Kansas Citys, Missouri and Kansas
Flood Damage Reduction Feasibility Study
(Section 216 – Review of Completed Civil Works Projects)
Engineering Appendix to the Interim Feasibility Report

Chapter A-10

GEOTECHNICAL ANALYSIS NORTH KANSAS CITY - LOWER (NATIONAL STARCH AREA)

CHAPTER A-10
GEOTECHNICAL ANALYSIS
NORTH KANSAS CITY – LOWER
(NATIONAL STARCH AREA)

A-10.1 INTRODUCTION

This chapter presents the geotechnical evaluation results for the National Starch area of the North Kansas City - Lower Unit, which was determined to have a high enough probability of failure under the existing level of protection to warrant further study. This determination relies on historical borings and soil test information combined with recent subsurface borings and soil test information.

A-10.2 SOURCES OF EXISTING LEVEE DESIGN INFORMATION

The primary sources of information for this geotechnical analysis include the references listed in the References section of this chapter.

A-10.3 DESCRIPTION OF THE LEVEE UNITS

Refer to Section A-4.3.9 for a detailed description of the North Kansas City – Lower Unit.

A-10.4 LEVEE DESIGN FEATURES

A-10.4.1 Existing Levee and Floodwall Sections

The North Kansas Unit is a Federal protection system. It consists of the Airport Section and the Lower Section, as explained by the General chapter of this appendix. It was originally constructed as a non-Federal levee, but was removed and replaced using Federal standards in 1947. The final contract for construction of the project was completed in 1955.

Upper reach of the Lower Section - The section of the North Kansas City levee not included in the Airport Section is called the Lower Section. It includes Stations 0+00 to 70+40 and Stations 210+40 to 469+17. The upper reach of the Lower Section consists of a levee section with one stoplog gap. The levee was constructed with a 1V on 3H riverside slope and 1V on 4H landside slope. No underseepage control measures were constructed in the upper reach due to the low height of the levee and thick blanket conditions.

Lower reach of the Lower Section - The lower reach consists of a levee section with one sandbag gap and two stoplog gaps. The levee was constructed with a 1V on 4H riverside slope and 1V on 3H landside slope. The underseepage control measure consists of landside seepage berm in open areas. Industry restricted the lateral extent of underseepage berm in the Harlem area (no berm constructed) and the National Starch area (partial berm constructed). Very large berms in excess of 1,000 feet landward of the primary levee toe were constructed between Stations 280+00 to 400+00.

A plan view of the North Kansas City Unit and typical sections are provided as Exhibits A-9.1 through A-9.7 in the Supplemental Exhibits section of Chapter 9.

A-10.4.2 Future Flood Protection Concerns

This levee unit is not recommended for a raise based on the hydraulic analysis of the Missouri and Kansas River flows. During the 1993 flood, Station 210+40 to Station 275+00 was reported to have serious flood fighting (see Exhibit A-10.1 in the Supplemental Exhibits section). Property owners reported excessive water pressures below pavement and building slabs. That pressure resulted in uncontrolled piping of silt foundation blanket materials. Their flood fight efforts consisted of sandbag ring dikes with temporary sand fill placement inside the seepage areas. In one building foundation near National Starch, a standpipe was constructed to offset the excessive head and reduce the piping potential. In another location inside of the National Starch property, sewer piping collapsed resulting in multiple sinkholes inside the protected area.

The 1993 flood did not reach the top of levee in these problem areas. A full head to the top of the levee may have lead to catastrophic underseepage failure of this area and all contiguous area inside the North Kansas City protection unit.

A-10.4.3 Area Site Characterization

The foundation characteristics for the reach between Station 259+00 to 273+00 were developed using existing Corps borings taken in the late 1940's supplemented with private boring information obtained during review of Completed Works for the expansion of National Starch within this reach. Exhibits A-10.2 through A-10.4 were used to characterize the foundation below and inside of the levee for Station 259+00 to 273+00. Corps borings DH-33, DH-34, DH-38, DH-39, DH-43, DH-44 and DH-48 are on the centerline of the existing levee. Alpha Omega borings B1 to B7 were located landside of the landside stability berm. Borings B1 to B7 were obtained to provide geotechnical assessment of underseepage pressures to design the expansion of National Starch facilities. The C.W. Nofsinger Company report identifies underseepage problems encountered during the flood of 1993 and flood fighting efforts taken to control the loss of foundation soils. Piping of foundation silt materials is reported, as well as sinkhole collapse of paved areas well inside the flood protection levee. High foundation pressures were observed and movement of foundation soils raised a concern regarding the overall reliability of the constructed flood protection levee section. The limits of foundation soil movement towards the flood protection were not discussed in the report.

The cross section provided in Exhibit A-10.5 indicates the intent of the original designers to cutoff upper pressures in the known heterogeneous layering of sand, silts and clays. The performance of the foundation inside of the levee indicates that the cutoff was not entirely reliable. The flow below the levee is finding a seepage path below the cutoff and into the upper sand lenses. This mixture of layering of foundation sands makes assessment of existing conditions very difficult. The boring information in the reach being considered shows the blanket conditions characterized as approximately 5 feet of "equivalent" blanket overlying the foundation sands for underseepage piping existing condition assessment. The 5 feet of blanket is determined using the assumption that the impervious cutoff shown in the section is not fully reliable. River waters have found an entrance into the upper sands lenses without losing a considerable amount of head. This would explain the 1993 reported surface sinkholes problems.

A-10.4.4 Underseepage Analysis

The reach from Stations 259+00 to 273+00 experienced excessive uplift pressure during the 1993 flood below the existing access road and adjacent structural foundations. The underseepage analysis was modeled after consideration of the types of soils landward of the levee, the consistency of the thickness of the soil blanket clays or silts, the thickness of the sand deposit below the levee blanket materials, the lateral extent of the blanket landside and riverward of the levee, the effects of the location of the Missouri River, and the height of the existing levee. All of these variables were considered during the development of the model to characterize the representative reaches along the alignment of the levee.

The reach was analyzed to determine the landside resistance to upward gradient pressures which could initiate piping of the blanket materials. This could lead to subsequent piping of sand grains toward the river entrance, leading to ultimate collapse of the levee section due to the foundation voids caused by piping. Soil begins moving in the blanket when the pressure change in a vertical column of material exceeds the weight of the material bearing on the location where the pressure change occurs. Because pressure typically decreases from depth to the surface, a diagram of the change in pressure typically produces a sloping line or “gradient”. The underseepage design aims to assure that the weight of the soil column at any depth exceeds the upward gradient by a safety factor.

The safety factor for checking the materials at the landside toe of the North Kansas City levee is 1.1. An additional design requirement is to provide underseepage control when the safety factor with respect to critical gradient is less than 1.5 with the design water surface 3 feet below the top of levee. Usually the 1.5 safety factor controls the required underseepage design. If the 1.1 safety factor or secondary check of 1.5 is not satisfied, the underseepage control is designed to meet a safety factor of 1.5 for the berm design, the buried collector design, and the pressure relief well design.

Berm design was considered only when the area landside of the levee was available for construction. If area for a berm was not available, a buried collector system was considered. In areas that exhibited a blanket thickness of less than 5 feet, relief wells were considered appropriate to provide the underseepage control. The safety factor was set midway between wells to a minimum of 1.5. The pressures at the base of the blanket at the midpoint between wells will reach a maximum, and initiation of soil grain movement will begin at these locations.

Permeability parameters were assigned to the blanket materials based on the content of silt, clay or sand. Only areas that contained a blanket thickness of at least ¼ the height of the levee were considered meaningful in the underseepage model. For thin blanket areas, pressure relief wells are considered appropriate for underseepage control.

The existing safety factor in the underseepage analysis was calculated using water at the top of levee. The relative magnitude of the permeability ratios of the clean foundation sands to the blanket materials was set after observation of boil activity from the 1951 flood. The Kansas City District method of estimating the underseepage gradient and the required safety factors deviates somewhat from the method presented in the EM-1110-2-1913. The Kansas City District’s traditional empirical approach has been used since the 1960’s and has proven effective in providing adequate underseepage control for most reaches within the North Kansas City Unit. This method is based on conclusions of a Corps of Engineers conference, held in Omaha in November, 1962. The excellent historical performance of the levees during the 1993 flood event on the Missouri River demonstrates the effectiveness of this procedure. The traditionally assumed permeability ratios for blanket materials are shown in Table A-10.1.

TABLE A-10.1
Permeability Ratios for Blanket Materials

Blanket Material	Assigned Permeability Ratio
SM : Silty Sand	100
ML : Silt	200-400
ML-CL : Silt/Clay	400
CL: Lean Clay	400-600
CH: Fat Clay	800-1000

The calculations of the underseepage factors of safety that were used in the underseepage analysis are as follows:

The gradient piping factor of safety is defined as:

FSi = ic / io

where io = actual gradient and ic = critical gradient

ic = γb / γw   when soils particles movement can begin at the toe

and γb = γsat - γw where γsat = saturated unit weight of the soil and

γw = unit weight of water

io = upward gradient through the blanket = change in head from the base of the blanket to the top of the blanket. The reference datum is set at the top of the blanket because the movement of the soil grain will begin at the top of the blanket.

Δh = gradient head calculated at the base of the blanket measure from the reference datum, the top of the blanket. This gradient calculation procedure is provided in the Geotechnical Analysis – Existing Conditions chapter of this appendix with defined equations and illustrative nomenclature.
zbl = the thickness of the blanket

$io = \Delta h / zbl$

then $FSi = ic / io = (\gamma b / \gamma w) / (\Delta h / zbl) = (\gamma b * zbl) / (\Delta h * \gamma w)$

A-10.4.5 Proposed Future Conditions Assessment

The existing conditions “equivalent” section was analyzed to determine the factor of safety with respect to piping at the toe of the existing landside stability berm. The existing landside stability berm varies from 70 feet to 210 feet. The analysis indicates a 600 feet long underseepage berm is needed. Refer to Exhibit A-10.6 in the Supplemental Exhibits section for calculations related to the berm analysis. The berm design considered the existing berm length due to the presence of the stability berm. The required length landside of the existing toe of levee, 600 feet, results in an additional 155,000 cubic yards of random materials. The 600 feet long berm would require many structures, utilities, and railroad line to be relocated and appears to be very cost prohibitive. Also, the use of an underseepage berm will control piping failure at the immediate toe of the existing levee, but may exacerbate the magnitude of the pressure landward into existing basement foundations that extend deeper into the foundation sands. A buried collector was another considered solution for this reach, but it could ultimately be as unreliable as the original design if the collector does not intercept all sand lenses carrying high river head. A positive cutoff to bedrock represents the most effective, but also the most costly, solution. The most reliable solution is considered to be the use of pressure relief wells. Due to the restrictive right-of-way near the toe of the levee, it is felt that the relief wells will provide the most effective control for all areas adjacent to the levee. A line of wells was designed to provide the needed pressure relief to result in a factor of safety of 1.5 at the point midway between wells. Twenty 10-inch diameter stainless steel pressure relief wells, spacing on 75-foot centers, are estimated to bring the area within present design requirements. Refer to Exhibit A-10.7 for calculations related to the relief well design. Table A-10.2 provides a summary of the two most feasible alternatives.

TABLE A-10.2
Design Alternatives Considered

Design Alternates	Design Head, Feet	Blanket Thickness, Feet	Well Discharge (each), cfs	Well Spacing, Feet	Berm Length, Feet	Well Losses, Feet	Discharge Below Grade, feet
Relief Wells	16.3	5.2	1.25	75	NA	1.3	1.75
Berm Design	16.3	5.2	NA	NA	600	NA	NA

The foundation sand thickness assumed for the above design option was fixed at 90 feet based on experience in the Missouri River Valley for this reach of the valley. The well losses consist of friction head loss, well entrance loss, and velocity head losses. Well entrance losses are generally less than 0.1 feet. The well velocity and friction head losses are a function of the discharge flowing from the wells. The well velocity and friction losses were modeled using Civil Works Bulletin 55-11.

A relief well spacing of 75 feet is recommended for the feasibility level cost estimate with a discharge location 2 feet below grade to assure that the foundation gradient is kept below that needed to provide a factor of safety of 1.5 between wells. It is recommended that subsurface investigation be conducted to determine the lateral extent of the blanket materials to confirm the required spacing needed for the relief well system and supplement the expected subsurface soils for excavation of the header system and pumping plant.

A-10.4.6 Reassessment of Existing Risk and Uncertainty

The existing conditions analysis (refer to Geotechnical Anaylsis – Existing Conditions chapter) was provided as a limited initial evaluation of the North Kansas City Unit's underseepage risk. This chapter indicates that the National Starch area is an area of concern based on recent discovery of the flood fighting efforts inside of levee Stations 257+00 to 272+00. An additional risk and uncertainty analysis is provided for this area. The results are provided for consideration in Table A-10.3 below.

TABLE A-10.3
Existing Conditions Risk and Uncertainty Results

Station 257+00 to 272+00	
Height of Water on Levee, feet	Probability of Unsatisfactory Performance
1.0	0.0000
2.0	0.0000125
4.0	0.0036
6.0	0.0362
8.0	0.1224
10.0	0.2509
11.5 (1993)	0.3580
13.2	0.4760
15.7 (top of levee)	0.6261

The assessment of the existing conditions includes observations that led to the selection of a satisfactory performance with respect to underseepage using a factor of safety of 0.7. Historical observations concluded that a factor of safety of 0.55 represents impending failure of the toe of the levee. The observations in 1993 did not lead to total failure of the levee toe for the level of water on the levee. The levee from Sta. 257+00 to 273+00 included flood fighting to save the foundation of an existing processing building (landside of the toe in excess of 500 feet). ETL 1110-2-556 indicates the use of a factor of 1.0 in the underseepage analysis. The North Kansas City levee experienced a factor of safety lower than 1.0 and did not fail for that water level during the flood of 1993. The observations and calculations indicate a factor of safety near 0.7 may be representative. A higher river level most likely would result in an even lower factor of safety. For a factor of safety of 0.7, the probability of a catastrophic underseepage failure was calculated to be greater than 60% for Sta. 259+00 to 271+00. Refer to Exhibits A-10.8 through A-10.16 in the Supplemental Exhibits section for calculations and information related to the probability of failure calculations.

Pressure relief wells are recommended for Stations 259+00 to 271+00. These systems are to be designed in accordance with Corps of Engineers' manuals in order to strengthen the two weak sections of the levee and eliminate the serious risk of underseepage failure.

A-10.5 REFERENCES

1. North Kansas City Levee Unit, Definite Project Report, December 1943.

2. North Kansas City Levee Unit, Analysis of Design, Levee and Floodwall, May 1945.

3. North Kansas City Levee Unit, Supplement on Interior Drainage, June 1945.

4. North Kansas City Levee Unit, Supplement on Seepage Control, January 1946.

5. North Kansas City Levee Unit, Supplement on Interior Drainage, May 1947.

6. North Kansas City Levee Unit, Record Drawings for Levee, Floodwall and Appurtenances, December 1950.

7. North Kansas City Levee Unit, Analysis of Design - Burlington Pump Plant, January 1951.

8. North Kansas City Levee Unit, Analysis of Design – Howell Pump Plant, January 1951.

9. North Kansas City Levee Unit, Analysis of Design – Rock Creek Pump Plant, April 1951.

10. North Kansas City Levee Unit, Supplement on Interior Drainage, June 1951.

11. North Kansas City Levee Unit, Record Drawings – Structures, Appendix I, May 1953.

12. North Kansas City Levee Unit, Record Drawings, Pump Plants, Appendix IV, July 1951.

13. North Kansas City Levee Unit, Analysis of Design – Station 94+18.5 Pump Plant, October 1958.

14. North Kansas City Levee Unit Periodic General Inspection No. 1, July 1970.

15. North Kansas City Levee Unit, Periodic General Inspection No. 2, March 1976.

16. North Kansas City Levee Unit, Operations and Maintenance Manual Volume I, January 1978.

17. North Kansas City Levee Unit, Operations and Maintenance Manual Volume II, January 1978.

18. Geotechnical Engineering Report for National Starch & Chemical Company, Packing Line #3 and Blending Bin Expansion Project, North Kansas City, Missouri,
February 24, 2004.

19. Modified Version, NKC, Fall 1993, Vol 5, No. 4, National Starch Information Pamphlet.

20. The C.W. Mofsinger Company Letter to Mr. Don Janiak, Plant Supervisor, National Starch and Chemical Company, Regarding Adhesive Loading Pit Inspection, August 10, 1993, 2 pages.

21. The C.W. Mofsinger Company Letter to Mr. Louis J. Jones, Mechanical Supervisor, National Starch and Chemical Company, August 10, 1993, 5 pages.

22. The C.W. Mofsinger Company Letter to Mr. Don Janiak, Mechanical Supervisor, National Starch and Chemical Company, Regarding Adhesive Building Joint Inspection, August 10, 1993, 2 pages.

23. The C.W. Mofsinger Company Letter to Mr. Fred Kidd, Construction & Utilities Supervisor, National Starch and Chemical Company, Regarding Structural Concerns at National Starch, August 9, 1993, 6 pages.

A-10.6 SUPPLEMENTAL EXHIBITS

EXHIBIT A-10.1

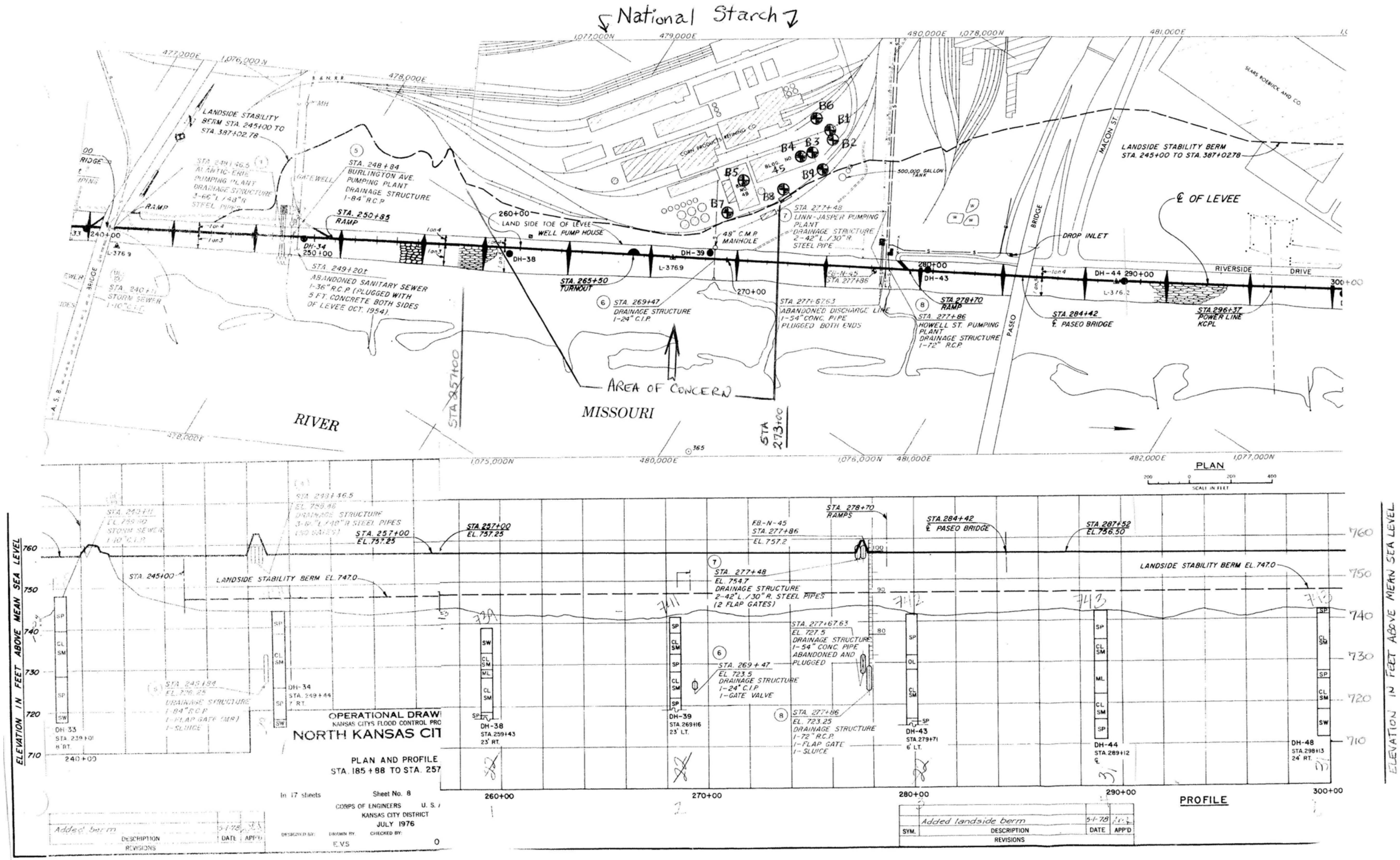
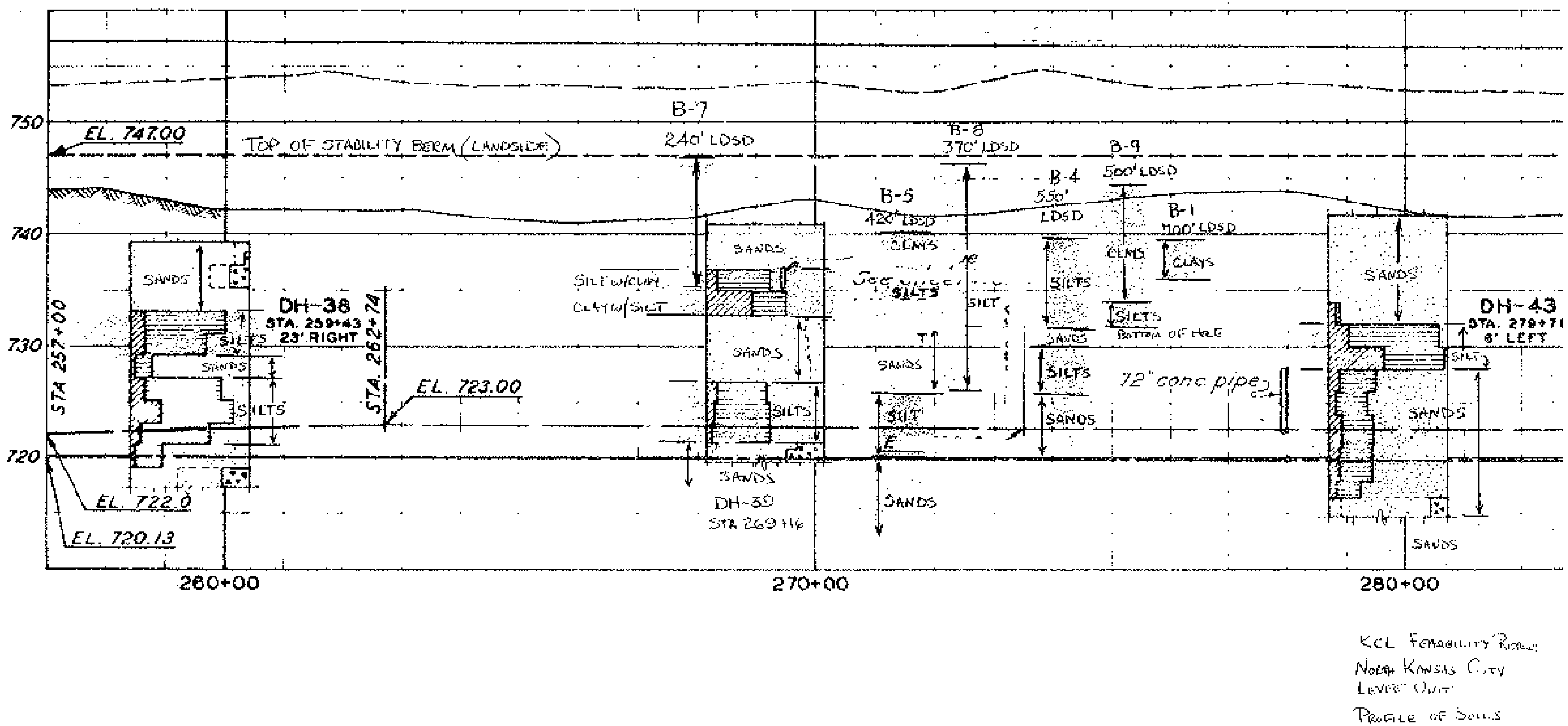


EXHIBIT A-10.2



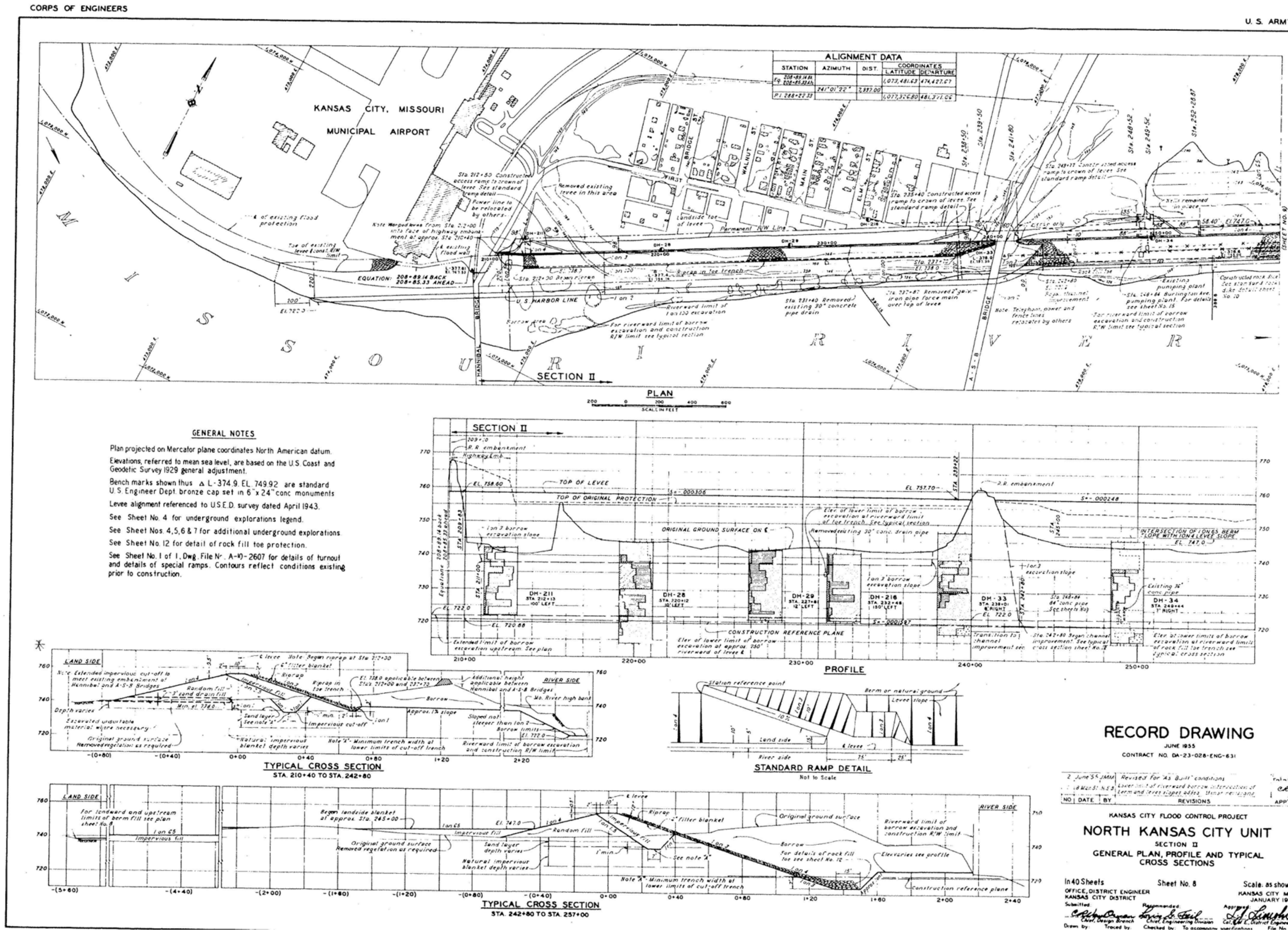
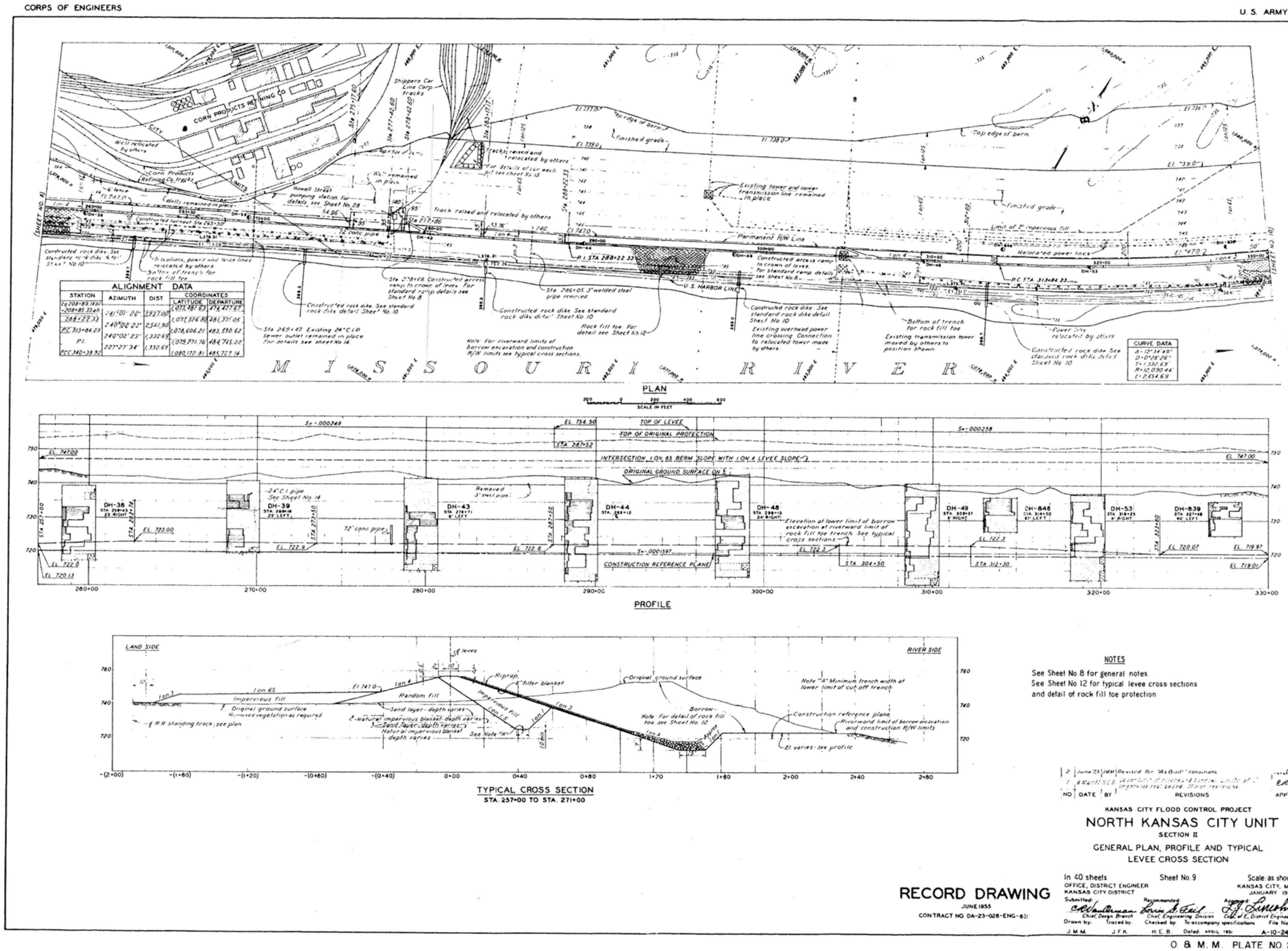
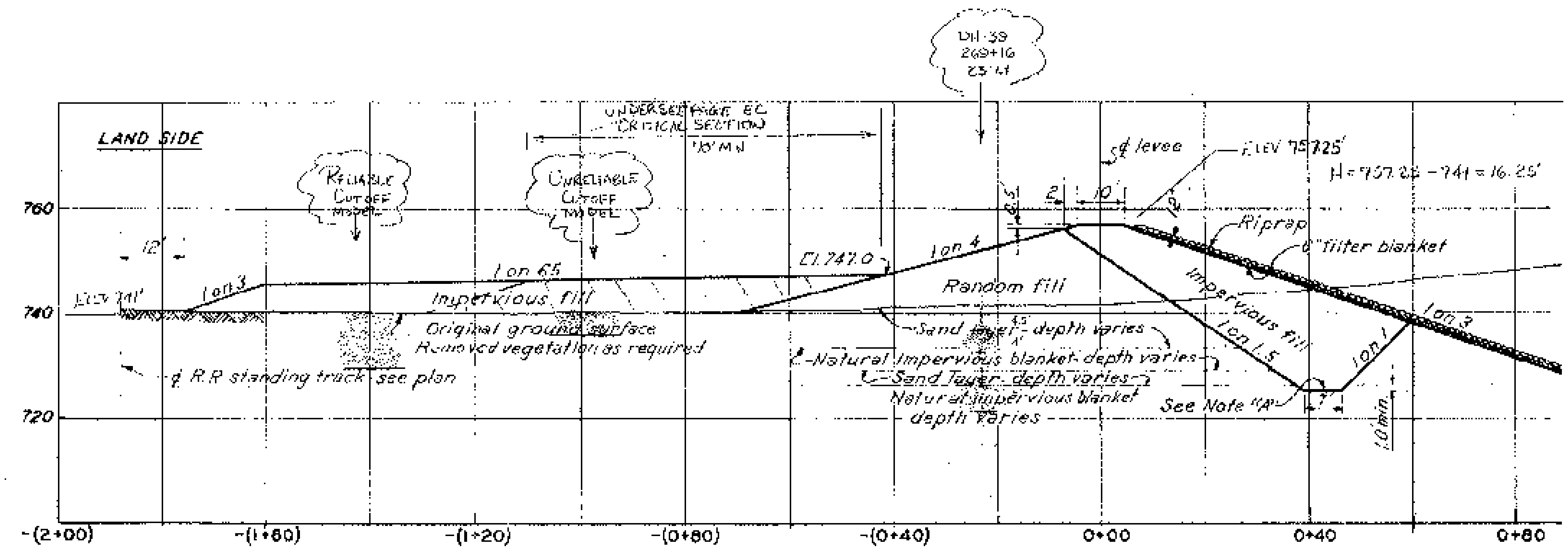

CORPS OF ENGINEERS
U. S. ARMY
ALIGNMENT DATA
KANSAS CITY, MISSOURI
MUNICIPAL AIRPORT
U.S. HARBOR LINE
SECTION II
PLAN
GENERAL NOTES
Plan projected on Mercator plane coordinates North American datum.
Elevations, referred to mean sea level, are based on the U.S. Coast and Geodetic Survey 1929 general adjustment.
Bench marks shown thus △ L-374.9. EL. 749.92 are standard U.S. Engineer Dept. bronze cap set in 6"x 24" conc monuments
Levee alignment referenced to U.S.E.D. survey dated April 1943.
See Sheet No. 4 for underground explorations legend.
See Sheet Nos. 4,5,6 & 7 for additional underground explorations.
See Sheet No. 12 for detail of rock fill toe protection.
See Sheet No. 1 of 1, Dwg. File Nr. A-10-2607 for details of turnout and details of special ramps. Contours reflect conditions existing prior to construction.
SECTION II
TOP OF LEVEE
TOP OF ORIGINAL PROTECTION
ORIGINAL GROUND SURFACE ON ℄
CONSTRUCTION REFERENCE PLANE
PROFILE
TYPICAL CROSS SECTION
STA. 210+40 TO STA. 242+80
STANDARD RAMP DETAIL
Not to Scale
TYPICAL CROSS SECTION
STA. 242+80 TO STA. 257+00
RECORD DRAWING
JUNE 1955
CONTRACT NO. DA-23-028-ENG-631
2 June '55 JMM Revised for "As Built" conditions
NO DATE BY REVISIONS APP'D
KANSAS CITY FLOOD CONTROL PROJECT
NORTH KANSAS CITY UNIT
SECTION II
GENERAL PLAN, PROFILE AND TYPICAL CROSS SECTIONS
In 40 Sheets
Sheet No. 8
Scale: as shown
OFFICE, DISTRICT ENGINEER
KANSAS CITY DISTRICT
KANSAS CITY, MO.
JANUARY 1951
Submitted:
Recommended:
Approved:
Chief, Design Branch
Chief, Engineering Division
District Engineer

EXHIBIT A-10.4





TYPICAL CROSS SECTION
STA. 257+00 TO STA. 271+00

SECTION ANALYZED: STA 269+00

NOTE:
FOR IMPERVIOUS BERMS

SEE FIGURE C-1 of EM 1110-2-1913, 30 APR 2000 ⇒ $FS_i = 2.8$ EM

$FS_i = 1.5$ KCD

$$L_T = L_e\left(\frac{H}{h_a} - 1\right) - (L_1 + L_2)$$

$$h_o' = H\left(\frac{L_e + W_T}{L_1 + L_2 + L_e + W_T}\right)$$ ⟸ INDICATES FULL WIDTH OF BERM TO BE USED FOR DESIGN

$$t = \frac{h_o' - L_T\left(\frac{\gamma_b'}{FS_i \cdot \gamma_w}\right)}{\left(1 + \left(\frac{\gamma_b'}{FS_i \cdot \gamma_w}\right)\right)}$$

CHARACTERIZE FOUNDATION	k_f/k_b	30 APR 2000 EM 1110-2-1913 TRANSFORMED RELIABLE CUTOFF DESIGN SECTION	UNRELIABLE CUTOFF DESIGN SECTION
4.5' SILTY SANDS	100	$\frac{100}{400} \times 4.5' = 1.125'$	$\frac{100}{400} \times 4.5 = 1.125'$
4.0' CLAY SILT	400	$\frac{400}{400} \times 4 = 4'$	$\frac{400}{400} \times 4' = 4'$
5' SILTY SANDS	100	$\frac{100}{400} \times 5 = 1.25'$	SANDS
5' CLAY SILT	400	$\frac{400}{400} \times 5 = 5$	
SANDS			

EL. 741'
11.4' k_f/k_b = 400
729.6'
SANDS

EL. 741'
5.2' k_f/k_b = 400
735.8'
SANDS

DESIGNER: LOEHR 4/17/05
REVIEWER:

NORTH KANSAS CITY
LEVEE UNIT
NATIONAL STARCH REACH

EXHIBIT

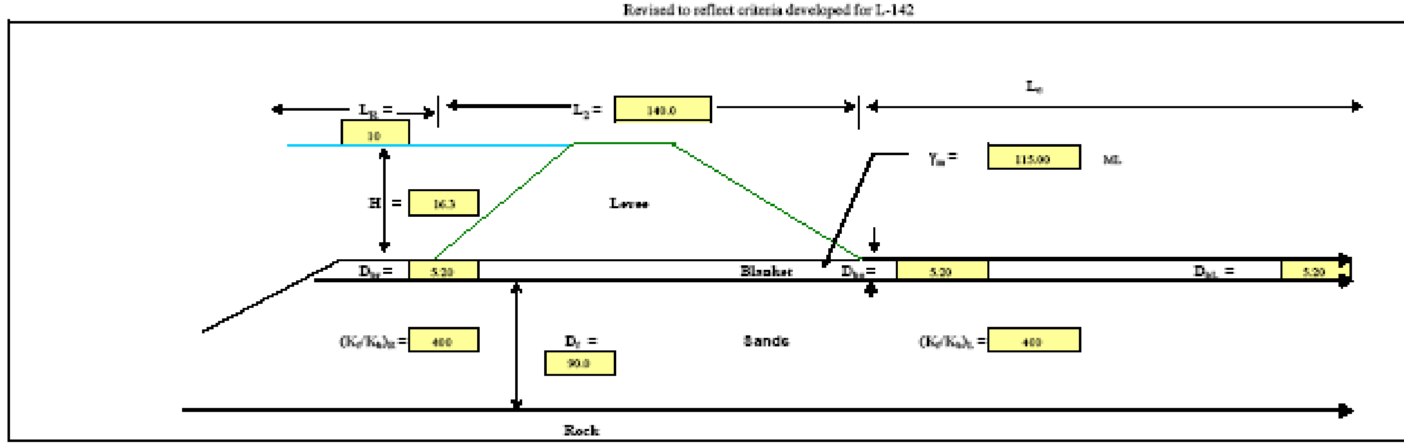
EXHIBIT A-10.6

UNDERSEEPAGE ANALYSIS

Note : This spreadsheet analysis should be used only if the blanket thickness is at least 1/4 of the height of the levee.

National Starch : NKC Lower	
Designer:	Loehr
Date :	2/17/2005
Checker	Jones
Date :	2/17/2005

Revised to reflect criteria developed for L-142



Recommended Permeability Ratio
For Foundation Blanket Materials
Chapter Underseepage Revision dated Oct 1998

Blanket Material	Assumed Permeability Ratio, (Kf/Kb)
SM	100
ML	200 to 400
ML-CL	400
CL	400 to 600
CH	800 to 1000

NOMENCLATURE

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thicl
D_{bt} = levee toe blanket thic
D_{bL} = landside blanket thick
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height
$H(W_T)$ = head above tailwater at end of underseepage berm
$H(W_T)$ = $H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
= $H * L_e / L'_t$
W_T = berm width
i_o = seepage gradient
C_r = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
L_1 = riverside effective length
where L_1 = $C * (e^{(2LR/C)}) / (e^{(2LR/C)})$
L_2 = levee base width
L_e = landside effective length
L_t = total effective length
L'_t = Total Effective Length + Full width of Berm*
t' = required Berm thickness at toe
Sc = calc'd slope of underseepage berm
q = seepage /unit Length
Q = cummulated seepage
FS_i = i_c / i_o

* per EM 1110-2-1913 30 APR 2005

Input Parameters

Station	Begin Station Feet	End Station Feet	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL}	D_{bt}	D_{br}	D_f	L_R	H	Remarks
Current Condition:											
Example			400	400	5.2	5.2	5.2	90.0	10	16.3	Example
257+00 to 260+00	25700.00	26000.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 210' Berm
260+00 to 265+00	26000.00	26500.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 110' Berm
265+00 to 269+00	26500.00	26900.00	400	400	5.2	5.2	5.2	90.0	10	16.3	Has 70' Berm
269+00 to 272+00	26900.00	27200.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 180' Berm

Analysis of Without Berm Conditions

Station	C_R	C_L	L_1	L_2	L_e	L_t	h_o	i_o	i_c	Check #1 Water at TOL FS_i at Levee Toe (need 1.1)	Check #2 Water 3' Below TOL Check Toe (need 1.5)	Remarks
Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Ft/Ft	Ft/Ft			
	433	433	10	140	433	583	12.10	2.33	0.84	0.36	0.44	
257+00 to 260+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm
260+00 to 265+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm
265+00 to 269+00	433	433	10	140	433	583	12.10	2.33	0.84	0.36	0.44	Has Exist Berm
269+00 to 272+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm

EXHIBIT A-10.6 (Continued)

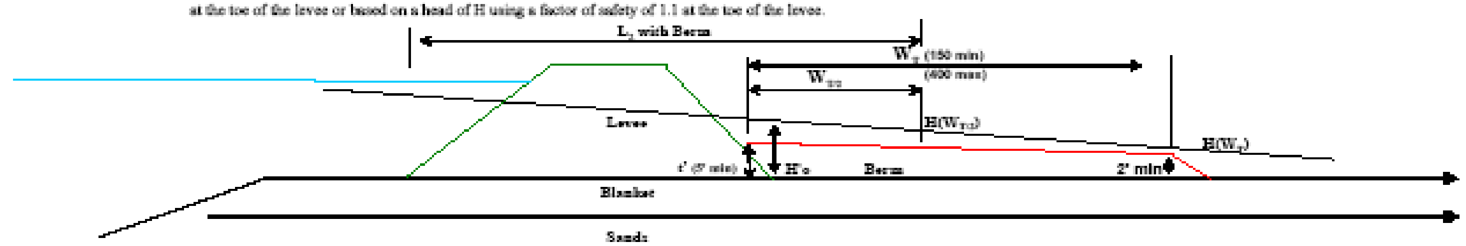
General Notes

Designer:	Loehr
Date :	2/17/2005

Checker	Jones
Date :	2/17/2005

Analysis of Existing Conditions: This portion uses full head for the check #1 for FS_i = 1.1 and Full Head less 3 feet for the Check #2 for FS_i = 1.5.
If either of these two columns indicate that the required FS_i is not met then the underseepage berm design is needed.
Berm Design Information : The Excessive head columns provides the designer with a feel for which check case control.
The design of the berm at the toe of the primary levee requires a FS_i of at least 1.5 for the controlling case, using the reduced head (87% of full head) for a new levee design.
For an existing levee design the berm thickness at the primary toe of the levee for a FS of 1.1 with water 3 feet below TOL. The FS for full head is shown for information.
The design of the extension of the berm is controlled using full head and a required FS_i of 1.1 at the toe of the berm.
If the FS_i = 1.1 is not met with the width = 400 feet minimum, then the 400 feet is used. The berm thickness required at the toe of the levee is controlled using an H'o at the levee toe set based on FS_i = 1.1, projecting back to the width less than 400 feet, with no adjustment made to H'o.
If the trail width is less than 400 feet, no adjustment to H'o is made. The minimum berm thickness is 5 feet (EM 1110-2-1913). The calculated berm thickness will be based on full head less 3 feet using a Factor of safety of 1.5 at the toe of the levee or based on a head of H using a factor of safety of 1.1 at the toe of the levee.

TOL : Top of Levee



Berm Design Information															
Berm Width Design									Berm Thickness Design for an Existing Levee						
Station	Excessive Head Control (Feet)		Design Berm Width	Effective Length	Mid Berm Head, Feet Water at TOL	Head at Toe of Berm with water at TOL	Berm Toe Gradient Water at TOL	Gradient Factor of Safety	Foundation Sand Pressure head above Ground, H'o at Levee Toe (1) 3' below TOL (2) Water at TOL	Design Total Berm Thickness at Levee Toe	Gradient at the Location of the Primary Levee Toe	Safety Factor Check at Levee Toe With Berm		Berm Length Increase needed	Berm Thickness Increase at Levee Toe
												Water at TOL (for info - not design)	Water 3' drop (Design using 1.1 minimum)		
	FS_i = 1.1	FS_i = 1.6	W_T	L'_3	$H(W_{T/2})$	$H(W_T)$	I_{Berm}	FS_i	Feet	t'	i'_o			Feet	Feet
257+00 to 260+00	7.18	6.19	590	1222	5.77	2.92	0.56	1.50	7.92	7.5	0.62	1.10	1.36	380.0	0.6
									9.70		0.76				
260+00 to 265+00	7.18	6.19	590	1222	5.77	2.92	0.56	1.50	7.92	7.5	0.62	1.10	1.36	480.0	0.6
									9.70		0.76				
265+00 to 269+00	8.13	6.96	612	1195	5.90	2.91	0.56	1.50	8.22	8	0.62	1.10	1.36	542.0	1.0
									10.08		0.76				
269+00 to 272+00	7.18	6.19	590	1222	5.77	2.92	0.56	1.50	7.92	7.5	0.62	1.10	1.36	520.0	0.6
									9.70		0.76				

UNDERSEEPAGE ANALYSIS

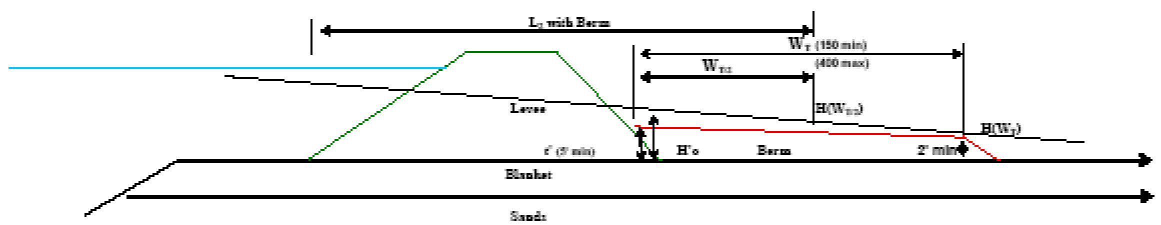
National Starch : NKC Lower Sta 257+00 to 273+00

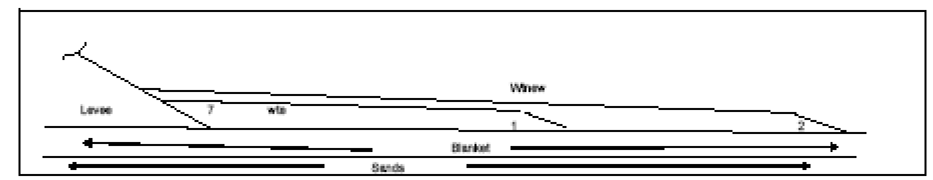
Designer:	Loehr
Date :	1/6/2005

Checker	Jones
Date :	2/17/2005

Approximate Quantity : [{ (Wtnew - Wte) * [({ (t' - ([{ t'-2} / Wtnew]*(Wte)) } + 2) / 2] } + [([(t' - 7) + { t' - ([{ t'-2} / Wtnew] * Wte) -1 }] / 2) * Wtex]] * L

Shape Factor : Depth of Pervious Foundation Divided By the Effective Total length of Seepage





Recommended Final Berm Thickness, Width and Flow Analysis

Begin Station	End Station	Increase in t' for shrinkage settlement and design (Include 10%)	Recommended t' (5 feet minimum required)	Recommended Total W_T	Sc	Shape factor	Coefficient of Permeability, k_f	Unit Discharge, q	Unit Discharge, q	Length of Reach	Q, Underseepage Flow
Feet	Feet	Feet	Feet	Feet	Ft / Ft		GPD / SF	GPD / FT	CFS / FT	Feet	CFS
25700.00	26000.00	7.55	7.5	600	109	0.0736	2120	2544	0.0039	300.00	1.2
26000.00	26500.00	7.55	7.5	600	109	0.0736	2120	2544	0.0039	500.00	2.0
26500.00	26900.00	8.10	8.0	625	104	0.0753	2120	2603	0.0040	400.00	1.6
26900.00	27300.00	7.55	7.5	600	109	0.0736	2120	2544	0.0039	400.00	1.6
									Total Underseepage Flow		6.5 cfs

Volume of Berm Fill

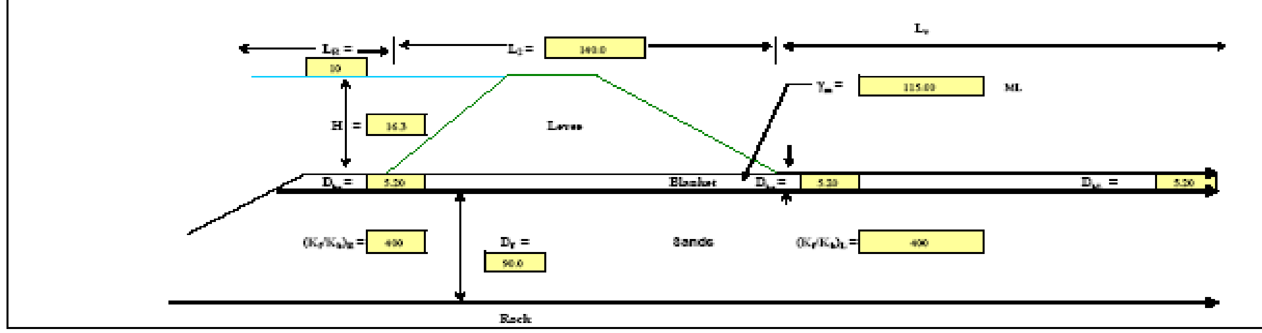
Wte	Wtnew	t'	L	Approximate Quantity per Reach
Ft	Ft	FT	FT	Cubic Feet
				3798000
210	600	7.5	300.00	603000
110	600	7.5	500.00	1205000
70	625	8.0	400.00	1138000
180	600	7.5	400.00	852000

Total Quantity = 164,733 cubic yards
Includes 10% contingency

UNDERSEEPAGE ANALYSIS

Note : This spreadsheet analysis should be used only if the blanket thickness is at least 1/4 of the height of the levee.

National Starch : NKC Lower			
Designer:	Loehr	EC-GD	
Date :	2/17/2005	Checked by :	



Recommended Permeability Ratio
For Foundation Blanket Materials
Chapter Underseepage Revision dated Oct 1998

Blanket Material	Assumed Permeability Ratio, (Kf/Kb)
SM	100
ML	200 to 400
ML-CL	400
CL	400 to 600
CH	800 to 1000

NOMENCLATURE

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height
$H(W_T)$ = head above tailwater at end of underseepage berm
$H(W_T)$ = $H(W_T/2)*e^{[illegible]}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
= $H * L_e / L'_t$
W_T = berm width
i_o = seepage gradient
C_r = riverside effective length coefficient
C_L = landside effective length coefficient
where C = [(Kf/Kb) * Df * Db]$^{1/2}$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
L_1 = riverside effective length
where L_1 = C * ($e^{[illegible]}$) / ($e^{[illegible]}$)
L_2 = levee base width
L_e = landside effective length
L_t = total effective length
L'_t = Total Effective Length + Full width of Bem EM 1110-2-1913 Apr 200

t' = required Berm thickness at toe
Sc = calc'd slope of underseepage berm
q = seepage /unit Length
Q = cummulated seepage
FS_i = i_c / i_o

Input Parameters

Station	Begin Station Feet	End Station Feet	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL}	D_{br}	D_{bo}	D_f	L_R	H	Remarks
Current Condition:											
Example			400	400	5.2	5.2	5.2	90.0	10	16.3	Example
257+00 to 260+00	25700.00	26000.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 210' Berm
260+00 to 265+00	26000.00	26500.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 110' Berm
265+00 to 269+00	26500.00	26900.00	400	400	5.2	5.2	5.2	90.0	10	16.3	Has 70' Berm
269+00 to 272+00	26900.00	27200.00	400	400	5.2	5.2	5.2	90.0	60	16.3	Has 180' Berm

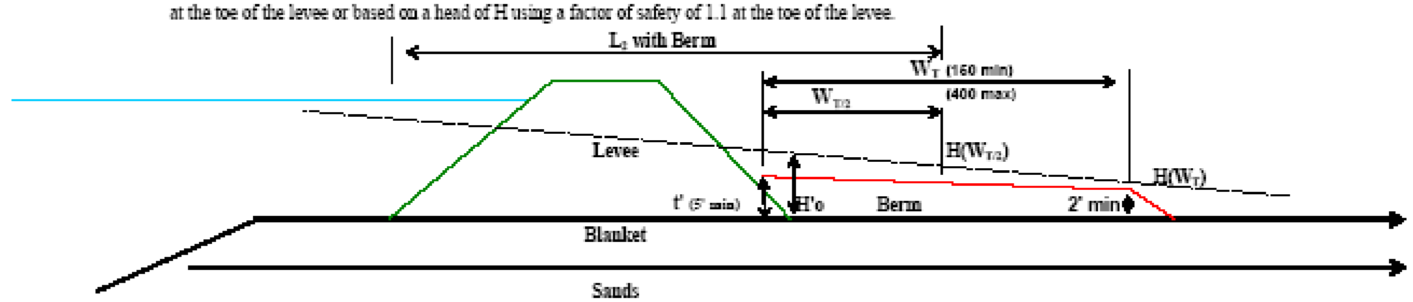
Analysis of Without Berm Conditions

Station Feet	C_R Feet	C_L Feet	L_1 Feet	L_2 Feet	L_e Feet	L_t Feet	h_o Feet	i_o Ft/Ft	i_c Ft/Ft	Check #1 Full Head Toe FSi (need 1.1)	Check #1 Reduced Head Toe FSi (need 1.5)	Remarks
	433	433	10	140	433	583	12.07	2.32	0.84	0.36	0.45	
257+00 to 260+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm
260+00 to 265+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm
265+00 to 269+00	433	433	10	140	433	583	12.10	2.33	0.84	0.36	0.44	Has Exist Berm
269+00 to 272+00	433	433	60	140	433	632	11.15	2.14	0.84	0.39	0.48	Has Exist Berm

General Notes

Analysis of Existing Conditions : This portion uses full head for the check #1 for $FS_i = 1.1$ and Full Head less 3 feet for the Check #2 for $FS_i = 1.5$.
If either of these two columns indicate that the required FS_i is not met then the underseepage berm design is needed.

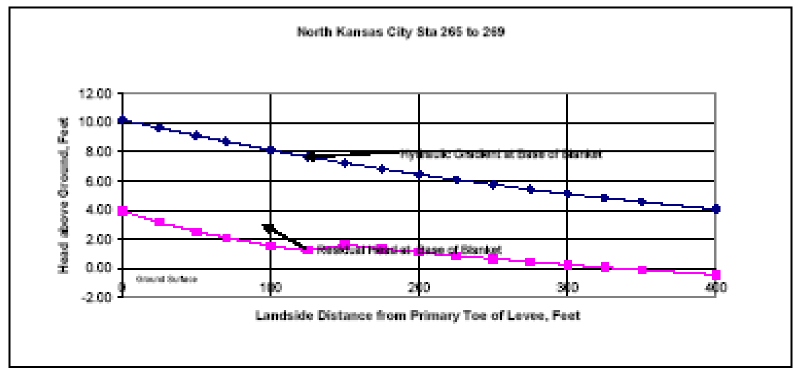
Berm Design Information : The Excessive head columns provides the designer with a feel for which check case control.
The design of the berm at the toe of the levee requires a FS_i of at least 1.5 for the controlling case, using the reduced head (87% of full head).
The design of the extension of the berm is controlled using full head and a required FS_i of 1.1 at the toe of the berm.
If the $FS_i = 1.1$ is not met with the width = 400 feet minimum, then the 400 feet is used . The berm thickness required at the toe of the levee is controlled using an H'o at the levee toe set based on $FS_i = 1.1$, projecting back to the width less than 400 feet, with no adjustment made to H'o.
If the trail width is less than 400 feet, no adjustment to H'o is made. The minimum berm thickness is 5 feet (EM 1110-2-1913). The calculated berm thickness will be based on full head less 3 feet using a Factor of safety of 1.5 at the toe of the levee or based on a head of H using a factor of safety of 1.1 at the toe of the levee.

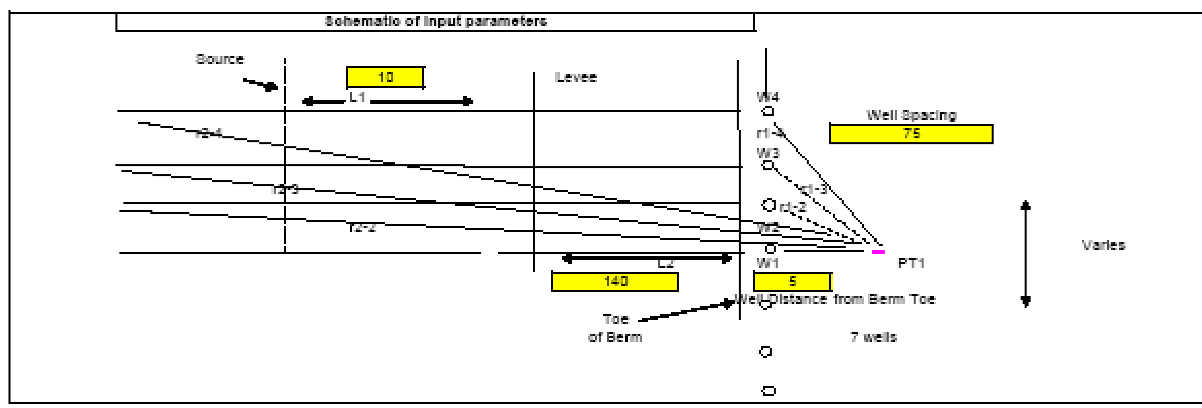


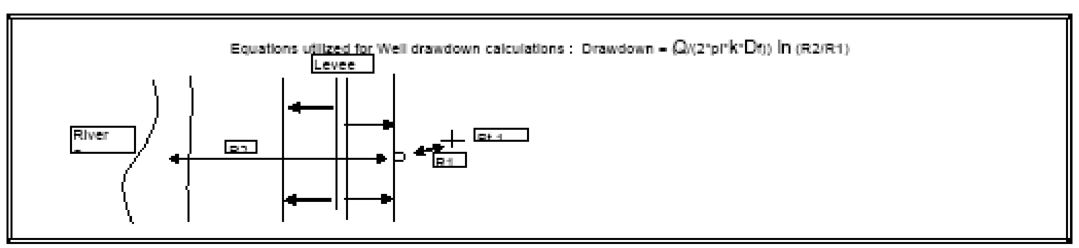
Berm Design Information

Station	Excessive Head Control (Feet)		Actual Imper Berm Width	Effective Length	Mid Berm Head, ft	$H(W_T)$ Feet	Berm Toe Gradient	Safety Factor	H'o at Levee Toe	Existing Berm Thickness	Levee Toe Gradient	Safety Factor Check at Levee Toe	
	Berm Width Design								Berm Thickness Design				
	$FS_i = 1.1$	$FS_i = 1.5$	W_T	L'_1	$H(W_{T/2})$		I_{Berm}	Berm Toe	Feet	t'	I'o	For 1.5	For 1.1
Current Condition:													
Example	8.08	6.92	1	584	12.05	12.03	2.31	0.36	9.84	0	1.89	0.45	Example
									12.07	0	2.32	Example	0.36
257+00 to 260+00	7.18	6.19	210	842	8.37	6.57	1.26	0.66	10.15	7	0.83	1.01	
									12.44	7	1.02		0.82
260+00 to 265+00	7.18	6.19	110	742	9.50	8.37	1.61	0.52	9.72	7	0.80	1.05	Exist Berm
									11.92	7	0.98	Exist Berm	0.86
265+00 to 269+00	8.13	6.96	0	583	12.10	12.10	2.33	0.36	9.88	7	0.81	1.04	Exist Berm
									12.10	7	0.99	Exist Berm	0.85
269+00 to 272+00	7.18	6.19	180	812	8.68	7.05	1.36	0.62	10.03	7	0.82	1.02	Exist Berm
									12.29	7	1.01	Exist Berm	0.83

Well Design Calculations





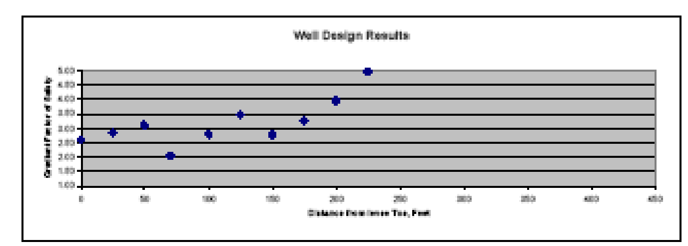


Well Drawdown Influence Table

North Kansas City : Station 265 to 269

	Ic =	0.84	Well losses	1.3	(entrance, velocity bends)		
Ground = 0			Discharge elev loss	-1.5	Dbl=	5.2	Feet
Location of points at the base of the blanket perpendicular to the center well			DD at Well	5.60	Qw =	1.25	cfs
			X_L	433	k =	0.0052	ft /sec
			h0	9.88	Df =	90.0	feet
Distance	Head	Well 0	DDwx	Residual Head	Gradient Factor		Add 1-foot fill
gx	hx	wx	Feet	Feet	of Safety		to Berm at levee
0	9.88		6.23	3.66	2.81	7" Berm	
25	9.32		6.44	2.88	3.58		
50	8.80		6.74	2.06	4.98		
70	8.40	5	6.6	2.80	1.60		3.82
100	7.84	100	6.6	1.24	3.62		
125	7.40	125	6.36	1.04	4.20		
150	6.98	150	6.16	0.83	6.23		
175	6.59	175	6.97	0.62	7.01		
200	6.22	200	6.8	0.42	10.32		
225	6.87	225	6.66	0.22	19.49		
250	6.64	250	6.61	0.03	126.51		
275	6.23	275	6.38	-0.16	-29.81		
300	4.94	300	6.27	-0.33	High FS		
325	4.66	325	6.16	-0.60	High FS		
350	4.40	350	6.06	-0.66	High FS		
400	3.92	400	4.89	-0.87	High FS		

		PT1				
		data	well 1		well 2	
			S =	150		
			r2-1=	305	r2-2=	314
Example Calculation			r1-1=	5	r1-2 =	75
			DDw1=	1.75	DDw2=	0.61
			well 3		well4	
			r2-3 =	340	r2-4=	379
			r1-3=	150	r1-4=	225
			DDw3=	0.35	DDw4=	0.22
	Dist x	DDwx	Headlosses	Number	All DD	
	5	1.75	-0.2	1	1.95	
		0.61	-0.2	2	1.62	
		0.35	-0.2	2	1.09	
		0.22	-0.2	2	0.84	
		PT1 Sum DD =		5.60	feet	



UNDERSEEPAGE ANALYSIS			Reliability
North Kansas City		Loehr	EC-GD
Missouri		Date :	6-Jul-04
Station 265 to 269			RSK 7/30/04
Crest width (feet)	10.00		

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2) * e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H * L_e / L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 1

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	200	200	5.70	5.70	5.70	90.00	0.10	1.220	10.00	70.00	122.37	505	0.06	0.06	0.01	320	320	10	140	320	470	0.07
265 to 269	120	120	5.70	5.70	5.70	90.00	0.10	1.220	10.00	70.00	139.78	433	0.06	0.05	0.01	248	248	10	140	248	398	0.07
265 to 269	280	280	5.70	5.70	5.70	90.00	0.10	1.220	10.00	70.00	113.50	564	0.07	0.06	0.01	379	379	10	140	379	529	0.07
265 to 269	200	200	2.85	2.85	2.85	90.00	0.10	1.220	10.00	70.00	73.72	411	0.06	0.05	0.02	226	226	10	140	226	376	0.06
265 to 269	200	200	8.55	8.55	8.55	90.00	0.10	1.220	10.00	70.00	167.82	577	0.07	0.06	0.01	392	392	10	140	392	542	0.07
265 to 269	200	200	5.70	5.70	5.70	72.00	0.10	1.220	10.00	70.00	129.31	471	0.06	0.05	0.01	286	286	10	140	286	436	0.07
265 to 269	200	200	5.70	5.70	5.70	108.00	0.10	1.220	10.00	70.00	117.34	536	0.07	0.06	0.01	351	351	10	140	351	501	0.07

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	0.06	0.01		
	120	5.70	90.0	248	150	0.05	0.01	0.0000010	4.4847
	280	5.70	90.0	379	150	0.06	0.01		
	200	2.85	90.0	226	150	0.05	0.02	0.0000215	94.499
	200	8.55	90.0	392	150	0.06	0.01		
	200	5.70	72.0	286	150	0.05	0.01	0.0000002	1.0168
	200	5.70	108.0	351	150	0.06	0.01		
							Total	0.0000228	100

E[I] =	0.009969814
Var[I]=	2.27754E-05
sigma[I]=	0.00477236
COV(I) =	0.47868094
I crit =	1.220

E[ln I] =	-4.71135
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

BETA	10.81030462
Pu	0.0000000
F(z) =	1.00000
Pu(%) =	0.00000

Table 1 : Random Variables for the North Kansas City Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200	80.00	40.00
Fdn Sand d	90.0	18.00	20.00

Head	Pu
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000
0.10	0.0000000

EXHIBIT A-10.9

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GD
Date : 6-Jul-04

Crest width (feet) 10.00

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe
$= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 2

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	200	200	5.70	5.70	5.70	90.00	2.00	1.220	10.00	70.00	6.12	505	1.27	1.14	0.20	320	320	10	140	320	470	1.41
265 to 269	120	120	5.70	5.70	5.70	90.00	2.00	1.220	10.00	70.00	6.99	433	1.15	0.99	0.17	248	248	10	140	248	398	1.31
265 to 269	280	280	5.70	5.70	5.70	90.00	2.00	1.220	10.00	70.00	5.67	564	1.34	1.23	0.21	379	379	10	140	379	529	1.47
265 to 269	200	200	2.85	2.85	2.85	90.00	2.00	1.220	10.00	70.00	3.69	411	1.10	0.94	0.33	226	226	10	140	226	376	1.27
265 to 269	200	200	8.55	8.55	8.55	90.00	2.00	1.220	10.00	70.00	8.39	577	1.36	1.24	0.15	392	392	10	140	392	542	1.48
265 to 269	200	200	5.70	5.70	5.70	72.00	2.00	1.220	10.00	70.00	6.47	471	1.22	1.08	0.19	286	286	10	140	286	436	1.36
265 to 269	200	200	5.70	5.70	5.70	108.00	2.00	1.220	10.00	70.00	5.87	536	1.31	1.19	0.21	351	351	10	140	351	501	1.44

	Kf/Kb	D_{bo}	D_f	L_e = C	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	1.14	0.20		
	120	5.70	90.0	248	150	0.99	0.17	0.0004086	4.4847
	280	5.70	90.0	379	150	1.23	0.21		
	200	2.85	90.0	226	150	0.94	0.33	0.0086090	94.499
	200	8.55	90.0	392	150	1.24	0.15		
	200	5.70	72.0	286	150	1.08	0.19	0.0000926	1.0168
	200	5.70	108.0	351	150	1.19	0.21		
							Total	0.0091102	100

E[I] =	0.199396285
Var[I]=	0.009110168
sigma[I]=	0.095447201
COV(I) =	0.47868094
I crit =	1.220

E[ln I] =	-1.71562
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

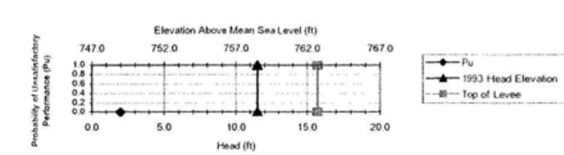
BETA	4.214894981
Pu	0.0000125
F(z) =	0.99999
Pu(%) =	0.00125

Table 1 : Random Variables for the North Kansas City Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200.00	80.00	40.00
Fdn Sand d	90.00	18.00	20.00

Head	Pu
2.00	0.0000125
2.00	0.0000125
2.00	0.0000125
2.00	0.0000125
2.00	0.0000125
2.00	0.0000125
2.00	0.0000125

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GL
Date : 6-Jul-04

RSK 7/30/04

Crest width (feet) 10.00

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 3

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	200	200	5.70	5.70	5.70	90.00	6.10	1.220	10.00	70.00	2.01	505	3.87	3.47	0.61	320	320	10	140	320	470	4.29
265 to 269	120	120	5.70	5.70	5.70	90.00	6.10	1.220	10.00	70.00	2.29	433	3.49	3.03	0.53	248	248	10	140	248	398	3.99
265 to 269	280	280	5.70	5.70	5.70	90.00	6.10	1.220	10.00	70.00	1.86	564	4.10	3.74	0.66	379	379	10	140	379	529	4.48
265 to 269	200	200	2.85	2.85	2.85	90.00	6.10	1.220	10.00	70.00	1.21	411	3.36	2.88	1.01	226	226	10	140	226	376	3.88
265 to 269	200	200	8.55	8.55	8.55	90.00	6.10	1.220	10.00	70.00	2.75	577	4.15	3.79	0.44	392	392	10	140	392	542	4.52
265 to 269	200	200	5.70	5.70	5.70	72.00	6.10	1.220	10.00	70.00	2.12	471	3.71	3.28	0.58	286	286	10	140	286	436	4.16
265 to 269	200	200	5.70	5.70	5.70	108.00	6.10	1.220	10.00	70.00	1.92	536	3.99	3.61	0.63	351	351	10	140	351	501	4.39

	Kf/Kb	D_{bo}	D_f	L_e = C	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	3.47	0.61		
	120	5.70	90.0	248	150	3.03	0.53	0.0038006	4.4847
	280	5.70	90.0	379	150	3.74	0.66		
	200	2.85	90.0	226	150	2.88	1.01	0.0800850	94.499
	200	8.55	90.0	392	150	3.79	0.44		
	200	5.70	72.0	286	150	3.28	0.58	0.0008617	1.0168
	200	5.70	108.0	351	150	3.61	0.63		
							Total	0.0847473	100

E[I] =	0.608158668
Var[I]=	0.08474734
sigma[I]=	0.291113963
COV(I) =	0.47868094
I crit =	1.220

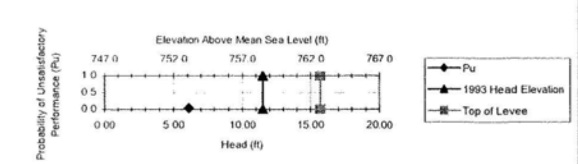
E[ln I] =	-0.60047
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

BETA	1.759797222
Pu	0.0392211
F(z) =	0.96078
Pu(%) =	3.92211

Table 1 : Random Variables for the North Kansas City Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200	80.00	40.00
Fdn Sand d	90.0	18.00	20.00

Head	Pu
6.10	0.0392211
6.10	0.0392211
6.10	0.0392211
6.10	0.0392211
6.10	0.0392211
6.10	0.0392211
6.10	0.0392211

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GL
Date : 6-Jul-04

RSK 7/30/04

Crest width (feet) 10.00

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 4

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	200	200	5.70	5.70	5.70	90.00	11.50	1.220	10.00	70.00	1.06	505	7.29	6.54	1.15	320	320	10	140	320	470	8.09
265 to 269	120	120	5.70	5.70	5.70	90.00	11.50	1.220	10.00	70.00	1.22	433	6.59	5.72	1.00	248	248	10	140	248	398	7.52
265 to 269	280	280	5.70	5.70	5.70	90.00	11.50	1.220	10.00	70.00	0.99	564	7.73	7.05	1.24	379	379	10	140	379	529	8.44
265 to 269	200	200	2.85	2.85	2.85	90.00	11.50	1.220	10.00	70.00	0.64	411	6.33	5.42	1.90	226	226	10	140	226	376	7.31
265 to 269	200	200	8.55	8.55	8.55	90.00	11.50	1.220	10.00	70.00	1.46	577	7.81	7.15	0.84	392	392	10	140	392	542	8.51
265 to 269	200	200	5.70	5.70	5.70	72.00	11.50	1.220	10.00	70.00	1.12	471	6.99	6.18	1.08	286	286	10	140	286	436	7.84
265 to 269	200	200	5.70	5.70	5.70	108.00	11.50	1.220	10.00	70.00	1.02	536	7.53	6.82	1.20	351	351	10	140	351	501	8.28

	Kf/Kb	D_{bo}	D_f	L_e = C	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	6.54	1.15		
	120	5.70	90.0	248	150	5.72	1.00	0.0135081	4.4847
	280	5.70	90.0	379	150	7.05	1.24		
	200	2.85	90.0	226	150	5.42	1.90	0.2846344	94.499
	200	8.55	90.0	392	150	7.15	0.84		
	200	5.70	72.0	286	150	6.18	1.08	0.0030625	1.0168
	200	5.70	108.0	351	150	6.82	1.20		
							Total	0.3012049	100

E[I] =	1.146528637
Var[I]=	0.301204936
sigma[I]=	0.548821406
COV(I) =	0.47868094
I crit =	1.220

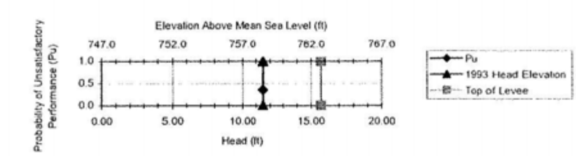
E[ln I] =	0.03358
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

BETA	0.363853391
Pu	0.3579838
F(z) =	0.64202
Pu(%) =	35.79838

Table 1 : Random Variables for the North Kansas City Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200	80.00	40.00
Fdn Sand d	90.0	18.00	20.00

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



Head	Pu
11.50	0.3579838
11.50	0.3579838
11.50	0.3579838
11.50	0.3579838
11.50	0.3579838
11.50	0.3579838
11.50	0.3579838

UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GD
Date : 6-Jul-04

Crest width (feet) 10.00

RBK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe
$= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm
$= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_i = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where $C = [(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 1993

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	200	200	5.70	5.70	5.70	90.00	13.20	1.220	10.00	70.00	0.93	505	8.37	7.50	1.32	320	320	10	140	320	470	9.28
265 to 269	120	120	5.70	5.70	5.70	90.00	13.20	1.220	10.00	70.00	1.06	433	7.56	6.57	1.15	248	248	10	140	248	398	8.63
265 to 269	280	280	5.70	5.70	5.70	90.00	13.20	1.220	10.00	70.00	0.86	564	8.87	8.09	1.42	379	379	10	140	379	529	9.69
265 to 269	200	200	2.85	2.85	2.85	90.00	13.20	1.220	10.00	70.00	0.56	411	7.27	6.23	2.18	226	226	10	140	226	376	8.39
265 to 269	200	200	8.55	8.55	8.55	90.00	13.20	1.220	10.00	70.00	1.27	577	8.97	8.20	0.96	392	392	10	140	392	542	9.77
265 to 269	200	200	5.70	5.70	5.70	72.00	13.20	1.220	10.00	70.00	0.98	471	8.02	7.10	1.25	286	286	10	140	286	436	9.00
265 to 269	200	200	5.70	5.70	5.70	108.00	13.20	1.220	10.00	70.00	0.89	536	8.64	7.82	1.37	351	351	10	140	351	501	9.51

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	7.50	1.32		
	120	5.70	90.0	248	150	6.57	1.15	0.0177969	4.4847
	280	5.70	90.0	379	150	8.09	1.42		
	200	2.85	90.0	226	150	6.23	2.18	0.3750071	94.499
	200	8.55	90.0	392	150	8.20	0.96		
	200	5.70	72.0	286	150	7.10	1.25	0.0040349	1.0168
	200	5.70	108.0	351	150	7.82	1.37		
							Total	0.3968389	100

E[I] =	1.316015479
Var[I]=	0.396838926
sigma[I]=	0.629951527
COV(I) =	0.47868094
I crit =	1.220

E[ln I] =	0.17145
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

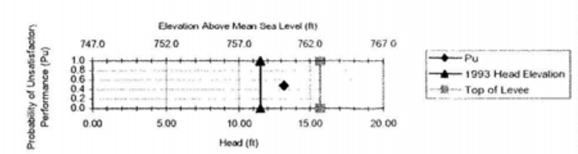
BETA	0.060319
Pu	0.4759507
F(z) =	0.52405
Pu(%) =	47.59507

Table 1 : Random Variables for the North Kansas City Levee Unit

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200	80.00	40.00
Fdn Sand d	90.0	18.00	20.00

1993 Flood	
Head	Pu
13.20	0.4759507
13.20	0.4759507
13.20	0.4759507
13.20	0.4759507
13.20	0.4759507
13.20	0.4759507
13.20	0.4759507

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



UNDERSEEPAGE ANALYSIS
North Kansas City
Missouri

Reliability
Loehr : EC-GD
Date : 6-Jul-04

Crest width (feet) 10.00

RSK 7/30/04

Probability of Levee Failure Due to Underseepage

$(K_f/K_b)_R$ = riverside permeability
$(K_f/K_b)_L$ = landside permeability
D_{br} = riverside blanket thickness
D_{bo} = levee toe blanket thickness
D_{bL} = landside blanket thickness
D_f = thickness of pervious foundation
L_R = length of riverside blanket
L_L = length of landside blanket
H = max head or levee height

$H(W_T)$ = head above tailwater at end of underseepage berm without a berm = to head at the toe $= H(W_T/2)*e^{(-WT/(2*CL))}$
$H(W_{T/2})$ = head above tailwater midpoint of underseepage berm $= H*L_e/L'_t$
H'o = head above tailwater at levee toe (w/ berm)
i_c = critical seepage gradient
W_T = berm width
i_o = seepage gradient
$FS_t = i_c / i_o$

C_R = riverside effective length coefficient
C_L = landside effective length coefficient
where C = $[(Kf/Kb) * Df * Db]^{1/2}$
L_1 = riverside effective length
where $L_1 = C * (e^{(2LR/C-1)}) / (e^{(2LR/C+1)})$
L_2 = levee base width
L_e = landside effective length
where Le = C when L_L = infinity
L_t = total effective length
L'_t = Total Effective Length + 1/2 of Berm

Blanket Material	Assumed Permibility Ratio
SM	100
ML	200-400
ML-CL	400
CL	400-600
CH	800-1000

UNDER SEEPAGE VALUES WITH EACH RANDOM VARIABLE CHANGE PLUS AND MINUS ONE STANDARD DEVIATION RIVER LEVEL 5

Station (ft)	$(K_f/K_b)_R$	$(K_f/K_b)_L$	D_{bL} (ft)	D_{bo} (ft)	D_{br} (ft)	D_f (ft)	H (ft)	i_c	L_R (ft)	Wt (ft)	FS @ Levee Toe or Berm	L't (ft)	$H(W_T/2)$ (ft)	H(WT) (ft)	i_o	C_R (ft)	C_L (ft)	L_1 (ft)	L_2 (ft)	L_e (ft)	L_t (ft)	H'o (ft)
265 to 269	**200**	**200**	**5.70**	**5.70**	**5.70**	**90.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.78**	**505**	**9.95**	**8.92**	**1.57**	**320**	**320**	**10**	**140**	**320**	**470**	**11.04**
265 to 269	**120**	**120**	**5.70**	**5.70**	**5.70**	**90.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.89**	**433**	**8.99**	**7.81**	**1.37**	**248**	**248**	**10**	**140**	**248**	**398**	**10.26**
265 to 269	**280**	**280**	**5.70**	**5.70**	**5.70**	**90.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.72**	**564**	**10.55**	**9.62**	**1.69**	**379**	**379**	**10**	**140**	**379**	**529**	**11.52**
265 to 269	**200**	**200**	**2.85**	**2.85**	**2.85**	**90.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.47**	**411**	**8.64**	**7.40**	**2.60**	**226**	**226**	**10**	**140**	**226**	**376**	**9.98**
265 to 269	**200**	**200**	**8.55**	**8.55**	**8.55**	**90.00**	**15.70**	**1.220**	**10.00**	**70.00**	**1.07**	**577**	**10.67**	**9.76**	**1.14**	**392**	**392**	**10**	**140**	**392**	**542**	**11.62**
265 to 269	**200**	**200**	**5.70**	**5.70**	**5.70**	**72.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.82**	**471**	**9.54**	**8.44**	**1.48**	**286**	**286**	**10**	**140**	**286**	**436**	**10.71**
265 to 269	**200**	**200**	**5.70**	**5.70**	**5.70**	**108.00**	**15.70**	**1.220**	**10.00**	**70.00**	**0.75**	**536**	**10.28**	**9.30**	**1.63**	**351**	**351**	**10**	**140**	**351**	**501**	**11.31**

	Kf/Kb	D_{bo}	D_f	$L_e = C$	$L_1 + L_2$	Ho	io	Variance Component	Percent of Variance
Mean	200	5.70	90.0	320	150	8.92	1.57		
	120	5.70	90.0	248	150	7.81	1.37	0.0251766	4.4847
	280	5.70	90.0	379	150	9.62	1.69		
	200	2.85	90.0	226	150	7.40	2.60	0.5305068	94.499
	200	8.55	90.0	392	150	9.76	1.14		
	200	5.70	72.0	286	150	8.44	1.48	0.0057079	1.0168
	200	5.70	108.0	351	150	9.30	1.63		
							Total	0.5613913	100

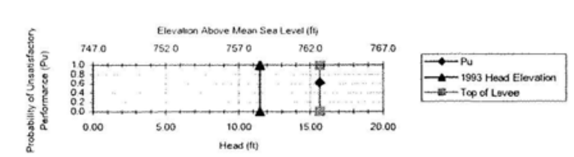
E[I] =	1.565260835
Var[I]=	0.561391339
sigma[I]=	0.749260528
COV(I) =	0.47868094
I crit =	1.220

E[ln I] =	0.34490
sigma [ln I] =	0.454215
ln(I crit) =	0.19885

BETA	-0.321535368
Pu	0.6260976
F(z) =	0.37390
Pu(%) =	62.60976

Table 1 : Random Variables for the North Kansas City Levee Unit			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	5.70	2.85	50.00
Perm Ratio	200	80.00	40.00
Fdn Sand d	90.0	18.00	20.00

Probability of Unsatisfactory Performance Due to Seepage for the North Kansas City Levee Unit



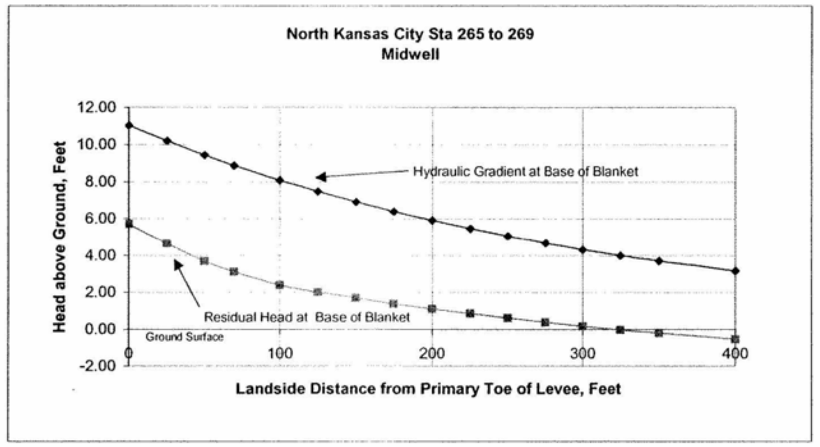
Head	Pu
15.70	0.6260976
15.70	0.6260976
15.70	0.6260976
15.70	0.6260976
15.70	0.6260976
15.70	0.6260976
15.70	0.6260976

EXHIBIT A-10.14

Well Design Calculations

Loehr : EC-GD
Date : 8/2/2004

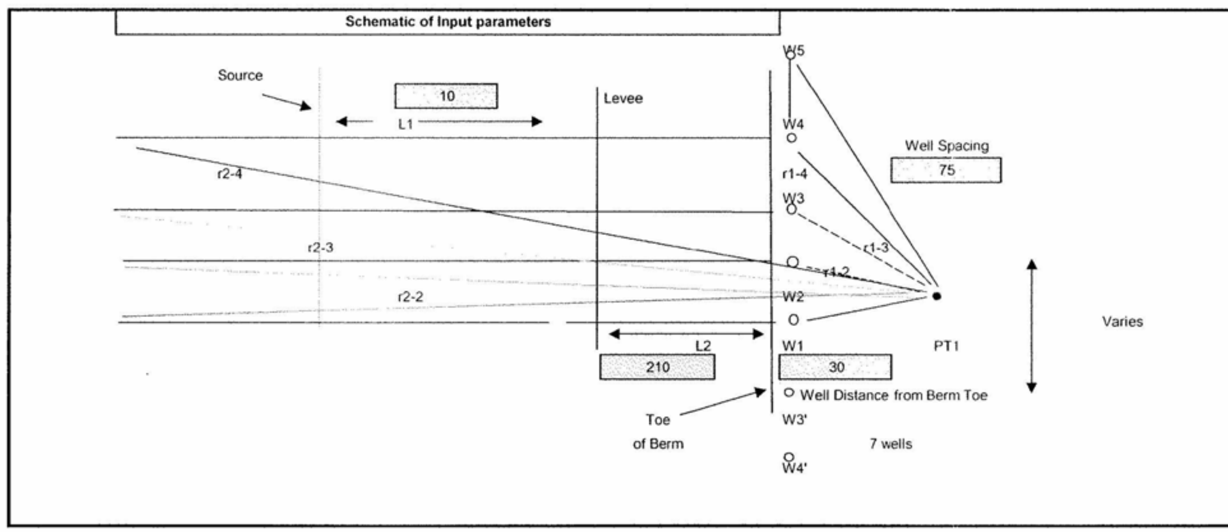
Peer : D. Jones
Date : 8/4/2004



Well Drawdown Influence Table

North Kansas City : Station 265 to 269

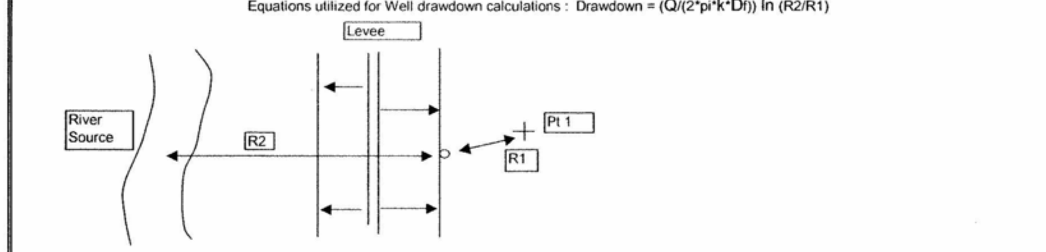
	ic =	0.84	Well losses	1.3	(entrance, velocity bends)		
Ground = 0			Discharge elev loss	-1.5	Dbl=	5.7	Feet
Location of points at the base of the blanket perpendicular to the center well			DD at Well	5.76	Qw =	1.25	cfs
			X_L	320	k =	0.0052	ft /sec
			h0	11.04	Df =	90.0	feet
Distance	Head	Well 0	DDwx	Residual Head	Gradient Factor		Add 1-foot fill
gx	hx	wx	Feet	Feet	of Safety		to Berm at levee
0	11.04		5.32	5.72	1.87	↑	1.87
25	10.21		5.55	4.66	2.03		No Fill Added
50	9.44		5.76	3.68	2.25	Existing	
70	8.87	0	5.76	3.11	1.54	Berm	
100	8.08	30	5.69	2.39	2.01		
125	7.47	55	5.46	2.01	2.38		
150	6.91	80	5.22	1.69	2.84		
175	6.39	105	5.01	1.38	3.47		
200	5.91	130	4.81	1.10	4.36		
225	5.46	155	4.62	0.84	5.67		
250	5.05	180	4.45	0.60	7.92		
275	4.67	205	4.3	0.37	12.79		
300	4.32	230	4.16	0.16	29.34		
325	4.00	255	4.03	-0.03	-150.91		
350	3.70	280	3.91	-0.21	-22.56		
400	3.16	330	3.7	-0.54	-8.91		



Example Calculation

		PT1				
		data	well 1		well 2	
			S =	220		
			r2-1=	471	r2-2=	471
			r1-1=	48	r1-2 =	48
			DDw1=	0.97	DDw2=	0.97
			well 3		well4	
			r2-3 =	483	r2-4=	506
			r1-3=	116	r1-4=	190
			DDw3=	0.61	DDw4=	0.42
Well 5	r2-5 =	538	r1-5 =	264	DDw5 =	0.30
	Dist x	DDwx	Headlosses	Number	All DD	
W1 & W2	30	0.97	-0.2	2	2.34	
W3 & W3'		0.61	-0.2	2	1.61	
W4 & W4'		0.42	-0.2	2	1.23	
W5		0.30	-0.2	1	0.50	
			PT1 Sum DD =	5.69	feet	

Equations utilized for Well drawdown calculations : Drawdown = (Q/(2*pi*k*Df)) ln (R2/R1)



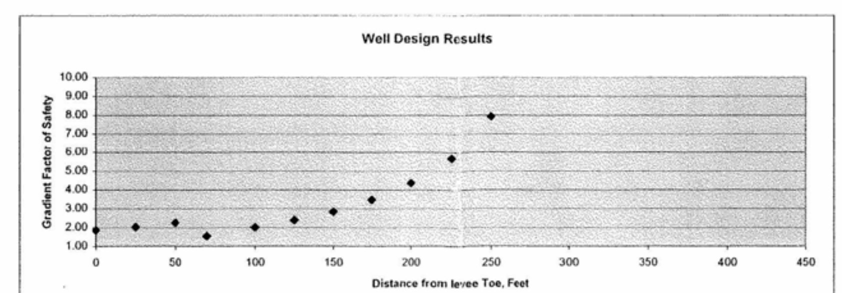
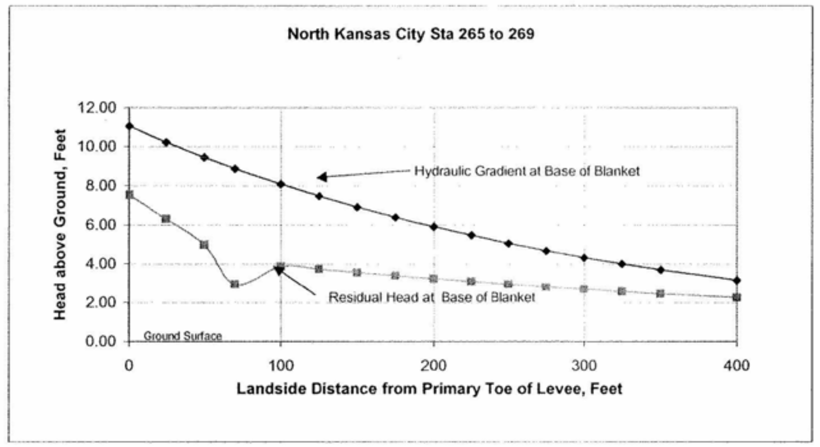


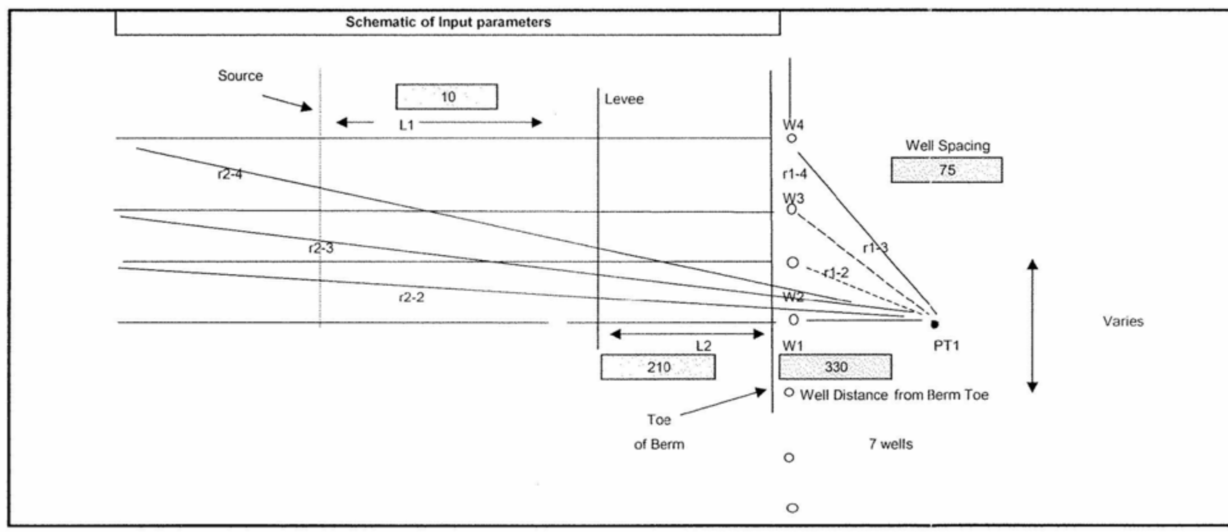
EXHIBIT A-10.15

Well Design Calculations

Lochr: EC-GD
Date: 8/3/2004

Peer: D. Jones
Date: 8/4/2004





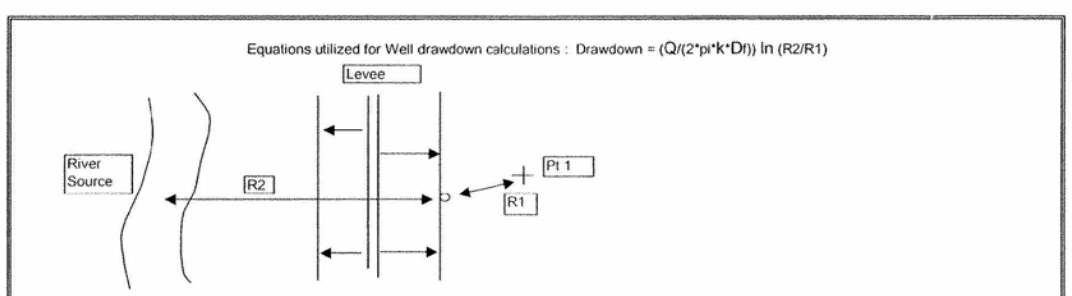
Well Drawdown Influence Table

North Kansas City : Station 265 to 269

	ic =	0.84	Well losses	0.9	(entrance, velocity bends)		
Ground = 0			Discharge elev loss	-0.5	Dbl=	5.7	Feet
Location of points at the base of the blanket perpendicular to the center well			DD at Well	**5.92**	Qw =	2	cfs
			X_L	320	k =	0.0052	ft /sec
			h0	11.04	Df =	90.0	feet
Distance	**Head**	**Well 0**	**DDwx**	**Residual Head**	**Gradient Factor**		Add 1-foot fill
gx	**hx**	**wx**	**Feet**	**Feet**	**of Safety**		to Berm at levee
0	**11.04**		3.51	7.53	**1.42**	↑	**1.53**
25	**10.21**		3.91	6.30	**1.50**		
50	**9.44**		4.47	4.97	**1.66**		
70	**8.87**	**0**	5.92	2.95	**1.62**	**Berm**	
100	**8.08**	**30**	4.21	3.87	**1.24**		
125	**7.47**	**55**	3.74	3.73	**1.28**		
150	**6.91**	**80**	3.35	3.56	**1.35**		
175	**6.39**	**105**	3	3.39	**1.41**		
200	**5.91**	**130**	2.68	3.23	**1.48**		
225	**5.46**	**155**	2.38	3.08	**1.55**		
250	**5.05**	**180**	2.11	2.94	**1.63**		
275	**4.67**	**205**	1.87	2.80	**1.71**		
300	**4.32**	**230**	1.64	2.68	**1.78**		
325	**4.00**	**255**	1.43	2.57	**1.86**		
350	**3.70**	**280**	1.24	2.46	**1.95**		
400	**3.16**	**330**	0.9	2.26	**2.12**		

Example Calculation

		PT1				
		data	well 1		well 2	
			S =	220		
			r2-1=	770	r2-2=	774
			r1-1=	330	r1-2 =	338
			DDw1=	0.58	DDw2=	0.56
			well 3		well4	
			r2-3 =	784	r2-4=	802
			r1-3=	362	r1-4=	399
			DDw3=	0.53	DDw4=	0.47
	Dist x	DDwx	Headlosses	Number	All DD	
	330	0.58	0.4	1	0.18	
		0.56	0.4	2	0.32	
		0.53	0.4	2	0.25	
		0.47	0.4	2	0.15	
			PT1 Sum DD =	**0.90**	feet	



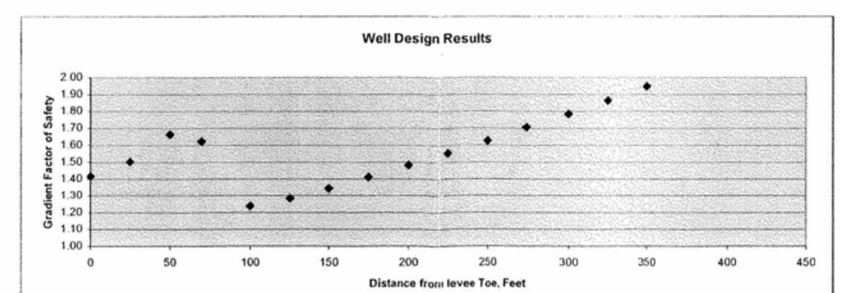


EXHIBIT A-10.16
Missouri River Existing Conditions Water Surface Elevations

Reach	Controlling Discharge	HEC-RAS River Mile	Profile Frequency		Q Total (cfs)	Water Surface Elevation (ft)	Energy Grade Elevation (ft)	Energy Grade Slope (ft/ft)	Average Channel Velocity (ft/s)	Flow Area (sq ft)	Top Width (ft)	Channel Froude #
			Percent	Year								
Lower	Lower Missouri	364.05	0.067%	1,500	625,000	754.7	756.9	0.00028	12.1	59,364	1,625	0.31
Lower	Lower Missouri	364.34	10%	10	245,000	737.9	738.8	0.00017	7.4	34,479	1,297	0.22
Lower	Lower Missouri	364.34	1%	100	401,000	746.6	747.9	0.00021	9.4	46,421	1,432	0.26
Lower	Lower Missouri	364.34	0.5%	200	454,000	748.8	750.4	0.00022	10.1	49,634	1,447	0.27
Lower	Lower Missouri	364.34	0.2%	500	530,000	751.8	753.6	0.00024	11.0	53,999	1,459	0.28
Lower	Lower Missouri	364.34	0.133%	750	565,000	753.0	755.0	0.00025	11.4	55,734	1,463	0.29
Lower	Lower Missouri	364.34	0.100%	1,000	590,000	753.9	755.9	0.00025	11.6	57,059	1,466	0.29
Lower	Lower Missouri	364.34	0.080%	1,250	610,000	754.6	756.7	0.00026	11.9	58,101	1,469	0.29
Lower	Lower Missouri	364.34	0.067%	1,500	625,000	755.1	757.3	0.00026	12.0	58,849	1,470	0.30
Lower	Lower Missouri	364.65	10%	10	245,000	738.2	739.1	0.00018	7.5	33,526	1,341	0.23
Lower	Lower Missouri	364.65	1%	100	401,000	746.9	748.3	0.00021	9.6	45,481	1,406	0.26
Lower	Lower Missouri	364.65	0.5%	200	454,000	749.1	750.7	0.00023	10.2	48,665	1,422	0.27
Lower	Lower Missouri	364.65	0.2%	500	530,000	752.2	754.0	0.00024	11.1	53,038	1,472	0.29
Lower	Lower Missouri	364.65	0.133%	750	565,000	753.4	755.4	0.00025	11.5	54,816	1,483	0.29
Lower	Lower Missouri	364.65	0.100%	1,000	590,000	754.3	756.4	0.00026	11.8	56,172	1,491	0.30
Lower	Lower Missouri	364.65	0.080%	1,250	610,000	755.0	757.2	0.00026	12.0	57,243	1,498	0.30
Lower	Lower Missouri	364.65	0.067%	1,500	625,000	755.5	757.7	0.00027	12.1	58,015	1,503	0.30
Lower	Lower Missouri	364.730*	10%	10	245,000	738.2	739.2	0.00020	7.7	32,517	1,354	0.24
Lower	Lower Missouri	364.730*	1%	100	401,000	747.0	748.4	0.00023	9.7	44,563	1,411	0.27
Lower	Lower Missouri	364.730*	0.5%	200	454,000	749.2	750.8	0.00024	10.4	47,772	1,435	0.28
Lower	Lower Missouri	364.730*	0.2%	500	530,000	752.2	754.2	0.00026	11.2	52,167	1,459	0.29
Lower	Lower Missouri	364.730*	0.133%	750	565,000	753.5	755.5	0.00027	11.7	53,932	1,468	0.30
Lower	Lower Missouri	364.730*	0.100%	1,000	590,000	754.4	756.5	0.00028	11.9	55,277	1,474	0.30
Lower	Lower Missouri	364.730*	0.080%	1,250	610,000	755.1	757.3	0.00028	12.1	56,338	1,479	0.31
Lower	Lower Missouri	364.730*	0.067%	1,500	625,000	755.6	757.9	0.00028	12.3	57,102	1,490	0.31
Lower		364.734	Paseo Bridge									
Lower	Lower Missouri	364.75	10%	10	245,000	738.3	739.2	0.00022	7.8	32,301	1,355	0.25
Lower	Lower Missouri	364.75	1%	100	401,000	747.0	748.5	0.00025	9.8	44,401	1,413	0.27
Lower	Lower Missouri	364.75	0.5%	200	454,000	749.3	750.9	0.00027	10.4	47,624	1,428	0.28
Lower	Lower Missouri	364.75	0.2%	500	530,000	752.3	754.3	0.00028	11.3	52,021	1,462	0.30
Lower	Lower Missouri	364.75	0.133%	750	565,000	753.6	755.6	0.00029	11.7	53,801	1,471	0.30
Lower	Lower Missouri	364.75	0.100%	1,000	590,000	754.5	756.6	0.00030	11.9	55,155	1,478	0.31
Lower	Lower Missouri	364.75	0.080%	1,250	610,000	755.2	757.4	0.00030	12.1	56,224	1,483	0.31
Lower	Lower Missouri	364.75	0.067%	1,500	625,000	755.7	758.0	0.00031	12.3	56,993	1,487	0.31
Lower	Lower Missouri	364.78	10%	10	245,000	738.3	739.3	0.00025	8.1	30,957	1,229	0.26
Lower	Lower Missouri	364.78	1%	100	401,000	747.0	748.6	0.00028	10.1	42,597	1,396	0.29
Lower	Lower Missouri	364.78	0.5%	200	454,000	749.3	751.0	0.00029	10.8	45,775	1,412	0.30
Lower	Lower Missouri	364.78	0.2%	500	530,000	752.3	754.3	0.00031	11.6	50,115	1,443	0.31
Lower	Lower Missouri	364.78	0.133%	750	565,000	753.5	755.7	0.00032	12.0	51,868	1,453	0.31
Lower	Lower Missouri	364.78	0.100%	1,000	590,000	754.4	756.7	0.00033	12.3	53,202	1,459	0.32
Lower	Lower Missouri	364.78	0.080%	1,250	610,000	755.2	757.5	0.00033	12.5	54,256	1,465	0.32
Lower	Lower Missouri	364.78	0.067%	1,500	625,000	755.7	758.1	0.00034	12.6	55,014	1,469	0.32
Lower	Lower Missouri	365.1	10%	10	245,000	738.8	739.7	0.00019	7.5	33,312	1,274	0.23
Lower	Lower Missouri	365.1	1%	100	401,000	747.6	749.0	0.00023	9.5	45,270	1,396	0.26
Lower	Lower Missouri	365.1	0.5%	200	454,000	749.9	751.5	0.00024	10.1	48,506	1,411	0.27
Lower	Lower Missouri	365.1	0.2%	500	530,000	753.0	754.8	0.00026	11.0	52,925	1,452	0.28
Lower	Lower Missouri	365.1	0.133%	750	565,000	754.3	756.2	0.00027	11.4	54,741	1,478	0.29
Lower	Lower Missouri	365.1	0.100%	1,000	590,000	755.2	757.2	0.00028	11.6	56,123	1,486	0.29
Lower	Lower Missouri	365.1	0.080%	1,250	610,000	755.9	758.0	0.00028	11.8	57,215	1,492	0.30
Lower	Lower Missouri	365.1	0.067%	1,500	625,000	756.5	758.6	0.00028	12.0	58,003	1,497	0.30
Lower	Lower Missouri	365.43	10%	10	245,000	739.1	740.0	0.00023	7.9	32,229	1,335	0.25
Lower	Lower Missouri	365.43	1%	100	401,000	748.0	749.4	0.00026	9.8	44,367	1,396	0.27

STA 257 to 273