CHICAGO DISTRICT

MCCOOK LEVEE

MCCOOK, IL

# Appendix E: Geotechnical Analysis

08 February 2018

**MCCOOK, IL SECTION 205**
**APPENDIX E: GEOTECHNICAL ANALYSIS**

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# MCCOOK, IL
# SECTION 205 FLOOD RISK MANAGEMENT

## INTRODUCTION

1. For the McCook, IL Section 205 project, this Geotechnical Appendix was developed to investigate the subsurface factors that would influence the project construction, cost, and feasibility. The existing McCook Levee is discussed based on the existing condition compared to USACE levee standards.

## GEOLOGY

2. The geology of the Chicago area is largely a consequence of a series of continental glacial advances and retreats. During the most recent glaciations, the Wisconsinan, the area was covered by several thousand feet of ice of the Lake Michigan lobe. The area had been covered with surficial deposits which vary from very thin and up to 300 feet thick (IDNR drift thickness map) that were deposited by glaciers and higher level stages of Lake Michigan. Bedrock typically consists of sedimentary dolomitic limestone, dolomite shale, and sandstone.

3. Based on the Illinois State Geological Survey (ISGS), Surficial Geology of the Chicago Region Map (1970), the majority of the project is within the Glacial Sluiceway (sl) and Lake Plain (lp), with the Cahokia Alluvium (c) and exposed bedrock (S) regions nearby. Descriptions of each of these regions are included below.

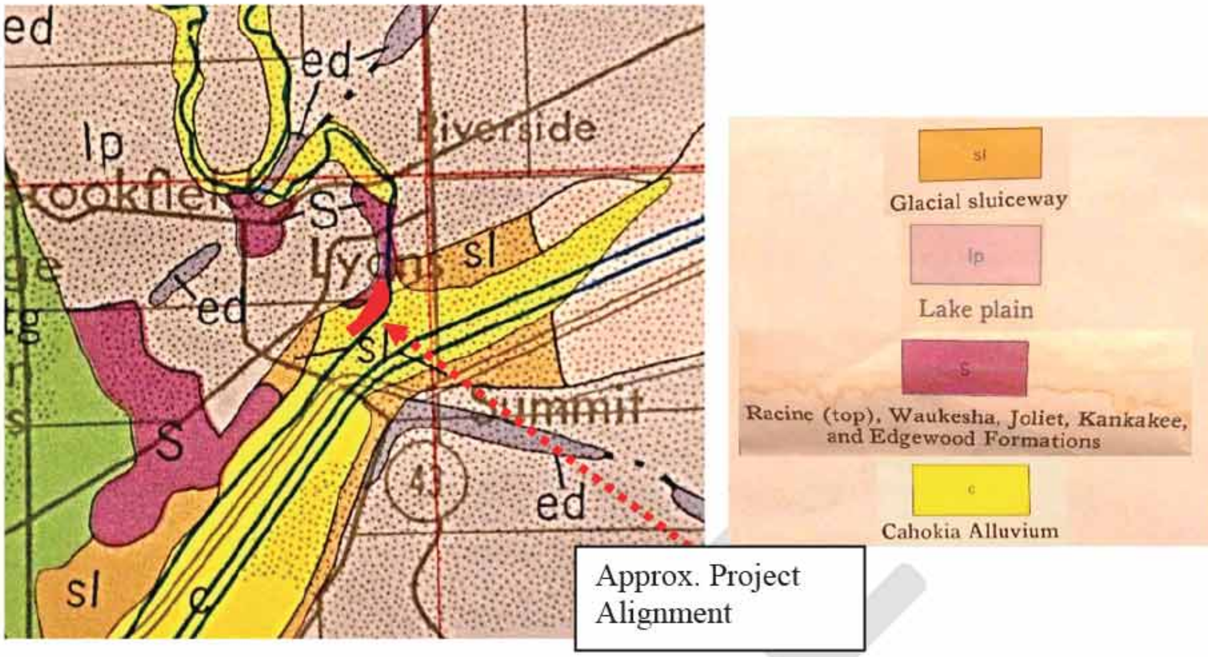



*Figure 1. Soil Type Map of Project Area indicating several subsurface types (1970)*

- Glacial Sluiceway – Erosional channels; mostly outlets of glacial lakes where cut into till; where cut into bedrock, as along Illinois, Des Plaines, and Kankakee Valleys, the bedrock formation is mapped instead; contains local deposits (mostly bars) of sand and gravel of the Henry Formation.

- Cahokia Alluvium – Deposits in floodplains and channels of modern rivers and streams; mostly poorly sorted silt and sand containing local deposits of sandy gravel; in many places overlies relatively well sorted glacial outwash of the Henry Formation.

- Lake Plain – Floors of glacial lakes flattened by wave erosion and by minor deposition in low areas; largely underlain by glacial till; thin deposits of silt, clay, and sand of the Equality Formation present locally.

- Racine (top), Waukesha, Joliet, Kankakee, and Edgewood Formations – Largely dolomite, slightly to moderately argillaceous with scattered chert nodules; Racine Formation contains large reefs of massive to well bedded pure dolomite; minor beds of shale and shaly dolomite in lower part and locally bordering reefs in upper part; partly limestone in places near Kankakee Valley; fills pre-Silurian valleys as much as 100 feet deep in Maquoketa Shale in some areas.

4. The Natural Resources Conservation Service website (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) was also used to develop a soil survey map below. This source provides general data of the predominant soil classification in an area.


*Figure 2. NRCS Soils Map with levee alignment almost all Sawmill silty clay loam*

*Table 1. NRCS soils identified in project area*

| Map Unit Symbol | Map Unit Name | Percent of Area |
|---|---|---|
| 392A | Urban land-Orthents, loamy, complex, nearly level | 6.4% |
| 533 | Urban land | 75.1% |
| 1107A* | Sawmill silty clay loam, undrained, 0-2% slopes, frequently flooded | 9.7% |
| 503B | Rockton silt loam, 2 to 6% slopes | 1.2% |
| W | Water | 7.6% |

**Identified as likely hydric soil*

5. The majority of the leveed area of McCook Levee is considered urban land, which has been modified due to development. Along the levee alignment, the soil is considered Sawmill silty clay loam, which is defined as nearly level, poorly drained soil on flood plains along rivers and streams and generally consists of firm silty clay loam. A small area to the north of the West Lyons Levee consists of Rockton silt loam, which is defined as loamy drift over clayey residuum derived from

limestone and dolomite. This would indicate very shallow bedrock to the north. The soils and their locations are shown in *Figure 2*.

6. The NRCS map was also checked to determine the extent of hydric soils onsite. Hydric soils are soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Of the soil types identified in *Table 1*; Sawmill silty clay loam was the only identified as having geomorphic conditions that would classify it as hydric.

7. The main takeaways from the geology maps presented above indicate the subsurface is not uniform as the NRCS map indicates silty clays while the ISGS map indicates alluvial silts/sands. There may be some shallower bedrock on the north portion, north of 47th Street as indicated by the ISGS map, as well. Soil borings are available from previous investigations completed in 1979 and 1984 along McCook Levee which are discussed below.

Old Topographic Maps

8. As part of this investigation, old topographic maps were pulled to determine previous conditions of the site. Maps were available from USGS via (https://ngmdb.usgs.gov/topoview/) with maps from 1891, 1893, 1901, 1928, 1953, 1957, 1963, 1980, 1993, and 1998 available. Selected maps are shown in *Figure 3*, *Figure 4*, and *Figure 5* indicating various items of interest. Between 1893 and 1901, the Des Plaines River was straightened to approximately the present condition. It appears the levee was constructed between 1901 and 1928. The levee on the topographic maps has not noticeably changed since then.

9. The two topographic maps prior to levee construction shown below also have the approximate levee alignment shown in red. It appears that the southwest end of the levee may have been constructed on the old river channel from the 1893 map, prior to the river being straightened.

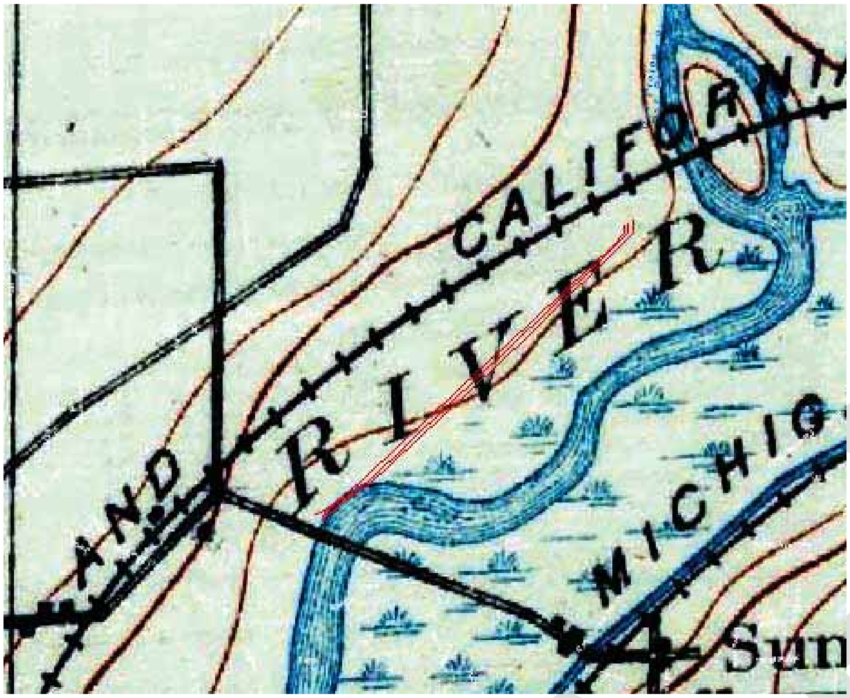



*Figure 3. Topographic Map from 1893, approximate future levee alignment shown in red. Note south end may have been constructed on old channel*

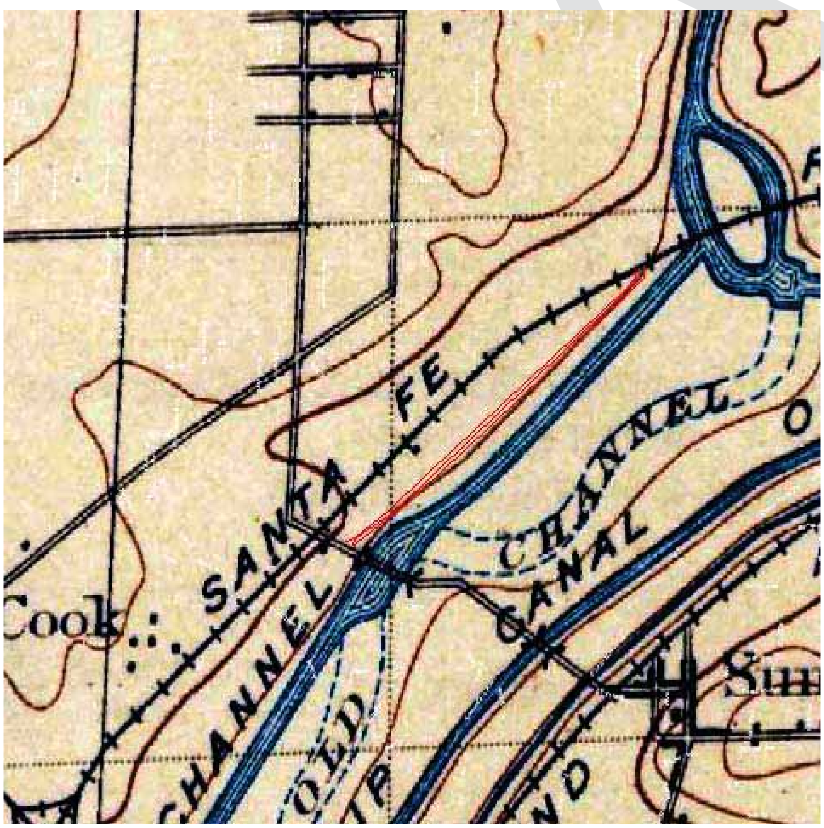



*Figure 4. Topographic Map from 1901, approximate future levee alignment in red, note Des Plaines River straightened*

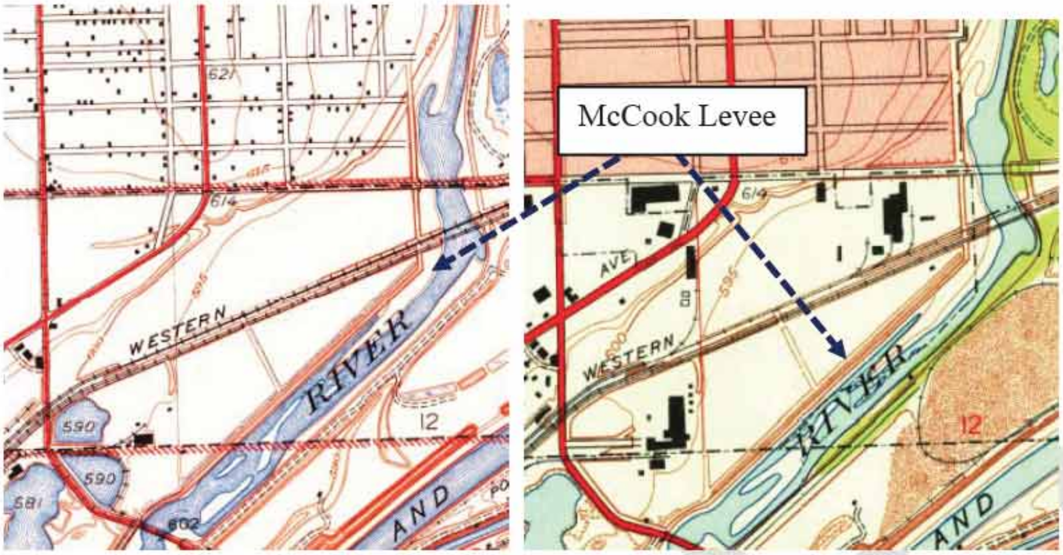



*Figure 5. Old topographic maps with McCook Levee; 1928 (Left), 1953 (Right) indicating presence of McCook Levee*

Local Geology

10. A total of 15 soil borings were completed along the existing levee. Nine of these were completed in 1979 by Walter H. Flood & Co while six were completed in 1984 by Patrick Engineering, Inc. These borings were completed between Lawndale Road and 47th Street, so no subsurface information is available for the West Lyons Levee north of 47th Street.

11. All borings were sampled at 2.5 foot intervals with a split spoon sampler or thinwall Shelby tubes via hollow stem auger. However, the 1984 borings did switch to mud rotary drilling at deeper depths as described on the logs. If bedrock or a boulder were encountered, it was penetrated not less than five feet with a roller rock bit. Rock coring was not completed.

12. The boring logs generally identified 4 types of soil that make up the existing levee as described on **Plate 1, which includes levee stationing**;

(Zone 1) Random rubble fill consisting of brown to black silty clay, old bricks, concrete, wood, slag, limestone residual and stone. The material properties and consistency within this Zone are extremely variable. This material was found in the southern end around Station 0+00 to Station 8+00.

(Zone 2) This material is a very stiff to hard silty clay fill, typical of a well compacted, modern highway fill. The moisture content is approximately twenty percent which appears to be near to slightly higher than the optimum moisture content of the material. This Zone appears to have good shear strength characteristics, is relatively consistent and is confined to between approximately Stations 8+00 and 14+00. This material may be recent fill replacing a breached zone.

(Zone 3) This material is predominantly silty clayey sand to sandy silty clay fill. This Zone consists of medium dense silty clayey sands generally having greater than thirty percent fines. The material is reasonably uniform in density and particle size distribution. The material was only encountered between approximately Station 32+00 and 48+00.

(Zone 4) The bulk of the levee appears to be constructed of moderately organic silty clay. This Zone consists of organic material having moisture contents ranging from 20 percent to 35 percent depending on the organic content and the location relative to the river level. The the natural density is approximately 120 to 130 pcf. Generally, the shear strength decreases with depth. The range of unconfined compressive strength (estimated using a pocket penetrometer) varies from greater than 4.5 tons per square foot to as little as 1.5 tons per square foot. Due to the fill nature, these values may not be reliable representatives of the entire strata. Because of the organic content, this material is moderately compressible and minor consolidation is possible under increased loading conditions.

13. The foundation material was identified under 5 general descriptions;

(Zone 5) Loose well graded silty to clean sand was encountered immediately below the levee fill from about Station 32+00 to Station 48+00. This sand is saturated and has moderate shear resistance based on the N values. Due to the loose nature of this Zone, additional loading may produce minor additional settlements. Borehole recharge test results indicate this material has a coefficient of permeability ranging from 10-4 to 10-2 cm/sec with moderate seepage and piping potential.

(Zone 5A) Similar to Zone 5 but with saturated gravel layers and cobbles.

(Zone 6) Zone 6 consists of normally consolidated soft brown and gray silty clay. The material within this Zone is saturated and has moisture contents of approximately 30 percent to 35 percent. Unconfined compressive strengths estimated with the aid of a pocket penetrometer range between 0.7 and 2.2 tons per square foot. The relatively high water content and low shear strength suggest this material is moderately compressible and would develop high pore pressures under rapid loading. This material appears to be common to all reaches, and is the weakest material encountered.

(Zone 7) This soil is very stiff to hard silty clay borderline clayey silt. The Zone is saturated and extremely dense (overconsolidated) with an average moisture content of fifteen percent. This material yields natural wet densities of approximately 140 pcf. The material was tested in a few locations with a pocket penetrometer which read in excess of 4.5 tons per square foot each time. However for this report, Zone 7 will be treated as a cohesionless material like it was for the 1980’s feasibility report. The site stratigraphy will be reevaluated once additional investigations are completed.

(Zone 8) The layer immediately overlying bedrock over most of the length of the levee except for approximately Sta. 14+00 to 25+00 is an extremely dense silty sand. This Zone consistently has greater than twenty percent silt and N values greater than 100. The high N values indicate the shear strength of the silty sand is high and the silty nature of the soil indicates this layer will have limited seepage potential and is virtually incompressible.

14. The bedrock underlying the site is Racine Formation of Silurian age. This is a moderately jointed, pure to locally argillaceous, reef forming dolomite with scattered chert and thin to thick bedding. Near surface joints and bedding plane fractures are open and so permeable but close and become less permeable with depth. Rock was not cored so local conditions are not known. Bedrock was encountered as shallow as 583 ft NGVD29 near Sta. 14+00, but is at least 15 feet deeper in some locations underneath the McCook Levee. The results of these borings can be found on **Plate 1**.

Groundwater

15. Soil borings completed along the existing McCook Levee recorded the groundwater elevation as shown in *Table 2* below. The water elevations for the second round of sampling were taken on various dates from November 1984 and January 1985, indicating that the water levels can fluctuate by up to 10 feet depending on when the reading was taken in the borehole. Groundwater readings within clay soils are generally unreliable due to the slope rate of seepage. Also, all but CBM-6-84 of the 1984 boreholes introduced water via mud rotary, borehole recharge test, or both decreasing the likelihood of representative groundwater level readings for all cases except those taken one month after drilling. Groundwater quality in the area of the project is unknown.

*Table 2. Groundwater Elevations generally indicating levels similar to river*

| Boring Number, moving North to South along alignment | Water Level During Drilling* | Water Level After Drilling* | Water Level 24 Hours After Drilling* | Water Level ~1 Month After Drilling* |
|---|---|---|---|---|
| CBM-5-84** | 589.1 | -- | -- | 591.5 |
| 9 | 583.5 | 583.5 | 583.5 | -- |
| CBM-1-84** | 586.2 | -- | -- | 590.7 |
| 8 | 586.0 | 586.0 | 586.0 | -- |
| 7 | -none encountered- | | | |
| CBM-6-84 | -- | 571.5 | -- | 588.0 |
| 6 | -none encountered- | | | |
| CBM-2-84** | -- | 583.0 | 582.0 | 588.7 |
| 5 | -none encountered- | | | |
| 4 | -none encountered- | | | |
| CBM-4-84** | 587.0 | 591.0 | -- | 588.5 |
| 3 | -none encountered- | | | |
| 2 | -none encountered- | | | |
| CBM-3-84** | -- | -- | 586.1 | 591 |
| 1 | -none encountered- | | | |

**Elevations given in feet MSL 1929*

***Added water during drilling for mud rotary and/or in-situ permeability test*

16. Water level can fluctuate over time and may be different than what was measured in *Table 2*. Additionally, the Des Plaines River normal stage elevation around 589 ft NAVD88, which is roughly the same elevation as the water heights measured about 1 month after drilling. So it is likely that the river has influence over the water level along the levee.

## EXISTING LEVEE

17. The McCook Levee is an existing levee along the Des Plaines River which reduces the risk of flooding in the communities of McCook, Lyons, and Summit, Illinois. The south stretch extends from Lawndale Road at Sta. 0+00, across railroad lines around Sta. 42+00 and ends at 47$^{th}$ Street around Sta. 48+00, so approximately 4,800 feet long. Refer to **Plate 1** for a map with Stationing. The north stretch was not included in the previous feasibility report, but is being considered in this study. This stretch starts at 47$^{th}$ Street and extends north to high ground, about 900 feet long and is referred to as the West Lyons Levee.

18. The levees are between 89 and 116 years old, as they are shown on the 1928 topographic map (*Figure 5*) but not the 1901 map (*Figure 4*). The southern levee was reportedly with a 20 ft wide berm and 2H: 1V slopes. However, there are some areas where the slopes are closer to 1.5H: 1V. The embankment height is approximately 15 feet from the original ground and the crest has a gravel pathway. In 1979, the levee was breached by high water between Sta. 8+00 and 14+00. Later in 1979 after the breach, the levee was repaired and sheetpile was installed to increase the height from Sta. 1+00 to 41+00 (south of the railroad). Since 1979, the levee has been loaded many times and while there were some instances of noted seepage, the levee has not failed or overtopped.

19. West Lyons Levee (north of 47$^{th}$ St) was likely constructed around the same time but there is no records of construction for this stretch, either. The slopes are generally 2:1 with a 20+ ft wide crest and about 10 feet tall.

20. In October 1986, the levee was inspected during a high water event and seepage was noted between Sta. 3+60 to 4+50. Ponded water was noted on the crest and erosion was noted on both landside and riverside. Field inspection reports can be found in **Attachment 4** which include photos of the event, as well. The field inspection focused on the south portion, only. The slopes of both stretches of the levee are heavily vegetated with tall grass, brush, and mature trees. A typical cross section with sheetpile is shown below.

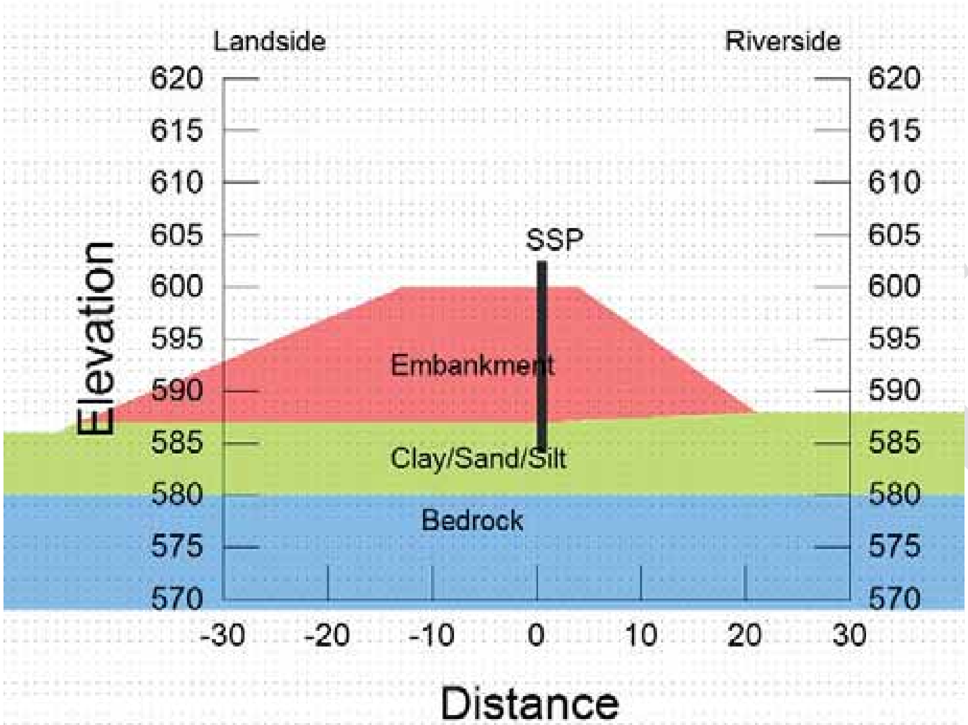



*Figure 6. Typical McCook Levee Cross Section Showing Sheetpile not cutting off Seepage (Sta. 1+00 to 41+00)*

Vegetation

21. Throughout the entire stretch of the levee north and south of 47th St, mature trees, and some several feet in diameter are growing at the toe, slope and crest. The unwanted vegetation inhibits the inspection, maintenance, and emergency operations. The root systems may encourage piping through the levee system and impair the stability. Additionally, trees that fall over can rip out significant chunks of the levee in their root balls.

22. To remove vegetation, the plans being developed should follow the recommendations in ETL 1110-2-583. This includes having a vegetation-free zone that consists of perennial grasses to cover the levee and at least 15 ft from each toe. The grass cover allows for easy access during inspection and emergency events. The existing trees would be removed, as well as their stump, rootball, and roots greater than ½ inch diameter on and within 15 ft of the levee toe. This reduces the risk of root penetrations into and under the levee. Backfill should consist of similar materials compacted so that they are similar to the surrounding area.

Soil Parameters

23. The 1980's feasibility report identified design parameters for the different 'Zones' of soil defined in the above section. These are shown in *Table 3*.

*Table 3. Soil Parameters from 1980's Feasibility Report*

| Zone | Moist Unit Weight (pcf) | Wet Unit Weight (pcf) | End of Construction | | Long Term | |
|---|---|---|---|---|---|---|
| | | | Cohesion (psf) | Phi Angle | Cohesion (psf) | Phi Angle |
| New Clay Fill | 125 | 130 | 1000 | 0 | 200 | 32 |
| 1 | 120 | 130 | 0 | 27 | 0 | 27 |
| 2 | 125 | 130 | 1000 | 0 | 0 | 30 |
| 3 | 120 | 130 | 0 | 28 | 0 | 28 |
| 4 | 120 | 125 | ~~250~~ → 500* | 0 | 0 | 24 |
| 5 | 125 | 125 | 0 | 30 | 0 | 30 |
| 5A | 130 | 130 | 0 | 30 | 0 | 30 |
| 6 | 120 | 120 | ~~300~~ → 600* | 0 | 0 | 26 |
| 7 | 140 | 140 | 0 | 28 | 0 | 28 |
| 8 | 145 | 145 | 0 | 40 | 0 | 40 |
| Bedrock | 130 | 135 | 0 | 35 | 0 | 35 |

**revisited due to apparent low values compared to lab data*

24. As noted in *Table 3* above, the cohesion values for Zone 4 and Zone 6 materials seem to be low when comparing them to field and lab data in *Table 4*.

*Table 4. N-Values and Unconfined Compressions for Zone 4 & 6, indicating original analysis undervalued their cohesions*

| Zone | N-Value (blows/ft) | Unconfined Compression* (tsf) |
|---|---|---|
| 4 | CBM-3-84: N/A<br>CBM-4-84: 18, 11<br>CBM-2-84: 13, 13, 15<br>CBM-6-84: **10**, 16, 16, 12<br>CBM-1-84: 11, 10<br>CBM-5-84: 19<br>**AVERAGE: 13.7** | CBM-3-84: N/A<br>CBM-4-84: 2.0, 2.5<br>CBM-2-84: 3.3, 2.7, 1.6, 1.7, **1.5**<br>CBM-6-84: 3.5, 4.5, 4.5, 4.5, 4.5, 2.5<br>CBM-1-84: 4.5, 2.7<br>CBM-5-84: 4.0, 2.75<br>**AVERAGE: 3.1** |
| 6 | CBM-3-84: 12<br>CBM-4-84: 14<br>CBM-2-84: 9, 8<br>CBM-6-84: **5**<br>CBM-1-84: 5<br>CBM-5-84: N/A<br>**AVERAGE: 8.8** | CBM-3-84: 1.8<br>CBM-4-84: 1.0<br>CBM-2-84: 1.3, **0.7**<br>CBM-6-84: 2.2<br>CBM-1-84: 1.0<br>CBM-5-84: N/A<br>**AVERAGE: 1.3** |

**from pocket penetrometer*

25. For Zone 4, which is described as an organic silty clay fill placed for levee construction, the average unconfined compression test via pocket penetrometer is over 3 tsf, with the minimum value being 1.5 tsf. Converting this to cohesion requires dividing by 2, then converting the units to psf, so the average cohesion is 3000 psf and minimum is 1500 psf. These values are well above the one used in the 1980's Feasibility Report. Based on this data, it is reasonable to double the cohesion value from 250 to 500 psf. There is still some uncertainty associated with the material since it is fill, otherwise the cohesion would be increased even further. Additional investigations and advanced triaxial testing will better inform the final design.

26. For Zone 6, which is described as native silty clay, the average unconfined compression test via pocket penetrometer is 1.3 tsf, with the minimum value at 0.7 tsf (equivalent to 1300 and 700 psf cohesion, respectively). These values are also much higher than the 300 psf assigned in the 1980's Feasibility Report. Therefore, this value is doubled as well to 600 psf. The new value is still below the minimum reading and since this material is native, there is less variability than the Zone 4. So there is a greater confidence that 600 psf is a conservative representative cohesion value of the layer.

27. The 1984 subsurface investigation included field permeability tests focused on Zone 5 to provide an indication of the magnitude of the potential for seepage and piping. The seepage potential of three areas within the levee was measured by simple recharge tests. Eight tests were attempted and four were considered useful. These tests provide an indication of the relative permeability of the soil surrounding the open area below the temporary borehole casing or hollow stem auger. The test procedure consists of pumping water into the casing and allowing it to flow out through the bottom cross sectional area of the cased holes into a zone of soil. The hydraulic head, when testing saturated zones, is the difference between the top of the casing and the natural groundwater table. The tests resulted in a range of permeability's from 1E-2 cm/sec to 7E-5 cm/sec as shown in the below table. These correspond to 3E-4 ft/sec to 2E-6 ft/sec.

SUMMARY OF BOREHOLE RECHARGE TEST RESULTS

| Boring No. | Test Interval (Depth) | Method Of Test | Period Of Test | Hydraulic Head (ft.) | Computed Mean Coefficient Of Permeability |
|---|---|---|---|---|---|
| CBM-1-84 | 13.5-15.5 | Constant Head | 20 seconds | 16.3 | $1x10^{-2}$ cm/sec |
| CBM-1-84 | 13.5-15.5 | Falling Head | 5 minutes | 16.3 | $7x10^{-3}$ cm/sec |
| CBM-1-84 | 19.0-20.0 | Falling Head | 10 minutes | 16.5 | $7x10^{-5}$ cm/sec |
| CBM-1-84 | 18.0-22.0 | Constant Head | 1 minute | 17.5 | $2x10^{-3}$ cm/sec |
| CBM-1-84 | 18.0-22.0 | Falling Head | 10 minutes | 17.5 | $1x10^{-3}$ cm/sec |
| CBM-5-84 | 17.5 | Falling Head | 15 minutes | 17.0 | $2x10^{-5}$ cm/sec |

28. These correspond to a range of 3E-4 ft/sec to 2E-6 ft/sec and average to 1E-4 ft/sec.

*Table 5. Soil Permeability Values*

| Zone | Permeability (ft/sec) & |
|---|---|
| 1 | 1E-3^ |
| 2 | 1E-7+ |
| 3 | 1E-6# |
| 4 | 1E-7+ |
| 5 | 1E-4* |
| 5A | 1E-3^ |
| 6 | 1E-7+ |
| 7 | 1E-7+ |
| 8 | 1E-6# |
| Sheetpile | 1E-6~ |
| Bedrock | Impermeable |

** Average of 1984 falling head tests*
*+Assumed based on clay composition*
*# Assumed based on coarser grains intermixed with less permeable clay/silts*
*~ Assumed based on permeable joints*
*^ Assumed based on more permeable than Zone 5 material with larger grained material*
*& To be verified in future studies*

29. These permeability values are either assumed or derived from the recharge tests completed in the 1984 investigation. However, based on the soil types listed in the logs and typical values, the recharge tests may be overstating the permeability of the silty sand material in Zone 5. Additional investigations including borings, test pits, and laboratory tests should be completed to better understand the permeability of the various zones.

**DESIGN ANALYSIS**

Slope Stability

30. The 1980's feasibility report completed several different stability analyses based on parameters developed from the soil borings.

*Table 6. Slope Stability Results (USACE, 1984) Show Failure to meet acceptable factors of safety for Sta. 23+00, location of organic levee soils*

| Station | Levee Height | Side Slopes | | Case | Side Analyzed | Method | Minimum Factor of Safety Req'd | Factor of Safety Calculated** |
|---|---|---|---|---|---|---|---|---|
| | | River Side | Land Side | | | | | |
| 11+25 (Location of 1979 breach) | Existing (600) | 2:1 | 1:1 | Infinite Slope | River | - | 1.0 | 1.15 |
| | 100-year (604.5 - raised) | 2:1 Stone | 2:1 Clay | Partial pool | River | Wedge | 1.4 | 1.61 |
| | | | | EOC | River | | 1.3 | 2.79 |
| | | | | EOC | Land | | 1.3 | 2.63 |
| | | 2:1 Clay | | Partial pool | River | | 1.4 | 2.06 |
| | | | | EOC | River | Arc | 1.3 | 2.01 |
| | | | | EOC | Land | | 1.3 | 2.04 |
| **23+00* (Location of Organic Soil Em-bankment** | **Existing (599.5)** | **2:1 Clay** | **3:2 Clay** | **Infinite Slope** | **River** | **-** | **1.0** | **0.89** |
| | **100-year (605 - raised)** | | 2:1 Clay | Partial pool | River | Wedge | 1.4 | 1.86 |
| | | | | **EOC** | **River** | **Arc** | **1.3** | **1.18** |
| | | | | **EOC** | **River** | | **1.3** | **1.07** |
| | | **5:2 Clay** | **5:2 Clay** | Partial pool | Land | | 1.4 | 1.73 |
| | | | | EOC | River | | 1.3 | 1.65 |
| | | | | **EOC** | **Land** | | **1.3** | **1.23** |
| 11+25 23+00 | 100-year (604.5 - raised) | 2:1 Stone | 2:1 Clay | Partial pool | River | Wedge | 1.4 | 2.97 |
| 11+25 | | | | EOC | River | Wedge | 1.3 | 3.70 |
| 11+25 | | | 2:1 Clay w/berm | EOC | Land | Arc | 1.3 | 1.84 |

**For the proposed plan 3A – segmented levee, the levee repair technically ends near Sta. 21+00 where it ties back into high ground. However, the cross section analyzed uses soil information based on Boring CBM-2-84 which is located at Sta. 20+88, just south of the proposed tieback. Therefore, the analysis is still applicable for all cases.*
***Calculated with unedited cohesion values for Zone 4 and 6*

31. The above stability runs focused on these two cross sections as they were determined to be the most critical. Sta. 11+25 is where the breach occurred in 1979 and due to the proximity of the levee to the river and access road, there is a severe constraint on the base width and location of any proposed levee rehab. As shown in the above table, 2:1 slopes

on either side are acceptable for this area. Sta. 23+00 is where the levee is constructed out of weak organic silty clay with a soft organic silty clay foundation. The analyses above indicate that 2:1 slopes for this area are insufficient. A 2.5:1 slope is required for the riverside slope, while the landside slope requires a flatter slope.

32. The cross sections from the 1980's feasibility report were based on raising the height to elevation 604.5 ft NGVD per *Figure 7* below. Since this report does not recommend increasing the height of the levee, the slopes will not be as high as what was modeled prior. Therefore, some of the slopes were reexamined via SLOPE/W software to determine if a steeper slope could be used.

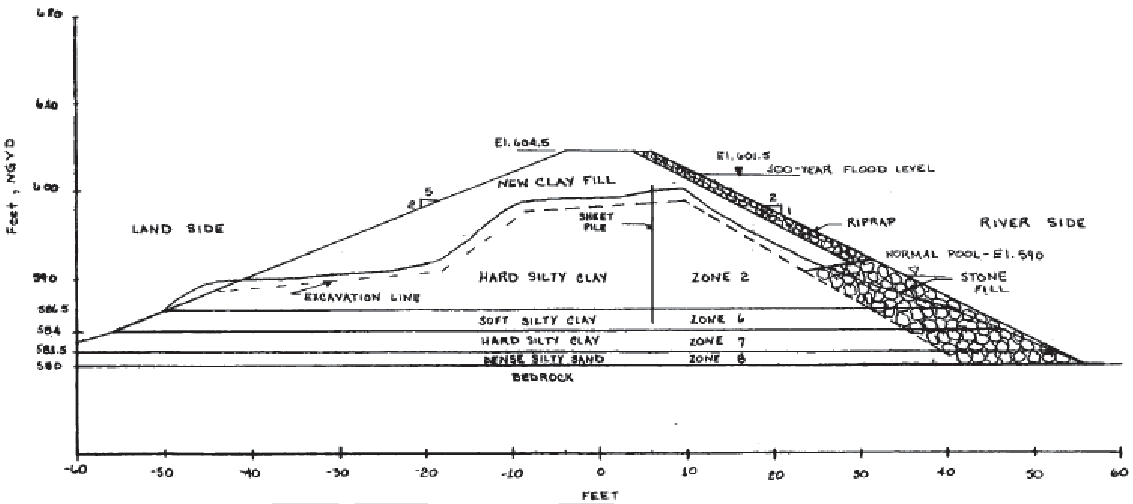



*Figure 7. Analyzed cross section from 1980's Feasibility Report (Sta. 11+25) with taller levee than what is proposed in this report*

33. The Sta 22+50 cross section was reexamined with a 2.5:1 landside slope, since the 1980's feasibility report recommended a flatter slope. The cross section was run in SLOPE/W for the long term case, as well as, the end of construction. Per EM 1110-2-1913, Table 6-1b, the minimum long term stability should be 1.4, while end of construction is 1.3.

34. The cross section below has a 2.5:1 slope on the landside, with Zone 4 soils making up the embankment. A slight modification was made to the drained strength parameters by including 25 psf effective cohesion to account for some preconsolidation of the soils from placement as embankment fill and effects of desiccation and also to account for negative pore pressures which would be generated during shearing since these soils are partially saturated. The rest of the parameters are the same as *Table 3*. The program uses Morgenstern-Price analysis and finds the critical slip surface via entry-exit. The water line is assumed to be the same throughout, at the normal river level of 590 ft NAVD88.

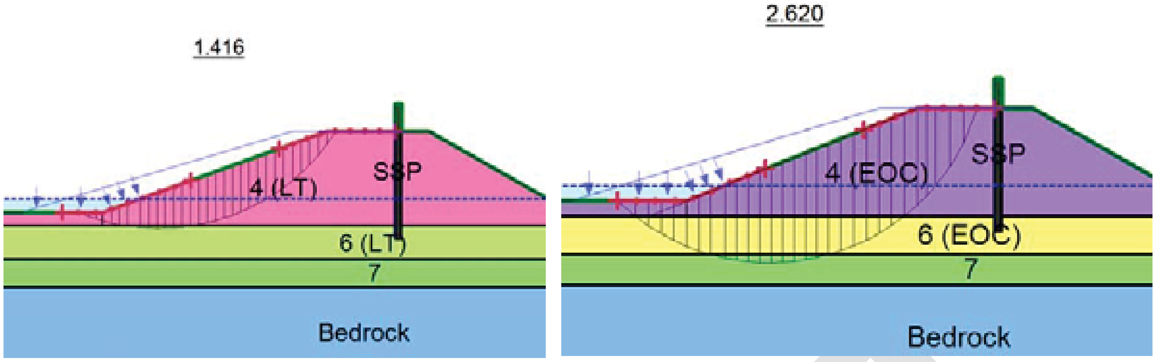



*Figure 8. Landside stability at Sta. 22+50, Long Term (left) FS = 1.416 & EOC (right) FS = 2.620)*

35. As shown above, a 2.5:1 slope is acceptable for the area with Zone 4 materials as 1.416 is greater than the recommended 1.4 for long term stability, while 2.620 is greater than 1.3 for end of construction. Therefore, the entire landside slope can be assumed to be at this 2.5:1 gradation.

36. On the riverside, the 1980's report assumed 2:1 riprapped slope for the Sta. 0+00 to 14+00 and 2.5:1 clay slope for the rest. This is still the case for the proposed riverside slope, although the riprap area will be extended to Sta. 20+00, where it will then transition to 2.5:1 clay slope.

I-Wall Stability

37. During the analyses to determine the fragility curve, sheetpile stability was analyzed with regard to riverside erosion, as well as, ETL-1110-2-575 using CWALSHT.

38. The analysis tried to determine a point which the existing sheetpile may become unstable. It used CWALSHT to run multiple iterations of the cross section at Sta. 23+00 with varying heights on the riverside. At this cross section, the top material is Zone 4, middle is Zone 6, and bottom material is Zone 7. It determined that the sheetpile is stable as long as not more than 6.5 feet has eroded on the riverside.

39. Deflection was also checked at this time. The levee cross section in Plate 1 calls out sheetpile as PSA-23, but that is a flat sheetpile type. The sheetpile onsite is a U-shape, which most closely resembles JSP-2 based on measurements. CWALSHT estimates the deflection of JSP-2 to be less than 1 inch for runs completed on where there is little riverside erosion.

*Figure 9: Measurement of existing sheetpile, most closely resembles JSP-2*

Gap Analysis

40. ETL-1110-2-575 was developed post-Hurricane Katrina and describes three failure modes that all floodwalls should be checked against. The first is creation of a flood-side gap in cohesive soils, second is rotational stability failure around the floodwall point considering this gap, and the third is rating the floodwall against criteria for consolidation of deflections. Each of these failure modes are checked in the analysis below.

Flood-side Gap

41. The flood-side gap is caused when cohesive soils are present on the water side of the floodwall and a high water event occurs. Floodwaters enter the gap which extends to a depth of $Z_0$ defined below. A stability analysis was completed to determine how the gap filled with water affects the stability of the floodwall. The depth of a potential gap can be defined as $Z_0 = 2c/(\gamma_{sat} - \gamma_{water})$ using parameters from Zone 4.

$$Z_0 = 2c/(\gamma_{sat} - \gamma_{water}) = 2*500/(125-62.4) = 16.0 \text{ ft}$$

42. Since the total embedment depth of the sheetpile is roughly equal to the $Z_0$ value, the gap extends all the way to the tip. Therefore, there is no active earth pressure on the riverside of the wall. The cross section was drawn without the floodwall and river side soils to determine how a saturated gap would act on the land side soils.

43. The protected side is considered to be completely saturated to be conservative, with the water to the top of the sheetpile on the riverside. The run is shown in *Figure 10* below and based on these characteristics, the gap analysis produces a factor of safety of 1.789. Referring to Table B-1 in EM 1110-2-575, the minimum factor of safety for this stability situation with an ACE = 1% and ordinary knowledge of subsurface conditions is 1.7. Therefore, this configuration is acceptable for the gap analysis.

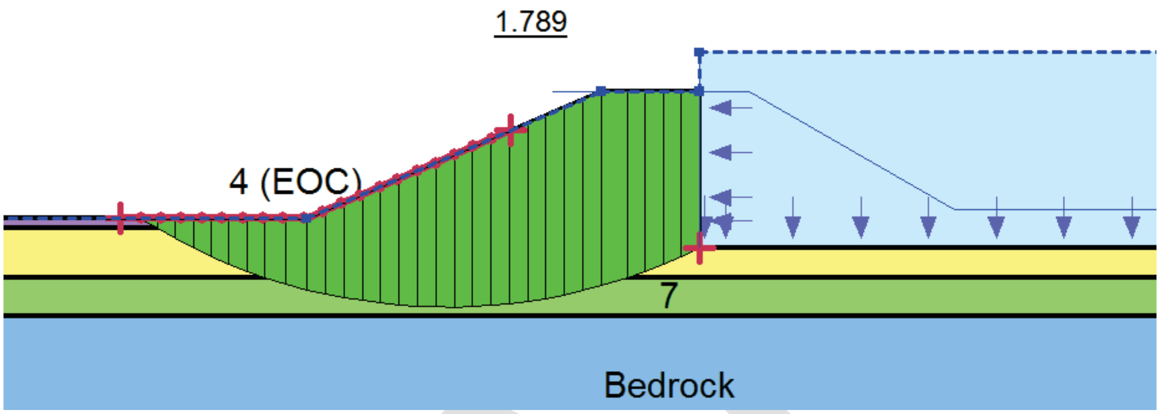



*Figure 10: SLOPE/W gap analysis result with acceptable FS = 1.789*

Rotational Failure

44. To determine the rotational stability of the floodwall, an analysis using CWALSHT was performed using the elevations developed in the gap analysis. Applying a minimum factor of safety of 1.5, the calculated sheetpile tip elevation is higher than the actual, so the wall meets the rotational failure criteria.

Deformation/Deflection Failure

45. The final check is based on maximum water levels for a deformation evaluation. The heights are shown on Table B-2 of ETL-1110-2-575, extracted below.

| Annual Chance of Exceedance | Foundation Type | | | |
|---|---|---|---|---|
| | Sand $\varphi \geq 32.5$, $D_r = 0.50$ | Soft Clay $S_u \leq 300$ psf (14.4 kPa) | Stiff Clay $S_u \geq 1{,}500$ psf (71.8 kPa) | I-wall on Levee |
| 1% and above | 7 (2.1) | 5 (1.5) | 8 (2.4) | 4 (1.2) |
| 0.2% | 9 (2.7) | 7 (2.1) | 12 (3.7) | 4 (1.2) |
| 0.1% and below | 11 (3.4) | 8 (2.4) | 15 (4.6) | 4 (1.2) |

*Figure 11: Table B-2 from ETL 1110-2-575 showing max height of sheetpile allowed to be exposed to water*

46. This floodwall height is elevation 602.5 ft NAVD88, with a maximum of about 4 feet between the protected side ground and the flood height. The foundation type is 'I-wall on levee' and the protection level is equivalent to the 0.2% chance exceedance level (500-year storm), which equates to a maximum of 4 feet before permanent deflection of the soils occurs. Since that is the maximum height, permanent deflection is not anticipated and the McCook Levee is acceptable for this condition. If it becomes apparent that more than 4 feet is exposed in an area, the design will include raising the berm height.

47. There is additional erosion on the riverside slopes, particularly one location where there is an 11-½ ft drop from the top of sheetpile to ground (*Figure 12*). Areas such as this would be repaired during this project.

*Figure 12: Photo of unacceptable erosion on riverside, about 11-½ ft of sheetpile exposed*

48. The McCook Levee sheetpile passes the requirements of ETL-1110-2-575, aside from the erosion present on the riverside. Therefore, there will likely not be any additional rehabilitation requirements with respect to the sheetpile.

Settlement

49. In areas where the subsurface is predominantly organic silty clay overlaying soft clay generally has a lower crest height than the rest of the levee (Zone 4 over Zone 6). The crest is roughly 3 feet lower than the rest of the levee and is likely due to settlement of the soft material. Since the levee is about 100 years old, settlement has likely finished. However, additional fill placed on the levee should account for additional settlement. Fill is required in several low areas of the levee to maintain a similar levee height. But no more than 3 feet is required across the project, and this amount of added fill is unlikely to result in settlement that would need to be quantified for this feasibility study.

Seepage

50. The sheet pile installed after the 1979 breach does not penetrate deep enough to cut off critical permeable soil zones. Therefore, seepage is a concern for the McCook Levee. Seepage was noted during the October 1986 high water event, particularly around Sta. 3+60 to 4+50. This stationing corresponds to the location of a sand and gravel lens (Zone 5A) below the sheet pile, as well as, the rubble fill levee section (Zone 1). Information from this flood event is included in Attachment 4. Another high water event occurred in 2013, which overtopped the berm south of Lawndale. Due to the overtopping, the landside toe was under water so it was not possible to monitor seepage.

51. The program SEEP/W was used to estimate the amount of seepage, as well as, uplift pressure at the landside toe. A steady state condition was used with the river at the top of the levee/sheetpile. This is considered conservative, as the Des Plaines River has roughly a week-long flood duration which would not fully saturate the cross section. The riverside assumes a 604 ft elevation, while the landside assumes a potential seepage face. The cross sections were developed from Plate 1. Subsurface profiles were carried horizontally since there were no borings on either the landside or riverside.

52. The first cross section is around Sta. 4+00, where the levee is constructed out of Zone 1 material, the foundation includes more permeable materials, and sheetpile is present. This is also where seepage was noted during the 1986 event. This results in a 1.6 E-4 cfs and an exit gradient at the landside toe of 0.17.

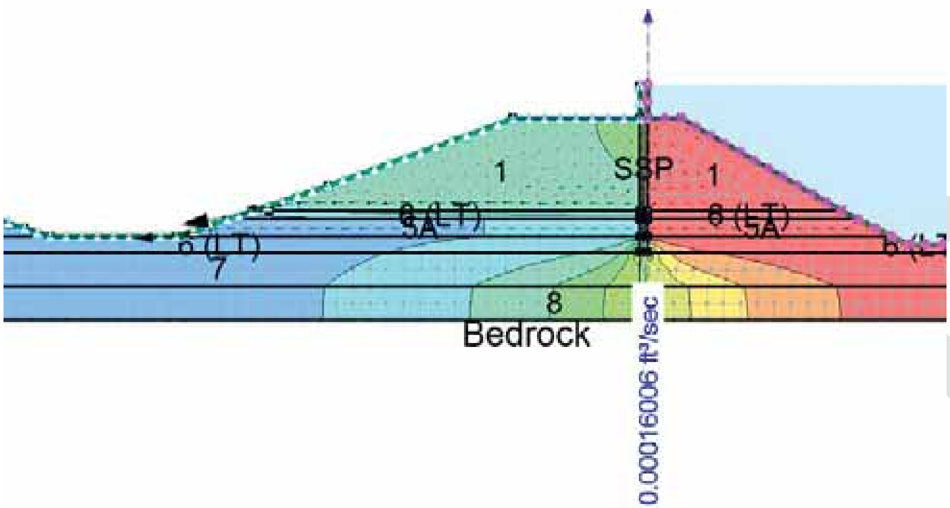



*Figure 13. Sta. 4+00 Seepage Diagram where seepage was observed indicates higher rate of seepage*

53. The second cross section analyzed was at Sta. 11+25, where the levee was repaired after the 1979 breach and sheetpile is present. This results in total seepage of 1.1 E-5 cfs and an exit gradient at the landside toe of 0.19.

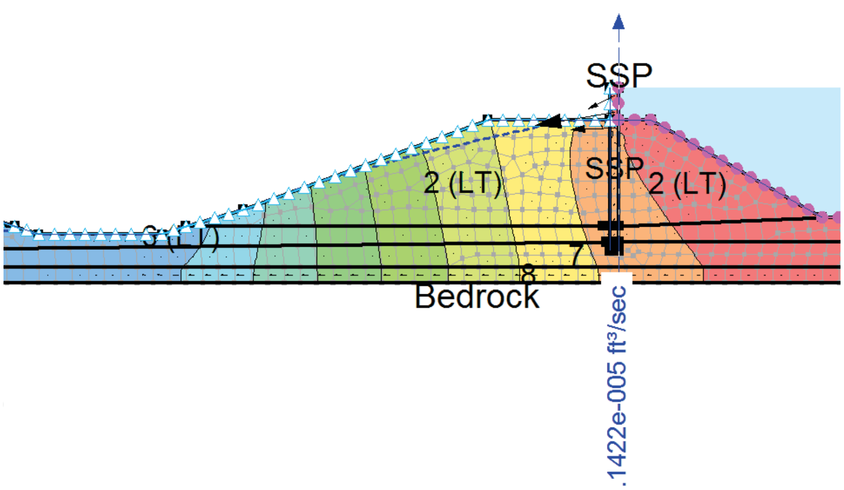



*Figure 14. Sta. 11+25 Seepage Diagram at repair location indicates lower rate of seepage*

54. The third cross section is around Sta. 23+00, where the levee is Zone 4 (clay), the subsurface is Zone 6 (clay) underlain by Zone 7 (silty clay/clayey silt), and sheetpile is present. This results in a 6.4 E-7 cfs and an exit gradient at the landside toe of 0.19.

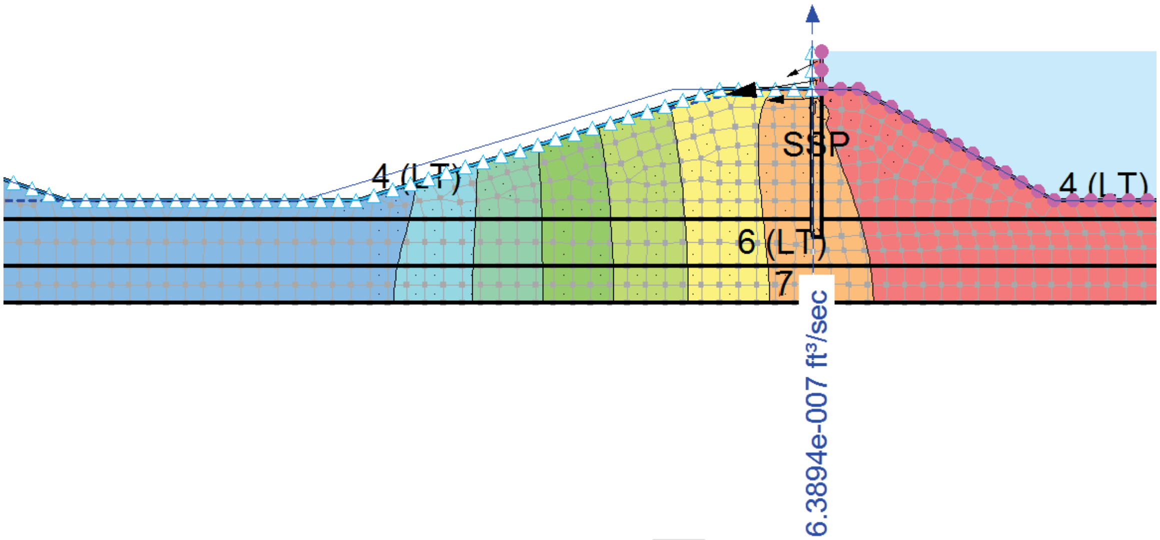



*Figure 15. Sta. 23+00 Seepage Diagram indicates very low rate of seepage with clay foundation material*

55. The fourth cross section is around Sta. 42+00, after the sheetpile ends and north of the railroad. This cross section differs in that there is no ditch on the landside. The levee was constructed of Zone 3 and 4 materials, while the foundation is predominantly Zone 5. This results in a seepage rate of 1.6E-5 cfs and an exit gradient at the landside toe of 2.5.

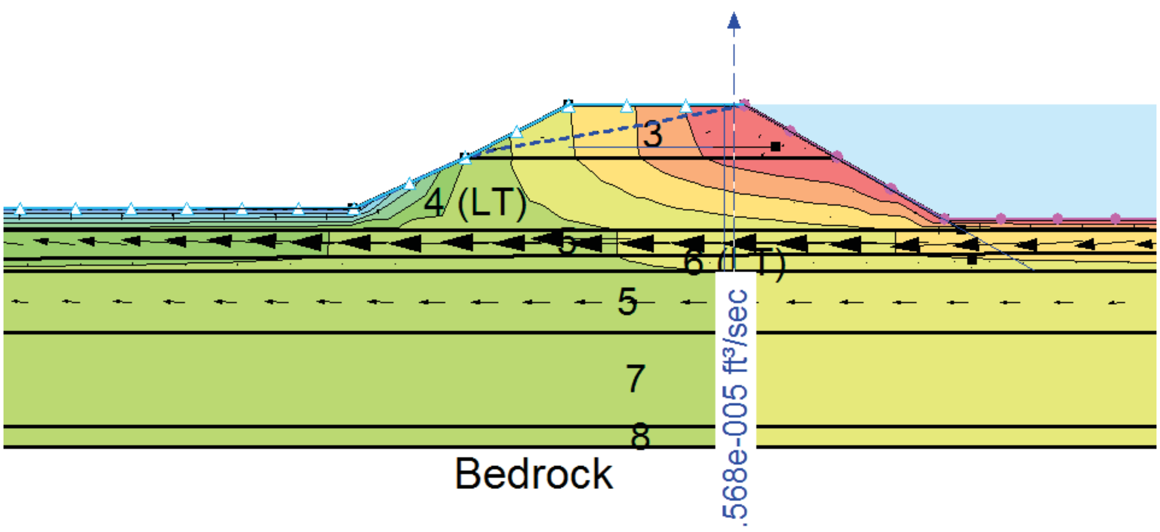



*Figure 16. Sta. 42+00 Seepage Diagram indicates high rate of seepage due to sandy foundation material*

*Table 7. Summary of Seepage Calculations*

| Station | Comments | Seepage Rate (cfs/ft) | Seepage Rate (gpm/100 ft) | Exit Gradient | Factor of Safety |
|---|---|---|---|---|---|
| 4+00 | Sheetpile, coarser grained levee & foundation, seepage noted in 1986 | 1.6E-4 | 7 | 0.17 | 2.9 |
| 11+25 | Sheetpile, repaired in 1979, finer grained foundation | 1.1E-5 | 0.5 | 0.19 | 2.6 |
| 23+00 | Sheetpile, original levee, finer grained foundation | 6.4E-7 | 0.03 | 0.19 | 2.6 |
| 42+00 | No sheetpile, coarser grained levee and foundation | 1.6E-5 | 0.7 | **2.5*** | **0.2** |

*requires mitigation

56. As shown in the summary table above, there is a variable amount of seepage across the levee system. These results do not seem to match the historic flood performances, as the area around 42+00 doesn't appear to have been negatively affected by seepage. Further investigations should be implemented to better understand the subsurface. However, this analysis is valid at least for putting together the feasibility level estimate. ETL 1110-2-569, dated May 2005 recommends that the allowable factor of safety for use in evaluations and/or design of seepage control measures should correspond to an exit gradient at the toe of the levee of i=0.5. In general, this would provide a factor of safety of about 1.5. As shown above, 42+00 does not meet this criteria and will require mitigation. The high exit gradient at Sta. 42+00 would indicate that sand boils can develop as a result of high water. No sand boils have historically been observed near this location, but the thick vegetation prevents thorough inspection.

57. According to the USACE Waterways Experiment Station Publication, "Investigation of Underseepage and Its Control – Lower Mississippi River Levees", Technical Memorandum No. 3-424, Vol. 1, October 1956, an underseepage flow of less than 5 gpm per 100 ft is considered light seepage. As shown above, the calculated seepage for all but Sta. 4+00 is considered light. There is significant amount of seepage modeled at Sta. 4+00, which is also the location of observed seepage. However, the existing ditch can collect and discharge seepage water through the summit conduit before it affects any structure within the leveed area. Finally, highly erodible materials like silt are assumed to not be at the surface. Therefore, no remediation is recommended.

58. In order to reduce the exit gradient at the Sta. 42+00 cross section, a toe drain should be added. This would extend into the sandy Zone 5 layer to alleviate the gradient pressure and allow water to exit freely. The model below assumes the toe drain would have the same permeability as Zone 5A, and be 4' deep and 5' wide. It results in a maximum exit gradient of 0.30, which is at the far left of the model and a revised seepage rate of 2.7E-5 cfs. The revised seepage is almost double the amount of the previous model, but is still relatively light at 1.2 gpm/100 ft.

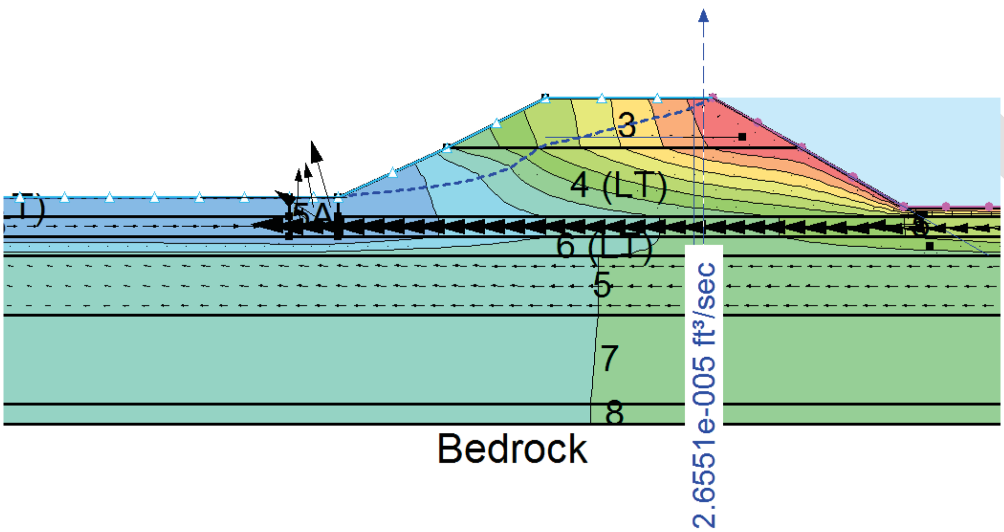



*Figure 17. Sta. 42+00 Seepage Diagram with Toe Drain to reduce exit gradient to acceptable level*

59. The profile above was rerun with sheetpile in place for the cross section at Sta. 38+00 (*Figure 18*). This analysis results in a similar exit gradient of 2.2 since the sheetpile does not cut off the permeable layer. Therefore, the toe drain should extend to the first boring that did not encounter Zone 5; Boring 7 at Sta. 30+00.

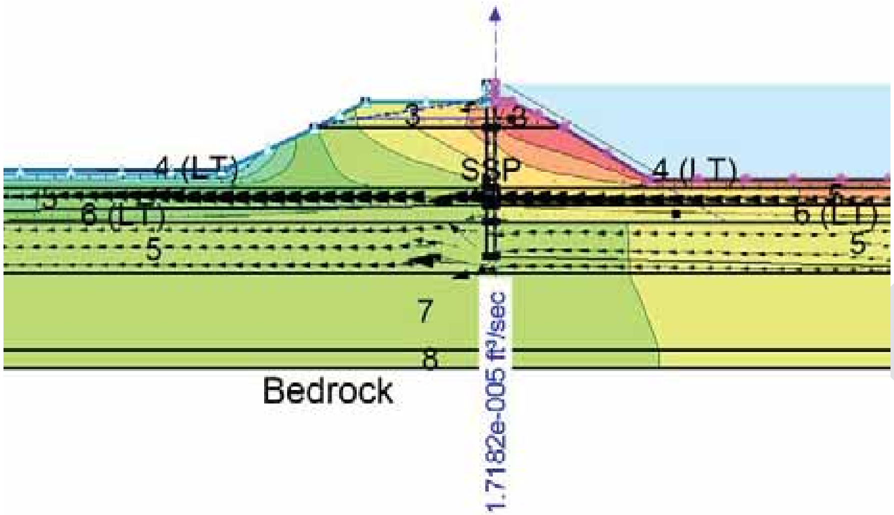



*Figure 18. Sta. 38+00 Seepage Diagram indicates high exit gradient which will also require toe drain*

60. Instead of a toe drain on the landside toe, additional analysis was completed to determine if a cutoff trench could be used on the riverside toe instead. The trench was assumed to be 10 feet wide at the riverside toe and extend to the first less-permeable layer of Zone 6 material (3 feet below grade). It would be constructed out of Zone 4 material. The cross section is shown in *Figure 19* below. This modification reduces the exit gradient from 2.2 to 1.8, but this is still greater than 0.5.

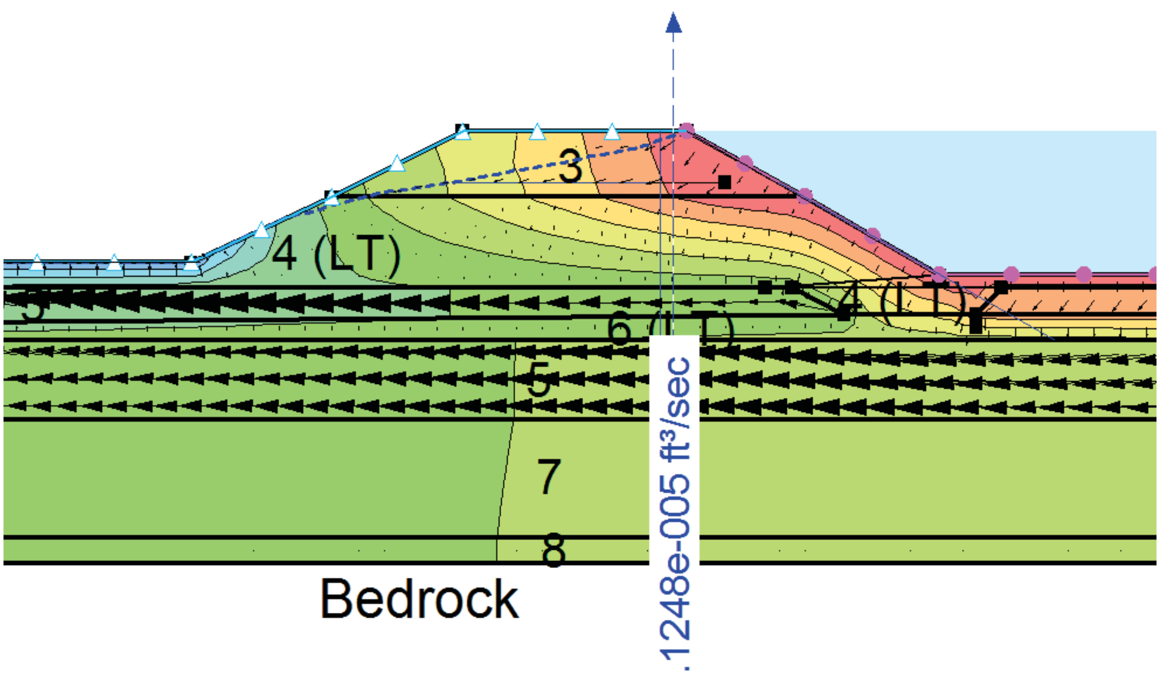


*Figure 19. Sta. 42+00 Seepage Diagram with riverside cutoff to first layer of native clay does not meet exit gradient criteria*

61. To create a successful cutoff in the model, new clay fill is introduced in the model with a permeability of 1E-9 ft/sec. This low permeability clay would cover the riverside slope, as well as, used as backfill for a cutoff trench to cut off all of the Zone 5 soils which is assumed to be an 11 foot excavation and backfill. The cross section also adds a small berm to the landside toe. This effectively reduces the exit gradient to 0.44, which is acceptable.

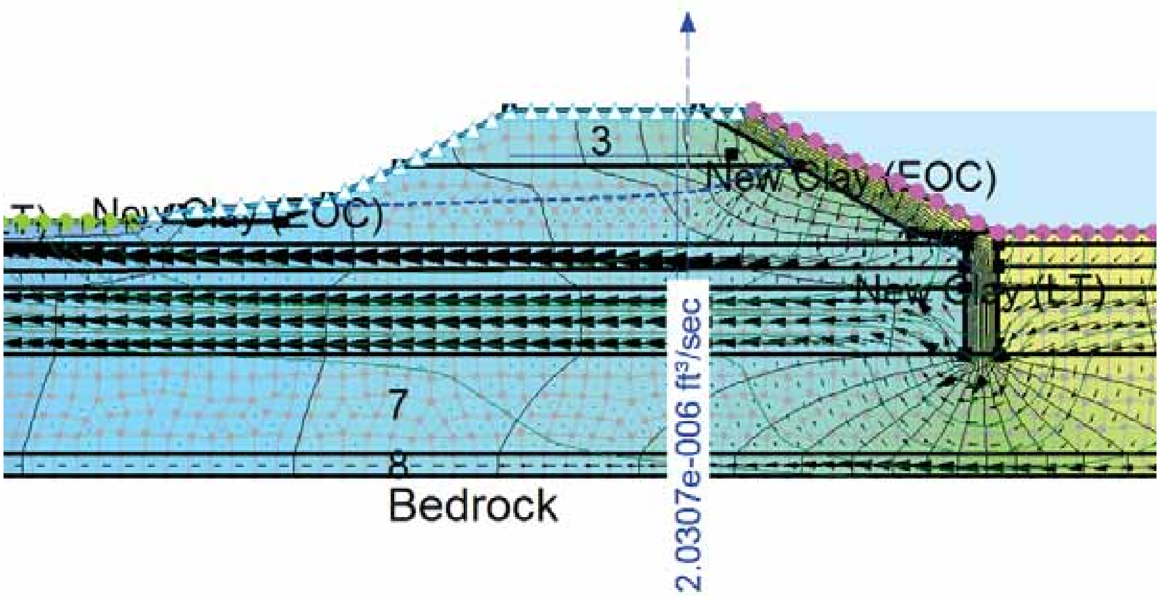



*Figure 20. Sta. 42+00 Seepage Diagram with riverside cutoff to second layer of native clay and clay blanket on slope is effective in reducing exit gradient to acceptable levels*

62. The *Figure 20* above indicates an alternative method than a landside toe drain for reducing the exit gradient. This model relies heavily on assumptions made about the permeability of the existing materials, as well as, the subsurface strata. Additional borings on both toes and additional permeability tests will help finalize a feasible cross section. Generally, a clay cutoff is preferable to a toe drain as it requires no additional maintenance and does not increase seepage to the landside. However, at this time the clay cutoff method would be more expensive than the toe drain, so the preferred plan will include a toe drain. Once additional data is collected on the subsurface, a clay cutoff will be revisited.

63. No subsurface information was available for the levee north of 47th St. At this time, it is assumed the levee is adequately constructed to reduce the risk of seepage. But additional data may indicate that mitigation may be necessary, such as a toe drain.

64. Additional soil borings will help to finalize the design and ensure the proposed work is adequate. Information to focus on is natural permeability rates, thickness of clay at the toes, extent of coarser grained materials, and filling in gaps without information. Per EM 1110-2-1913, borings should be spaced every 200 to 1,000 feet and on both toes of the

levee. Once the investigations are completed, a final analysis will be performed to establish the design basis and boundary conditions.

65. With this additional information, a final design of the toe drains can be completed, which would include required dimensions and a filter design. For the feasibility estimate, it can be assumed the toe drains are 4' deep by 5' wide, lined with a heavy geotextile and filled with CA-7 stone.

CLOSURE FEATURES

66. The south end of the project has culverts which extend underneath Lawndale Ave. These culverts could result in end around flooding due to overtopping of the levee south of Lawndale, which occurred in 2013 and diagramed in *Figure 21*.


*Figure 21. Existing end around Flooding Source south of Lawndale will be cut off with closure*

67. However, in this instance in 2013 the amount of water that overtopped was handled by the Summit Conduit and contained within the landside ditch. In order to not affect the downstream stages of the Des Plaines River and not overload the Summit Conduit, a sluice

gate-type of structure will be installed. This structure will have the ability to limit/close off the flow south of Lawndale to the landside levee ditch. The foundation of this structure will require subsurface investigations to inform the design. With the information available, there may be some soft soils based on *Figure 3* where this area may have been an old river meander.

HIGH GROUND TIE-INS

68. The existing levee plans were checked to ensure they tie into high ground at both ends so that end around inundation is prevented. The levee south of 47$^{th}$ St ties into high ground along Lawndale Ave, where a small berm must be constructed to connect the 603 contour lines (thick blue) as shown on *Figure 22* below.

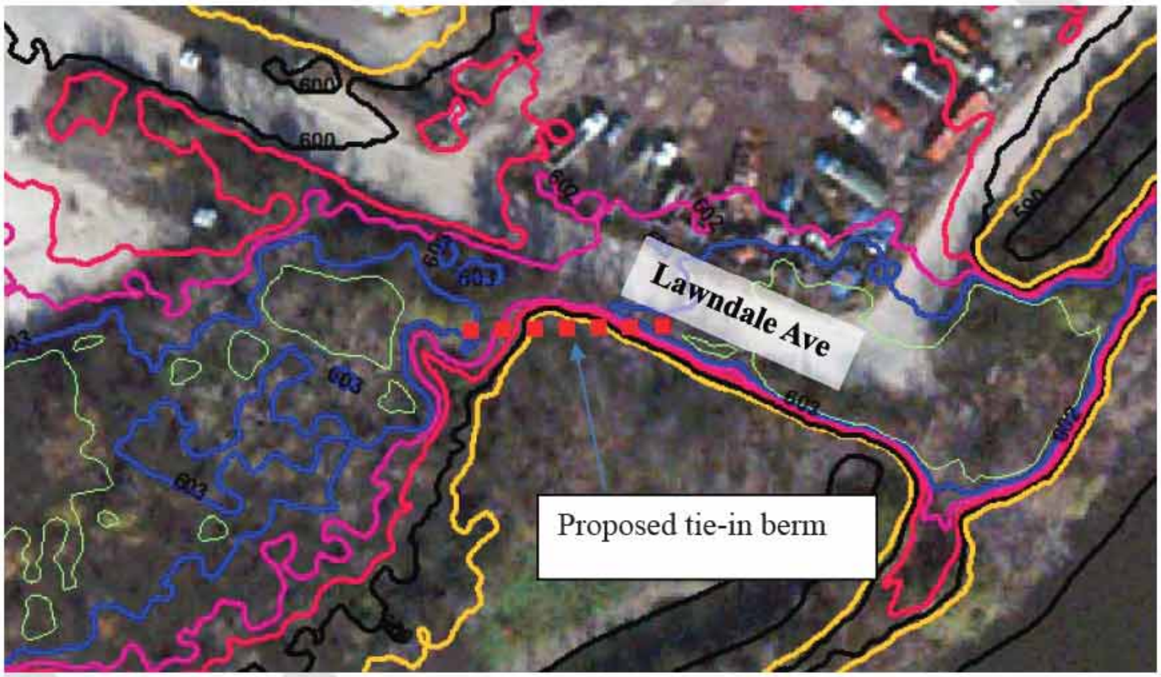



*Figure 22. South end of levee near Sta. 0+00 that requires berm to tie to high ground*

69. If only the portion south of 47$^{th}$ Street is repaired, then the West Lyons Levee would not be considered for providing flood reduction. Therefore, 47$^{th}$ Street would be considered the high ground tie-in for the levee south of 47$^{th}$ Street and would have to be checked for pipes that run underneath the road so the leveed and riverside are not connected. There is also a small area which may require a small berm along 47$^{th}$ St if the West Lyons Levee north of 47$^{th}$ St is ignored, but a more detailed survey is required. The levee north of 47$^{th}$ Street also ties into high ground to the north as shown in *Figure 23*.

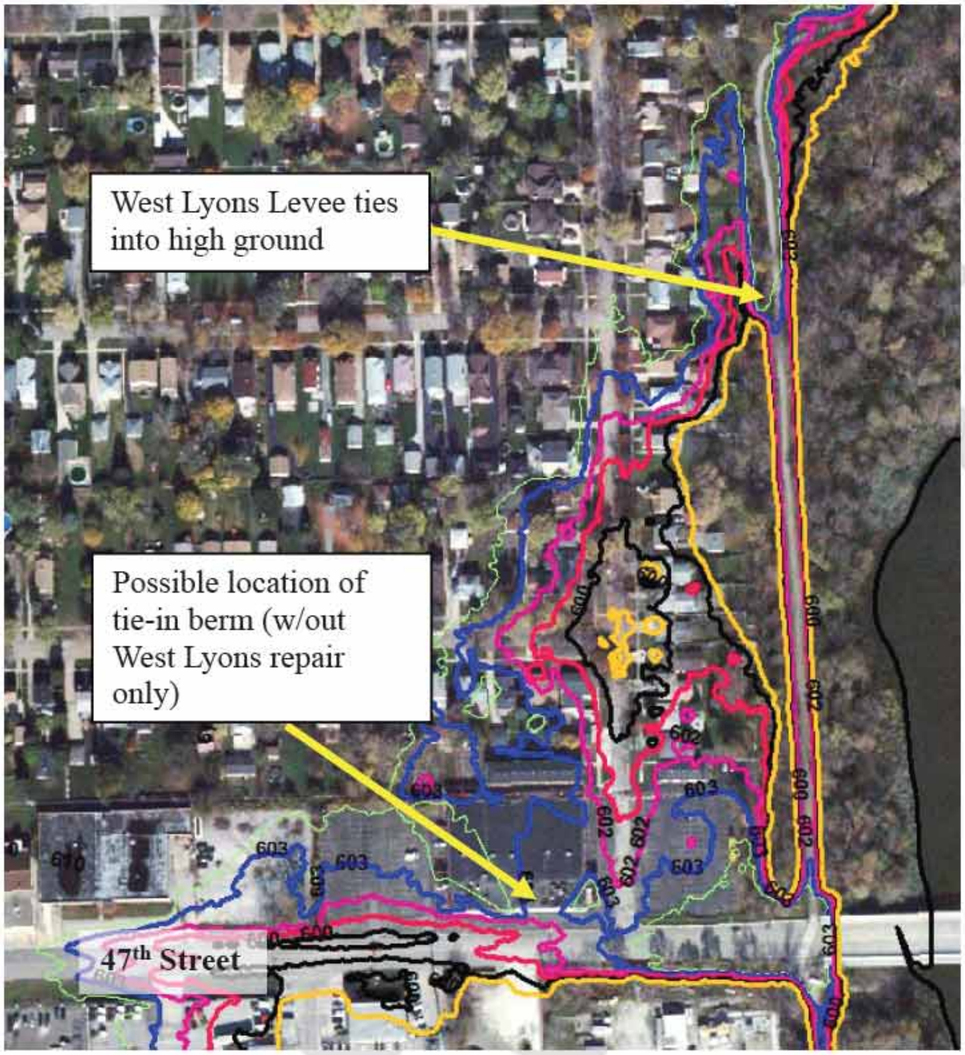



*Figure 23. North end tie-in topographic map indicating north end and 47th St are likely high ground*

70. South of 47th St, there are two railroad lines which form high ground. Based on the LiDAR data, these railroads may be lower than the desired levee height by a foot or so. Possible mitigation techniques would include a short tieback levee, clay blanket along the embankments to reduce the likelihood of seepage through the railroad ballast, or another option. The potential alignments of these mitigation techniques are shown in yellow on *Figure 24*. The solution depends on the actual surveyed elevations across the railroad, which will be surveyed prior to design. This area is assumed to have a toe drain on the landside per the seepage analysis above.

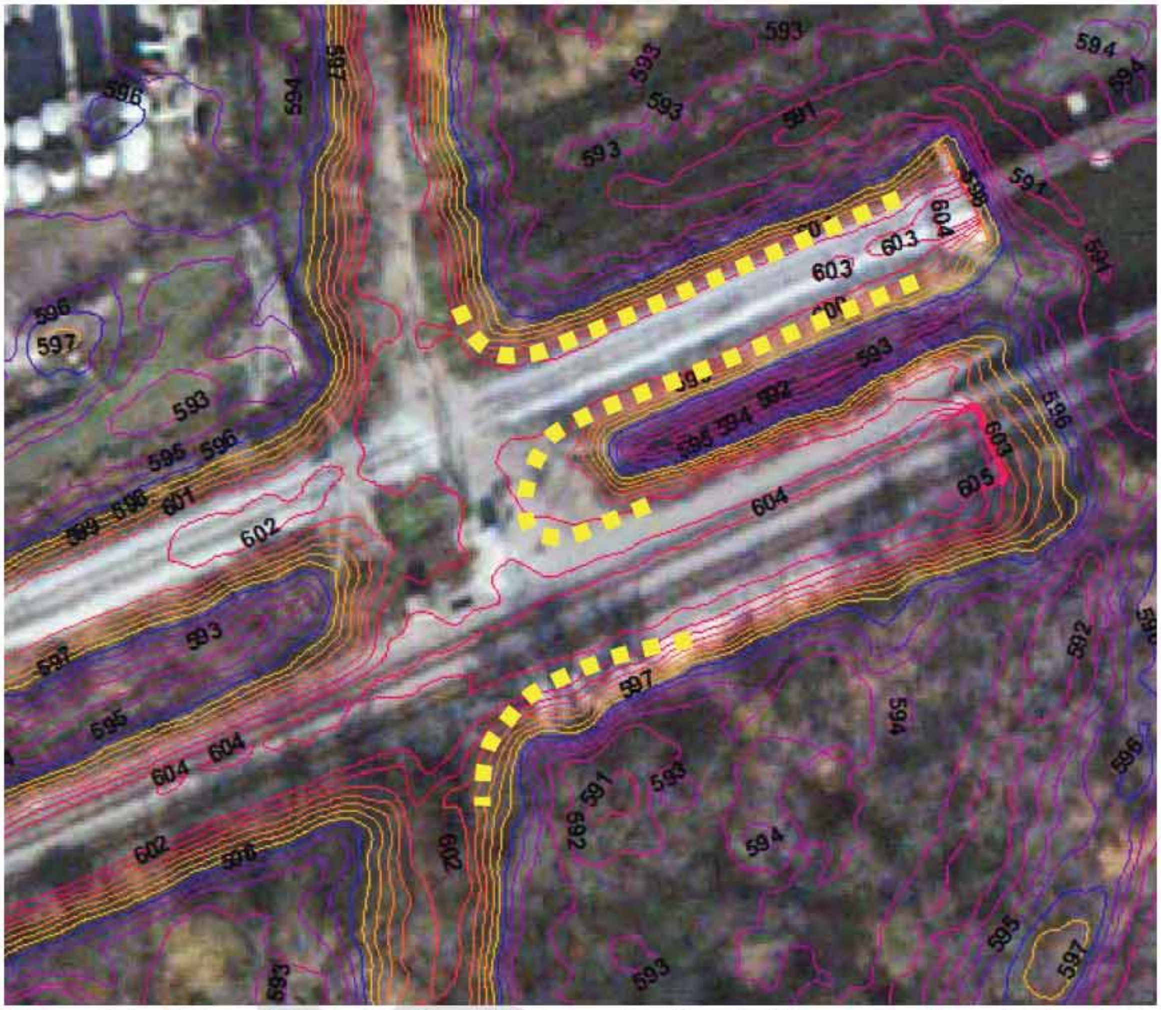



*Figure 24. Railroad tie-ins south of 47th Street, yellow indicates possible extents of clay blanket/small berm*

71. Measure 3 includes an option to split the levee south of 47$^{th}$ St into two segments. As shown on the below *Figure 25*, the ground is high in between the two tie-ins which would thus make rehabilitating the levee in between roughly Sta. 21+00 to 40+00 unnecessary. The ground that the levee ties into should be investigated to ensure there are no seepage paths.

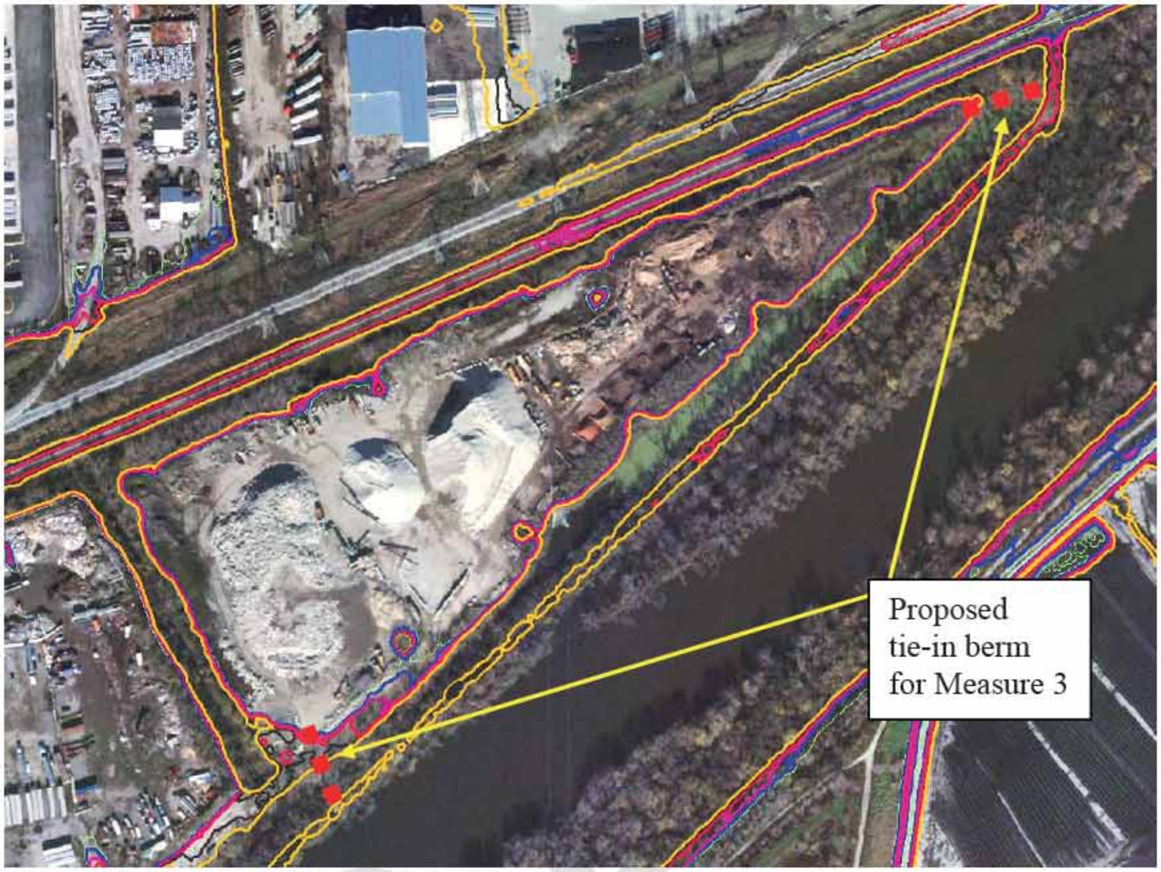



*Figure 25. Segmented Levee Tieback locations*

OVERTOPPING PROTECTION

72. There are four methods where the landside of a levee would be inundated, as shown in the *Figure 26* below. The risk of breach prior to overtopping and malfunction of levee system components are mitigated with recommendations made in the rest of this appendix. Overtopping without breach is an accepted risk, as no levee is constructed to handle all floods. Overtopping with breach, however, should be addressed.

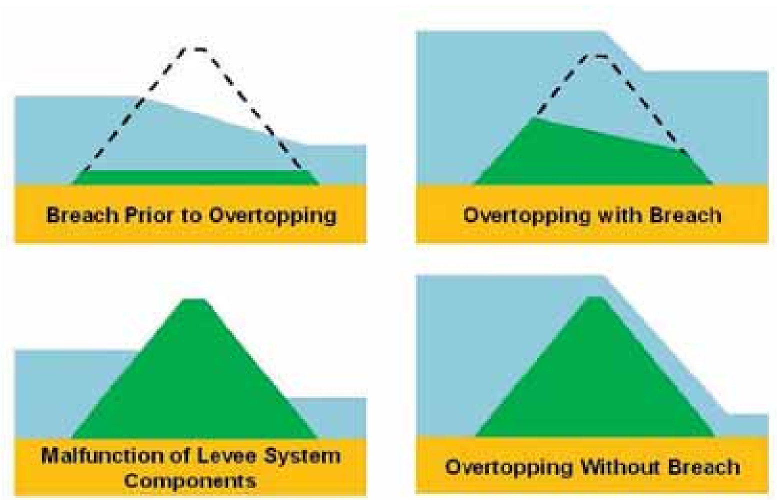



*Figure 26. Landside inundation methods for a levee*

73. Based on hydraulic modeling, the likely overtopping location would occur on the stretch of levee north of 47th St. It can be beneficial in some cases to consider lining of the levee crest at the lowest portion of the levee that is subjected to the greatest risk of overtopping. However, in this case, the levee crest is uniformly low for a significant distance; therefore, there is no one relatively short levee portion where overtopping flows are concentrated and can be controlled without significantly increasing the construction cost for a liner system. Furthermore, the proper design of such a liner system would have to consider the fact that such a system can introduce additional risk with respect to seepage pathways under the liner system, as well as overtopping flow accelerations on liner surfaces that can promote added stresses to the levee on the downstream slope and toe. These design considerations would require design countermeasures that would add significantly to the cost of the levee restoration. In addition, the levee armor feature would be intended to reduce the time of breach formation and the associated risks of the development of a flood wave through a breach. The life safety risk associated with a faster developing breach is low at this site due to the limited number of residents that would be affected, along with the fact that those affected would be inundated by only about 2 feet of water. A levee crest lining was therefore not considered for the levee improvements design.

FRAGILITY CURVE

74. Several memorandums were completed to identify the fragility of the existing McCook Levee. These can be found in Attachment 3, which describe the methodology for determining the failure points depicted in the below charts. Basically, the fragility points were determined by in field observations, as well as, historical performance. Since the levee has withstood several recent high water events, the PFP was determined to be the top of the levee. The PNP was determined based on the exposed sheetpile on the riverside, as shown in *Figure 12*. Summary tables are shown in *Figure 27* and *Figure 28*.

| Failure Node | Probability of Failure by Node | Elevation Assignment for Failure Condition | | |
|---|---|---|---|---|
| | | **Best Estimate Case** (Most Likely Probability of Failure) | **Best Reasonable Case** (Low Likelihood of Failure) | **Worst Reasonable Case** (High Likelihood of Failure) |
| **Levee Crest** | 1.00 | 600.6 | 600.6 | 600.6 |
| **Probable Failure Point (PFP)** | 0.85 | 600.6 | 600.6 | 597.0 |
| **Probable Non-Failure Point (PNP)** | 0.15 | 593.5 | 599.0 | 593.0 |
| **Levee Toe** | 0.00 | 593.0 | 593.0 | 593.0 |

*Figure 27. Summary of Fragility Curve south of 47th Street indicating PFP at top of levee and PNP at base of existing erosion*

| Failure Node | Probability of Failure by Node | Elevation Assignment for Failure Condition | | |
|---|---|---|---|---|
| | | **Best Estimate Case** (Most Likely Probability of Failure) | **Best Reasonable Case** (Low Likelihood of Failure) | **Worst Reasonable Case** (High Likelihood of Failure) |
| **Levee Crest** | 1.00 | 602.5 | 602.5 | 602.5 |
| **Probable Failure Point (PFP)** | 0.85 | 602.5 | 602.5 | 601.0 |
| **Probable Non-Failure Point (PNP)** | 0.15 | 596.0 | 599.0 | 595.0 |
| **Levee Toe** | 0.00 | 592.0 | 592.0 | 592.0 |

*Figure 28. Summary of Fragility Curve north of 47th Street indicating PFP at top of levee and PNP at lowest elevation of leveed structures*

SURVEY DATA

75. Survey information used for this feasibility study include primarily the LiDAR data available to Cook County. This data is rough and does not account for smaller features such as the sheetpile top. Therefore, USACE surveyors visited the site to obtain several x, y, z coordinates highlighted by the design team. A full topographic survey will be completed during the design phase of the project.

SUMMARY OF MEASURES

76. There are several measures considered to reduce the effects of flooding within this USACE study. They are defined as below and discussed more in detail in the main report, Section 3.5. Each measure can be applied to only south of 47th St, north of 47th St, or both other than Measure 3 which just applies south of 47th St.

Measure 0 – No Action

77. No action would result in an increased risk of the existing levee failing and inundating the structures within the leveed area. The probability of the levee failing was determined in Attachment 3 with the Fragility Curve detailed in *Figure 27* and *Figure 28*.

Measure 1 – Non-Structural

78. Non-structural remedies include floodproofing, relocation, and buyouts. Since these do not involve new construction, there are no geotechnical considerations for this Plan.

Measure 2 – Levee Repair

79. This measure includes repairing the existing levee in place as discussed in the main report. It includes removing vegetation within 15 feet of the levee toe, grading the slopes, adding the closure structure, and adding toe drains as recommended in this report.

Measure 3 – Segmented Levee Repair

80. This measure only applies to south of 47th St. Based on reviewing the LiDAR data, it appears that the levee could be shortened into two segments that tie into high ground as discussed in the main report and shown on *Figure 25*. Additional subsurface investigation along the proposed tie-in levees should be completed.

SUMMARY

81. The existing McCook Levee does not meet USACE standards requires remediation. There are several recommendations from the analysis in this appendix based on the recommended plan of the segmented repair of the McCook Levee (Measure 3) and repair of the West Lyons Levee (Measure 2).

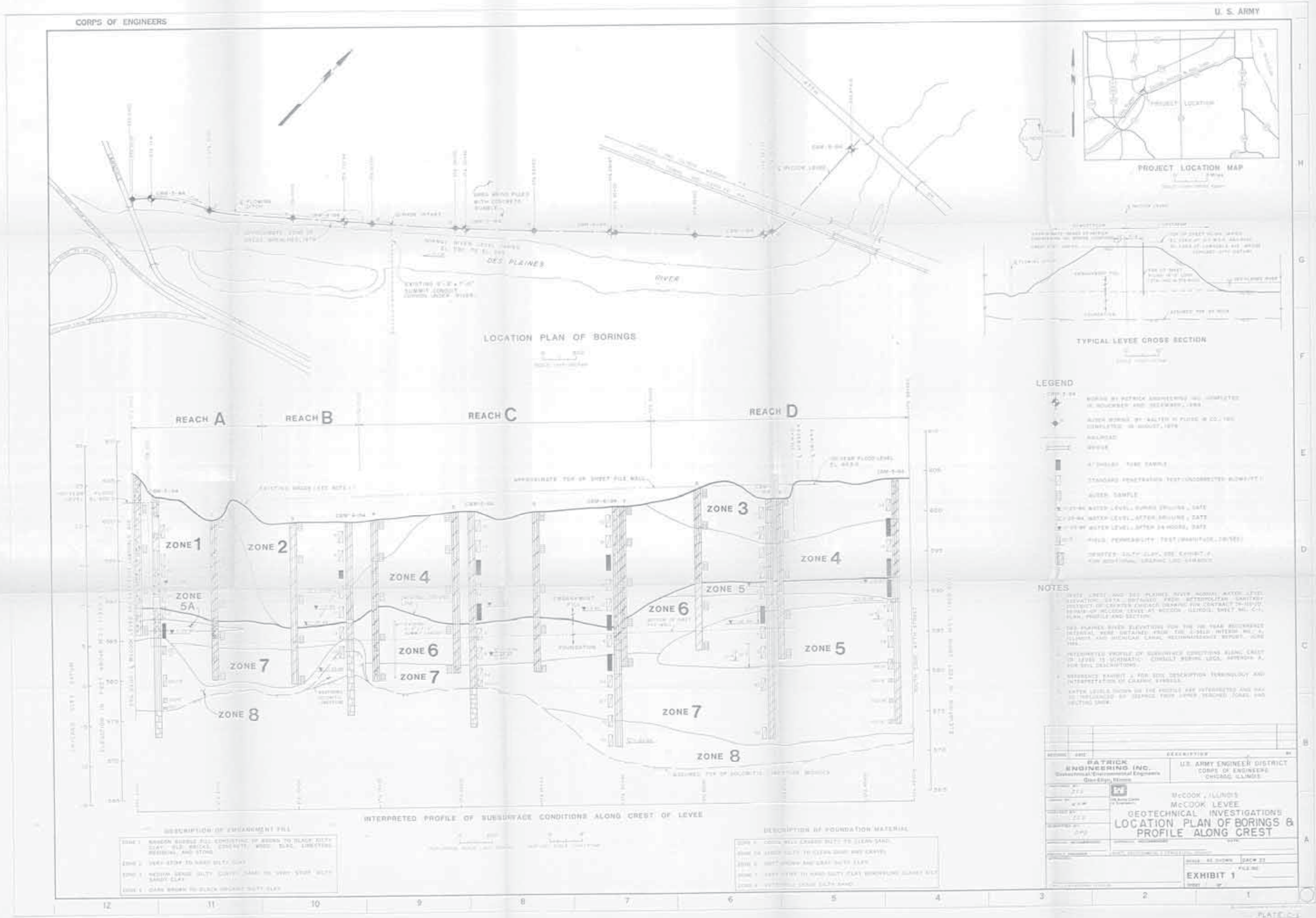
- Trees and vegetation needs to be removed per ETL 1110-2-583 on the embankment and within 15 feet of the toe
- Landside slopes should be 2.5 horizontal to 1 vertical or shallower
- Riverside slopes should be at least 2:1 with riprap or 2.5:1 with clay
- A toe drain should be installed or the entire north segmented levee (Sta. 40+00 to 48+00) to mitigate uplift pressure, assumed 4 ft by 5 ft lined with geotextile and filled with CA-7
    - Could use clay cutoff on riverside, depending on additional subsurface investigations
- Seepage is expected at the southern end of the levee, but should be handled by the existing ditch
- Sheetpile should not be exposed to a height greater than 4 feet

- Complete survey of the project area should be completed to identify the tie-back areas, railroad high ground issues, and other areas as requested by other appendices

82. Without the recommended repairs, the existing levee will continue to degrade. The fragility of the existing levee was determined in Attachment 3 which reflects the current conditions. Additional high water events will continue to erode the levee and increase the risk of failure.

83. There are still some geotechnical concerns that require to be addressed during design to reduce the risk during construction. This includes completing additional soil borings to close the gaps left by previous investigations. Areas to focus on are north of 47th St, landside/riverside toes, closure feature south of Lawndale Ave, tieback areas, and in between existing borings. The area being abandoned by the segmented levee plan does not require additional information. These borings will reduce the risk associated with unknown subsurface conditions and better define required features. It will also allow for reevaluating the Zones previously selected in the 1980's report and used in this one. The additional subsurface investigations should also revisit the permeability values of the various zones, as the falling head tests completed in 1984 may not be accurate. The foundation of the closure structure has a high amount of risk as it will require design informed by subsurface investigation. Additionally, the toe drain will vary depending on the subsurface along the levee toe, which may indicate it would be more beneficial for a clay cutoff instead.

# Attachment 1: Historic Soil Boring Logs


CORPS OF ENGINEERS
U. S. ARMY
PROJECT LOCATION MAP
PROJECT LOCATION
DES PLAINES
RIVER
LOCATION PLAN OF BORINGS
TYPICAL LEVEE CROSS SECTION
LEGEND
NOTES
REACH A
REACH B
REACH C
REACH D
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5A
ZONE 5
ZONE 6
ZONE 7
ZONE 8
INTERPRETED PROFILE OF SUBSURFACE CONDITIONS ALONG CREST OF LEVEE
DESCRIPTION OF EMBANKMENT FILL
DESCRIPTION OF FOUNDATION MATERIAL
PATRICK ENGINEERING INC.
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
McCOOK, ILLINOIS
McCOOK LEVEE
GEOTECHNICAL INVESTIGATIONS
LOCATION PLAN OF BORINGS &
PROFILE ALONG CREST
EXHIBIT 1
PLATE C-1

Walter H. Flood & Co., Inc.
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 1

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | HS |
|---|---|
| S.S. O.D. 2" 140# HAMMER 30" DROP | |
| SHELBY TUBE SIZE | |
| CASING SIZE | 20'-2¼" IDHS |
| CORE SIZE | |

| WATER LEVEL READINGS | |
|---|---|
| Dry | W.D. |
| Dry | B.C.R. |
| Dry | A.C.R. |
| | HRS. A.D. |
| | HRS. A.D. |

| DRILLING DATA | |
|---|---|
| DATE | 8-19-79 |
| FOREMAN | CE |
| CREW NO. | 3 |
| JOB NO. | 79050128 |
| VERT. SCALE | 1"=5' |

| BACKFILLING DATA | |
|---|---|
| DATE | |
| BY | |
| METHOD | |
| GROUT | |
| QUANTITY | |

| DEPTH | S | T | N | L R | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | | | | | | Fill, brown to black silty clay, some brick, concrete, wood, stone (erratic drilling hard to easy) |
| | 1 | A | | | | |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 17.0 | | | | | | Brown silty clay, some small to large gravel, stiff |
| 20.0 | 4 | A | | | | |
| | | | | | | End of boring |

QU ● LABORATORY X 1000 PSF 2 4 6 8 10 — O PENETROMETER
WC ▲ NATURAL % 10 20 30 40 50

LEGEND: A—AUGER
ACR—AFTER CASING REMOVAL
AD—AFTER DRILLING
BCR—BEFORE CASING REMOVAL
C—CORE
DCI—DRY CAVE IN
DD—DRY DENSITY, LB. PER CU. FT
DEPTH—FEET BELOW GROUND SURFACE
FT—FISHTAIL
HA—HAND AUGER
HS—HOLLOW STEM AUGER
L—SAMPLE LENGTH
N—PENETRATION, BLOWS PER FT.
QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.
R—LENGTH OF SAMP. RECOVERED
S—SAMPLE NUMBER
SS—SPLIT SPOON
ST—SHELBY TUBE
T—TYPE OF SAMPLE
WC—WATER CONTENT %
WCI—WET CAVE IN
WD—WHILE DRILLING
WO—WASHOUT

PLATE C-2

Walter H. Flood & Co., Inc.

7510 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 2

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | HS | WATER LEVEL READINGS | | DRILLING DATA | | BACKFILLING DATA |
|---|---|---|---|---|---|---|
| S.S. O.D. 2" 140# HAMMER 30" DROP | | Dry | W.D. | DATE | 8-13-79 | DATE |
| SHELBY TUBE SIZE | | Dry | B.C.R. | FOREMAN | CE | BY |
| CASING SIZE | 20'-2¼" IDHS | Dry | A.C.R. | CREW NO. | 3 | METHOD |
| CORE SIZE | | | HRS. A.D. | JOB NO. | 79050128 | GROUT |
| | | | HRS. A.D. | VERT. SCALE | 1"=5' | QUANTITY |

| DEPTH | S | T | N | L R | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| | | | | | | Ground surface |
| 0.0 | 1 | A | | | | Fill, brown & black silty clay, some concrete, stone (concrete boulder sized; erratic drilling, hard to easy) |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 12.5 | | | | | | Black silty clay, some small to medium gravel, stiff |
| | 4 | A | | | | |
| 15.0 | | | | | | Brown silty clay, occasional boulder, stiff (Boulder at 19') |
| | 5 | A | | | | |
| 20.0 | | | | | | End of boring |

QU ⊗ LABORATORY X 1000 PSF — 2, 4, 6, 8, 10 — O PENETROMETER

WC ▲ NATURAL % — 10, 20, 30, 40, 50

LEGEND: A—AUGER; ACR—AFTER CASING REMOVAL; AD—AFTER DRILLING; BCR—BEFORE CASING REMOVAL; C—CORE; DCI—DRY CAVE IN; DD—DRY DENSITY, LB. PER CU. FT; DEPTH—FEET BELOW GROUND SURFACE; FT—FISHTAIL; HA—HAND AUGER; HS—HOLLOW STEM AUGER; L—SAMPLE LENGTH; N—PENETRATION, BLOWS PER FT.; QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.; R—LENGTH OF SAMP. RECOVERED; S—SAMPLE NUMBER; SS—SPLIT SPOON; ST—SHELBY TUBE; T—TYPE OF SAMPLE; WC—WATER CONTENT %; WCI—WET CAVE IN; WD—WHILE DRILLING; WO—WASHOUT

Walter H. Flood
& Co., Inc.
7500 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 3

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | | WATER LEVEL READINGS | | DRILLING DATA | | BACKFILLING DATA |
|---|---|---|---|---|---|---|
| | HS | Dry | W.D. | DATE | 8-13-79 | DATE |
| S.S. O.D. 2" 140# HAMMER 30" DROP | | Dry | B.C.R. | FOREMAN | CE | BY |
| SHELBY TUBE SIZE | | Dry | A.C.R. | CREW NO. | 3 | METHOD |
| CASING SIZE | 20'-2¼" IDHS | | HRS. A.D. | JOB NO. | 79050128 | GROUT |
| CORE SIZE | | | HRS. A.D. | VERT. SCALE | 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | 1 | A | | | | Fill, brown silty clay, some small to large gravel, cobbles |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 12.0 | | | | | | Brown silty clay, trace of small to medium gravel, occasional cobble, boulders, stiff (boulder at 14') |
| 15.0 | 4 | A | | | | |
| | | | | | | Brown gray silty clay, trace of small to large gravel, cobble, boulder, medium dense (boulder at 15.5') |
| 20.0 | 5 | A | | | | |
| | | | | | | End of boring |

QU O LABORATORY X 1000 PSF — O PENETROMETER: 2, 4, 6, 8, 10

WC ▲ NATURAL %: 10, 20, 30, 40, 50

LEGEND: A—AUGER; ACR—AFTER CASING REMOVAL; AD—AFTER DRILLING; BCR—BEFORE CASING REMOVAL; C—CORE; DCI—DRY CAVE IN; DD—DRY DENSITY, LB. PER CU. FT; DEPTH—FEET BELOW GROUND SURFACE; FT—FISHTAIL; HA—HAND AUGER; HS—HOLLOW STEM AUGER; L—SAMPLE LENGTH; N—PENETRATION, BLOWS PER FT.; QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.; R—LENGTH OF SAMP. RECOVERED; S—SAMPLE NUMBER; SS—SPLIT SPOON; ST—SHELBY TUBE; T—TYPE OF SAMPLE; WC—WATER CONTENT %; WCI—WET CAVE IN; WD—WHILE DRILLING; WO—WASHOUT

Walter H. Flood & Co., Inc.
7503 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 4

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | WATER LEVEL READINGS | DRILLING DATA | BACKFILLING DATA |
|---|---|---|---|
| HS | Dry W.D. | DATE 8-13-79 | DATE |
| S.S. O.D. 2" 140# HAMMER 30" DROP | Dry B.C.R. | FOREMAN CE | BY |
| SHELBY TUBE SIZE | Dry A.C.R. | CREW NO. 3 | METHOD |
| CASING SIZE 20'-2½" IDHS | HRS. A.D. | JOB NO. 79050128 | GROUT |
| CORE SIZE | HRS. A.D. | VERT. SCALE 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | 1 | A | | | | Fill, brown & gray silty clay, some small to large gravel, cobbles (crushed stone), stiff |
| 5.0 | 2 | A | | | | |
| | | | | | | Fill, brown and black silty clay, trace of small to medium gravel, stiff |
| 10.0 | 3 | A | | | | |
| | | | | | | Dark gray, black, and brown silty clay, trace of small to large gravel, cobbles, boulder, stiff (boulder at 16', 19') |
| | 4 | A | | | | |
| 20.0 | 5 | A | | | | |
| | | | | | | End of boring |

QU ⊙ LABORATORY X 1000 PSF 2 4 6 8 10; O PENETROMETER

WC ▲ NATURAL % 10 20 30 40 50

LEGEND: A—AUGER
ACR—AFTER CASING REMOVAL
AD—AFTER DRILLING
BCR—BEFORE CASING REMOVAL
C—CORE
DCI—DRY CAVE IN
DD—DRY DENSITY, LB. PER CU. FT
DEPTH—FEET BELOW GROUND SURFACE
FT—FISHTAIL
HA—HAND AUGER
HS—HOLLOW STEM AUGER
L—SAMPLE LENGTH
N—PENETRATION, BLOWS PER FT.
QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.
R—LENGTH OF SAMP. RECOVERED
S—SAMPLE NUMBER
SS—SPLIT SPOON
ST—SHELBY TUBE
T—TYPE OF SAMPLE
WC—WATER CONTENT %
WCI—WET CAVE IN
WD—WHILE DRILLING
WO—WASHOUT

PLATE C-5

Walter H. Flood
& Co., Inc.
ENGINEERS
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 5

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | WATER LEVEL READINGS | DRILLING DATA | BACKFILLING DATA |
|---|---|---|---|
| METHOD OF BORING: HS | Dry W.D. | DATE 8-13-79 | DATE |
| S.S. O.D. 2" 140# HAMMER 30" DROP | Dry B.C.R. | FOREMAN CE | BY |
| SHELBY TUBE SIZE | Dry A.C.R. | CREW NO. 3 | METHOD |
| CASING SIZE 20'-2½" IDHS | HRS. A.D. | JOB NO. 79050128 | GROUT |
| CORE SIZE | HRS. A.D. | VERT. SCALE 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| | | | | | | Ground surface |
| 0.0 | 1 | A | | | | Fill, black to brown silty clay, trace of small to medium gravel, stiff |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 14.0 | 4 | A | | | | Dark gray silty clay, stiff |
| 16.5 | | | | | | Brown silty clay, trace of small to large gravel, occasional cobble, boulder, stiff (boulder at 17.5', 19.5') |
| 20.0 | 5 | A | | | | End of boring |

QU ● LABORATORY X 1000 PSF — 2, 4, 6, 8, 10 — O PENETROMETER

WC ▲ NATURAL % — 10, 20, 30, 40, 50

LEGEND: A—AUGER; ACR—AFTER CASING REMOVAL; AD—AFTER DRILLING; BCR—BEFORE CASING REMOVAL; C—CORE; DCI—DRY CAVE IN; DD—DRY DENSITY, LB. PER CU. FT.; DEPTH—FEET BELOW GROUND SURFACE; FT—FISHTAIL; HA—HAND AUGER; HS—HOLLOW STEM AUGER; L—SAMPLE LENGTH; N—PENETRATION, BLOWS PER FT.; QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.; R—LENGTH OF SAMP. RECOVERED; S—SAMPLE NUMBER; SS—SPLIT SPOON; ST—SHELBY TUBE; T—TYPE OF SAMPLE; WC—WATER CONTENT %; WCI—WET CAVE IN; WD—WHILE DRILLING; WO—WASHOUT

Walter H. Flood
& Co., Inc.
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49031

# SOIL BORING LOG NO. 6

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | HS | WATER LEVEL READINGS | | DRILLING DATA | | BACKFILLING DATA |
|---|---|---|---|---|---|---|
| S.S. O.D. 2" 140# HAMMER 30" DROP | | Dry | W.D. | DATE | 8-13-79 | DATE |
| SHELBY TUBE SIZE | | Dry | B.C.R. | FOREMAN | CE | BY |
| CASING SIZE | 20'-2¼" IDHS | Dry | A.C.R. | CREW NO. | 3 | METHOD |
| CORE SIZE | | | HRS. A.D. | JOB NO. | 79050128 | GROUT |
| | | | HRS. A.D. | VERT. SCALE | 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| | | | | | | Ground surface |
| 0.0 | 1 | A | | | | Fill, black and brown silty clay, trace of small gravel, stiff |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 13.0 | | | | | | Black, dark brown & gray silty clay, trace of small gravel, stiff |
| | 4 | A | | | | |
| 20.0 | 5 | A | | | | |
| | | | | | | End of boring |

QU @ LABORATORY X 1000 PSF: 2, 4, 6, 8, 10 — O PENETROMETER
WC ▲ NATURAL %: 10, 20, 30, 40, 50

LEGEND:
A—AUGER
ACR—AFTER CASING REMOVAL
AD—AFTER DRILLING
BCR—BEFORE CASING REMOVAL
C—CORE
DCI—DRY CAVE IN
DD—DRY DENSITY, LB. PER CU. FT.
DEPTH—FEET BELOW GROUND SURFACE
FT—FISHTAIL
HA—HAND AUGER
HS—HOLLOW STEM AUGER
L—SAMPLE LENGTH
N—PENETRATION, BLOWS PER FT.
QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.
R—LENGTH OF SAMP. RECOVERED
S—SAMPLE NUMBER
SS—SPLIT SPOON
ST—SHELBY TUBE
T—TYPE OF SAMPLE
WC—WATER CONTENT %
WCI—WET CAVE IN
WD—WHILE DRILLING
WO—WASHOUT

PLATE C-7

Walter H. Flood
& Co., Inc.
ENGINEERS
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 7

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | HS |
|---|---|
| S.S. O.D. 2" 140# HAMMER 30" DROP | |
| SHELBY TUBE SIZE | |
| CASING SIZE | 20'-2¼" IDHS |
| CORE SIZE | |

| WATER LEVEL READINGS | |
|---|---|
| W.D. | Dry |
| B.C.R. | Dry |
| A.C.R. | Dry |
| HRS. A.D. | |
| HRS. A.D. | |

| DRILLING DATA | |
|---|---|
| DATE | 8-13-79 |
| FOREMAN | CE |
| CREW NO. | 3 |
| JOB NO. | 79050128 |
| VERT. SCALE | 1"=5' |

| BACKFILLING DATA | |
|---|---|
| DATE | |
| BY | |
| METHOD | |
| GROUT | |
| QUANTITY | |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | 1 | A | | | | Fill, brown & black & gray silty clay, trace of small gravel, stiff |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 12.0 | | | | | | Black silty clay, trace of small gravel, stiff |
| 15.0 | 4 | A | | | | Brown & gray silty clay, trace of small gravel, stiff |
| 20.0 | 5 | A | | | | End of boring |

QU ⊙ LABORATORY X 1000 PSF — O PENETROMETER (2, 4, 6, 8, 10)

WC ▲ NATURAL % (10, 20, 30, 40, 50)

LEGEND:
A—AUGER
ACR—AFTER CASING REMOVAL
AD—AFTER DRILLING
BCR—BEFORE CASING REMOVAL
C—CORE
DCI—DRY CAVE IN
DD—DRY DENSITY, LB. PER CU. FT
DEPTH—FEET BELOW GROUND SURFACE
FT—FISHTAIL
HA—HAND AUGER
HS—HOLLOW STEM AUGER
L—SAMPLE LENGTH
N—PENETRATION, BLOWS PER FT.
QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.
R—LENGTH OF SAMP. RECOVERED
S—SAMPLE NUMBER
SS—SPLIT SPOON
ST—SHELBY TUBE
T—TYPE OF SAMPLE
WC—WATER CONTENT %
WCI—WET CAVE IN
WD—WHILE DRILLING
WO—WASHOUT

Walter H. Flood
& Co., Inc.
ENGINEERS
4421 HARRISON STREET
HILLSIDE, ILLINOIS 60162
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 8

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | WATER LEVEL READINGS | DRILLING DATA | BACKFILLING DATA |
|---|---|---|---|
| METHOD OF BORING: HS | 17.0' W.D. | DATE 8-13-79 | DATE |
| S.S. O.D. 2" 140# HAMMER 30" DROP | 17.0' B.C.R. | FOREMAN CE | BY |
| SHELBY TUBE SIZE | 17.0' A.C.R. | CREW NO. 3 | METHOD |
| CASING SIZE 20'-2½" IDHS | HRS. A.D. | JOB NO. 79050128 | GROUT |
| CORE SIZE | HRS. A.D. | VERT. SCALE 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | 1 | A | | | | Fill, black & dark brown sandy clay, stiff |
| 5.0 | 2 | A | | | | Fill, black & brown silty clay, some fine sand, trace of small gravel, stiff |
| | 3 | A | | | | |
| 12.0 | | | | | | Gray sandy clay to clayey sand, trace of small gravel, stiff |
| | 4 | A | | | | |
| 20.0 | 5 | A | | | | End of boring |

QU ⊙ LABORATORY X 1000 PSF 2 4 6 8 10 — O PENETROMETER

WC ▲ NATURAL % 10 20 30 40 50

LEGEND: A—AUGER; ACR—AFTER CASING REMOVAL; AD—AFTER DRILLING; BCR—BEFORE CASING REMOVAL; C—CORE; DCI—DRY CAVE IN; DD—DRY DENSITY, LB. PER CU. FT; DEPTH—FEET BELOW GROUND SURFACE; FT—FISHTAIL; HA—HAND AUGER; HS—HOLLOW STEM AUGER; L—SAMPLE LENGTH; N—PENETRATION, BLOWS PER FT.; QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.; R—LENGTH OF SAMP. RECOVERED; S—SAMPLE NUMBER; SS—SPLIT SPOON; ST—SHELBY TUBE; T—TYPE OF SAMPLE; WC—WATER CONTENT %; WCI—WET CAVE IN; WD—WHILE DRILLING; WO—WASHOUT

Walter H. Flood
& Co., Inc.
ENGINEERS
4421 HARRISON STREET
HILLSIDE, ILLINOIS 60162
7509 S. WESTNEDGE AVENUE
PORTAGE, MICHIGAN 49081

# SOIL BORING LOG NO. 9

FOR: The Metropolitan Sanitary District of Greater Chicago

PROJECT: McCook Levee

LOCATION: McCook, Illinois

| METHOD OF BORING | WATER LEVEL READINGS | DRILLING DATA | BACKFILLING DATA |
|---|---|---|---|
| HS | 18.0' W.D. | DATE 8-13-79 | DATE |
| S.S. O.D. 2" 140# HAMMER 30" DROP | 18.0' B.C.R. | FOREMAN CE | BY |
| SHELBY TUBE SIZE | 18.0' A.C.R. | CREW NO. 3 | METHOD |
| CASING SIZE 20'-2¼" IDHS | HRS. A.D. | JOB NO. 79050128 | GROUT |
| CORE SIZE | HRS. A.D. | VERT. SCALE 1"=5' | QUANTITY |

| DEPTH | S | T | N | LR | DD | DESCRIPTION |
|---|---|---|---|---|---|---|
| 0.0 | | | | | | Ground surface |
| | 1 | A | | | | Fill, dark brown, black silty clay, trace of small gravel, stiff |
| | 2 | A | | | | |
| | 3 | A | | | | |
| 11.5 | | | | | | Brown sandy clay, to clayey sand, trace of small gravel, stiff |
| | 4 | A | | | | |
| | 5 | A | | | | |
| 20.0 | | | | | | End of boring |

QU ● LABORATORY X 1000 PSF 2 4 6 8 10 — O PENETROMETER

WC ▲ NATURAL % 10 20 30 40 50

LEGEND: A—AUGER; ACR—AFTER CASING REMOVAL; AD—AFTER DRILLING; BCR—BEFORE CASING REMOVAL; C—CORE; DCI—DRY CAVE IN; DD—DRY DENSITY, LB. PER CU. FT.; DEPTH—FEET BELOW GROUND SURFACE; FT—FISHTAIL; HA—HAND AUGER; HS—HOLLOW STEM AUGER; L—SAMPLE LENGTH; N—PENETRATION, BLOWS PER FT.; QU—UNCON. COMP. STRENGTH LBS. PER SQ. FT.; R—LENGTH OF SAMP. RECOVERED; S—SAMPLE NUMBER; SS—SPLIT SPOON; ST—SHELBY TUBE; T—TYPE OF SAMPLE; WC—WATER CONTENT %; WCI—WET CAVE IN; WD—WHILE DRILLING; WO—WASHOUT

Hole No. CBM-1-84

**DRILLING LOG**

| | |
|---|---|
| DIVISION | NCD |
| INSTALLATION | Chicago District |
| SHEET | 1 OF 2 SHEETS |
| 1. PROJECT | McCook Levee Subsurface Investigation |
| 2. LOCATION (Coordinates or Station) | Sta 39+35 |
| 3. DRILLING AGENCY | Patrick Engineering Inc. |
| 4. HOLE NO. (As shown on drawing title and file number) | CBM-1-84 |
| 5. NAME OF DRILLER | Pat Bolger |
| 6. DIRECTION OF HOLE | [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. |
| 7. THICKNESS OF OVERBURDEN | |
| 8. DEPTH DRILLED INTO ROCK | Not Encountered |
| 9. TOTAL DEPTH OF HOLE | 30.0 |
| 10. SIZE AND TYPE OF BIT | 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | M.S.L. 1929 5th General Adj. |
| 12. MANUFACTURER'S DESIGNATION OF DRILL | |
| 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED 11 / UNDISTURBED 1 |
| 14. TOTAL NUMBER CORE BOXES | |
| 15. ELEVATION GROUND WATER | 586.2 during drilling. |
| 16. DATE HOLE | STARTED 11/26/84 / COMPLETED 11/26/84 |
| 17. ELEVATION TOP OF HOLE | 601.7 |
| 18. TOTAL CORE RECOVERY FOR BORING | % |
| 19. SIGNATURE OF INSPECTOR | Kerry Van Allen |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 601.7 | 0.0 | | Black and brown silty clay, little medium to fine sand, very stiff, low plasticity, moist, fill CL | | | Advanced borehole using 3-1/4" I.D. hollow stem auger. |
| | | | | 11"/ 18" | SS-1A, 1B 1.0-2.5 | $q_u$* = 2.2 tsf 4/5/7 |
| 600.3 | 1.4 | | Brown coarse to fine sand, some silt, trace clay, loose, damp, fill SM | | | |
| 598.7 | 3.0 | | Brown and black silt and coarse to fine sand, poorly graded, medium dense, dry to moist, fill SM-ML | 15"/ 18" | SS-2, 3.5-5.0 | 6/7/6 |
| 596.2 | 5.5 | | Black organic silty clay, little medium to fine sand, very stiff, low plasticity, moist, fill OL | 6"/ 18" | SS-3 6.0-7.5 | 5/5/6 $q_u$* = 4.5 tsf |
| | | | | 8"/ 18" | SS-4 8.5-10.0 | 3/6/4 $q_u$* = 2.7 tsf |
| 591.7 | 10.0 | 1/2/85 ▼ | Brown and gray silty coarse to fine sand, trace to little clay, loose, saturated SC-SM | | | |
| | | | | 18"/ 18" | SS-5A, 5B 11.0-12.5 | 2/2/3 |
| 589.7 | 12.0 | | Brown and gray silty clay, little coarse to fine sand, medium consistency, medium plasticity, saturated CL | | | $q_u$* = 1.0 tsf |
| | | | | 24"/ 24" | ST-6 13.5-15.5 | Borehole recharge test @ 13.5'-15.5'. |
| 587.6 | 14.1 | 11/26/84 ▽ | Brown coarse to fine sand, occasional coarse to fine gravel, well graded, trace to little silt, loose, saturated SW-SM | | | Encountered water @ 15.5' prior to borehole recharge test. |
| | | | | 18"/ 18" | SS-7 16.0-17.5 | 4/5/4 |
| | | | | 10"/ 18" | SS-8 18.5-20.0 | 2/2/3 Borehole recharge test from 18'-22.0'. |

Hole No. CBM-1-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT: McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT: 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station): Sta 39+35 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY: Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL: |
| 4. HOLE NO. (As shown on drawing title and file number): CBM-1-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 11; UNDISTURBED 1 |
| 5. NAME OF DRILLER: Pat Bolger | 14. TOTAL NUMBER CORE BOXES: |
| 6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER: 586.2 during drilling. |
| | 16. DATE HOLE: STARTED 11/26/84; COMPLETED 11/26/84 |
| 7. THICKNESS OF OVERBURDEN: | 17. ELEVATION TOP OF HOLE: 601.7 |
| 8. DEPTH DRILLED INTO ROCK: Not Encountered | 18. TOTAL CORE RECOVERY FOR BORING: % |
| 9. TOTAL DEPTH OF HOLE: 30.0 | 19. SIGNATURE OF INSPECTOR: Kerry Van Allen |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 580.7 | 21.0 | | Gray clayey silt, some coarse to fine sand, occasional coarse to fine gravel, hard, low plasticity saturated ML-CL | | | |
| | | | | 12"/ 18" | SS-9 22.5-24.0 | 22/42/40 Drilled to 23.5' for sampling, but sand continuously blowing in. Switched to rotary drilling, 3" roller bit. $q_u$* = 4.5+ tsf |
| | | | | 15"/ 18" | SS-10 28.5-30.0 | 27/38/61 $q_u$* = 4.5+ tsf |
| 571.7 | 30.0 | | End of boring @ 30.0'. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT McCook Levee HOLE NO. CBM-1-84

MODIFIED BY PATRICK ENGINEERING 11/84

Hole No. CBM-2-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station) Sta 20+86 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-2-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 9; UNDISTURBED 2 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 582.7 before drilling 11/24 |
| | 16. DATE HOLE: STARTED 11/23/84; COMPLETED 11/24/84 |
| 7. THICKNESS OF OVERBURDEN 22.0 | 17. ELEVATION TOP OF HOLE 600.7 |
| 8. DEPTH DRILLED INTO ROCK 5.0 | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 27.0 | 19. SIGNATURE OF INSPECTOR Kerry Van Allen |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 600.7 | 0.0 | | Brown, black and gray silty clay, some coarse to fine sand, occasional coarse to fine gravel, very stiff, low plasticity, moist, fill CL | | | Advanced borehole using 3-1/4" I.D. hollow stem auger. |
| | | | | 13"/ 18" | SS-1A 1B 1.0- 2.5 | 5/6/7 $q_u$* = 3.3 tsf |
| 598.7 | 2.0 | | Dark brown to black organic silty clay, trace medium to fine sand, very stiff, low to medium plasticity, very stiff, moist, fill OH | | | |
| 597.7 | 3.0 | | Brown, black and gray silty clay, some coarse to fine sand, occasional coarse to fine gravel, very stiff, low plasticity, moist, fill CL | 13" 18" | SS-2 3.5- 5.0 | 5/6/7 $q_u$* = 2.7 tsf |
| 595.2 | 5.5 | | Dark brown to black organic silt and clay, trace fine sand, stiff, medium plasticity, moist, fill OH | 13"/ 24" | 3T-3 6.0- 8.0 | |
| | | | | | | $q_u$* = 1.6 tsf @ bottom of tube. |
| | | | Wet to saturated | 15"/ 18" | SS-4 9.0- 10.5 | 5/7/8 $q_u$* = 1.7 tsf |
| | | 1/2/85 ▼ | | 14"/ 24" | 3T-5 11.5- 13.5 | |
| | | | | | | $q_u$* = 1.5 tsf @ end of tube. |
| 586.7 | 14.0 | | Blue gray and brown silty clay, little medium to fine sand, stiff, medium plasticity, saturated CL | 18"/ 18" | SS-6 14.5- 16.0 | 3/4/5 $q_u$* = 1.3 tsf |
| 583.4 | 17.3 | 11/24/84 ▽ 11/24/84 ▼ 12 hrs. | Gray silty clay, trace fine sand, medium, medium plasticity, saturated CL | 18"/ 18" | SS-7A, 7B 17.0- 18.5 | 3/3/5 $q_u$* = 0.7 tsf @ 18.0'. |
| 581.7 | 19.0 | | Gray clayey silt, some coarse to fine sand, occasional coarse to fine gravel, hard, low plasticity, wet/saturated ML-CL | | | $q_u$* = 4.5+ tsf @ 19.5'. |

Hole No. CBM-2-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT: McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT: 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station): Sta 20+86 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY: Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL: |
| 4. HOLE NO. (As shown on drawing title and file number): CBM-2-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 9; UNDISTURBED 2 |
| 5. NAME OF DRILLER: Pat Bolger | 14. TOTAL NUMBER CORE BOXES: |
| 6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER: 582.7 before drilling 11/24 |
| | 16. DATE HOLE: STARTED 11/23/84; COMPLETED 11/24/84 |
| 7. THICKNESS OF OVERBURDEN: 22.0 | 17. ELEVATION TOP OF HOLE: 600.7 |
| 8. DEPTH DRILLED INTO ROCK: 5.0 | 18. TOTAL CORE RECOVERY FOR BORING: % |
| 9. TOTAL DEPTH OF HOLE: 27.0 | 19. SIGNATURE OF INSPECTOR: Kerry Van Allen |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Gray clayey silt, some coarse to fine sand, occasional coarse to fine gravel, hard, low plasticity, wet/saturated ML-CL | 18"/ 18" | SS-8 19.5-21.0 | 12/13/41 $q_u$* = 4.5+ tsf @ 19.5'. Encountered cobble @ 21'. |
| | | | | 8"/ 10" | SS-9 21.0-21.9 | 100 Blows/10" $q_u$* = 4.5+ tsf High gravel content from 21' |
| 578.7 | 22.0 | | Buff to tan dolomitic limestone, medium to fine grained | | | Borehole recharge test @ 22' Switched to rotary drilling (set up only). Stopped drilling after SS-9, 11/23. W.L. @ 18.0' before drilling 11/24. W.L. @ 17.5' after drilling. |
| 573.7 | 27.0 | | End of boring @ 27.0'. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT McCook Levee HOLE NO. CBM-2-84

MODIFIED BY PATRICK ENGINEERING 11/84

Hole No. CBM-3-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station) Sta 1+41 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-3-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 10; UNDISTURBED 1 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 585.9, 11/23/84 |
| | 16. DATE HOLE: STARTED 11/20/84; COMPLETED 11/23/84 |
| 7. THICKNESS OF OVERBURDEN 26.5 | 17. ELEVATION TOP OF HOLE 602.9 |
| 8. DEPTH DRILLED INTO ROCK 3.5 | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 30.0 | 19. SIGNATURE OF INSPECTOR Kerry [signature] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 602.9 | 0.0 | | Coarse to fine gravel, some coarse to fine sand, little organic silt, moist, fill GM | | | Advanced borehole using 3-1/4" I.D. hollow stem auger. |
| 601.4 | 1.5 | | Black organic silt, some white medium to fine limestone residual, occasional coarse to fine gravel, moist, fill ML | | | |
| 600.4 | 2.5 | | White medium to fine limestone residual, medium dense, dry to moist, fill | 13"/ 18" | SS-1A, 1B 3.5-5.0 | 10/7/3 |
| 598.4 | 4.5 | | Brown organic silt and white medium to fine limestone residual, little sand, occ. gravel, moist, fill | | | |
| 597.9 | 5.0 | | Gray sandy bentonite-cement mixture, saturated, fill | | | |
| 596.4 | 6.5 | | Brown to dark brown very sandy silt, little gravel, trace to little organics, loose, moist, fill ML | 8"/ 18" | SS-2 7.0-8.5 | 4/3/5 |
| | | | | 0"/ 18" | SS 8.5-10.0 | 24/24/10 Tried to take tube @ 8.5', crushed tube. Very permeable rock zone 9.0-11.0; tried to run a k test @ 10' but water dropped faster than could be read. Filled up casing again but it came up around flights. |
| 593.9 | 9.0 | 1/2/85 ▼ | Brown silty sand, gravel and cobble, fill, high permeability, SM-GM | | | |
| | | | | 0"/ 18" | SS- 11.5-13.0 | 5/18/17 |
| 590.4 | 12.5 | | White limestone residual, occasional rock pieces, saturated, fill | | | |
| 589.1 | 13.8 | | Brown silty clay, some coarse to fine sand, occasional coarse to fine gravel, stiff, medium plasticity, saturated CL | 13"/ 18" | SS-3A, 3B, 3C 13.5-15.0 | 15/7/5 $q_u$* = 1.8 tsf |
| 588.5 | 14.4 | | Brown and gray silty clay, little coarse to fine sand, trace organics stiff, low plasticity, saturated CL | | | |
| 587.7 | 15.2 | 11/23/84 | Dark grayish brown sand and gravel, trace to little silt, loose, saturated SM-GM | 19"/ 20" | 3T-4 15.5-17.2 | |
| 586.5 | 16.4 | ▼ | Dark Gray to black organic silty clay, trace to little coarse to fine sand, med. consist., wet OH | | | From 17.2'-17.7', very hard gravelly layer. |
| 586.1 | 16.8 | | Brown and gray silty clay, some coarse to fine sand, stiff, wet CL | | | |
| 585.7 | 17.2 | | Gray silty coarse to very fine sand, little coarse to fine gravel, very dense, saturated SM | | | |
| | | | | 9"/ 12" | SS-5 18.5-19.5 | 44/56/- |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.
MODIFIED BY PATRICK ENGINEERING 11/84

PROJECT McCook Levee | HOLE NO. CBM-3-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station) Sta 1+41 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-3-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 10 — UNDISTURBED 1 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 585.9, 11/23/84 |
| | 16. DATE HOLE — STARTED 11/20/84 — COMPLETED 11/23/84 |
| 7. THICKNESS OF OVERBURDEN 26.5 | 17. ELEVATION TOP OF HOLE 602.9 |
| 8. DEPTH DRILLED INTO ROCK 3.5 | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 30.0 | 19. SIGNATURE OF INSPECTOR Kerry Van Allen |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Gray silty coarse to very fine sand, little coarse to fine gravel, very dense, saturated SM<br><br>GRADES TO | | | |
| | | | Gray silty coarse to fine sand and coarse to fine gravel, poorly graded, very dense, saturated SM-GM | 12"/ 12" | SS-6 22.0-23.5 | 36/64/- 100 Blows/1'<br><br>Stopped drilling after SS-6, 11/20/84.<br>W.L. @ -17', 11/23/84.<br>Borehole recharge test @ 23.5'. |
| 578.9 | 24.0 | | Gray silty gravelly coarse to fine sand, poorly graded, extremely dense, saturated SM | 3"/ 4" | SS-7 25.0-25.5 | Drilling difficult in sand/gravel zone.<br>100/-/- 100 Blows/4" on SS-7 |
| | | | | 1"/ 1" | SS-8 26.0-26.1 | 100 Blows/1" on SS-8 |
| 576.4 | 26.5 | | Buff to tan dolomitic limestone, fine to medium grained | | | Possibly drilled onto weathered limestone bedrock refusal @ 26.5'. Will have to switch to rotary drilling w/water. |
| 572.9 | 30.0 | | End of boring @ 30.0'. | | | |

Hole No. CBM-4-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station) Sta 13+44 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-4-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 9; UNDISTURBED 1 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 581.0 before rotary drill. |
| 7. THICKNESS OF OVERBURDEN 19.0 | 16. DATE HOLE: STARTED 11/23/84; COMPLETED 11/23/84 |
| 8. DEPTH DRILLED INTO ROCK 5.0 | 17. ELEVATION TOP OF HOLE 599.5 |
| 9. TOTAL DEPTH OF HOLE 24.0 | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR [signature] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 599.5 | 0.0 | | Brown and gray very silty clay, some coarse to fine sand, occasional coarse to fine gravel, hard, low plasticity, moist, fill CL | | | Advanced borehole using 3-1/4" I.D. hollow stem augers. |
| | | | | 5"/ 18" | SS-1 1.0-2.5 | 7/7/8 $q_u$* = 4.5+ tsf |
| | | | | 12"/ 18" | SS-2 3.5-5.0 | 7/6/8 $q_u$* = 4.5+ tsf |
| 594.0 | 5.5 | | Brown, gray and black silty clay, little sand, trace gravel, low plasticity, dry to moist CH-OH | | | |
| | | | | 4"/ 12" | 3T-3 6.0-7.0 | Unable to push tube more 1". Took sample of bottom of 3T-3. |
| 592.0 | 7.5 | 11/23/84 ▽ | Black organic silty clay, little medium to fine sand, stiff to very stiff, low plasticity, saturated, fill OH | | | |
| | | | | 14"/ 18" | SS-4 8.0-9.5 | 6/8/10 $q_u$* = 2.0 tsf |
| | | 1/2/85 ▼ | | 18"/ 18" | SS-5A, 5B, 10.5-12.0 | 4/5/6 $q_u$* = 2.5 tsf @ 11.0'. $q_u$* = 1.7 tsf @ 11.8'. |
| 587.7 | 11.8 | 11/23/84 ▼ | Black clayey to silty fine sand, stiff, low plasticity, saturated, fill SC | | | |
| 587.0 | 12.5 | | Brown and gray silty clay, some coarse to fine sand, occasional coarse to fine gravel, medium, medium plasticity, saturated CL | | | |
| | | | | 7"/ 18" | SS-6 13.0-14.5 | 4/5/9 $q_u$* = 1.0 tsf Encountered water on SS-6, W.L. @ 12.5'. |
| 585.0 | 14.5 | | Gray silty sandy medium to fine gravel, poorly graded, extremely dense, saturated GM | | | |
| | | | | 8"/ 18" | SS-7A 7B 15.5-17.0 | 32/70/50 |
| 583.5 | 16.0 | | Very weathered buff to tan dolomitic limestone, residual soil consisting of rock fragments and soil | | | |
| | | 11/23/84 ▼ | | 2"/ 3" | SS-8 18.5-19.0 | W.L. @ 18.5' before rotary drilling, poker chips @ 16'-17'. Encountered bedrock @ 19'. Had refusal of HSA's @ 19', switched to rotary drilling using 3" roller bit. Obtained cuttings for sample. |
| 580.5 | 19.0 | | Buff to tan dolomitic limestone, medium to fine grained, less weathered | | | |

Hole No. CBM-4-84

| DRILLING LOG | DIVISION: NCD | INSTALLATION: Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT: McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT: 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station): Sta 13+44 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY: Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL: |
| 4. HOLE NO. (As shown on drawing title and file number): CBM-4-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 9; UNDISTURBED 1 |
| 5. NAME OF DRILLER: Pat Bolger | 14. TOTAL NUMBER CORE BOXES: |
| 6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER: 581.0 before rotary drill. |
| | 16. DATE HOLE: STARTED 11/23/84; COMPLETED 11/23/84 |
| 7. THICKNESS OF OVERBURDEN: 19.0 | 17. ELEVATION TOP OF HOLE: 599.5 |
| 8. DEPTH DRILLED INTO ROCK: 5.0 | 18. TOTAL CORE RECOVERY FOR BORING: % |
| 9. TOTAL DEPTH OF HOLE: 24.0 | 19. SIGNATURE OF INSPECTOR: Kerry Van Alle |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Buff to tan dolomitic limestone, medium to fine grained, less weathered | | | Continued rotary drilling w/clear water and 3" roller bit. |
| | | | | | | Removed HSA's, W.L. @ 8.5' after drilling 11/23/84. |
| 575.5 | 24.0 | | End of boring @ 24.0'. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. MODIFIED BY PATRICK ENGINEERING 11/84

PROJECT: McCook Levee | HOLE NO.: CBM-4-84

Hole No. CBM-5-84

# DRILLING LOG

| | |
|---|---|
| DIVISION | NCD |
| INSTALLATION | Chicago District |
| SHEET | 1 OF 2 SHEETS |
| 1. PROJECT | McCook Levee Subsurface Investigation |
| 2. LOCATION (Coordinates or Station) | Sta 47+18 |
| 3. DRILLING AGENCY | Patrick Engineering Inc. |
| 4. HOLE NO. (As shown on drawing title and file number) | CBM-5-84 |
| 5. NAME OF DRILLER | Pat Bolger |
| 6. DIRECTION OF HOLE | [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. |
| 7. THICKNESS OF OVERBURDEN | |
| 8. DEPTH DRILLED INTO ROCK | Not Encountered |
| 9. TOTAL DEPTH OF HOLE | 30'-6" |
| 10. SIZE AND TYPE OF BIT | 6-3/4" O.D. x 3-1/4" I.D.HSA |
| 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | M.S.L. 1929, 5th General ADJ. |
| 12. MANUFACTURER'S DESIGNATION OF DRILL | |
| 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED: 12; UNDISTURBED: 3 |
| 14. TOTAL NUMBER CORE BOXES | 0 |
| 15. ELEVATION GROUND WATER | 589.1 30 min.after drill. |
| 16. DATE HOLE | STARTED: 11/26/84; COMPLETED: 11/26/84 |
| 17. ELEVATION TOP OF HOLE | 604.1 |
| 18. TOTAL CORE RECOVERY FOR BORING | % |
| 19. SIGNATURE OF INSPECTOR | Jeffrey C. Schuh |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 604.1 | 0.0 | | Brown silty sandy gravel, moist, fill SM-GM | | | Advanced borehole using 3-1/4" I.D. hollow stem auger. |
| 603.1 | 1.0 | | Dark brown sandy silty clay, some gravel, little organics, moist, fill CL | | | |
| 601.6 | 2.5 | | Brown very silty clay, little fine sand, trace coarse to medium sand, trace gravel, very stiff, low plasticity, dry, fill CL-ML | 10"/ 18" | SS-1 2.5-4.0 | 9/12/12 |
| 599.1 | 5.0 | | Dark brown to black organic silty clay, silty clay, little sand, trace gravel, very stiff, low plasticity, moist, fill OL | 19"/ 26" | 3T-2 5.0-7.2 | $q_u$* = 4.0 |
| | | | GRADES TO | 8"/ 18" | SS-3 7.5-9.0 | 4/9/10 |
| | | | Dark brown sandy organic silty clay, trace gravel, very stiff, low plasticity, saturated, fill OL | 16"/ 26" | 3T-4 10.0-12.2 | $q_u$* = 2.75 |
| 591.9 | 12.2 | 1/2/85 ▼ | Brown well graded sand, some silt, saturated SM | 15"/ 26" | 3T-5 12.5-14.7 | |
| | | | | | | Borehole recharge test #1 @ depth = 15' - water came up around flights |
| 589.3 | 14.8 | 11/26/84 ▽ | Brown, gray, and black silty clay, little to some sand, soft, low plasticity, saturated CL | 17"/ 18" | SS-6 A,B,C 15.0-16.5 | 4/3/6 |
| 588.6 | 15.5 | | Brown silty coarse to fine sand, loose, saturated SM | | | |
| 587.9 | 16.2 | | Brown coarse to fine sand, some silt, medium dense, saturated SM | | | Borehole recharge test #2 @ depth = 17.5' |
| | | | GRADES TO | 8"/ 18" | SS-7 17.5-19.0 | 5/2/5 |
| | | | Brown coarse to fine sand, little silt, loose, saturated SM | | | |

Hole No. CBM-5-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D.HSA |
| 2. LOCATION (Coordinates or Station) Sta 47+18 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-5-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 12 — UNDISTURBED 3 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES 0 |
| 6. DIRECTION OF HOLE [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 589.1 30 min.after drill. |
| | 16. DATE HOLE — STARTED 11/26/84 — COMPLETED 11/26/84 |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE 604.1 |
| 8. DEPTH DRILLED INTO ROCK Not Encountered | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 30'-6" | 19. SIGNATURE OF INSPECTOR Jeffrey C. Schulz |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 584.9 | 19.2 | | Grayish brown silty coarse to fine sand, trace to little silt, medium dense, saturated SM | 18"/ 18" | SS-8 19.5-21.0 | Sand blew into hole upon plug removal. Bottom of HSA @ 20'. 6/19/9 |
| | | | GRADES TO | | | |
| | | | Brown medium to fine sand grading to coarse to fine sand, trace little silt, very dense, saturated SM | 15"/ 15" | SS-9A 9B 22.5-23.8 | 31/46/ 50/3" |
| 581.1 | 23.0 | | Gray very silty clay, little coarse to fine sand, trace gravel, hard, low plasticity, moist CL-ML | | | |
| | | | w/occasional large gravel and cobbles | 4"/ 4" | SS-10 25.0-25.3 | 100/4" |
| | | | | 4"/ 4" | SS-11 27.5-27.8 | 100/4" |
| | | | Gray very silty clay, trace medium to fine sand, very hard, low plasticity, moist CL-ML | 6"/ 6" | SS-12 30.0-30.5 | 100/6" |
| 573.6 | 30.5 | | End of boring @ 30.5'. | | | |

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PROJECT McCook Levee — HOLE NO. CBM-5-84

Hole No. CBM-6-84

| DRILLING LOG | DIVISION: NCD | INSTALLATION: Chicago District | SHEET 1 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT: McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT: 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station): Sta 29+87 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY: Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL: |
| 4. HOLE NO. (As shown on drawing title and file number): CBM-6-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 13; UNDISTURBED 3 |
| 5. NAME OF DRILLER: Pat Bolger | 14. TOTAL NUMBER CORE BOXES: |
| 6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER: 571.5 after drilling |
| | 16. DATE HOLE: STARTED 11/24/84; COMPLETED 11/24/84 |
| 7. THICKNESS OF OVERBURDEN: | 17. ELEVATION TOP OF HOLE: 601.0 |
| 8. DEPTH DRILLED INTO ROCK: Not Encountered | 18. TOTAL CORE RECOVERY FOR BORING: % |
| 9. TOTAL DEPTH OF HOLE: 30.0 | 19. SIGNATURE OF INSPECTOR: Kerry VanOlde |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 601.0 | 0.0 | | Brown, gray and black silty clay, little coarse to fine sand, very stiff, medium plasticity, moist, fill CL | | | Advanced borehole using 3-1/4" I.D. hollow stem auger. |
| | | | | 7"/18" | SS-1 1.0-2.5 | 5/5/5 $q_u$* = 3.5 tsf |
| 598.0 | 3.0 | | Black organic silty clay, trace medium to fine sand, low to medium plasticity, moist, fill OL | | | |
| | | | | 8"/18" | SS-2 3.5-5.0 | 7/7/9 $q_u$* = 4.5+ tsf |
| | | | | 24"/24" | 3T-3 6.0-8.0 | $q_u$* = 4.5+ tsf Took sample from bottom of tube. |
| | | | | 13"/18" | SS-4 9.0-10.5 | 7/8/8 $q_u$* = 4.5+ tsf |
| | | 1/2/85 ▼ | | 15"/18" | SS-5 11.5-13.0 | 5/6/6 $q_u$* = 4.5 tsf @ 11.5' $q_u$* = 2.5 tsf @ 13.0' |
| | | | | 16"/24" | 3T-6 13.5-15.5 | $q_u$* = 0.7 tsf @ end of tube sample from bottom of tube taken. |
| 585.8 | 15.2 | | Brown and gray very silty clay and very fine sand, wet CL-SC | | | |
| 585.2 | 15.8 | | Dark gray organic very silty clay, trace roots, low to medium plasticity, stiff, saturated CL | 18"/18" | SS-7A, 7B, 7C 16.0-17.5 | 1/2/3 |
| 584.4 | 16.6 | | Dark gray organic clayey silt, some fine sand, medium plasticity, medium, medium plasticity, saturated ML | | | $q_u$* = 1.1 tsf @ 17.0' $q_u$* = 2.2 tsf @ 17.5' |
| 583.7 | 17.3 | | Gray silty clay, w/silt seams, some coarse to fine sand, very stiff, low plasticity, saturated CL | | | |
| 583.0 | 18.0 | | Dark grayish brown silt, trace clay, trace coarse to fine sand, very dense, low to nonplastic, saturated ML | 20"/24" | 3T-8 18.5-20.5 | $q_u$* = 3.5 tsf @ bottom of tube. |

Hole No. CBM-6-84

| DRILLING LOG | DIVISION NCD | INSTALLATION Chicago District | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT McCook Levee Subsurface Investigation | 10. SIZE AND TYPE OF BIT 6-3/4" O.D. x 3-1/4" I.D. HSA |
| 2. LOCATION (Coordinates or Station) Sta 29+87 | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. 1929 5th General Adj. |
| 3. DRILLING AGENCY Patrick Engineering Inc. | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) CBM-6-84 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 13; UNDISTURBED 3 |
| 5. NAME OF DRILLER Pat Bolger | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER 571.5 after drilling |
| | 16. DATE HOLE: STARTED 11/24/84; COMPLETED 11/24/84 |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE 601.0 |
| 8. DEPTH DRILLED INTO ROCK ~~Not Encountered~~ | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE 30.0 | 19. SIGNATURE OF INSPECTOR [signature] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | REC./RUN e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | | | Dark grayish brown silt, trace clay, clay, trace coarse to fine sand, very dense, low to nonplastic, saturated ML | | | Sample taken from end of tube. |
| 579.9 | 21.1 | | Gray silty clay to clayey silt, little coarse to fine sand, very stiff, low plasticity, moist CL-ML | 18"/ 18" | SS-9A, 9B 21.0-22.5 | 6/11/13<br>$q_u$* = 4.5 tsf @ 22.5' |
| | | | | 18"/ 18" | SS-10 23.5-25.0 | 6/8/19<br>$q_u$* = 4.5 tsf |
| | | | | 16"/ 18" | SS-11A, 11B 26.0-27.5 | 7/20/50<br>$q_u$* = 2.5 @ 26' |
| 574.2 | 26.8 | | Gray silty coarse to fine sand, some coarse to fine gravel, well graded, very dense, saturated SM | | | |
| | | 11/24/84 ▽ | | 17"/ 18" | SS-12 28.5-30.0 | 27/52/49<br>Water @ 29.5' after drilling. |
| 571.0 | 30.0 | | End of boring @ 30.0'. | | | |

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PROJECT McCook Levee | HOLE NO. CBM-6-84

## SUMMARY OF BOREHOLE RECHARGE TEST RESULTS

| Boring No. | Test Interval (Depth) | Method Of Test | Period Of Test | Hydraulic Head (ft.) | Computed Mean Coefficient Of Permeability |
|---|---|---|---|---|---|
| CBM-1-84 | 13.5-15.5 | Constant Head | 20 seconds | 16.3 | $1 \times 10^{-2}$ cm/sec |
| CBM-1-84 | 13.5-15.5 | Falling Head | 5 minutes | 16.3 | $7 \times 10^{-3}$ cm/sec |
| CBM-1-84 | 19.0-20.0 | Falling Head | 10 minutes | 16.5 | $7 \times 10^{-5}$ cm/sec |
| CBM-1-84 | 18.0-22.0 | Constant Head | 1 minute | 17.5 | $2 \times 10^{-3}$ cm/sec |
| CBM-1-84 | 18.0-22.0 | Falling Head | 10 minutes | 17.5 | $1 \times 10^{-3}$ cm/sec |
| CBM-5-84 | 17.5 | Falling Head | 15 minutes | 17.0 | $2 \times 10^{-5}$ cm/sec |

## BOREHOLE RECHARGE TEST PROCEDURES

Borings and intervals were selected for recharge testing by the field engineer when permeable zones were encountered. The auger flight connections were sealed with Vaseline and rubber "O" rings to prevent loss of water through the auger joints. Intervals to be tested were typically identified after the split spoon sample was retrieved. Prior to filling the hollow stem auger with water, the following information was recorded:

1. Boring number.
2. Distance to the bottom of the auger head from ground surface.
3. Stickup of the augers.
4. Length of interval tested.
5. Inside diameter of hollow flight auger.
6. Depth to phreatic surface (static water level) below ground surface.

After filling the hollow stem auger with water, either a falling head or constant head test was performed depending on the water take. For the falling head test, the depth to water within the auger was taken versus time. For the constant head test, water was added to the top of the auger string and the rate of flow required to keep the casing full recorded. Each test was performed for the length of time required to produce consistent results.

## REFERENCES


1. U. S. Department of the Interior, Bureau of Reclamation, Earth Manual, Second Edition, A Water Resources Technical Publication, 1974, pp. 573-578.

2. Winterkorn, H. F. and Fang, H. Y., Foundation Engineering Handbook, Von Nostrand Reinhold Company, New York, NY, 1975, p. 32.

# SUMMARY TABLE OF TEST RESULTS

MCCOOK LEVEE GEOTECHNICAL INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS



| | | | | Grain Size Analysis | | | | Atterberg Limits | | | | | Unconfined Strength | | Triaxial Shear Strength | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring No. | Sample No. | Depth (ft.) | Soil Description & Classification | Gravel (%) | Sand (%) | Fines (%) | $D_{10}$ (mm) | LL | PL | PI | Natural Water Content (%) | Natural Dry Density (pcf) | $Q_u$ (tsf) | $Q_u$* (tsf) | Type Of Test | Number Of Points | C' (tsf) | C (tsf) | Ø' | Ø |
| CBM-1-84 | SS-1B | 1.4-2.5 | Silty sand, SM | 0 | 71 | 29 | | | | | | | | | | | | | | |
| | SS-2 | 3.5-5.0 | Silt & sand, SM-ML | 1 | 53 | 46 | | | | | | | | | | | | | | |
| | SS-3 | 6.0-7.5 | Organic silty clay, OL | | | | | | | | 23.6 | | | | | | | | | |
| | SS-4 | 8.5-10.0 | Organic silty clay, OL | | | | | | | | 32.5 | | | | | | | | | |
| | SS-5A | 10.0-11.0 | Silty sand, trace to little clay, SM-SC | 1 | 66 | 33 | | | | | | | | | | | | | | |
| | 3T-6 | 14.1-15.5 | Well graded sand, little silt, SM | 2 | 83 | 15 | | | | | | | | | | | | | | |
| | SS-7 | 16.0-17.5 | Well graded sand, trace to little silt, SM-SW | 6 | 82 | 12 | | | | | | | | | | | | | | |
| | SS-8 | 18.5-20.0 | Well graded sand, trace silt, SW-SM | 5 | 89 | 6 | 0.22 | | | | | | | | | | | | | |
| | SS-9 | 22.5-24.0 | Clayey silt, CL-ML | | | | | | | | 11.4 | | | | | | | | | |
| | SS-10 | 28.5-30.0 | Clayey silt, CL-ML | | | | | | | | 12.0 | | | | | | | | | |
| CBM-2-84 | SS-1B | 2.0-2.5 | Organic silty clay, OH | | | | | | | | 21.5 | | | | | | | | | |
| | SS-2 | 3.5-5.0 | Silty clay, CL | | | | | | | | 25.6 | | | | | | | | | |
| | 3T-3 | 6.0-8.0 | Organic silt & clay, OH | 0 | 7 | 93 | | 66 | 32 | 34 | 24.6 | 99.3 | 2.1 | 2.0 | | | | | | |
| | SS-4 | 9.0-10.5 | Organic silt & clay, OH | | | | | | | | 30.9 | | | | | | | | | |
| | 3T-5 | 11.5-13.5 | Organic silt & clay, OH | 0 | 8 | 92 | | 60 | 31 | 29 | 32.3 | | | 1.5 | | | | | | |
| | SS-6 | 14.5-16.0 | Silty clay, CL | | | | | | | | 30.2 | | | | | | | | | |
| | SS-7B | 17.3-18.5 | Silty clay, CL | | | | | | | | 33.7 | | | | | | | | | |
| | SS-8 | 19.5-21.0 | Clayey silt, ML-CL | | | | | | | | 13.5 | | | | | | | | | |

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MCCOOK LEVEE GEOTECHNICAL INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS



| Boring No. | Sample No. | Depth (ft.) | Soil Description & Classification | Grain Size Analysis: Gravel (%) | Sand (%) | Fines (%) | $D_{10}$ (mm) | Atterberg Limits: LL | PL | PI | Natural Water Content (%) | Natural Dry Density (pcf) | Unconfined Strength: $Q_u$ (tsf) | $Q_u$* (tsf) | Triaxial Shear Strength: Type Of Test | Number Of Points | C' (tsf) | C (tsf) | Ø' | Ø |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CBM-3-84 | SS-2 | 7.0-8.5 | Sandy silt, ML | | | | | | | | 14.8 | | | | | | | | | |
| | SS-3B | 13.8-14.4 | Silty clay, CL | | | | | | | | 27.8 | | | | | | | | | |
| | 3T-4 | 16.4-16.8 | Organic silty clay, OH | | | | | | | | 24.8 | | | 0.75 | | | | | | |
| | 3T-4 | 16.8-17.2 | Silty clay, CL | 4 | 21 | 75 | | 30 | 17 | 13 | 15.8 | 114.0 | | 1.25 | CIU | 1 | 0 | 0 | 31° | 27° |
| | SS-5 | 18.5-19.5 | Silty sand, SM | | | | | | | | 8.4 | | | | | | | | | |
| | SS-6 | 22.0-23.5 | Silty sand & gravel, SM-GM | 43 | 35 | 22 | | | | | | | | | | | | | | |
| | SS-7 | 25.0-25.5 | Silty gravelly sand, SM | 30 | 45 | 25 | | | | | | | | | | | | | | |
| | SS-8 | 26.0-26.1 | Silt & sand, SM-ML | 9 | 42 | 49 | | | | | | | | | | | | | | |
| CBM-4-84 | SS-1 | 1.0-2.5 | Very silty clay, CL | | | | | | | | 18.2 | | | | | | | | | |
| | SS-2 | 3.5-5.0 | Very silty clay, CL | | | | | | | | 21.0 | | | | | | | | | |
| | 3T-3 | 6.0-7.0 | Silty clay, little organics, CH-OH | | | | | 52 | 22 | 30 | 18.6 | | | 4.5+ | | | | | | |
| | SS-4 | 8.0-9.5 | Organic silty clay, OH | | | | | | | | 46.4 | | | | | | | | | |
| | SS-5A | 10.5-11.8 | Organic silty clay, OH | | | | | | | | 30.9 | | | | | | | | | |
| | SS-6 | 13.0-14.5 | Silty clay, CL | | | | | | | | 30.8 | | | | | | | | | |
| | SS-7A | 15.5-16.0 | Silty sandy gravel, GM | 43 | 22 | 25 | | | | | | | | | | | | | | |
| CBM-5-84 | SS-1 | 2.5-3.0 | Very silty clay, CL-ML | | | | | | | | 16.9 | | | | | | | | | |
| | SS-1 | 3.0-4.0 | Very silty clay, CL-ML | | | | | | | | 10.8 | | | | | | | | | |
| | 3T-2 | 5.0-7.2 | Organic silty clay, OL | | | | | | | | 22.5* | 101.6* | | 4.5+ | UU | 2 | N/A | 1.4 | N/A | 0° |
| | 3T-4 | 10.0-12.2 | Organic silty clay, OL | <1 | 28 | 71 | | 48 | 27 | 21 | 23.9 | 98.9 | | 3.25 | UU | 1 | N/A | | N/A | |
| | 3T-5 | 12.5-14.7 | Silty sand, SM | 5 | 67 | 28 | | | | | | | | | | | | | | |

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MCCOOK LEVEE GEOTECHNICAL INVESTIGATION

SUMMARY OF LABORATORY TEST RESULTS



| Boring No. | Sample No. | Depth (ft.) | Soil Description & Classification | Grain Size Analysis Gravel (%) | Sand (%) | Fines (%) | $D_{10}$ (mm) | Atterberg Limits LL | PL | PI | Natural Water Content (%) | Natural Dry Density (pcf) | Unconfined Strength $Q_u$ (tsf) | $Q_u$* (tsf) | Triaxial Shear Strength Type Of Test | Number Of Points | C' (tsf) | C (tsf) | ø' | ø |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CBM-5-84 | SS-7 | 17.5-19.0 | Poorly graded sand, little silt, SM | 1 | 83 | 16 | | | | | | | | | | | | | | |
| | SS-8 | 19.5-21.0 | Well graded sand, little silt, SM | 10 | 77 | 13 | | | | | | | | | | | | | | |
| | SS-9B | 23.0-23.8 | Very silty clay, CL-ML | | | | | | | | 10.3 | | | | | | | | | |
| | SS-11 | 27.5-27.8 | Very silty clay, CL-ML | | | | | | | | 10.1 | | | | | | | | | |
| CBM-6-84 | SS-2 | 3.5-5.0 | Organic silty clay, OL | | | | | | | | 20.0 | | | | | | | | | |
| | 3T-3 | 6.0-8.0 | Organic silty clay, OL | 0 | 9 | 91 | | 50 | 28 | 22 | 24.6 | 92.4* | | 4.5+ | CIU | 2 | 0 | 0 | 28° | 20.5° |
| | SS-5 | 11.5-13.0 | Organic silty clay, OL | | | | | | | | 25.1 | | | | | | | | | |
| | 3T-6 | 13.5-15.2 | Organic silty clay, OL | | | | | 35 | 19 | 16 | 26.3 | 83.6 | 0.9 | 0.5 | | | | | | |
| | SS-7B | 16.6-17.3 | Organic clayey silt, OL | | | | | | | | 34.0 | | | | | | | | | |
| | 3T-8 | 18.5-20.5 | Silt, trace clay, ML | 1 | 19 | 80 | | 22 | 20 | 2 | 13.2 | 120.7 | 4.1 | 4.5+ | | | | | | |
| | SS-10 | 23.5-25.0 | Very silty clay, CL-ML | | | | | | | | 14.4 | | | | | | | | | |
| | SS-11B | 26.8-27.5 | Silty sand, little gravel, SM | 18 | 56 | 26 | | | | | | | | | | | | | | |
| | SS-12 | 28.5-30.0 | Silty gravelly sand, SM | 25 | 51 | 24 | | | | | | | | | | | | | | |

*Average Value For Sample Interval

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