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Coal Combustion Residue Impoundment
Round 12 - Dam Assessment Report

City of Ames Power Plant

Lime and Ash Pond
City of Ames
Ames, Iowa

Prepared for:

United States Environmental Protection Agency
Office of Resource Conservation and Recovery

Prepared by:

Dewberry & Davis, LLC
Fairfax, Virginia

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INTRODUCTION, SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The release of over five million cubic yards of coal combustion residue from the Tennessee Valley Authority's Kingston, Tennessee facility in December 2008, which flooded more than 300 acres of land and damaged homes and property, is a wake-up call for diligence on coal combustion residue disposal units. A first step toward this goal is to assess the stability and functionality of the ash impoundments and other units, then quickly take any needed corrective measures.

This assessment of the stability and functionality of the City of Ames Power Plant Ash Pond and Lime Cell impoundment dikes is based on a review of available documents and on the site assessment conducted by Dewberry personnel on August 20, 2012. This is an unusual management unit configuration, because the Fly Ash Pond operated by the City of Ames Power Plant shares an impoundment with the Water Department's Lime Cell. We found the supporting technical documentation incomplete (Section 1.1.3). As detailed in Section 1.2, there are two recommendations that would help to ensure a safe and trouble-free operation.

In summary, the Ames City Power Plant Ash Pond and Lime Cell management unit is **POOR** for continued safe and reliable operation.

PURPOSE AND SCOPE

The U.S. Environmental Protection Agency (EPA) is investigating the potential for catastrophic failure of Coal Combustion Surface Impoundments (i.e., management units) from occurring at electric utilities in an effort to protect lives and property from the consequences of a dam failure or the improper release of impounded slurry. The EPA initiative is intended to identify conditions that may adversely affect the structural stability and functionality of a management unit and its appurtenant structures (if present); to note the extent of deterioration (if present) and the status of maintenance and/or a need for immediate repair; to evaluate conformity with current design and construction practices; and to determine the hazard potential classification for units not currently classified by the management unit owner or by a state or federal agency. The initiative will address management units that are classified as having a Less-than-Low, Low, Significant, or High Hazard Potential ranking (for Classification, see pp. 3-8 of the 2004 Federal Guidelines for Dam Safety).

In early 2009, the EPA sent letters to coal-fired electric utilities seeking information on the safety of surface impoundments and similar facilities that receive liquid-borne material to store or dispose of coal combustion residue. This letter was issued under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e), to assist the Agency in assessing the structural stability and functionality of such management units, including which facilities should be visited to perform a safety assessment of the berms, dikes, and dams used in the construction of these impoundments.

EPA requested that utility companies identify all management units including surface impoundments or similar diked or bermed management units or management units designated as landfills that receive liquid-borne material used for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. Utility companies provided information on the size, design, age, and the amount of material placed in the units.

The purpose of this report is **to evaluate the condition and potential of residue release from management units and to determine the hazard potential classification**. This evaluation included a site visit. Prior to conducting the site visit, a two-person team reviewed the information submitted to EPA, reviewed any relevant, publicly available information from state or federal agencies regarding the unit hazard potential classification (if any) and accepted information provided via telephone communication with the management unit owner. After the field visit, additional information was received by Dewberry & Davis LLC about the City of Ames Power Plant Lime and Ash Pond that was reviewed and used in preparation of this report.

This report presents the opinion of the assessment team as to the potential of catastrophic failure and reports on the condition of the management unit(s).

Note: The terms "embankment", "berm", "dike" and "dam" are used interchangeably within this report, as are the terms "pond", "basin", and "impoundment".

LIMITATIONS
The assessment of dam safety reported herein is based on field observations and review of readily available information provided by the owner/operator of the subject coal combustion residue management unit(s). Qualified Dewberry engineering personnel performed the field observations and review and made the assessment in conformance with the required scope of work and in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is made with regard to our assessment of dam safety.

DRAFT

Table of Contents

Page

DRAFT

1.0 CONCLUSIONS AND RECOMMENDATIONS

1.1 CONCLUSIONS

Conclusions are based on visual observations from a one-day site visit on August 20, 2012, and review of technical documentation provided by the City of Ames, IA Electrical Department.

1.1.1 Conclusions Regarding the Structural Soundness of the Management Unit(s)

The dike embankments appear to be structurally sound based on Dewberry engineers' observations during the site visit. Documentation of slope stability Factors of Safety under static and seismic conditions for the Lime and Ash Pond was not provided for review.

Based on the lack of documentation of slope stability factors of safety, the embankments are rated POOR for structural soundness.

1.1.2 Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit

Documentation of the hydrologic and hydraulic safety was not provided to Dewberry for review.

Based on the lack of documentation of hydrologic and hydraulic analyses, the management unit is rated POOR for hydrologic and hydraulic safety.

1.1.3 Conclusions Regarding the Adequacy of Supporting Technical Documentation

The supporting technical documentation is inadequate. No documentation of either hydrologic and hydraulic safety, or slope stability was provided to Dewberry for review.

1.1.4 Conclusions Regarding the Description of the Management Unit(s)

The description of the management unit provided by the owner was an accurate representation of what Dewberry observed in the field.

1.1.5 Conclusions Regarding the Field Observations

Dewberry staff was provided access to all areas in the vicinity of the management unit required to conduct a thorough field observation. The visible parts of the embankments were observed to have no signs of overstress, significant settlement, shear failure, or other signs of instability. Embankments appear structurally sound. There are no apparent indications of unsafe conditions or conditions needing remedial action.

The Fly Ash Pond does not have an outlet structure (i.e., there is no discharge to the environment). Sluice water and storm water falling into the Fly Ash Pond are directed to the Clear Water pond before being pumped back to the power plant for reuse.

1.1.6 Conclusions Regarding the Adequacy of Maintenance and Methods of Operation

The presence of trees on the exterior and interior slopes of the embankment, and erosion along sections of the interior embankments of the Fly Ash Pond indicate the maintenance program needs enhancement.

1.1.7 Conclusions Regarding the Adequacy of the Surveillance and Monitoring Program

The Lime and Ash Pond monitoring program consists of daily monitoring of the Fly Ash Pond pool elevation, and the condition of the recirculation pumps. The surveillance program appears to lack a component regarding observation of the embankments for signs of distress, or potential threats to the safety of the slope, including trees on the slope, potential seepage issues, animal burrows, etc.

1.1.8 Classification Regarding Suitability for Continued Safe and Reliable Operation

The Fly Ash Pond and Lime Cell impoundment embankments are rated POOR for continued safe and reliable operation.

1.2 RECOMMENDATIONS

1.2.1 Recommendations Regarding Structural Stability

Recommendations regarding structural stability relates to documentation and operational issues. Specifically, the utility needs to provide the Lime and Ash Pond embankment slope stability Factors of Safety for static and seismic loading conditions. Recommendations pertaining to documenting those elements are presented in the following paragraphs.

1.2.2 Recommendations Regarding the Supporting Technical Documentation

Additional documentation is recommended to:

- Provide hydrologic and hydraulic data to verify the Lime and Ash Pond can contain the one-percent probability in any given year's storm events without overtopping the embankments
- Provide engineering documentation that the Lime and Ash Pond embankment slope stability Factors of Safety for static and seismic loading conditions meet or exceed minimum requirements
- Provide documentation of construction quality control/quality assurance activities to verify that specified compaction of embankment subgrade soils and fill materials were met.

1.2.3 Recommendations Regarding Continued Safe and Reliable Operation

Recommendations for continued safe and reliable operation of the management unit include:

- Add a weekly visual inspection of the embankment for signs of distress or conditions that are adverse to the continued safe operation of the management unit. Inspections can be documented using a checklist form.
- Increase maintenance activities for the embankments, including:
  - Removal of trees on the exterior and interior slopes
  - Repair eroded area along interior slope of Fly Ash Pond

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1.3 PARTICIPANTS AND ACKNOWLEDGEMENT

1.3.1 List of Participants

Brian Trower, City of Ames, IA
Curtis Spence, City of Ames, IA
Tim McCollough, City of Ames, IA
Dave Gammon, City of Ames, IA
Lyle Hammes, City of Ames, IA
Chad Stobbe, Iowa Department of Natural Resources
Bill Gross, Iowa Department of Natural Resources
Joseph P. Klein, III, P.E, Dewberry
Michael McLaren, P.E, Dewberry

1.3.2 Acknowledgement and Signature

We acknowledge that the management unit referenced herein has been assessed on August 20, 2012.

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Joseph P. Klein, III, P.E.

____
Michael McLaren, P.E.

2.0 DESCRIPTION OF THE COAL COMBUSTION RESIDUE MANAGEMENT UNIT(S)

2.1 LOCATION AND GENERAL DESCRIPTION

The City of Ames Power Plant is located at the intersection of E. 5th Street and Carroll Ave. in Ames, Iowa. The coordinates of the plant site are 42.0259° N and 93.6091° W. The site is about 800 feet west of the South Skunk River. The Lime and Ash Pond is a single, dual-use diked impoundment. The impoundment is about 1,600 feet long by about 650 feet wide. The long axis is oriented in the east-west direction. The impoundment is divided into two approximately equal cells, with the Fly Ash Pond on the eastern end, and the Ames Water Department Lime Cell on the western end. The cells are separated by an engineered divider dike that was part of the original facility constructions. Figure 2.1a depicts a vicinity map around the Ames Power Plant and the Lime and Ash Pond. Figure 2.1b depicts an aerial view of the City of Ames Power Plant and the CCR impoundment. Table 2.1 presents size information about the active disposal areas.

Figure 2.1 a: Ames, IA Power Plant Vicinity Map

Figure 2.1 b: City of Ames Power Plant and Fly Ash/Lime Cell Impoundment Locations

Table 2.1: Summary of Dam Dimensions and Size[1]	
	Lime & Ash Pond
Dam Height (ft)	18
Crest Width (ft)	16
Length/Circumference (ft)	4,550
Side Slopes (upstream) H:V	3:1
Side Slopes (downstream) H:V	2.5:1 to 3:1 varies by location

[1] Dimensions based on design drawings prepared by Lutz, Daily and Brain (See Appendix A – Doc 01)

2.2 COAL COMBUSTION RESIDUE HANDLING

2.2.1 Fly Ash

The Ames Power Plant currently operates two coal fired electrical power generating units, designated Units 7 and 8. Fly ash is collected at the base of each stack by electrostatic precipitators. The Unit 7 precipitator ash is deposited into six hoppers. Unit 8 has two precipitators, each with eight hoppers. The collected ash is stored in hoppers and conveyed pneumatically to a silo. Periodically ash from the silo is loaded into trucks for sale, or off-site disposal.

Fly ash is also collected from the flue gas duct in each unit and deposited into the three hoppers installed at each unit. A jet pump is used to draw ash from the hoppers and transport the ash water sluice to the Fly Ash Pond.

2.2.2 Bottom Ash

Bottom ash and "clinker," or unburned coal and other debris, is collected in hoppers beneath the boilers. A jet pump and sluice method is used to draw material from the hoppers through a crusher and sluice gate before sluicing the crushed material to the Fly Ash Pond (Photograph 2.2.2-1).

Photograph 2.2.2-1: Ash sluice pipes to Fly Ash Pond Receiving Ditch

2.2.3 Boiler Slag

Boiler slag is collected in the hoppers with the bottom ash.

2.2.4 Flue Gas Desulfurization Sludge

No Scrubbers are used in this plant so there is no flue gas desulfurization (FGD) process or related waste products to be discharged.

2.3 SIZE AND HAZARD CLASSIFICATION

Based on the size of the Lime and Ash Pond embankment height and impoundment storage capacity, the impoundment would be classified as Small by US Army Corps of Engineers (USACE) criteria.

Table 2.2a: USACE ER 1110-2-106 Size Classification		
	Impoundment	
Category	**Storage (Ac-ft)**	**Height (ft)**
Small	50 and < 1,000	25 and < 40
Intermediate	1,000 and < 50,000	40 and < 100
Large	> 50,000	> 100

Federal guidelines for dam safety hazard classification use two criteria: potential loss of human life and economic, environmental, and lifeline losses. Per the Federal Guidelines for Dam Safety dated April 2004, a Significant Hazard Potential classification applies to those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant Hazard Potential dams are often located in agricultural areas. Based on the presence of an active corn field adjacent to the north embankment of the Lime and Ash Pond, and considering the low probability of loss of life should the Lime and Ash Pond embankments fail, a Federal Hazard Classification of **Significant** is appropriate for these facilities.

Table 2.2b: FEMA Federal Guidelines for Dam Safety Hazard Classification		
	Loss of Human Life	**Economic or Environmental Damage**
Low	None Expected	Low and generally limited to owner site
Significant	None Expected	Yes
High	Probable. One or more expected	Yes (but not necessary for classification)

2.4 AMOUNT AND TYPE OF RESIDUALS CURRENTLY CONTAINED IN THE UNIT(S) AND MAXIMUM CAPACITY

The Fly Ash cell of the Lime and Ash Pond only receives sluiced bottom ash, sluiced fly ash, and direct precipitation. The Lime cell of the Lime and Ash Pond receives only dredged lime recovered from the Ames water treatment plant, and direct precipitation.

Table 2.3: Maximum Capacity of Unit		
	Ash Pond Cell	**Lime Pond Cell**
Surface Area (acre)	12.7	12.8
Current Storage Capacity (cubic yards)	69,059	62,354
Current Storage Capacity (acre-feet)	42.8	38.6
Total Storage Capacity (cubic yards)[1]	209,532	249,142
Total Storage Capacity (acre-feet)	129.9	154.4
Crest Elevation (feet)	+74 ft, including divider dike	+71 ft
Normal Pond Level (feet)	+70	N/A

[1] Elevations relative to City of Ames datum

2.5 PRINCIPAL PROJECT STRUCTURES

2.5.1 Earth Embankment

The north, east and west embankments were designed for a random fill core overlain by a three-foot thick impervious layer on the interior slope and crest.

The south embankment was designed to expand an existing levee by raising the crest elevation three feet, and widening the crest to 20 feet using impervious fill. Widening the embankment was accomplished by placing new fill in the area of the new Lime and Fly Ash Pond.

Technical specifications provided to Dewberry for review defined two types of materials (See Appendix A – Doc 02).

- Pervious material: Free draining sand or gravelly sand consisting of sound, durable particles with no more than 10 percent passing the U.S. Standard No. 200 sieve
- Impervious Material: Fine grained materials of low permeability consisting of clays, clayey silts, or silts and free of plant growth, roots and humus. Particle size of the impermeable material was to have a minimum of 50 percent passing the U.S. Standard No. 200 sieve, and preferably meet the requirements as a soil type CL or

CH based on the USACOE plasticity chart published in the Vicksburg Experiment Station Technical Memorandum 3-357.

Random fill was specified as consisting of pervious materials, non pervious materials, or any combination thereof.

2.5.2 Outlet Structures

Sluice water in the Fly Ash Pond cell drains to the southeast portion of the cell. A drop inlet riser allows decant water into a "Clear Water Pond" located inside the south perimeter of the Fly Ash Pond. Water is pumped from the Clear Water Pond to the plant for recycling through the ash collection systems.

There are no other outlets from the Lime and Ash Pond.

2.6 CRITICAL INFRASTRUCTURE WITHIN FIVE MILES DOWN GRADIENT

The Ames Power Plant is located on the east side of Ames, Iowa. The area to the west of the Lime and Ash Pond is heavily developed with residential, commercial, industrial, and transportation facilities. Topography in the area slopes to the east toward the South Skunk River, about 900 feet west of the Lime and Ash Pond. Based on the size of the impoundment, and site topographic conditions, a release due to failure or misoperation of the impoundment embankments is not expected to impact critical infrastructure facilities. Area topographic conditions are shown on Figure 2.6-1.

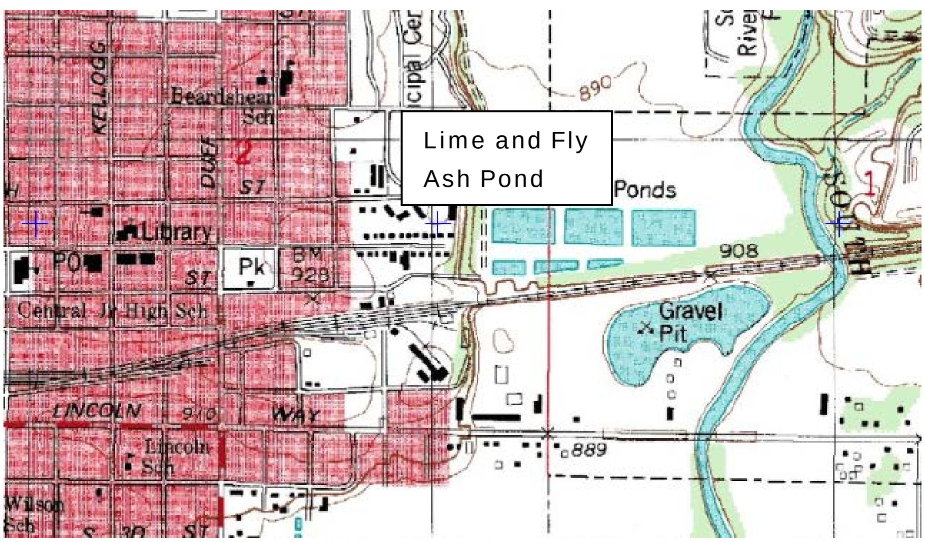


Figure 2.6-1: Lime and Ash Pond Area Topography

3.0 SUMMARY OF RELEVANT REPORTS, PERMITS, AND INCIDENTS

3.1 SUMMARY OF REPORTS ON THE SAFETY OF THE MANAGEMENT UNITS

Ames Electric Services provided a representative report of 2012 daily inspection reports prepared by plant personnel for the ash sluicing system. The inspection report focuses on the Fly Ash Pond pool elevation and the condition of the recirculation pump intakes. The inspection report does not discuss observations of the embankments.

3.2 SUMMARY OF LOCAL, STATE, AND FEDERAL ENVIRONMENTAL PERMITS

The State of Iowa Department of Natural Resources has issued a National Pollutant Discharge Elimination System Permit. Permit No. 85003-0-02 was issued July 23, 2001 (See Appendix A – Doc 03). The permit expired July 22, 2006. Ames Electric Services submitted an application for renewal which is still being reviewed by the State.

3.3 SUMMARY OF SPILL/RELEASE INCIDENTS

No recent documented spills or releases have been reported for the Lime and Ash Pond.

4.0 SUMMARY OF HISTORY OF CONSTRUCTION AND OPERATION

4.1 SUMMARY OF CONSTRUCTION HISTORY

4.1.1 Original Construction

Based on construction drawings provided to Dewberry for review, the Lime and Ash Pond was designed in 1980 and constructed between 1981 and 1982. Dimensions of the Lime and Ash Pond are about 1,600 feet along the east-west axis, and 660 feet along the north-south axis (See Appendix A – Doc. 1).

The north, east and west dikes were constructed of materials excavated from inside the pond footprint, and from the area between the pond and the South Skunk River. The dikes were designed as a random earth fill core with a three-foot thick impervious cover along the interior slope and crest.

The south slope was designed to expand an existing dike that formed an abandoned ash disposal area to the south of the current Lime and Ash Pond. The existing levee was expanded by adding a three-foot thick impervious soil cap to the existing crest, and extending the new slope northward into the footprint of the Lime and Ash Pond. The abandoned ash disposal area is overgrown with vegetation and does not impound water.

An engineered separator dike divides the pond about in half with the Lime Pond on the west side of the divider dike, and the Fly Ash Pond on the east side. The Fly Ash Pond is lined with a three-foot thick layer of compacted impervious material. Other than the interior embankment slopes, the Lime Pond is unlined.

The Fly Ash Pond includes engineered interior dikes inside the south perimeter that form a Clear Water Pond. Decant water in the Fly Ash Pond flows into the Clear Water Pond through a concrete riser structure. Stop logs control the pool elevation and flow into the 3.5-foot square riser that is connected to an 18-inch diameter discharge pipe (See Appendix A – Doc 04).

Water from the Clear Water Pond is sent into a pump house water supply cell that is separated from the Clear Water Pond by an engineered divider dike. Two 24-inch diameter steel pipes carry the water from the Clear

Water Pond to the pump house supply cell. Flow in the pipes is controlled by valves installed in a concrete control riser near the toe of the divider dike on the Clear Water Pond side of the dike (See Appendix A – Doc-04).

4.1.2 Significant Changes/Modifications in Design since Original Construction

Based on information provided to Dewberry during the site visit, no significant changes or modifications have been made to the impoundment since the original construction.

4.1.3 Significant Repairs/Rehabilitation since Original Construction

No significant repairs or rehabilitation have been made to the Lime and Ash Pond.

4.2 SUMMARY OF OPERATIONAL PROCEDURES

4.2.1 Original Operational Procedures

The Fly Ash Pond receives sluiced bottom ash and fly ash from the plant. Ash is discharged at the west side of the Fly Ash Pond and allowed to settle out of suspension. An interior ditch directs sluice water to the east end of the Fly Ash Pond. Sluice water flows from the east end of the Fly Ash Pond through an outlet structure into the Clear Water Pond, and then into the pump house. From the pump house pond the water is recycled back to the plant.

The Lime Pond receives dried lime from the lime reclamation impoundment adjacent to the south side of the Lime Pond.

4.2.2 Significant Changes in Operational Procedures and Original Startup

Based on information provided to Dewberry during the site visit, no significant change on operational procedures have been made since the Lime and Ash Pond was originally put into service.

4.2.3 Current Operational Procedures

Based on observations made during the Dewberry site visit current operations are substantively the same as described in the original operational procedures.

4.2.4 Other Notable Events since Original Startup

No notable events were reported to Dewberry during the site visit.

5.0 FIELD OBSERVATIONS

5.1 PROJECT OVERVIEW AND SIGNIFICANT FINDINGS

Dewberry personnel Michael McLaren, P.E., and Joseph P. Klein, III, P.E. conducted a site visit on August 20, 2012 in company with the participants.

The site visit began at 8:30 AM. The weather was sunny and warm. Photographs were taken of conditions observed. Please refer to the Dam Inspection Checklist in Appendix B for additional information. Selected photographs are included here for ease of visual reference. All pictures were taken by Dewberry personnel during the site visit. Copies of all photographs were provided to Ames Electric Services.

The overall visual assessment of the dam slopes was that the dikes are in satisfactory condition and no significant findings were noted.

5.2 BOTTOM ASH DISPOSAL AREA 2

5.2.1 Crest

Overall, there were no signs of rutting, depressions, tension cracking, or other indications of settlement or shear failure and the crest appeared to be in satisfactory condition (see Figure 5.2.1-1).

Figure 5.2.1-1 North Dike Crest View East along Fly Ash Pond

5.2.2 Upstream/Inside Slope

No scarps, sloughs, depressions, bulging or other indications of slope instability were observed (see Figure 5.2.2-1). Vegetation along the interior slope generally consisted of various types of grass and weeds. Small trees were observed along the interior slope of the south embankment. Areas of slope erosion were also observed along sections of the south embankment. The erosion was observed to be undermining trees growing on the slope (See Figure 5.2.2-2)

Figure 5.2.2-1 North Dike Interior Slope View West along Fly Ash Pond

Figure 5.2.2-2 Erosion along Inside Slope South Embankment

No scarps, sloughs, depressions, bulging, erosion, or other indications of slope instability were observed along the interior slopes of the Lime Pond (see Figure 5.2.2-3). Vegetation along the interior slope generally consisted of various types of grass and weeds.

Figure5.2.2-3: Lime Pond Interior Slope North Embankment Viewing West

5.2.3 Downstream/Outside Slope and Toe

No scarps, sloughs, depressions, bulging, or other indications of slope instability or signs of erosion were observed. Exterior slopes were vegetated with grass, weeds, and sections of small to medium trees (See Figure 5.2.3-1).

Figure 5.2.3-1: Outside Slope North Embankment Viewing West

No evidence of seepage was observed in the exterior slopes or along the toe of the embankments.

5.2.4 Abutments and Groin Areas

The Lime and Ash Pond is a fully diked and incised impoundment with no abutments. Groins were found to be in satisfactory condition with no signs of distress (See Figure 5.2.4-1)

Figure 5.2.4-1: Ash Pond Southeast Groin

5.3 OUTLET STRUCTURES

5.3.1 Overflow Structure

The Lime and Fly Ash Pond does not have an overflow structure. Sluice water is routed through the Fly Ash Pond to the Clear Water Pond within the impoundment, and pumped back to the plant for recycling. No water from the impoundment is discharged to the environment.

5.3.2 Outlet Conduit

The Ash Pond outlet structure consists of a concrete box riser with an 18-inch diameter outlet pipe discharging into the Clear Water Pond (See Figure 5.3.2-1). The Clear Water Pond is located within the Lime and Ash Pond impoundment. Stop logs in the outlet structure are used to manage the pool elevation in the Ash Pond.

The Clear Water outlet consists of two 24-inch diameter pipes from the Clear Water Pond to the recirculation pumps located at the southwest corner of the Fly Ash Pond. Flow through the pipes is controlled by a pair of butterfly valves located in a concrete manhole along a dike separating sections of the Clear Water Pond (See Figure 5.3.2-2).

Figure 5.3.2-1 Ash Pond Outlet Structure

Figure 5.3.2-2: Clear Water Pond Outlet Valve Control Structure

5.3.3 Emergency Spillway

The Lime and Ash Pond does not have an emergency spillway.

5.3.4 Low Level Outlet

The Lime and Ash Pond does not have a low level outlet.

6.0 HYDROLOGIC/HYDRAULIC SAFETY

6.1 SUPPORTING TECHNICAL DOCUMENTATION

6.1.1 Flood of Record

No documentation has been provided about the flood of record.

6.1.2 Inflow Design Flood

According to FEMA Federal Guidelines for Dam Safety, the current practice in the design of dams is to use the Inflow Design Flood (IDF) that is deemed appropriate for the hazard potential of the dam and reservoir, and to design spillways and outlet works that are capable of safely accommodating the flood flow without risking the loss of the dam or endangering areas downstream from the dam to flows greater than the inflow. The recommended IDF or spillway design flood for a significant hazard, small-sized structure (See section 2.2) in accordance with the USACE Recommended Guidelines for Safety Inspection of Dams ER 1110-2-106 criteria is the 100 year storm to ½ Probable Maximum Flood (PMF) (See Table 6.1.2).

Table 6.1.2: USACE Hydrologic Evaluation Guidelines Recommended Spillway Design Floods

Hazard	Size	Spillway Design Flood
Low	Small	50- to 100-year frequency
	Intermediate	100-year to ½ PMF
	Large	½ PMF to PMF
Significant	Small	100-year to ½ PMF
	Intermediate	½ PMF to PMF
	Large	PMF
High	Small	½ PMF to PMF
	Intermediate	PMF
	Large	PMF

The Probable Maximum Precipitation (PMP) is defined by the American Meteorological Society as the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. The National Weather Service (NWS) further states that in consideration of the complicated processes and interrelationships in storms, PMP values are identified as estimates. The NWS has published application procedures that can be used with PMP estimates to develop spatial and temporal characteristics of a Probable Maximum Storm (PMS). A PMS thus developed can be used with a precipitation-runoff simulation model to calculate a PMF hydrograph.

Hydrologic and hydraulic documentation provided to Dewberry for review consisted of the 1980 site plan drawing that shows the South Skunk River "Floodway limit – 0.1 foot rise on 100-year flood" located adjacent to the toe of the east embankment of the impoundment.

A brief internet search by Dewberry found data from the Iowa Stormwater Management Manual, Version 2, December 5, 2008 indicating the one percent probability in any given year (100-year storm) 24 hour precipitation event in central Iowa is 6.61 inches (See Appendix A – Doc 5).

6.1.3 Spillway Rating

The Lime and Ash Pond does not have a spillway discharge. The sole method of discharge from the impoundment is recirculation pumping from the Clear Water Pond cell to the plant.

6.1.4 Downstream Flood Analysis

No downstream flood analysis was provided.

6.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Supporting documentation reviewed by Dewberry is inadequate.

6.3 ASSESSMENT OF HYDROLOGIC/HYDRAULIC SAFETY

The crest elevation of the Lime and Ash Pond is a minimum of eight feet above the adjacent exterior grade. Stormwater into the impoundment is expected to be limited to direct rainfall.

The normal pool elevation of the Fly Ash Pond is managed to a relatively constant +70 feet, providing a four-foot freeboard. The freeboard is expected to be adequate to contain the one percent probability, 24-hour precipitation event without overtopping the impoundment embankments.

7.0 STRUCTURAL STABILITY

7.1 SUPPORTING TECHNICAL DOCUMENTATION

7.1.1 Stability Analyses and Load Cases Analyzed

No slope stability analyses data was provided to Dewberry for review.

7.1.2 Design Parameters and Dam Materials

No design parameters assigned to the dam materials was provided to Dewberry for review.

Dewberry was provided three sets of boring logs conducted at the Ames Power Plant in conjunction with the design of the Lime and Ash Pond waste management unit.

- 19 borings located near the power plant drilled June 1978
- 12 borings drilled March 1980 located within the Lime and Ash Pond area (See Appendix A, Doc – 6)
- 13 borings drilled July 1980 (See Appendix A – Doc 7)
    - Nine borings located between the proposed east embankment location and the South Skunk River
    - Four borings, designation borings 13 through 19, located within the Ash Pond section of the Lime and Ash impoundment.

The location of the 25 borings drilled in 1980 indicate the purpose of the borings was to identify suitable material for excavation and use as compacted fill in the embankments. The borings indicate subsurface conditions consisting of about two to 12 feet of silty to fine sandy clay, or clayey silt, underlain by silty fine to coarse sands. In the borings located within the Lime and Ash Pond impoundment footprint, the design subgrade elevation was in the silty fine to coarse sands range. Only one of the 25 soil borings included standard penetration results. The results indicate the embankment subgrade at the south end of the Lime Pond and Ash Pond divider dike consisted of six feet of very loose to loose, fine sand underlain by loose to medium dense coarse sands.

7.1.3 Uplift and/or Phreatic Surface Assumptions

No documentation of uplift force or phreatic surface assumptions was provided to Dewberry for review.

7.1.4 Factors of Safety and Base Stresses

Documentation of slope stability analyses or base stresses was not provided to Dewberry for review.

7.1.5 Liquefaction Potential

Documentation of liquefaction potential of soils at the site was not provided for review. Based on the limited data available, the loose silty fine sands at the subgrade elevation of the impoundment are expected to be susceptible to liquefaction resulting from a seismic event. However, the project specifications provided to Dewberry for review required the embankment subgrade to be compacted to a minimum density of 90 percent of the maximum dry density for impermeable soils, or 80 percent relative density for pervious soils.

The 2008 USGS seismic risk map indicates the estimated peak ground acceleration for an earthquake having a two percent probability of exceedance in 50 years is 0.06g.

7.1.6 Critical Geological Conditions

Surface geology in the vicinity of the site consists of loose sands and unconsolidated sandy clays deposited by glacial outwash and wind. Some areas are overlain by more recent sediment from stream and riverine flooding.

The boring logs and USGS seismic risk map do not suggest critical geologic conditions representing special hazards to the site.

7.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Structural stability documentation is inadequate to support a quantitative analysis of the stability of the embankments impounding the Lime and Ash Pond.

7.3 ASSESSMENT OF STRUCTURAL STABILITY

Based on the lack of technical documentation, the structural stability of the Lime and Ash Pond is rated as POOR.

8.0 ADEQUACY OF MAINTENANCE AND METHODS OF OPERATION

8.1 OPERATING PROCEDURES

Bottom ash and fly ash from the flue gas outlet ducts is collected and sluiced to the Fly Ash Pond section of the Lime and Ash Pond. Sluiced ash is discharged at the western end of the Fly Ash Pond where ash is allowed to settle out of suspension. Sluice water flows through a ditch to the east end of the Fly Ash Pond and is held to allow additional settling of suspended solids. Decant water from the settling area flows through a riser structure spillway structure to a Clear Water Pond inside divider dikes within the Fly Ash Pond. Water from the Clear Water Pond is pumped to the plant for recycling in the sluice process.

Water level in the Fly Ash Pond is controlled by stop logs in the riser structure to the Clear Water Pond.

The Lime Pond portion of the Lime and Ash Pond is used to store dry lime reclaimed from the City of Ames water treatment plant. Sluiced lime is discharged into a three cell basin adjacent to the Lime Pond. One cell receives sluiced material, the second cell allows lime to settle out of suspension, and the third cell allows the precipitated lime to dry. As the sluice-receiving cell reaches capacity, dry lime is dredged and moved to the Lime Pond. Upon transfer of the dredged lime to the Lime Pond, the sluiced material is routed to the empty cell. The prior settling cell becomes the drying cell, and the prior sluice cell becomes the settling cell. Information provided during the Dewberry site visit indicated that the cells cycle through the functions on an annual basis.

8.2 MAINTENANCE OF THE DAM AND PROJECT FACILITIES

Maintenance of the impoundment generally consists of adjustment to the Fly Ash Pond riser structure stop logs to control pool elevation, and maintenance on pumps used to recycle decanted sluice water back to the power plant. It appeared that mowing grass is performed periodically on the west and east embankment exterior slopes.

8.3 ASSESSMENT OF MAINTENANCE AND METHODS OF OPERATIONS

8.3.1 Adequacy of Operating Procedures

Based on assessments from received documents and the site visit, operating procedures appear to be adequate.

8.3.2 Adequacy of Maintenance

Based on assessments from received documents and the site visit, Dewberry recommends improvements to the maintenance program. Recommended improvements include:

- Repair interior embankment sections eroded by wind driven waves
- Remove trees from both the interior and exterior slopes of embankments.
- Modify the current inspection program to include weekly observation of the embankments.

9.0 ADEQUACY OF SURVEILLANCE AND MONITORING PROGRAM

9.1 SURVEILLANCE PROCEDURES

Normal plant surveillance procedures consist of daily monitoring of the water elevation in the Fly Ash Pond.

9.2 INSTRUMENTATION MONITORING

No instrumentation monitoring data was provided to Dewberry for review. Information provided during the site visit indicated that the embankments were not instrumented.

The boring logs provided indicate that three piezometers were installed as part of the 1980 boring program. Two of the piezometers were installed near the toe of the north embankment, and the third installed at the south end of the Lime Pond and Ash Pond divider dike. Elevations on the design drawings indicate the piezometers were installed to remain accessible after embankment construction (See Appendix A, Doc – 1). The piezometers were not visible in the vegetative cover during Dewberry's site visit.

9.3 ASSESSMENT OF SURVEILLANCE AND MONITORING PROGRAM

9.3.1 Adequacy of Inspection Program

Based on the data reviewed by Dewberry, including observations during the site visit, the inspection program is inadequate.

9.3.2 Adequacy of Instrumentation Monitoring Program

Based on the data reviewed by Dewberry, including observations during the site visit, the monitoring program is inadequate.

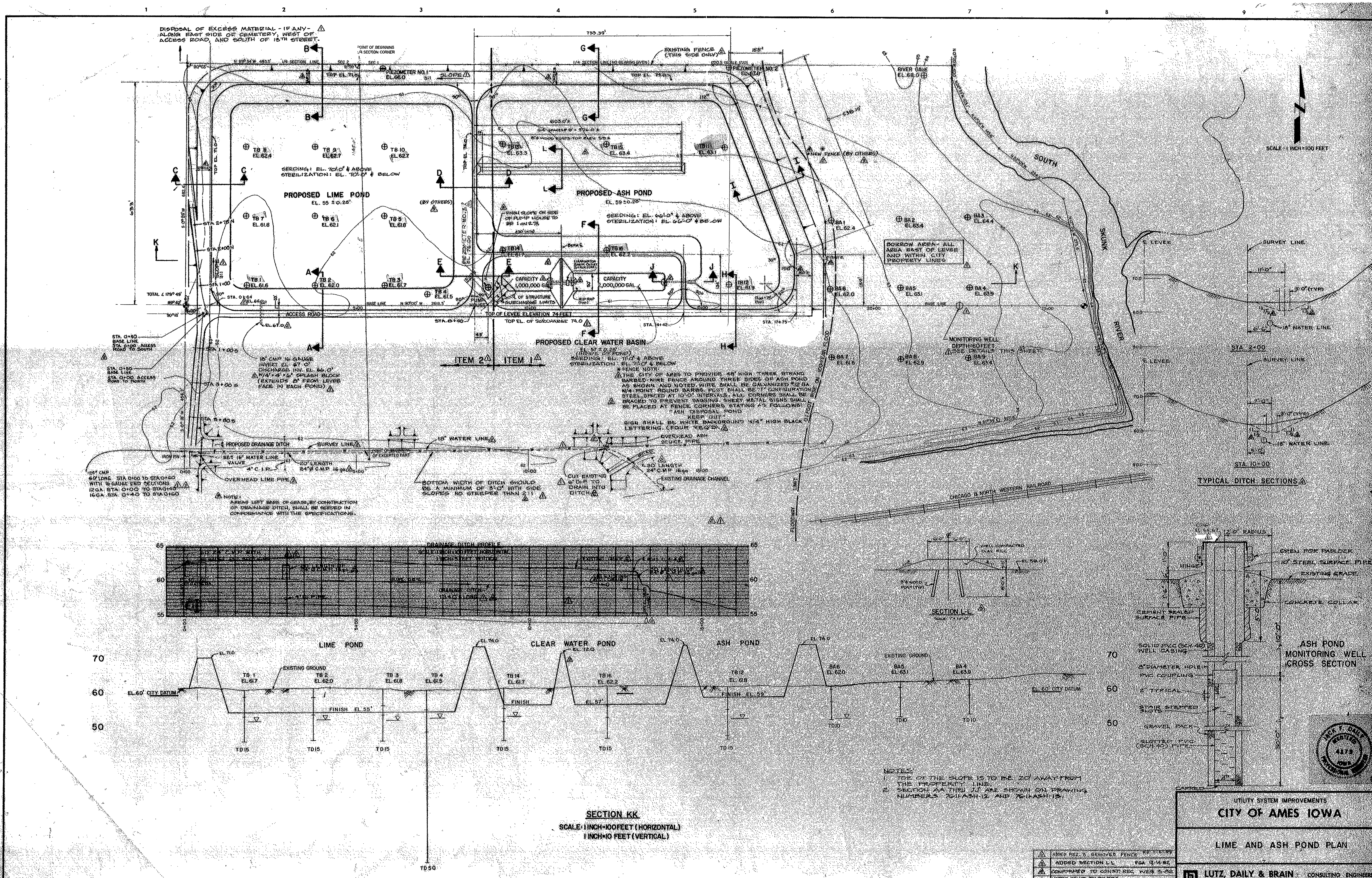
Dewberry recommends that the existing monitoring program be enhanced to include a weekly inspection of the embankments for signs of distress and to identify maintenance needs.

The small size of the impoundment does not warrant a sophisticated monitoring system. However, Dewberry recommends that the three existing piezometers be located and inspected to determine if they remain functional. If yes, the piezometers should be read monthly as part of an enhanced monitoring program.

APPENDIX A

Document 1

Lime and Ash Pond Embankment Design Drawings



NOTE
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WEG DATE 12-82

REV.	DESCRIPTION
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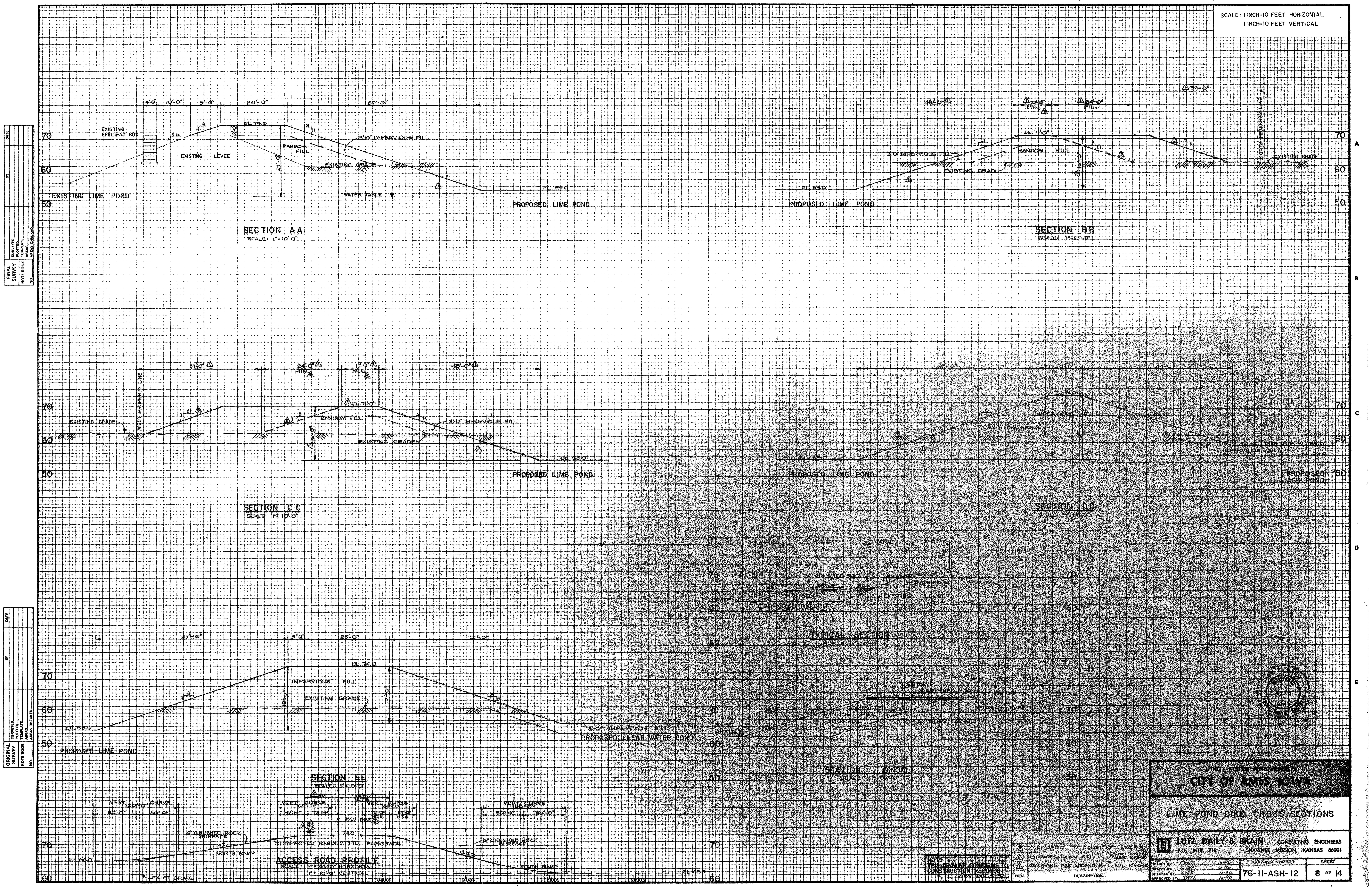
	ADDED SECTION L.L. FGA 12-14-82
	CONFORMED TO CONST. REC. WEG 3-82
	NOTED FENCE BY OTHERS, ADDED SEEDING FOR DITCH AHL 12-1-80
	REVISED DITCH, ADDED ASH PD. FENCE, CLR WATER PD. PARTITION
1	REVISIONS PER ADDENDUM 1 AHL 10-16-80

UTILITY SYSTEM IMPROVEMENTS
CITY OF AMES IOWA

LIME AND ASH POND PLAN

LUTZ, DAILY & BRAIN CONSULTING ENGINEERS
P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201

DRAWING NUMBER 76-11-ASH-11
SHEET 7 OF 14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1 INCH=10 FEET VERTICAL
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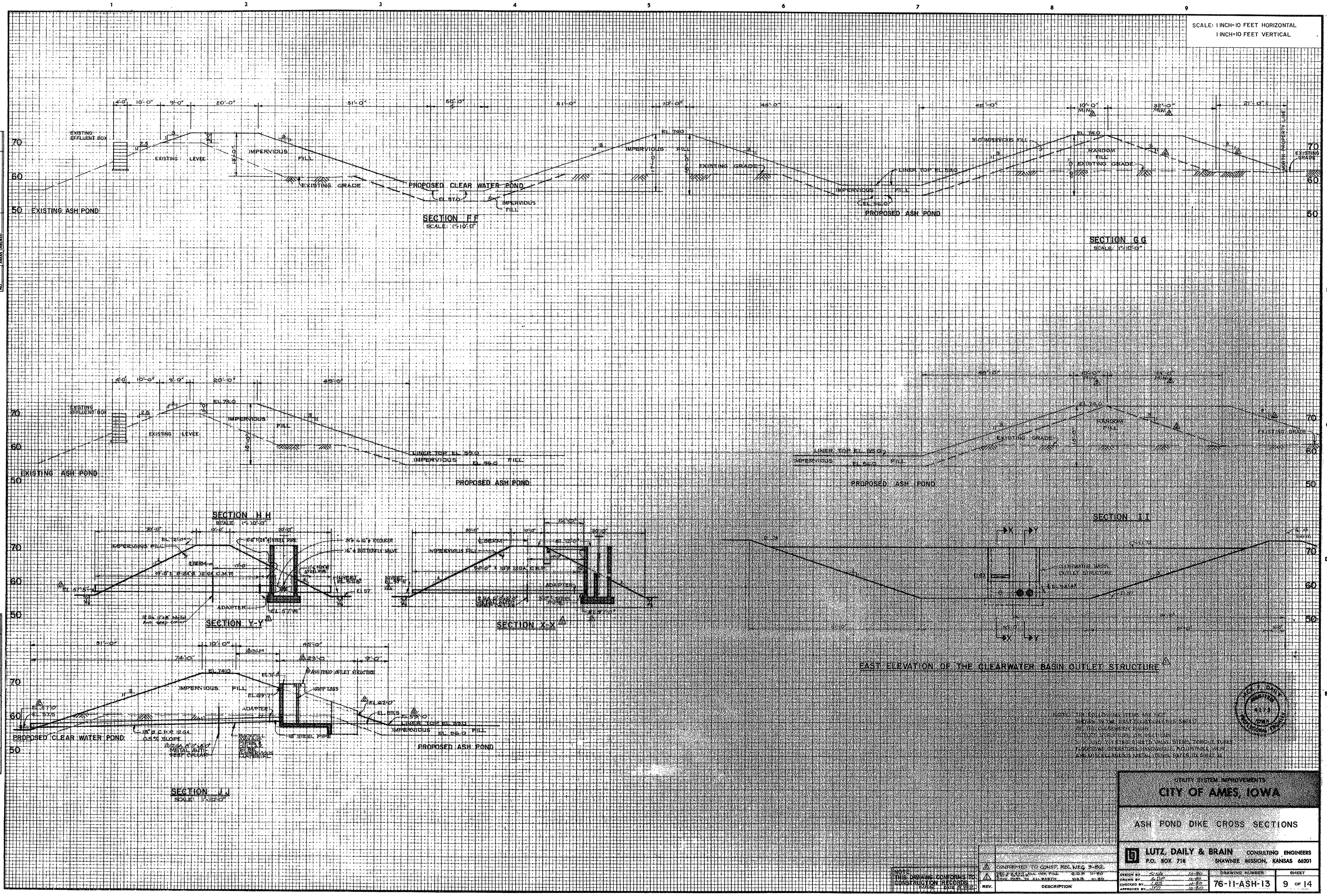
EXISTING LEVEE
EL. 74.0
RANDOM FILL
3'-0" IMPERVIOUS FILL
EXISTING GRADE
WATER TABLE
EXISTING LIME POND
PROPOSED LIME POND
SECTION AA
SCALE: 1"=10'-0"
SECTION BB
SCALE: 1"=10'-0"
SECTION CC
SCALE: 1"=10'-0"
SECTION DD
SCALE: 1"=10'-0"
PROPOSED ASH POND
TYPICAL SECTION
4" CRUSHED ROCK
EXISTING LEVEL
SECTION EE
IMPERVIOUS FILL
PROPOSED CLEAR WATER POND
STATION 0+00
COMPACTED RANDOM FILL SUBGRADE
ACCESS ROAD PROFILE
VERT. CURVE
NORTH RAMP
SOUTH RAMP
NOTE
THIS DRAWING CONFORMS TO CONSTRUCTION RECORDS
REV.
DESCRIPTION
CONFORMED TO CONST. REC. WEG 2-82
CHANGE ACCESS RD. WEB 10-31-80
REVISIONS PER ADDENDUM 1 AHL 10-10-80
UTILITY SYSTEM IMPROVEMENTS
CITY OF AMES, IOWA
LIME POND DIKE CROSS SECTIONS
LUTZ, DAILY & BRAIN CONSULTING ENGINEERS
P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201
DESIGN BY
DRAWN BY
CHECKED BY
APPROVED BY
DRAWING NUMBER
76-11-ASH-12
SHEET
8 OF 14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IMPERVIOUS FILL
EXISTING GRADE
PROPOSED CLEAR WATER POND
EXISTING ASH POND
SECTION G-G
SCALE: 1"=10'-0"
RANDOM FILL
LINER TOP EL 55.0
PROPOSED ASH POND
NORTH PROPERTY LINE
SECTION H-H
SCALE: 1"=10'-0"
SECTION I-I
SECTION Y-Y
SECTION X-X
SECTION J-J
SCALE: 1"=10'-0"
EAST ELEVATION OF THE CLEARWATER BASIN OUTLET STRUCTURE
CLEARWATER BASIN OUTLET STRUCTURE
UTILITY SYSTEM IMPROVEMENTS
CITY OF AMES, IOWA
ASH POND DIKE CROSS SECTIONS
LUTZ, DAILY & BRAIN CONSULTING ENGINEERS
P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201
NOTE: THIS DRAWING CONFORMS TO CONSTRUCTION RECORDS
CONFORMED TO CONST. REC. WEG 3-82
REV.
DESCRIPTION
DESIGN BY SHR 10-80
DRAWN BY GDP 10-80
CHECKED BY LAS 10-80
APPROVED BY JFD 10-80
DRAWING NUMBER
76-11-ASH-13
SHEET
9 OF 14

APPENDIX A

Document 2

Embankment Construction Earthwork Specifications

EXCAVATION AND BACKFILL

SCOPE OF WORK: The Contractor shall furnish all materials, machinery, equipment, and labor necessary to perform all stripping operations, excavation work, backfilling and grading indicated on the drawings or herein stipulated. This work shall include necessary preparation of the site, removal and disposal of all debris, the handling, storage, transportation and disposal of all excavated material, all necessary sheeting, shoring and protection work, preparation of grades and final grading, including repair or replacement of disturbed surface material and dressing of the site to the grades and elevations shown on the drawings or specified to be done.

This Contract shall include excavation for all foundations, sumps, pits, piping, drain lines or any other construction which shall require excavation to construct the project as shown on the accompanying plans.

This work shall be done so as to conform with all local and state ordinances and laws with respect to safety and excavation including safety provisions of the Williams-Steiger Occupational Safety and Health Act of 1970 and its latest revisions and regulations.

TEST HOLES: The log of test holes on the building site is included in these specifications (see section SUBSURFACE EXPLORATION in these specifications).

GENERAL: Excavation shall be done carefully to lines and elevations shown on the drawings, and shall provide proper room for all construction operations. Work shall be done so that the premises shall be as free as possible from all obstructions and from interference with transportation, storage or handling of materials. Care should be taken at all times to conduct the work safely, with all precautions against hazards of any kind. Before placing pipe or concrete structures upon any subgrade, all loose material shall be removed so that the pipe or structure will rest on solid, undisturbed ground.

Concrete forms will be required for foundations, walls and footings of any kind; therefore, the excavation shall provide adequate clearance for their installaw tion and removal. In no case shall excavation faces be undercut to provide for extended footings.

EXISTING BURIED UTILITIES: Underground utilities consisting of water lines, telephone cable and power circuits exist on the plant site. This Contractor shall exercise extreme caution in the excavation work performed in the area of the utilities and shall protect the services from damage.

APPROVAL OF OPERATION: All excavation of every description and of whatever substance encountered shall be performed in accordance with a plan of operation reviewed by the Engineer. Removal and relocation of utilities shall be coordinated with Owner. Hand excavation shall be used to the extent necessary to insure that the pipes and structures are placed at the proper elevation and that existing structures to remain are not damaged. Excavation for pipes and structures shall be in accordance with the applicable provisions and classifications under that section specifying the structure or pipe to be constructed or removed.

DEFINITIONS: Terminology for this section are defined as follows:

Natural Blanket Soil: Natural blanket soils (or materials) refers to the natural deposit of finegrained soils. The surface soils encountered by the test borings primarily consist of silty clays and clayey silts varying in thickness and containing a slight to moderate sand content at various locations. The silty clayey surface soil is principally underlain by a brown silty medium fine textured sand which may contain clayey levels and seams and becoming courser with depth, altering to a course textured sand. These soils are typically stratified having been water-deposited and reworked many time. The natural moisture of these materials varies generally with the season of the year and stage of the river.

Pervious Fill: Pervious materials shall be free-draining sand or gravelly sand consisting of sound durable particles and shall contain not over 10% passing the U.S. standard No. 200 sieve.

Impervious Fill: Impervious materials shall be fine-grained materials of low permeability consisting of clays, clay silts, or silts, and shall be free of plant growth, roots, and humus. In general, the particle size of impervious material shall be such that a minimum of 50 percent of the soil particles shall pass a U.S. Standard No. 200 screen and, where possible, shall be material classified as CL or CH on the plasticity chart of the Unified Soil Classification Chart, revised 1960 and published in Vicksburg Experiment Station Technical Memorandum 3-357.

Top Soil: Soil with sufficient humus and of approximate texture to be used to support plant growth.

REQUIRED OVER EXCAVATION: Any pipe or structure subgrade that is less than three feet above the bottom of the pond impervious soil liner or embankment impervious zone within the pond limits, the trench or excavation shall be overexcavated to three feet below and three feet beyond the limits of the pipe or structure and backfilled to the top of the pond impervious soil liner or embankment impervious zone with impervious material compacted as hereinafter specified.

ZONED BACKFILL: Except in the case of overexcavation as described above, all backfill shall be zoned to match the adjacent material.

MIXING OF MATERIALS: When materials in borrow areas and required excavations are considerably stratified or when the natural moisture content varies considerably from the optimum value for proper placement and obtaining maximum density in compacted fill, the Engineer may require that excavation be done in a manner to provide mixing during excavation to obtain a more homogenous material and with a more desirable moisture content after required manipulation of the fill.

LINES AND GRADES: The natural and existing ground surfaces shown on the drawings are approximate only. Material shall be excavated at the locations as specified and to the lines and grades as shown on the drawings. Any excessive excavation, including borrow excavation, shall be backfilled as specified herein.

SEGREGATION OF MATERIAL: Suitable material shall be used in the respective zone of the work. Excess or unsuitable material shall be disposed of as hereinafter specified. Excavated material shall be segregated into three stockpiles: top soil, pervious material and impervious material to permit replacement in the proper lone.

BORROW: Any random material borrow required for work under this Contract shall be obtained from the designated borrow area as shown on the drawings for use in random fill zones.

The limits of this borrow are shown on the drawings. Any excavation beyond and outside the lines, elevations, and dimensions shown on the drawings or referred to herein shall be backfilled to the allowable excavation limits with material similar to the original soil at no additional cost to the Owner. When directed, the backfill shall be compacted to a density at least equal to 95 percent of maximum density at optimum moisture as defined in section EMBANKMENT. Side slopes of excavated borrow areas shall be four horizontal to one vertical except as shown on the drawings. Construction haul roads and access ways along traverses and adjacent to borrow areas shall be maintained and left in a smooth and reasonably level condition. Upon completion of the levees and berms, and prior to acceptance, all disturbed area surrounding excavated borrow areas and the borrow areas themselves shall be graded smooth and left in a clean, neat, and workmanlike condition. Drainage of the borrow areas shall be the Contractor's responsibility during his operations in the borrow area.

REMOVAL OF WATER: The Contractor shall provide and maintain proper and adequate dewatering equipment for the removal and disposal of all surface and ground water entering excavations or other parts of the work, and shall keep each such excavation dry until the structure or embankment to be built therein is completed to the extent that no damage from hydrostatic pressure, flotation or otherwise will result from contact with such water. No reinforcement steel shall be placed in water, and no water shall be permitted to rise over such steel before the concrete has been deposited. Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches, to the greatest extent practicable without causing damage to adjacent property.

The Contractor will be held responsible for the condition of any sewer drain, or other conduit or pipe line which may be used for drainage purposes, and all such pipes or conduits shall be clean and free from sediment before acceptance thereof by the Owner.

SHEETING AND SHORING: The Contractor, as his subsidiary obligation, shall provide and construct all sheeting and shoring required to protect and maintain the stability of existing structures, or of banks or sides of excavation, and to prevent caving, sliding or any movement of such banks into the excavated area. This provision shall apply equally to excavation for structures and to trench work. Such excavations shall be sheeted and braced as required by any governing state laws and as may be necessary to protect life, property or the work.

Sheeting, bracing and shoring shall be adequate in design and construction to withstand all loads that might be caused by earth movement or pressure, and it shall be rigid, maintaining its shape and position under all circumstances. When close sheeting is required, it shall be so driven as to prevent adjacent soil from entering the excavation either below or through such sheeting. Where sheeting and bracing are used, the excavation width shall be increased accordingly.

In all cases, the safety of personnel shall be maintained, and hazardous and dangerous conditions shall be prevented.

The stability of existing structures shall not be impaired or endangered by any excavation work hereunder. The Contractor shall at his own expense install and maintain adequate shoring or sheeting to protect all existing structures adjacent to his areas of excavation. Such protection shall extend to the prevention of hazard to all structures or to their safety. The Contractor alone shall be responsible for the safety and adequacy of all bracing, sheeting, shoring, and methods of construction used.

CLASSIFICATION OF EXCAVATION: The term "excavation" shall include all materials excavated or removed on the site or sites of the work regardless of the type, character, composition or condition of the materials so excavated, and shall further include all debris, junk, broken concrete, brick, stone, pipe, logs, stumps, roots and all other materials encountered within the specified excavation limits.

PREPARATION OF CONSTRUCTION AREA: Vegetation shall be stripped from all areas to be excavated or to receive compacted fill to a depth sufficient to remove top soil, grass, weeds and roots. Stripping of borrow areas will be required insofar as it is necessary to provide suitable material for required fills. Stripped topsoil shall be stockpiled separately as directed by the Resident Engineer for replacement by this Contractor on the project.

All combustible debris resulting from preparation shall be disposed of by burning in an air-curtain type destructor. The Contractor shall be responsible for compliance with all Federal, State, County and City laws and regulations relative to the disposal of combustibles by burning.

In areas to be occupied by the embankment and related fills, any material designated as objectionable material by the Engineer, such as soft, low shear strength clays, muck, trash and excessively wet foundation soils or material determined to be objectionable because of high permeability, stability or is otherwise unsuitable as a foundation for compacted fill, shall be removed to the limits shown on the drawings, or as directed by the Engineer within reasonable limits.

Drainage ditches and inlet and outlet ditches to drainage structures shall be excavated at the locations and to the cross sections and grades shown.

VERTICAL TRENCH WIDTH: Where vertical trench walls are permitted the trench shall be ample to permit the pipe to be laid and joined properly, and the backfill to be placed and compacted as hereinafter specified. The following are minimum trench widths:

Pipe Outside Diameter or Ductbank Width	Minimum Trench Width
12 inch and under	OD + 1 foot
14 inch through 21 inch	OD + 2 feet
24 inch through 42 inch	OD + 3 feet
48 inch and over	OD + 4 feet

EXCAVATION TO SUBGRADE: Except where over excavation is required for pipe or structure as specified hereinbefore, all excavation shall be made to the depth required so as to provide a uniform and continuous bearing and support for the pipe or structure on solid and undisturbed ground. Any part of the bottom of the pipe trench excavated below the specified grade shall be corrected with approved material, thoroughly compacted as directed by the Engineer. The finished subgrade shall be prepared accurately by means of hand tools. In the case of pipe installation, a maximum length of 18 inches near the middle of each length of pipe may be left only sufficiently low to permit withdrawal of pipe slings or other lifting tackle.

If, in the opinion of the Engineer, soil conditions are encountered at subgrade which require all or part of the work to be performed in accordance with the paragraph EXCAVATION IN POOR SOIL the Engineer shall have the authority to require the work to be so performed.

REQUIRED EXCAVATION BELOW SUBGRADE: Where the trench or excavation is required to be excavated below pipe or structure subgrade by these specifications, the subgrade shall be made by backfilling with an approved material in three inch to six inch uncompacted layers. The layers shall be thoroughly tamped or otherwise compacted as specified under COMPACTION to subgrade elevation or in the case of pipe to an elevation which is at least 0.1 of the pipe diameter above pipe subgrade and re-excavated to grade in such manner as to provide a uniform continuous bearing support for the pipe.

EXCAVATION IN POOR SOIL: Material, which at the bottom of the trench or excavation at subgrade is found to be, in the judgement of the Engineer, unstable or to include ashes, cinders, any type of refuse, vegetable or other organic material, or large pieces or fragments of inorganic material shall be removed. The Contractor shall excavate and remove such unsuitable material to the width and depth required by the Engineer. The subgrade shall be reconstructed as specified in the paragraphs REQUIRED EXCAVATION BELOW SUBGRADE and COMPACTION.

UNAUTHORIZED EXCAVATION: All material excavated below the bottoms of concrete walls, footings and foundations shall be replaced, by and at the expense of the Contractor, with concrete placed at the same time and monolithic with the concrete above, unless noted otherwise in these specifications.

SUBGRADE INSPECTION AND SOIL TESTS: The opened excavation shall be examined and approved by the Engineer before concrete or footings are poured. The Engineer may then order the surfaces to be placed in better condition, may order a test of the bearing capacity. Cost of such tests would be borne by the Owner and shall not be a part of this Contract.

SUBSOIL STABILIZATION: Subgrade soil for all concrete structures regardless of type or location, shall be firm, dense, and thoroughly compacted and consolidated, shall be free from mud and muck, and shall be sufficiently stable to remain firm and intact under the feet of the workmen engaged in subgrade surfacing or laying reinforcement steel, and depositing concrete thereon.

Subsoil which is otherwise solid, but which becomes mucky on top due to construction operations, shall be, unless specified otherwise, reinforced with one or more layers of crushed stone or gravel as directed by the Engineer at no additional cost to the Owner. Pervious material, crushed rock or other layer materials through which seepage might pass will not be permitted within the impervious fill zones of the ash disposal area.

Concrete shall not be placed on frozen subsoil.

EXCAVATION AND REMOVAL OF EXISTING PIPES AND STRUCTURES: Any existing culverts, sewers, water and gas lines and telephone conduit including valves, gates, concrete, brick and masonry manholes, headwalls, and other structures which are abandoned or are to be abandoned during the course of the work, as defined on the accompanying drawings, shall be removed within the limits shown. Ends of pipes remaining in place beyond the limits of removal shall be plugged with concrete for a minimum distance of 12 inches.

HAND EXCAVATION: Hand excavation shall be employed where shown on the drawings or where required to protect existing structures. Elsewhere machine excavation may be employed.

BACKFILLING IN FREEZING WEATHER: When frozen soil exists in either the surface of the original ground, excavation, trench, backfill material or partially constructed backfill, work shall not proceed until such time that the area in question has been prepared in a manner that is acceptable to the Resident Engineer.

BACKFILL MATERIAL: All backfill material shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, rocks or stone, frozen material or other material which is unsuitable. All suitable backfill material shall have a moisture content to enable satisfactory placement and compaction.

USE OF EXCAVATED MATERIAL AS BACKFILL: Except as shown on the plans, backfill of pipes and structures shall be zoned to match the material in the adjacent undisturbed sides of the excavation, i.e., impervious material shall be placed against impervious material and pervious (sand and gravel) against pervious material. The Engineer shall designate the zones of material if there is any question.

Material from excavation for pipes and structures shall be reused as backfill insofar as it meets the requirements for the materials specified in each zone of the work. Impervious material that is mixed with sand during the excavation process or any excess material will be disposed of on the site in an area acceptable for random fill as directed by the Engineer.

EXCAVATED MATERIALS FROM PONDS AND OTHER REQUIRED EXCAVATIONS: Materials obtained from these sources may be used in the embankments and required fills insofar as the materials meet the requirements of section EMBANKMENT.

COMPACTION: Compaction shall be performed at moisture content necessary to achieve required results with equipment used. Compaction of backfill materials shall be performed with spreading equipment supplemented by hand-operated equipment and rollers as required to obtain density specified. Backfilling and compaction shall be accomplished without inundation or flooding. Unless otherwise specified, compaction shall be adequate to prevent significant future settlement.

Impervious material shall be compacted to at least 95 percent of maximum density at optimum moisture content as determined by ASTM D-698 (Standard Proctor). Pervious material shall be compacted to at least 80 percent relative density, as determined by ASTM Specification D-2049. When backfill material is a combination of pervious and impervious material and there is a question as to which method of compaction should be used, the method of compaction shall be determined by the Engineer.

Tractors and other heavy construction equipment will not be permitted on pipes or conduit until at least two feet of compacted material is in place over the pipes. Power tampers shall be used, as necessary, for compaction of backfill in areas adjacent to pipes and structures. Placement of backfill materials shall be layers of thickness within compacting ability of equipment used, except that within two feet of any pipe or wall the lift thickness shall be from three to six inch layers of uncompacted thickness.

BACKFILL PLACED AGAINST STRUCTURES: Backfill material shall be brought up evenly on all sides of the structures and shall be compacted as specified under COMPACTION. Care shall be exercised in the use of heavy equipment to prevent damage or displacement of structures. Backfill shall not be placed against or over structures until the concrete has attained a minimum compressive strength of 4000 psi as determined by authorized laboratory test results unless specifically authorized by the Engineer.

BACKFILL OF TRENCH EXCAVATION FOR INSTALLATION OF PIPES, OR OTHER ITEMS: All trenches where the pipe, fittings and appurtenances are installed at subgrade in accordance with paragraph entitled EXCAVATION TO SUBGRADE shall be backfilled by hand, from the bottom of the trench to a plane located one foot above the top of the pipe, with suitable excavated material placed in layers of three inches and compacted by tamping with particular care given to the lower 90 degrees of the pipe and the bell holes. Backfilling material shall be deposited in the trench for its full width on each side of the pipe, fittings and appurtenances simultaneously. Care shall be taken not to damage the pipe in any way while backfilling and tamping.

DISPOSAL OF DEBRIS: Broken pipe, concrete, masonry, brick and other products of removal of existing pipes and structures shall be disposed of as directed by the Engineer. Salvageable items shall remain the property of the Owner and shall be stored on the site as directed by the Engineer.

FINISH GRADING: All backfilled area and areas disturbed by excavation and backfill operation shall be graded and hand dressed as required to restore the terrain to its original shape or to the grade and cross-section shown on the drawings.

EXCESS EXCAVATED MATERIAL: Excess excavated material that is left after backfilling and dressing with top soil at the power plant addition proper shall be placed at the designated borrow area as shown on the plans.

STOCKPILING EXCAVATED MATERIAL: All excavated material shall be stockpiled in a manner that will not endanger the work and that will avoid obstructing the work of other contractors.

All excavated material suitable for compacted fills and backfill shall be stockpiled as specified under the paragraph SEGREGATION OF MATERIAL.

All stumps, roots or other debris shall be disposed of off the plant site by this Contractor at an authorized dumping site approved by the City of Ames, Iowa.

This Contractor shall stockpile all topsoil excavated in this Contract. To the extent of topsoil available this topsoil shall be placed on the surface of all cuts, fills and on adjacent areas where topsoil has been stripped during construction under this Contract to the finish grades shown on the contract drawings to a uniform depth of six inches.

Topsoil shall be placed on slopes after the fill or excavation is completed to the final grade shown on the accompanying drawings. The surfaces shall be chiseled to bind the topsoil to the fill or excavated area.

RESPONSIBILITY FOR DAMAGE: This Contractor will be excavating near and around existing and new construction and shall take all necessary precautions to prevent damage as he will be held solely responsible for damage done.

EMBANKMENT

SCOPE OF WORK: The work covered by this section consists of furnishing all plant, equipment, tools, labor and materials and performing all operations necessary for constructing all required fills, embankments and any other required fill as shown on the drawings and/or as specified herein.

The natural and existing ground surfaces as shown on the drawings are approximate only. Embankments and fills shall be constructed to the net grade and cross section shown and except as otherwise specified without additional allowance for shrinkage of the fill.

MATERIALS: Embankment materials shall be obtained from required pond excavations and if necessary from the designated borrow area as shown on the drawings and as specified in the EXCAVATION AND BACKFILL section of the specification. All impervious embankment and fill materials shall be obtained from required pond excavations. Material shall be free of roots, stone, debris, or similar objects larger than two inches in diameter.

Pervious materials shall be free-draining sand or gravelly sand consisting of sound durable particles and shall contain not over 10% passing the U.S. standard No. 200 sieve.

Impervious materials shall be fine-grained materials of low permeability consisting of clays, clay silts, or silts, and shall be free of plant growth, roots, and humus. In general, the particle size of impervious material shall be such that a minimum of 50 percent of the soil particles shall pass a U. S. Standard No. 200 screen and, where possible, shall be material classified as CL or CH on the plasticity chart of the Unified Soil Classification Chart, revised 1960 and published in Vicksburg Experiment Station Technical Memorandum 3-357.

Random materials shall consist of pervious materials, impervious materials or any combination thereof.

Natural blanket soils (or materials) refers to the natural deposit of fine-grained soils. The surface soils encountered by the test borings primarily consist of silty clays and clayey silts varying in thickness and containing a slight to moderate sand content at various locations. The silty clayey surface soil is principally underlain by a brown silty medium fine textured sand which may contain clayey levels and seams and becoming courser with depth, altering to a course textured sand. These soils are typically stratified having been water-deposited and reworked many times. The natural moisture of these materials varies generally with the season of the year and stage of the river.

Waste fill is any existing sanitary and trash landfill excavated. The waste fill shall be removed to a licensed sanitary landfill approved by the Engineer.

The degree of compaction for impervious materials expressed hereinafter as a percentage of maximum density refers to a maximum density at optimum moisture, determined in accordance with test procedures presented in ASTM D-698 (Standard Proctor). The degree of compaction for pervious materials placed, expressed hereinafter as a percentage of relative density, shall be determined in accordance with the test procedures presented in ASTM D-2049.

The location in the work for materials will be classified by the Engineer and shall be placed within the proper fill zones of the embankments, as shown.

FOUNDATION PREPARATION: After stripping, horizontal surfaces to receive fill shall be thoroughly scarified to a depth of six inches immediately prior to compaction and compacted as specified. If, for any reason, the surface to receive fill becomes compacted in such a manner or growth of vegetation develops to such an extent that in the opinion of the Engineer, a plane, seepage, or weakness might be induced, the surface shall again be thoroughly scarified. Where embankments are constructed against an existing slope (either a natural or excavated slope or that of a previously placed portion of embankment), the existing slope, after stripping operations, shall be cut or notched through any loose or dried material on the surface, and the compaction equipment shall work on both the existing material and the new fill to bond them together. Excavation for removal of objectionable material for embankment and drainage ditches, depressions and holes resulting from clearing and grubbing operations and voids caused by the removal or part removal of old foundations and structures or any other excavation required for removal of materials considered objectionable by the Engineer shall be backfilled and compacted to original grade or to the excavation shown on the applicable drawings, with impervious material compacted to at least 95 percent of maximum density and pervious material compacted to at least 80 percent of relative density.

GROUND WATER CONTROL: Where excavation is to be performed below ground water level and placement of compacted fill is required, placement of fill shall be conducted in the dry. If seepage occurs and results in any loosening of the foundation soils, or if, in the opinion of the Engineer, there is reason to believe loosening of the foundation soils will occur, the Contractor shall install a suitable dewatering system which will nullify the excess seepage gradient. Any loosened foundation material shall be compacted to at least 95 percent of maximum density. The water level shall be allowed to rise only after sufficient fill has been placed to offset the uplift pressure of the water. Methods for care of water and controlling the ground water level and seepage gradients shall be subject to review by the Engineer.

PLACEMENT AND COMPACTION REQUIREMENTS: The embankment and fills shall be constructed of compacted earth fill zones as indicated. Except on surfaces of impervious fill material, the top six inches of material placed on surfaces of ramps, road and pond embankment fills shall consist of topping material consisting of friable clay silts possessing characteristics of representative soils in the vicinity which produce a heavy growth of vegetation and meet the requirements for impervious material. The surfaces shall be chiseled to bind the topping material to the fill material. The material shall be free from stones or similar objects larger than two inches in diameter, stumps, roots, and any toxic substance or substances which may be harmful to plant growth or be a hindrance to grading, planting and maintenance operations. The fill areas shall be graded to drain and shall be left in a reasonably smooth condition that will not result in the ponding of water.

EQUIPMENT: Tamper-type rollers shall consist of a heavy-duty, double drum unit with a drum diameter not less than 60 inches and an individual drum length of not less than 60 inches. The drums shall be liquid, or sand and liquid ballasted during use. Each drum shall have staggered feet uniformly spaced over the cylindrical surface such as to provide approximately three tamping feet for each two feet of drum surface. The tamper feet shall be seven to nine and a half inches in clear projection from the cylindrical surface of the roller and shall have a face area of not less than six or more than 10 square inches. The rolling units of multiple-type tamping rollers shall be pivoted on the main frame in a manner which will permit the units to adapt themselves to uneven ground surfaces and to rotate independently. The roller shall be equipped with cleaner bars, designed and attached to prevent the accumulation of material between the tamping feet; and these cleaner bars shall be maintained at their full length throughout the period of roller use. The weight of the roller shall be between 1000 pounds and 1500 pounds per linear foot of drum length empty and be capable of being ballasted to at least 2000 pounds per foot of linear drum length. The design and operation of the tamping roller shall be acceptable to the Engineer. At any time during prosecution of the work, repairs to the tamping feet, minor alterations in the rollers, and variations in the weight as may be found necessary to secure optimum compaction of the earth fill materials shall be performed. Rollers shall be self-propelled or drawn by a crawler-type tractor. Self-propelled rollers exceeding the empty weight requirement may be used provided that by the substitution of tamping feet having a face area not exceeding 14 square inches, the nominal foot pressure on the tamping feet of the self-propelled roller can be adjusted to approximate the nominal foot pressure of the towed roller for the particular working condition required for the towed rollers. If the self-propelled rollers cause shearing of the fill or laminations in the fill, the Engineer may direct that the self-propelled rollers be removed from the fill and that tractor-drawn tamping rollers be used. For self-propelled rollers, in which steering is accomplished through the use of rubber-tired wheels, the tire pressure shall not exceed 40 pounds per square inch. Rollers shall be operated at a speed not to exceed 3.5 miles per hour.

Crawler-type tractors used for compaction shall weigh not less than 40,000 pounds.

Power tampers will be acceptable subject to obtaining densities comparable to that specified for the material and zone of the embankment being compacted.

Sprinkling equipment shall consist of pressure distributors designed to apply water in controlled quantities to variable widths of surface. Sprinkling equipment depending solely on gravity flow for dispensing water to the fill will not be permitted.

COVERAGE:

a. Tamping Rollers. A complete pass shall consist of complete coverage of the area to be compacted with each trip of the roller overlapping the adjacent trip by not less than one foot.

b. Crawler Tractor. One pass shall consist of complete coverage by the tractor with sufficient overlap of successive tread paths to ensure complete coverage.

c. Power Tampers. Surfaces to be compacted in confined areas inaccessible for rolling shall be tamped uniformly with power tampers to obtain densities equal to that obtained by rollers or crawler tractors as applicable.

PLACEMENT AND COMPACTION: Layers shall be started full width out to the slope stakes and shall be carried substantially horizontal with sufficient slope to provide satisfactory drainage during construction. Portions of the fill, which are inaccessible to rolling, shall be compacted in three inch uncompacted lifts with power tampers. Hauling equipment shall be operated to avoid tracking insofar as practicable. When ruts appear in the surface of any layer of material to be rolled, the surface shall be scarified so that all ridges and bridging between ruts are broken down and the surface of the layer regraded and made uniform before compaction. Where the surface of any layer in the impervious fill or random fill has been made too smooth to bond properly with the succeeding layer, it shall be loosened by scarifying and recompacted. If the work is stopped for 24 hours or more, or if rainfall is imminent and is anticipated in sufficient amounts to cause temporary shutdown of operations, the impervious or random zones (except where the random fill is pervious material) shall be smooth bladed to drain and sealed with rubber-tired rollers, or other acceptable equipment as required to inhibit absorption of rainfall. Embankment and fills shall be scarified and recompacted after becoming unduly wet or after freezing before additional fill material is placed. Finished slopes shall present a uniform appearance without pronounced irregularities.

An overbuild of 0.5 foot above the prescribed grades will be permitted in the final dressing, provided any excess material is so distributed that there are no abrupt humps or depressions in the surfaces or bulges in the width of the crown. The above grade tolerance may be modified at locations where such modifications will not impair the design or appearance of the embankment. Fill material shall not be placed upon frozen surfaces nor shall frozen earth, snow, or ice be placed in the fill.

Impervious materials shall be placed in impervious fill zones in approximately horizontal layers not exceeding eight inches in thickness. Each layer shall be compacted to at least 95 percent of maximum density at optimum moisture. Before rolling is started, each layer shall be dried by aeration or have moisture added as necessary to obtain a uniform moisture content within the limits of three percent above and three percent below the optimum moisture for maximum density.

Random materials shall be placed in the random fill zones where shown on the drawings.

When random fill consists of impervious materials, it shall be placed and compacted in accordance with all requirements specified for impervious fill. When random fill consists of pervious material and is placed by rolled fill method, it shall be placed in maximum 12 inch uncompacted lifts. Each lift of pervious material when placed as fill shall be wetted as directed to facilitate compaction by not less than three passes of a crawler type tractor or vibrating roller acceptable to the Engineer. Pervious material placed by roll filled methods shall be compacted to at least 80 per cent relative density, as determined by ASTM Specification D-2049. When the random fill is a combination of pervious and impervious material and there is a question as to which method of compaction should be used, the method of compaction shall be determined by the Engineer.

After each layer of material is finished, it shall be inspected by the Engineer or his representative before beginning a new layer. If the material fails to meet the density specified, the course shall be reworked as necessary to obtain the specified compaction, and the compaction method or subsequent work shall be altered to obtain the specified density. Such procedure shall be determined by the Engineer.

Materials placed in area fill shall meet the requirements for embankment fill.

Materials placed in the required area fill shall be placed and compacted as described for rolled fill.

ACCESS ROADS, HAUL ROADS AND RAMPS: At locations where access roads to fields or buildings are destroyed because of the work required under this Contract, the Contractor shall provide temporary access roads during the construction period. Such facilities shall be removed to the extent required by the Engineer. Excavated materials or stockpiles of supplies shall not be placed, nor shall equipment be stored or operated in such manner as to preclude ingress to or egress from the fields and buildings.

Haulroads and ramps constructed for the prosecution of the work shall be to such line, grade, and width as to fulfill the requirements for safe and efficient hauling operations, and shall be subject to review and acceptance by the Engineer. Construction of ramps by excavation into the side slopes of the new or existing embankments will not be permitted., Subsequent to the completion of the work prior to acceptance by the Owner, the Contractor shall, where so directed by the Engineer, remove temporary construction ramps, and plow, scarify or otherwise loosen all haul roads, the areas occupied by ramps, and the access way (other than existing roads) to a minimum depth of six inches and the surface left in a reasonably smooth condition.

APPENDIX A

Document 3

NPDES Permit No. TN 85003-0-02

File
NPDES Permit

Fields of Opportunities

STATE OF IOWA

THOMAS J. VILSACK, GOVERNOR
SALLY J. PEDERSON, LT. GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
JEFFREY R. VONK, DIRECTOR

RECEIVED
JUL 27 2001
ELEC. ADMIN.

July 23, 2001

Mr. Gary Titus
Electric - Assistant Director
City of Ames Power Plant
P.O. Box 811
502 Carroll Avenue
Ames, IA 50010

RE: NPDES Permit Number 85-03-0-02

Dear Mr. Titus:

Enclosed please find a National Pollutant Discharge Elimination System (NPDES) permit for your wastewater discharge. You are authorized to discharge the pollutants specified in this permit in accordance with the effluent limitations, monitoring requirements and other terms set forth in this permit.

Any existing Iowa NPDES permit previously issued by the department for this facility is revoked by the issuance of this Iowa NPDES operation permit.

All reporting and monitoring set forth in this permit shall be directed to the Iowa Department of Natural Resources Field Office #5, 401 SW 7th - Suite I, Des Moines, Iowa 50309.

Sincerely,

Marcia A. Decker

Marcia A. Decker
NPDES Permit Writing Specialist
Wastewater Section
marcia.decker@dnr.state.ia.us

Enc: NPDES Permit

cc: Field Office 5

IOWA DEPARTMENT OF NATURAL RESOURCES
National Pollutant Discharge Elimination System (NPDES) Permit

PERMITTEE

CITY OF AMES
5TH AND CARROLL
AMES, IA 50010

IDENTITY AND LOCATION OF FACILITY

AMES MUNICIPAL ELECTRIC SYSTEM
Section 1, T 83N, R24W
STORY County, Iowa

IOWA NPDES PERMIT NUMBER: 8503002

DATE OF ISSUANCE: 07-23-2001

DATE OF EXPIRATION: 07-22-2006

RECEIVING STREAM

SOUTH SKUNK RIVER

ROUTE OF FLOW

YOU ARE REQUIRED TO FILE
FOR RENEWAL OF THIS PERMIT BY: 01-23-2006

EPA NUMBER: IA0033235

This permit is issued pursuant to the authority of section 402(b) of the Clean Water Act (33 U.S.C 1342(b)), Iowa Code section 455B.174, and rule 567--64.3, Iowa Administrative Code. You are authorized to operate the disposal system and to discharge the pollutants specified in this permit in accordance with the effluent limitations, monitoring requirements and other terms set forth in this permit.

You may appeal any conditions of this permit by filing a written notice of appeal and request for administrative hearing with the director of this department within 30 days of your receipt of this permit.

Any existing, unexpired Iowa operation permit or Iowa NPDES permit previously issued by the department for the facility identified above is revoked by the issuance of this Iowa NPDES operation permit.

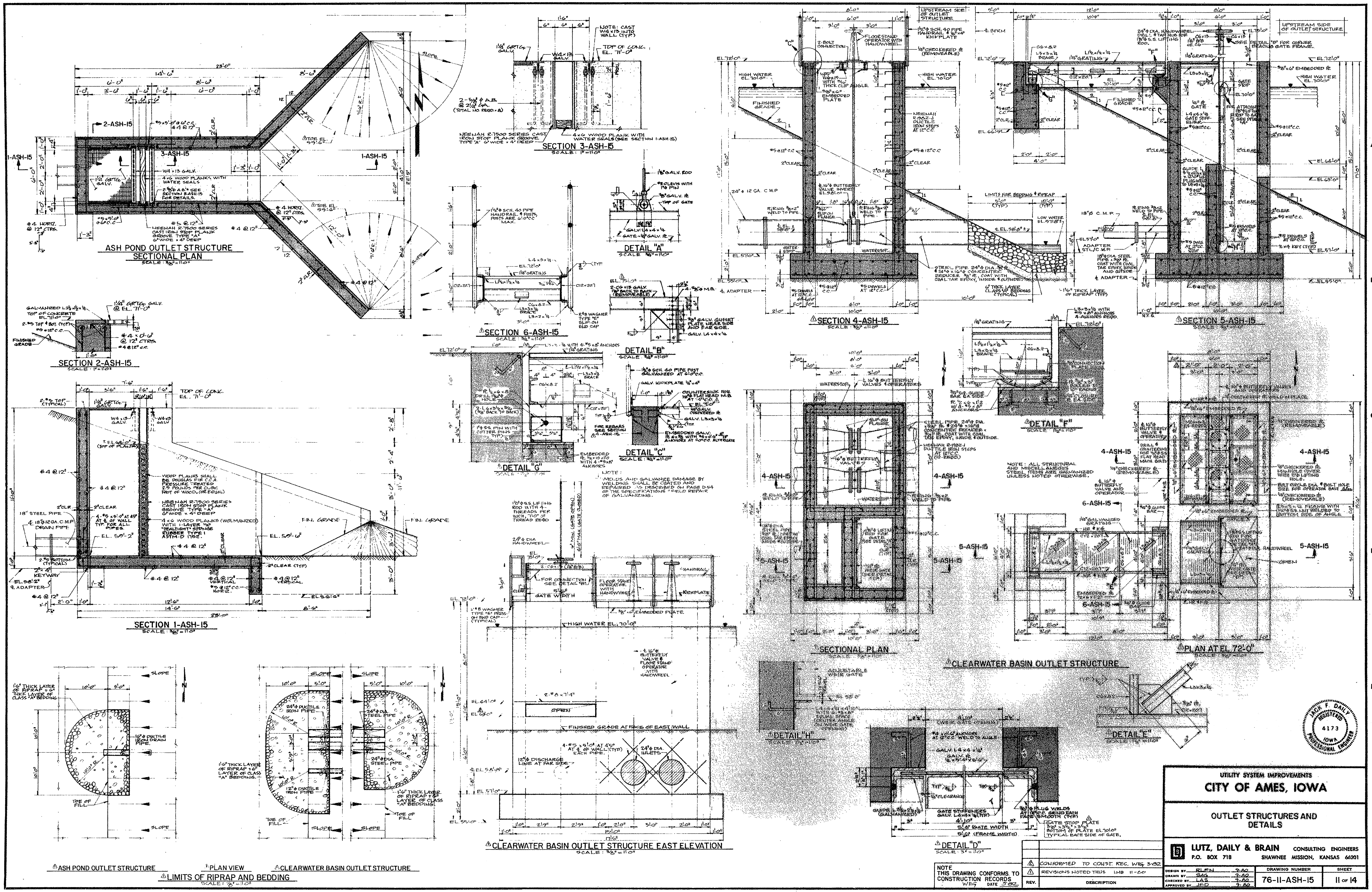
FOR THE DEPARTMENT OF NATURAL RESOURCES

By ______________________
Wayne Farrand, Supervisor
Wastewater Section
ENVIRONMENTAL PROTECTION DIVISION

APPENDIX A

Document 4

Design Drawing "Lime and Ash Pond Outlet Structures and Details"



NOTE
THIS DRAWING CONFORMS TO CONSTRUCTION RECORDS
WEG DATE 5-82

REV.	DESCRIPTION
2	CONFORMED TO CONST. REC. WEG 3-82
1	REVISIONS NOTED THUS LMB 11-80

UTILITY SYSTEM IMPROVEMENTS
CITY OF AMES, IOWA
OUTLET STRUCTURES AND DETAILS

LUTZ, DAILY & BRAIN CONSULTING ENGINEERS
P.O. BOX 718 SHAWNEE MISSION, KANSAS 66201

DESIGN BY	RLFN	9-80
DRAWN BY	SAG	9-80
CHECKED BY	LAS	9-80
APPROVED BY	JFD	9-80

DRAWING NUMBER: 76-11-ASH-15
SHEET: 11 OF 14

APPENDIX A

Document 5

Iowa Stormwater Management Manual, Section 2C-2, Rainfall and Runoff Analysis

2C-2 Rainfall and Runoff Analysis

A. Introduction

1. The first step in any hydrologic analysis is an estimation of the rainfall that will fall on the site for a given time period. The amount of rainfall can be quantified with the following characteristics:

   a. **Duration (hours).** Length of time over which rainfall (storm event) occurs.

   b. **Depth (inches).** Total amount of rainfall occurring during the storm duration.

   c. **Intensity (inches per hour).** Depth divided by the duration.

2. A design event is used as a basis for determining the design of a new urban storm water management project or evaluating an existing project. It is presumed that the project will function properly if it can accommodate the design event at full capacity. For economic reasons, some risk of failure is allowed in selection of the design event. This risk is usually related to return period.

3. The frequency of a rainfall event is the recurrence interval of storms having the same duration and volume (depth). This can be expressed either in terms of exceedence probability or return period.

   a. **Exceedence probability.** Probability that a storm event having the specified duration and volume will be exceeded in one given time period, typically one year.

   b. **Return period.** Average length of time between events that have the same duration and volume.

   Thus, if a storm event with a specified duration and volume has a 1% chance of occurring in any given year, then it has an exceedence probability of 0.01, and a return period of 100 years.

Urban stormwater projects are designed based on storm runoff, so a runoff event must be selected for design. However, runoff data are usually not available to determine the discharge-return period or runoff volume-return period for design. Rainfall data is available in various formats for a number of gauge stations across Iowa.

Summary data can be accessed at: http://mesonet.agron.iastate.edu/climodat/index.phtml. Hourly (TD3240) and 15-minute (TD3260) rainfall data are available from the National Climate Data Center: http://www.ncdc.noaa.gov/oa/ncdc.html for the National Weather Service Coop recording gauge stations in Iowa. Most all of the Coop stations in Iowa have a minimum of 60 years of hourly rainfall data, and many have 100 years on record. A rainfall record is converted to runoff using a rainfall-runoff model. Two methods are available: a continuous simulation approach, and the single-event design storm approach. For the continuous simulation method, a chronological record of rainfall for the area of interest is used as input to a rainfall-runoff model of the urban watershed being considered. The output can then be used as a chronological record of runoff to determine the maximum runoff peak and total volume for a selected design period. The Storm Water Management Model (SWMM v.5, EPA) and HEC-HMS (Hydraulic Engineering Center, USACE) are examples of models with continuous simulation capability. Both of these programs are available as public domain software programs. The software programs define the format for importing the rainfall data.

In the single-event design storm method, a rainfall record is analyzed to obtain a rainfall-return period relationship. Next, the storm event corresponding to a design return period is identified as the design storm. This design storm is then used as input to a mathematical rainfall-runoff model (i.e. Rational method, NRCS WINTR-55), and the resulting output is adopted as the design runoff (peak rate and/or volume). The single-event design storm method is the most commonly-used method for smaller urban catchments and urban developments. For assessment of larger urban stormwater systems (>1 mi^2) and regional detention basins, a continuous simulation method is recommended.

The design storm can be described as a return period, rainfall depth, average rainfall intensity, rain duration, or a time distribution of rainfall. Rainfall intensity refers to the time rate of rainfall (in/hr). The intensity will vary over the duration of the event, and a plot of rainfall intensity vs. time is called a hyetograph. The total depth of rainfall is the depth to which the rain would accumulate if it stayed in place where it fell. The average intensity is the total rainfall depth divided by the storm duration. Rain intensity will exhibit spatial variation, but is usually not considered for small urban watersheds (< 2000 acres).

The selection of the return period for design will depend on the relative importance of the facility being designed, cost (economics), desired level of protection, and damages resulting from a failure. Typical design return periods for storm sewer conveyance in Iowa (inlets and piping) vary from 2-10 years, with 5 years being most common. For culverts, design periods of 25-50 years are typical, depending on the type and level of service for the roadway. For detention basins, 25-100 years are common. Additional specific design storm criteria for stormwater quality and quantity management are covered in later sections of this manual.

The design storm duration also depends on the type of project. For peak discharge design of urban storm sewers and culverts, the design storm should be the one that results in the largest peak discharge for a given return period. For urban areas with a mix of pervious and impervious area, as the imperviousness increases, the time of concentration will decrease, and the peak runoff rate will increase. The shorter T_c will result in a higher rainfall intensity, and will give the highest peak discharge. As will be covered later in the Rational method for determining peak runoff rate, duration, and subsequently the rainfall intensity used for input, is dependent on the time of concentration for the catchment configuration. For storm sewer design, a minimum duration of 5 minutes is typically specified.

For development of runoff hydrographs using unit hydrograph methods, a storm duration much longer than than the time of concentration is selected. For the NRCS methods for unit hydrograph development, the duration of the storm will be almost twice the time of concentration. For the design of detention basins, the duration of the storm should be that which yields the highest storage requirement. The duration then becomes a function of the relative size of the detention basin, the watershed size, and the outlet configuration, and will be much longer than the duration used for peak discharge determination. This is of particular note when the Modified Rational method is used to size detention basin volume, particularly for catchment sizes more than 15-20 acres.

As described later in this manual, the design storm for management of stormwater quality is defined as the rainfall depth representing the 90% cumulative probability annual rainfall depth – this is the depth of rainfall that represents 90% of the rainfall events, based on a cumulative occurrence frequency. These will be the rainfall events with a recurrence interval of 3-4 months and generally will be less than 1.25 inches in depth. This water quality design storm is used to determine the water quality volume (WQv) for sizing stormwater quality BMPs. Additional details are provided in section 2C-6. The water quality design storm depth is determined using a cumulative frequency analysis of 24-hour precipitation event totals for the period of record for a local area. The rainfall events with a depth of less than 0.1 inches are excluded from the analysis, since these very seldom produce measurable runoff. The individual events are then grouped by depth intervals of 0.2 inches, and the frequency of depth occurrence tabulated to determine the cumulative rainfall depth occurrence until all of the rainfall events in the period of record are included. The smaller rainfall events are more frequent (smaller return period) while the larger storms more infrequent (smaller number) and have a larger return period.

For example, 90% of the annual rainfall events recorded at the NWS Coop rainfall gauge in Ames, Iowa for the period of record from 1960-2006, are less than or equal to 1.25 inches (computation based only on those rainfall events that generate measurable runoff; rainfall events less than 0.1 inch were subtracted from the total for calculation of occurrence frequency. For all rainfall events in the total period of record (100 years for most stations in Iowa), the 90% occurrence depth is 1 inch or less.

A rainfall analysis for the NWS Coop gauge on the southwest edge of Ames was performed for the period of record 1960-2006. The results are summarized in Table 1. Rainfall data for all of the NWS Coop sites in Iowa is available from the National Climate Data Center (NCDC) http://lwf.ncdc.noaa.gov/oa/climate/climatedata.html. The data is available in 24-hour totals recorded at 15-minute and 1-hour intervals. The frequency analysis is completed by first identifying the individual rainfall events by a separation interval (in this case, 6 hours). This means that each rainfall event is separated from the next measurable rainfall by the selected interval. The individual rainfall events are then grouped into discrete depth categories, as shown in the tabulated data for Ames. The number of events in each depth category are totaled, and the depth class total is divided by the total number of rainfall events for the period of record. For the 1960-2006 period of record, there were 3,362 events with more than 0.1 inches of precipitation. Rainfall depths less than 0.1 inches usually do not produce any measurable runoff, so when these events are subtracted from the total, there are 1,999 rainfall events with greater 0.1 inches depth. The cumulative frequency is computed by dividing the cumulative number of events at each depth category by the total number of events (1,999) to provide a percent frequency of occurrence for each depth range.

For the Ames data, 90.6% of the rainfall events (greater than 0.1 inch) had a depth of 1.25 inches or less. This is termed the "90% cumulative occurrence frequency," and is the rainfall depth recommended for determining the WQv for Iowa. Also note, for the rainfall frequency for Ames, that the average annual rainfall for the period 1960-2006 was 31.58 inches, and the mean rainfall depth (P_6) is 0.62 inches. The mean rainfall depth, P_6, is used in the calculation of the water quality capture volume (WQCV) for sizing extended detention storage for water quality improvement. The WQv is one of the unified sizing criteria discussed in Part 2B and used throughout this manual for the sizing of stormwater quality BMPs. The method for WQCV is discussed in more detail in Section 2C-6.

Table 1: Rainfall summary for Ames, IA for the period 1960-2006

Rainfall Depth - inches	Number of Events	Cumulative Frequency	Annual Rainfall in Frequency Class	Cumulative Percent of Annual Average Rainfall
0.01 - 0.10	1363		2.30	
0.11 - 0.25	651	32.57%	2.98	
0.26 - 0.50	596	62.38%	5.66	
0.51 - 0.75	262	75.49%	4.21	
0.76 - 1.00	182	84.59%	4.08	
1.01 - 1.25	120	90.60%	3.47	69.7%
1.26 - 1.50	73	94.25%	2.57	78.4%
1.51 - 1.75	37	96.10%	1.56	83.8%
1.76 - 2.00	32	97.70%	1.52	89.0%
2.01 - 3.00	35	99.45%	2.14	96.3%
3.01 - 4.00	8	99.85%	0.70	98.7%
4.01 - 5.00	1	99.90%	0.11	99.0%
5.01 - 6.00	2	100.00%	0.28	100.0%
> 6.00	0			
		Annual Average Precipitation	**31.58**	
Total Events > 0.01	**3362**			
Total events > 0.10	**1999**	**Mean Storm Depth**	**0.62-inches**	

B. Rainfall frequency analysis

Additional frequency analysis techniques are used to develop relationships between the average intensity, storm duration, and return period from rainfall data. Often, the rainfall depth is used in place of the average intensity. To establish the importance of the relationship between average intensity, duration, and frequency, the U.S. Weather Bureau compiled data for development of Intensity-Duration-Frequency (I-D-F) curves based on historic rainfall data for most localities across the country. Herschfield (1961) developed these relationships for the entire US, and the data was published in the National Weather Service Technical Paper 40 (TP40) publication. The Rainfall Frequency Atlas of the Midwest – Bulletin 71 (Huff and Angell, 1992), published by the Midwest Climate Center and the Illinois Water Survey, includes rainfall depth, duration, and return period frequency analysis in tabular format for the nine climate districts in Iowa (Figure 1). The Bulletin 71 summary data are provided in both rainfall depth and rainfall intensity in Tables 2 and 3 respectively. The Bulletin 71 data includes the additional rainfall data for the additional period or record since 1960, and is recommended as the primary source for single-event design procedures.

Figure 1: Climatic Sectional Codes for Iowa*

01 - Northwest	04 - West Central	07 - Southwest
02 - North Central	05 – Central	08 - South Central
03 - Northeast	06 - East Central	09 - Southeast

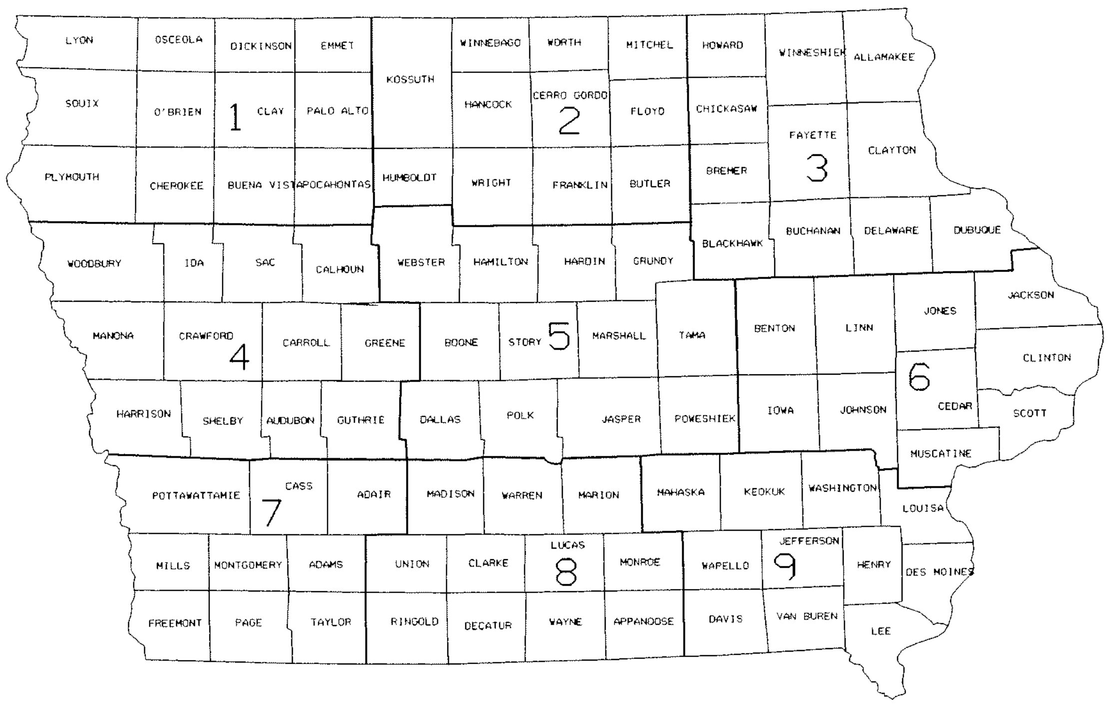


Table 2: Sectional mean rainfall amounts for storm periods of 5 minutes to 10 days and recurrence intervals of 3 months to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	3-mo	4-mo	6-mo	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
01	10-day	2.39	2.75	3.24	4.05	4.81	5.84	6.70	8.02	9.11	10.31
01	5-day	1.90	2.15	2.49	3.11	3.77	4.68	5.43	6.61	7.60	8.75
01	72-hr	1.66	1.88	2.18	2.72	3.33	4.21	4.99	6.07	7.12	8.23
01	48-hr	1.55	1.73	2.00	2.50	3.01	3.81	4.52	5.60	6.53	7.52
01	24-hr	1.42	1.55	1.80	2.22	2.75	3.50	4.14	5.11	5.97	6.92
01	18-hr	1.34	1.46	1.69	2.09	2.59	3.29	3.89	4.80	5.61	6.50
01	12-hr	1.24	1.35	1.56	1.93	2.39	3.05	3.60	4.45	5.19	6.02
01	6-hr	1.06	1.16	1.34	1.66	2.06	2.62	3.11	3.83	4.48	5.19
01	3-hr	0.91	0.99	1.15	1.42	1.76	2.24	2.65	3.27	3.82	4.43
01	2-hr	0.83	0.90	1.04	1.29	1.59	2.03	2.40	2.96	3.46	4.01
01	1-hr	0.67	0.73	0.84	1.04	1.29	1.64	1.95	2.40	2.81	3.25
01	30-min	0.52	0.57	0.66	0.82	1.02	1.30	1.53	1.89	2.21	2.56
01	15-min	0.38	0.42	0.49	0.60	0.74	0.95	1.12	1.38	1.61	1.87
01	10-min	0.30	0.33	0.38	0.47	0.58	0.73	0.87	1.07	1.25	1.45
01	5-min	0.17	0.19	0.22	0.27	0.33	0.42	0.50	0.61	0.72	0.83
02	10-day	2.37	2.73	3.21	4.01	5.04	6.26	7.32	8.93	10.37	11.40
02	5-day	2.10	2.37	2.75	3.44	4.13	5.05	5.80	7.00	8.03	9.28
02	72-hr	1.74	1.97	2.29	2.86	3.53	4.45	5.15	6.33	7.30	8.30
02	48-hr	1.66	1.84	2.14	2.67	3.30	4.11	4.78	5.80	6.67	7.67
02	24-hr	1.51	1.65	1.91	2.36	2.98	3.72	4.38	5.33	6.14	7.07
02	18-hr	1.42	1.55	1.80	2.22	2.80	3.50	4.12	5.01	5.77	6.65
02	12-hr	1.31	1.43	1.66	2.06	2.59	3.24	3.80	4.64	5.34	6.15
02	6-hr	1.13	1.24	1.43	1.77	2.24	2.79	3.29	4.00	4.61	5.30
02	3-hr	0.97	1.06	1.22	1.51	1.91	2.38	2.80	3.41	3.93	4.52
02	2-hr	0.88	0.96	1.11	1.37	1.73	2.16	2.54	3.09	3.56	4.10
02	1-hr	0.71	0.78	0.90	1.11	1.40	1.75	2.06	2.51	2.89	3.32
02	30-min	0.56	0.61	0.70	0.87	1.10	1.38	1.62	1.97	2.27	2.62
02	15-min	0.41	0.45	0.52	0.64	0.80	1.00	1.18	1.44	1.66	1.91
02	10-min	0.32	0.35	0.41	0.50	0.63	0.78	0.92	1.12	1.29	1.48
02	5-min	0.18	0.20	0.23	0.28	0.36	0.45	0.53	0.64	0.74	0.85
03	10-day	2.49	2.87	3.38	4.22	5.04	6.17	7.07	8.29	9.20	10.19
03	5-day	2.03	2.29	2.66	3.32	3.94	4.86	5.64	6.84	7.75	8.77
03	72-hr	1.74	1.97	2.29	2.86	3.44	4.33	5.14	6.19	7.00	7.84
03	48-hr	1.61	1.79	2.07	2.59	3.20	4.02	4.69	5.62	6.34	7.09
03	24-hr	1.48	1.62	1.88	2.32	2.91	3.67	4.31	5.11	5.73	6.36
03	18-hr	1.40	1.53	1.77	2.18	2.74	3.45	4.05	4.80	5.39	5.98
03	12-hr	1.29	1.41	1.64	2.02	2.53	3.19	3.75	4.45	4.99	5.53
03	6-hr	1.11	1.22	1.41	1.74	2.18	2.75	3.23	3.83	4.30	4.77
03	3-hr	0.95	1.04	1.20	1.48	1.86	2.35	2.76	3.27	3.67	4.07
03	2-hr	0.86	0.94	1.09	1.35	1.69	2.13	2.50	2.96	3.32	3.69
03	1-hr	0.70	0.76	0.88	1.09	1.37	1.72	2.03	2.40	2.69	2.99
03	30-min	0.55	0.60	0.70	0.86	1.08	1.36	1.59	1.89	2.12	2.35
03	15-min	0.40	0.44	0.51	0.63	0.79	0.99	1.16	1.38	1.55	1.72
03	10-min	0.31	0.34	0.40	0.49	0.61	0.77	0.91	1.07	1.20	1.34
03	5-min	0.18	0.20	0.23	0.28	0.35	0.44	0.52	0.67	0.69	0.76

Source: Bulletin 71, *Rainfall Frequency Atlas of the Midwest*, 1992

Table 2 (continued): Sectional mean rainfall amounts for storm periods of 5 minutes to 10 days and recurrence intervals of 3 months to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	3-mo	4-mo	6-mo	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
04	10-day	2.59	2.99	3.51	4.39	5.22	6.31	7.16	8.24	9.21	10.27
04	5-day	2.11	2.39	2.77	3.46	4.06	4.94	5.74	7.04	8.13	9.27
04	72-hr	1.79	2.02	2.34	2.93	3.51	4.37	5.13	6.28	7.26	8.46
04	48-hr	1.67	1.86	2.15	2.69	3.16	3.97	4.71	5.86	6.81	7.82
04	24-hr	1.59	1.74	2.01	2.48	2.94	3.64	4.30	5.27	6.08	7.00
04	18-hr	1.49	1.63	1.89	2.33	2.76	3.42	4.04	4.95	5.72	6.58
04	12-hr	1.38	1.51	1.75	2.16	2.56	3.17	3.74	4.58	5.29	6.09
04	6-hr	1.19	1.30	1.51	1.86	2.20	2.73	3.23	3.95	4.56	5.25
04	3-hr	1.02	1.11	1.29	1.59	1.88	2.33	2.75	3.37	3.89	4.48
04	2-hr	0.92	1.01	1.17	1.44	1.71	2.11	2.49	3.06	3.53	4.06
04	1-hr	0.75	0.82	0.95	1.17	1.38	1.71	2.02	2.48	2.86	3.29
04	30-min	0.59	0.64	0.75	0.92	1.09	1.35	1.59	1.95	2.25	2.59
04	15-min	0.43	0.47	0.54	0.67	0.79	0.98	1.16	1.42	1.64	1.89
04	10-min	0.33	0.36	0.42	0.52	0.62	0.76	0.90	1.11	1.28	1.47
04	5-min	0.19	0.21	0.24	0.30	0.35	0.44	0.52	0.63	0.73	0.84
05	10-day	2.64	3.05	3.58	4.48	5.20	6.22	7.22	8.61	9.66	10.88
05	5-day	2.11	2.39	2.77	3.46	4.05	4.94	5.72	6.92	7.98	9.18
05	72-hr	1.77	2.00	2.32	2.90	3.47	4.41	5.16	6.22	7.06	8.12
05	48-hr	1.64	1.82	2.11	2.64	3.13	3.93	4.67	5.75	6.52	7.33
05	24-hr	1.52	1.67	1.93	2.38	2.91	3.64	4.27	5.15	5.87	6.61
05	18-hr	1.43	1.57	1.81	2.24	2.74	3.42	4.01	4.84	5.52	6.21
05	12-hr	1.32	1.45	1.68	2.07	2.53	3.17	3.71	4.48	5.11	5.75
05	6-hr	1.15	1.25	1.45	1.79	2.18	2.73	3.20	3.86	4.40	4.96
05	3-hr	0.97	1.06	1.23	1.52	1.86	2.33	2.73	3.30	3.76	4.23
05	2-hr	0.88	0.97	1.12	1.38	1.69	2.11	2.48	2.99	3.40	3.83
05	1-hr	0.72	0.78	0.91	1.12	1.37	1.71	2.01	2.42	2.76	3.11
05	30-min	0.56	0.62	0.71	0.88	1.08	1.35	1.58	1.91	2.17	2.45
05	15-min	0.41	0.45	0.52	0.64	0.79	0.98	1.15	1.39	1.58	1.78
05	10-min	0.32	0.35	0.41	0.50	0.61	0.76	0.90	1.08	1.23	1.39
05	5-min	0.19	0.20	0.23	0.29	0.35	0.44	0.51	0.62	0.70	0.79
06	10-day	2.57	2.96	3.49	4.36	5.21	6.27	7.12	8.25	9.27	10.35
06	5-day	2.20	2.48	2.88	3.60	4.12	4.89	5.61	6.70	7.75	9.00
06	72-hr	1.84	2.08	2.41	3.01	3.59	4.53	5.31	6.42	7.35	8.42
06	48-hr	1.61	1.79	2.08	2.60	3.21	4.15	5.05	6.02	6.87	7.83
06	24-hr	1.54	1.68	1.94	2.40	3.06	3.84	4.44	5.42	6.25	7.13
06	18-hr	1.45	1.58	1.83	2026	2.88	3.61	4.17	5.09	5.88	6.70
06	12-hr	1.34	1.46	1.69	2.09	2.66	3.34	3.86	4.72	5.44	6.20
06	6-hr	1.15	1.26	1.46	1.60	2.30	2.88	3.33	4.07	4.69	5.35
06	3-hr	0.99	1.08	1.25	1.54	1.96	2.46	2.84	3.47	4.00	4.56
06	2-hr	0.89	0.97	1.13	1.39	1.77	2.23	2.58	3.14	3.62	4.14
06	1-hr	0.72	0.79	0.92	1.13	1.44	1.80	2.09	2.55	2.94	3.35
06	30-min	0.57	0.62	0.72	0.89	1.13	1.42	1.64	2.01	2.31	2.64
06	15-min	0.42	0.45	0.53	0.65	0.83	1.04	1.20	1.46	1.69	1.93
06	10-min	0.32	0.35	0.41	0.50	0.64	0.81	0.93	0.14	1.31	1.50
06	5-min	0.19	0.20	0.23	0.29	0.37	0.46	0.53	0.65	0.75	0.86

Table 2 (continued): Sectional mean rainfall amounts for storm periods of 5 minutes to 10 days and recurrence intervals of 3 months to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	3-mo	4-mo	6-mo	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
07	10-day	2.76	3.18	3.74	4.67	5.47	6.54	7.53	9.00	10.25	11.66
07	5-day	2.17	2.45	2.84	3.55	4.26	5.30	6.20	7.59	8.71	9.86
07	72-hr	1.94	2.19	2.54	3.18	3.85	4.79	5.56	6.78	7.80	8.99
07	48-hr	1.84	2.05	2.38	2.97	3.53	4.38	5.11	6.19	7.09	8.04
07	24-hr	1.77	1.93	2.24	2.76	3.22	3.93	4.57	5.56	6.45	7.28
07	18-hr	1.66	1.81	2.10	2.59	3.03	3.69	4.30	5.23	6.06	6.84
07	12-hr	1.54	1.68	1.94	2.40	2.80	3.42	3.98	4.48	5.61	6.33
07	6-hr	1.32	1.45	1.68	2.07	2.41	2.95	3.43	4.17	4.84	5.46
07	3-hr	1.13	1.24	1.43	1.77	2.06	2.52	2.92	3.56	4.13	4.66
07	2-hr	1.02	1.12	1.30	1.60	1.87	2.28	2.65	3.22	3.74	4.22
07	1-hr	0.83	0.91	1.05	1.30	1.51	1.85	2.15	2.61	3.03	3.42
07	30-min	0.65	0.71	0.83	1.02	1.19	1.45	1.69	2.06	2.39	2.69
07	15-min	0.48	0.52	0.61	0.75	0.87	1.06	1.23	1.50	1.74	1.97
07	10-min	0.37	0.41	0.47	0.58	0.68	0.83	0.96	1.17	1.35	1.53
07	5-min	0.21	0.23	0.27	0.33	0.39	0.47	0.55	0.67	0.77	0.87
08	10-day	2.74	3.16	3.72	4.65	5.45	6.61	7.57	8.99	10.09	11.04
08	5-day	2.17	2.45	2.84	3.55	4.32	5.37	6.26	7.64	8.78	9.99
08	72-hr	1.88	2.13	2.46	3.08	3.67	4.68	5.64	6.90	7.96	9.24
08	48-hr	1.74	1.93	2.24	2.80	3.39	4.30	5.06	6.28	7.35	8.60
08	24-hr	1.60	1.75	2.03	2.50	3.11	3.87	4.65	5.78	6.73	7.74
08	18-hr	1.50	1.64	1.90	2.35	2.92	3.64	4.37	5.43	6.33	7.28
08	12-hr	1.39	1.52	1.76	2.17	2.71	3.37	4.05	5.03	5.86	6.73
08	6-hr	1.20	1.32	1.52	1.88	2.33	2.90	3.49	4.34	5.05	5.80
08	3-hr	1.02	1.12	1.30	1.60	1.99	2.48	2.98	3.70	4.31	4.95
08	2-hr	0.93	1.01	1.17	1.45	1.80	2.24	2.70	3.35	3.90	4.49
08	1-hr	0.75	0.82	0.95	1.17	1.46	1.82	2.19	2.72	3.16	3.64
08	30-min	0.60	0.65	0.75	0.93	1.15	1.43	1.72	2.14	2.49	2.86
08	15-min	0.44	0.48	0.55	0.68	0.84	1.04	1.26	1.56	1.82	2.09
08	10-min	0.33	0.36	0.42	0.52	0.65	0.81	0.98	1.21	1.41	1.63
08	5-min	0.19	0.21	0.24	0.30	0.37	0.46	0.56	0.69	0.81	0.93
09	10-day	2.64	3.04	3.58	4.47	5.44	6.50	7.35	8.45	9.33	10.42
09	5-day	2.13	2.41	2.79	3.49	4.31	5.45	6.32	7.60	8.69	9.95
09	72-hr	1.82	2.06	2.38	2.98	3.79	4.87	5.74	6.95	7.88	8.98
09	48-hr	1.73	1.93	2.23	2.79	3.50	4.46	5.20	6.35	7.32	8.40
09	24-hr	1.60	1.75	2.03	2.50	3.14	4.03	4.67	5.67	6.58	7.59
09	18-hr	1.50	1.64	1.90	2.35	2.95	3.79	4.39	5.33	6.19	7.13
09	12-hr	1.39	1.52	1.76	2.17	2.73	3.51	4.06	4.93	5.72	6.60
09	6-hr	1.20	1.32	1.52	1.88	2.36	3.02	3.50	4.25	4.93	5.69
09	3-hr	1.02	1.12	1.30	1.60	2.01	2.58	2.99	3.63	4.21	4.86
09	2-hr	0.93	1.01	1.17	1.45	1.82	2.34	2.71	3.29	3.82	4.40
09	1-hr	0.75	0.82	0.95	1.17	1.48	1.89	2.19	2.66	3.09	3.57
09	30-min	0.60	0.65	0.75	0.93	1.16	1.49	1.73	2.10	2.43	2.81
09	15-min	0.44	0.48	0.55	0.68	0.85	1.09	1.26	1.53	1.78	2.05
09	10-min	0.33	0.36	0.42	0.52	0.66	0.85	0.98	1.19	1.38	1.59
09	5-min	0.19	0.21	0.24	0.30	0.38	0.48	0.56	0.68	0.79	0.91

Table 3: Sectional mean rainfall intensity for storm periods of 5 minutes to 10 days and recurrence intervals of 2 years to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
01	10-day	0.02	0.02	0.03	0.03	0.04	0.04
01	5-day	0.03	0.04	0.05	0.06	0.06	0.07
01	72-hr	0.05	0.06	0.07	0.08	0.10	0.11
01	48-hr	0.06	0.08	0.09	0.12	0.14	0.16
01	24-hr	0.12	0.15	0.17	0.21	0.25	0.29
01	18-hr	0.14	0.18	0.22	0.27	0.31	0.36
01	12-hr	0.20	0.25	0.30	0.37	0.43	0.50
01	6-hr	0.34	0.44	0.52	0.64	0.75	0.87
01	3-hr	0.59	0.75	0.88	1.09	1.27	1.48
01	2-hr	0.80	1.02	1.20	1.48	1.73	2.01
01	1-hr	1.29	1.64	1.95	2.40	2.81	3.25
01	30-min	2.40	2.60	3.06	3.78	4.42	5.12
01	15-min	2.96	3.80	4.48	5.52	6.44	7.48
01	10-min	3.48	4.38	5.22	6.42	7.50	8.70
01	5-min	3.96	5.04	6.00	7.32	8.64	9.96
02	10-day	0.02	0.03	0.03	0.04	0.04	0.05
02	5-day	0.03	0.04	0.05	0.06	0.07	0.08
02	72-hr	0.05	0.06	0.07	0.09	0.10	0.12
02	48-hr	0.07	0.09	0.10	0.12	0.14	0.16
02	24-hr	0.12	0.16	0.18	0.22	0.26	0.30
02	18-hr	0.16	0.19	0.23	0.28	0.32	0.37
02	12-hr	0.22	0.27	0.32	0.39	0.45	0.51
02	6-hr	0.37	0.47	0.55	0.67	0.77	0.88
02	3-hr	0.64	0.79	0.93	1.14	1.31	1.51
02	2-hr	0.87	1.08	1.27	1.55	1.78	2.05
02	1-hr	1.40	1.75	2.06	2.51	2.89	3.32
02	30-min	2.20	2.76	3.24	3.94	4.54	5.24
02	15-min	3.20	4.00	4.72	5.76	6.64	7.64
02	10-min	3.78	4.68	5.52	6.72	7.74	8.88
02	5-min	4.32	5.40	6.36	7.68	8.88	10.20
03	10-day	0.02	0.03	0.03	0.04	0.04	0.04
03	5-day	0.03	0.04	0.05	0.06	0.07	0.07
03	72-hr	0.05	0.06	0.07	0.09	0.10	0.11
03	48-hr	0.07	0.08	0.10	0.12	0.13	0.15
03	24-hr	0.12	0.15	0.18	0.21	0.24	0.27
03	18-hr	0.15	0.19	0.23	0.27	0.30	0.33
03	12-hr	0.21	0.27	0.31	0.37	0.42	0.46
03	6-hr	0.36	0.46	0.54	0.64	0.72	0.80
03	3-hr	0.62	0.78	0.92	1.09	1.22	1.36
03	2-hr	0.85	1.07	1.25	1.48	1.66	1.85
03	1-hr	1.37	1.72	2.03	2.40	2.69	2.99
03	30-min	2.16	2.72	3.18	3.78	4.24	4.70
03	15-min	3.16	3.96	4.64	5052	6.20	6.88
03	10-min	3.66	4.62	5.46	6.42	7.20	8.04
03	5-min	4.20	5.28	6.24	8.04	8.28	9.12

Source: Bulletin 71, *Rainfall Frequency Atlas of the Midwest*, 1992

Table 3 (continued): Sectional mean rainfall intensity for storm periods of 5 minutes to 10 days and recurrence intervals of 2 years to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
04	10-day	0.02	0.03	0.03	0.03	0.04	0.04
04	5-day	0.03	0.04	0.05	0.06	0.07	0.08
04	72-hr	0.05	0.06	0.07	0.09	0.10	0.12
04	48-hr	0.07	0.08	0.10	0.12	0.14	0.16
04	24-hr	0.12	0.15	0.18	0.22	0.25	0.29
04	18-hr	0.15	0.19	0.22	0.28	0.32	0.37
04	12-hr	0.21	0.26	0.31	0.38	0.44	0.51
04	6-hr	0.37	0.46	0.54	0.66	0.76	0.88
04	3-hr	0.63	0.78	0.92	1.12	1.23	1.49
04	2-hr	0.86	1.06	1.25	1.53	1.77	2.03
04	1-hr	1.38	1.71	2.02	2.48	2.86	3.29
04	30-min	2.18	2.70	3.18	3.90	4.50	5.18
04	15-min	3.16	3.92	4.64	5.68	6.56	7.56
04	10-min	3.72	4.56	5.40	6.66	7.68	8.82
04	5-min	4.20	5.28	6.24	7.56	8.76	10.08
05	10-day	0.02	0.03	0.03	0.04	0.04	0.05
05	5-day	0.03	0.04	0.05	0.06	0.07	0.08
05	72-hr	0.05	0.06	0.07	0.09	0.10	0.11
05	48-hr	0.06	0.08	0.10	0.12	0.14	0.15
05	24-hr	0.12	0.15	0.18	0.22	0.25	0.28
05	18-hr	0.15	0.19	0.22	0.27	0.31	0.34
05	12-hr	0.21	0.26	0.31	0.37	0.43	0.48
05	6-hr	0.36	0.46	0.53	0.64	0.73	0.83
05	3-hr	0.62	0.78	0.91	1.10	1.25	1.41
05	2-hr	0.85	1.06	1.24	1.50	1.70	1.92
05	1-hr	1.37	1.71	2.01	2.42	2.76	3.11
05	30-min	2.16	2.70	3.16	3.82	4.34	4.90
05	15-min	3.16	3.92	4.60	5.56	6.32	7.12
05	10-min	3.66	4.56	5.40	6.48	7.38	8.34
05	5-min	4.20	5.28	6.12	7.44	8.40	9.48
06	10-day	0.02	0.03	0.03	0.03	0.04	0.04
06	5-day	0.03	0.04	0.05	0.06	0.07	0.08
06	72-hr	0.05	0.06	0.07	0.09	0.10	0.12
06	48-hr	0.07	0.09	0.11	0.13	0.14	0.16
06	24-hr	0.13	0.16	0.19	0.23	0.26	0.30
06	18-hr	0.16	0.20	0.23	0.28	0.33	0.37
06	12-hr	0.22	0.28	0.32	0.39	0.45	0.52
06	6-hr	0.38	0.48	0.56	0.68	0.78	0.89
06	3-hr	0.65	0.82	0.95	1.16	1.33	1.52
06	2-hr	0.89	1.12	1.29	1.57	1.81	2.07
06	1-hr	1.44	1.80	2.09	2.55	2.94	3.35
06	30-min	2.26	2.84	3.28	4.02	4.62	5.28
06	15-min	3.32	4.16	4.80	5.84	6.76	7.72
06	10-min	3.84	4.86	5.58	6.84	7.86	9.00
06	5-min	4.44	5.52	6.36	7.80	9.00	10.32

Table 3 (continued): Sectional mean rainfall intensity for storm periods of 5 minutes to 10 days and recurrence intervals of 2 years to 100 years in Iowa (see Figure 2, Iowa Map)

Rainfall (inches) for given recurrence interval T, return period, years

*Section	Duration	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
07	10-day	0.02	0.03	0.03	0.04	0.04	0.05
07	5-day	0.04	0.04	0.05	0.06	0.07	0.08
07	72-hr	0.05	0.07	0.08	0.09	0.11	0.13
07	48-hr	0.07	0.09	0.11	0.13	0.15	0.17
07	24-hr	0.13	0.16	0.19	0.23	0.27	0.30
07	18-hr	0.17	0.21	0.24	0.29	0.34	0.38
07	12-hr	0.23	0.29	0.33	0.37	0.47	0.53
07	6-hr	0.40	0.49	0.57	0.70	0.81	0.91
07	3-hr	0.69	0.84	0.97	1.19	1.38	1.55
07	2-hr	0.94	1.14	1.33	1.61	1.87	2.11
07	1-hr	1.51	1.85	2.15	2.61	3.03	3.42
07	30-min	2.38	2.90	3.38	4.12	4.78	5.38
07	15-min	3.48	4.24	4.92	6.00	6.96	7.88
07	10-min	4.08	4.98	5.76	7.02	8.10	9.18
07	5-min	4.68	5.64	6.60	8.04	9.24	10.44
08	10-day	0.02	0.03	0.03	0.04	0.04	0.05
08	5-day	0.04	0.05	0.05	0.06	0.07	0.08
08	72-hr	0.05	0.07	0.08	0.10	0.11	0.13
08	48-hr	0.07	0.09	0.11	0.13	0.15	0.18
08	24-hr	0.13	0.16	0.19	0.24	0.28	0.32
08	18-hr	0.16	0.20	0.24	0.30	0.35	0.40
08	12-hr	0.23	0.28	0.34	0.42	0.49	0.56
08	6-hr	0.39	.048	0.58	0.72	0.84	0.97
08	3-hr	0.66	0.83	0.99	1.23	1.44	1.65
08	2-hr	0.90	1.12	1.35	1.68	1.95	2.25
08	1-hr	1.46	1.82	2.19	2.72	3.16	3.64
08	30-min	2.30	2.86	3.44	4.28	4.98	5.72
08	15-min	3.36	4.16	5.04	6.24	7.28	8.36
08	10-min	3.90	4.86	5.88	7.26	8.46	9.78
08	5-min	4.44	5.52	6.72	8.28	9.72	11.16
09	10-day	0.02	0.03	0.03	0.04	0.04	0.04
09	5-day	0.04	0.05	0.05	0.06	0.07	0.08
09	72-hr	0.05	0.07	0.08	0.10	0.19	0.13
09	48-hr	0.07	0.09	0.11	0.13	0.15	0.18
09	24-hr	0.13	0.17	0.20	0.24	0.27	0.32
09	18-hr	0.16	0.21	0.24	0.30	0.34	0.40
09	12-hr	0.23	0.29	0.34	0.41	0.48	0.55
09	6-hr	0.39	0.50	0.58	0.71	0.82	0.95
09	3-hr	0.67	0.86	1.00	1.21	1.40	1.62
09	2-hr	0.91	1.17	1.36	1.65	1.91	2.20
09	1-hr	1.48	1.89	2.19	2.66	3.09	3.57
09	30-min	2.32	2.98	3.46	4.20	4.86	5.62
09	15-min	3.40	4.36	5.04	6.12	7.12	8.20
09	10-min	3.96	5.10	5.88	7.14	8.28	9.54
09	5-min	4.56	5.76	6.72	8.16	9.48	10.92

The Rational method uses the I-D-F curves or rainfall depth/duration frequency transforms directly, while the NRCS methods generalize the rainfall data taken from the I-D-F curves and create rainfall distributions for various regions of the country. Rainfall intensity-duration-and-return period frequency data are provided in tabular format in Table 4 for the nine climate districts in Iowa. The data in Table 2 can be used directly in the Rational method once the T_c for the catchment and the critical duration have been determined. The initial task for the designer is to determine which combinations of storm durations and intensities are appropriate to use in a hydrologic analysis for a typical urban development. Working within the limitations of the procedures described later in this section, small drainage areas in an urban setting can be accurately modeled using either NRCS or the Rational methods. The methods are empirical, and the designer must stay within the bounds of the assumptions and restrictions relevant to the method being used. The belief that the short, very intense storm generates the greatest need for stormwater management often leads designers to use the Rational method for stormwater management design, since this method is based on short-duration storms. However, the NRCS 24-hour storm is also appropriate for short duration storms since it includes short storm intensities within the 24-hour distribution.

The selection of an appropriate time distribution for the design rainfall event must also be considered. The design objective is to select a runoff event of a particular frequency. A particular rainfall frequency may not always produce a runoff event with an identical frequency – i.e., a smaller rainfall depth occurring in a very short period may actually produce a larger peak runoff than a larger rainfall event spread more uniformly over the event duration. As the size of the watershed decreases and the imperviousness increases, the selection of the distribution becomes critical. Larger and less impervious watersheds will often attenuate the large pulses of rainfall and smooth out the runoff hydrographs. This rainfall distribution criterion is inherent in the governing assumption in the Rational method that the duration be equal to the time of concentration, and the watershed be fairly homogeneous in land use.

C. NRCS 24-hour storm distribution

The NRCS 24-hour storm distribution curve was derived from the National Weather Bureau's Rainfall Frequency Atlases of compiled data for areas less than 400 square miles, for durations up to 24 hours, and for frequencies from 1 to 100 years. Data analysis resulted in four regional distributions:

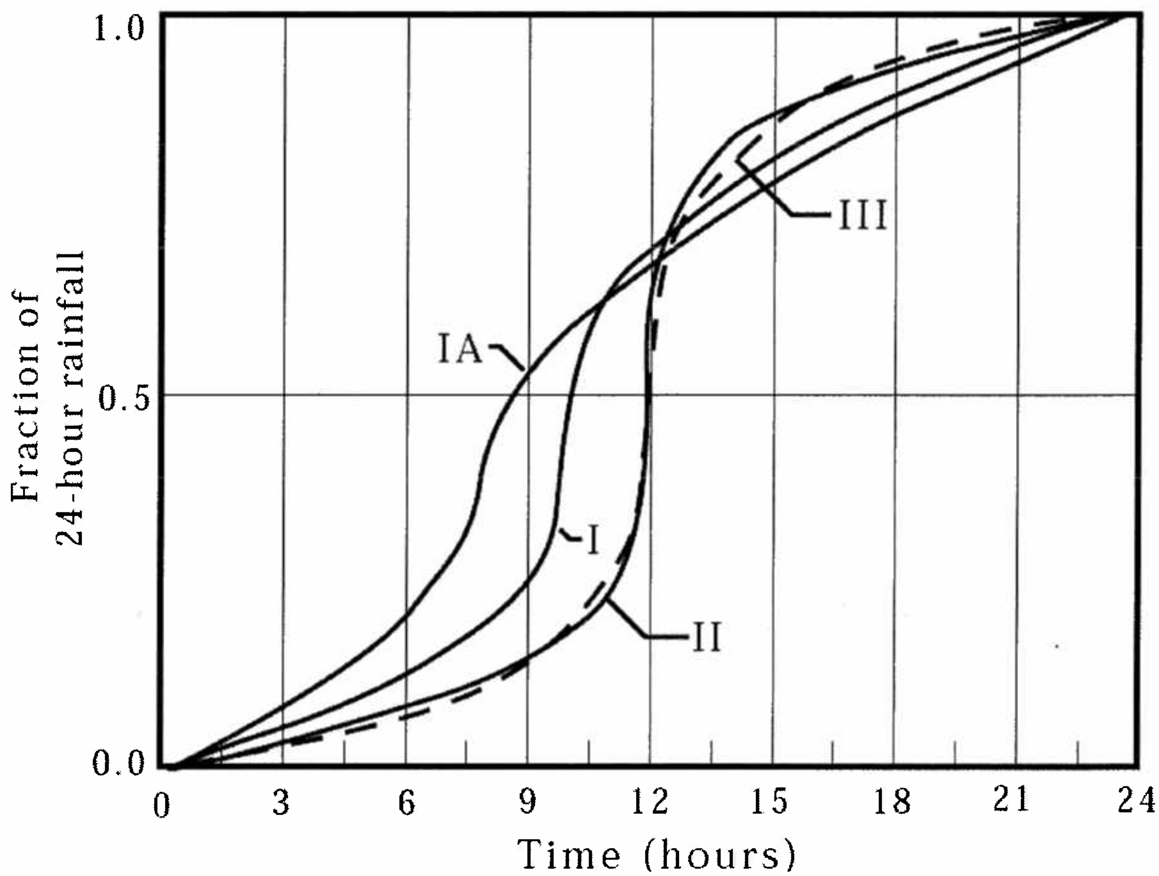
- Type I and Ia for use in Hawaii, Alaska, and the coastal side of the Sierra Nevada and Cascade Mountains in California, Washington, and Oregon
- Type II distribution for most of the remainder of the United States (including Iowa)
- Type III for the Gulf of Mexico and Atlantic coastal areas. The Type III distribution represents the potential impact of tropical storms which can produce large 24-hour rainfall amounts.

Iowa and all of the upper Midwest fall under the Type II rainfall distribution. For a more detailed description of the development of dimensionless rainfall distributions, refer to the USDA Soil Conservation Service's National Engineering Handbook (NRCS NEH), Part 630, Section 4 - http://www.info.usda.gov/CED/.

The NRCS 24-hour storm distributions are based on the generalized rainfall depth-duration-frequency relationships collected for rainfall events lasting from 30 minutes up to 24 hours. Working in 30-minute increments, the rainfall depths are arranged with the maximum rainfall depth assumed to occur in the middle of the 24-hour period. The next largest 30-minute incremental depth occurs just after the maximum depth; the third largest rainfall depth occurs just prior to the maximum depth, etc. This continues with each decreasing 30-minute incremental depth until the smaller increments fall at the beginning and end of the 24-hour rainfall (see Figure 2).

The length of the most intense rainfall period contributing to the peak runoff rate is related to the time of concentration (T_c) for the watershed. In a hydrograph created with NRCS procedures, the duration of rainfall that directly contributes to the peak is about 170 percent of the T_c. For example, the most intense 8.5-minute rainfall period would contribute to the peak discharge for a watershed with a T_c of 5 minutes; the most intense 8.5-hour period would contribute to the peak for a watershed with a 5-hour T_c. To avoid the use of different sets of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having "nested" rainfall intensities was developed. The set maximizes the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level. For the size of the drainage areas for which NRCS usually provides assistance, a storm period of 24 hours was chosen for the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges, but also the runoff volumes for a range of drainage area sizes.

Figure 2: NRCS 24-hour rainfall distributions



Source: NRCS, 1986

The NRCS Urban Hydrology for Small Watersheds (WINTR-55) prompts the user to enter the rainfall distribution type (I, Ia, II, or III), and then computes the direct surface runoff volume in inches and the peak runoff rate using the applicable 24-hour rainfall distribution.

There are numerous excellent texts and handbooks that describe the use of rainfall data to generate a design storm for the design of drainage systems (e.g., ASCE, 1994; Chow, 1964; NRCS, 1985). For low-impact development (LID) hydrology, a unique approach has been developed to determine the design storm based on the basic philosophy of LID. This approach is described in Section 2C-8.

Rainfall abstractions include the physical processes of interception of rainfall by vegetation, evaporation from land surfaces and the upper soil layers, transpiration by plants, infiltration of water into soil surfaces, and storage of water in surface depressions. Although these processes can be evaluated individually, simplified hydrologic modeling procedures typically consider the combined effect of the various components of rainfall abstraction. The rainfall abstraction can be estimated as a depth of water (inches) over the total area of the site. This depth effectively represents the portion of rainfall that does not contribute to surface runoff. The portion of rainfall that is not abstracted by interception, infiltration, or depression storage is termed the excess rainfall or runoff. The rainfall abstraction may change depending on the configuration of the site development plan. Of particular concern is the change in impervious cover. Impervious areas prevent infiltration of water into soil surfaces, effectively decreasing the rainfall abstraction and increasing the resulting runoff. Post-development conditions, characterized by higher imperviousness, significantly decrease the overall rainfall abstraction, resulting not only in higher excess surface runoff volume, but also a rapid accumulation of rainwater on land surfaces.

In the Rational method the runoff coefficient "C" determines the amount of rainfall converted to runoff (Section 2C-4). In the NRCS method, a curve number "CN" is used to determine the direct runoff volume and rate based on the land use and soil type. The NRCS runoff curve number (CN) method is described in detail in NRCS NEH-4, and a summary is provided in Section 2C-5.

APPENDIX A

Document 6

Soil Boring Logs for Lime and Ash Pond, Borings Drilled March, 1980

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 194874

Boring No. 1

Date Drilled 3/21/80
Surface Elevation 61.7
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Proposed Lagoon System and Pumphouse
Ames Municipal Power Plant Facility
Client City of Ames, c/o Lutz Daily and Brain
Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
								2	Very dark brown silty fine sandy clay (CL), moist Brown and very sandy after 1.75'
	1	ST		13.8	110				Brown silty medium fine sand (SM), moist Cleaner after 4' with minor silt seams
5								7.25	Medium textured after 6'
10							▽	15	Brown coarse sand (SW), wet with minor gravel to 5/8" Gray levels after 9' Gray sand and interbedded with gray clayey silt seams after 12.5'
15									

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(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 194874

Boring No. 2

Date Drilled 3/21/80

Surface Elevation 62.0

Depth Drilled 15'

Drilling Method 4" CFA

Project Proposed Lagoon System and Pumphouse
Ames Municipal Power Plant Facility

Client City of Ames, c/o Lutz Daily and Brain
Shawnee Mission, Kansas

Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Very dark brown silty clay (CL), moist Very sandy to 6" Brown and sandy after 2'
								2.5	
	1	ST		19.3	103				Brown silty medium fine sand (SM), moist
5									Clayey levels (SC) and seams alternating with medium fine sand seams after 5.5'
								7.5	
									Brown coarse sand (SW), saturated
							▽		Medium fine after 9' with brown and gray levels
10									Interbedded with gray clayey silt seams after 10.5' to 12.5' Coarse sand after 12.5'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 3

Date Drilled 3/21/80
Surface Elevation 61.8
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ______ ft @ ______ hrs. (▼), ______ ft@ ______ hrs.

Project: Proposed Lagoon System and Pumphouse Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Very dark brown silty clay (CL), moist Sandy to 6" Mottled with brown after 2' Brown after 2.75' Sandy after 3'
	1	ST							
5								4.75	Brown and light gray brown clayey silt and fine sand (ML-SM), moist
								7.5	Brown medium to coarse sand (SW), saturated
							▽		
10									
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 4 (Page 1 of 2)

Date Drilled 3/19/80
Surface Elevation 61.5
Depth Drilled 50'
Drilling Method 4" CFA
Depth to Water 8 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL-CH), moist
									Brown after 3.75'
5								5.5	Sandy after 5'
	1	ST		18.4					Brown medium fine sand (SP), damp clayey to 6'
10	2	SS	4, 2, 3, 7	21.8			▽		Clayey and silty levels (CL-SC) after 8' and wet
			6, 10					12	Brown coarse sand (SW) silty levels, saturated
15			10, 15, 11, 7						Gray silty clay seams, wet (6" thick) at 17.5'
20			11, 10, 13						Gray coarse sand after 18' Fine gravel content
25		D C	20, 12, 9, 11, 17, 9						
30			16, 16, 17, 23, 25, 19						
35			16, 11, 12						Coal shale chip and fragment content after 34'
40			20, 24, 19, 22, 24, 31						Medium fine sand, saturated after 40' Minor to medium gray
45			13, 14, 14						

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 4 (Page 2 of 2)

Date Drilled 3/19/80
Surface Elevation 61.5
Depth Drilled 50'
Drilling Method 4" CFA
Depth to Water 8 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
			15, 19, 16, 20						Medium fine sand, saturated
50			21					50	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 5

Date Drilled 3/19/80
Surface Elevation 61.9
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 8 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft@ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Very dark brown silty clay (CL), moist
									Dark brown after 2'
	1	ST		21.8	101				Brown after 4'
5									Sandy after 5.25'
								5.5	Brown clayey sand and silt (SC), very moist to moist
								7	Brown coarse sand (SW), wet
							▽		
10									Red-brown after 10' to 10.5' Gray silty clay seams, wet at 10.5' to 10.75' Light gray brown medium sand after 10.75'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 6

Date Drilled 3/19/80
Surface Elevation 62.2
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs.(▼), ____ ft@ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL), moist Brown after 2' Sandy (CL-SC) after 2.5'
	1	ST		16.9	107				
5								5	Brown medium fine sand (SP), damp
								7.5	Brown coarse sand (SW), wet to saturated
							▽		
10									Gray silty sandy clay layer, wet at 11' to 11.5'
15								15	

K-31

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 7

Date Drilled 3/19/80
Surface Elevation 61.9
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 8.5 ft @ completion (▽), ______ ft @ ______ hrs. (▼), ______ ft@ ______ hrs.

Project Proposed Lagoon System and Pumphouse
Ames Municipal Power Plant Facility
Client City of Ames, c/o Lutz Daily and Brain
Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL), moist Brown with a gray tint after 2' Sandy after 2.5'
	1	ST		16.6	108			4	
5									Brown medium fine sand (SP), damp Wet to saturated after 7'
							▽		
10									Gray silty clay layer, wet 10.5' to 11' Gray silty coarse sand (SM) after 11'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 8

Date Drilled 3/19/80
Surface Elevation 62.5
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ______ ft @ ______ hrs. (▼), ______ ft@ ______ hrs.

Project Proposed Lagoon System and Pumphouse
Ames Municipal Power Plant Facility
Client City of Ames, c/o Lutz Daily and Brain
Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL), moist Brown and sandy after 2'
	1	ST						4	
5									Brown medium fine sand (SP), moist Silty levels and seams Medium textured (SW), wet after 7'
							▽ (9)		
10									Gray clayey silt and sand seams, wet at indefinite levels after 10.5' Gray coarse sand after 11.5'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 9

Date Drilled 3/19/80
Surface Elevation 62.7
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9.5 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Very dark brown silty clay (CL), moist
									Dark brown after 2'
									Sandy after 2.25'
	1	ST							
5								5.75	
									Brown medium fine sand (SP), moist
									Silty and clayey (SM), wet after 7.5'
10							▽		Cleaner formation (SW) after 10'
									Coarse and silty after 11.5'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 10

Date Drilled 3/19/80
Surface Elevation 62.7
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL), moist
									Dark brown to brown and slightly sandy after 2'
	1	ST		23.2	96				Sand content increases with depth after 3.75'
5								4.5	
									Brown medium fine sand (SP), moist Medium after 6'
									Wet after 7.5'
							▽		
10									Minor to coarse (SW) after 10'
									Gray clayey seams at 12.5' Gray silty coarse sand (SM) after 12.75'
15								15	

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 11

Date Drilled 3/21/80
Surface Elevation 63.1
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs.(▼), ____ ft@ ____ hrs.

Project: Proposed Lagoon System and Pumphouse, Ames Municipal Power Plant Facility
Client: City of Ames, c/o Lutz Daily and Brain, Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
	1	ST						4.74	Dark brown silty sandy clay (CL), moist. High sand content to 6". Dark brown to brown after 2.25' and a gray tint
5								6.25	Silty clayey medium fine sand (SM-SC)
								8	Light gray brown to brown clayey silt (ML), very moist. Medium rust leaching. Sandy to 7'
10							▽	10.25	Brown medium sand (SP), wet to saturated
								12	Light gray brown and brown clayey silt (ML), wet. Sandy after 11.5'
15								15	Brown and light gray-brown medium fine sand (SW), saturated

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LOG OF TEST BORING

LAB. NO. 194874

Boring No. 12

Date Drilled 3/21/80
Surface Elevation 61.9
Depth Drilled 15'
Drilling Method 4" CFA
Depth to Water 9 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Proposed Lagoon System and Pumphouse
Ames Municipal Power Plant Facility
Client City of Ames, c/o Lutz Daily and Brain
Shawnee Mission, Kansas

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
0									Dark brown silty clay (CL), moist Dark brown to brown after 2' Slightly sandy after 3' Brown after 4'
3–4	1	ST							
								6.5	Brown silty medium fine sand (SM), wet
9							▽		
								11.5	Light gray-brown silty medium fine sand (SP-SM), saturated Brown medium coarse sand (SW) after 14'
15								15	

APPENDIX A

Document 7

Soil Boring Logs for Lime and Ash Pond, Borings Drilled July, 1980

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. P 1 (Piezometer)

Date Drilled 7/29/80
Surface Elevation
Depth Drilled 25'
Drilling Method 6" CFA
Depth to Water 11 ft @ completion (▽), ft @ hrs. (▼), ft @ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty sandy clay to clayey silt, moist
5									Brown after 5'
									Sandy after 7'
								8	
10									Brown fine sand, moist Medium sand (wet) after 10'
							▽		
15									Coarse levels Gray after 15'
20									
25								25	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. P 2 (Piezometer)

Date Drilled 7/29/80
Surface Elevation
Depth Drilled 25'
Drilling Method 6" CFA
Depth to Water 12 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and silty sandy clay, damp Moist after 1' Sandy after 8'
								8.5	Brown medium sand, moist Wet after 10'
							▽		Coarse after 12' and gray (gravel to 2" dia.)
								25	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. P 3 (Piezometer)

Date Drilled 7/29/80

Surface Elevation

Depth Drilled 25'

Drilling Method 6" CFA

Project Lagoon System Borrow Site, Ames Municipal Power Plant

Client City of Ames, c/o Lutz, Daily, & Brain

Depth to Water 13 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
0–10								10	Dark brown silty fine sand, damp Moist after 3.5' Very silty sandy clay after 4'
10–25							▽ (13)	25	Brown medium sand, damp to moist Wet after 12.5' Coarse after 15'

Boring 1-9 - Flood zone between east dike South Skunk River
Borings 13-16 in Ash Pond cell - additional data from March 1980 borings

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 1

Date Drilled 7/29/80
Surface Elevation 62.4'
Depth Drilled 10'
Drilling Method 6" CFA
Project Lagoon System Borrow Site, Ames Municipal Power Plant
Client City of Ames, c/o Lutz, Daily, & Brain
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft@ ____ hrs.

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey sandy silt, damp
									Very silty clay to silty clay (ML-CL), moist after 2'
									Silty clay (CL) after 3'
5									
									Wet sandy clay seams at 6.5'
									Very moist after 6.5'
10								10	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 2

Date Drilled 7/29/80
Surface Elevation 63.4'
Depth Drilled 10'
Drilling Method 6" CFA

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily & Brain

Depth to Water Dry-10 ft @ completion (▽), ______ ft @ ______ hrs. (▼), ______ ft @ ______ hrs.

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand, damp Silty and fine sandy clay (SM-ML), moist after 1.5' Dark brown to brown silty clay (CL) after 3'
5								6	
									Brown silty medium fine sand (SM), moist Slightly clayey
10								10	

K-43

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 3

Date Drilled 1/29/80
Surface Elevation 64.4'
Depth Drilled 10'
Drilling Method 6" CFA
Project Lagoon System Borrow Site, Ames Municipal Power Plant
Client City of Ames, c/o Lutz, Daily, & Brain
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand (SM), damp Dark brown silty clay (ML-CL), moist after 2' Trace of sand
5								6	
									Brown silty medium fine sand (SM), moist Slightly clayey
10								10	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 4

Date Drilled 7/29/80
Surface Elevation 63.9'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz Daily Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand (SM), damp Silty clay (ML-CL), moist after 1.5' Trace of sand
5								4.5	Brown slightly silty fine sand (SP), damp
10								10	

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 5

Date Drilled 7/29/80
Surface Elevation 63.1'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz Daily Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand (SM), damp Silty clay (ML-CL), moist after 1.5' Trace of sand Sandy after 4'
5								4.5	Brown slightly silty fine sand (SP), damp
10								10	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 6

Date Drilled 7/29/80
Surface Elevation 62.0'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water 9.5 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft@ ____ hrs.

Project: Lagoon System Borrow Site
Ames Municipal Power Plant
Client: City of Ames
c/o Lutz Daily Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey sandy silt (SM-ML), damp Silty clay (ML-CL), moist after 1' Trace of sand
5								4.5	
									Brown silty medium fine sand (SM-SP), moist Wet after 8'
10							▽	10	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 7

Date Drilled 7/29/80
Surface Elevation 61.6'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water Dry-10 ft @ completion (▽), ______ ft @ ______ hrs. (▼), ______ ft @ ______ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey sandy silt (ML), damp Very silty and fine sandy clay (ML), after 1' Dark brown to brown very silty sandy clay (CL), after 3'
5								6	
									Brown fine sand (SP), damp
10								10	

PATZIG TESTING LABORATORIES CO. INC.

(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 8

Date Drilled 7/29/80
Surface Elevation 62.9'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft@ ____ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and medium fine sand (SM-ML)
									Dark brown to brown silty and fine sandy clay (ML-CL) after 3'
5									Brown silty clay (CL) after 4.5'
								7.5	
									Brown medium fine sand (SW), moist Clayey seams
10								10	

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. BA 9

Date Drilled 7/29/80
Surface Elevation 63.4'
Depth Drilled 10'
Drilling Method 6" CFA
Depth to Water Dry-10 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Lagoon System Borrow Site
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand (ML), damp Silty and fine sandy clay, moist after 2' Silty clay (CL), moist after 4'
5								6	
									Dark brown clayey fine sand to silty fine sand (SM-SP) after 8'
10								10	

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. 13

Date Drilled 8/27/80
Surface Elevation 62.3'
Depth Drilled 15'
Drilling Method 6" CFA
Depth to Water 8.2 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft@ ____ hrs.

Project Lagoon System
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown very silty clay to silty clay (CL), damp Moist after 1'
5									Dark brown to brown clayey silt (ML-CL) after 6' Brown after 7'
							▽	9.5	
10								10.8	Brown clayey silt and fine sand (ML-SM), moist
15								15	Brown medium fine sand (SP), saturated

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. 14

Date Drilled 8/27/80
Surface Elevation 61.7'
Depth Drilled 15'
Drilling Method 6" CFA
Depth to Water 8 ft @ completion (▽), ___ ft @ ___ hrs. (▼), ___ ft @ ___ hrs.

Project: Lagoon System
Ames Municipal Power Plant

Client: City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown silty clay (CL), moist
5									Dark brown to brown after 4.5'
									Brown clayey silt after 5.5'
									Very moist after 7'
									Sandy (ML-SM) after 7.2'
							▽		
10								9.5	Brown medium fine sand (SP), wet
									Coarse after 12'
15								15	

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. 15

Date Drilled 8/27/80
Surface Elevation 63.4'
Depth Drilled 15'
Drilling Method 6" CFA
Depth to Water 8 ft @ completion (▽), ____ ft @ ____ hrs. (▼), ____ ft @ ____ hrs.

Project Lagoon System
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown clayey silt and fine sand (ML-SM), damp Moist after 1'
5									Dark brown to brown silty clay (CL), after 5'
							▽	9	
10								11.5	Brown slightly clayey silt and fine sand (ML-SM), very moist
15								15	Brown medium coarse sand (SW), wet

PATZIG TESTING LABORATORIES CO. INC.
(515) 266-5101 3922 DELAWARE AVENUE DES MOINES, IOWA 50313

LOG OF TEST BORING

LAB. NO. 196959

Boring No. 16

Date Drilled 8/27/80
Surface Elevation 62.2'
Depth Drilled 15'
Drilling Method 6" CFA
Depth to Water * ft @ completion (▽), ____ ft @ ____ hrs.(▼), ____ ft@ ____ hrs.

Project Lagoon System
Ames Municipal Power Plant
Client City of Ames
c/o Lutz, Daily, & Brain

Depth ft	Sample No.	Sample Type	SPT	MC %	D pcf	UCS psf	WL	Depth ft	Soil Description
									Dark brown very silty and fine sandy clay (CL), damp Moist after 1' Dark brown to brown after 4.5'
5								5.5	
									Brown clayey silt and fine sand (ML), moist Light gray-brown after 7'
								9	
10									Red-brown medium sand, (SW), moist Brown after 10' and wet
15								15	
									*Caved and dry @ 9'

APPENDIX B

Document 8

Dam Inspection Check List Lime and Ash Pond

Site Name:	**City of Ames Lime and Ash Pond**	Date:	**August 20, 2012**
Unit Name:	**Lime and Ash Pond**	Operator's Name:	**City of Ames, IA**
Unit I.D.:		Hazard Potential Classification:	**High** ☐ **Significant** ☒ **Low** ☐
	Inspector's Name:	Michael McLaren, P.E. and Joseph P. Klein, III, P.E.	

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?		X	18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	+70 ft		19. Major erosion or slope deterioration?	X	
3. Decant inlet elevation (operator records)?	+70 ft		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?	N/A	
5. Lowest dam crest elevation (operator records)?	+71/+74		Is water exiting outlet, but not entering inlet?	N/A	
6. If instrumentation is present, are readings recorded (operator records)?	N/A		Is water exiting outlet flowing clear?	X	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?	X		From underdrain?	N/A	
9. Trees growing on embankment? (If so, indicate largest diameter below)	X		At isolated points on embankment slopes?		X
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	X		From downstream foundation area?		X
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?	N/A	
15. Are spillway or ditch linings deteriorated?	X		22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?	N/A		23. Water against downstream toe?		X
17. Cracks or scarps on slopes?		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Issue #	Comments
1	Pool elevation measured daily. Inspection reports provided to Dewberry for review indicate the daily inspection focus is on pumps, valves, and pool elevation.
5	The 1,600 ft. long by 630 ft. wide impoundment was designed and constructed to be a dual purpose facility. The impoundment is divided into two main cells separated by an engineered dike that was included in the original design. The west cell is operated by the City of Ames Water Department to store dry lime recovered from the water treatment process. The crest elevation of the west and north dikes forming the Lime Pond is +71ft. The crest elevation of the three dikes forming the exterior perimeter of the Fly Ash Pond is +74ft. The crest elevation of the divider dike separating the Fly Ash Pond and Lime Pond is also +74ft. Elevations are based on City of Ames, IA datum.
9	Trees on the exterior slope of the north dike range up to about 3-in. to 4-in. in diameter.

12	Decant water from the Clear Water Pond cell within the Fly Ash Pond is pumped to the plant for recycling. The Fly Ash Pond does not discharge water to the environment.
19	Erosion observed along interior slope of south embankment. Erosion undermining small trees growing along slope. Based on the 15-ft. slope height, and 20-ft. crest width, the erosion is not considered an immediate threat to the stability of the embankment.

Coal Combustion Waste (CCW)

Impoundment Inspection

Impoundment NPDES Permit 85-03-0-02 **INSPECTOR** M. McLaren & Joe Klein

Date Issued July 23, 2001

Impoundment Name NPDES permit includes discharge from the coal pile runoff settling pond. As the Lime Pond/Fly Ash Pond management unit does not discharge to the environment, it is not listed on the NPDES permit.

Impoundment Company City of Ames Power Plant

EPA Region 7

State Agency (Field Office) Address Iowa Department of Natural Resources
Field Office 5
401 SW 7th St.
Suite I
Des Moines, IA 50309

Name of Impoundment Coal Pile Runoff Settling Pond
Lime Pond/Fly Ash Pond management unit not included on permit

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ☐ **Update** ☐

	Yes	**No**
Is impoundment currently under construction?	☐	☒
Is water or ccw currently being pumped into the impoundment?	☐	☒

IMPOUNDMENT FUNCTION: West portion of impoundment used to store dry lime recovered from the City of Ames water treatment process.
East portion of impoundment used to store sluiced bottom ash from the City of Ames Power Plant.

Nearest Downstream Town Name: Ames, Iowa

Distance from the impoundment: Ames Power Plant and CCR impoundment are located within the city limit of Ames, IA.

Location:

Latitude	42	Degrees	01	Minutes	41.27	Seconds	**N**
Longitude	93	Degrees	57	Minutes	57.71	Seconds	**W**

State IA **County** Story

	Yes	No
Does a state agency regulate this impoundment?	☒	☐

If So Which State Agency? Iowa Department of Natural Resources

HAZARD POTENTIAL *(In the event the impoundment should fail, the following would occur):*

☐ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

☐ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

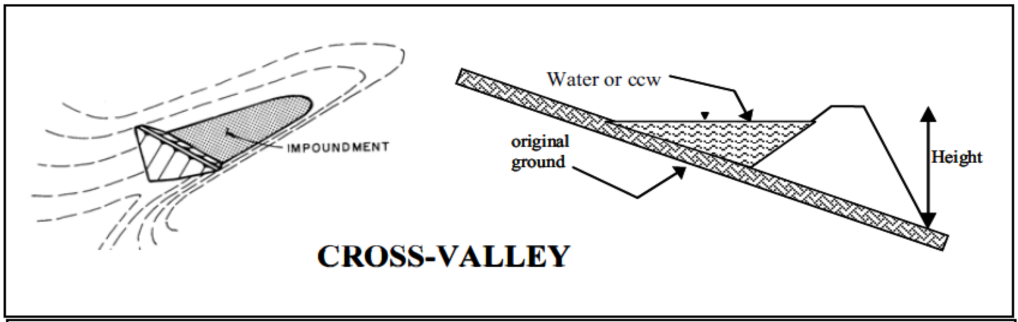
☒ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

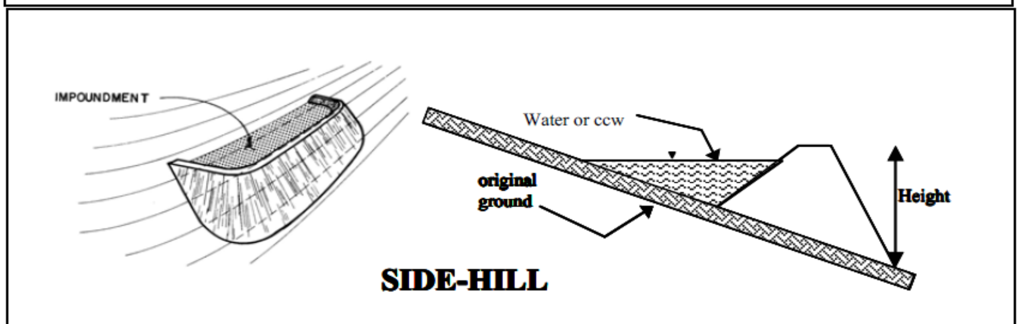
☐ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

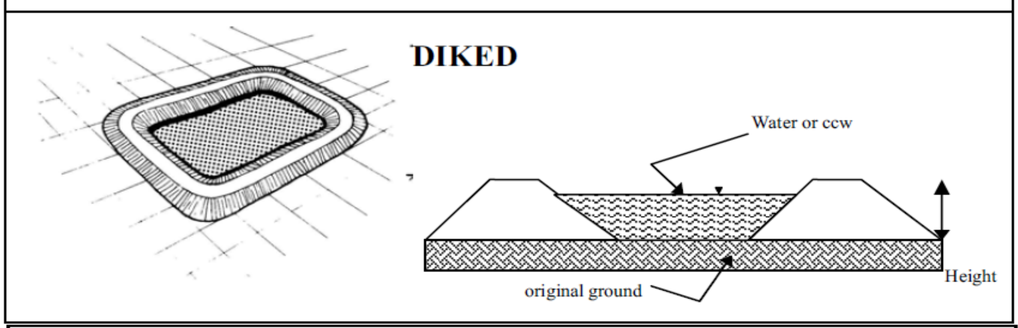
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

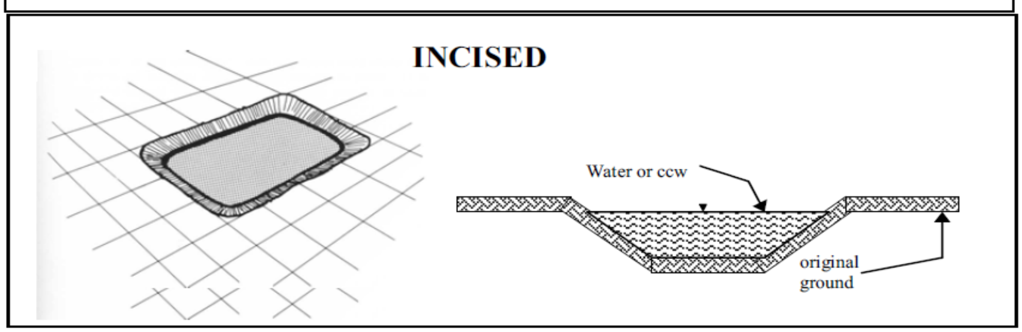
Significant hazard potential based on the potential for loss of corn crop in active agriculture land bordering the toe of the impoundment's north embankment.
No loss of human life is probable in the event of a failure or misoperation of the impoundment.

CONFIGURATION:









☐ Cross-Valley ☐ Side-Hill ☒ Diked

☐ Incised (form completion optional) ☐ Combination Incised/Diked

Embankment Height (ft)	15 to 20 ft.	**Embankment Material**	Compacted earth obtained from pond excavation or approved off-site sources.
Pool Area (ac)	Total ≈ 23 ac	**Liner**	Compacted clay

	Fly Ash Pond ≈ 12 ac.		
Current Freeboard (ft)	4-ft	**Liner Permeability**	Data not available

TYPE OF OUTLET (Mark all that apply)

☐ **Open Channel Spillway**

☐ Trapezoidal

☐ Triangular

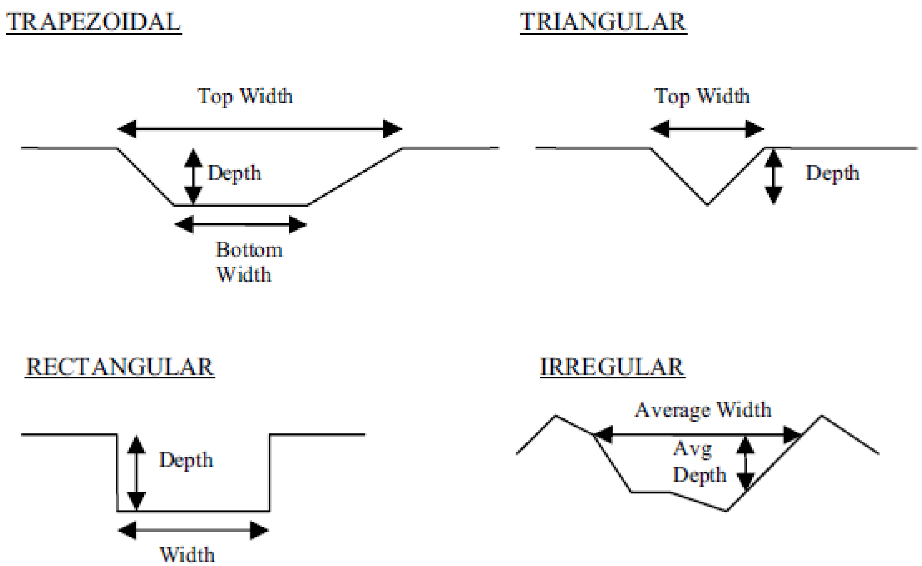
☐ Rectangular

☐ Irregular

depth (ft)

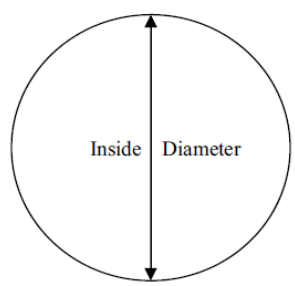
average bottom width (ft)

top width (ft)



☐ **Outlet**

18” inside diameter
(SDR 17 – smooth lined – 19.5” OD)



Material

☐ corrugated metal

☐ welded steel

☐ concrete

☐ plastic (hdpe, pvc, etc.)

☐ other (specify):

	Yes	No
Is water flowing through the outlet?	☐	☐

☐ **No Outlet**

☒ **Other Type of Outlet** (specify): Decant water from Clear Water Pond cell is pumped back to power plant for recycling.
No outlet to the environment from the impoundment.

The Impoundment was Designed By Lutz, Daily & Brain Consulting Engineers, Shawnee Mission, KS

	Yes	No
Has there ever been a failure at this site?	☐	☒

If So When?

If So Please Describe :

	Yes	No
Has there ever been significant seepages at this site?	☐	☒

If So When?

If So Please Describe :

	Yes	No
Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site?	☐	☒

If so, which method (e.g., piezometers, gw pumping,...)?

If So Please Describe :

ADDITIONAL INSPECTION QUESTIONS

Concerning the embankment foundation, was the embankment construction built over wet ash, slag, or other unsuitable materials? If there is no information just note that.

Based on the soil boring logs provided to Dewberry for review, the embankment foundation material consists of sandy to silty clay, and coarse to fine sand. The boring logs do not indicate the presences of ash, slag or other unsuitable materials.

Did the dam assessor meet with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation?

Dewberry did not meet with, or have documentation from the design Engineer-of-Record concerning the foundation preparation. Dewberry was provided a copy of the construction specifications requiring that all vegetation be excavated to a depth sufficient to remove all topsoil, grass, weeds, and roots.

The specifications also required that any material designated as objectionable by the engineer, including soft clays, muck, trash, excessively wet foundation soils, or other material unsuitable as a foundation material be removed.

From the site visit or from photographic documentation, was there evidence of prior releases, failures, or patchwork on the dikes?

During the site visit Dewberry did not observe evidence of, nor did the owner provided photographic documentation indicating prior releases, failures, or patchwork repairs on the dikes.

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name:	Date:
Unit Name:	Operator's Name:
Unit I.D.:	Hazard Potential Classification: High Significant Low
Inspector's Name:	

Inspection Issue #	Comments