATION): 12" D.I. - 3.00 $/ft.
18" D.I. - 3.75 $/ft.
FOR FITTINGS - ESTIMATE 10 x $/ft (INST)

PIPE LENGTHS: (SEE APPENDIX A FOR DRAWINGS)

OPTION I - 750' STRAIGHT + 30' DRAINAGE
10 FITTINGS

OPTION II - 330' STRAIGHT
6 FITTINGS

FORM 1047

CU

JOB NO. ______ PAGE NO. 15

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

COSTS:

OPTION I

12" RCP	PIPE (7.25 + 3.00)(780') = 7995	}	$9,195
	FITTINGS (12 x 7.25 + 10 x 3.00)(10) = 1200		
12" CMP	PIPE (8.79 + 1.10)(780') = 7714	}	$8832
	FITTINGS (65.65 + 4(8.79) + 10 x 1.10)(10) = 1118		
12" CMP COATED	PIPE (11.81 + 1.10)(780') = 10,070	}	$11,309
	FITTINGS (65.65 + 4(11.81) + 10 x 1.10)(10) = 1239		
12" D.I.	PIPE (8.88 + 3.00)(780) = 9266	}	$10816
	FITTINGS (125 + 10(3.00))(10) = 1550		
18" RCP	PIPE (11.05 + 3.75)(780) = 11,544	}	$13,245
	FITTINGS (12 x 11.05 + 10 x 3.75)(10) = 1701		
18" CMP	PIPE (11.82 + 2.75)(780) = 11365	}	$13,051
	FITTINGS (93.77 + 4(11.82) + 10 x 2.75)(10) = 1686		
18" CMP COATED	PIPE (16.28 + 2.75)(780) = 14,843	}	$16,707
	FITTINGS (93.77 + 4(16.28) + 10(2.75))(10) = 1864		
18" DI.	PIPE (22 + 3.75)(780) = 20,085	}	$22,210
	FITTINGS (175 + 10(3.75))(10) = 2125		

OPTION II

12" RCP	PIPE (7.25 + 3.00)(330') = 3383	}	$4085
	FITTINGS (12 x 7.25 + 10 x 3.00)(6) = 702		
12" CMP	PIPE (8.79 + 1.10)(330') = 3264	}	$3935
	FITTINGS (65.65 + 4(8.79) + 10 x 1.10)(6) = 671		
12" CMP COATED	PIPE (11.81 + 1.10)(330') = 4260	}	$5499
	FITTINGS (65.65 + 4(11.81) + 10(1.10))(10) = 1239		
12" DI.	PIPE (8.88 + 3.00)(330) = 3920	}	$5470
	FITTINGS (125 + 10(3.00))(10) = 1550		
18" RCP	PIPE (11.05 + 3.75)(330) = 4884	}	$5905
	FITTINGS (12 x 11.05 + 10 x 3.75)(6) = 1021		
18" CMP	PIPE (11.82 + 2.75)(330) = 4808	}	$5819
	FITTINGS (93.77 + 4(11.82) + 10(2.75))(6) = 1011		
18" CMP COATED	PIPE (16.28 + 2.75)(330) = 6280	}	$7398
	FITTINGS (93.77 + 4(16.28) + 10(2.75))(6) = 1118		

FORM 1047

JOB NO. ______ PAGE NO. 16

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

18" D.I. PIPE (22 + 3.75)(330) = 8498 } $9773
FITTINGS (175 + 10(3.75))(6) = 1275 }

EXCAVATION

USING A BACKHOE WITH A 12" BUCKET - 20 $/yd³

OPTION I

12" PIPE - 3' WIDE x 750' LONG x 1' DEEP = 2250 ft³ = 83.3 yd³
COST = 83.3 x 20 = $1666
18" PIPE - 3.5' WIDE x 750' LONG x 1' DEEP = 2625 ft³ = 97.2 yd³
COST = 97.2 x 20 = $1944

OPTION II

12" PIPE - 3' WIDE x 270' LONG x 1' DEEP = 810 ft³ = 30 yd³
+ TRENCHES (4' WIDE x 25' LONG x 4' DEEP) 2 = 768 ft³ = 28.4 yd³
COST = (30 + 28.4)(20) = $1168
18" PIPE - 3.5' WIDE x 270' LONG x 1' DEEP = 945 ft³ = 35 yd³
+ TRENCHES (5' WIDE x 25' LONG x 4' DEEP)(2) = 1000 ft³ = 37 yd³
COST = (35 + 37)(20) = $1440

BACKFILL

STRUCTURAL BACKFILL - COMPACTED - 6 $/yd³

OPTION I

(190' + 160')(144 ft²) = 50,400 ft³ = 1867 yd³
COST = (1867)(6) = $11,202

OPTION II

(85')(25 ft²) = 2125 ft³ = 78.7 yd³
COST = (78.7)(6) = $473

FORM 1047

CU

JOB NO. ______ PAGE NO. 17

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

GRANULAR BACKFILL

COMPACTED - 10 $/yd³

QUANTITIES ARE THE SAME AS FOR EXCAVATION

OPTION I

12" PIPE COST = 83.3 x 10 = $833

18" PIPE - COST = 97.2 x 10 = $972

OPTION II

12" PIPE COST = 58.4 x 10 = $584

18" PIPE COST = 72 x 10 = 720

SUPPORTS

PIPE TYPE (OPTION I)

EACH SUPPORT -	25'	2" GALV. PIPE	25 x $2.30 =	57.50
	4	2" GALV. CAPS	4 x $2.40 =	9.60
	2	CLAMPS	2 x $2.00 =	4.00
				71.10
			x	2 (EST)
				142.2

SAY 150 $/EACH

FOR ALIGNMENT AND STABILITY - NEED 1 SUPPORT EVERY 25' FOR OPTION I

750/25 = 30 SUPPORTS x 150 $/EA = $4500

CONCRETE TYPE (OPTION II)

2 MEN FORMING, POURING & FINISHING 1 DAY - 2 x 8 x 20 =	$320
CONCRETE - 1 yd³	50
FORMS, STRAPS, ANCHORS, etc.	50
	$420 EACH

270/25 = 11 SUPPORTS NEEDED x 420 = $4620

SUMMARY - ESTIMATED COSTS

OPTION I	PIPE & FITTINGS INSTALLED	EXCAVATION	BACKFILL	GRANULAR BACKFILL	SUPPORTS	TOTAL*
A. 12" RCP	9195	1666	11202	833	4500	$27,396
B. 12" CMP	8832	1666	11202	833	4500	27,033
C. 12" CMP-COATED	11309	1666	11202	833	4500	29,510
D. 12" D.I.	10816	1666	11202	833	4500	29,017
A,. 18" RCP	13245	1944	11202	972	4500	31,724
B,. 18" CMP	13051	1944	11202	972	4500	31,530
C,. 18" CMP-COATED	16707	1944	11202	972	4500	35,186
D,. 18 D.I.	22210	1944	11202	972	4500	40,689
OPTION II						
A. 12" RCP	4085	1168	473	584	4620	$10,930
B. 12" CMP	3935	1168	473	584	4620	10,780
C. 12" CMP-COATED	5499	1168	473	584	4620	12,344
D. 12" D.I.	5470	1168	473	584	4620	12,315
A,. 18" RCP	5905	1440	473	720	4620	13,022
B,. 18" CMP	5819	1440	473	720	4620	12,936
C,. 18" CMP-COATED	7398	1440	473	720	4620	14,515
D,. 18" D.I.	9773	1440	473	720	4620	16,890

* DOES NOT INCLUDE ANY CONTRACTOR OVERHEAD OR PROFIT

FORM 1047

COMPUTED BY ____ DATE ____
CHECKED BY ____ DATE ____
REVIEWED BY ____ DATE ____
APPROVED BY ____ DATE ____

JOB NO. ____
SUBJECT ____
SHEET NO. ____ OF ____

FORM 1047

CU JOB NO. ______ PAGE NO. 19

SUBJECT ______

COMPUTED BY ______ DATE ______
CHECKED BY ______ DATE ______
REVIEWED BY ______ DATE ______
APPROVED BY ______ DATE ______

SHEET NO. ______ OF ______

CONCLUSION

EITHER OF THE MAIN OPTIONS, I OR II, IF IMPLEMENTED, WOULD GIVE THE DESIRED RESULTS. A 12" DIAMETER PIPING SYSTEM IS REQUIRED IF THE OVERFLOW SYSTEM IS SIZED BASED UPON NOT EXCEEDING THE DOWNSTREAM PIPE CAPACITY. AN 18" DIAMETER PIPING SYSTEM IS REQUIRED IF THE OVERFLOW SYSTEM IS SIZED WITH RESPECT TO THE NORMAL OUTFALL FLOW. OPTION I IS MUCH MORE COSTLY THAN OPTION II. THE REINFORCED CONCRETE PIPING SYSTEM AND THE CORRUGATED METAL PIPING SYSTEMS HAVE ESSENTIALLY THE SAME COSTS.

RECOMMENDATION

1. SELECT OPTION II DUE TO MUCH LESS COST.

2. SELECT 12" PIPING SYSTEM DUE TO LESSER COST AND TO MINIMIZE THE POSSIBILITY OF OVERFLOWING THE WEIR STRUCTURE.

3. DUE TO CLOSENESS OF ESTIMATED COSTS, SPECIFICATIONS SHOULD ALLOW CONTRACTORS TO BID EITHER REINFORCED CONCRETE PIPE OR CORRUGATED METAL PIPE.

4. COATING ON CMP WOULD ADD DURABILITY, BUT IS NOT CONSIDERED NECESSARY FOR THIS APPLICATION.

FORM 1047

JOB NO. ______ PAGE NO. ______

COMPUTED BY ______ DATE ______

CHECKED BY ______ DATE ______

REVIEWED BY ______ DATE ______

APPROVED BY ______ DATE ______

SUBJECT ______

SHEET NO. ______ OF ______

APPENDIX A

DRAWINGS

FORM 1047

JOB NO. ____________ PAGE NO. ____________

SUBJECT OPTION I - DETAILS

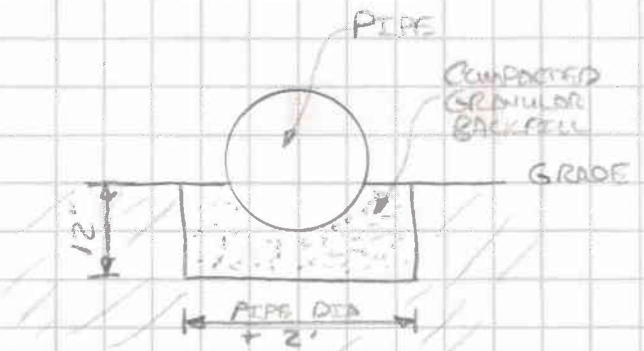
COMPUTED BY MRW DATE 11/19/85

CHECKED BY ____________ DATE ____________

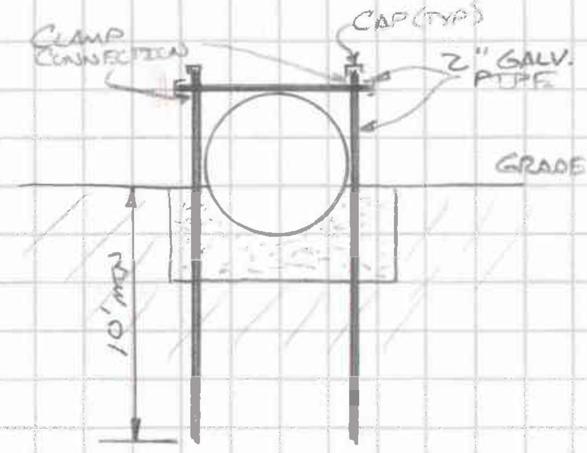
REVIEWED BY ____________ DATE ____________

APPROVED BY ____________ DATE ____________

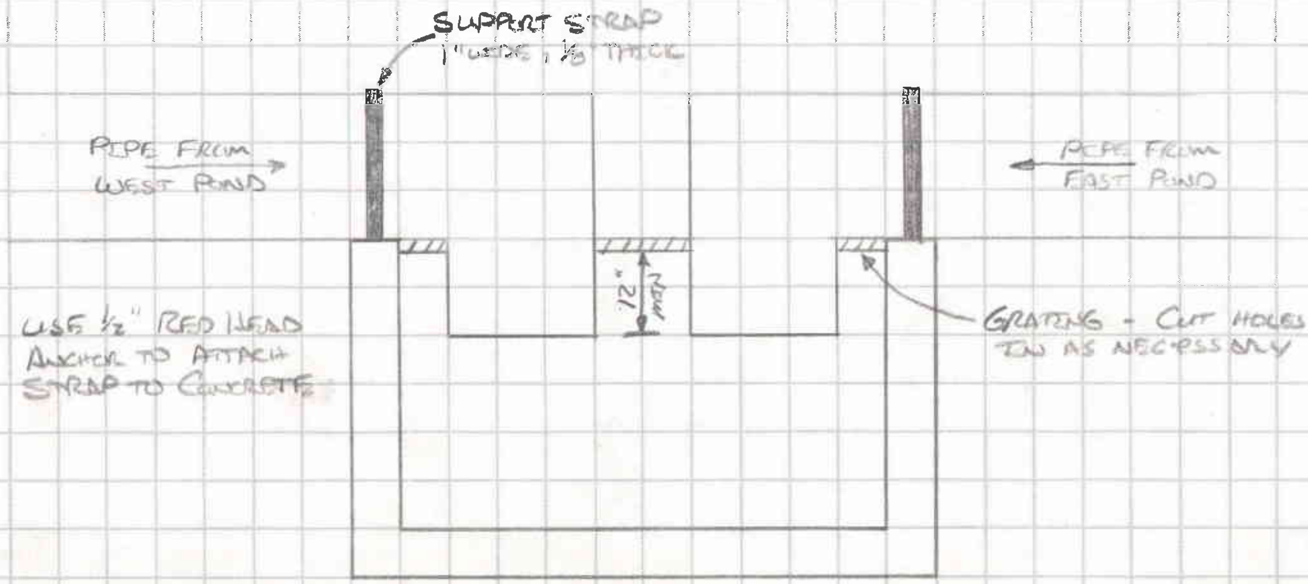
SHEET NO. ____________ OF ____________



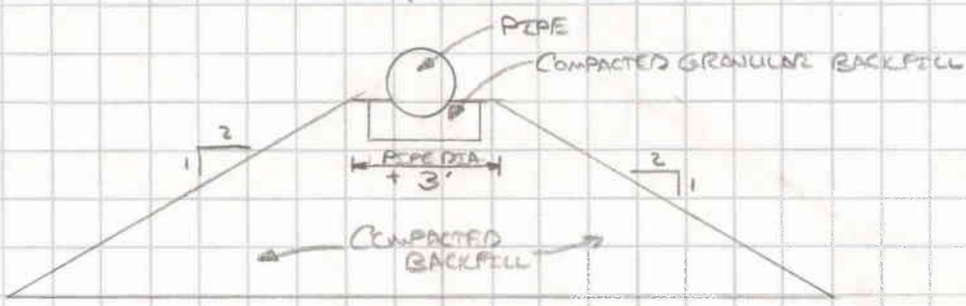
TYPICAL SECTION
N.T.S.



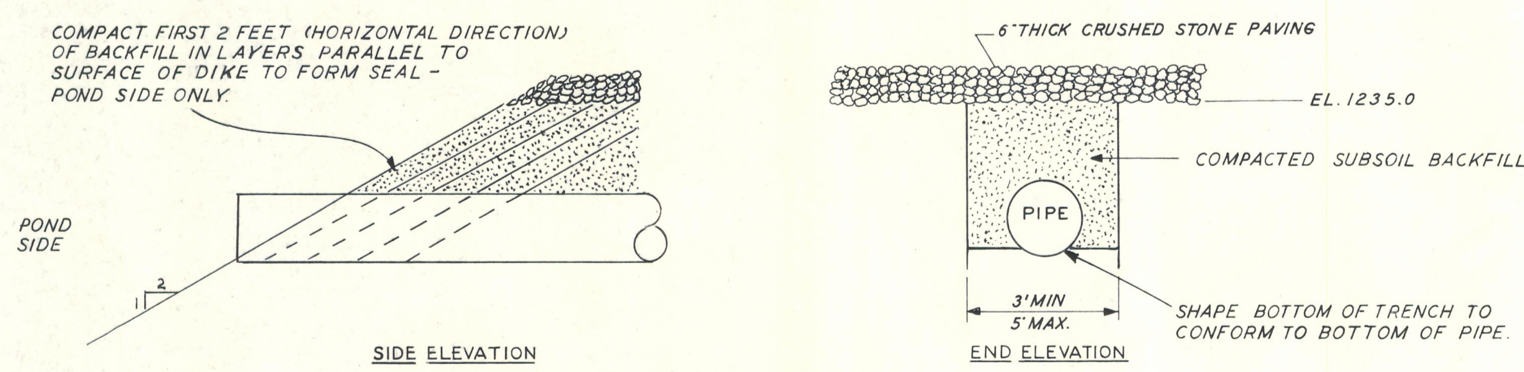
TYPICAL SUPPORT
N.T.S.



M.H. 45 DETAIL
N.T.S.

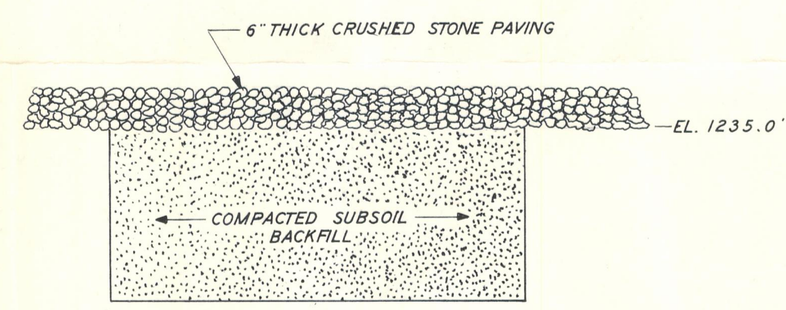


BACKFILL SECTION



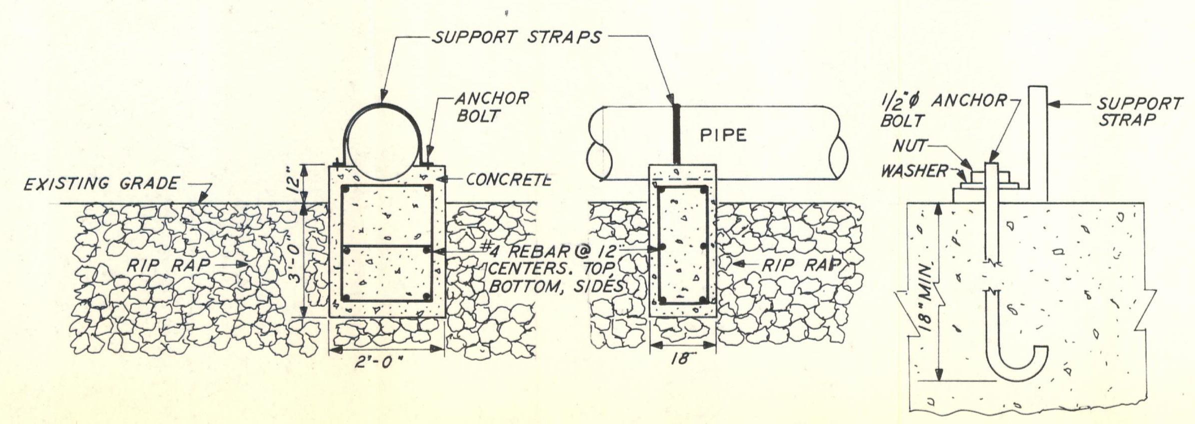
DETAIL 1 - TRENCH

N.T.S.



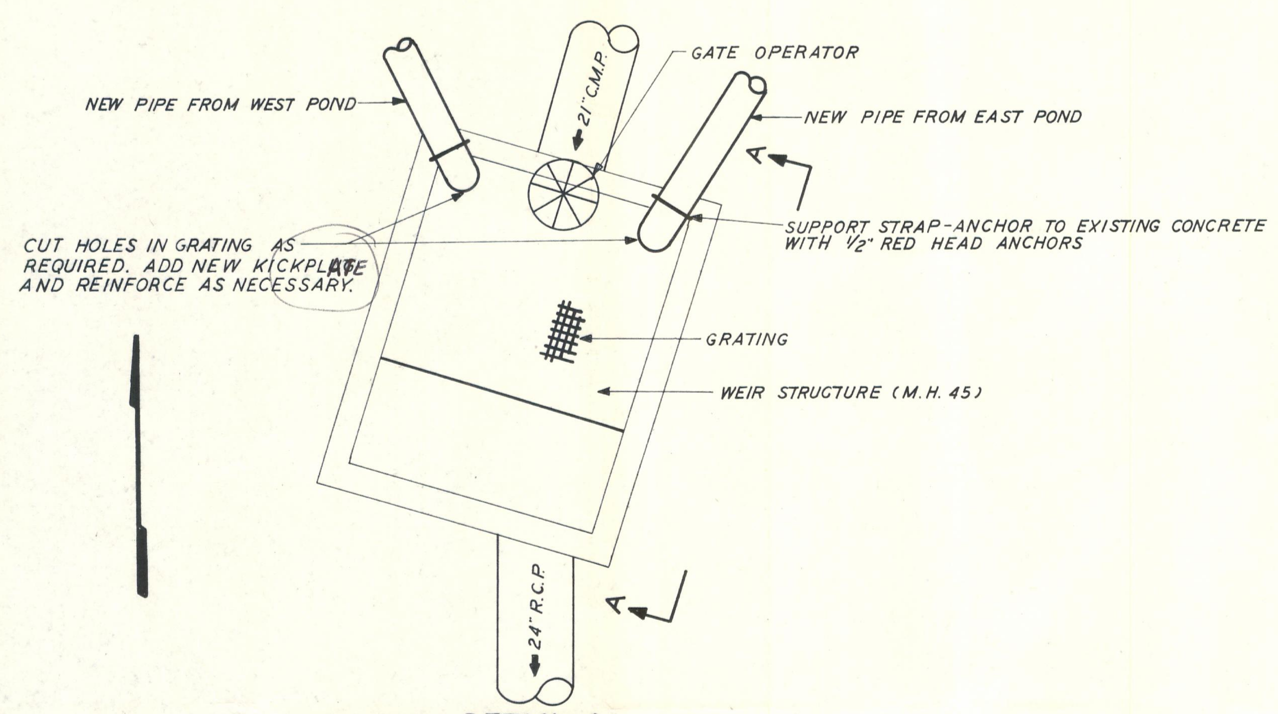
DETAIL 2 - TRENCH

N.T.S.



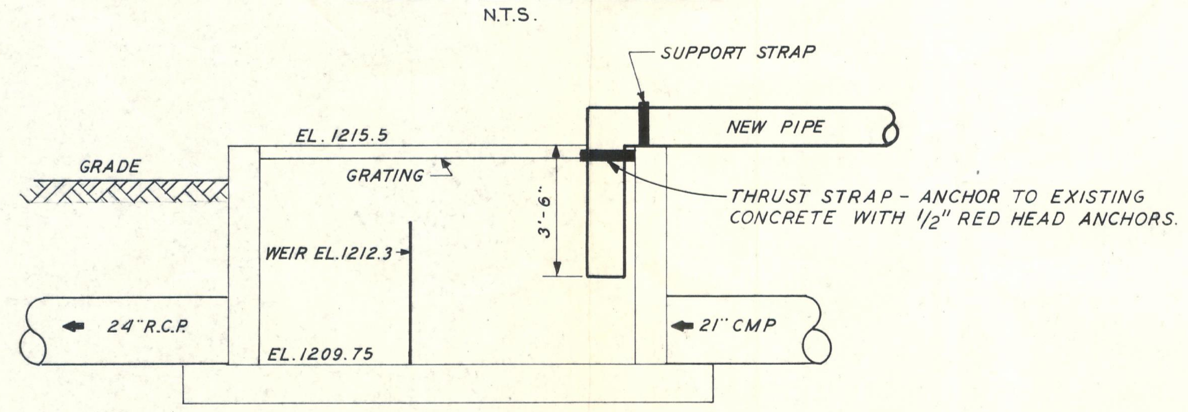
DETAIL 3 - TYPICAL SUPPORT

N.T.S.



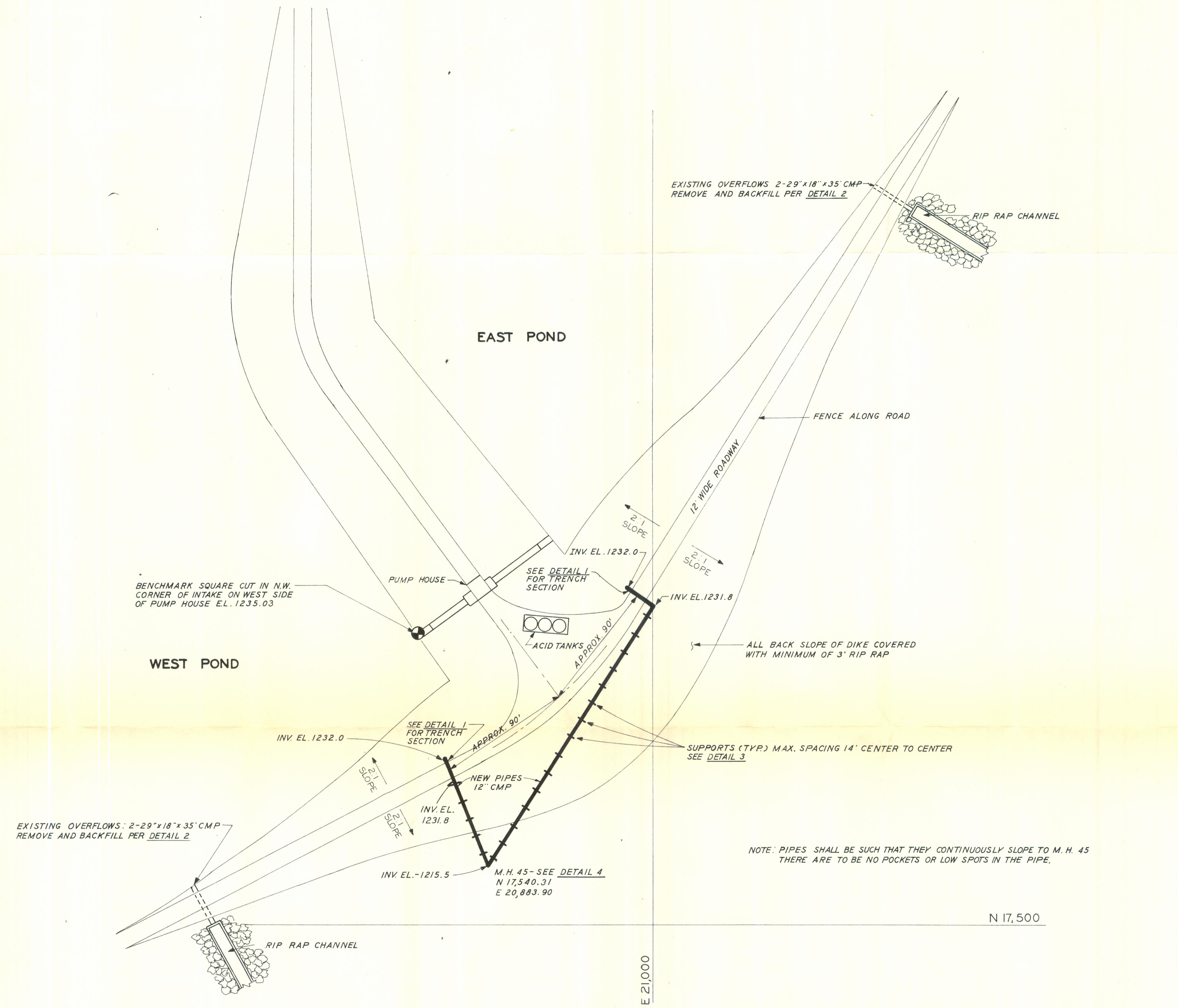
DETAIL 4
WATER STRUCTURE DETAIL

N.T.S.



SECTION A-A

N.T.S.



NOTE: PIPES SHALL BE SUCH THAT THEY CONTINUOUSLY SLOPE TO M.H. 45
THERE ARE TO BE NO POCKETS OR LOW SPOTS IN THE PIPE.

PROPOSED PIPE ROUTING - PLAN VIEW

SCALE 1" = 50'

CITY UTILITIES OF SPRINGFIELD, MO.				
AUTH J.O. 151242-652		ASH PONDS OVERFLOW MODIFICATIONS SOUTHWEST POWER STATION		
DATE ISSUED				
ELECTRIC WATER				
ENGR. BY M.R.W	APPD. BY	REVISED	BELL ENGR.	SCALE AS NOTED ABOVE
DWN. BY RW	DATE 12-31-85	MAP NO.	SHEET 1 OF 1	DWG. NO. 24,879-B

GEOTECHNICAL ENGINEERING REPORT

SITE STRUCTURAL ASSESSMENT

COAL COMBUSTION WASTE IMPOUNDMENTS

CITY UTILITIES OF SPRINGFIELD

JOHN TWITTY ENERGY CENTER

SPRINGFIELD, MISSOURI

Prepared for:

CITY UTLILITIES OF SPRINGFIELD
P.O. Box 551
Springfield, Missouri 65801-0551

Prepared by:

PPI
• Geotechnical Services
• Environmental Services
• Material Testing Services
PALMERTON & PARRISH, INC.

Springfield, MO
4168 W. Kearney Springfield, MO 65803
Call 417.864.6000 Fax 417.864.6004
www.ppimo.com

PROJECT NUMBER: 219892

March 17, 2014

PALMERTON & PARRISH, INC.

GEOTECHNICAL & MATERIALS ENGINEERS
MATERIALS TESTING LABORATORIES
ENVIRONMENTAL SERVICES

4168 W. Kearney Street.
Springfield, MO 65803
Ph: (417) 864-6000
www.ppimo.com

March 17, 2014

Mr. Ted C. Salveter, P.E.
City Utilities of Springfield
P.O. Box 551
Springfield, Missouri 65801-0551

RE: Geotechnical Engineering Report
Site Structural Assessment – Coal Combustion Waste Impoundments
City Utilities of Springfield – John Twitty Energy Center
Springfield, Missouri
PPI Project Number: 219892

Dear Mr. Salveter:

Please find the attached Report summarizing the results of a Geotechnical Subsurface Investigation and Slope Stability Analysis conducted for the above-referenced Project. PPI appreciates this opportunity to be of services. Please don't hesitate to contact this office if you have any questions regarding our Report or need additional information.

PALMERTON & PARRISH, INC.
By:

Taylor L. Anderson, E.I.
Geotechnical Engineer

PALMERTON & PARRISH, INC.
By:

Rachel J. Goeke, P.E.
Geotechnical Engineer

STATE OF MISSOURI
RACHEL JEANNE GOEKE
NUMBER
PE-2007020268
PROFESSIONAL ENGINEER

PALMERTON & PARRISH, INC.
By:

Brad R. Parrish, P.E.
President

Submitted: Three (3) Bound Copies
One (1) Electronic .pdf Copy

BRP:RJG::TLA:/jrh

TABLE OF CONTENTS

FIGURES

APPENDICES

PALMERTON & PARRISH, INC.

EXECUTIVE SUMMARY

A Geotechnical Investigation was performed at the John Twitty Energy Center located at 5100 West Farm Road 164, Springfield, Missouri 65801. The investigation was performed to investigate the nature of the existing embankment and underlying residual soils.

Palmerton & Parrish (PPI) drilled, a total of four (4) geotechnical borings were drilled in two (2) sets of two (2) borings (one at the slope crest and one at the slope toe), in order to develop two (2) geologic cross sections. Borings were discontinued at auger refusal in limestone bedrock at depths ranging from 9.7 to 47.3 feet below the existing ground surface. Temporary piezometers were installed in all four (4) borings, and water levels were recorded during two (2) separate measuring events.

A slope stability analysis was performed on the downstream slopes using data from the field and laboratory investigation, as well as groundwater level readings from the temporary piezometers. The slope stability analysis considered the following cases:

- Steady state seepage, maximum pool (effective stress conditions); and
- Steady state seepage, maximum pool, earthquake loading (total stress conditions).

Factors of safety determined from the slope stability analysis were compared to safety factors considered to be adequate in guidelines published by various government agencies. Based upon this comparison and the information developed from the field and laboratory studies as well as literature research, the Factors of Safety obtained are considered satisfactory for the Coal Combustion Waste (CCW) impoundment slope.

Analyses Summary		
Condition	**Required Factor of Safety**	**Computed Factor of Safety**
Steady State Seepage Under Maximum Pool (Deep Failure)	1.5	1.89
Steady State Seepage Under Maximum Pool (Shallow Failure)	1.5	1.58
Steady State Seepage Under Maximum Pool with Seismic Event	1.1	1.39

EXECUTIVE SUMMARY CONTINUED

Important geotechnical considerations for the project are summarized below. However, users of the information contained in the report must review the entire report for specific details pertinent to geotechnical design considerations.

GEOTECHNICAL ENGINEERING REPORT

JTEC SITE STRUCTURAL ASSESSMENT

COAL COMBUSTION WASTE IMPOUNDMENTS

SPRINGFIELD, MISSOURI

1.0 INTRODUCTION

This is the Report of the Geotechnical Investigation and subsequent slope stability analysis performed at the John Twitty Energy Center located at 5100 West Farm Road 164 in Springfield, Missouri. This investigation was conducted in accordance with a letter proposal dated January 21, 2014 and approved by Mr. Ted C. Salveter, P.E. representing City Utilities of Springfield. The work was performed under a Blanket Contract for Services between Palmerton & Parrish, Inc. and the City Utilities of Springfield. The purpose of this Geotechnical Investigation is to analyze the stability of waste impoundment slopes containing coal combustion waste (CCW). The approximate site location is shown in the aerial photograph below.

2.0 SCOPE OF SERVICES

Specific tasks completed by PPI include the following:

- Review of site documents provided by CU;
- Completion of a Subsurface Investigation program to investigate the condition of the coal ash impoundment levees. The Subsurface Investigation included completion of subsurface borings, collection of soil samples, installation of groundwater level piezometers, and completion of laboratory testing;
- Field reconnaissance by an Engineer from our staff to document the condition of the existing impoundment levees;
- Laboratory soil testing to determine soil classifications and soil strength parameters;
- Literature research to assist selection of soil strength parameters;
- Slope stability analysis of existing CCW impoundment levee slopes, including seismic analysis; and
- Evaluation of the liquefaction potential of the levee embankment soils, and underlying natural soils.

3.0 PROJECT & SITE DESCRIPTION

The John Twitty Energy Center is a coal fired power plant initially constructed in the early 1970s with a major upgrade to generating capacity in recent years. The major electrical generating facility is heavily developed with building foundations, two (2) emission stacks, cooling towers, overhead power lines, buried utilities and combustion coal waste impoundments. The earth embankments forming these CCW impoundments are the focus of this study. The impoundments have a maximum height on the order of 31 feet. Background information and history of these embankments is described in more detail in Sections 4.0 and 5.0 of this report.

4.0 PROJECT BACKGROUND INFORMATION

CDM Smith was one of several Engineering Consultants (Contractors) retained by the United States Environmental Protection Agency (EPA) to perform Site Structural Assessments of the structural stability and hydrologic / hydraulic safety of selected coal combustion waste (CCW) impoundments located across the United States. CDM Smith visited CU's John Twitty Energy Center (JTEC) on August 27 and 28, 2012, and completed a site reconnaissance and interviews with CU Staff. CDM Smith issued a Draft Report in July 2013.

CDM Smith's Draft Report is entitled "Assessment of Dam Safety of Coal Combustion Surface Impoundments – Draft Report; City Utilities of Springfield; John Twitty Energy Center; Springfield, Missouri". The Report is referred to as the "CDM Smith Draft Report" throughout this letter. The CDM Smith Draft Report discusses the two (2) CCW Impoundments at JTEC, identified as the West CCW Impoundment and the East CCW Impoundment.

Discussion throughout the CDM Smith Draft Report gives the impression that the structural stability, hydrologic / hydraulic safety, and operating procedures of the CCW Impoundments are generally adequate. The list below summarizes statements of that nature that are included in the CDM Smith Draft Report.

1. The CCW Impoundments have a "Low" Hazard Rating, based upon their total height, storage capacity, and the extent of downstream development.
2. The CCW Impoundment embankments were observed to be in overall good condition at the time of CDM Smith's Site Visit.
3. The CCW Impoundments appear to have adequate capacity with regard to hydrologic / hydraulic safety.
4. CU's Operating and Maintenance Procedures appear to be generally adequate.

However, the CDM Smith Draft Report ultimately rates the CCW Impoundments as POOR due to a lack of specific documentation of the structural stability, hydrologic and hydraulic safety, and operating and maintenance procedures. The CDM Smith Draft

Report outlines the need for documentation of several Studies, Operating and Maintenance Procedures, and Surveillance and Monitoring Plans before they will change the POOR rating.

5.0 SITE HISTORY

The CCW Impoundments were originally constructed in 1976. The Impoundments are identified as the West CCW Impoundment (approximately 3.89 acres) and the East CCW Impoundment (approximately 3.36 acres). Based upon information provided on the original Design Drawings and Supplemental Cross Sections prepared by Burns & McDonnell Engineering Company, Inc., the Impoundment embankments were originally constructed with controlled earth fill and 2 Horizontal to 1 Vertical (2H:1V) side slopes. A cutoff trench was constructed out of select fill material beneath the center of the embankments.

The exterior levees and water handling system remain basically unchanged from original construction. CU has added an interior dike in the approximate north-south center of both Impoundments. The dike allows for additional sedimentation and filtering before water reaches the downstream portion of the channel.

Flow through the Impoundments generally trends north to south. Bottom ash is transported to the Impoundments in slurry form via pipeline. Prior to reaching the Impoundments, the bottom ash slurry passes through a series of three (3) tiered concrete detention basins. A large portion of the bottom ash settles out, and is periodically dredged and stockpiled prior to eventual disposal at the JTEC Landfill.

The bottom ash slurry that reaches the Impoundments is retained in the northern portion of the Impoundment, north of the interior dikes added by CU. Additional bottom ash settles out in the northern portion of the Impoundments. CU periodically schedules maintenance of the Impoundments to remove the accumulated bottom ash, and reworks the clay bottom liner as necessary to maintain an approximate 2-foot thickness of well-compacted clay.

In addition to the bottom ash slurry, the Impoundments receive water from the cooling tower blowdown, boiler blowdown, Plant drain water, and storm water from the ponds' approximately 67 acre drainage area around the Plant. The East and West CCW Impoundments share a common Recycle Pump House and Outlet Structure located near the southern end of the interior embankment that divides the Impoundments. A large portion of the water that enters the Impoundments is recirculated back to the Power Plant for reuse as bottom ash sluice water. Water that is discharged downstream exits the Outlet Structure via a 24-inch diameter corrugated metal outlet pipe to a weir south of the Impoundments. The discharged water is tested and routed to eventual discharge under CU's NPDES Operating Permit MO-0089940.

Each impoundment has a high water outlet pipe near the top of the embankment, consisting of a 12-inch diameter corrugated metal pipe. The pipe invert elevations on the upstream, interior embankment slope are 1232.1 feet and 1232.4 feet for the West and East CCW Impoundments, respectively. Based upon information provided by CU, the water elevation in the Impoundments has never approached the high water outlet pipe invert elevation, and the pipes have never been utilized.

During normal operations, only one (1) of the CCW Impoundments is in service at any given time. The normal operating water elevation is maintained near the top elevation of the interior dikes, at approximate elevation 1227 feet. Only the West CCW Impoundment was in service on January 13, 2014 during PPI's Site Visit and completion of Anderson Engineering's topographic survey. The water elevation in the northern portion of the West CCW Impoundment was approximately 1227.3 feet, while the water elevation in the southern portion was a couple feet below normal pool elevation at approximate elevation 1223.7 feet.

The maximum embankment cross section occurs on the south side of the Impoundments. At its approximate lowest point, the top elevation of the embankment is 1235.3 feet. The embankment crest width is a minimum of approximately 10 feet, and more typically on the order of 12 to 15 feet. The maximum cross section height is approximately 31 feet, with a corresponding toe of slope elevation of 1204 feet.

6.0 ENGINEER'S SITE VISIT

An engineer from PPI's staff, Ms. Rachel Goeke, P.E., visited the JTEC CCW Impoundment Site with Mr. Ted Salveter, P.E., CU Environmental Affairs, on Monday, January 13, 2014. Mr. Salveter and Ms. Goeke walked and/or drove around the perimeter of the CCW Impoundments. Mr. Salveter described the typical operating procedures of the Impoundments. A survey crew from Anderson Engineering, Inc. (AE) was on-site at the same time, completing a current topographic survey of the CCW Impoundments and surrounding areas.

7.0 DOCUMENTS REVIEWED BY PPI

CU provided the documents listed below to PPI via email during the period from January 13, 2014 through January 16, 2014.

- CDM Smith; July 1, 2013; "Assessment of Dam Safety of Coal Combustion Surface Impoundments – Draft Report; City Utilities of Springfield; John Twitty Energy Center; Springfield, Missouri", prepared for the United States Environmental Protection Agency
- Burns & McDonnell Engineering Company, Inc.; July 10, 1974; "Sheet Y49, Rev. 2; Contract No. 343: Yard Structures; Ash Pond Grading Details"
- Burns & McDonnell Engineering Company, Inc.; July 10, 1974; "Sheet Y45, Rev. 4, Contract No. 343: Yard Structures; Area V Grading and Drainage Plan"
- Burns & McDonnell Engineering Company, Inc.; Excerpt from the Project Specifications: Contract No. 343: Division 2: Site Work
- Burns & McDonnell Engineering Company, Inc.; April 10, 1975; Letter Correspondence to Martin K. Eby Construction Company, Revised Design Cross Sections
- Anderson Engineering, Inc.; December 15, 2005, "City Utilities of Springfield, Ash Pond Topographic Survey, Southwest Power Station, Springfield, Missouri"
- Anderson Engineering, Inc.; December 9, 2011, Excerpts from "AEWO#70045-11: Ash Landfill Slope Stability and Engineering Analyses; John Twitty Energy Center, Springfield, MO"

- Anderson Engineering, Inc.; January 15, 2014; "City Utilities of Springfield, East and West Ash Pond Topographic Survey, JTEC, Springfield, Missouri"

In Addition, PPI reviewed the documents listed below during development of assumed soil strength parameters for use in slope stability analysis

- NAVFAC Design Manual 7.2 - Foundations and Earth Structures, SN 0525-LP-300-7071, REVALIDATED BY CHANGE 1 SEPTEMBER 1986
- Swiss Standard SN 670 010b, Characteristic Coefficients of Soils, Association of Swiss Road and Traffic Engineers
- Subsurface Exploration using the Standard Penetration Test and the Cone Penetrometer Test J.D. Rogers. 2006. The Geological Society of America. Environmental and Engineering Geoscience, Vol. XIII, No.2, pp. 161-179.

8.0 SUBSURFACE INVESTIGATION

Subsurface conditions were investigated through completion of subsurface borings, collection of soil samples during drilling, installation of groundwater level piezometers, and laboratory testing of collected soil samples.

8.1 Subsurface Borings

Subsurface conditions at this site were investigated by drilling a total of four (4) sample borings in the vicinity of the Coal Combustion Waste impound levees. The boings were drilled in two (2) sets of two (2) borings with one (1) at the slope crest and one (1) boring at the slope toe. Temporary piezometers were installed in all four (4) borings for the purpose of more accurately monitoring groundwater levels in the borings. Boring locations were selected and staked in the field by PPI using the January 15, 2014 topographic survey completed by Anderson Engineering and provided to PPI by CU. Approximate boring locations are shown on Figure 1: Boring Location Plan.

The Missouri One-Call System was notified prior to the investigation to assist in locating buried public utilities. PPI coordinated the field drilling schedule, as well as private utility locations with representatives of CU.

Borings were drilled on January 28 through January 31, 2014 using 4.5-inch O.D. continuous flight augers powered by a CME-75 truck-mounted drill rig. Soil samples were collected at 2.5 to 5-ft. centers during drilling. Soil sample types included split spoon samples collected while performing the Standard Penetration Test (SPT) in general accordance with ASTM D1586 and thin walled Shelby tubes pushed hydraulically in advance of drilling in accordance with ASTM D1587.

As discussed in greater detail later in this report, collection of good quality thin-walled Shelby tube samples was not possible in the embankment fill zone due to significant chert content. PPI remobilized to the site later and attempted to collect Shelby tube samples in certain zones adjacent to Boring 2A. Collected Shelby tube samples from the embankment fill were not viable for triaxial or direct shear testing, but were useful in determining soil classifications.

Logs of the borings showing descriptions of soil and rock units encountered, as well as results of field and laboratory tests are presented in Appendix I. Please refer to Appendix II for general notes regarding boring logs and additional soil sampling information.

8.2 Laboratory Testing

Collected samples were sealed and transported to the laboratory for further evaluation and visual examination. Laboratory soil testing included the following:

- Moisture Content (ASTM D2216);
- Direct Shear Tests (ASTM D3080);
- Particle Size Analysis (ASTM D422);
- Atterberg Limits (ASTM D4318);
- Pocket Penetrometers; and
- Torvane Shear Tests (ASTM D4648).

"High end" shear strength testing was performed on selected thin-walled Shelby tube samples for determination of shear strength parameters for use in slope stability analysis. Drained direct shear tests were performed on three (3) representative soil samples from the levee embankment foundation soils. Results of the direct shear tests are shown graphically in Appendix V.

As previously mentioned, procurement of undisturbed samples of embankment fill satisfactory for triaxial or direct shear laboratory strength testing was attempted, but could not be recovered due to high gravel content within embankment fill. To assist characterization of shear strength of these embankment soils, torvane shear strength tests were performed in the laboratory, and literature research was conducted for the soil types characterized in the embankment fill. Laboratory test results are shown on each boring log in Appendix I and are summarized in the following table.

Boring	Depth (ft.)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Moisture Content (%)	USCS Symbol	Cohesion (psf) (eff)	Friction Angle (deg) (eff)	Dry Unit Wt. (pcf)	*Torvane Cohesion (psf) (total)
B-1A	29-30.5	83	38	45	56.3	CH	-	-	-	
B-1A	39-40.17	85	37	48	95.4	CH	133	17	51.6	
B-1A	43.3-44.8	-	-	-	49.9	CH	-	-	-	500
B-1B	0-1.5	-	-	-	19.2	CL	-	-	-	750
B-1B	5-6.33	86	30	56	49.1	CH	492	24	74.3	
B-1B	10-11.5	-	-	-	57.0	CH	-	-	-	1750
B-1B	18-20.08	-	-	-	67.2	CH	580	15	60.3	
B-1B	23.5-24.58	87	32	55	-	CH	424	18	67.1	
B-2A	9-10.5	-	-	-	35.9	GC	-	-	-	1700
B-2A	19.5-21.5	38	17	21	-	GC	-	-	-	1100
B-2A	39-40.5	-	-	-	46.5	CH	-	-	-	1200
B-2B	0-1.5	34	17	17	20.5	CL	-	-	-	
B-2B	8.5-9.25	74	35	39	38.0	CH	-	-	-	

*Torvane Shear was determined for multiple surfaces in each sample. The reported cohesion reported represents lowest value measured upon each specimen.

9.0 SITE GEOLOGY

The general site area is underlain at depth by the Mississippian Age Burlington Limestone Formation. This unit characteristically consists of coarse-grained gray limestone, which is nearly pure calcium carbonate. Isolated chert nodules and discontinuous chert layers are present throughout the formation. The upper surface of this limestone unit is generally irregular due to the effects of differential vertical weathering and solution activity. Limestone pinnacles, some of which are 10 to 15 feet high, are common in the general area. In upland areas, overburden soils are usually composed of red clay and chert and are residual having developed from physical and chemical weathering of the parent limestone. The chert fragments were interbedded with the limestone, but are much more resistant to weathering and retain rock-like properties. The contact between comparatively unweathered bedrock and the residual soils is usually abrupt.

The general site area is located within the Ozarks Physiographic Region of Missouri, which is characterized by rugged to rolling hill terrain, meandering streams and karst topography. Karst topography forms over areas of carbonate bedrock where groundwater has solutionally enlarged openings to form a subsurface drainage system. Springs, caves, losing streams and sinkholes are common in karst areas. Sinkholes are defined as a depression in the landscape with an internal drainage system. Although there are indications of a pinnacled limestone surface from the boring data, indications of sinkhole development were not observed along impoundment slopes.

10.0 GENERAL SITE & SUBSURFACE CONDITIONS

Based upon subsurface conditions encountered within the borings drilled at the project site, generalized subsurface conditions are summarized in the table below. Soil stratification lines on the boring logs indicate approximate boundary lines between different types of soil and rock units based upon observations made during drilling. In-situ transitions between soil and some rock types are typically gradual.

10.1 Generalized Subsurface Conditions

Description	Borings	Approx. Depth to Bottom of Stratum	Material Encountered	Moisture	Consistency/ Density
Stratum 1	B-1A & B-2A	28 to 32 ft.	Fill – Clayey Gravel, Lean Clay, Fat Clay w/Varying Amounts of Chert Sand & Gravel	Moist	Medium Dense to Dense, Very Stiff
Stratum 2	B-2B	5 ft.	Lean Clay w/Silt	Moist	Medium Stiff
Stratum 3	All	9.3 to 45 ft.	Fat Clay w/Varying Amounts of Chert Sand & Gravel	Moist to Wet	Medium Stiff to Stiff
Stratum 4	All	Boring Completion	Limestone	-	Moderately Hard

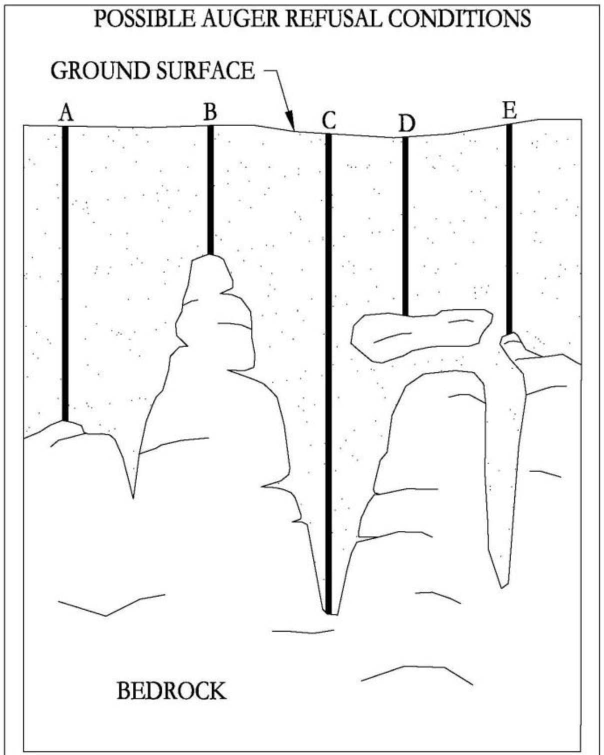
Three (3) general earth and bedrock material types were encountered in the borings. Existing fill was encountered within the embankments consisting primarily of dense to medium dense clayey gravel or stiff to medium stiff gravelly lean to fat clay. These soils classify as CL, CH, and GC in accordance with the Unified Soils Classification System (USCS). SPT N-values were 12 blows per foot or greater, but generally on the order of 15 to 30 or more blows per foot. Construction records documenting fill compaction were not available. Based upon drilling resistance and SPT values, the fill appears to be fairly well compacted.

Natural foundation soils below the fill material consist primarily of medium stiff to very stiff fat clay with variable quantities of chert, although medium stiff lean clay was encountered in Boring B-2B to a depth of 5 ft. Fat clay was found to be soft immediately above limestone in Boring B-1A, which is typical condition in the site area. SPT values recorded in the natural overburden soils were 7-blows per foot or greater, except within the soft clay.

Limestone bedrock was encountered in all borings drilled. Limestone was encountered at depths of 44.8 and 45.5 in Borings B-1A and B-2A drilled from the crest of the slope. In Borings B-1B and B-2B, several feet from the toe of slope limestone was found at depths of 24.7 and 9.3 ft. respectively. The sometimes erratic depth to bedrock is typical of the Burlington Limestone Formation which can have a pinnacled top of rock surface.

10.2 Auger Refusal

Auger refusal is defined as the depth below the ground surface at which a boring can no longer be advanced with the soil drilling technique being used. Auger refusal is subjective and is based upon the type of drilling equipment and types of augers being used, as well as the effort exerted by the driller. Several different auger refusal conditions are possible in the general site area. These conditions are represented graphically in the adjacent figure: (A) on the upper surface of continuous bedrock, (B) on rock "pinnacles", (C) in widened joints that may extend well below the surrounding bedrock surface, (D) slabs of unweathered rock suspended in the residual soil matrix, or "floaters", or (E) on the upper surface of discontinuous bedrock.



THE BEDROCK CONDITIONS ILLUSTRATED ABOVE ARE FOR REFERENCE ONLY & DO NOT INDICATE CONDITIONS ENCOUNTERED AT THE PROJECT SITE.

11.0 GROUNDWATER

Groundwater was observed in Boring 2A at depth of 34 ft. below the existing ground surface on the date drilled. After drilling completion Piezometers were installed in all four (4) boreholes with a 5 foot length of 2-inch diameter PVC screen at the bottom of boring. The borehole was then backfilled with sand to 4 ft. below the surface. PPI plans to close the Piezometers by drilling them and grouting full depth via tremie. Results of groundwater monitoring are summarized in the table below.

11.1 Generalized Groundwater Conditions

Monitoring Well	Sample Date	Water Level	Sample Date	Water Level	Notes
B-1B	2/19/14	Dry	3/4/14	Dry	Riser 2.8 ft. above ground
B-1A	2/19/14	Dry	3/4/14	Dry	Riser 0.4 ft. below ground
B-2A	2/19/14	41.0 ft.	3/4/14	41.1 ft.	Riser 3.0 ft. above ground
B-2B	2/19/14	Dry	3/4/14	Dry	Riser 0.3 ft. below ground

12.0 SLOPE STABILITY ANALYSIS

PPI completed slope stability analysis on the approximate maximum cross section which occurs on the south side of the East CCW Impoundment. PPI Utilized the topographic survey data collected by Anderson Engineering during the week of January 13, 2014 to determine the cross section geometry. Assumptions regarding the approximate bottom elevation of the East CCW Impoundment were made using data from the original Design Drawings. The tallest slope of the East CCW Impoundment was used in this analysis since the slope height is appreciably greater than the slopes of the West CCW Impoundment and soil types and strengths do not vary appreciably.

Soil stratigraphy was assumed based upon information shown on the original Design Drawings, as well as data provided by the boring logs from the subsurface investigation. For the purposes of the analysis, only maximum pool, steady sate seepage conditions were analyzed. The water level on the embankment interior was assumed at elevation 1232.4 ft. Soil Strength parameters were assumed from data collected using effective stress conditions for steady state seepage conditions and total stress conditions for seismic analysis.

Effective soil strength parameters for natural foundation soils used in the slope stability analysis were based upon the results of laboratory direct shear testing upon natural foundation soils. Total strength (undrained) parameters for natural foundation soils were based upon the results of Torvane Cohesion Testing and assuming $\Phi = 0$ conditions. As previously mentioned, torvane cohesion was determined upon multiple surfaces for each sample. The more conservative torvane cohesion determined was reported and used in this analysis.

For embankment fill containing high gravel content, strength parameters were selected based upon classification testing (particle size distribution and plasticity), torvane cohesion testing, and the results of Standard Penetration Tests (SPT values used only as an indication of strength and density), as well as the following documents. Strength parameters were selected by literature research using conservative assumptions plus the more conservative torvane cohesion values for each sample were used for this analysis.

- Subsurface Exploration using the Standard Penetration Test and the Cone Penetrometer Test J.D. Rogers. 2006. The Geological Society of America. Environmental and Engineering Geoscience, Vol. XIII, No.2, pp. 161-179
- NAVFAC Design Manual 7.2 - Foundations and Earth Structures, SN 0525-LP-300-7071, REVALIDATED BY CHANGE 1 SEPTEMBER 1986
- Swiss Standard SN 670 010b, Characteristic Coefficients of soils, Association of Swiss Road and Traffic Engineers

The following table summarizes soil parameters utilized in the slope stability analysis.

Natural Foundation Soils – Table 1										
Sample	Depth (ft.)	Description	Direct Shear Test Results (3 Point)			W (%)	Atterberg Limits		Torvane Testing	
			C_{eff} (psf)	Φ_{eff}	γ_d		LL	PI	C_{total} (psf)	ϕ_{total}
B-1B	0-1.5	Lean Clay	-	-	-	19.2	-	-	750	0
B-1B	5 to 6.3	Fat Clay	492	24	74.3	49.1	86	30	-	-
B-1B	10-11.5	Fat Clay	-	-	-	57.0	-	-	1750	0
B-1B	18.8 to 20	Fat Clay	580	15	60.3	67.2	-	-	-	-
B-1B	24-24.7	Fat Clay	424	18	67.1	-	87	55	-	-
B-1A	39 to 40	Fat Clay	133	17	51.6	95.4	85	37	-	-
B-1A	43.3-44.8	Fat Clay	-	-	-	49.9	-	-	500	0
B-2A	39-40.5	Fat Clay	-	-	-	46.5	-	-	1200	0

Embankment Fill – Table 2											
Sample	Depth (ft.)	Description	Direct Shear Test Results (3 Point)			W (%)	Atterberg Limits		% - No. 200 Sieve	Torvane Test	
			*C_{eff} (psf)	*Φ_{eff}	γ_d		LL	PI		C_{total} (psf)	ϕ_{total}
B-1A	5 to 6.5	Clayey Gravel w/Sand	-	-	-	19.7	-	-	34.5	-	-
B-2A	4 to 5.5	Clayey Gravel w/Sand	-	-	-	18.9	-	-	36.3	-	-
B-2A	9-10.5	Clayey Gravel w/Sand	-	-	-	35.9	-	-	-	1700	0
B-2A	14 to 15	Clayey Gravel w/Sand	-	-	-	-	-	-	37.7	-	-
B-2A	19.5 to 21.5	Gravelly Lean Clay	-	-	-	18.8	38	17	68.0	1100	0

*Based upon classification tests and literature research, use C_{eff} = 100 psf and Φ_{eff} = 28°

Slope Stability Analysis Values – Table 3						
Stratum	Effective Stress			Total Stress		
	Unit Weight (pcf)	Cohesion (psf)	ϕ_{eff}	Unit Weight (pcf)	Cohesion (psf)	ϕ_{total}
Earth Fill	120	100	28	120	1100	0
Residual Soil – A	115	500	24	115	750	0
Residual Soil – B	100	600	15	100	1750	0
Residual Soil – C	100	150	17	100	500	0
Limestone	140	5000	45	140	5000	45

Slope stability analysis was performed using the computer program Slope/W, part of the GeoStudio 2012 software package. Spencer's method was selected as the finite difference analysis method, since it achieves both moment and force equilibrium. The grid and radius method was utilized to search for the critical slope failure surface.

The project site is located in an area of low seismicity. The project site lies within Seismic Zone 1 according to the Uniform Building Code map, which is presented as Appendix C within the USACE ER 1110-2-1806 Engineering and Design: Earthquake Design and Evaluation for Civil Works Projects.

Probabilistic seismic hazard analysis (PSHA) was utilized to evaluate earthquake design accelerations at the project site in accordance with guidance provided in ER 1110-2-1806. The PSHA was performed using the 2008 Interactive Deaggregation Program available on the United States Geological Survey (USGS) Earthquake Hazards Mapping Website (http://earthquake.usgs.gov/).

A 2,475-year return period earthquake event (2% Probability of Exceedance in 50-years) is commonly accepted as the Design Earthquake Event for seismic slope stability analysis.

Graphical output from the PSHA run is included in Appendix IV. Resultant peak horizontal ground acceleration (pga) data from PSHA run is summarized in the following table.

Summary of PSHA Runs – Table 4	
Earthquake Return Period	**Peak Horizontal Ground Acceleration (pga) for BC Rock**
2,475-year (2% PE in 50 years)	0.08132g

The required minimum Factor of Safety for steady state seepage and seismic conditions required by various United States Army Corps of Engineers, Federal Emergency Management Association, and Missouri Department of Natural Resources guidelines is 1.5 and 1.1 respectively. PPI completed two (2) different slope stability analysis runs, using data collected during drilling as well as subsequent laboratory testing. Results of the analyses are summarized below in Table 3. Copies of the slope stability analysis output are included in Appendix II.

Analyses Summary – Table 5		
Condition	**Required Factor of Safety**	**Computed Factor of Safety**
Steady State Seepage Under Maximum Pool (Deep Failure)	1.5	1.89
Steady State Seepage Under Maximum Pool (Shallow Failure)	1.5	1.58
Steady State Seepage Under Maximum Pool with Seismic Event	1.1	1.39

13.0 LIQUEFACTION ANALYSIS

PPI reviewed the subsurface conditions encountered at the project site with regard to their susceptibility to liquefaction during a large earthquake event.

The levee embankment foundation soils should not be susceptible to liquefaction based upon their Unified Soil Classification System (USCS) classification and in situ density. Foundation soils typically consist of medium stiff to stiff lean clay and fat clay with gravel (CL and CH); dense to very dense clayey gravel (GC); or dense to very dense gravel with clay (GC).

The sub-sections below discuss the technical references used for review of liquefaction potential, and PPI's evaluation of liquefaction potential of the embankment foundation soils and impounded CCW.

13.1 Liquefaction Reference Documents

The EM 1110-2-1902 Engineering and Design: Slope Stability discusses liquefaction and emphasizes the importance of evaluating the liquefaction potential of foundation soils. The EM 1110-2-1902 provides the following summary restated below regarding liquefaction (pg. 1-6).

> "d. *Liquefaction.* The phenomenon of soil liquefaction, or significant reduction in soil strength and stiffness as a result of shear-induced increase in pore water pressure, is a major cause of earthquake damage to embankments and slopes. Most instances of liquefaction have been associated with saturated loose sandy or silty soils. Loose gravelly soil deposits are also vulnerable to liquefaction…. Cohesive soils with more than 20 percent of particles finer than 0.005 mm, or with liquid limit (LL) of 34 or greater, or with the plasticity index (PI) of 14 or greater are generally considered not susceptible to liquefaction."

The technical paper "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils" (Youd & Idriss, et al, 2001) gives the following definition of liquefaction:

> "Liquefaction is defined as the transformation of a granular material from a solid to a liquefied state as a consequence of increased pore-water pressure and reduced effective stress (Marcuson 1978). Increased pore-water pressure is induced by the tendency of granular materials to compact when subjected to cyclic shear deformations. The change of state occurs most readily in loose to moderately dense granular soils with poor drainage, such as silty sands or sands and gravels capped by or containing seams of impermeable sediment."

The levee embankment foundation soils should not be susceptible to liquefaction based upon their Unified Soil Classification System (USCS) classification and in situ density. Foundation soils typically consist of medium stiff to stiff lean clay and fat clay with gravel (CL and CH); dense to very dense clayey gravel (GC); or dense to very dense gravel with clay (GC).

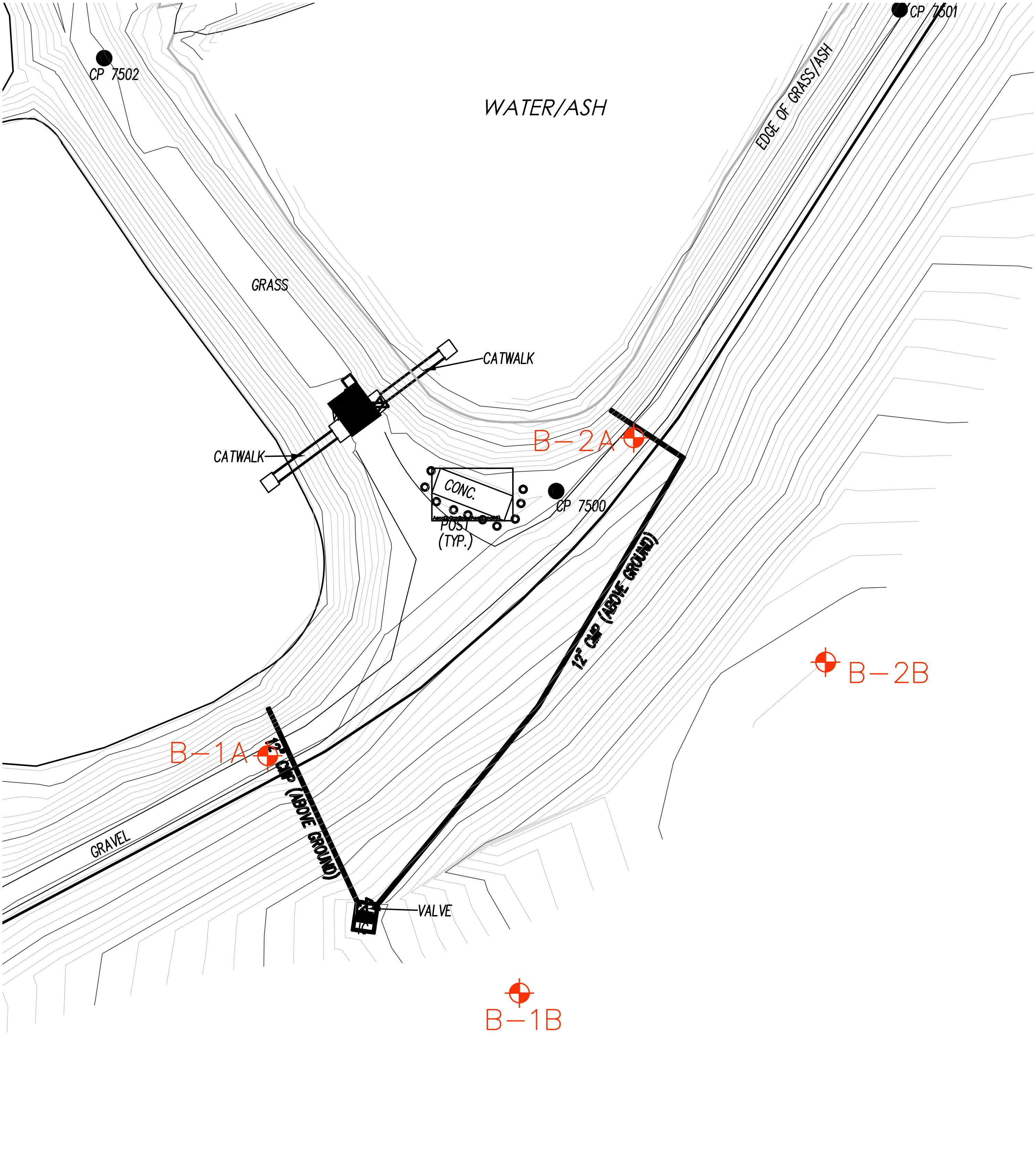
14.0 CONCLUSIONS & RECOMMENDATIONS

From the results of the slope stability analyses and the minimum Factor of Safety required by the various United States Army Corps of Engineers, Federal Emergency Management Association, and Missouri Department of Natural Resources guidelines stated in Section 12.0, it is our opinion that the JTEC Coal Combustion Waste Impoundment site conforms with the minimum requirements for global slope stability. It is recommended that C.U. continue to perform periodic inspections of the impoundment embankments. Any change in profile, tension cracks, bulging, etc., should be reported immediately to the Geotechnical Engineer for evaluation. Large rooted vegetation should be prevented from growing in the earthen embankments. Embankments should be inspected for animal bore holes and repaired as necessary.

15.0 REPORT LIMITATIONS

This Report has been prepared in accordance with generally accepted practices of other consultants undertaking similar studies at the same time and in the same geographical area. PPI observed that degree of care and skill generally exercised by other consultants under similar circumstances and conditions. Palmerton & Parrish's findings and conclusions must be considered not as scientific certainties, but as opinions based on our professional judgment concerning the significance of the data gathered during the course of this investigation. Other than this, no warranty is implied or intended.

FIGURE



LEGEND

BORING LOCATION

SCALE
1"=50'

Project: JTEC Site Structural Assessment
Client: City Utilities of Springfield

Boring Location Plan

DATE: March 6, 2014 | Project Number: 219892

PALMERTON & PARRISH, INC.
GEOTECHNICAL AND MATERIALS ENGINEERS/MATERIALS TESTING LABORATORIES/ENVIRONMENTAL SERVICES

FIGURE 1

APPENDIX I

BORING LOGS

4168 W. Kearney St.
Springfield, Missouri 65803
Telephone: (417) 864-6000
Fax: (417) 864-6004

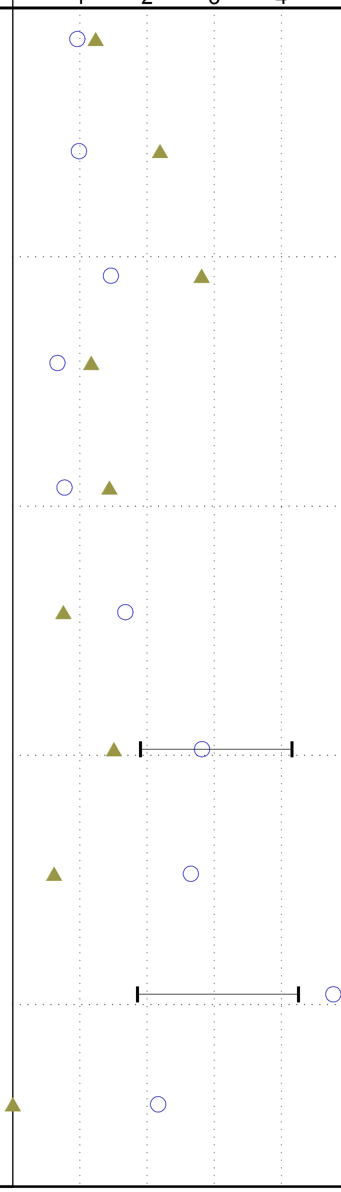
GEOTECHNICAL BORING LOG

BORING NUMBER **B-1A**

CLIENT City Utilities
PROJECT NAME JTEC CCW Impoundments - SSA
PROJECT NO. 219892
PROJECT LOCATION Springfield, Missouri
DATE STARTED 1/28/14 **COMPLETED** 1/29/14
SURFACE ELEVATION **BENCHMARK EL.**
DRILLER RD **DRILL RIG** CME 75
GROUND WATER LEVELS
HAMMER TYPE Auto
AT TIME OF DRILLING None
LOGGED BY CC **CHECKED BY** RG
AT END OF DRILLING
NOTES Installed Piezometer in borehole. 5-ft. of 2-inch PVC screen. Sand to 4-ft. below the surface.

Drilling method: HSA - 4.25" I.D.

Bottom depth	MATERIAL DESCRIPTION (Unified Soil Classification System)	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)
0.5 ft	BASE ROCK				
7.5 ft	FILL - CLAYEY GRAVEL with Silt and Sand, Brown Red, Medium Dense to Dense, Moist (GC)	SPT 1		16-12-12 (24)	
		SPT 2		49-21-23 (44)	
12.5 ft	FILL - CLAYEY GRAVEL with Sand, Red, Dense, Moist (GC)	SPT 3		7-25-32 (57)	
17.0 ft	FILL - CHERT GRAVEL and Cobbles with Sand and Brown Clay, White, Medium Dense, Moist (GP)	SPT 4		22-10-14 (24)	
22.0 ft	FILL - GRAVELLY LEAN CLAY, Brown, Very Stiff, Moist (CL)	SPT 5		16-15-14 (29)	
28.0 ft	FILL - FAT CLAY with Scattered Chert Sand and Gravel, Red Brown to Red, Very Stiff, Moist (CH)	SPT 6		7-8-7 (15)	
30.1 ft	FAT CLAY with Trace Chert Sand & Gravel, Red, Very Stiff, Moist (CH)	SPT 7		3-16-14 (30)	
30.5 ft	CHERT, White, Hard (GP)				
41.5 ft	FAT CLAY with Scatterd Chert Sand and Gravel, Red, Stiff, Moist (CH) Weathered Limestone in Tip of Split Spoon	SPT 8		1-7-5 (12)	
		ST 9	100		
44.8 ft	FAT CLAY with Weathered Limeston, Red, Soft, Wet (CH)	SPT 10		0-0-0 (0)	
47.3 ft	LIMESTONE, Hard				



ELEVATION (ft)

Refusal at 47.3 feet.
Bottom of borehole at 47.3 feet.

PPI
4168 W. Kearney St.
Springfield, Missouri 65803
Telephone: (417) 864-6000
Fax: (417) 864-6004

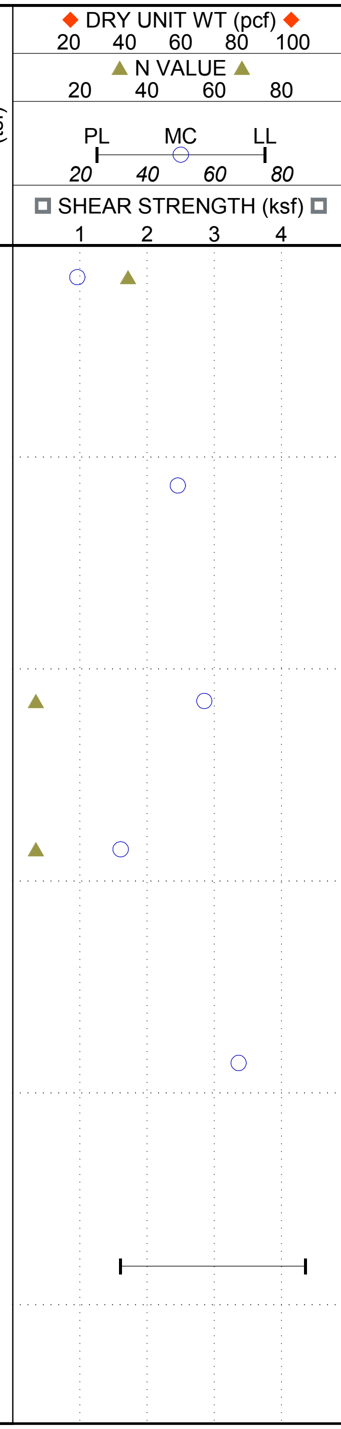
GEOTECHNICAL BORING LOG

BORING NUMBER **B-1B**

CLIENT City Utilities
PROJECT NAME JTEC CCW Impoundments - SSA
PROJECT NO. 219892
PROJECT LOCATION Springfield, Missouri
DATE STARTED 1/27/14 **COMPLETED** 1/28/14
SURFACE ELEVATION **BENCHMARK EL.**
DRILLER RD **DRILL RIG** CME 75
GROUND WATER LEVELS
HAMMER TYPE Auto
AT TIME OF DRILLING 0 ft
LOGGED BY CC **CHECKED BY** RG
AT END OF DRILLING
NOTES Piezometer installed at boring completion. 5-ft. of 2-inch PVC screen. Sand to 4-ft. below the surface.

Drilling method: HSA - 4.25" I.D.

DEPTH (ft)	MATERIAL DESCRIPTION (Unified Soil Classification System)	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0 – 6.3	FAT CLAY with Chert Gravel and Sand, Red Brown to Red, Very Stiff to Stiff, Moist, Grass Covered (CH)	SPT 1		7-14-21 (35)		
		ST 2	100			
6.3 – 12.5	FAT CLAY with Scattered Chert Gravel and Sand, Red, Medium Stiff, Moist (CH)	SPT 3		4-3-4 (7)		
12.5 – 16.5	FAT CLAY with Chert Gravel and Sand, Red, Medium Stiff, Moist (CH)	SPT 4		7-4-3 (7)		
16.5 – 23.5	FAT CLAY with Scattered Chert Gravel and Sand, Red, Medium Stiff, Moist (CH)	ST 5	100			
23.5 – 24.7	FAT CLAY, Red, Medium Stiff, Moist, Weathered limestone in Tip of Split Spoon (CH)	ST 6	100			
24.7 – 27.5	LIMESTONE, Weathered					
27.5 – 27.8	LIMESTONE, Hard					



Refusal at 27.8 feet.
Bottom of borehole at 27.8 feet.

4168 W. Kearney St.
Springfield, Missouri 65803
Telephone: (417) 864-6000
Fax: (417) 864-6004

GEOTECHNICAL BORING LOG

BORING NUMBER B-2A

CLIENT City Utilities
PROJECT NAME JTEC CCW Impoundments - SSA
PROJECT NO. 219892
PROJECT LOCATION Springfield, Missouri
DATE STARTED 1/30/14 **COMPLETED** 1/31/14
SURFACE ELEVATION **BENCHMARK EL.**
DRILLER RD **DRILL RIG** CME 75
GROUND WATER LEVELS
HAMMER TYPE Auto
AT TIME OF DRILLING 34 ft
LOGGED BY CC **CHECKED BY** RG
AT END OF DRILLING
NOTES Piezometer installed at boring completion. 5-ft. of 2-inch PVC screen. Sand to 4-ft. below the surface.

DEPTH (ft)	DRILLING METHOD	MATERIAL DESCRIPTION (Unified Soil Classification System)	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	◆ DRY UNIT WT (pcf) ◆ 20 40 60 80 100; ▲ N VALUE ▲ 20 40 60 80; PL MC LL 20 40 60 80; ◻ SHEAR STRENGTH (ksf) ◻ 1 2 3 4	ELEVATION (ft)
0	HSA - 4.25" I.D.	BASE ROCK (1.1 ft)	SPT 1		12-10-15 (25)			
		FILL - CLAYEY GRAVEL with Sand, Red Brown, Medium Dense to Dense, Moist (GC) (9.0 ft)	SPT 2		18-18-22 (40)			
10		FILL - CLAYEY GRAVEL with Sand, Red, Dense, Moist (GC)	SPT 3		4-5-7 (12)			
		(17.0 ft)	ST 4	42				
20		FILL - GRAVELLY LEAN CLAY, Red Brown to Brown, Stiff, Moist (CL)	SPT 5		8-10-12 (22)			
			SPT 6		8-8-11 (19)			
30		(32.0 ft)	SPT 7		8-11-5 (16)			
		FAT CLAY with Abundant Chert Gravel and Sand, Red, Stiff to Medium Stiff, Wet (CH) ▽	ST 8	100				
40			SPT 9		4-3-5 (8)			
		(45.5 ft)	SPT 10		10-8-11 (19)			
		LIMESTONE, Weathered (46.5 ft)						
		LIMESTONE, Hard						

Refusal at 46.5 feet.
Bottom of borehole at 46.5 feet.

4168 W. Kearney St.
Springfield, Missouri 65803
Telephone: (417) 864-6000
Fax: (417) 864-6004

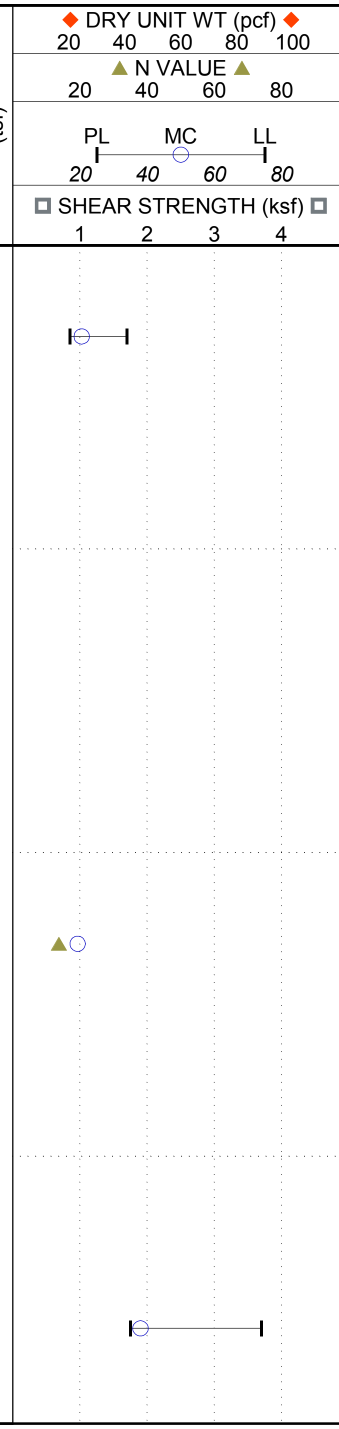
GEOTECHNICAL BORING LOG

BORING NUMBER **B-2B**

CLIENT City Utilities
PROJECT NAME JTEC CCW Impoundments - SSA
PROJECT NO. 219892
PROJECT LOCATION Springfield, Missouri
DATE STARTED 1/30/14 **COMPLETED** 1/31/14
SURFACE ELEVATION **BENCHMARK EL.**
DRILLER RD **DRILL RIG** CME 75
GROUND WATER LEVELS
HAMMER TYPE Auto
AT TIME OF DRILLING 0 ft
LOGGED BY CC **CHECKED BY** RG
AT END OF DRILLING
NOTES Piezometer installed at boring completion. 5-ft. of 2-inch PVC screen. Sand to 4-ft. below the surface.

Drilling method: HSA - 4.25" I.D.

DEPTH (ft)	MATERIAL DESCRIPTION (Unified Soil Classification System)	SAMPLE TYPE NUMBER	RECOVERY % (RQD %)	CORRECTED BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ELEVATION (ft)
0.0–5.0	LEAN CLAY with Silt, Brown, Medium Stiff, Moist, Grass Covered (CL) — 5.0 ft	ST 1	67			
5.0–8.5	FAT CLAY with Chert Gravel and Sand, Red, Stiff, Moist (CH) — 8.5 ft	SPT 2		5-8-5 (13)		
8.5–9.3	FAT CLAY, Red Brown, Medium Stiff, Moist, Weathered Limestone in Tip of Split Spoon (CH) — 9.3 ft	ST 3	100			
9.3–9.7	LIMESTONE, Weathered — 9.7 ft					



LIMESTONE, Hard
Refusal at 9.7 feet.
Bottom of borehole at 9.7 feet.

APPENDIX II

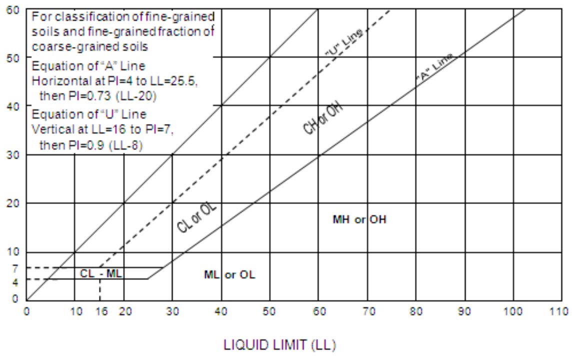
GENERAL NOTES

GENERAL NOTES

SOIL PROPERTIES & DESCRIPTIONS

COHESIVE SOILS

Consistency	Unconfined Compressive Strength (Qu)	Pocket Penetrometer Strength	N-Value
	(psf)	(tsf)	(blows/ft)
Very Soft	<500	<0.25	0-1
Soft	500-1000	0.25-0.50	2-4
Medium Stiff	1001-2000	0.50-1.00	5-8
Stiff	2001-4000	1.00-2.00	9-15
Very Stiff	4001-8000	2.00-4.00	16-30
Hard	>8000	>4.00	31-60
Very Hard			>60



Group Symbol	Group Name
CL –	Lean Clay
ML –	Silt
OL –	Organic Clay or Silt
CH –	Fat Clay
MH –	Elastic Silt
OH –	Organic Clay or Silt
PT –	Peat
CL-CH –	Lean to Fat Clay

Plasticity		Moisture	
Description	Liquid Limit (LL)	Descriptive Term	Guide
Lean	<45%	Dry	No indication of water
Lean to Fat	45-49%	Moist	Indication of water
Fat	≥50%	Wet	Visible water

Fine Grained Soil Subclassification	Percent (by weight) of Total Sample
Terms: SILT, LEAN CLAY, FAT CLAY, ELASTIC SILT	PRIMARY CONSTITUENT
Sandy,gravelly, abundant cobbles, abundant boulders	>30-50]
with sand, with gravel, with cobbles, with boulders	>15-30] – secondary coarse grained constituents
scattered sand, scattered gravel, scattered cobbles, scattered boulders	5-15]
a trace sand, a trace gravel, a few cobbles, a few boulders	<5]
The relationship of clay and silt constituents is based on plasticity and normally determined by performing index tests. Refined classifications are based on Atterberg Limits tests and the Plasticity Chart.	

NON-COHESIVE (GRANULAR) SOILS

RELATIVE DENSITY	N-VALUE
Very Loose	0-4
Loose	5-10
Medium Dense	11-24
Dense	25-50
Very Dense	≥51

MOISTURE CONDITION	
Descriptive Term	Guide
Dry	No indication of water
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table.

**GRAIN SIZE IDENTIFICATION		
Name	Size Limits	Familiar Example
Boulder	12 in. or more	Larger than basketball
Cobbles	3 in. to 12 in.	Grapefruit
Coarse Gravel	¾-in. to 3 in.	Orange or lemon
Fine Gravel	No. 4 sieve to ¾-in.	Grape or pea
Coarse Sand	No. 10 sieve to No. 4 sieve	Rock salt
Medium Sand	No. 40 sieve to No. 10 sieve	Sugar, table salt
Fine Sand*	No. 200 sieve to No. 40 sieve	Powdered sugar
Fines	Less than No. 200 sieve	
*Particles finer than fine sand cannot be discerned with the naked eye at a distance of 8 in.		

Coarse Grained Soil Subclassification	Percent (by weight) of Total Sample
Terms: GRAVEL, SAND, COBBLES, BOULDERS	PRIMARY CONSTITUENT
Sandy,gravelly, abundant cobbles, abundant boulders	>30-50]
with gravel, with sand, with cobbles, with boulders	>15-30] – secondary coarse grained constituents
scattered gravel, scattered sand, scattered cobbles, scattered boulders	5-15]
a trace gravel, a trace sand, a few cobbles, a few boulders	<5]
Silty (MH & ML)*, clayey (CL & CH)*	<15]
(with silt, with clay)*	5-15] – secondary fine grained constituents
(trace silt, trace clay)*	<5]
*Index tests and/or plasticity tests are performed to determine whether the term "silt" or "clay" is used.	

*Modified after Ref. ASTM D2487-93 & D2488-93
**Modified after Ref. Oregon DOT 1987 & FHWA 1997
***Modified after Ref. AASHTO 1988, DM 7.1 1982, and Oregon DOT 1987

PALMERTON & PARRISH, INC.

GENERAL NOTES

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION (RQD)	
Description of Rock Quality	*RQD (%)
Very Poor	< 25
Poor	25-50
Fair	50-75
Good	75-90
Excellent	90-100

*RQD is defined as the total length of sound core pieces 4 in. or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams and bedding planes.

SCALE OF RELATIVE ROCK HARDNESS

Term	Field Identification	Approx. Unconfined Compressive Strength (tsf)
Extremely Soft	Can be indented by thumbnail	2.6-10
Very Soft	Can be peeled by pocket knife	10-50
Soft	Can be peeled with difficulty by pocket knife	50-260
Medium Hard	Can be grooved 2 mm deep by firm pressure of knife	260-520
Moderately Hard	Requires one hammer blow to fracture	520-1040
Hard	Can be scratched with knife or pick only with difficulty	1040-2610
Very Hard	Cannot be scratched by knife or sharp pick	>2610

DEGREE OF WEATHERING	
Slightly Weathered	Rock generally fresh, joints stained and discoloration extends into rock up to 25mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered	Rock mass is decomposed 50% or less, significant portions of rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

GRAIN SIZE (TYPICALLY FOR SEDIMENTARY ROCKS)

Description	Diameter (mm)	Field Identification
Very Coarse Grained	>4.76	
Coarse Grained	2.0-4.76	Individual grains can easily be distinguished by eye.
Medium Grained	0.42-2.0	Individual grains can be distinguished by eye.
Fine Grained	0.074-0.42	Individual grains can be distinguished by eye with difficulty.
Very Fine Grained	<0.074	Individual grains cannot be distinguished by unaided eye.

VOIDS	
Pit	Voids barely seen with naked eye to 6mm (¼-in)
Vug	Voids 6 to 50mm (¼ to 2 in) in diameter
Cavity	50 to 6000mm (2 to 24 in) in diameter
Cave	>600mm

BEDDING THICKNESS	
Very Thick Bedded	> 3' thick
Thick Bedded	1' to 3' thick
Medium Bedded	4" to 1' thick
Thin Bedded	1¼" to 4" thick
Very Thin Bedded	½" to 1¼" thick
Thickly Laminated	⅛" to ½" thick
Thinly Laminated	⅛" or less (paper thin)

DRILLING NOTES

Drilling and Sampling Symbols

NQ – Rock Core (2-in. diameter)
HQ – Rock Core (3 in. diameter)
HSA – Hollow Stem Auger
CFA – Continuous Flight (Solid Stem) Auger
SS – Split Spoon Sampler
ST – Shelby Tube
WB – Wash Bore or Mud Rotary
TP – Test-Pit
HA – Hand Auger

Soil Sample Types

Shelby Tube Samples: Relatively undisturbed soil samples were obtained from the borings using thin wall (Shelby) tube samplers pushed hydraulically into the soil in advance of drilling. This sampling, which is considered to be undisturbed, was performed in accordance with the requirements of ASTM D 1587. This type of sample is considered best for the testing of "in-situ" soil properties such as natural density and strength characteristics. The use of this sampling method is basically restricted to soil containing little to no chert fragments and to softer shale deposits.

Split Spoon Samples: The Standard Penetration Test is conducted in conjunction with the split-barrel sampling procedure. The "N" value corresponds to the number of blows required to drive the last 1 foot of an 18-in. long, 2-in. O.D. split-barrel sampler with a 140 lb. hammer falling a distance of 30 in. The Standard Penetration Test is carried out according to ASTM D-1586.

Water Level Measurements

Water levels indicated on the boring logs are levels measured in the borings at the times indicated. In permeable materials, the indicated levels may reflect the location of groundwater. In low permeability soils, shallow groundwater may indicate a perched condition. Caution is merited when interpreting short-term water level readings from open bore holes. Accurate water levels are best determined from piezometers.

Automatic Hammer

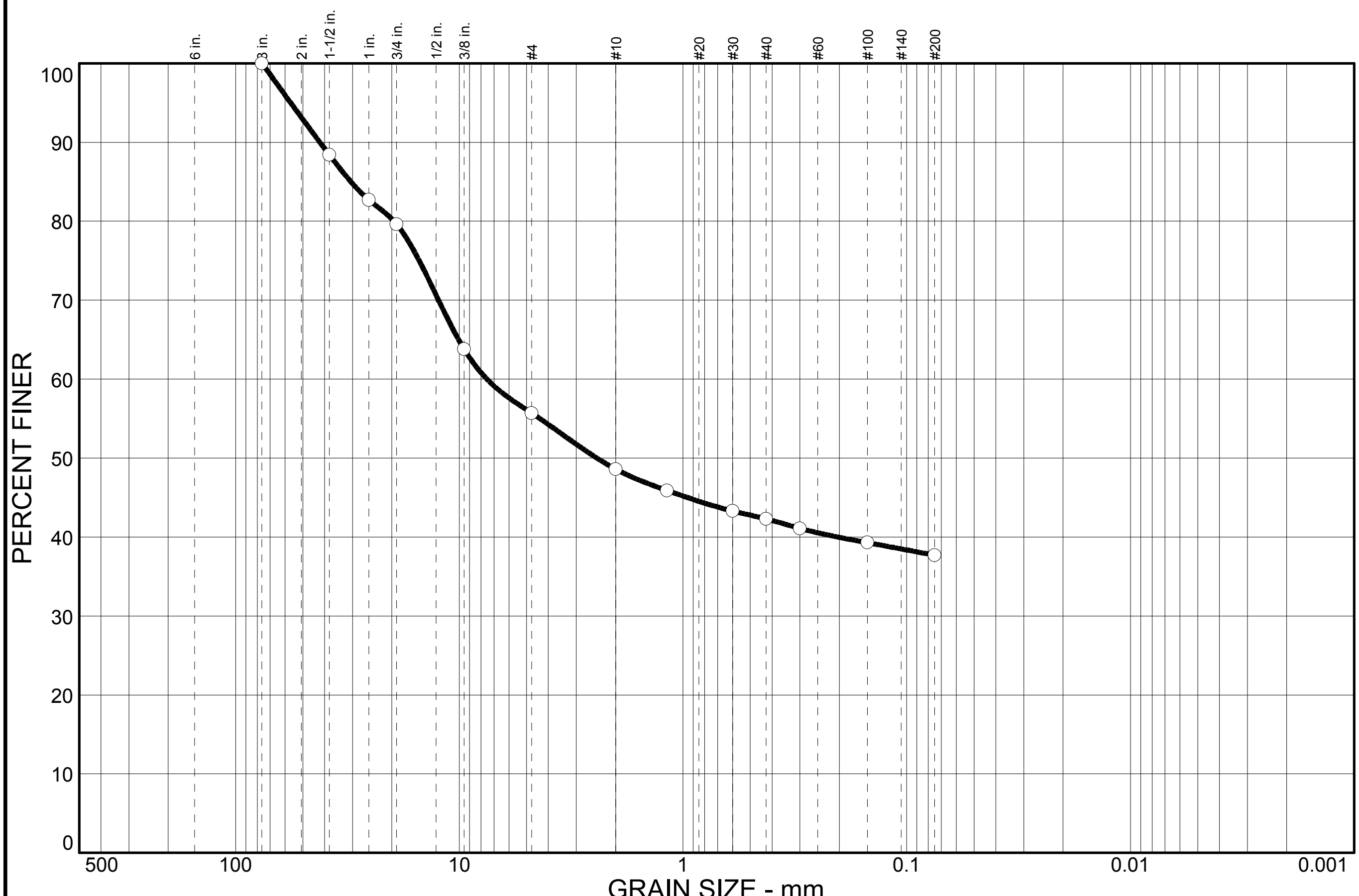
Palmerton and Parrish's CME's are equipped with automatic hammers. The conventional method used to obtain disturbed soil samples used a safety hammer operated by company personnel with a cat head and rope. However, use of an automatic hammer allows a greater mechanical efficiency to be achieved in the field while performing a Standard Penetration resistance test based upon automatic hammer efficiencies calibrated using dynamic testing techniques.

*Modified after Ref. ASTM D2487-93 & D2488-93
**Modified after Ref. Oregon DOT 1987 & FHWA 1997
***Modified after Ref. AASHTO 1988, DM 7.1 1982, and Oregon DOT 1987

APPENDIX III

LABORATORY TEST RESULTS

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	20.4	23.9	7.1	6.3	4.6	37.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3 in.	100.0		
1-1/2 in.	88.4		
1 in.	82.7		
3/4 in.	79.6		
3/8 in.	63.8		
#4	55.7		
#10	48.6		
#16	45.9		
#30	43.3		
#40	42.3		
#50	41.1		
#100	39.3		
#200	37.7		

* (no specification provided)

Material Description

Clayey gravel with sand

Atterberg Limits

PL= 17 LL= 38 PI= 21

Coefficients

D_{85}= 30.5 D_{60}= 7.53 D_{50}= 2.43
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

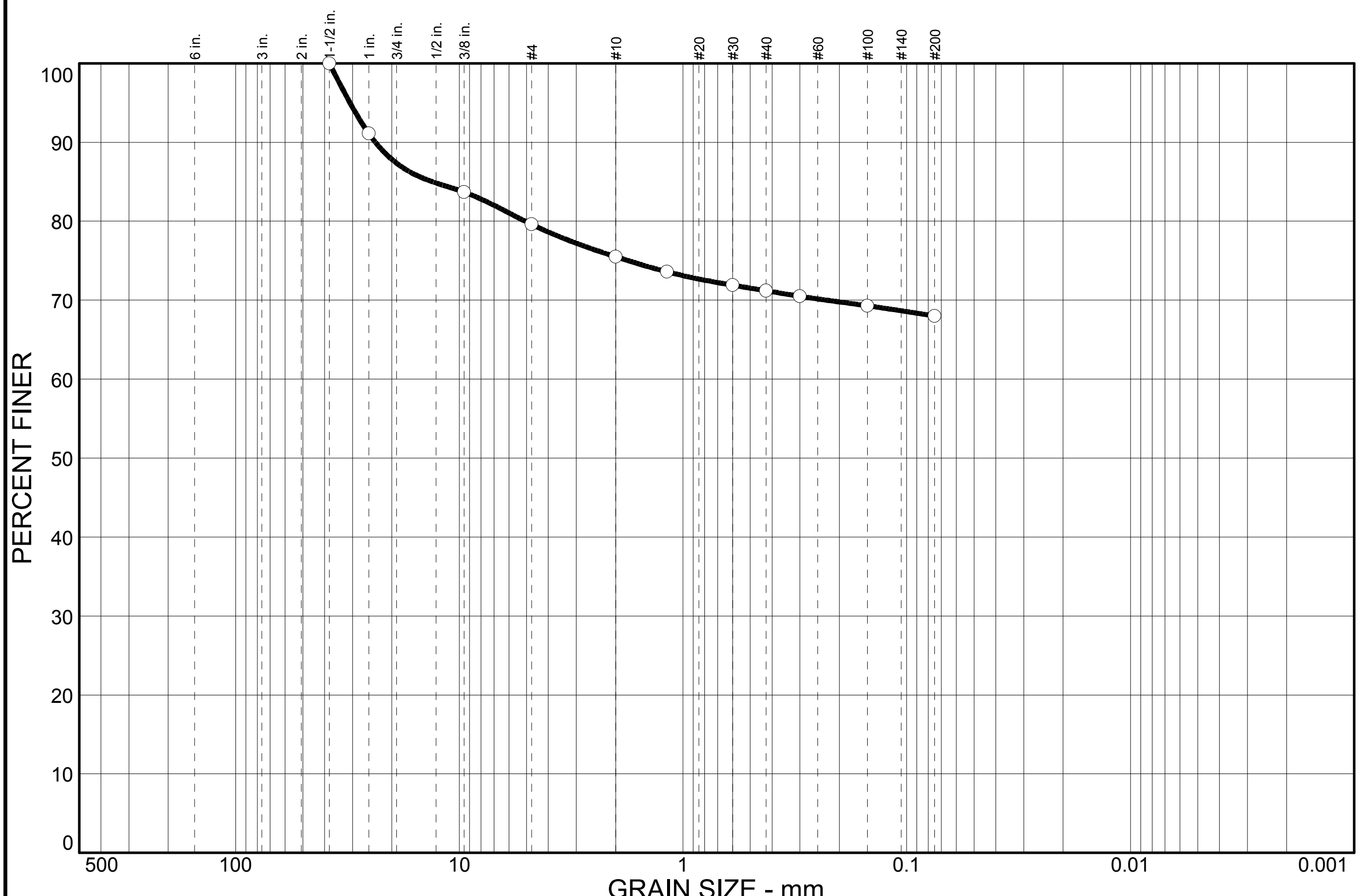
Sample No.: **Source of Sample:** **Date:** 2/19/2014
Location: B-2A **Elev./Depth:** 14'-15'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: City Utilities of Springfield
Project: JTEC CCW Impoundments-SSA

Project No: 219892 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	12.7	7.7	4.1	4.3	3.2	68.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2 in.	100.0		
1 in.	91.1		
3/8 in.	83.7		
#4	79.6		
#10	75.5		
#16	73.6		
#30	71.9		
#40	71.2		
#50	70.5		
#100	69.3		
#200	68.0		

* (no specification provided)

Material Description

Gravelly lean clay

Atterberg Limits

PL= 17 LL= 38 PI= 21

Coefficients

D_{85}= 13.2 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO=

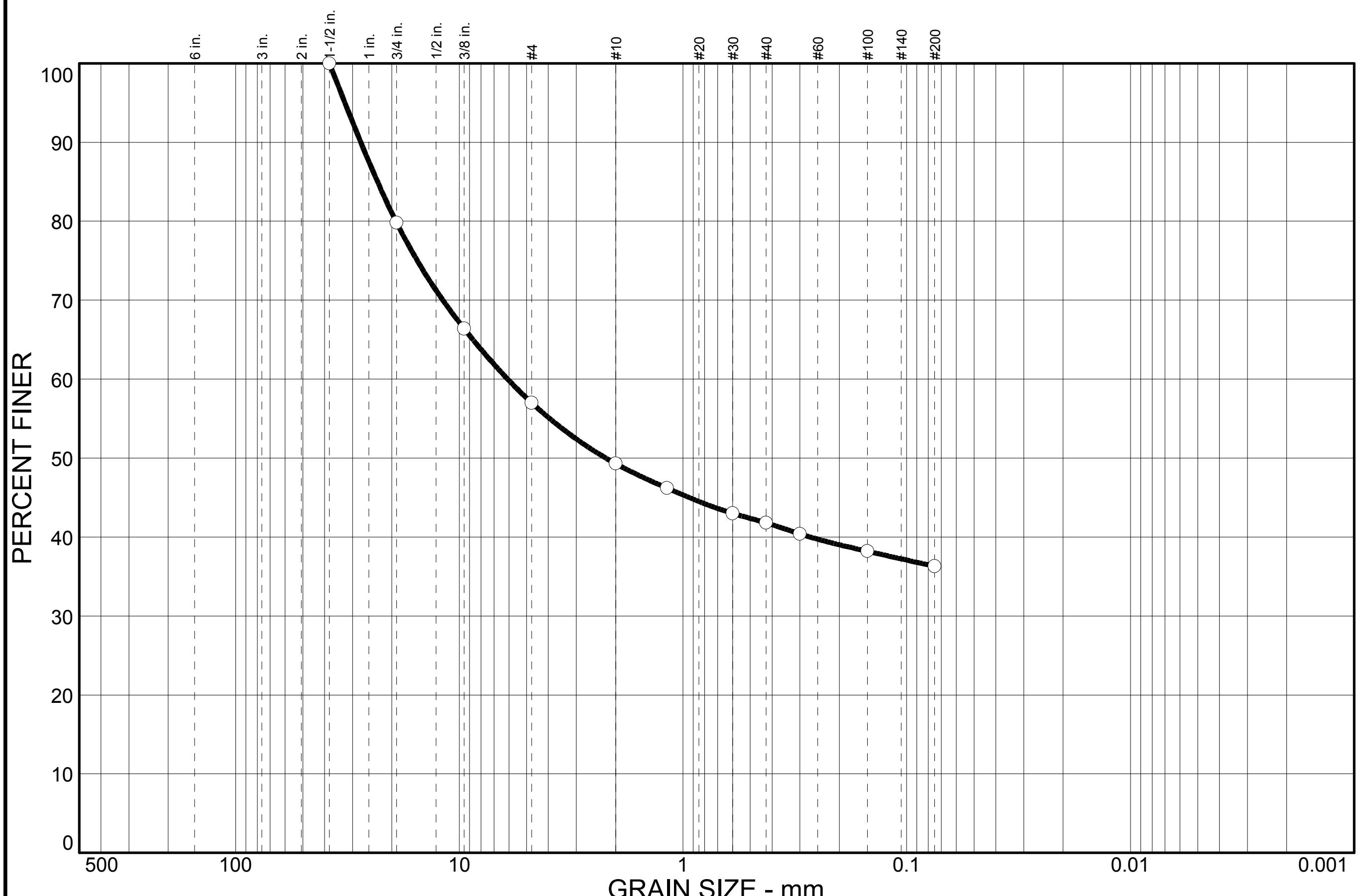
Remarks

Sample No.: **Source of Sample:** **Date:** 2/19/2014
Location: B-2A **Elev./Depth:** 19.5'-21.5'

PALMERTON & PARRISH, INC. Springfield, MO

Client: City Utilities of Springfield
Project: JTEC CCW Impoundments-SSA
Project No: 219892 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	20.2	22.8	7.7	7.5	5.5	36.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2 in.	100.0		
3/4 in.	79.8		
3/8 in.	66.4		
#4	57.0		
#10	49.3		
#16	46.2		
#30	43.0		
#40	41.8		
#50	40.4		
#100	38.2		
#200	36.3		

* (no specification provided)

Material Description

Clayey gravel with sand

Atterberg Limits

PL= 17 LL= 38 PI= 21

Coefficients

D_{85}= 23.2 D_{60}= 6.08 D_{50}= 2.21
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

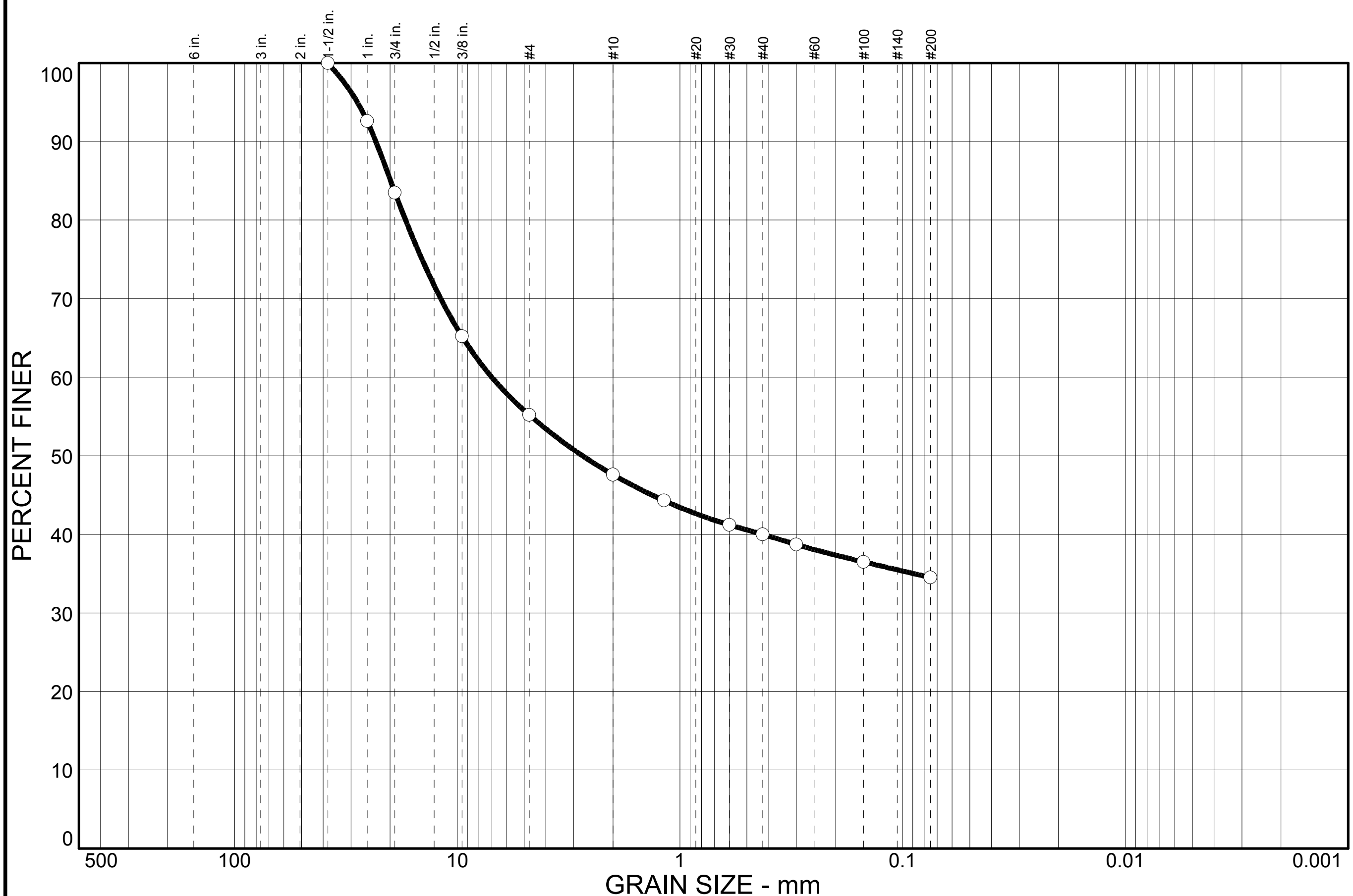
Sample No.: **Source of Sample:** **Date:** 2/19/2014
Location: B-2A **Elev./Depth:** 4'-5.5'

PALMERTON & PARRISH, INC. Springfield, MO

Client: City Utilities of Springfield
Project: JTEC CCW Impoundments-SSA

Project No: 219892 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	16.5	28.3	7.6	7.6	5.5	34.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1-1/2 in.	100.0		
1 in.	92.6		
3/4 in.	83.5		
3/8 in.	65.2		
#4	55.2		
#10	47.6		
#16	44.3		
#30	41.2		
#40	40.0		
#50	38.7		
#100	36.5		
#200	34.5		

* (no specification provided)

Material Description

Clayey gravel with sand

Atterberg Limits

PL= 17 LL= 38 PI= 21

Coefficients

D_{85}= 19.9 D_{60}= 7.00 D_{50}= 2.74
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

Sample No.: **Source of Sample:** **Date:** 2/19/2014
Location: B-1A **Elev./Depth:** 5'-6.5'

PALMERTON & PARRISH, INC.
Springfield, MO

Client: City Utilities of Springfield
Project: JTEC CCW Impoundments-SSA
Project No: 219892 **Figure**

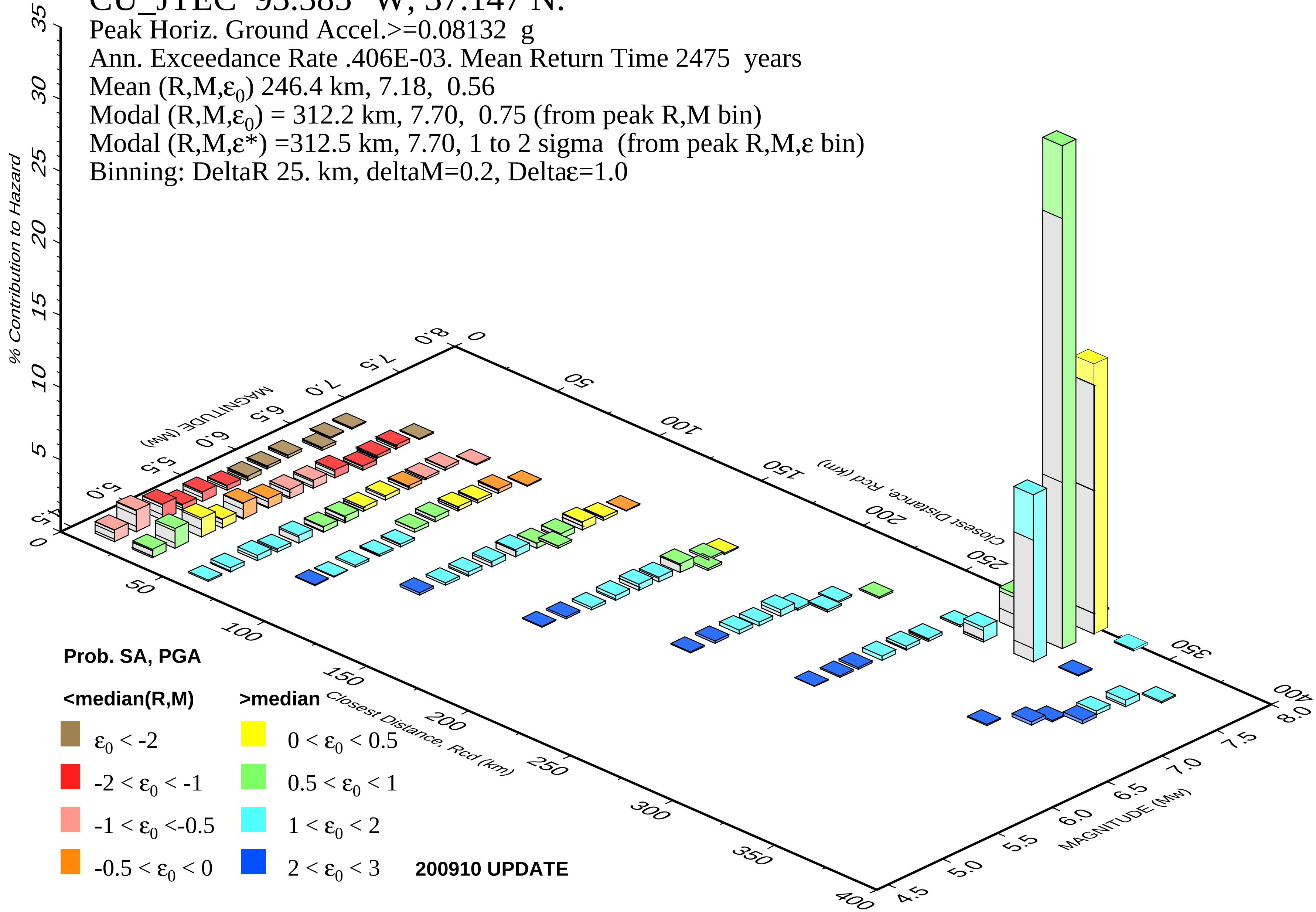
APPENDIX IV

EARTHQUAKE PSHA OUTPUT

PSH Deaggregation on NEHRP BC rock

CU_JTEC 93.385° W, 37.147 N.

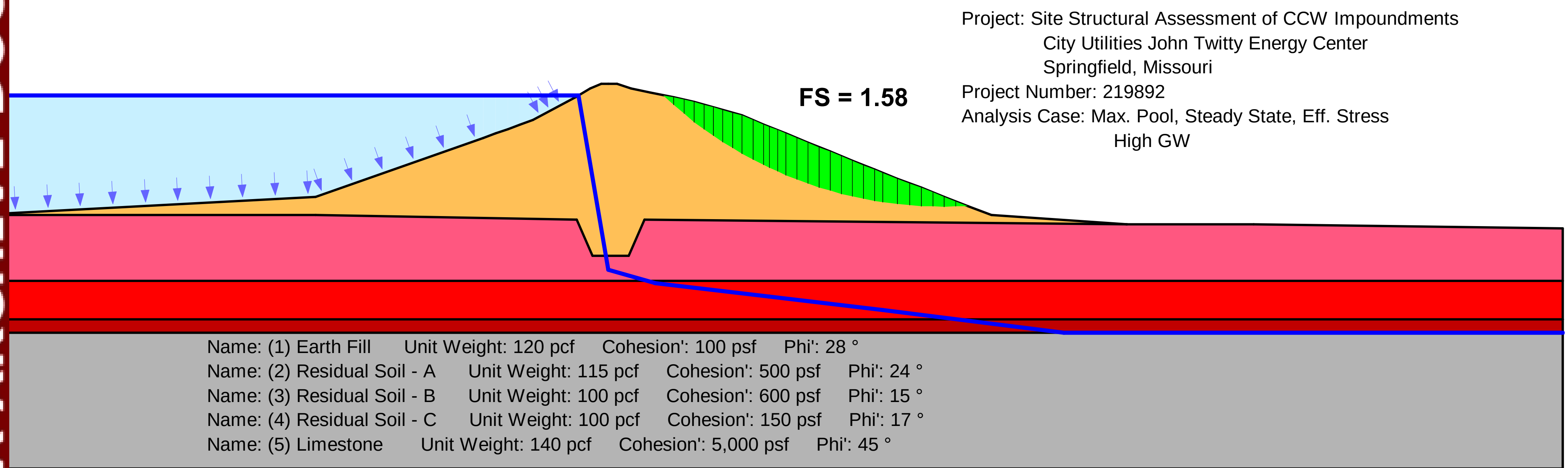
Peak Horiz. Ground Accel.>=0.08132 g
Ann. Exceedance Rate .406E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 246.4 km, 7.18, 0.56
Modal (R,M,ε_0) = 312.2 km, 7.70, 0.75 (from peak R,M bin)
Modal (R,M,ε*) =312.5 km, 7.70, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0

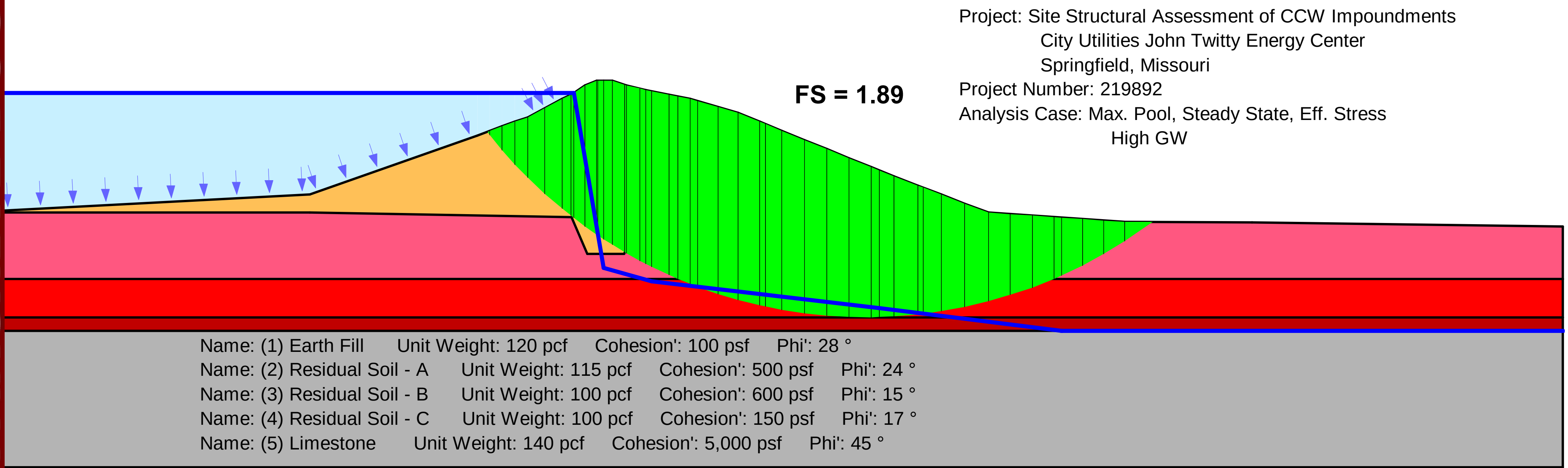


GMT 2014 Feb 24 20:47:35 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

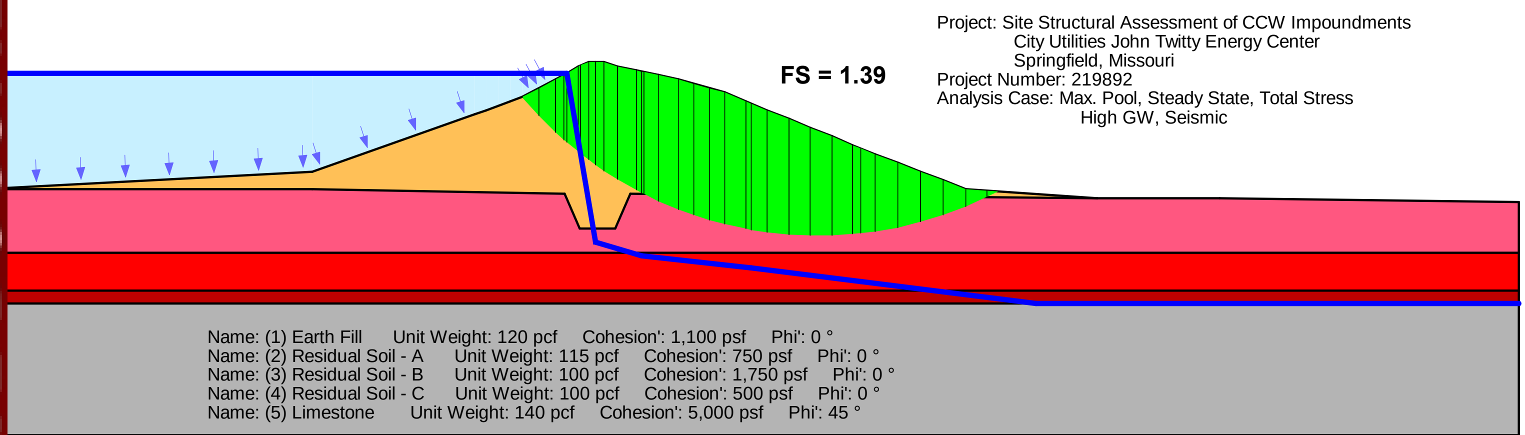
APPENDIX V

SLOPE STABILITY ANALYSIS RESULTS


Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
High GW
FS = 1.58
Name: (1) Earth Fill Unit Weight: 120 pcf Cohesion': 100 psf Phi': 28 °
Name: (2) Residual Soil - A Unit Weight: 115 pcf Cohesion': 500 psf Phi': 24 °
Name: (3) Residual Soil - B Unit Weight: 100 pcf Cohesion': 600 psf Phi': 15 °
Name: (4) Residual Soil - C Unit Weight: 100 pcf Cohesion': 150 psf Phi': 17 °
Name: (5) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °



FS = 1.89
Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Eff. Stress
High GW
Name: (1) Earth Fill Unit Weight: 120 pcf Cohesion': 100 psf Phi': 28 °
Name: (2) Residual Soil - A Unit Weight: 115 pcf Cohesion': 500 psf Phi': 24 °
Name: (3) Residual Soil - B Unit Weight: 100 pcf Cohesion': 600 psf Phi': 15 °
Name: (4) Residual Soil - C Unit Weight: 100 pcf Cohesion': 150 psf Phi': 17 °
Name: (5) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °

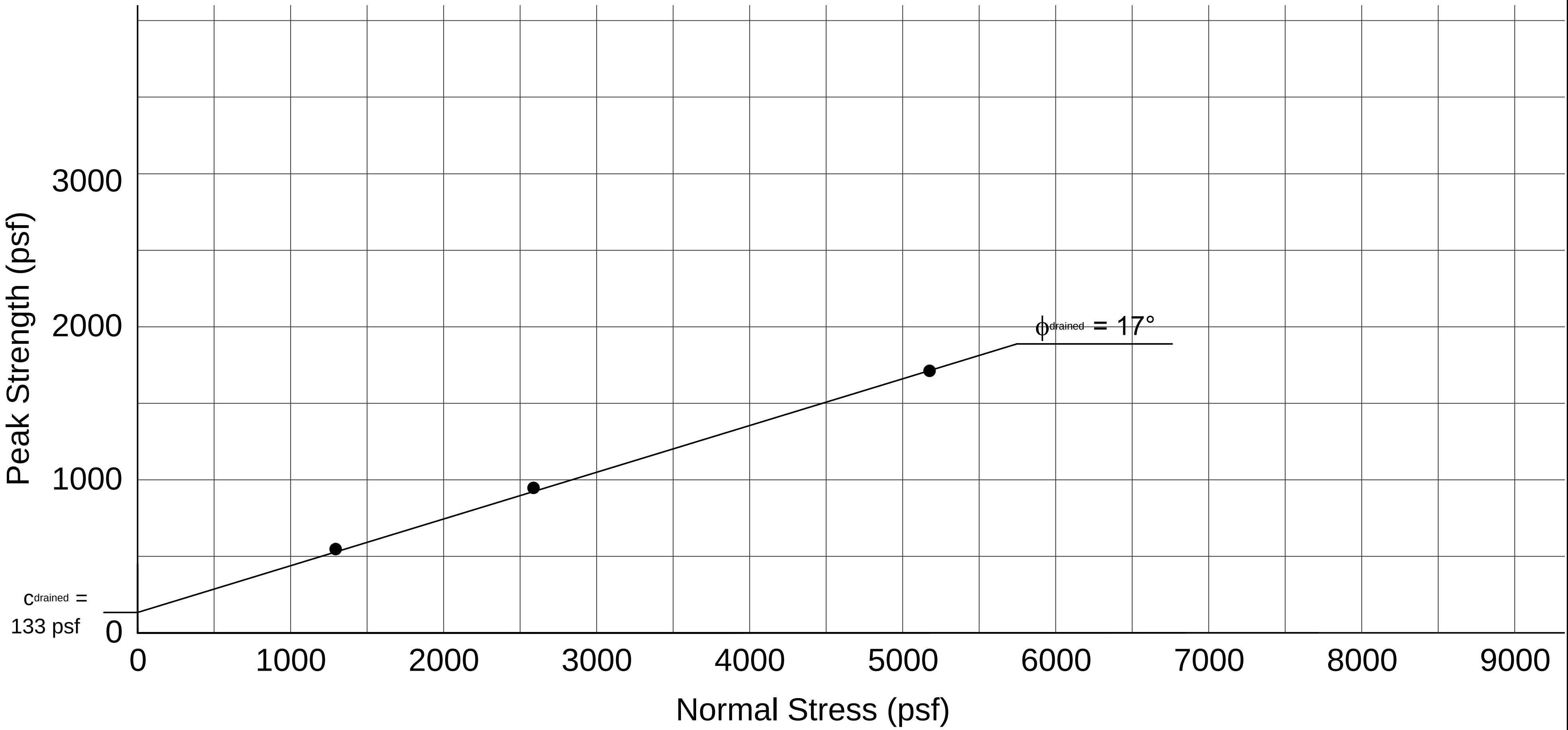


FS = 1.39
Project: Site Structural Assessment of CCW Impoundments
City Utilities John Twitty Energy Center
Springfield, Missouri
Project Number: 219892
Analysis Case: Max. Pool, Steady State, Total Stress
High GW, Seismic
Name: (1) Earth Fill Unit Weight: 120 pcf Cohesion': 1,100 psf Phi': 0 °
Name: (2) Residual Soil - A Unit Weight: 115 pcf Cohesion': 750 psf Phi': 0 °
Name: (3) Residual Soil - B Unit Weight: 100 pcf Cohesion': 1,750 psf Phi': 0 °
Name: (4) Residual Soil - C Unit Weight: 100 pcf Cohesion': 500 psf Phi': 0 °
Name: (5) Limestone Unit Weight: 140 pcf Cohesion': 5,000 psf Phi': 45 °

APPENDIX VI

DIRECT SHEAR RESULTS

Results:
C = 133 psf
ϕ = 17°



Sample: CU B-1A, ST 39'-40.17'
Sample Description: Fat Clay (CH)

Avg. Initial Specimen Data
γ_d = 51.6 pcf
w = 95.4%
LL = 85, PL= 37, PI = 48

Project: JTEC Site Slope Stability - Springfield, Missouri
Client: City Utilities of Springfield

Drained Direct Shear Test

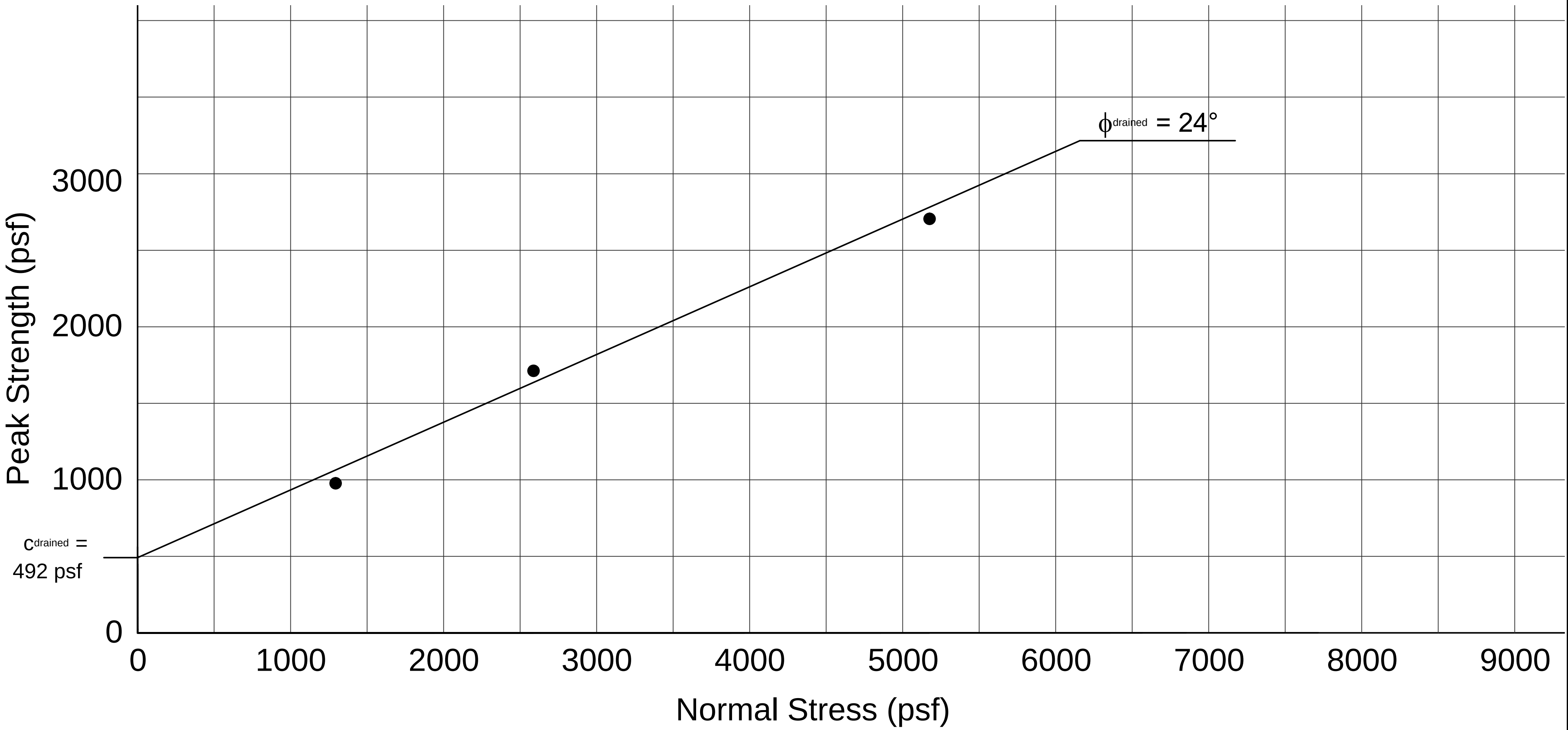
DATE: February 24, 2014
Project Number: 219892

PALMERTON & PARRISH, INC.
GEOTECHNICAL, AND MATERIALS ENGINEERS / MATERIALS TESTING LABORATORIES / ENVIRONMENTAL SERVICES

CU B-1A

S:_MASTER PROJECT FILE\C\City Utilities of Spfld-219892-JTEC Site Structural Assessment-CCW Imp.-Sub\Direct Shear\B-1A 39-40.17\CU B-1A 39-40.17.dwg

Results:
C = 492 psf
ϕ = 24°



Sample: CU B-1B, ST 5'-6.33'
Sample Description: Fat Clay (CH)

Avg. Initial Specimen Data

γ_d = 74.3 pcf
w = 49.1%

LL = 86, PL= 30, PI = 56

Project: JTEC Site Slope Stability - Springfield, Missouri
Client: City Utilities of Springfield

Drained Direct Shear Test

DATE: February 24, 2014

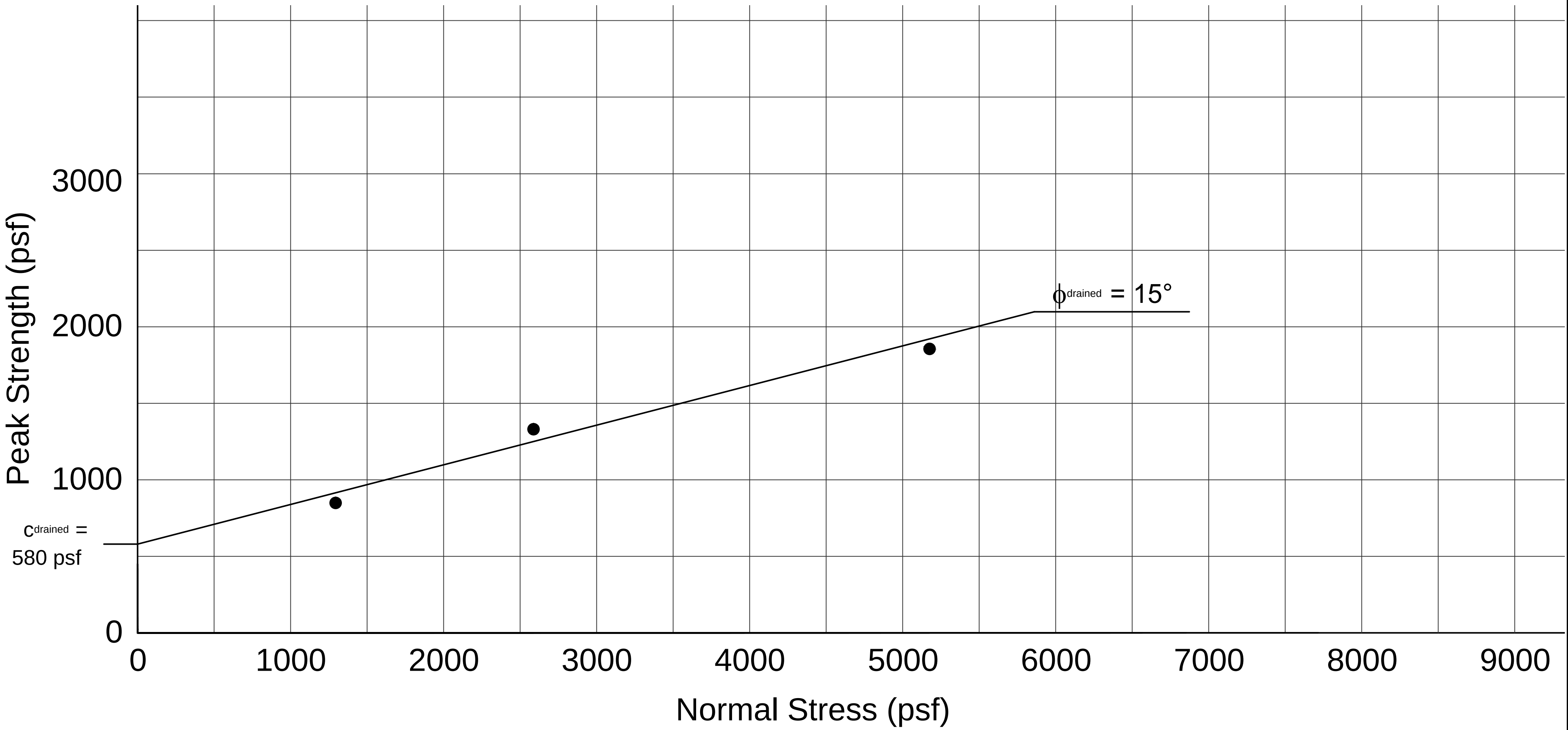
Project Number: 219892

PALMERTON & PARRISH, INC.
GEOTECHNICAL, AND MATERIALS ENGINEERS / MATERIALS TESTING LABORATORIES / ENVIRONMENTAL SERVICES

CU B-1B

S:_MASTER PROJECT FILE\C\City Utilities of Spfld-219892-JTEC Site Structural Assessment-CCW Imp.-Sub\Direct Shear\B1B 5-6.33\CU B-1B 5-6.33.dwg

Results:
C = 580 psf
ϕ = 15°



Sample: CU B-1B, ST 18.5'-20.08'
Sample Description: Fat Clay (CH)

Avg. Initial Specimen Data
γ_d = 60.3 pcf
w = 67.2%

Project: JTEC Site Slope Stability - Springfield, Missouri
Client: City Utilities of Springfield

Drained Direct Shear Test

DATE: February 24, 2014

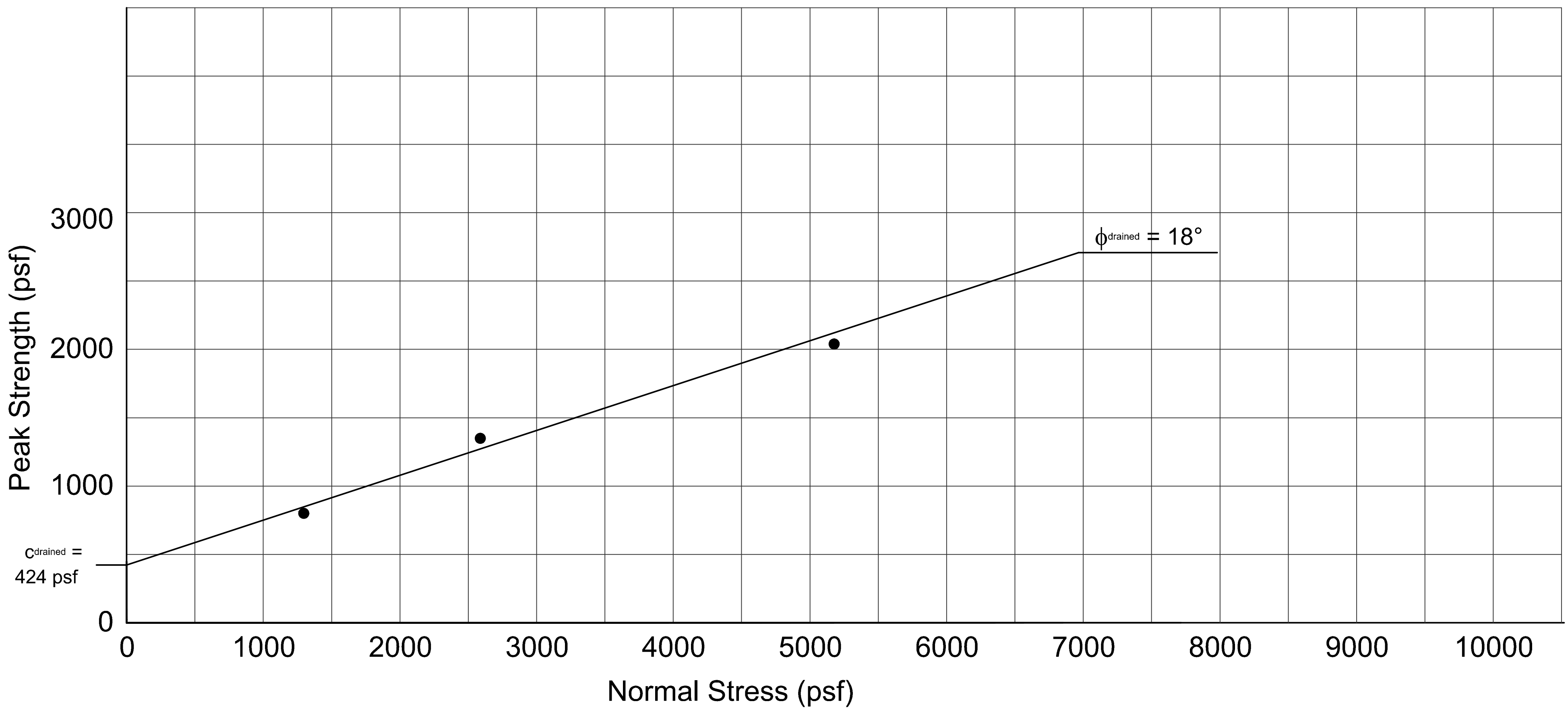
Project Number: 219892

PALMERTON & PARRISH, INC.
GEOTECHNICAL, AND MATERIALS ENGINEERS / MATERIALS TESTING LABORATORIES / ENVIRONMENTAL SERVICES

CU B-1B

S:_MASTER PROJECT FILE\C\City Utilities of Spfld-219892-JTEC Site Structural Assessment-CCW Imp.-Sub\Direct Shear\B-1B 18.5-20.08\CU B-1B 18.5-20.08.dwg

Results:
C = 424 psf
ϕ = 18°



Sample: CU B-1B, ST 24'-24.7'
Sample Description: Fat Clay (CH)

Avg. Initial Specimen Data
γ_d = 67.1 pcf
w = 57.7%
LL = 87, PL= 32, PI = 55

Project: JTEC Site Slope Stability - Springfield, Missouri
Client: City Utilities of Springfield

Drained Direct Shear Test

DATE: February 24, 2014
Project Number: 219892

PALMERTON & PARRISH, INC.
GEOTECHNICAL, AND MATERIALS ENGINEERS / MATERIALS TESTING LABORATORIES / ENVIRONMENTAL SERVICES

CU B-1B

S:_MASTER PROJECT FILE\C\City Utilities of Spfld-219892-JTEC Site Structural Assessment-CCW Imp.-Sub\Direct Shear\B-1B24\CU B-1B 24.dwg

Southwest Power Station

CITY UTILITIES of SPRINGFIELD

301 E. Central • P.O. Box 551 • Springfield, Missouri 65801 • (417) 831-8311

May 20, 1985

MAY 22 1985

John R. Nixon, P.E.
Regional Administrator
Missouri Department of Natural Resources
1155 East Cherokee
Springfield, Missouri 65807

Dear Mr. Nixon:

Reference: Your Wastewater Inspection Report for Southwest Power Station, April 30, 1985

This is to acknowledge receipt of the referenced report and to express our general concurrence with the observations and comments contained therein. We note that the results of sample analysis were not included with this report. City Utilities may wish to review and comment upon these results as they become available.

Page 2 of your report requests that we notify your office regarding our plans concerning the ash pond overflow lines which were noted to be discharging at the time of the inspection. Accordingly, this will serve to advise you that City Utilities has opted for a solution which will entail relocating the overflow pipes and tying them directly into the existing 002 effluent line. We feel that this remedy offers distinct advantages over the overflow management and outfall licensing options suggested by your office. To wit:

1. Retention of the overflow lines provides continued protection of the pond embankment in the event of a severe water balance upset. Embankment and roadway protection are essential to maintain the serviceability of the pond, the discharge structure, and the effluent treatment system.

2. A tie-in with the existing outfall avoids the operational and administrative inefficiencies of permitting, monitoring, reporting, and inspecting separate discharges. This advantage accrues both to CU and to MDNR.

3. Water quality interests are better served inasmuch as the overflow will be measured, sampled, and treated if necessary, as an integral component of the total ash pond discharge in accordance with existing permit requirements.

City Utilities will advise you of the progress and completion of this alteration by way of our regular quarterly discharge monitoring reports. In the interim, please do not hesitate to contact me or my staff if you desire further information in this matter.

Yours very truly,

Robert E. Roundtree
General Manager

DMF/RER:nd

cc: C. E. Stiefermann, P.E.
Arlie K. Roesener
Dave Plank, P.E.

MISSOURI DEPARTMENT OF NATURAL RESOURCES
P.O. Box 176 Jefferson City, Missouri 65102 (314) 751-3443

1.300 Springfield
Southwest Power Plant

April 30, 1985

Mr. Robert E. Roundtree, General Manager
City Utilities
P.O. Box 551
Springfield, MO 65801

Dear Mr. Roundtree:

Please find enclosed a copy of the report on inspection of wastewater treatment facilities serving the Southwest Power Station in Springfield, Greene County, Missouri, which I believe is self-explanatory.

If you have any questions, please advise.

Yours truly,

John R. Nixon, P.E.
Administrator
Springfield Regional Office
Department of Natural Resources

JRN/TM/cg

Enclosure

cc Mr. David Plank, P.E.
Mr. David M. Fraley, Ph.D.
Water Pollution Control Program

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Report on Inspection of Wastewater Treatment Facilities Serving the Southwest Power Station Springfield, Missouri

April 30, 1985

INTRODUCTION:

On April 11, 1985, representatives of the Missouri Department of Natural Resources conducted an inspection of the wastewater treatment facilities serving the Southwest Power Station. The facilities are operated under NPDES Permit MO-0089940. The permit lists four outfalls. Unsatisfactory features of the operation of or management of the facilities are noted below.

UNSATISFACTORY FEATURES:

1. The west ash pond was bypassing from a high water overflow pipe (outfall 002).

COMMENTS:

1. A construction permit has been issued to correct leakage problems in the lagoon receiving runoff from the coal storage area (outfall 001).

2. This inspection was conducted concurrent with compliance monitoring sampling conducted by the Laboratory Services Program. The results of sample analysis will be forwarded when available.

3. There was no discharge during the inspection from outfalls 001, 003, and 004.

RECOMMENDATIONS:

1. City Utilities should either request that the NPDES permit be modified to include the ash pond overflow lines as outfalls in the permit or change management practices and/or maintenance schedules to assure that bypasses do not occur. We request that City Utilities notify this office within 30 days of the date of this report of the decision in this matter. If City Utilities opts to change management practices instead of adding outfalls to the permit we request that a short description of the changes to be made and a explanation of how and why the changes will preclude future bypasses be submitted to this office within the above 30 day time frame.

SUBMITTED BY:

Tracy McCracken
Tracy McCracken
Environmental Specialist

APPROVED BY:

John R. Nixon, P.E.
Administrator

File 1300 Springfield Southwest Power Plant

NPDES MO- MO0089940

Purpose: Compliance/O & M ✓

Enforcement ___

SUMMARY INSPECTION REPORT FOR OPERATING
WASTEWATER TREATMENT FACILITIES

Section A: General Information
(Retain in facility file for use as cover for inspection-gathered data.)

Facility Name	Owner/Phone	POTW	Type of Facility
Southwest Power Station	City Utilities	YES___ NO ✓	Lagoon + other
Location/County/Address SW¼ SW¼ Sec 7 T28N R22W	**Project Number**	**Design Avg. Flow**	**Design P.E.**
Collection System Combined___ Separate___ Both___	**Certified Operator Classification Required** A___ B___ C___ D___ None ✓		**River Reach Number** 11010002-17-01

Identify Receiving Waters - Stream Standards and/or Uses

Tributary of Wilsons Creek

Effluent Standards and/or Requirements of NPDES Permit

001 NFR 50 Daily Max; pH

002 NFR 30 mo X̄; O+G 10 " "; T 35° Max; FAC 1.2 mo X̄

003 NFR 50 Max; PH

004 NFR 50 Max; PH

Plant Flow Diagram or Written Description of Plant Units in Flow Sequence
(Attach additional sheets as necessary)

4 outfalls see file

Mayor	Director of Public Works/Phone
City Clerk	**Plant Superintendent or Operator/Phone/Certificate Grade** Ken Craig

Checklists that must be completed for each facility:

___Unit Processes ___Stream Survey Land Application ___ Sludge ___ WW Safety Items ___

If facility is a POTW, include checklists for:

___Pretreatment Program ___Industrial Survey ___ Pump Station

File______________________

____

NPDES MO-______________________

Facility Name SW. Power Station

Discharge Sampled at Inspection

Yes ✓ Sample Number (s)______

NO ____ Compliance Monitoring

If NO, explain______________________

Section B: Inspection Information - General

Date of Inspection Year 85 Month 04 Day 11	Inspected by/Title: Tracy McCracken ES
Persons Contacted Dave Fraley	Permit Status/Comment Valid ✓ Expired ____ No Permit ____
DMR Results Compliance ____ Noncompliance ____ Timely Submissions ____ Missing Report(s) ____	Laboratory/Name if Contracted ____ On-Site ✓ Contract ____ Both ____ BOD + NFR analysis at other city own facilities

Observed Appearance of Effluent 002 clear, relatively clean
ND fm other outfalls

Observed Appearance of Receiving Stream:

Above Point of Discharge: No flow

Below Point of Discharge: OK

General Appearance and Operation of the Facility ______________________

Comments: bypassing from West pond
C.R. issued to correct leaking lagoon at 001

Section C: Laboratory Evaluation - On-Site Only

Three Years of original bench data for DMR's available? YES ____ NO ____	Date balance was last checked against Class S weights Year____ Month____ Day____	General Comments

Quality Control - List the dates from the original records below

Parameter	Duplicate	Control	Audit	Reference Analytical Procedure
pH				
NFR				
BOD_5				Inhibited? YES ____ NO ____
DO				
Sample Collection & Preparation	Sat. ____	Unsat. ____		Comments:
Others (list)				

Section D: Plant Staffing Data

Number of Full time wastewater Employees ____	Part time employees ____
Number of hours devoted to wastewater operations (weekly) 5 hrs	
Number of certified operators ____	Number by each level ____

List any Industrial Contributors:

Section E. Visual Observations - Unit Process

Rate each unit inspected by completing the appropriate checklists as per Inspection and Enforcement Manual procedures. If a section is not applicable, cross it out and so note.

S = Satisfactory; U = Unsatisfactory; M = Marginal; IN = In Operation; Out = Out of operation

	Unit Inspected (checklist)	Rating	Comments
General	Grounds	N/A	
	Buildings		
	Potable Water Supply Protection		
	Safety Features		
	Bypasses (Explain)		
	Stormwater Overflow		
	Safety Equipment		
	Emergency Operation (Describe)		
Preliminary	Maintenance of Collection System		
	Pump Station		
	Ventilation		
	Bar Screen		
	Disposal of Screenings		
	Comminutor		
	Grit Chamber		
	Disposal of Grit		
	Holding Basins		
	Alternate Power Source		
Primary	Settling Tanks		
	Scum removal		
	Sludge Removal		
	Effluent		
Sludge Disposal	Digesters		
	Temperature and pH		
	Gas Production		
	Heating Equipment		
	Sludge Pumps		
	Drying Beds		
	Vacuum Filter		
	Incineration		
	Disposal of Sludge (Describe)		
Other	Flow measurement		
	Records and Reports		
	Lab Controls		
	Warning Systems		
	Lab. Facilities and Procedures		
	Maintenance Program		
Secondary -Tertiary	(list items as required)		

Section E (continued)

		Rating	Comments
Chlorine	Effluent		
	Chlorinators		
	Effective Dosage		
	Contact Time		
	Contact Tank		
	Storage and Handling		

Section F: Wastewater Lagoon Information

#002

Number of Cells 2

Operated In Series Yes ____ No ✓

Rate Each Item by Completing the appropriate checklists as per the Inspection and Enforcement Manual procedures (S, U, M, IN, OUT)

	Item (checklist)	Rating	Comments
Lagoon	Control of Vegetation	S	
	Control of Algae Growth	S	
	Control of Erosion	S	
	Control of Floating Mats	S	
	Control of Insects	S	
	Control of Burrowing Animals	S	
	Fence and Gate	S	
	Posted	S	
	Access Road	S	
	Structure - Inlet	S	
	- Outlet	S	
	Berm Structure	S	
	Berm Ground Cover	S	
	Surface Drainage	S	
	Operating Depth	S	
	Equipment Maintenance	S	
	Odors	S	
	Other (Describe)		
Additional Items	Submerged Sand Filters		
	Chlorination Facilities		
	Flow Measurement		
	Other (Describe)		
	Other (Describe)		

Key to Materials Submitted to EPA/CDM – January 24, 2014

Documentation requested in EPA/City Utilities conference call of 1/9/2014.

Request	Documentation Requested	Document/Reference
1	Copies of records of inspection	**1-1:** Sample inspection logs for period of time prior to and around orignal CDM site visit
2	Hydraulics/hydrology calculations	**2-1:** Pond contour survey by Anderson Engineering; 1/17/14 **2-2:** Calculations by Ted Salveter (CU)
3	Indication of reference storm event	* Included in Salveter/Wehrly/ Palmerton & Parrish calculations
4	Emergency action plan	**4-1:** Greene County Emergency Operations plan; references to flood preparedness, warnings, etc. highlighted (Available; 20MB file)
5	Additional information on piezometers	**5-1:** Map showing piezometer locations in relation to west/east ash ponds **5-2:** Typical piezometer construction log
6	Stability analysis (static, seismic, liquefaction)	**6-1:** Palmerton & Parrish initial opinion and scope letter
7	Clarification on MDNR requirement to replace spillway with overflow outlets	**7-1:** Write-up on modification effort with references to drawings and hydraulic calculations **7:2:** M.R. Wehrly calculations related to ash pond overflow modifications, 1986 **7-3:** 1986 overflow modification detail dwgs

From: Dave Fraley
To: Englander, Jana; Kelly, PatrickM
Cc: Mark Haden
Subject: Requested documentation - I
Date: Friday, January 24, 2014 12:36:42 PM
Attachments: Key to Materials Submitted.docx
1-1 JTEC Inspection forms.pdf
2-2 Salveter Pond storage volume calcs.pdf
2-1 pond survey & storage volume.pdf

Jana/Patrick,

Attached is the first installment of materials we discussed by telephone last week regarding the ash impoundments at John Twitty Energy Center. Since the materials total over 40 MB, I am sending submitting in two or more separate messages to avoid swamping your message system. The first document is a key or roadmap to the entire submittal.

The remaining attachments follow our conversation pretty much in the order requested, which was in line with the structure of the original report. Some of these materials are historic (e.g., related to the 1986 overflow modifications) and others were just concluded this past week. Where historic materials are less than representative of current conditions, we have attempted to explain in the accompanying narrative.

You specifically requested information on stability analysis and we have included a preliminary opinion by Palmerton & Parrish, Inc. (PPI), one of our local civil engineering firms. PPI advised us they could perform a more detailed analysis in 4-6 weeks and we released them to perform that evaluation earlier this week.

With respect to emergency action plans, we were unable to a find plant-specific plan such as we have for our regulated drinking water reservoirs. However we have downloaded the community-wide EAP for Greene County, which does detail community planning and resources for flood hazards from dam failures (generically). As indicated in the key, we can provide a copy of this 20 MB file if you think it would be of assistance to this effort.

Thanks again for your forbearance in this matter. If you have additional questions or comments, please do not hesitate to get in touch with me.

Thanks!

David M. Fraley, PhD
Director - Environmental Affairs
City Utilities of Springfield, MO
417.831.8778
