US Army Corps
of Engineers®
St. Paul District

Design Documentation Report

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

Doc Version: 35% Review Submittal

03 January 2014

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Design Documentation Report

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1 INTRODUCTION

1.1 Project Location

The cities of Fargo, located in southeast North Dakota, and Moorhead, located in northwest Minnesota, straddle the North Dakota-Minnesota border, as shown in *Figure 1*. The metropolitan area is located along the Red River and near the confluence of the Red and Sheyenne Rivers. The area encompasses land approximately 12 miles west to five miles east of the Red River and from 20 miles north to 20 miles south of Interstate 94. The total metropolitan area is approximately 90 square miles.

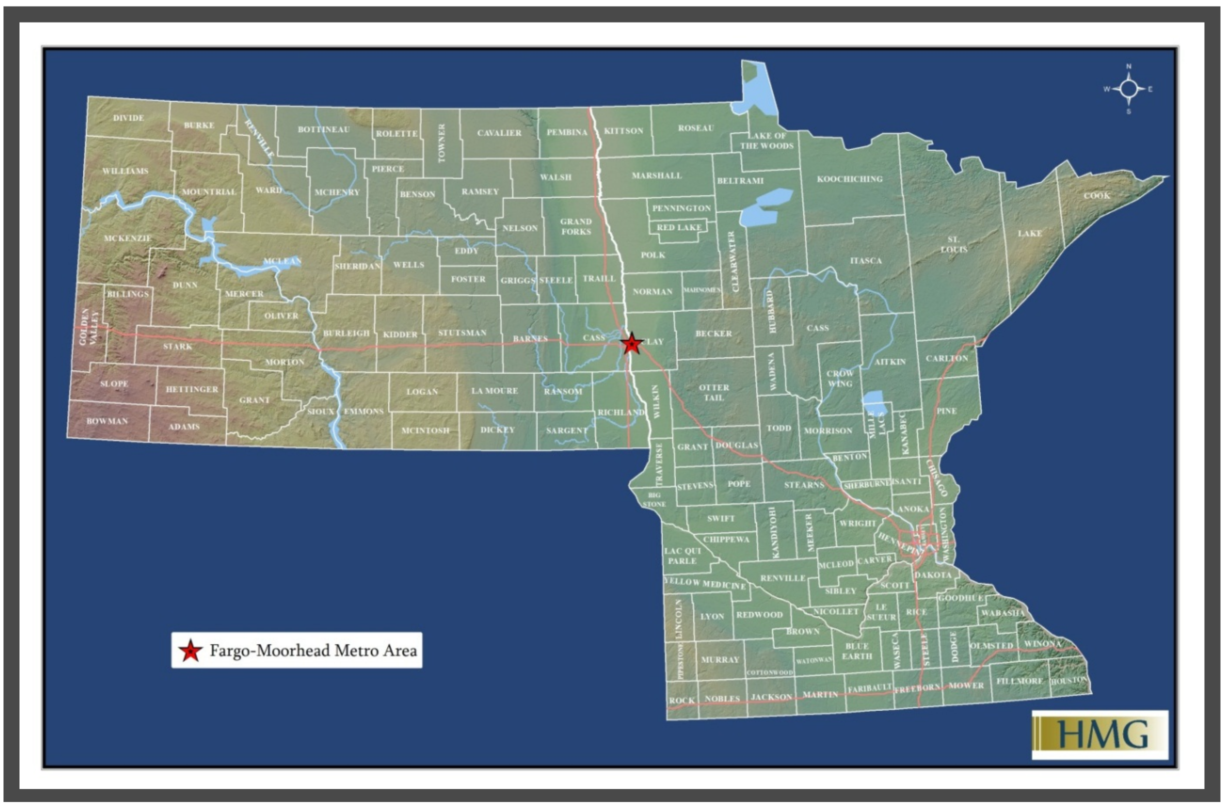

Figure 1 - Fargo-Moorhead General Location

1.2 Background

The Red River Valley was once the bed of glacial Lake Agassiz and the resulting terrain is extremely flat and prone to flooding. The National Weather Service (NWS) has designated 18 feet as the minor flood stage at the Fargo USGS gage. This stage has been exceeded by the Red River in 49 of the past 110 years. It was exceeded consecutively from 1993 to 2011, and again in 2013. *Figure 2* shows USGS hydrographs from five recent flood events [1]. The Fargo-Moorhead metropolitan area is currently protected by several permanent levees as well as a series of emergency levees that are constructed during flood events. Although the emergency flood protection has been effective for the past flood events, the United States Army Corps of Engineers (USACE) has estimated that the damages would exceed $195 million if emergency measures were to fail during another event equivalent to the 2009 flood [2] .

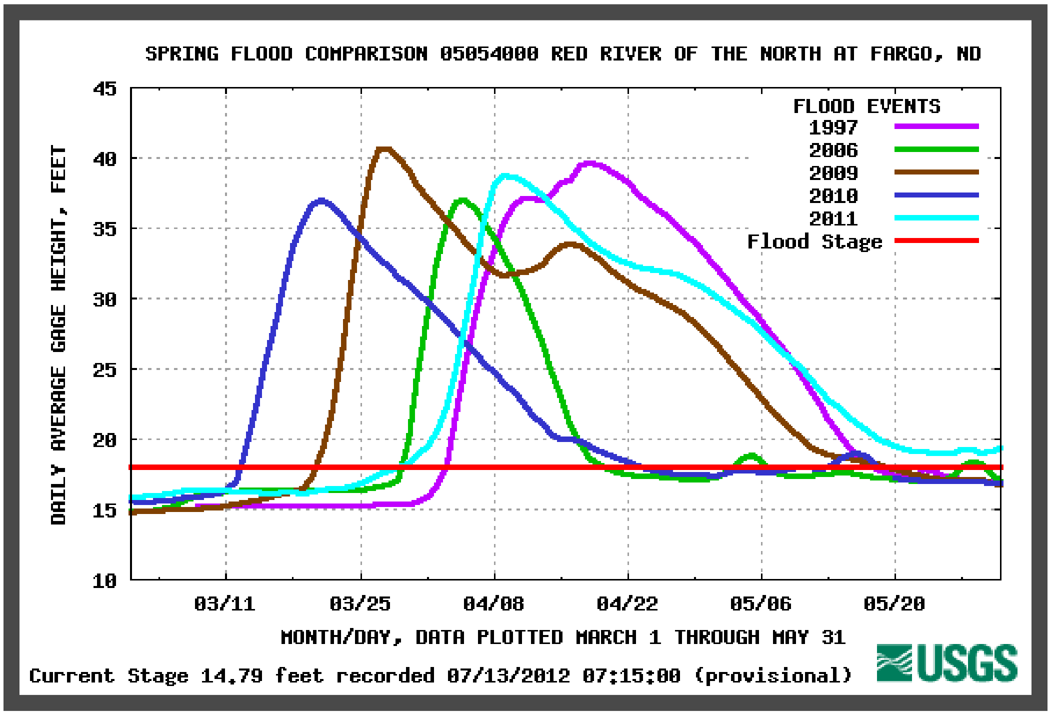

Figure 2 - Fargo USGS Gage Flood Event Comparison [1]

***USGS Gage height can be converted to sea level by adding 861.8 feet (NGVD 1929) or 862.74 (NAVD 1988)**

According to the 2010 census, the populations of Fargo and Moorhead were 105,549 and 38,065 people, respectively. Fargo and Moorhead, along with the cities of West Fargo, Dilworth and several smaller communities, make up the metropolitan area that serves home to over 200,000 people. There was a 20 percent increase in population in the metropolitan area over the last decade [3].

1.3 Project Features

The project consists of constructing a diversion channel around the metropolitan area in combination with a series of tie-back embankments and control structures that will divert a portion of the flood flows around the cities. The Fargo-Moorhead Metropolitan Flood Risk Management Project shown in *Figure 3* currently includes:

1) A diversion channel with a meandering low flow channel
2) A connecting channel and embankment from the Wild Rice River to the diversion channel
3) Upstream staging area
4) A diversion inlet structure

5) An outlet structure near Georgetown, MN with a fish passage structure
6) A drop structure at the Rush River with a fish passage structure
7) Drop structures at the Lower Rush River and County Drain 14
8) Aqueduct and fish passage structures at the Sheyenne and Maple Rivers
9) Control structures on the Red and Wild Rice Rivers
10) Embankments
11) Excavated Material Berms
12) Recreational features
13) Levees and floodwalls in downtown Fargo
14) Ring levee around the communities of Oxbow, Hickson, and Bakke, ND, located in the staging area
15) Ring levee around the City of Comstock, MN, located in the staging area

The project includes a connecting channel that begins at the Wild Rice River just west of Interstate 29. The connecting channel extends west to the diversion inlet structure that is located just south of Horace, ND at County Road 17. The diversion channel begins at the inlet structure and wraps around the cities of Horace, West Fargo, Fargo, and Harwood, reentering the Red River near the city of Georgetown, MN. The total length of the diversion and connecting channels is approximately 33 miles and the channel will cross the Sheyenne, Maple, Lower Rush, and Rush Rivers.

Hydraulic structures will be constructed on the Red and Wild Rice Rivers that will control the flows allowed into the flood risk reduction area during flood events. The structures on the Red River and Wild Rice River control the flow split between the diversion channel, the staging area, and the flow through the cities of Fargo and Moorhead. The USGS gage on the Red River at Fargo recorded a peak stream flow of 29,500 cfs during the 2009 flood, which is about a 2-percent chance event. For a similar 2-percent chance event after the project is built, approximately 20,000 cfs from the Red and Wild Rice Rivers would be rerouted into the diversion channel with the remaining 17,000 cfs staying in the river channel and passing through the flood risk reduction area. Approximately 20,000 cfs will be diverted into the diversion channel for larger events such as the 2, 1, and 0.2-percent chance events.

The upstream staging and storage of approximately 149,000 acre-feet will be required in order to ensure there are no increased water surface elevations in the Red River downstream of the project for the 1-percent chance event. The total volume in the staging area is 243,000 acre-feet, which includes the volume under existing conditions of 94,000 acre-feet. The staging area can be seen in *Figure 3.* A tieback embankment will extend east from the connection channel near the Wild Rice River, cross the Wild Rice and Red River control structures, and daylight into existing high ground located in Minnesota.

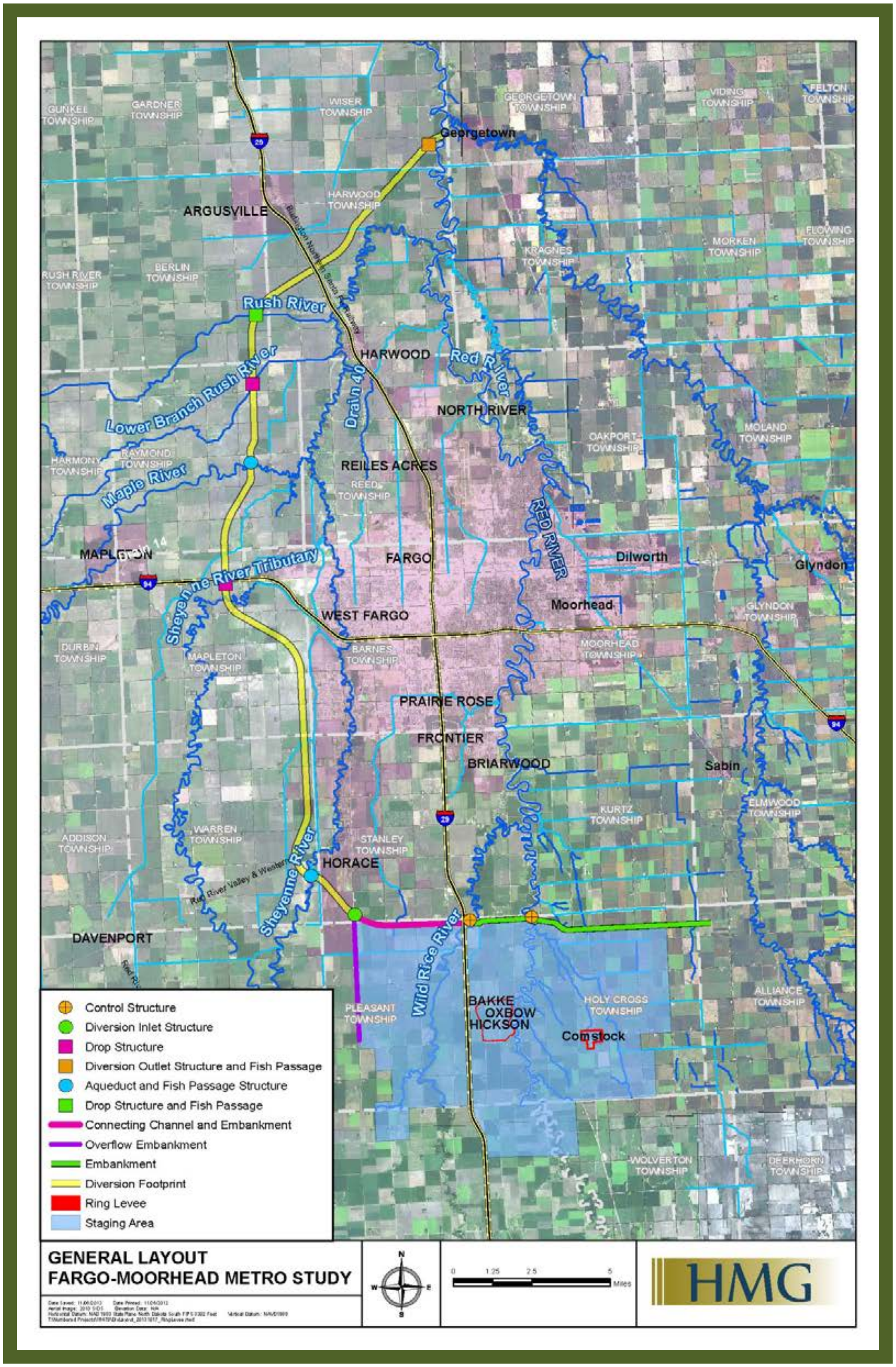

Figure 3 - Fargo-Moorhead Metro Diversion Project

The Sheyenne and Maple River crossings will consist of aqueduct structures at the diversion to allow base flows to follow their natural river channels while diversion flows pass beneath the existing tributary waters. Flows exceeding a 50-percent chance event on the Sheyenne and Maple Rivers will be diverted into the diversion channel. Flows from the Rush River, Lower Rush River and County Drain 14 enter the diversion channel through drop structures. The outlet structure near Georgetown, MN will be a rock spillway with a low flow channel for fish passage.

Stream restoration, riparian corridor restoration, a meandering low flow channel, and a fish passageway are required for aquatic habitat and connectivity mitigation. Fish passage will be provided at the Maple and Sheyenne River aqueducts, the Rush River drop structure, and the diversion outlet structure. Forest will be reestablished on 239 acres of floodplain agricultural land or pastured land. Native wetland species will be planted at the bottom and fringe of the side slopes of the diversion channel. The wetland habitat in the diversion channel will develop within the meandering low flow channel and associated grade control structures.

The result of the large cut sections required for the construction of the diversion channel is excess material beyond what is required for the construction of the project levees and road embankments. To minimize the cost of construction due to transporting large amounts of excavated material, the soil will be spoiled adjacent to the channel in excavated material berms (EMBs). A project levee will be embedded within the right (looking downstream) bank EMB. The left bank does not require a project levee and will only have an EMB.

The OHB Ring Levee is required to mitigate and reduce the flood risk for the three communities from flooding caused by the staging area of the FM Diversion Project. The alignment starts on the northeast side of Oxbow and will parallel the Red River through existing city lots along the east side of Oxbow. It will continue south along the Red River until County Road 18 where the levee will turn and go west. It will continue west on the north side of County Road 18 until it intersects County Road 81. The levee will continue northwesterly to encompass the west side of the Bakke Subdivision and will then parallel the north side of the Bakke Subdivision until it crosses County Road 81. Approximately 40 residential lots and portions of the existing Oxbow Country Club Golf Course will be relocated from the east side of the city into a new replacement area. Additional residential lots are included in the replacement area to replace the loss of nearby rural residents within the staging area.

The OHB Ring Levee design is distributed into 5 work packages that include 3 levee design packages, an interior flood control and road raise package, and a demolition and utility relocation package. The United States Army Corps of Engineers (USACE) will be completing the design of Work Package 43B (WP-43B) while Houston-Moore Group (HMG) will complete the other 4 Work Packages. The work packages described in this document are identified in *Figure 4*.

1.3.1 WP-43A

WP-43A is the levee portion on the south side of the City of Oxbow that will surround the new residential lots and golf course area. The east boundary of WP-43A parallels the Red River beginning at the existing southern limits of the City of Oxbow, while the south boundary of WP-43A runs adjacent to and north of County Road 18. The west boundary of WP-43A ends at County Road 81. The total length of levee is approximately 6,789 feet. HMG is designing this portion of the OHB Ring Levee Project.

1.3.2 WP-43B

WP-43B is the levee portion on the west side of County Road 81 and around the Bakke Subdivision. The west boundary of WP-43B runs through an existing agricultural field beginning at the intersection of County Roads 18 and 81 to the west side of the Bakke Subdivision. The north boundary of WP-43B runs parallel on the north side of the Bakke Subdivision until it intersects County Road 81. The total length of levee is approximately 12,983 feet. The USACE is designing this portion of the OHB Ring Levee Project.

1.3.3 WP-43C

WP-43C is the levee portion on the east side of the City of Oxbow that will run adjacent to the Red River. WP-43C will be the final constructed leg of the OHB Ring Levee, beginning at County Road 81 on the northeastern portion of the OHB Ring Levee where WP-43B ends, and ending at the existing southern limits of the City of Oxbow where WP-43A begins. The total length of levee is approximately 4,311 feet. HMG is designing this portion of the OHB Ring Levee Project.

1.3.4 WP-43D

WP-43D is the design of interior flood control systems for the drainage area inside the proposed ring levee. This includes designing new drainage infrastructure and upgrading existing infrastructure as well as designing stormwater retention ponds and a pump station. WP-43D also includes the design of the County Road 81 road raises in order to traverse the new ring levee, as well as the County Road 18 road raise between the I-29 interchange and County Road 81. HMG is designing this portion of the OHB Ring Levee Project.

1.3.5 WP-43E

WP-43E is the development of demolition and utility relocation plans for the OHB Ring Levee. The plans will include the demolition of all existing infrastructure along the levee alignment and relocation of all cut and capped utilities. HMG will be coordinating this portion of the project.

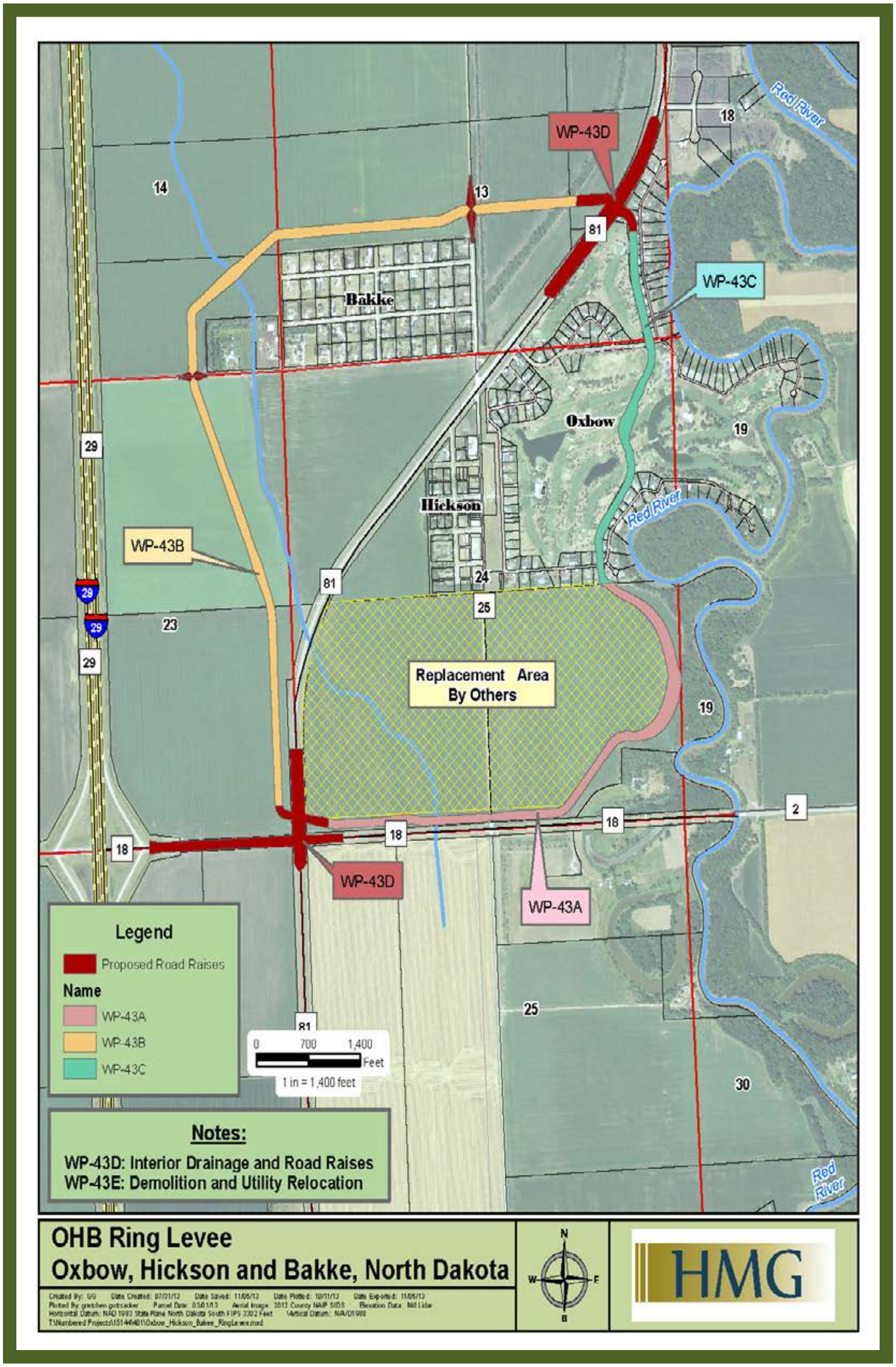

Figure 4 - OHB Ring Levee Work Packages

2 DESIGN DATA

2.1 Surfaces and Survey Data

Aerial Light Detection and Ranging (LiDAR) data and ground surveys performed by Merrick and Company in May 2011 were developed by the USACE and used for the existing topographic data in the design and drawings. The coordinate system and projection of the existing condition data is NAD83 (2007), North Dakota State Plane Coordinate System, South Zone (U.S. Survey Feet). The elevation datum for the existing condition data is NAVD88 (U.S. Survey Feet). The USACE developed an original base map drawing for all the design teams to incorporate in their work packages. Additional topographic surveys have been conducted by HMG for use in conjunction with the LiDAR data and this information will be incorporated into the base map by the USACE.

HMG collected utility information including existing easement documents in the summer and fall of 2013 and will field verify the utilities in the winter of 2013. These will be summarized and provided in Appendix E in future submittals.

2.2 Geotechnical Engineering and Geology

The subsurface investigation for OHB has been completed. Six soil borings were obtained along the WP-43B alignment along with four shallow borings (40 feet depth) located in the proposed ponding areas. Nested vibrating wire piezometers were installed at one of the instrumentation locations, which is located in the north ponding area. A more detailed geotechnical analysis report will be included in the 65% submittal.

2.3 Hydrology and Hydraulics

The OHB levee is being designed because of increased water surface elevations in the area associated with staging water upstream of the diversion to mitigate project impacts. Table 1 below includes peak water surface elevations at Oxbow for floods of varying magnitude under existing conditions as well as under project operation (with project) conditions. All levee design is based on the with project condition. The levee is being designed based on adding sufficient freeboard to the 0.2-percent chance (500-year) with project event.

	Existing Conditions	Diversion Project
10 year	910.69	910.65
50 year	916.46	921.68
100 year	917.50	922.34
500 year	919.68	922.59
*Values from RS 2548627 in Phase 7.0 models used for the EA.		

Table 1 - Oxbow-Hickson-Bakke Water Surface Elevations

2.3.1 Wave Action

A wave action analysis is currently being conducted by the USACE. The results of this study will be used to finalize the top of levee elevation as well as any erosion control features needed on the outside face of the levee. Additional detail will be provided in Appendix C for the 65% submittal.

3 LEVEE DESIGN

3.1 Levee

The OHB Ring Levee will have a 10 foot top width with a preliminary construction grade elevation at the control line of 928.1 feet. The inside levee slope will be a 5H:1V while the outside levee slope will be a 4H:1V with the exception of the NE segment between Main street and CR81 which will have an outside levee slope of 5H:1V to satisfy the wind/wave runup criteria . A typical section of the OHB Ring Levee is shown in *Figure 5*. The interior and exterior ditches were designed by HMG in the local drainage plan (See Appendix C), and were incorporated into the WP-43B design by the COE. The 10 levee foot top will include a gravel road for maintenance and inspection purposes. The gravel road will have a 2% cross slope towards the outside of the levee to shed precipitation. The levee slopes will have 6" of topsoil and seed for erosion protection.

The geotechnical analysis is still ongoing as stated in Section 2.2. Therefore, the levee dimensions and alignment are subject to change until this geotechnical analysis is completed. Levee slope stability and levee settlement analysis are some of the geotechnical parameters that will be investigated.

3.1.1 Inside Ditch

The inside ditch of the levee will be constructed to convey interior water from the levee slopes and watershed areas being blocked by the construction of the levee to the two interior retention ponds (West Pond and North Pond). At the southwest extent of WP-43B, which is the intersection of County Roads 18 and 81, there will be a ditch along CR 81 that will convey interior drainage north to the existing agricultural drainage swale. Because existing topography in this area will direct runoff from the levee to this drainage ditch, no inside ditch along the levee will be required. As the WP-43B levee runs northwest and away from CR81, and interior ditch will be required to covey runoff north to the future West Retention Pond. As the WP-43B levee proceeds around the west side of Bakke, there will be a drainage break. Southwest of this break the inside ditch will flow down to the West Retention Pond, and east of the break the flow will be east to the future North Retention Pond Additional documentation on the inside ditches and the interior flood control plans can be found in Appendix C

3.1.2 Outside Ditch

The outside ditches of the levee will be constructed to convey the local drainage paths intercepted by and around the levee to either existing field swales or existing road ditches. At the intersection of County Roads 18 and 81, an outside ditch will convey water north until the ditch intersects with the existing agricultural drainage swale. The swale will then take water north on its current path. On the north side of Bakke, the drainage break for the outside ditch is at the Main Street road raise. West of the road raise, the outside ditch will flow west to the existing agricultural drainage swale. East of the road raise, the outside ditch will flow east to the County Road 81 ditch. Additional information on the outside ditches can be found in Appendix C.

3.1.3 Exploration Trench

An exploration trench will be constructed as part of the levee construction. The dimensions of the inspection trench will be based on the ongoing geotechnical analysis and will follow guidelines outlined in USACE EM-1110-2-1913 [4].

3.1.4 Turnarounds, Turnouts and Access Roads

Access roads to the top of the levee will be at CR 81 road raise at both the southwest and northeast extents of WP-43B. There will also be levee access from road raises at Main Street (CR 25) and 51st Street that are needed primarily for farm equipment access to adjacent agricultural fields. USACE EM-1110-2-1913 recommends that turnouts be provided at intervals of approximately 2,500 feet provided there are no access roads within that length of levee. WP-43B has two turnouts; one between CR 81 South and 51st Street road raises and another between 51st Street and CR 81 North road raises.

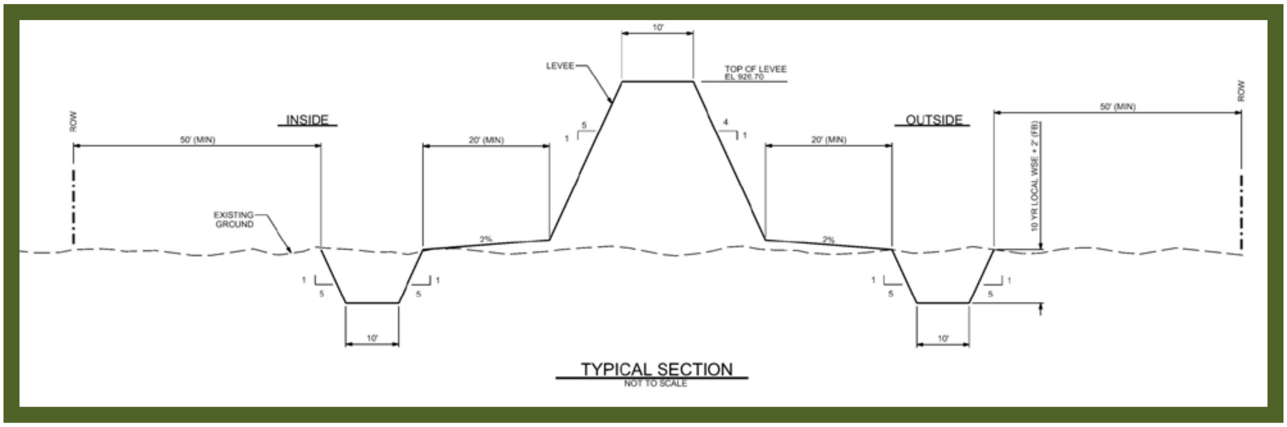

Figure 5 – Typical Levee Cross Section with Ditches

4 CIVIL-SITE

4.1 Vegetation Free Zone and Work Limits

Vegetation Free Zone (VFZ) requirements will follow the USACE's ETL-1110-2-571 [5]. For a typical levee, the ETL defines the minimum VFZ as the levee itself, and an additional 15' from the toe on both sides of the levee. The VFZ can be larger than this depending on site specific conditions. The VFZ for this project will be acquired in Fee Title.

The inside and outside ditches will be outside of the VFZ, so additional Fee Title property acquisition will be required for the ditch footprint, as well as area adjacent to the ditch to allow for maintenance. Temporary construction easements (Work Limits) may also need to be secured to allow adequate space to construct the project.

Work Limits will be shown on the construction plans. Fee Title and Temporary Easement boundaries will be shown on the Right of Way drawings.

4.2 Road Raises

CR 81 road raises will be designed by HMG in WP-43D. The road raises at Main Street (CR 25) and 51st Street will be designed by the COE in WP-43B. Details of this design can be found in Appendix E.

4.3 Utility Relocations

Existing utility locations will be shown in Appendix E in future submittals. All utility relocations are being done separately from this design and will comply with local and state requirements. Overhead and buried electrical lines will be relocated by the utility owner prior to construction of the project. The utility relocation will be developed after meetings are held with all utility companies. Utility relocations will comply with the MVP MFR for OHB Utility Relocation Requirements and local /state requirements.

4.4 Specifications and Bid Schedule

Each phase of the OHB Ring Levee design will have separate plans and specifications. The levee plans will adhere to the USACE specifications, which will be included in the 65% submittal. Each levee phase will have its own bid proposal sheet that will be used in the competitive bidding process to award a construction contract. Unit costs shown on the bid proposal are estimated bare project costs and do not contain contingencies or contractor profit. These unit prices will likely be adjusted as the design develops. Furthermore, construction items may be added or removed from the bid proposal as the project design evolves.

5 LANDSCAPE AND RECREATIONAL

5.1 Overall Recreation Plan

A conceptual recreation plan is being created for the project by the USACE in cooperation with the local sponsors. Additional recreation and landscape details will be provided in future submittals.

5.2 Plantings

Per local request, a row of trees will be planted between the interior drainage ditch and Bakke to serve as a visual screen. Details of this design will be provided in future submittals.

6 REVIEW DOCUMENTATION

6.1 District Quality Control (DQC) Review

The DQC review started on 25 November 2013 and ended on 09 December 2013. Formal comments are to be entered into ProjNet (Dr. Checks). Informal comments on minor items are to be provided directly to the designers. Documentation of the DQC Review can be found in Appendix L: Quality Control Documentation.

6.2 Agency Technical Review (ATR)

Documentation will be added after the ATR has been completed.

6.3 Independent External Peer Review (IEPR)

Documentation will be added after the IEPR has been completed.

7 REFERENCES

[1] "USGS Flood Tracking 05054000 RED RIVER OF THE NORTH AT FARGO, ND," 16 July 2012. [Online]. Available: http://nd.water.usgs.gov/floodtracking/charts/05054000.html.

[2] U.S. Army Corps of Engineers, "Appendix C: Economics," in *Fargo-Moorhead Metropolitan Area Flood Risk Management, Final Feasibility Report and Environmental Impact Statement*, July 2011.

[3] "State and County QuickFacts," U.S. Census Bureau, 6 June 2012. [Online]. Available: http://quickfacts.census.gov/qfd/index.html. [Accessed 16 July 2012].

[4] U.S. Army Corps of Engineers, "Engineering Manual (EM) 1110-2-1913 - Design and Construction of Levees," Washington DC, April 30, 2000.

[5] U.S Corps of Engineers, "Engineering Technical Letter (ETL) 1110-2-571 - Guidelines for Landscape Plantings and Vegetation Management at Levees, Floodwalls, Embankment dams, and Appurtenant Structures," Washington, D.C., April 10, 2009.

LIST OF COMMON ACRONYMS

AAA	Army Audit Agency (AAA)
AAR	After Action Review (AAR)
ACI	American Concrete Institute (ACI)
AE	Architect/Engineer (AE) firms
AEP	Alternatives Evaluation Report (AEP)
AO	Area of Operations (AO)
AOR	Area of Responsibility (AOR)
APIR	Abbreviated Project Information Report APIR)
AR	Army Regulation (AR)
ASA	Assistant Secretary of the Army
ASA(CW)	Assistant Secretary of the Army for Civil Works (ASA(CW))
ATR	Agency Technical Review (ATR)
ATTN	Attention (ATTN)
ASPRS	American Society of Photogrammetry and Remote Sensing (ASPRS)
ASTM	American Society for Testing and Materials (ASTM)
AWS	American Welding Society (AWS)
BCOE	Biddability, Constructability, Operability, and Environmental (BCOE) review
BCR	Benefit to Cost Ratio (BCR)
BM	Benchmarks (BMs)
BMP	Best Management Practices (BMP)
CAA	Clean Air Act (CAA)
CAD	Computer-Aided Design (CAD)
CAP	Continuing Authorities Program (CAP)
CBO	Congressional Budget Office (CBO)
CCR	Change Control Request (CCR)
CDM	Current Design Maximum (Water Level)
CDR	Commander (CDR)
CEFMS	Corps of Engineers Financial Management System (CEFMS)
CFS	Cubic Feet per Second (CFS)
CG	Commanding General (CG)
CIR	Compensability Interest Review
CMP	Corrugated Metal Pipe (CMP)
CO	Contracting Officer (CO)

COA	Course Of Action (COA)
COE	Corps of Engineers (COE);Chief of Engineers (COE)
CONUS	Continental United States (CONUS)
COR	Contracting Officer Representative (COR)
CORS	Continuously Operating Reference Stations (CORS)
CPRA	Coastal Protection Restoration Authority (CPRA)
CPT	Cone Penetration Test (CPT); Captain (CPT)
CRREL	Cold Regions Research and Engineering Laboratory (CRREL)
CS	Construction Schedule (CS)
CSI	Construction Specifications Institute
CT	Contracting Office
CW	Civil Works (CW)
CWA	Clean Water Act (CWA)
CWE	Current Working Estimate (CWE)
CWRB	Civil Works Review Board (CWRB)
DA	Design Agreement (DA); Department of the Army (DA)
DDR	Design Documentation Report (DDR)
DE	District Engineer (DE)
DEIS	Draft Environmental Impact Statement (DEIS)
DEM	Digital Elevation Model (DEM)
DNR	Department of Natural Resources (DNR)
DOD	Department of Defense (DOD)
DOI	Department of the Interior (DOI)
DOT	Department Of Transportation (DOT)
DQC	District Quality Control (DQC)
DRCheckS	Design Review and Checking System (DRCheckS)
DS	Direct Shear Test (DS)
DTM	Digital Terrain Model (DTM)
DTR	Draft Technical Review (DTR)
E&D	Engineering and Design (E&D)
EA	Environmental Assessment (EA)
EC	Engineer Circular (EC); Engineering and Construction Division (EC)
EDC	Engineering During Construction (EDC)
EEO	Equal Employment Opportunity (EEO)

EIS	Environmental Impact Statement (EIS)
EM	Engineer Manual (EM)
EMB	Excavated Material Berm (EMB)
EO	Executive Order (EO)
EOC	Emergency Operations Center (EOC)
EPA	Environmental Protection Agency (EPA)
ER	Engineer Regulation (ER)
ERDC	Engineer Research and Development Center (ERDC)
ESA	Environmental Site Assessment (ESA)
ETL	Engineer Technical Letter (ETL)
FCA	Flood Control Act (FCA)
FCSA	Federal Cost Share Agreement (FCSA)
FEIS	Final Environmental Impact Statement (FEIS)
FEMA	Federal Emergency Management Agency (FEMA)
FERC	Federal Energy Regulatory Commission (FERC)
FGDC	Federal Geographic Data Committee (FGDC)
FMM	Fargo Moorhead Metro (FMM)
FMV	Fair Market Value (FMV)
FOIA	Freedom of Information Act (FOIA)
FONSI	Finding of No Significant Impact (FONSI)
FTR	Final Technical Review (FTR)
FY	Fiscal Year (FY) – Federal FY begins October 1st annually
FYI	For Your Information (FYI)
GAO	General Accounting Office (GAO)
GIS	Geographic Information System (GIS)
GPS	Global Positioning System (GPS)
GSA	General Services Administration (GSA)
H&H	Hydrology and Hydraulics (H&H)
HTRW	Hazardous, Toxic, and Radioactive Waste (HTRW)
IAW	In Accordance With (IAW)
IEPR	Independent External Peer Review (IEPR)
IGE	Independent Government Estimate (IGE)
IJC	International Joint Commission (IJC)
LPCP	Local Project Control Points (LPCP)

M&IE	Miscellaneous and Incidental Expenses (M&IE)
MFR	Memorandum For Record (MFR)
MOA	Memorandum of Agreement (MOA)
MOB	Mobilization (MOB)
MOU	Memorandum of Understanding (MOU)
MVD	Mississippi Valley Division (MVD) – located in Vicksburg, MS
MVK	Vicksburg District (MVK)
MVM	Memphis District (MVM)
MVN	New Orleans District (MVN)
MVP	St. Paul District (MVP)
MVR	Rock Island District (MVR)
MVS	St. Louis District (MVS)
NAD83	North American Datum of 1983 (NAD83) – Horizontal Control Datum
NAVD 88	North American Vertical Datum of 1988 (NAVD 88)
NEPA	National Environmental Policy Act, 1969 (NEPA)
NGS	National Geodetic Survey (NGS)
NMAS	National Map Accuracy Standard (NMAS)
NPDES	National Pollutant Discharge Elimination System (NPDES)
NRCS	Natural Resource Conservation Service (NRCS)
NSRS	National Spatial Reference System (NSRS)
NSSDA	National Standard for Spatial Data Accuracy (NSSDA)
NWS	National Weather Service (NWS)
O&M	Operation and Maintenance (O&M)
OC	Office of Council (OC)
OCONUS	Outside Continental United States (OCONUS)
OMB	Office of Management and Budget (OMB)
OPM	Office of Personnel Management (OPM)
P&S	Plans and Specifications (P&S)
PAO	Public Affairs Office (PAO)
PDS	Permanent Duty Station (PDS)
PDT	Project Delivery Team (PDT)
PER	Preliminary Engineering Report (PER)
PIR	Project Information Report (PIR)
PM	Project Manager

PMP	Project Management Plan (PMP)
PM-R2	Reach Project Manager (PM-R2) – Reach 2
POC	Point of Contact (POC)
PPCP	Primary Project Control Points (PPCP)
PPM	Programs, Planning and Project Management Division (PPM)
PW	ProjectWise (PW)
QA	Quality Assurance (QA)
QC	Quality Control (QC)
QAP	Quality Assurance Plan (QAP)
QCP	Quality Control Plan (QCP)
QMP	Quality Management Plan (QMP)
R-Bar	pore-water pressure measurements (R-Bar)
RCP	Reinforced Concrete Pipe (RCP)
RDDR	Reach Design Documentation Report (RDDR)
RE	Real Estate (RE)
RF	Revolving Funds (RF)
RGG	Regional Geotechnical and Geology team (RGG)
RM	Resource Management
RMC	Risk Management Center (RMC)
RMP	Reach Management Plan (RMP)
ROE	Right of Entry (ROE)
ROW	Right of Way (ROW)
RP	Review Plan (RP)
RRN	Red River of the North (RRN)
SAACONS	Standard Army Automated Contracting System (SAACONS)
SBA	Small Business Administration (SMA)
SDEIS	Supplemental Draft Environmental Impact Statement (SDEIS)
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE)
SEP	Special Emphasis Program (SEP)
SITREP	Situation Report (SITREP)
SOP	Standard Operating Procedures (SOP)
SOW	Scope of Work (SOW)
SPCS	State Plane Coordinate System (SPCS)
SWPPP	Storm Water Pollution Prevention Plans (SWPPP)

TDY	Temporary Duty (TDY)
TM	Technical Manager (TM); Technical Manual (TM)
UFGS	Unified Facilities Guide Specifications (UFGS)
UMR	Upper Mississippi River (UMR)
USACE	US Army Corps of Engineers (USACE)
USC	United States Code (USC)
USCG	United States Coast Guard (USCG)
USDA	United States Department of Agriculture (USDA)
USFWS	United States Fish and Wildlife Service (USFWS)
USGS	United States Geological Survey (USGS)
VBDC	Value Based Design Charrette (VBDC)
VFZ	Vegetation Free Zone (VFZ)
VMZ	Vegetation Management Zone (VMZ)
VTC	Video Teleconference (VTC)
WBS	Work Breakdown Structure (WBS)
WRDA	Water Resources Development Act (WRDA)

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Appendix C: Hydraulics and Hydrology

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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Appendix C: Hydraulics and Hydrology

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References

Additional information will be provided in future submittals.

Attachments

Additional information will be provided in future submittals.

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Appendix C: Hydraulics and Hydrology

C.1 PROJECT DESCRIPTION

Hydraulic and Hydrology information will be provided in future submittals.

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Appendix D: Geotechnical Engineering and Geology

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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Appendix D: Geotechnical Engineering and Geology

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APPENDIX D: **Geotechnical Engineering and Geology**

Some general geotechnical information is included no and the detail information and design results will be included in the 65% submittal.

D.1 PROJECT DESCRIPTION

As currently proposed the Oxbow, Hickson, Bakke (OHB) Ring Levee Project consists of a levee surrounding the three communities. The levee is required to mitigate and reduce the flood risk for these communities from flooding caused by the staging area of the FMM Diversion Project. In addition, the project will have ponding areas and a pump station(s).

The project is broken into 5 work packages and this report covers only the work associated with Work Package (WP) 43B. All elevations reported are in NAVD 88, unless otherwise stated.

D.2 REGIONAL GEOLOGY and PHYSIOGRAPHY

The adjacent communities of Oxbow, Hickson, and Bakke, North Dakota are located approximately 6 miles upstream of the confluence of the Wild Rice River of ND and the Red River of the North, within the Red River Valley Division of the Central Lowlands Physiographic Province. Due to the close proximity of the OHB project to the Fargo-Moorhead Metro area, the discussion of the regional geology and physiography, detailed in *the General Report: Geotechnical Design and Geology* of the *Fargo-Moorhead Metropolitan Area Flood Risk Management Project North Dakota Diversion Alignment* also applies here. From a geotechnical design perspective the significant difference is that these comminutes, while still located upon the ancient glacial Lake Agassiz floor, are nearer the edge or shoreline of the ancient lake in comparison to the Fargo-Moorhead Metro area. Specific details for the OHB project are discussed below.

D.2.1 Topography

As discussed in paragraph D.1 this report is concerned only with the work package designated WP-43B. This package extends from the west side of the junction of Cass County Highway 18 and Cass County Highway 81 northward approximately 2.5 miles, and then turns eastward just north of the community of Bakke, ND. WP-43B terminates about 1.7 miles eastward of the turn near the intersection of the proposed levee and Cass County Highway 81; north of all three of the communities involved with this project. As such, all of the levee work anticipated with this work package lies outside the influence of the present day Red River Valley main-stem. The project area consists of a broad, nearly flat plain that was once the lakebed of ancient Glacial Lake Agassiz. Based on surveys for soil borings, the elevations range from a high (on the south end) of approximately 917 feet to 911 feet near a north flowing, shallow drainage that bisects the work package from south to north.

D.2.2 Geology

The proposed project area has a sequence of glacio-lacustrine deposits similar to Fargo-Moorhead Metro area, overlying a dense, over-consolidated glacial till. The description of each formation can be found in the *General Report*. The specific details for OHB are discussed from the bottom-most to ground surface.

The Unit "A" Till is the lowest formation of interest and is typically encountered between elevations 846 – 851.The till is characterized as gravelly, sandy, low-plasticity clay. Overlying, or interbedded with, the clay till in some locations, a coarse outwash material ranging from silty and/or clayey sands with gravel and cobbles or boulders may be found. Where it exists this coarse sediment layer can be 3 to 4 feet thick.

The Argusville Formation is the lowermost glacio-lacustrine deposit which overlies the glacial till. Generally it is 14 to 21 feet thick, and is typically encountered between elevations 863 – 870. In contrast to the underlying till, this formation has only scattered sand and gravel or silty inclusions. It may also be characterized as soft to medium-stiff, wet, highly plastic, and brown to dark grey in color.

It is typical throughout the Red River Valley, including north and westward of OHB, to encounter a homogenous, notoriously weak glacio-lacustrine clay unit known as the Brenna Formation above the Argusville Formation. It is believed that the Brenna Formation was primarily deposited into the deeper, more central portions of Lake Agassiz. The proposed OHB project is located nearer the southern end of the lake and soil borings reveal the Brenna Formation is interbedded with the Argusville Formation and, for the purposes of this report, is referred together as "Interbedded Lake Agassiz clays." The "Interbedded Lake Agassiz clays" range between 12 to 24 feet thick and are typically encountered between elevations 882 – 891.

The Sherack Formation deposited above the "Interbedded Lake Agassiz clays", is between 20 – 31 feet thick. This unit may be characterized as laminated, medium stiff, glacio-lacustrine clay, with minor amounts of sand, gypsum and calcite crystals, and/or organics. The upper portion of the Sherack Formation is usually brown to yellow-brown with frequent iron-oxide staining. The contact with the overlying present period sediments (Holocene Epoch) is an erosional unconformity.

For WP-43B the present period sediments consist almost entirely of organic-rich topsoil. The topsoil, ranges in thickness between 0.5 to 1.8 feet.

D.2.3 Structure

D.2.4 Site Hydrogeology

Groundwater levels determination is challenging due to the low permeability of the soils. Efforts were taken to determine the groundwater levels in four of the ten borings. It was observed that during the subsurface investigation, the groundwater level was between 6 to 12 feet below the ground surface, except in boring 13-9M, where it was 28 feet below the ground surface.

To get a better understanding of the groundwater regime nested vibrating wire piezometers (multiple vibrating wire piezometers installed at different elevations in one bore hole) have been installed throughout the Fargo-Moorhead Metro area. In the case of OHB, 3 locations have been selected in which nested vibrating wire piezometers will be installed. The first location is located in the area of the proposed north ponding area, and was installed in December 2013. The other two locations, one in the west ponding area and one in the southeast portion if the project, will be installed at a later date.

D.2.5 Seismic Risk and Earthquake History

The OHB area which is included in the FMM area, is one of the least seismically active places in the United States. A discussion on the seismic risk and earthquake history of the region is included in Attachment 1 of the *General Report: Geotechnical Design and Geology* of the *Fargo-Moorhead Metropolitan Area Flood Risk Management Project North Dakota Diversion Alignment*.

D.3 SUBSURFACE INVESTIGATION

D.3.1 Exploration

Six of the borings were completed along the centerline of WP-43B. Four borings were conducted in the areas of the proposed ponding. Ten other ten boring were conducted for WP-43A and WP-43C.

The machine borings were conducted using a continuous sampling method which is described in Attachment D-1. The locations of the borings are also shown on the map included within the attachment.

D.3.2 Testing

Laboratory tests consisting of moisture content and Atterberg limits were conducted on jar samples collected as part of the subsurface investigation.

D.4 DESIGN PARAMETERS

The laboratory testing results for the OHB projects were compared to the overall FMM project test data. It was observed that for some of the materials within the OHB area, the results compared more favorably with the FMM project samples taken from borings at or south of the Sheyenne River Aqueduct structure than all FMM results combined. Project specific design parameters were selected for the OHB project based on the testing. These are summarized in Attachment D-1.

D.5 LEVEE ANALYSIS

D.5.1 Modeling Summary

D.5.1.1 Levee Geometry

D.5.2 Sections

D.5.3 Seepage and Stability Methodology

The seepage and stability analyses will be completed follow the methodology described in Attachment D-2: Seepage and Slope Stability Methodology.

D.5.4 Stability

D.5.5 Results

D.6 SETTLEMENT

D.7 AGGREGATE SURFACING FOR LEVEE

The levee will have a 10’ wide maintenance road on top of the levee. ND DOT Class 5 Aggregate Base will be specified for the maintenance road. Class 5 material should be readily available in the area and will be sufficient for low-volume, low speed traffic. In areas of high speed, high volume traffic, a modified Class 13 Aggregate Surface material should be specified.

D.8 SOURCES OF CONSTRUCTION MATERIALS

D.8.1 Levee Material

D.8.2 Concrete Aggregate, Riprap, and Bedding

D.9 PHASE 1 ENVIRONMENTAL SITE ASSESSMENT

D.10 ATTACHMENTS

Attachment D-1: Geotechnical Engineering Parameters

Attachment D-2: Seepage and Slope Stability Methodology

Attachment D-3: Stratigraphy

Attachment D-4: Boring Log Plates

Attachment D-5: Stability Analysis

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Attachment D-1: Geotechnical Engineering Parameters

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee

Attachment D-1
Geotechnical Engineering Parameters

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D.1 PURPOSE

The purpose of the document is to summarize the general geotechnical engineering parameters used in the design of the Oxbow, Hickson, Bakke Ring Levee Project (OHB Project).

D.2 SUBSURFACE INVESTIGATION

D.2.1 Exploration

Twenty borings were completed for the OHB Project using a track-mounted Diedrich D-50 drill rig. The location of the borings are shown on the map included at the end of this attachment.

The machine borings were generally conducted using a continuous sampling method which allowed the soils to be classified in the field by a geologist. The sampling was done in 5 foot flights. The first 3 feet were sampled with a modified 2” ID x2 ½” OD split spoon, followed by the 2” standard penetration spoon for the remaining 2 feet. The already sampled 5 feet was then cleaned out with the noted drilling method, and sampling continued. The larger spoon above the standard spoon cleaned the hole out large enough to not affect the SPT blow counts of the standard spoon. The drive of the modified 2”x2 ½” spoon was recorded on the field logs. The standard SPT blows were also recorded in the field and are the blow counts presented on the drafted logs. SPT blows were performed dropping a 140 pound hammer 30”, unless otherwise stated, with the auto-hammer corresponding to the drill rig performing the boring. No corrections were completed for the blow counts. Disturbed samples were also collected and tested for moisture content and Atterberg limits.

Three undisturbed soil borings were completed which were located off-set to the machine borings in order to obtain 5-inch undisturbed samples.

D.3 TESTING

D.3.1 Jar Sample Testing

Testing was done on disturbed samples (jar samples) to determine in-situ moisture contents and Atterberg limits. The results of this testing helped identify the soil characteristics and define the stratigraphy. The results are included on the draft boring logs and also at the end of this attachment.

D.3.2 Undisturbed Testing

Undisturbed samples were gathered specifically for the OHB project in order to compare the strengths of these samples to the overall FMM project data. The laboratory testing performed was done to determine the shear strengths of the soils. The shear strength tests included isotropically consolidated-undrained triaxial compression tests with pore-water pressure measurements (R-Bar) and unconsolidated-undrained (Q tests). In addition, consolidation tests were performed on the samples. Moisture content and Atterberg limits were also determined on the test samples which help identify the soil characteristics and define stratigraphy. Table 1 shows the undisturbed testing completed for the OHB Ring Levee project.

Table 1: Summary of Undisturbed Testing for the OHB Project

Boring	Depth / Elevation	Formation	R-bar Triaxial Compression	UU Triaxial Compression	Consolidation	Ring Shear (Fully Softened and Residual)	Standard Proctor
13-2MU	13-15'	Sherack	x	x	x		
	23-25'	Sherack	x	x	x		
	37-39'	Interbedded Brenna	x	x	x		
	55-57'	Argusville	x	x	x		
13-3MU	18-20'	Sherack	x	x	x		
	32-34'	? Poplar river ?	x	x	x		
	42-44'	Interbedded Brenna	x	x	x		
	60-62'	Argusville	x	x	x	x	
13-4MU	11-13'	Alluvium	x	x	x		
	18-20'	Alluvium	x	x	x		
13-8M	48.5-49'	Argusville				x	
13-11A	1-5'	Fill	x	x			x
	10-15'	Fill	x	x			x
						x	

*The formations will be updated as testing data is received and stratigraphy is reviewed.

The undisturbed testing completed for the FMM project was obtained during the both the feasibility study and preengineering and design phase. The results of the laboratory test completed during feasibility can be found in "Attachment I-04" of *Appendix I, Geotechnical Design and Geology* of the *Fargo-Moorhead Metropolitan Area Flood Risk Management Final Feasibility Report and Environmental Impact Statement.* The laboratory tests completed during PED are presented in "Attachment I-05" of *General Report: Geotechnical Design and Geology* of the *Fargo-Moorhead Metropolitan Area Flood Risk Management Project North Dakota Diversion Alignment*.

D.4 DESIGN SHEAR STRENGTH PARAMETERS

The OHB project design shear strengths that were selected are summarized below in Table 2. These parameters are based on the site specific data with comparisons to the FMM project data. The design shear strength parameters are based on ultimate (post-peak) strength failure criteria that equated to a strain of 15%, which is the same criteria used for the FMM project. There are a number of reasons for this. First, ultimate strengths have been used for previous St. Paul District (MVP) projects within the Red River Valley. Secondly, experience within the Red River Valley indicates that clays within this region are fissured and the weakest of these clays exhibit brittle stress-strain behavior. This can lead to progressive failure of the riverbanks and cut slopes, which is commonly seen. As a result of the brittle stress-strain behavior and progressive failure mechanism, the peak shear strength cannot be mobilized along the potential shear surfaces simultaneously. Thirdly, experience indicates that large amount of strain (more than 10%) may occur in natural or cut slopes during the life time of the project. For these reasons, the strength parameters are based on the ultimate (post-peak) strength failure. Also, the design shear strength parameters were selected using the 1/3: 2/3 rule, meaning that approximately 1/3 of the data points fell below the failure envelope and 2/3 of the data plotted above it.

The shear strength plots can be found in at the end of this write-up.

D.4.1 Sherack Effective Stress Shear Strength Parameters

The effective stress shear strength data from the OHB Sherack formation samples plotted within the range of the FMM project data and were in good agreement with the overall FMM project bi-linear Mohr-Coulomb shear strength envelope. Therefore the OHB Sherack effective stress shear strength parameters are the same as the overall FMM project.

D.4.2 Brenna and Argusville Effective Stress Shear Strength Parameters

During the soil exploration program for the OHB project, it was observed that the typical sequence of Brenna overlaying Argusville was not readily observed in this location as it has been encountered during the previous exploration for the overall FMM project. Instead, the Brenna and Argusville formations appeared to be interbedded in the lower sequence (typically below 25 foot depth). The liquid limits in the lower sequence ranged from 50 to 90, which is lower than trends seen for the overall FMM project, corroborates this observation. It is believed that the Brenna and Argusville formations are interbedded due to being nearer the edge of the ancient glacial Lake Agassiz than the diversion project.

When the OHB Brenna and Argusville sample effective stress shear strength data was plotted against the overall FMM project Brenna and Argusville data, it showed that the OHB samples were stronger than over half of the overall FMM project data. A second comparison was done which compared the OHB samples to only the FMM project samples taken from borings at or south of the Sheyenne River Aqueduct structure. This produced a more favorable comparison. It was decided that for OHB, the Brenna and Argusville material would be given the same effective shear strength parameters based on the test data obtained from borings at or south of the Sheyenne River Aqueduct structure. A bi-linear Mohr-Coulomb shear strength envelope was developed that fits the data well.

D.4.3 Total Stress Shear Strength Parameters

The total stress strength data for the OHB project plotted within the range of the overall FMM project data. Therefore the OHB total stress shear strength parameters are based on the overall FMM project undrained parameters.

Table 2: Summary of Selected Soil Parameters for OHB Project

Formation	Unit Weight (1) γ_{sat} (pcf)	Shear Strength Parameters: Effective Stress (3) c' (psf)	Effective Stress (3) ϕ'	Total Stress, c (psf): Ultimate (4)	Total Stress, c (psf): Peak (5)	Residual $\phi'_{residual}$
Alluvium (1)	**120**	0	31	assume values of Sherack		20.0
Sherack	**115**	c' = 0, phi' = 28 at 2000 psf, phi' = 11		**900**	1400	13.0
Poplar River - West Fargo	**123**	0	**34**	**1900**	1900	25.0
Poplar River - Harwood	**116**	0	**26**	**1200**	1450	assume values of West Fargo
Brenna	**106**	use Lower Lake Agassiz Clays		**575**	650	9.0
Argusville	**110**	use Lower Lake Agassiz Clays		**575,** increasing 10 psf per foot depth	825	10.5
Lower Lake Agassiz Clays (6)	N/D	c' = 0, phi' = 25 at 2000 psf, phi' = 11		N/D	N/D	N/D
Unit "A" Till (7)	**123**	**225**	**22**	**1900**	2200	N/A
Levee Fill	**125**	c' = 150, phi' = 24 at 1500 psf, phi' = 11		**900**	N/D	N/A
Sand (8)	**125**	0	**32**	N/A		N/A
Riprap(8)	**125**	0	**30**	N/A		N/A

Notes:
(1) The effective stress parameters for Alluvium may be assumed as Sherack formation.
(2) The unit weights are taken as the average value of all the laboratory test results.
(3) The effective stress parameters are based on the R-Bar triaxial and direct shear tests. The failure criterion is defined as ultimate deviator stress which equates to the deviator stress at 15% axial strain.
(4) The ultimate total stress parameters are based on unconsolidated-undrained triaxial shear tests with the failure criterion defined at ultimate deviator stress which equates to the deviator stress at 15% axial strain.
(5) The peak total stress parameters are based on unconsolidated-undrained triaxial shear tests with the failure criterion defined at peak deviator stress. The peak undrained shear strength parameters are not used in the end-of-construction stability analysis, but are presented such that strain-softening behavior can be inferred.
(6) The Lower Lake Agassiz Clays parameters are for the Brenna and Argusville formations. The parameters are based on test results from undisturbed samples location at or south of the Sheyenne River aqueduct structure.
(7)The Unit "A" Till parameters are based on limited samples as undisturbed samples are difficult to obtain. These parameters are only valid for slope stability analysis; for foundation design, parameters should be determined using local knowledge and/or in situ testing results.
(8) Assumed values based judgment.

D.4.4 Seepage

Permeability parameters will be based on the general parameters used for the Fargo-Moorhead Metro Flood Risk Management Project and can be found in the "General Report: Geotechnical Engineering and Geology". These parameters were developed from a seepage calibration and are summarized below in Table 3.

Table 3: Summary of Selected Permeability Parameters (Table 10 from in the "General Report: Geotechnical Engineering and Geology)

Material	Material Model Type (1)	Sample Material (2)	Vertical Permeability		Method of Selection (3)	Horizontal Permeability			Volumetric Water Content (4)	M_v (5)	Residual Water Content (6)
			k_y (cm/sec)	k_y (ft/day)		k_y/k_x ratio	k_x (ft/day)	k_x (cm/sec)	(ft3/ft3)	(1/psf)	(ft3/ft3)
Alluvium	Sat / Unsaturated	Silty Clay	**1.0E-06**	2.8E-03	**Calibration**	**0.25**	0.0113	4.00E-06	0.5	9.0E-06	0.050
Sherack	Sat / Unsaturated	Silty Clay	**1.0E-06**	2.8E-03	**Calibration**	**0.25**	0.0113	4.00E-06	0.5	9.0E-06	0.050
PL Sherack	Sat / Unsaturated	Silty Clay	1.0E-04	2.8E-01	Judgement	1	0.28	1.00E-04	0.5	9.0E-06	0.050
West Fargo	Sat / Unsaturated	Silt	1.0E-04	2.8E-01	Judgement	1	0.28	1.00E-04	0.4	3.0E-06	0.040
Harwood	Sat / Unsaturated	Silt	1.0E-05	2.8E-02	Judgement	1	0.028	1.00E-05	0.5	9.0E-06	0.050
OX Brenna	Sat / Unsaturated	Silty Clay	**5.0E-07**	1.4E-03	**Calibration**	**1**	0.0014	5.00E-07	0.55	1.0E-05	0.055
Brenna	Saturated Only	N/A	**1.0E-07**	2.8E-04	**Calibration**	**1**	0.00028	1.00E-07	0.63	3.0E-05	0.063
Argusville	Saturated Only	N/A	**1.0E-07**	2.8E-04	**Calibration**	**1**	0.00028	1.00E-07	0.6	3.0E-05	0.060
Unit "A" Till	Saturated Only	N/A	**5.0E-06**	1.4E-02	**Calibration**	**0.25**	0.057	2.00E-05	0.45	3.0E-05	0.045
Silts	Saturated Only	N/A	1.0E-06	2.8E-03	Judgement	1	0.0028	1.00E-06	0.4	3.0E-06	0.040
Silty Sands	Saturated Only	N/A	1.0E-04	2.8E-01	Judgement	1	0.28	1.00E-04	0.4	3.0E-06	0.040
Sand	Sat / Unsaturated	Fine Sand	1.0E-02	2.8E+01	Judgement	1	28	1.00E-02	0.4	3.0E-05	0.040

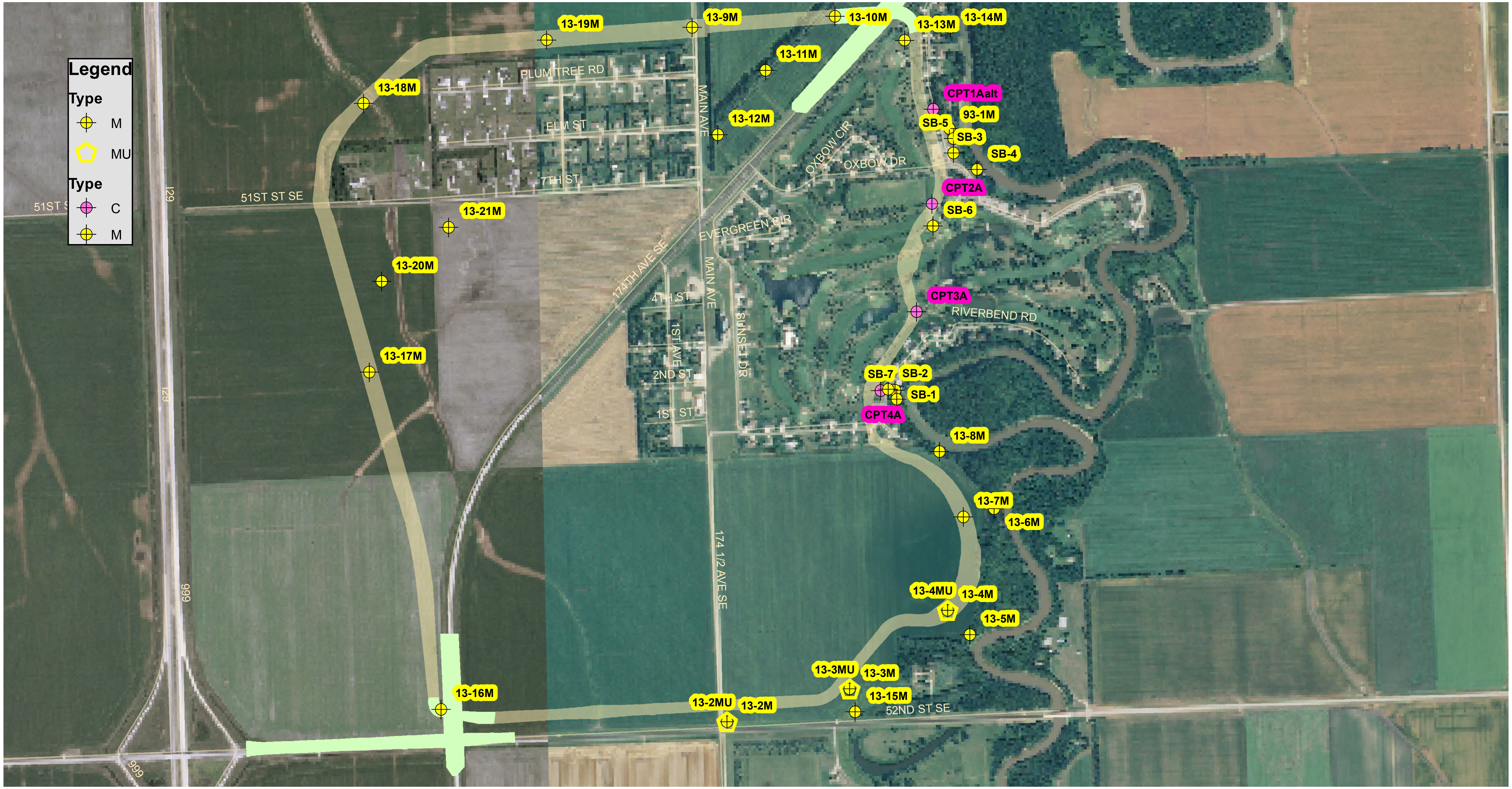
Notes:
(1) Indicates how the material was model in Seep/W. If material is exoected to be above groundwater table, Sat/Unsaturaded. If below the groundwater table, Saturated Only.
(2) Indicates what sample material type was used when estimating the volumetric water content function in Seep/W.
(3) The selection of the vertical permeability was based on engineering judgement and back-calculated permeability values from consolidation tests. Seepage calibration was completed to validate and refine certain formations.
(4) Volumetric Water Content Based on Porosity taken from testing except for PL Sherack, Sand, and Till which are estimated values.
(5) M_v for Alluvium, Sherack, OX Brenna, and Brenna based on consolidation data. All other materials estimated.
(6) The residual water conent was estimated to be 10% of the saturated water content.

D.4.5 Consolidation Parameters

Consolidation tests were performed on samples taken from the Oxbow, Hickson, Bakke area. The results were compared to the previous testing completed for the overall FMM project. It was observed that the consolidation parameters compared more favorably with samples taken from borings at or south of the Sheyenne River Aqueduct structure. Therefore the consolidation parameters selected for OHB were selected as average values of the OHB samples and the samples south of the Sheyenne River Aqueduct structure. These parameters are summarized below in Table 4.

Table 4: Summary of Consolidation Parameters for OHB Project

Formation	Average Values			
	OCR	C_r	C_c	e_o
Sherack (OHB)	5.1	0.124	0.51	1.24
Brenna (OHB)	3.4	0.086	0.55	1.21
Argusville (OHB)	2.2	0.081	0.59	1.21



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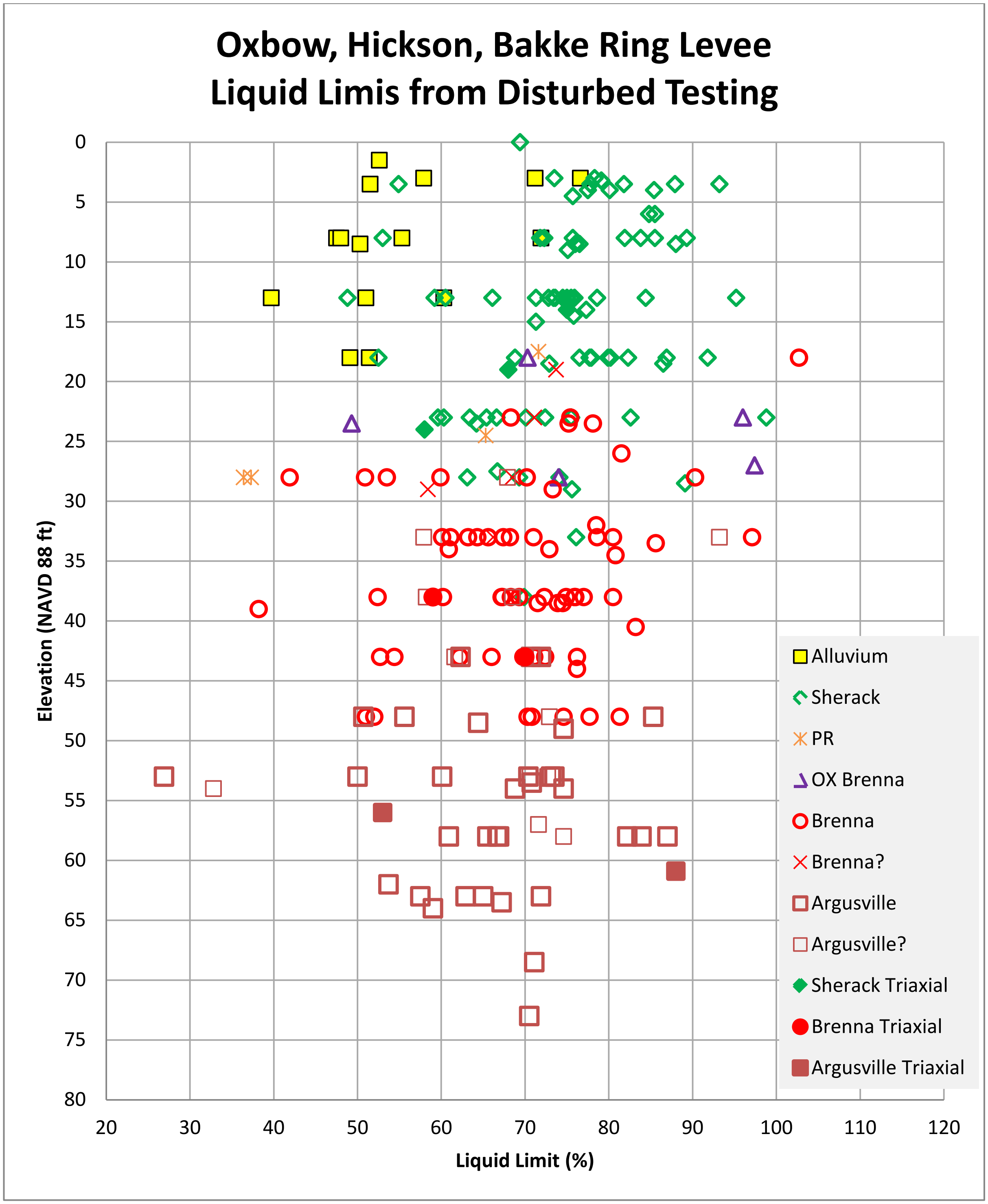
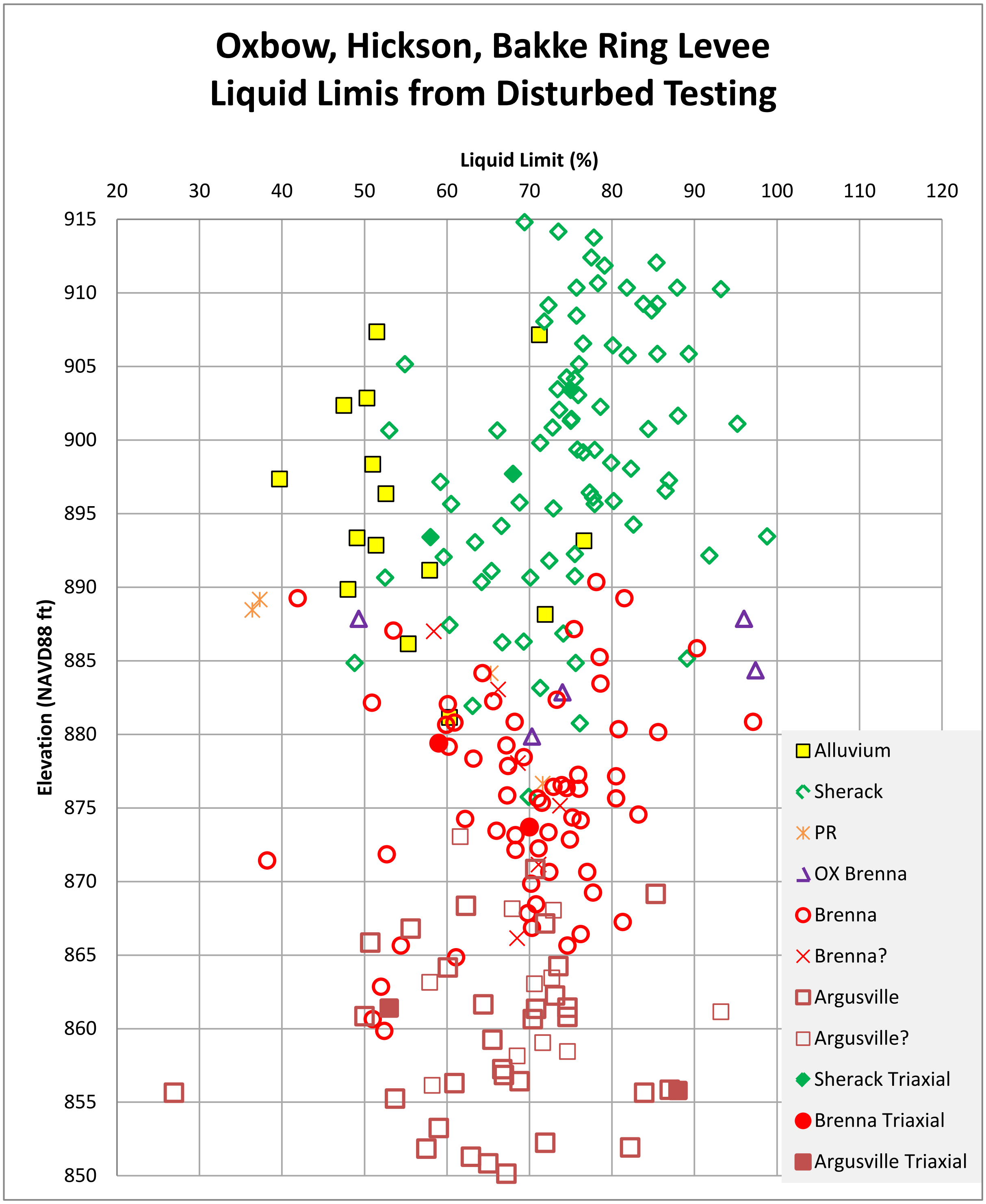
Oxbow, Hickson, Bakke Ring Levee Soil Exploration Location Map

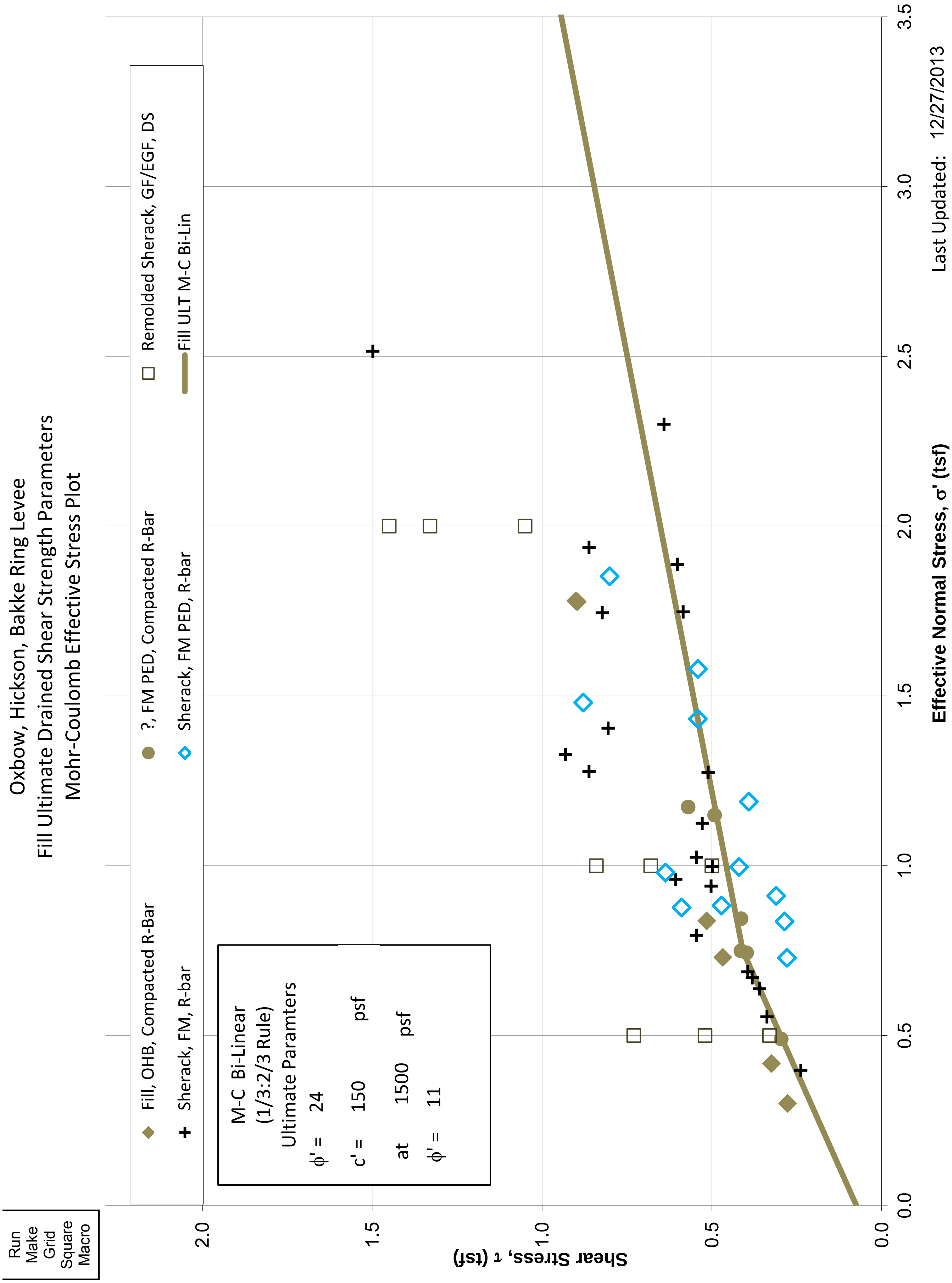
0 500 1,000 1,500 Feet

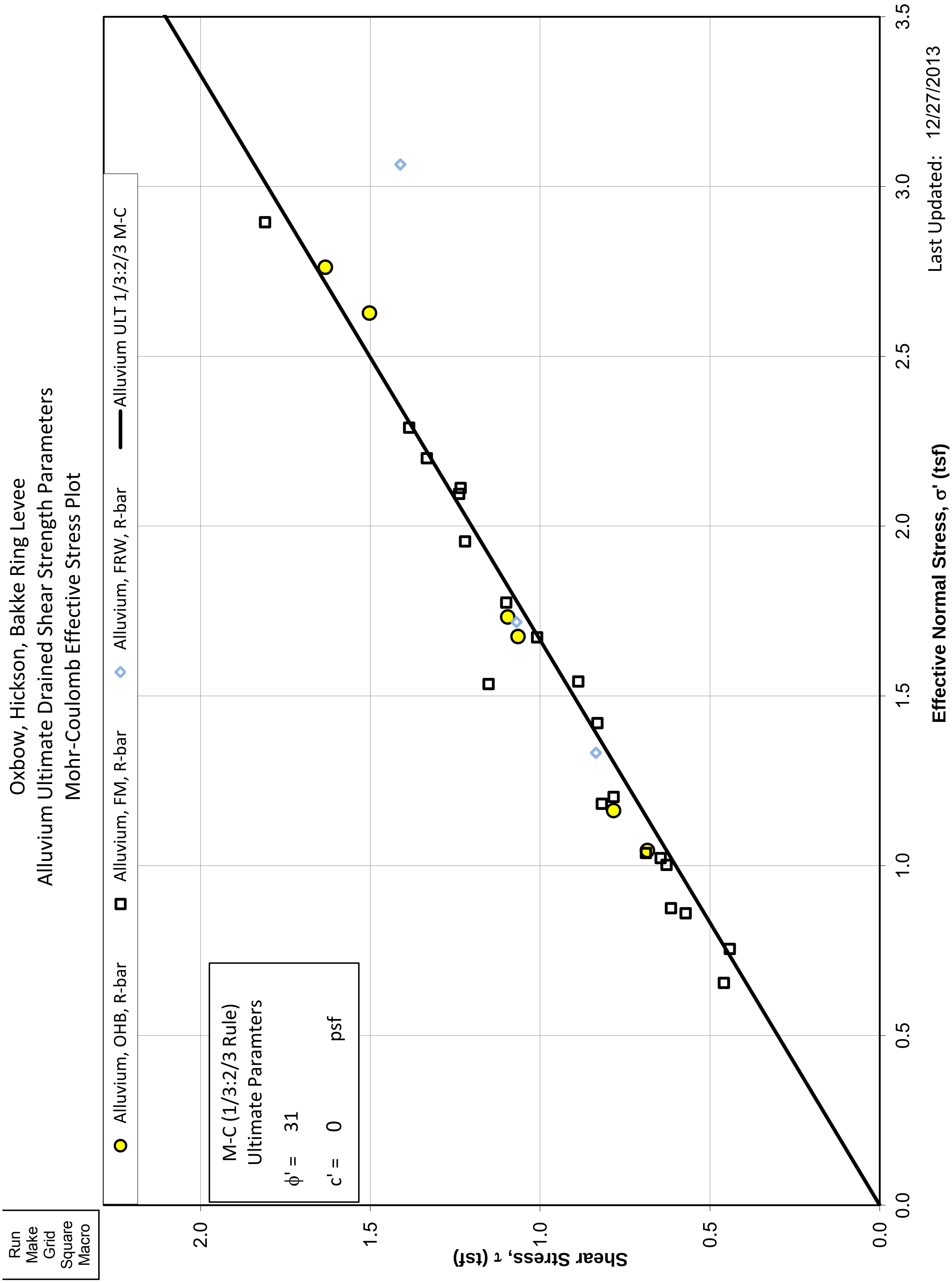
1 inch = 1,000 feet
1:12,000

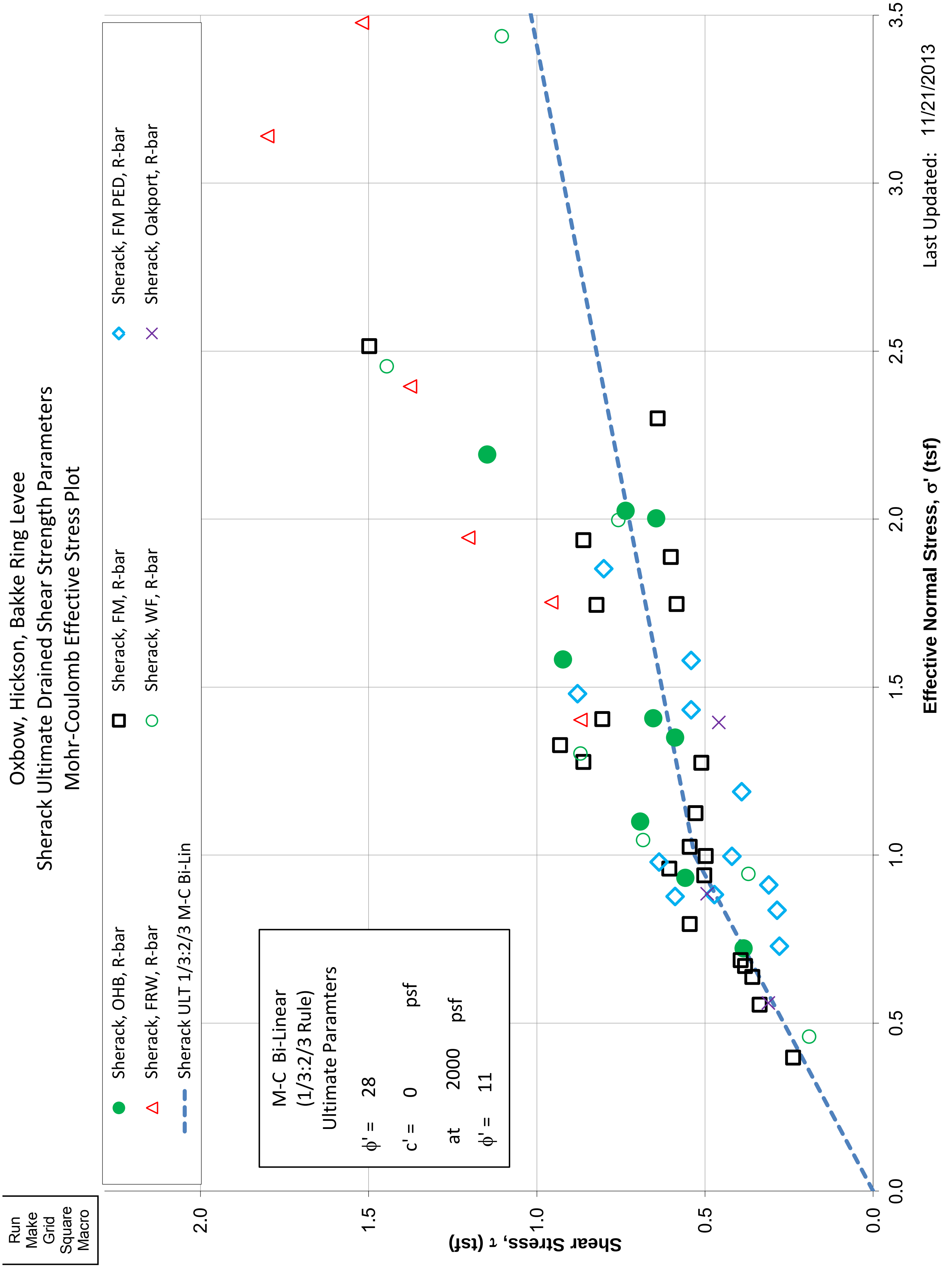
N W E S

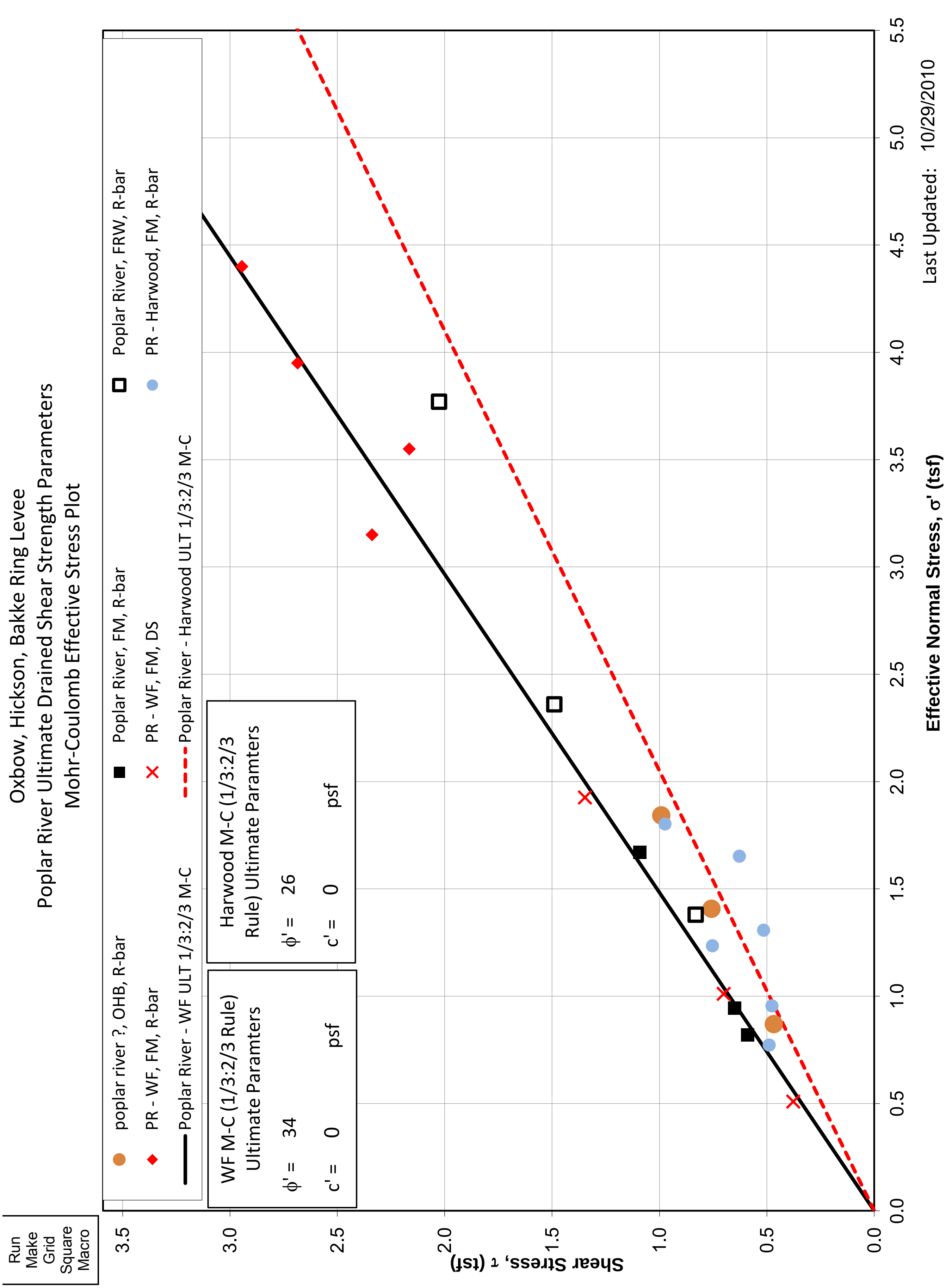

Oxbow, Hickson, Bakke Ring Levee
Liquid Limis from Disturbed Testing
Elevation (NAVD 88 ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
20
30
40
50
60
70
80
90
100
110
120
Liquid Limit (%)
Alluvium
Sherack
PR
OX Brenna
Brenna
Brenna?
Argusville
Argusville?
Sherack Triaxial
Brenna Triaxial
Argusville Triaxial

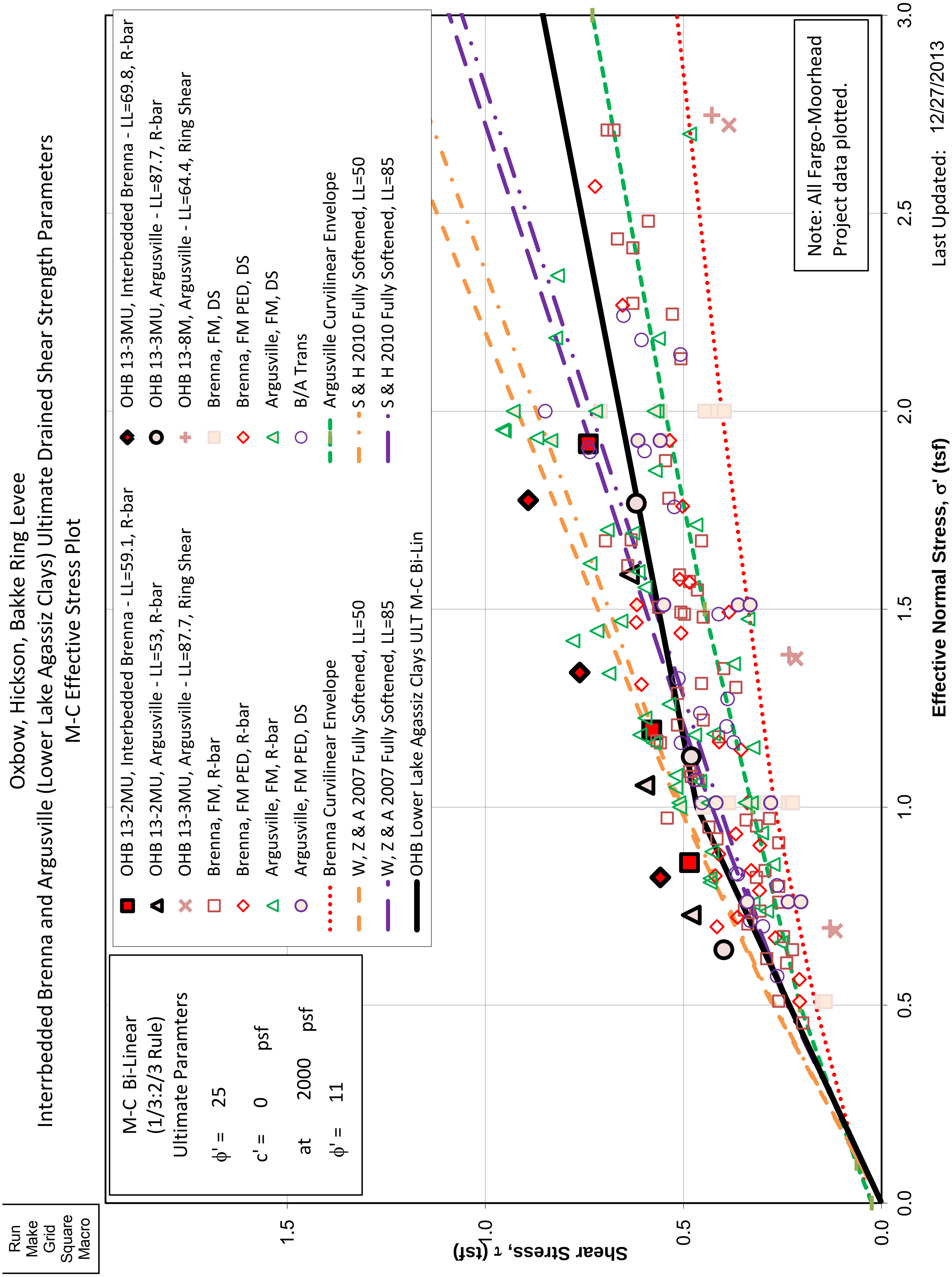

Oxbow, Hickson, Bakke Ring Levee
Liquid Limis from Disturbed Testing
Liquid Limit (%)
20
30
40
50
60
70
80
90
100
110
120
Elevation (NAVD88 ft)
915
910
905
900
895
890
885
880
875
870
865
860
855
850
Alluvium
Sherack
PR
OX Brenna
Brenna
Brenna?
Argusville
Argusville?
Sherack Triaxial
Brenna Triaxial
Argusville Triaxial

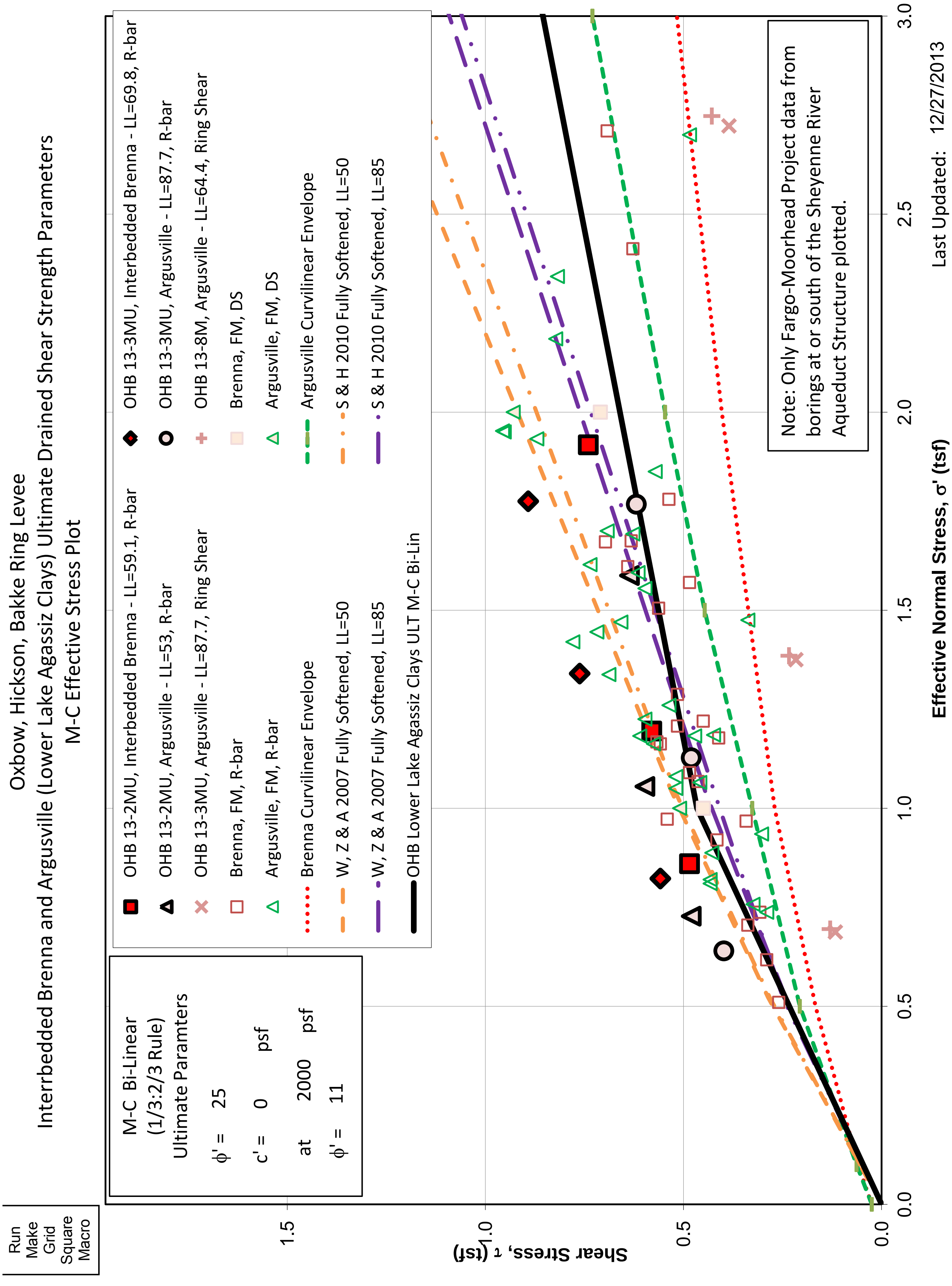

Oxbow, Hickson, Bakke Ring Levee
Fill Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Fill, OHB, Compacted R-Bar
?, FM PED, Compacted R-Bar
Remolded Sherack, GF/EGF, DS
Sherack, FM, R-bar
Sherack, FM PED, R-bar
Fill ULT M-C Bi-Lin
M-C Bi-Linear
(1/3:2/3 Rule)
Ultimate Paramters
φ' = 24
c' = 150 psf
at 1500 psf
φ' = 11
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Last Updated: 12/27/2013
Run Make Grid Square Macro

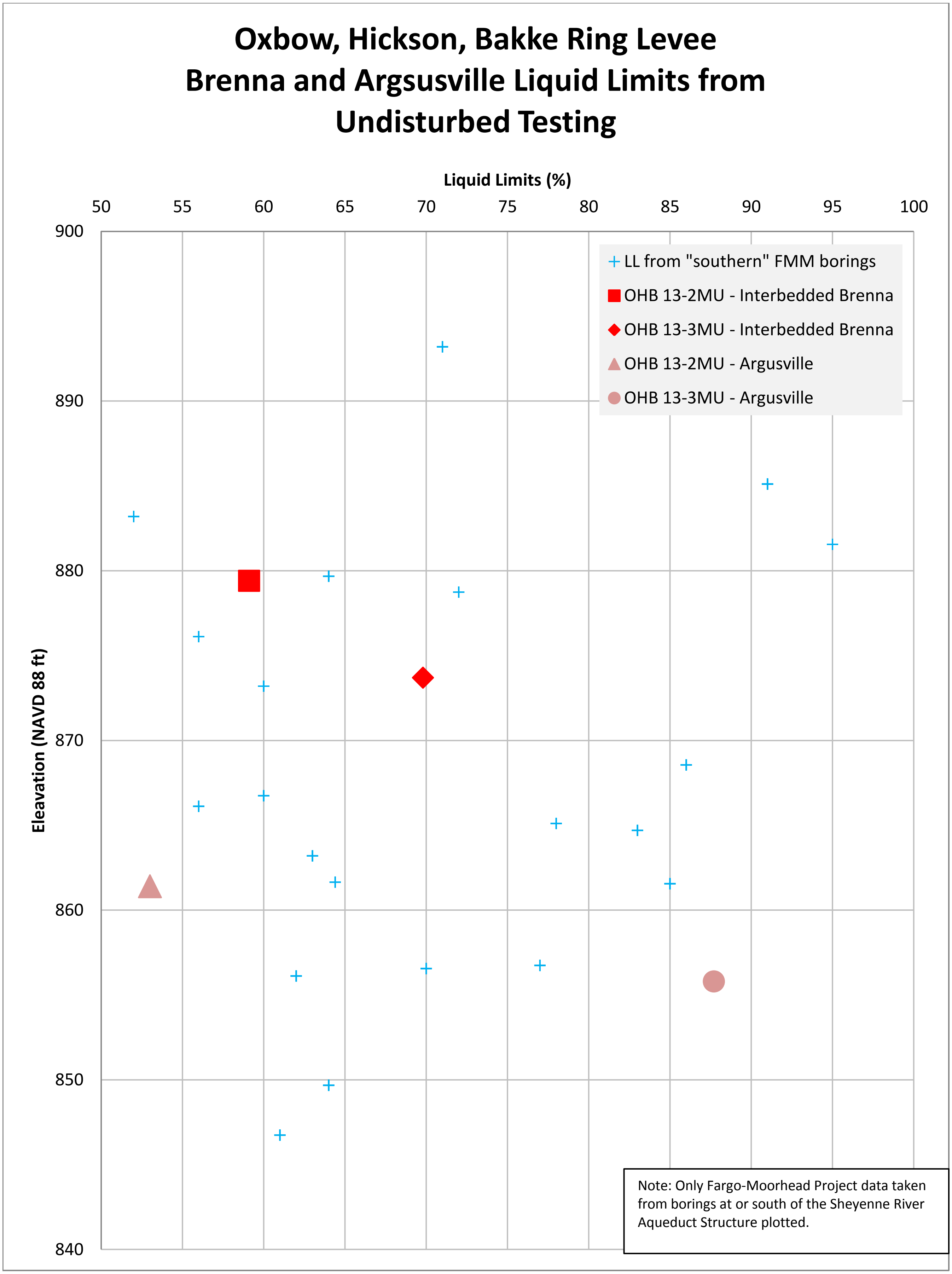

Oxbow, Hickson, Bakke Ring Levee
Alluvium Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Alluvium, OHB, R-bar
Alluvium, FM, R-bar
Alluvium, FRW, R-bar
Alluvium ULT 1/3:2/3 M-C
M-C (1/3:2/3 Rule)
Ultimate Paramters
ϕ' = 31
c' = 0 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Last Updated: 12/27/2013
Run Make Grid Square Macro

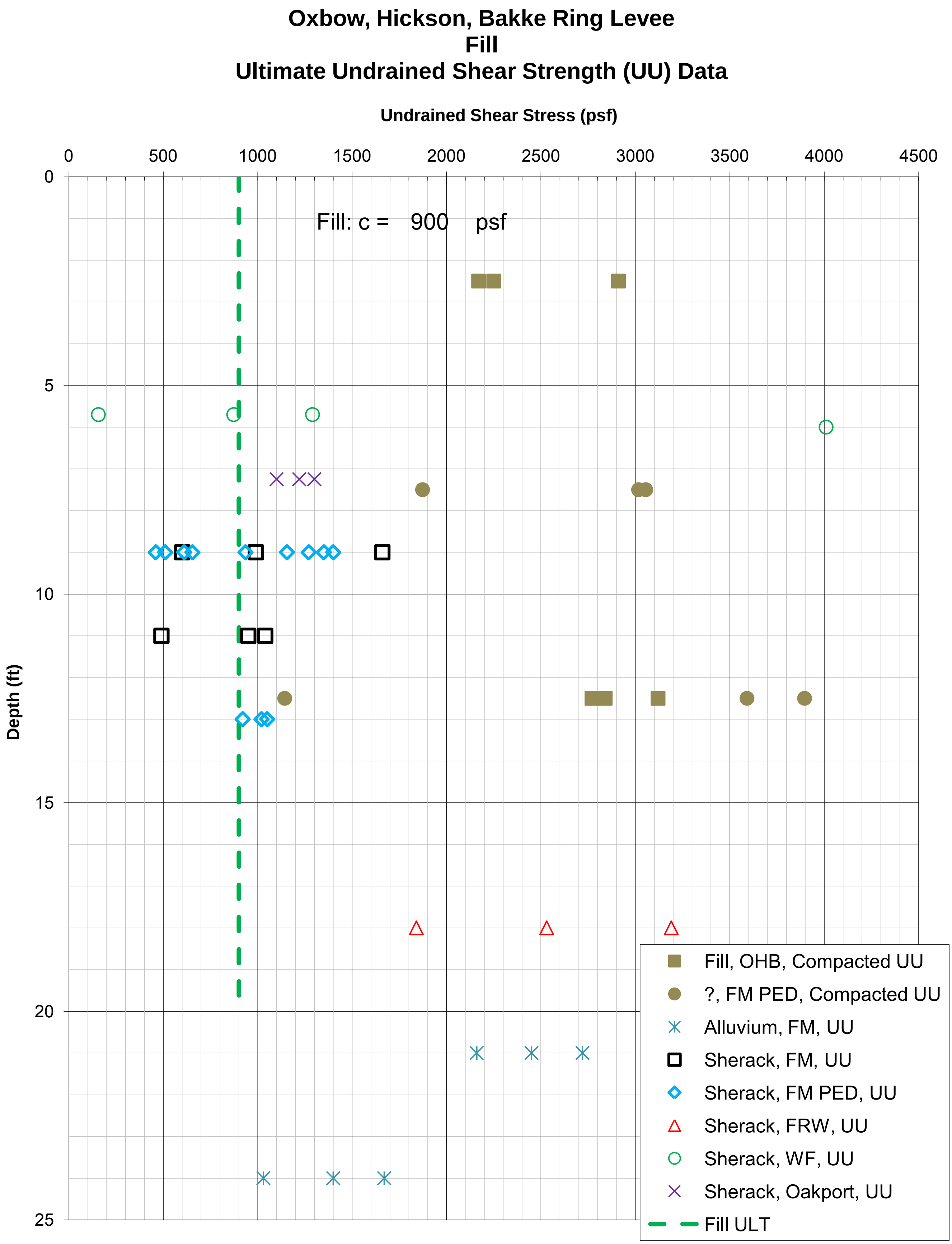

Oxbow, Hickson, Bakke Ring Levee
Sherack Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
Sherack, OHB, R-bar
Sherack, FM, R-bar
Sherack, FM PED, R-bar
Sherack, FRW, R-bar
Sherack, WF, R-bar
Sherack, Oakport, R-bar
Sherack ULT 1/3:2/3 M-C Bi-Lin
M-C Bi-Linear
(1/3:2/3 Rule)
Ultimate Paramters
φ' = 28
c' = 0 psf
at 2000 psf
φ' = 11
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Last Updated: 11/21/2013
Run Make Grid Square Macro

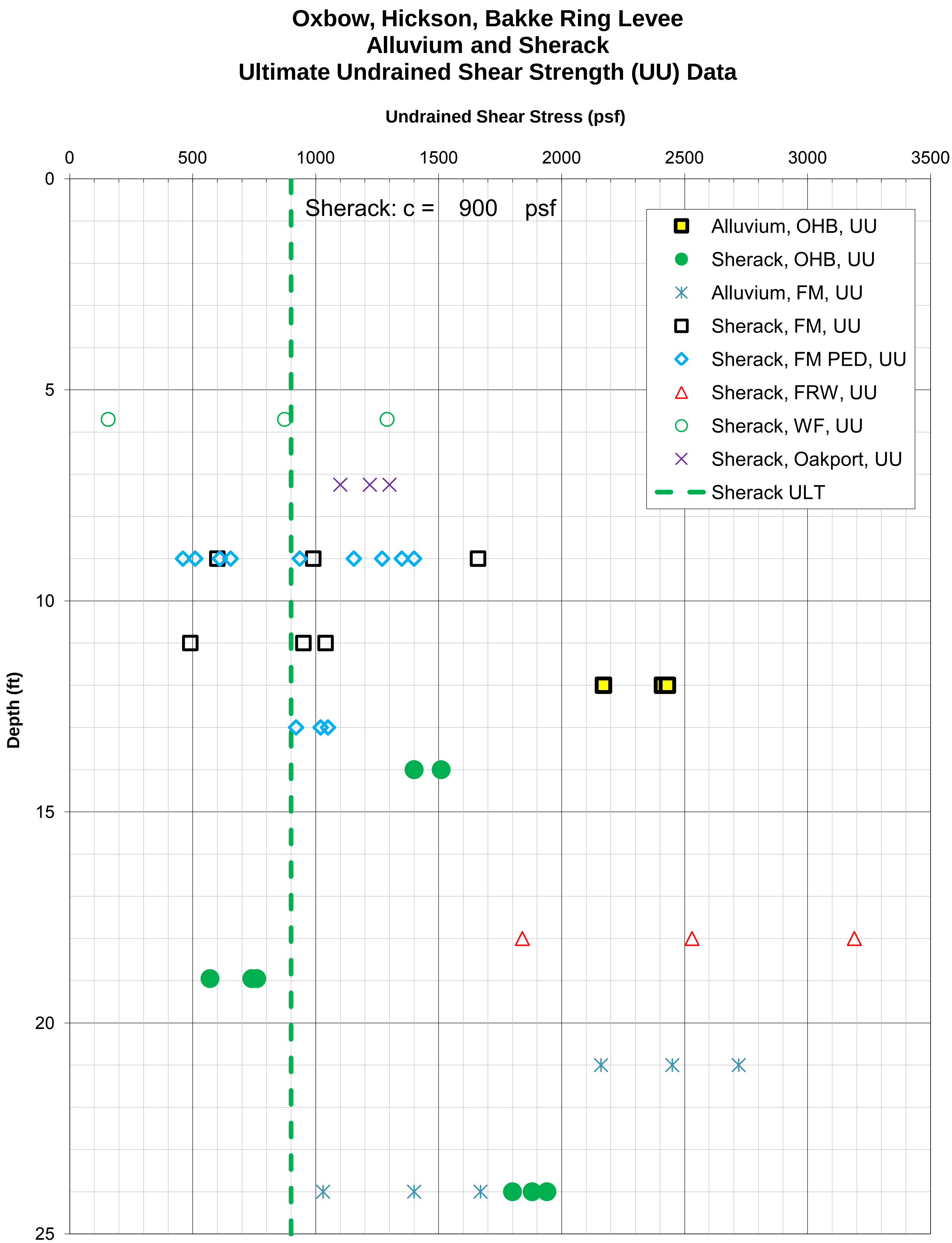

Oxbow, Hickson, Bakke Ring Levee
Poplar River Ultimate Drained Shear Strength Parameters
Mohr-Coulomb Effective Stress Plot
poplar river ?, OHB, R-bar
Poplar River, FM, R-bar
Poplar River, FRW, R-bar
PR - WF, FM, R-bar
PR - WF, FM, DS
PR - Harwood, FM, R-bar
Poplar River - WF ULT 1/3:2/3 M-C
Poplar River - Harwood ULT 1/3:2/3 M-C
WF M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 34
c' = 0 psf
Harwood M-C (1/3:2/3 Rule) Ultimate Paramters
ϕ' = 26
c' = 0 psf
Shear Stress, τ (tsf)
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Last Updated: 10/29/2010
Run
Make
Grid
Square
Macro

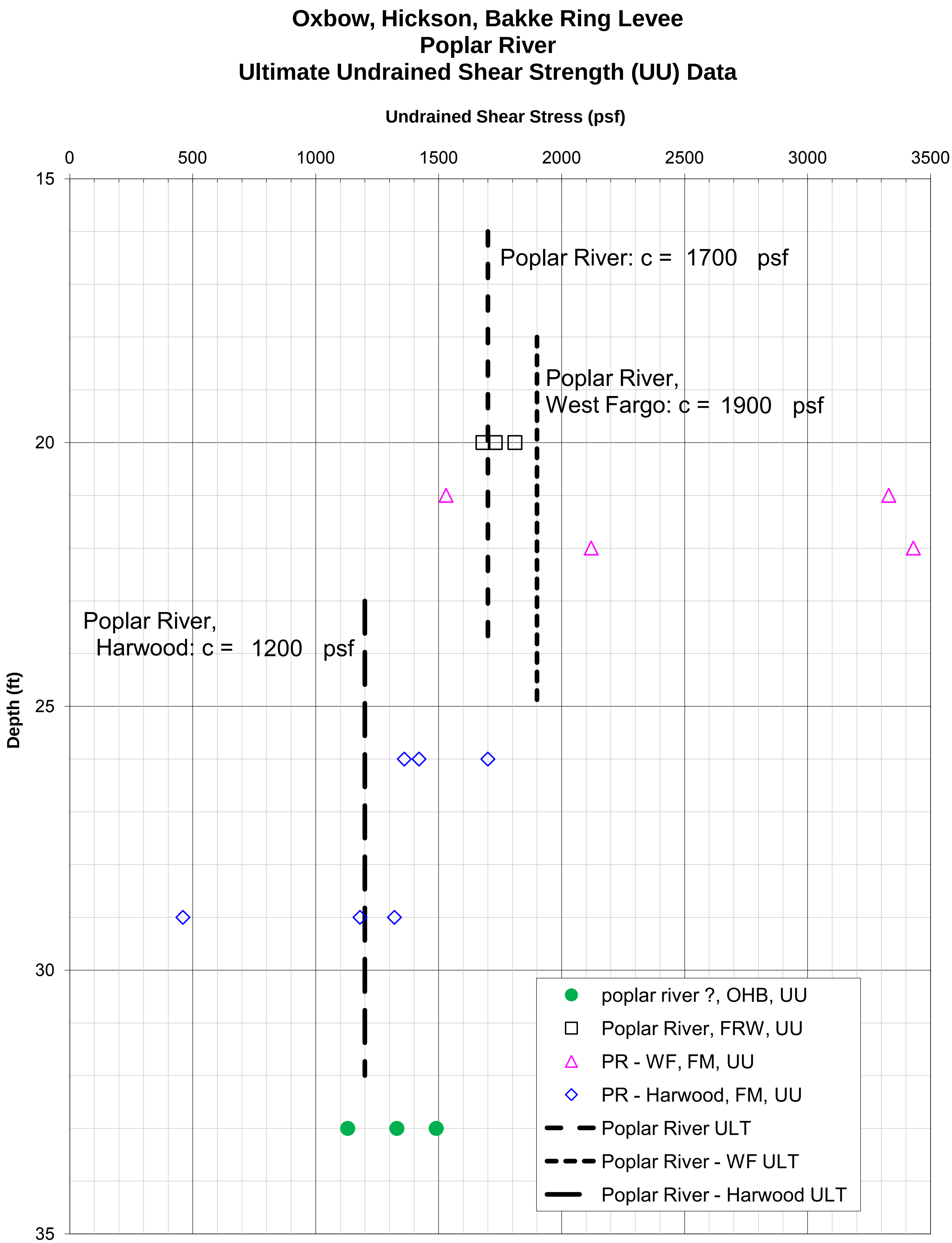

Oxbow, Hickson, Bakke Ring Levee
Interrbedded Brenna and Argusville (Lower Lake Agassiz Clays) Ultimate Drained Shear Strength Parameters
M-C Effective Stress Plot
M-C Bi-Linear
(1/3:2/3 Rule)
Ultimate Paramters
ϕ' = 25
c' = 0 psf
at 2000 psf
ϕ' = 11
OHB 13-2MU, Interbedded Brenna - LL=59.1, R-bar
OHB 13-2MU, Argusville - LL=53, R-bar
OHB 13-3MU, Argusville - LL=87.7, Ring Shear
Brenna, FM, R-bar
Brenna, FM PED, R-bar
Argusville, FM, R-bar
Argusville, FM PED, DS
Brenna Curvilinear Envelope
W, Z & A 2007 Fully Softened, LL=50
W, Z & A 2007 Fully Softened, LL=85
OHB Lower Lake Agassiz Clays ULT M-C Bi-Lin
OHB 13-3MU, Interbedded Brenna - LL=69.8, R-bar
OHB 13-3MU, Argusville - LL=87.7, R-bar
OHB 13-8M, Argusville - LL=64.4, Ring Shear
Brenna, FM, DS
Brenna, FM PED, DS
Argusville, FM, DS
B/A Trans
Argusville Curvilinear Envelope
S & H 2010 Fully Softened, LL=50
S & H 2010 Fully Softened, LL=85
Note: All Fargo-Moorhead Project data plotted.
Last Updated: 12/27/2013
Effective Normal Stress, σ' (tsf)
Shear Stress, τ (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Run Make Grid Square Macro


Oxbow, Hickson, Bakke Ring Levee
Interbedded Brenna and Argusville (Lower Lake Agassiz Clays) Ultimate Drained Shear Strength Parameters
M-C Effective Stress Plot
Run Make Grid Square Macro
M-C Bi-Linear
(1/3:2/3 Rule)
Ultimate Paramters
φ' = 25
c' = 0 psf
at 2000 psf
φ' = 11
OHB 13-2MU, Interbedded Brenna - LL=59.1, R-bar
OHB 13-2MU, Argusville - LL=53, R-bar
OHB 13-3MU, Argusville - LL=87.7, Ring Shear
Brenna, FM, R-bar
Argusville, FM, R-bar
Brenna Curvilinear Envelope
W, Z & A 2007 Fully Softened, LL=50
W, Z & A 2007 Fully Softened, LL=85
OHB Lower Lake Agassiz Clays ULT M-C Bi-Lin
OHB 13-3MU, Interbedded Brenna - LL=69.8, R-bar
OHB 13-3MU, Argusville - LL=87.7, R-bar
OHB 13-8M, Argusville - LL=64.4, Ring Shear
Brenna, FM, DS
Argusville, FM, DS
Argusville Curvilinear Envelope
S & H 2010 Fully Softened, LL=50
S & H 2010 Fully Softened, LL=85
Note: Only Fargo-Moorhead Project data from borings at or south of the Sheyenne River Aqueduct Structure plotted.
Shear Stress, τ (tsf)
0.0
0.5
1.0
1.5
Effective Normal Stress, σ' (tsf)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Last Updated: 12/27/2013

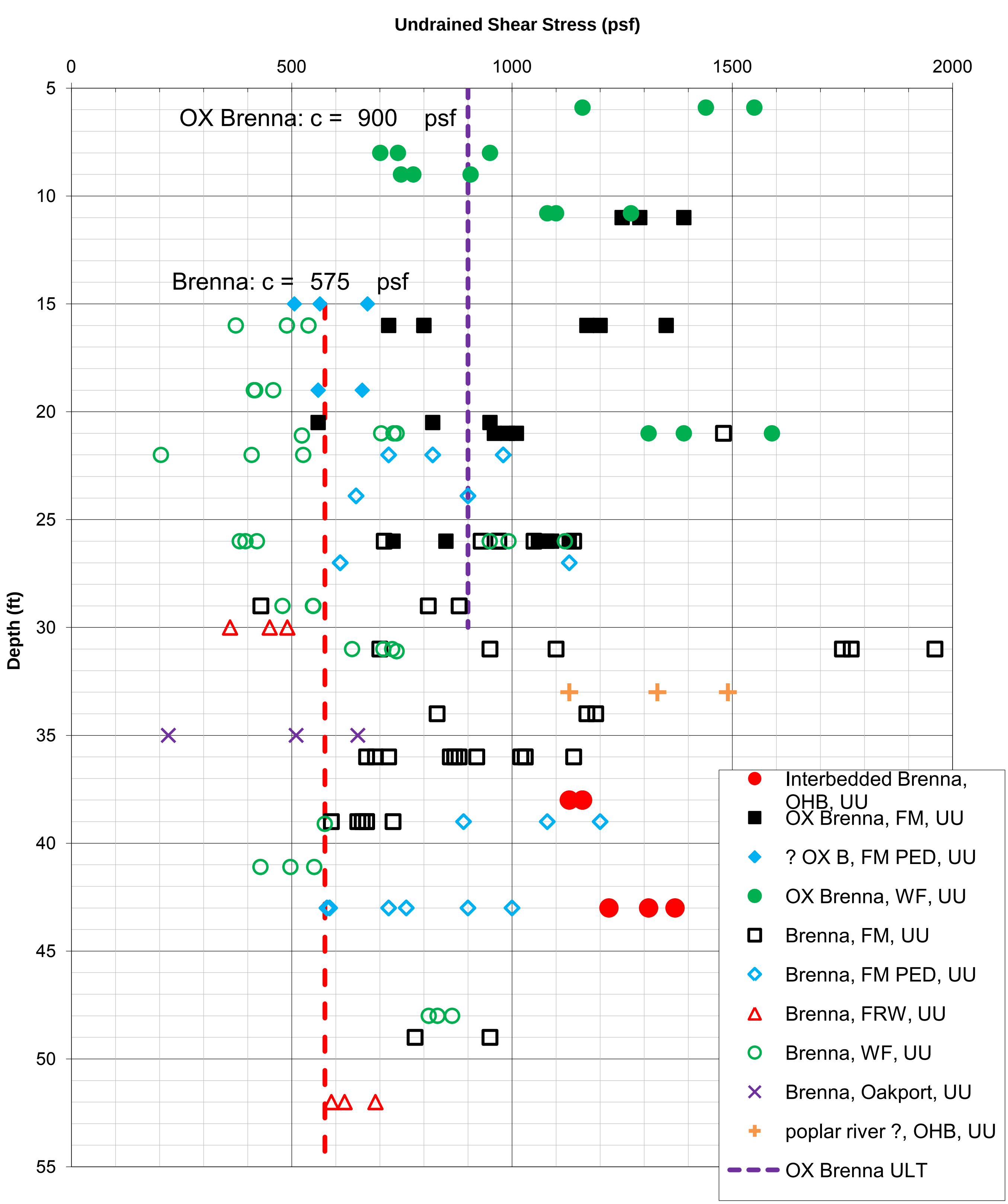

Oxbow, Hickson, Bakke Ring Levee
Brenna and Argsusville Liquid Limits from Undisturbed Testing
Liquid Limits (%)
50
55
60
65
70
75
80
85
90
95
100
Eleavation (NAVD 88 ft)
900
890
880
870
860
850
840
LL from "southern" FMM borings
OHB 13-2MU - Interbedded Brenna
OHB 13-3MU - Interbedded Brenna
OHB 13-2MU - Argusville
OHB 13-3MU - Argusville
Note: Only Fargo-Moorhead Project data taken from borings at or south of the Sheyenne River Aqueduct Structure plotted.


Oxbow, Hickson, Bakke Ring Levee
Fill
Ultimate Undrained Shear Strength (UU) Data
Undrained Shear Stress (psf)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Depth (ft)
0
5
10
15
20
25
Fill: c = 900 psf
Fill, OHB, Compacted UU
?, FM PED, Compacted UU
Alluvium, FM, UU
Sherack, FM, UU
Sherack, FM PED, UU
Sherack, FRW, UU
Sherack, WF, UU
Sherack, Oakport, UU
Fill ULT

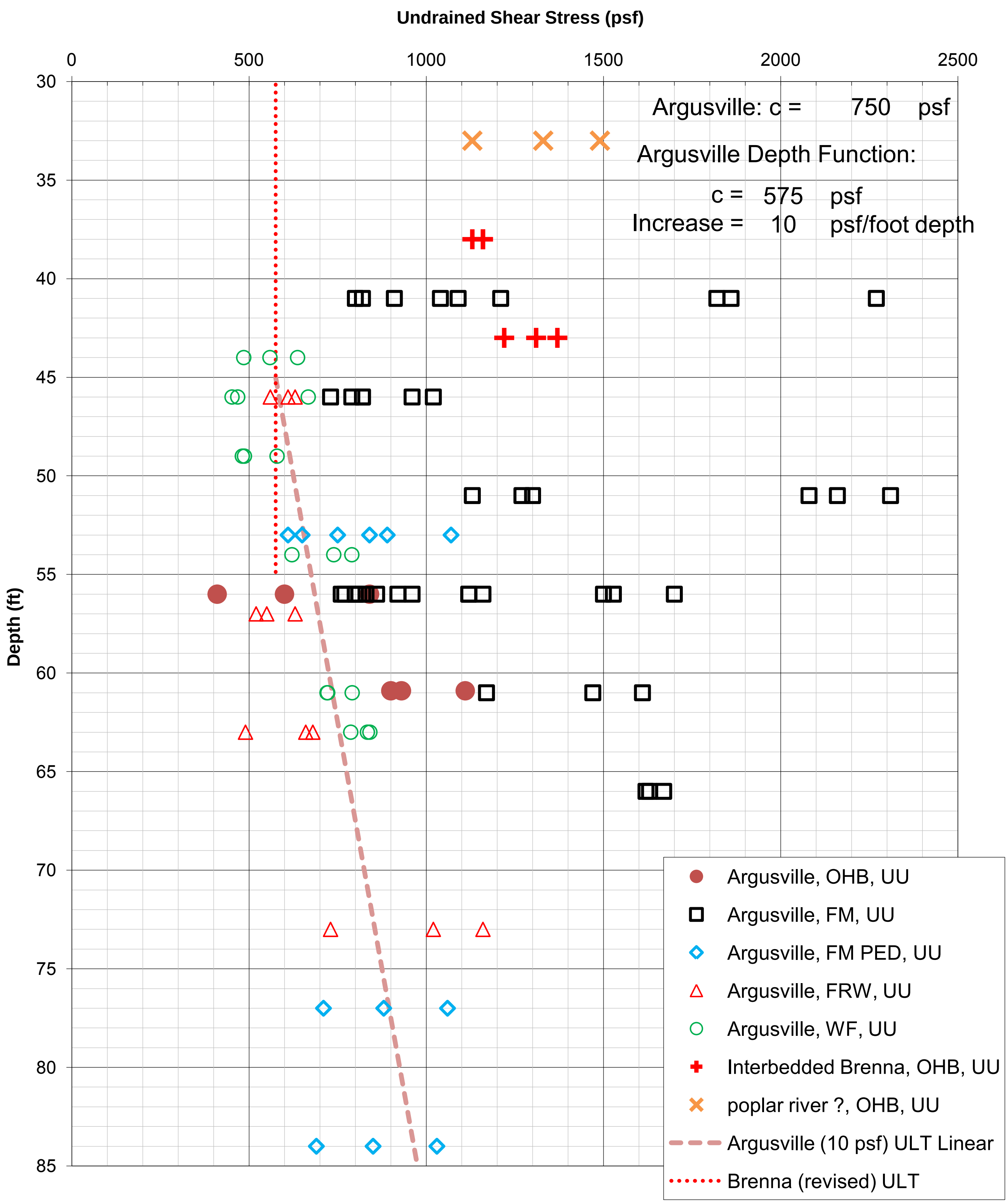

Oxbow, Hickson, Bakke Ring Levee
Alluvium and Sherack
Ultimate Undrained Shear Strength (UU) Data
Undrained Shear Stress (psf)
0
500
1000
1500
2000
2500
3000
3500
Depth (ft)
0
5
10
15
20
25
Sherack: c = 900 psf
Alluvium, OHB, UU
Sherack, OHB, UU
Alluvium, FM, UU
Sherack, FM, UU
Sherack, FM PED, UU
Sherack, FRW, UU
Sherack, WF, UU
Sherack, Oakport, UU
Sherack ULT

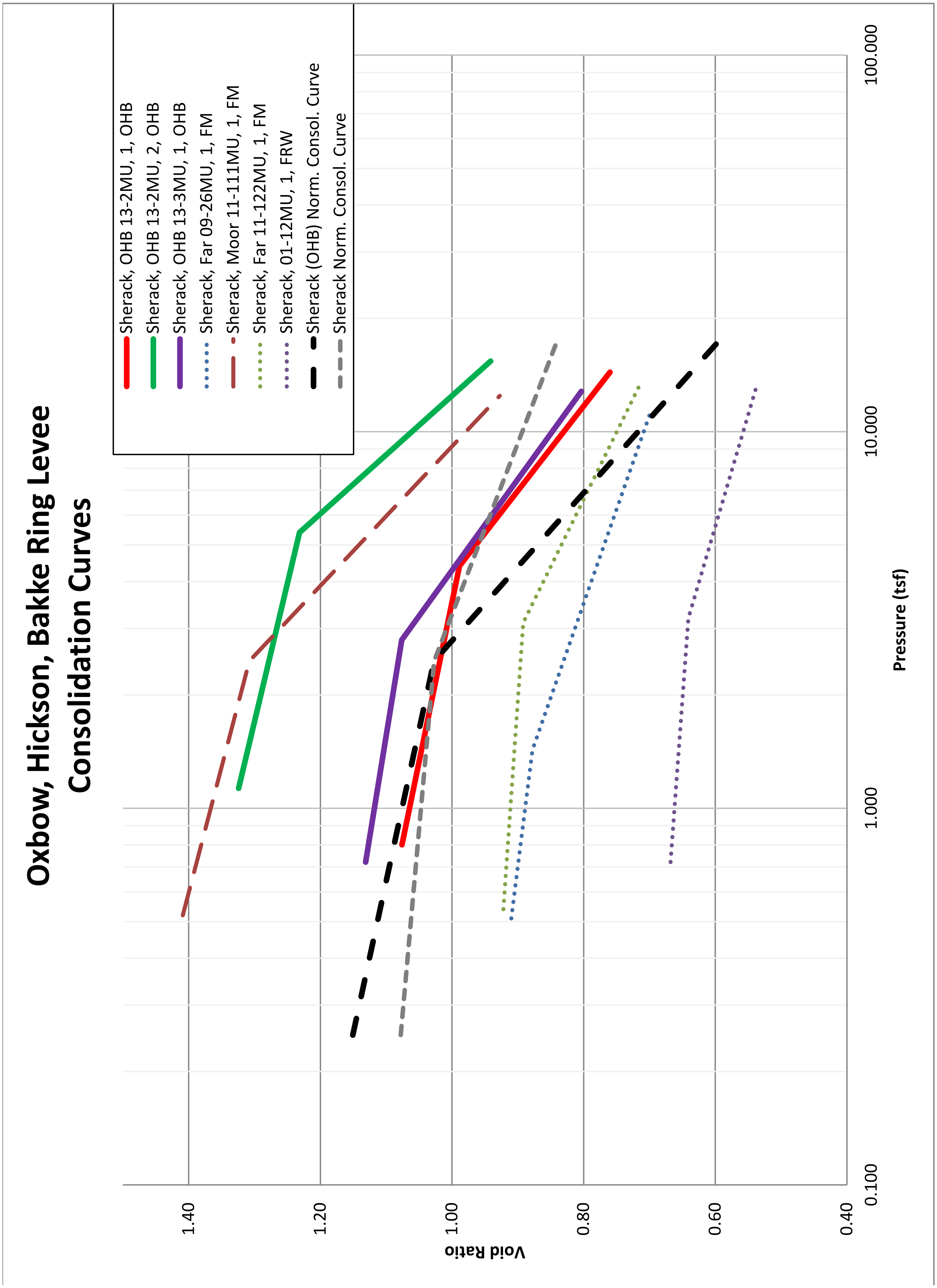

Oxbow, Hickson, Bakke Ring Levee
Poplar River
Ultimate Undrained Shear Strength (UU) Data
Undrained Shear Stress (psf)
0
500
1000
1500
2000
2500
3000
3500
15
20
25
30
35
Depth (ft)
Poplar River: c = 1700 psf
Poplar River,
West Fargo: c = 1900 psf
Poplar River,
Harwood: c = 1200 psf
poplar river ?, OHB, UU
Poplar River, FRW, UU
PR - WF, FM, UU
PR - Harwood, FM, UU
Poplar River ULT
Poplar River - WF ULT
Poplar River - Harwood ULT

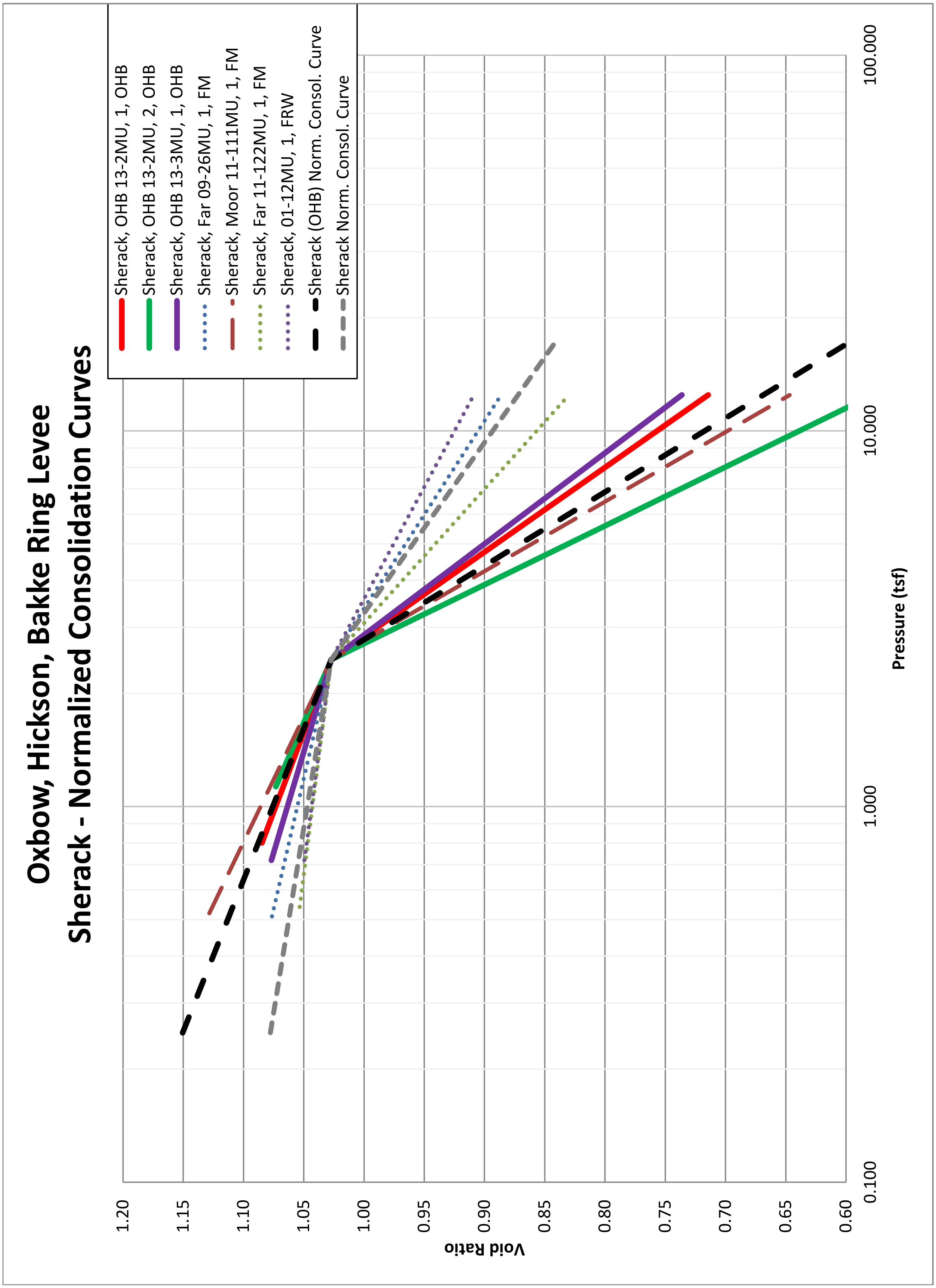
Oxbow, Hickson, Bakke Ring Levee
Brenna
Ultimate Undrained Shear Strength (UU) Data

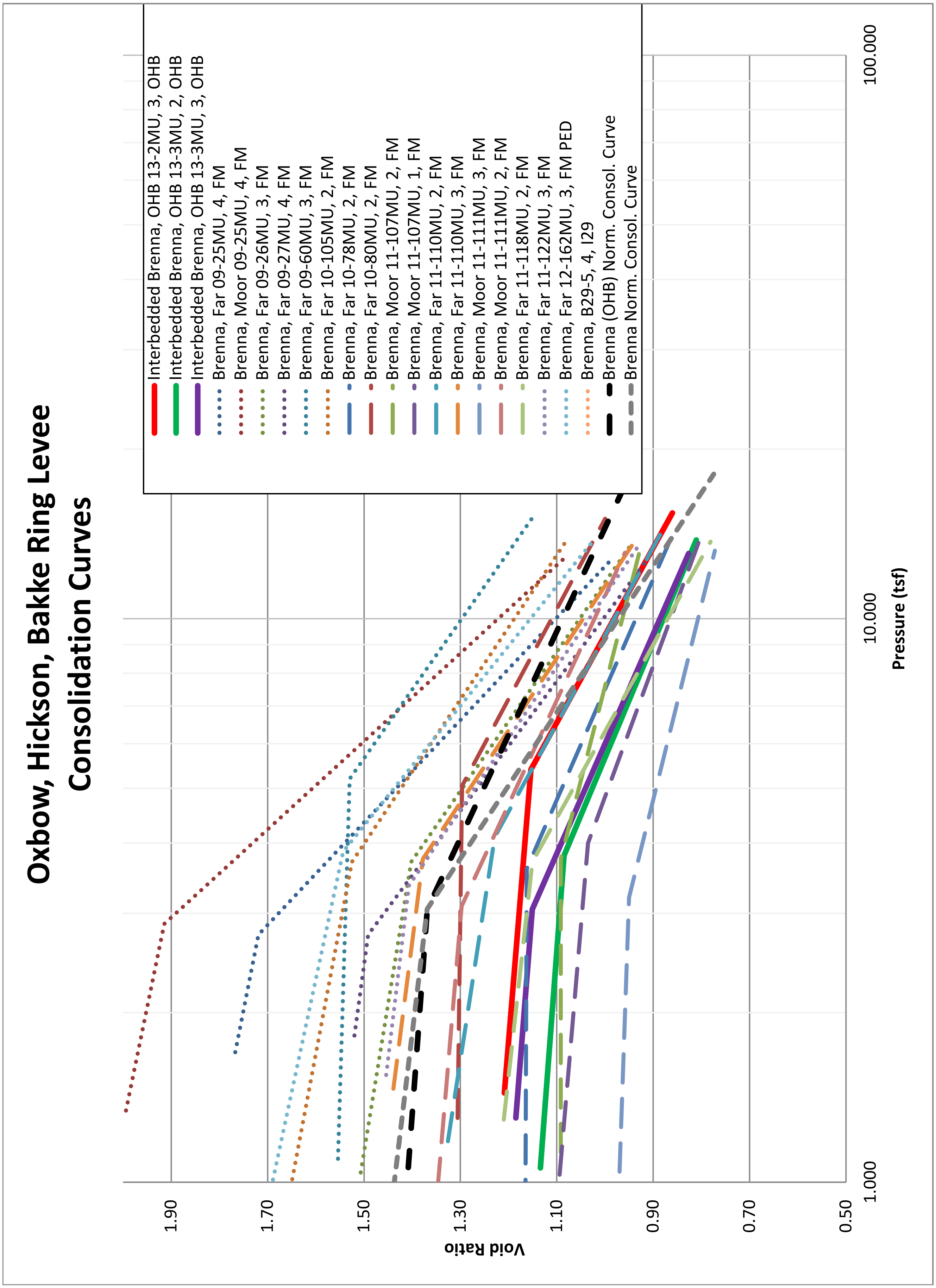


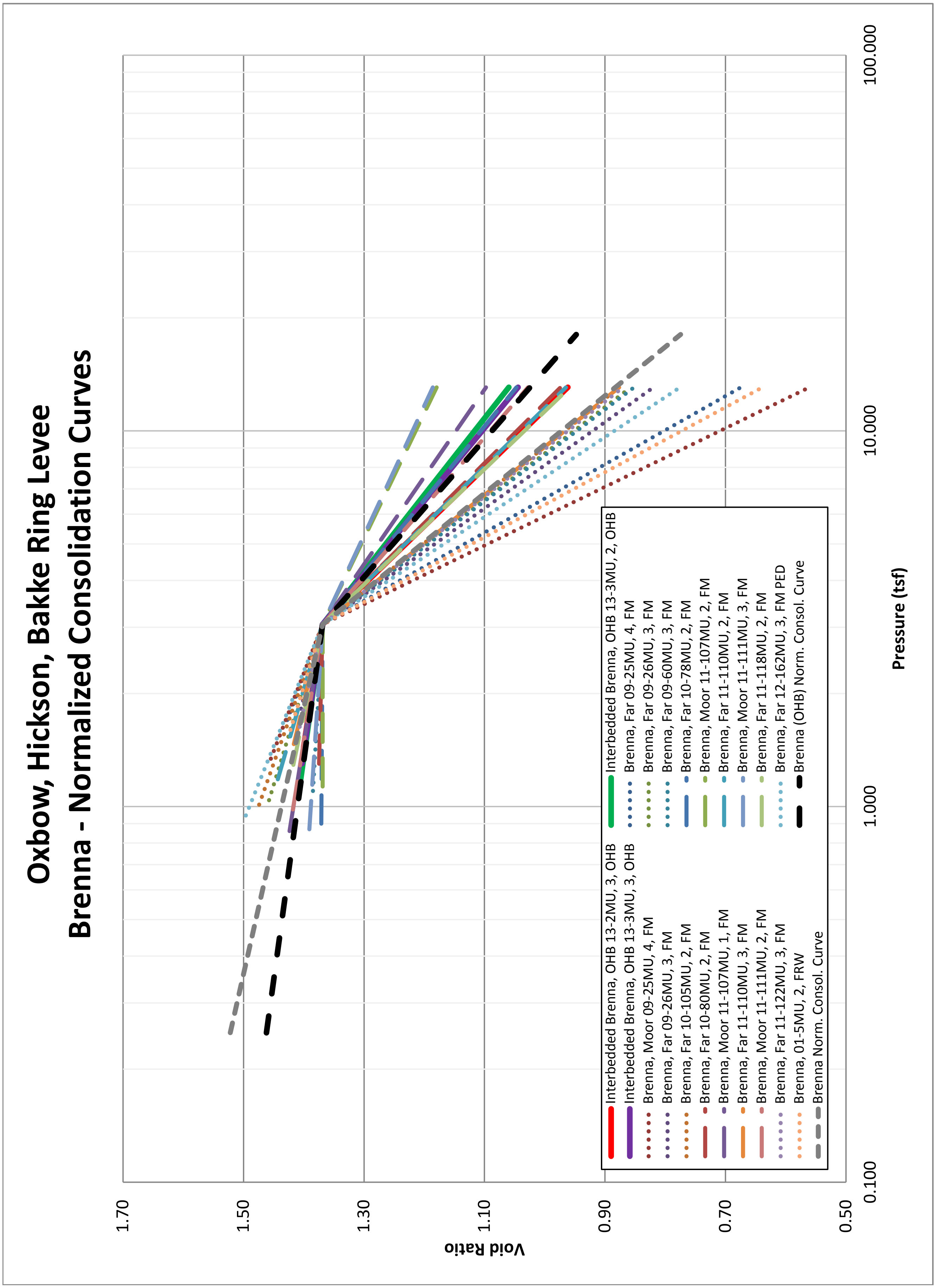
Oxbow, Hickson, Bakke Ring Levee
Argusville
Ultimate Undrained Shear Strength (UU) Data

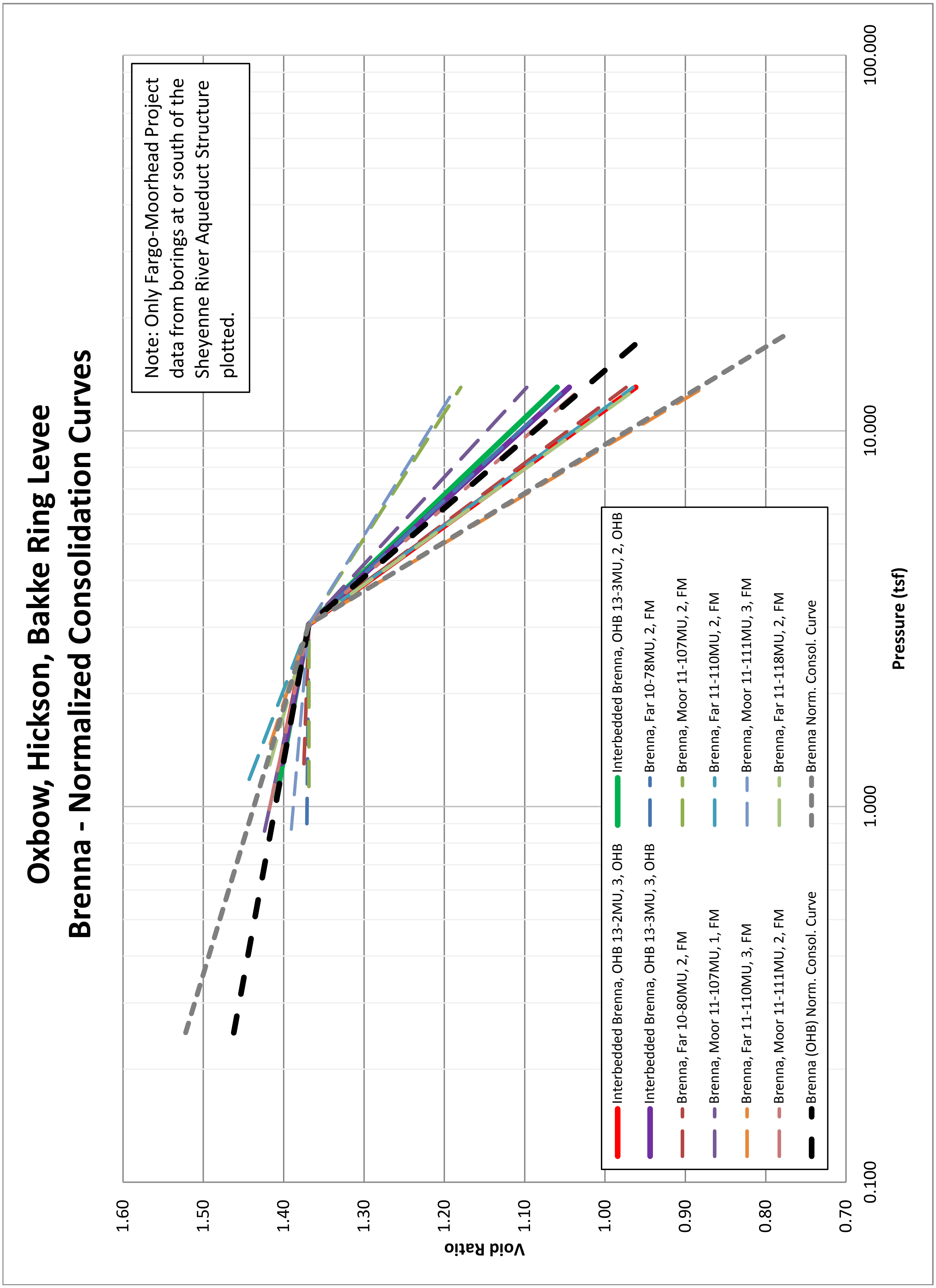


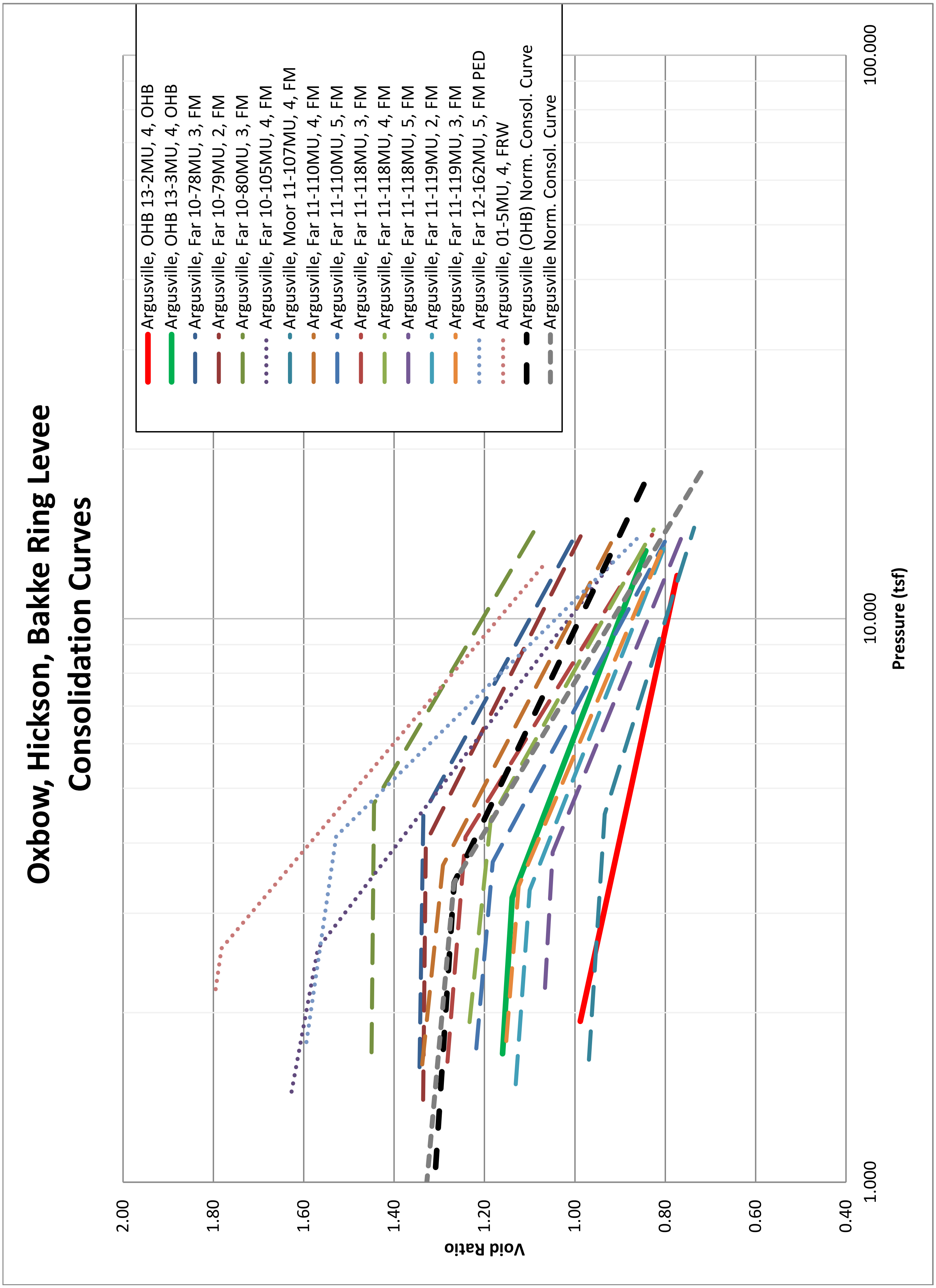

Oxbow, Hickson, Bakke Ring Levee
Consolidation Curves
Sherack, OHB 13-2MU, 1, OHB
Sherack, OHB 13-2MU, 2, OHB
Sherack, OHB 13-3MU, 1, OHB
Sherack, Far 09-26MU, 1, FM
Sherack, Moor 11-111MU, 1, FM
Sherack, Far 11-122MU, 1, FM
Sherack, 01-12MU, 1, FRW
Sherack (OHB) Norm. Consol. Curve
Sherack Norm. Consol. Curve
Void Ratio
1.40
1.20
1.00
0.80
0.60
0.40
Pressure (tsf)
0.100
1.000
10.000
100.000

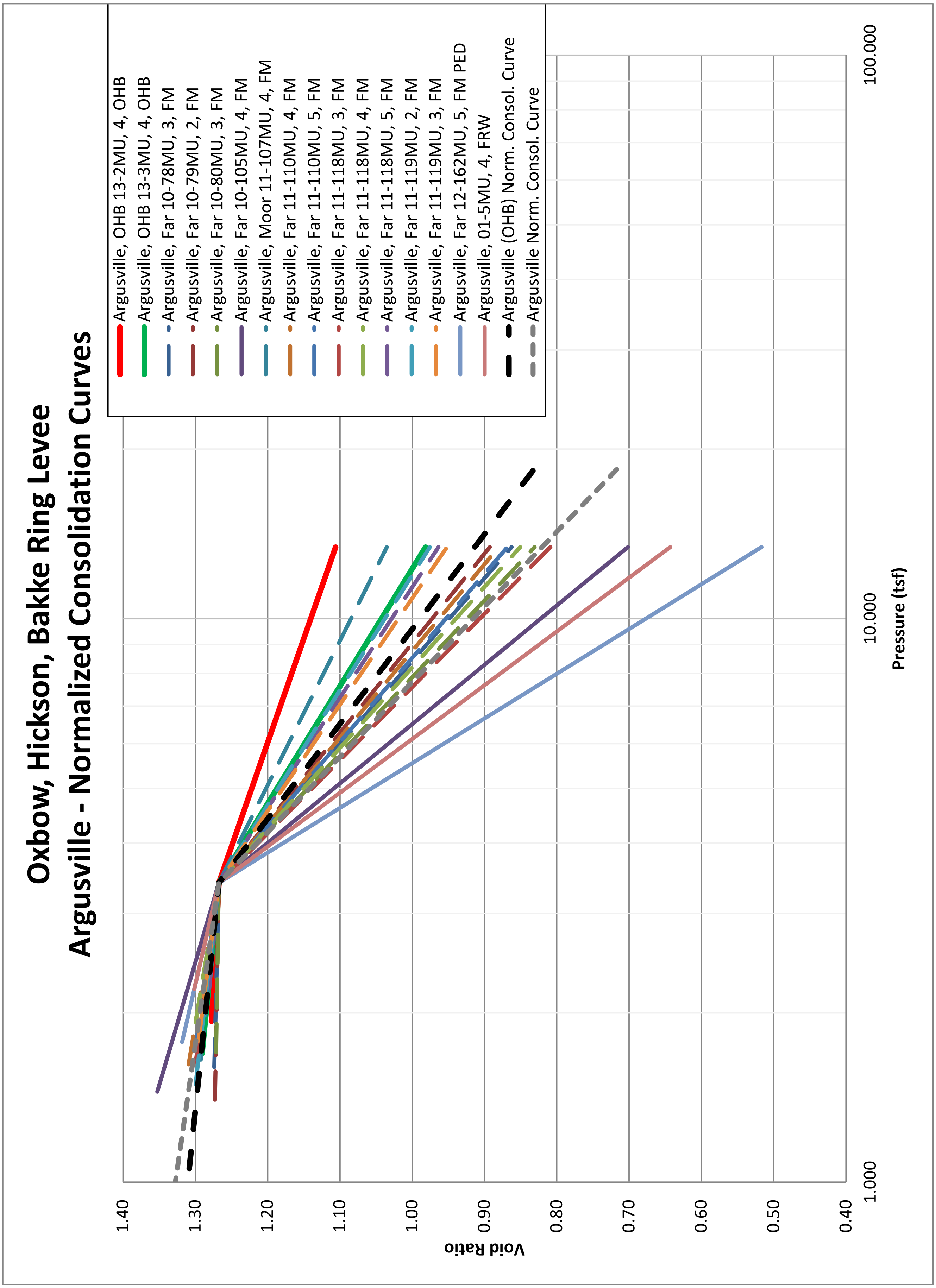

Oxbow, Hickson, Bakke Ring Levee
Sherack - Normalized Consolidation Curves
Sherack, OHB 13-2MU, 1, OHB
Sherack, OHB 13-2MU, 2, OHB
Sherack, OHB 13-3MU, 1, OHB
Sherack, Far 09-26MU, 1, FM
Sherack, Moor 11-111MU, 1, FM
Sherack, Far 11-122MU, 1, FM
Sherack, 01-12MU, 1, FRW
Sherack (OHB) Norm. Consol. Curve
Sherack Norm. Consol. Curve
Void Ratio
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Pressure (tsf)
0.100
1.000
10.000
100.000

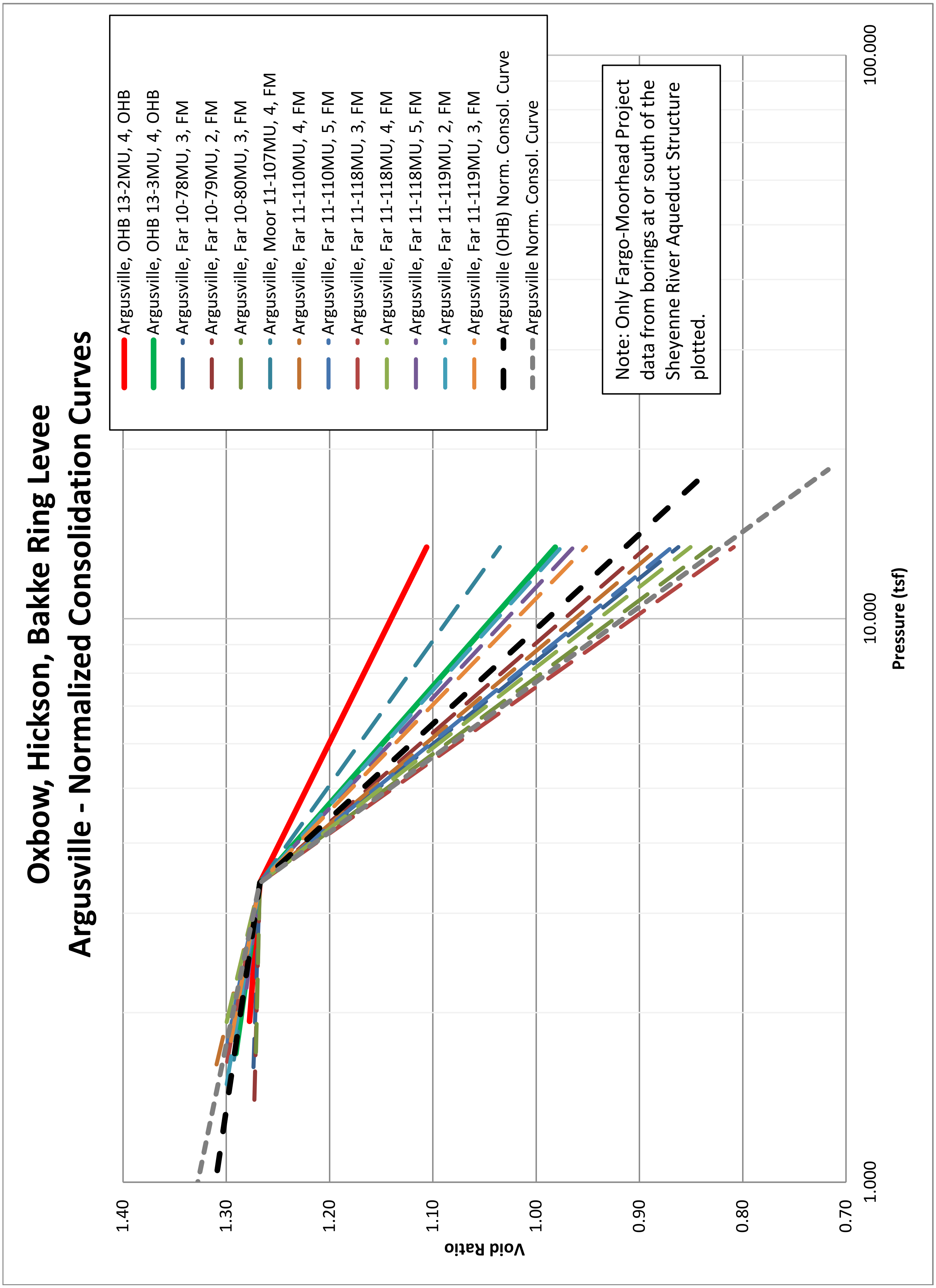

Oxbow, Hickson, Bakke Ring Levee
Consolidation Curves
Interbedded Brenna, OHB 13-2MU, 3, OHB
Interbedded Brenna, OHB 13-3MU, 2, OHB
Interbedded Brenna, OHB 13-3MU, 3, OHB
Brenna, Far 09-25MU, 4, FM
Brenna, Moor 09-25MU, 4, FM
Brenna, Far 09-26MU, 3, FM
Brenna, Far 09-27MU, 4, FM
Brenna, Far 09-60MU, 3, FM
Brenna, Far 10-105MU, 2, FM
Brenna, Far 10-78MU, 2, FM
Brenna, Far 10-80MU, 2, FM
Brenna, Moor 11-107MU, 2, FM
Brenna, Moor 11-107MU, 1, FM
Brenna, Far 11-110MU, 2, FM
Brenna, Far 11-110MU, 3, FM
Brenna, Moor 11-111MU, 3, FM
Brenna, Moor 11-111MU, 2, FM
Brenna, Far 11-118MU, 2, FM
Brenna, Far 11-122MU, 3, FM
Brenna, Far 12-162MU, 3, FM PED
Brenna, B29-5, 4, I29
Brenna (OHB) Norm. Consol. Curve
Brenna Norm. Consol. Curve
Void Ratio
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
1.000
10.000
100.000
Pressure (tsf)


Oxbow, Hickson, Bakke Ring Levee
Brenna - Normalized Consolidation Curves
Void Ratio
1.70
1.50
1.30
1.10
0.90
0.70
0.50
Pressure (tsf)
0.100
1.000
10.000
100.000
Interbedded Brenna, OHB 13-2MU, 3, OHB
Interbedded Brenna, OHB 13-3MU, 3, OHB
Brenna, Moor 09-25MU, 4, FM
Brenna, Far 09-26MU, 3, FM
Brenna, Far 10-105MU, 2, FM
Brenna, Far 10-80MU, 2, FM
Brenna, Moor 11-107MU, 1, FM
Brenna, Far 11-110MU, 3, FM
Brenna, Moor 11-111MU, 2, FM
Brenna, Far 11-122MU, 3, FM
Brenna, 01-5MU, 2, FRW
Brenna Norm. Consol. Curve
Interbedded Brenna, OHB 13-3MU, 2, OHB
Brenna, Far 09-25MU, 4, FM
Brenna, Far 09-26MU, 3, FM
Brenna, Far 09-60MU, 3, FM
Brenna, Far 10-78MU, 2, FM
Brenna, Moor 11-107MU, 2, FM
Brenna, Far 11-110MU, 2, FM
Brenna, Moor 11-111MU, 3, FM
Brenna, Far 11-118MU, 2, FM
Brenna, Far 12-162MU, 3, FM PED
Brenna (OHB) Norm. Consol. Curve


Oxbow, Hickson, Bakke Ring Levee
Brenna - Normalized Consolidation Curves
Note: Only Fargo-Moorhead Project data from borings at or south of the Sheyenne River Aqueduct Structure plotted.
Void Ratio
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
Pressure (tsf)
0.100
1.000
10.000
100.000
Interbedded Brenna, OHB 13-2MU, 3, OHB
Interbedded Brenna, OHB 13-3MU, 2, OHB
Interbedded Brenna, OHB 13-3MU, 3, OHB
Brenna, Far 10-78MU, 2, FM
Brenna, Far 10-80MU, 2, FM
Brenna, Moor 11-107MU, 2, FM
Brenna, Moor 11-107MU, 1, FM
Brenna, Far 11-110MU, 2, FM
Brenna, Far 11-110MU, 3, FM
Brenna, Moor 11-111MU, 3, FM
Brenna, Moor 11-111MU, 2, FM
Brenna, Far 11-118MU, 2, FM
Brenna (OHB) Norm. Consol. Curve
Brenna Norm. Consol. Curve


Oxbow, Hickson, Bakke Ring Levee
Consolidation Curves
Argusville, OHB 13-2MU, 4, OHB
Argusville, OHB 13-3MU, 4, OHB
Argusville, Far 10-78MU, 3, FM
Argusville, Far 10-79MU, 2, FM
Argusville, Far 10-80MU, 3, FM
Argusville, Far 10-105MU, 4, FM
Argusville, Moor 11-107MU, 4, FM
Argusville, Far 11-110MU, 4, FM
Argusville, Far 11-110MU, 5, FM
Argusville, Far 11-118MU, 3, FM
Argusville, Far 11-118MU, 4, FM
Argusville, Far 11-118MU, 5, FM
Argusville, Far 11-119MU, 2, FM
Argusville, Far 11-119MU, 3, FM
Argusville, Far 12-162MU, 5, FM PED
Argusville, 01-5MU, 4, FRW
Argusville (OHB) Norm. Consol. Curve
Argusville Norm. Consol. Curve
Void Ratio
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Pressure (tsf)
1.000
10.000
100.000


Oxbow, Hickson, Bakke Ring Levee
Argusville - Normalized Consolidation Curves
Argusville, OHB 13-2MU, 4, OHB
Argusville, OHB 13-3MU, 4, OHB
Argusville, Far 10-78MU, 3, FM
Argusville, Far 10-79MU, 2, FM
Argusville, Far 10-80MU, 3, FM
Argusville, Far 10-105MU, 4, FM
Argusville, Moor 11-107MU, 4, FM
Argusville, Far 11-110MU, 4, FM
Argusville, Far 11-110MU, 5, FM
Argusville, Far 11-118MU, 3, FM
Argusville, Far 11-118MU, 4, FM
Argusville, Far 11-118MU, 5, FM
Argusville, Far 11-119MU, 2, FM
Argusville, Far 11-119MU, 3, FM
Argusville, Far 12-162MU, 5, FM PED
Argusville, 01-5MU, 4, FRW
Argusville (OHB) Norm. Consol. Curve
Argusville Norm. Consol. Curve
Void Ratio
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
Pressure (tsf)
1.000
10.000
100.000


Oxbow, Hickson, Bakke Ring Levee
Argusville - Normalized Consolidation Curves
Argusville, OHB 13-2MU, 4, OHB
Argusville, OHB 13-3MU, 4, OHB
Argusville, Far 10-78MU, 3, FM
Argusville, Far 10-79MU, 2, FM
Argusville, Far 10-80MU, 3, FM
Argusville, Moor 11-107MU, 4, FM
Argusville, Far 11-110MU, 4, FM
Argusville, Far 11-110MU, 5, FM
Argusville, Far 11-118MU, 3, FM
Argusville, Far 11-118MU, 4, FM
Argusville, Far 11-118MU, 5, FM
Argusville, Far 11-119MU, 2, FM
Argusville, Far 11-119MU, 3, FM
Argusville (OHB) Norm. Consol. Curve
Argusville Norm. Consol. Curve
Note: Only Fargo-Moorhead Project data from borings at or south of the Sheyenne River Aqueduct Structure plotted.
Void Ratio
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
Pressure (tsf)
1.000
10.000
100.000

Attachment D-2: Seepage and Slope Stability Methodology

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee

Attachment D-2
Seepage and Slope Stability Methodology

Doc Version: Original

3 January 2014

D.1 PURPOSE

The purpose of the document is to summarize the seepage and slope stability methodology used in the design of the Oxbow, Hickson, Bakke Ring Levee Project (OHB Project).

D.2 PROGRAM

The seepage and slope stability program that was used to complete these analyses was GeoStudio 2007 from Geo-Slope International. For each design section, a GeoStudio model was developed and the required seepage and stability analyses run within the models.

D.3 SEEPAGE

Steady-state seepage analyses were run in order to estimate pore pressures. The seepage models were setup to replicate, as close as possible, field conditions. These pore pressures were then imported into the steady-state seepage slope stability (long –term, drained) conditions and used in the slope stability analysis.

The seepage parameters used in the analyses are summarized in Attachment D-1.

D.4 SLOPE STABILITY

Slope stability analyses were completed to determine the factor of safety against sliding for the levee. When running the slope stability analyses, the model was setup using the following criteria.

- Method: Spencer's Method for slope stability was used to determine the slope stability factor of safety.
- Number of Slices: 30 slices were used.
- The minimum slip surface depth was set at 2 feet.
- For the steady-state seepage slope stability analyses, the pore pressures from the seepage analyses were coupled with the stability analysis.

The conditions analyzed are summarize below in Table 1. For Case III, Steady-State Seepage, it was assumed that steady-state seepage conditions were established even though the duration of the floods are relatively short compared to the time necessary to develop steady-state seepage for the impervious materials.

Table 1: Required Minimum Factor of Safety for Levee Stability Analysis

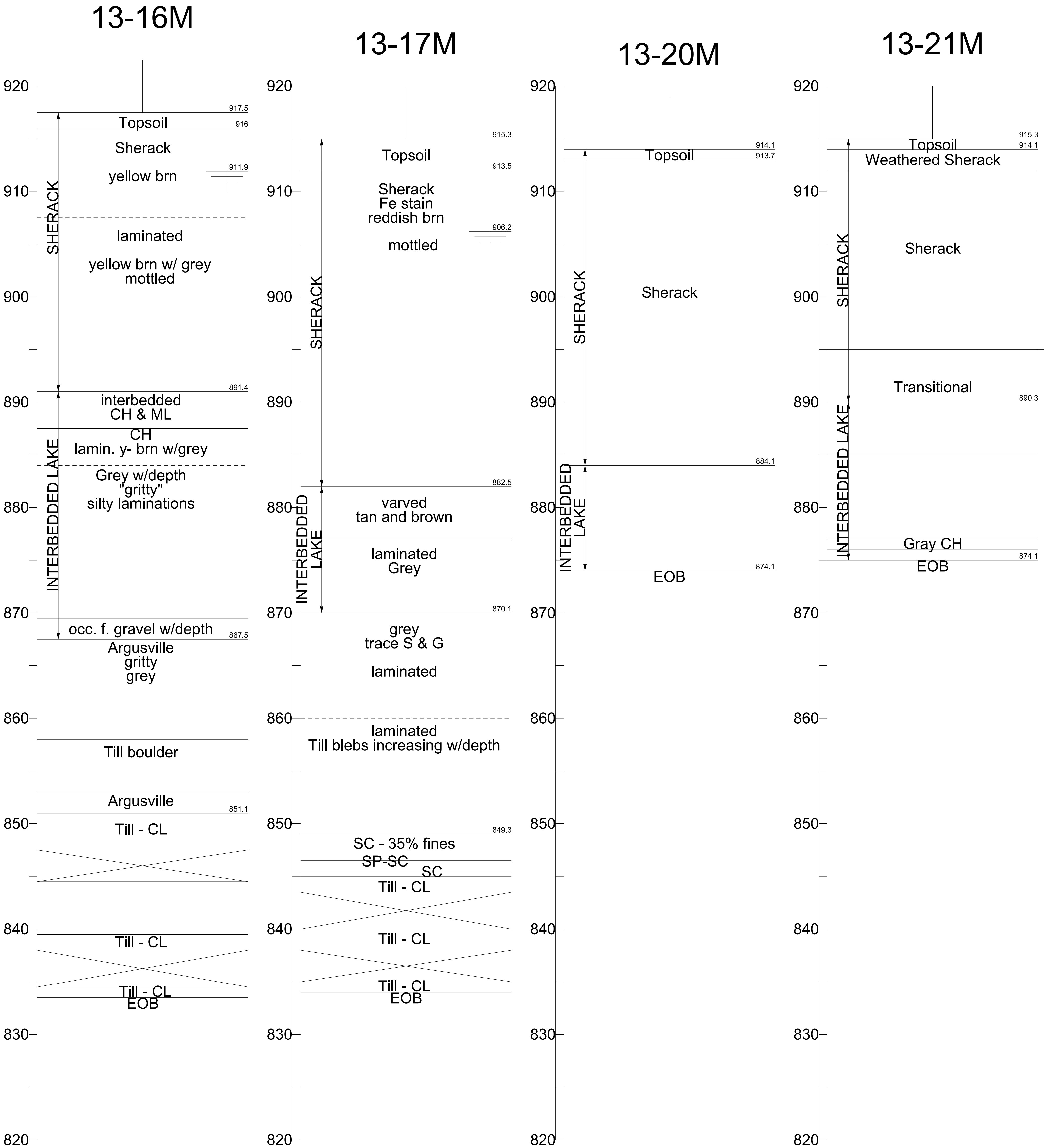
Levee Analysis					
Case	Name	Required Minimum Factor of Safety	Applicable Levee Slope	Description	Shear Strength Parameters
I	End of Construction	1.3	Wetside and Dryside	End of construction case.	Low-permeability soils - undrained; Free draining soils - effective stress
II	Sudden Drawdown	1	Wetside	Sudden or rapid drawdown condition where the flood stage saturates a portion of the slope and stays partially saturated as flood recedes.	Low-permeability soils - 3-stage; Free draining soils - effective stress
III	Steady-State Seepage	1.4	Dryside	Steady state seepage conditions that develop from a full flood stage. The flood stage needs to be long enough for steady state seepage to develop.	Effective stress
IV	Earthquake	N/A		Earthquake loading on the levee. Area is low seismic risk and non-liquefiable soils, therefore not applicable.	

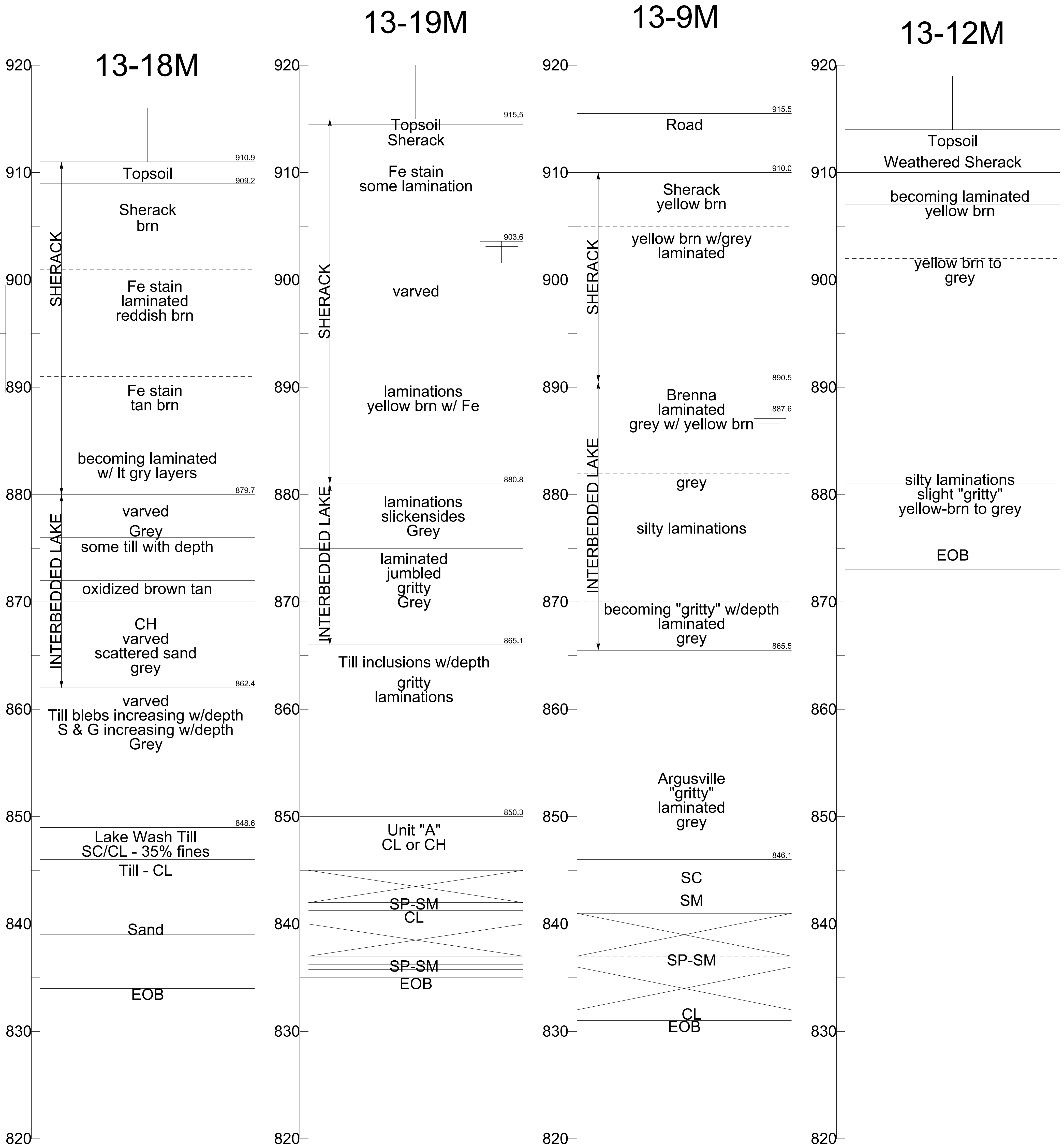
In addition to analyzing the stability of the levee, stability analyses were completed to determine the required setback distance for the levees when located adjacent to the Red River of the North. Where existing slides were found or assumed in the vicinity of the levee locations, a back analysis was completed to determine the residual shear strength of the failed soil formations under existing conditions. Using these residual shear strengths, the setback stability analysis was completed and the required minimum factor of safety was reduced. The conditions analyzed are summarized below in Table 2.

Table 2: Required Minimum Factor of Safety for Levee Setback Analysis

Setback Analysis				
Name	Required Minimum Factor of Safety	Applicable Levee Slope	Description	Shear Strength Parameters
Drained Levee Setback	1.4	N/A	Long-term stability analysis using steady-state seepage condition of the natural bank. Used to determine the required setback of the levee.	Effective stress
Back-analysis Levee Setback	1.2	N/A	When a slide has occurred, a back-analysis is performed to determine the shear strength of the residual soils and used in the long-term stability analysis to determine the required setback of the levee.	Effective stress: residual, back-calculated, and intact
Undrained Levee Setback	1.3	N/A	End of construction case	Low-permeability soils - undrained; Free draining soils - effective stress

Attachment D-3: Stratigraphy


13-16M
13-17M
13-20M
13-21M
920
910
900
890
880
870
860
850
840
830
820
917.5
Topsoil
916
Sherack
yellow brn
911.9
SHERACK
laminated
yellow brn w/ grey
mottled
891.4
interbedded
CH & ML
CH
lamin. y- brn w/grey
Grey w/depth
"gritty"
silty laminations
INTERBEDDED LAKE
occ. f. gravel w/depth
867.5
Argusville
gritty
grey
Till boulder
Argusville
851.1
Till - CL
Till - CL
Till - CL
EOB
915.3
Topsoil
913.5
Sherack
Fe stain
reddish brn
906.2
mottled
SHERACK
882.5
varved
tan and brown
laminated
Grey
INTERBEDDED
LAKE
870.1
grey
trace S & G
laminated
laminated
Till blebs increasing w/depth
849.3
SC - 35% fines
SP-SC
SC
Till - CL
Till - CL
Till - CL
EOB
914.1
Topsoil
913.7
Sherack
SHERACK
884.1
INTERBEDDED
LAKE
874.1
EOB
915.3
Topsoil
914.1
Weathered Sherack
Sherack
SHERACK
Transitional
890.3
INTERBEDDED LAKE
Gray CH
874.1
EOB


13-18M
13-19M
13-9M
13-12M
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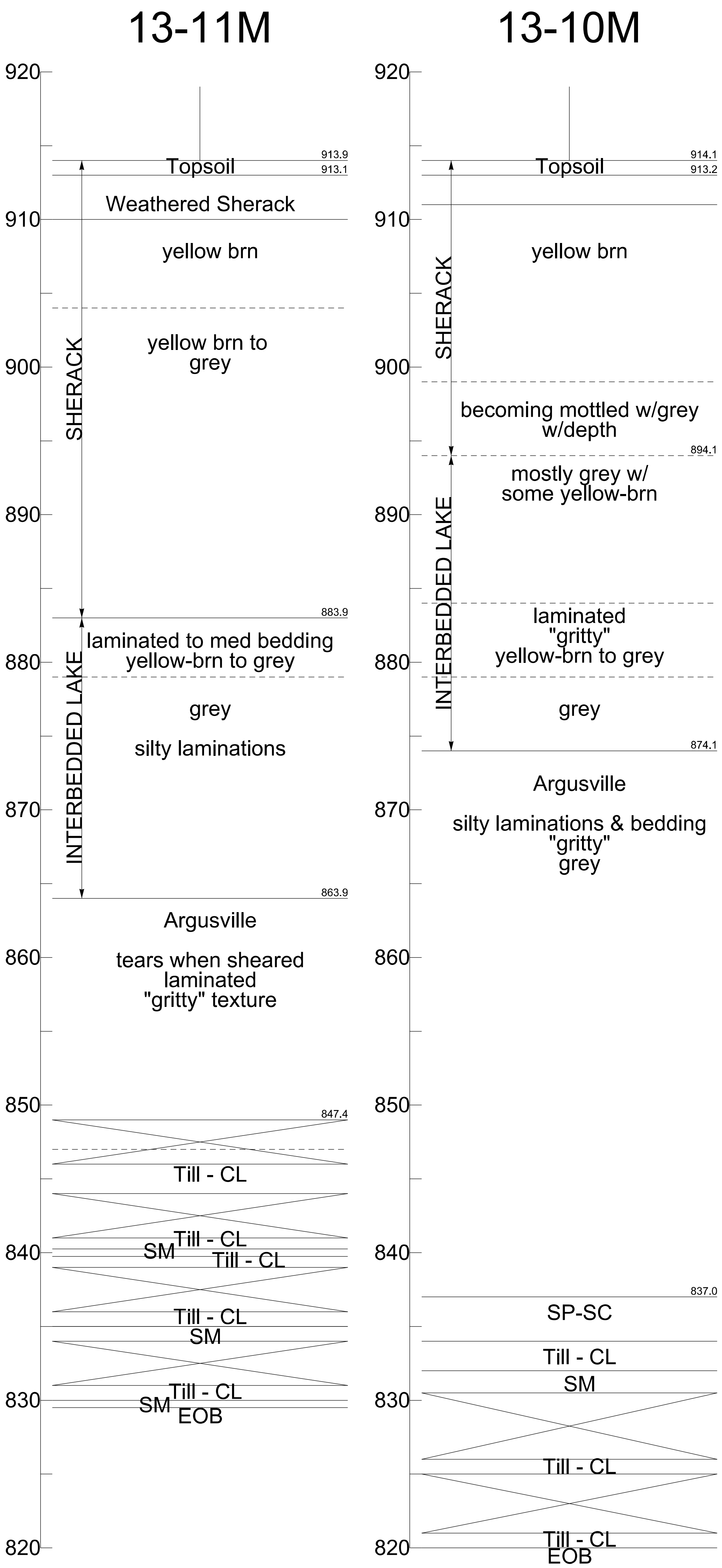
860
850
840
830
820
910.9
Topsoil
909.2
Sherack
brn
SHERACK
Fe stain
laminated
reddish brn
Fe stain
tan brn
becoming laminated
w/ lt gry layers
879.7
INTERBEDDED LAKE
varved
Grey
some till with depth
oxidized brown tan
CH
varved
scattered sand
grey
862.4
varved
Till blebs increasing w/depth
S & G increasing w/depth
Grey
848.6
Lake Wash Till
SC/CL - 35% fines
Till - CL
Sand
EOB
915.5
Topsoil
Sherack
Fe stain
some lamination
903.6
varved
laminations
yellow brn w/ Fe
880.8
laminations
slickensides
Grey
laminated
jumbled
gritty
Grey
865.1
Till inclusions w/depth
gritty
laminations
850.3
Unit "A"
CL or CH
SP-SM
CL
SP-SM
EOB
915.5
Road
910.0
Sherack
yellow brn
yellow brn w/grey
laminated
890.5
Brenna
laminated
grey w/ yellow brn
887.6
grey
silty laminations
becoming "gritty" w/depth
laminated
grey
865.5
Argusville
"gritty"
laminated
grey
846.1
SC
SM
SP-SM
CL
EOB
Topsoil
Weathered Sherack
becoming laminated
yellow brn
yellow brn to
grey
silty laminations
slight "gritty"
yellow-brn to grey
EOB


13-11M
13-10M
920
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880
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860
850
840
830
820
913.9
913.1
Topsoil
Weathered Sherack
yellow brn
yellow brn to grey
SHERACK
883.9
laminated to med bedding yellow-brn to grey
grey
silty laminations
INTERBEDDED LAKE
863.9
Argusville
tears when sheared laminated "gritty" texture
847.4
Till - CL
Till - CL
SM
Till - CL
Till - CL
SM
SM
Till - CL
EOB
914.1
913.2
Topsoil
yellow brn
SHERACK
becoming mottled w/grey w/depth
894.1
mostly grey w/ some yellow-brn
INTERBEDDED LAKE
laminated "gritty" yellow-brn to grey
grey
874.1
Argusville
silty laminations & bedding "gritty" grey
837.0
SP-SC
Till - CL
SM
Till - CL
Till - CL
EOB

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Appendix E: Civil-Site

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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Appendix E: Civil-Site

E.1 GENERAL

Civil design for this project will include clearing and grubbing, layout of levee, drainage ditches, access roads, and general grading. This section summarizes the proposed layout, method of analyses, and support for preparation of the plans, specifications, and cost estimate.

E.2 DEMOLITION

Utility demolition will be done by others in a separate contract. Existing utility information is forthcoming. Clearing and grubbing of vegetation will be included in future submittals. Demolition of homes/buildings is not anticipated in WP-43B, as the alignment avoids these conflicts.

E.3 LEVEES

The OHB Ring Levee will have a 10' top width, and will have a 6" thick aggregate road for inspection and maintenance purposes. The aggregate road will have a 2% cross slope towards the outside of the levee to shed precipitation. The inside levee slope will be 5H: 1V while the outside levee slope will be 4H:1V with the exception of the NE segment between Main Street and CR81 which will have an outside levee slope of 5H:1V to satisfy the wind/wave run-up criteria. Interior and exterior ditches and culverts were designed by HMG in the local drainage plan (See Appendix C), and were incorporated into the WP-43B design by the COE. The levee slopes will have 6" of topsoil and seed for erosion protection.

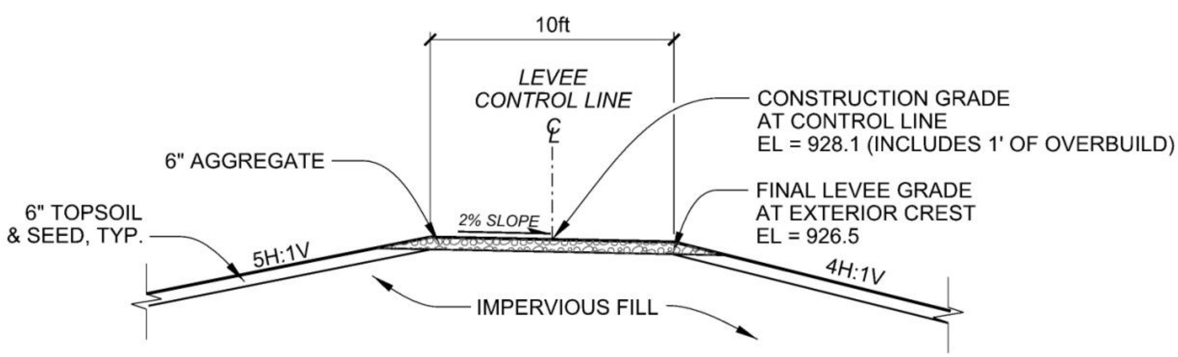

Figure 1 – Levee Design Elevations

E.4 LEVEE CONSTRUCTION GRADE AND FINAL DESIGN GRADE

The construction grade shown on the construction plan set is defined as the control line top of aggregate elevation taking into account the final levee design grade, the top of levee cross slope, aggregate road thickness, and overbuild to account for future settlement. Figure 1 shows these grades and they are discussed below.

- The final levee design grade is 926.5. This elevation is at the top exterior crest of the impervious fill. Overbuild will be added to this as defined below.
- The top of levee cross slope is 2% therefore the control line elevation top of impervious fill is 0.1' higher than the final levee design elevation.
- The aggregate road thickness is 0.5'.

Overbuild to account for future settlement is assumed to be 1'. This will be added to the final levee design grade to define the control line construction grade.

The control line construction grade = 926.5'+1'+0.1'+0.5'=928.1'

E.5 ACCESS ROADS AND TURNOUTS

EM 1110-2-1913 defines some design considerations for permanent project access roads as well as maintenance roads and turnouts. The maintenance road, turnouts and access roads are similar in design as the typical section for Cass County Roads: 6" gravel over compacted fill.

E.5.1 Project Access Roads

The geometric design criteria are preliminary and subject to change. The design criteria used for the design of the access roads are summarized below:

Main Street Access Road

- 24' wide with 6" thick ND Class 13 gravel surface
- Grade of ramp should be no steeper than 1:7.
- Design Speed of vertical curves 25 mph minimum
- Side slopes should not be less that 1:4 to allow grass cutting equipment to operate.

51st Street Access Road

- 24' wide with 6" thick ND Class 13 gravel surface
- Grade of ramp should be no steeper than 1:8.
- Design Speed of vertical curves 20 mph minimum
- Side slopes should not be less that 1:4 to allow grass cutting equipment to operate.

E.5.2 Vegetation Free Zone (VFZ) Access

The location and design of access over the ditches to the VFZ will be provided in future submittals.

E.5.3 Turnouts

As defined in EM 110-2-1913, turnouts should be used to provide a means for the passing of two motor vehicles on a one way access road on the levee. Turnouts should be designed at intervals of approximately 2500 ft, if there are no ramps within the reach. Turnouts shall be 24 ft wide and approximately 100 ft in length (including transitions). Turnouts in WP-43B are located at the following stations:

- Station B 26+50
- Station B 82+30

E.6 LOCAL DRAINAGE

Local drainage is being designed by the local sponsor for incorporation into the WP-43B construction documents. The local drainage design includes drainage ditches that run parallel along the outside and inside of the OHB ring levee. The outside ditches will convey local runoff from adjacent properties, as well as the levees, to either existing field swales or existing road ditches. The inside ditches are designed to convey water to interior ponds and pump station. A minimum 20ft wide buffer will be provided between the toe of the levee and ditches. The outside and inside ditches are shown in the construction plans. The horizontal alignment of the ditches is subject to change. Exact location of the ditches is contingent on pending geotechnical analysis.

Culvert information for the local drainage ditches will be provided in future submittals.

E.7 UTILITY INFORMATION

Utility information, including surveyed locations, was obtained from Moore Engineering under contract with the local sponsor.

E.7.1 Existing Utilities

Existing utility information will be provided in future submittals.

E.7.2 Utility Relocations

Utility relocations will comply withMFR-019 Oxbow, Hickson, Bakke Ring Levee Utility Relocation Requirements and local/state requirements. All relocations will be performed prior to construction. Utility relocation plans will be provided to the contractor as a plan reference document.

E.7.2.1 Overhead Electric

Overhead electrical lines will be relocated by the utility owner prior to project construction. Demolition of existing lines and poles will be the responsibility of the utility owner.

E.7.2.2 Buried Communication Lines

Buried Communication lines will be relocated by the utility owner prior to project construction. Existing lines will be abandoned in place by the Utility Company and removed by the WP-43E Contractor. The removals will be included in the WP-43E plans.

E.7.2.3 Water Mains

Existing water mains will be relocated by the utility owner prior to project construction. The WP-43E contractor's demolition activities may include demolition of existing water mains/lines abandoned in place.

E.8 VEGETATION FREE ZONE (VFZ)

The requirements for VFZ are outlined in the USACE Technical Letter ETL 1110-2-571. The VFZ will be a minimum of 15' from the toe of levee. The VFZ lines will not be shown in the WP-43B contract documents, but will be defined in the O&M documents provided to the local sponsor at project completion.

E.9 REAL ESTATE/WORK LIMITS/CONSTRUCTION

E.9.1 Easements

The VFZ for this project will be acquired in Fee Title. The inside and outside ditches will be outside of the VFZ, so additional Fee Title property acquisition will be required for the ditch footprint, as well as the area adjacent to the ditch to allow for maintenance. Temporary construction easements (Work Limits) may also need to be secured to allow for adequate space to construct the project. Work Limits are shown on the construction plans. Fee Title and Temporary Easement boundaries will be show in the Right of Way drawings.

E.9.2 Construction Staging Areas

Construction staging areas will be provided in future submittals.

E.10 TECHNICAL GUIDELINES AND REFERENCES

A Policy on Geometric Design of Highways and Streets, Fifth Edition; American Association of State Highway and Transportation Officials (AASHTO); 2004.
Guidelines for Geometric Design of Very Low-Volume Local Roads, American Association of State Highway and Transportation Officials (AASHTO); 2001
USACE EM 1110-2-1913, Design and Construction of Levees
USACE EM 1110-2-2902, Conduits, Culverts and Pipes
USACE EM 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Damns and Appurtenant Structures
USACE MVP MFR 019 Oxbow, Hickson, Bakke Ring Levee Utility Relocation Requirements

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Appendix J: Landscape and Recreation

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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Appendix J: Landscape and Recreation

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Appendix J: Landscape and Recreation

J.1 PROJECT DESCRIPTION

Additional recreation and landscape details will be provided in future submittals.

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Appendix K: Environmental

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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ATTACHMENTS

Additional information will be provided in future submittals.

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Appendix K: Environmental

K.1 SUMMARY OF IMPACTS

Impacts identified in the 2011 Fargo-Moorhead Metropolitan Area Flood Risk Management Feasibility Report and Environmental Impact Statement and the Supplemental Environmental Assessment July 2013 includes impacts to aquatic habitat, fish passage and connectivity, floodplain forest, wetland resources, and cultural resources.

K.1.1 Aquatic Habitat

There was no aquatic habitat impacts identified for the Oxbow, Hickson, Bakke Ring Levee project.

K.1.2 Fish Passage and Connectivity

There was no aquatic habitat impacts identified for the Oxbow, Hickson, Bakke Ring Levee project.

K.1.3 Floodplain Forest

The overall project will result in a loss of 143 acres of forested land consisting of floodplain forest, shelterbelts, and small pockets of trees around farmsteads. Twelve acres of the 143 acres will be impacted as a result of constructing the Oxbow, Hickson, Bakke Ring levee.

K.1.4 Wetlands

Wetlands delineation has recently been completed. Note: these numbers are for the entire Fargo-Moorhead Project, not specific to OHB.

Wetland Type	**Acres**
Open Water	0.69
Seasonally Flooded Basin	1476.97
Shallow Marsh	106.38
Shrub-Carr	1.32
Wet Meadow	119.85
Total Acres	**1705.20**

In general, the majority of the wetlands impacted are low functioning farmed, seasonally flooded type.

K.1.5 Cultural Resources

Phase 1 cultural resource surveys have been ongoing for the entire project area. Areas where Phase 2 testing and evaluation will be needed have been identified and will continue to be identified as the Phase 1 surveys are completed. The Phase 1 cultural resources survey of the Oxbow-Hickson-Bakke ring levee footprint and related areas was conducted in October-November 2013. At this time no areas have been identified that require Phase 2 testing for the Oxbow, Hickson, Bakke project.

K.2 OVERALL MITIGATION FEATURES

K.2.1 Aquatic Habitat Mitigation Features

None required for the project.

K.2.2 Fish Passage and Connectivity

None required for this project.

K.2.3 Floodplain Forest

Mitigation to offset the impacts to floodplain forest for the Oxbow, Hickson, Bakke Ring Levee includes converting 24 acres of floodplain farmland or pastured land into floodplain forest.

K.2.4 Wetlands

Various wetland mitigation plans are being evaluated. This is being done collaboratively with the USACE Omaha District Regulatory staff to ensure that the right amount of wetland mitigation is accomplished.

K.2.5 Cultural

Cultural resources mitigation for each Reach must be completed prior to the start of construction for that Reach. In addition monitoring by a professional archeologist will be required during construction in select reaches of the project. Cultural resources monitoring will be required during construction and earthwork of the eastern portion of the Oxbow-Hickson-Bakke ring levee within 328 feet (100 meters) of the top of the riverbank of the Red River and any oxbow thereof.

K.3 WP-43B MITIGATION FEATURES

The environmental consideration for mitigation for this Ring Levee includes planting of floodplain forest and wetland mitigation.

K.3.1 Wetland Planting Guidelines

Additional information will be provided in future submittals

K.4 CULTURAL RESOURCES

The Phase 1 cultural resources survey was conducted by URS archeologists in October-November 2013. Deep testing for buried archeological sites was also conducted at this time. In addition, an inventory of the built environment (buildings, structures, linear features) was conducted.

One prehistoric isolated artifact (FM19-2-IF), two historic debris scatters (FM19-3, FM15-2) and fifteen historic isolated artifacts (FM15-3-IF through FM15-17-IF) were recorded in the Oxbow-Hickson-Bakke project area. None of these archeological resources will require Phase 2 testing.

The previously reported locations of the Hickson Railroad Station (site lead 32CSX4) and the Hickson Milwaukee Station (site lead 32CSX200) were checked for cultural resources, but no remains of either were found. The Hickson Dam (32CS5096) on the Red River had been previously recorded in 2010 and recommended as eligible to the National Register of Historic Places under criterion A, association with significant historic events, due to its construction as one of four dams constructed in 1937 by the Works Progress Administration to provide a reliable supply of water to the cities of Fargo, North Dakota and Moorhead, Minnesota. The Hickson Dam, also known as Fargo Dam #3, will not be affected by the proposed ring levee project.

The previously recorded linear resource sites of County Road 81 (32CS2657) (the former Meridian Highway and North Dakota Highway 1) and the Hickson RR Crossing (32CS2655) (at Hwy 81 and the old grade of the Chicago, St. Paul, and Pacific Railroad) were updated. The National Register of Historic Places eligibility status of these two linear resources in the Oxbow-Hickson-Bakke project area is unknown at the present time.

Finally, an inventory of the buildings in the Oxbow-Hickson-Bakke project area was conducted to determine if any were 50 years old or older. At this time, no buildings have been identified as needing Phase 2 evaluation of their eligibility to the National Register of Historic Places.

K.5 ENVIRONMENTAL SURVEYS AND MONITORING

Raptor surveys were conducted by the Corps and the USFWS during the spring of 2013. Surveys will be conducted each spring prior to construction of the Ring Levee.

Based on the cultural resources programmatic agreement, any project excavation within 100 meters (328 feet) of any river should be monitored by a qualified professional archeologist.

K.6 NEPA COMPLIANCE

The proposed plan for the diversion channel was discussed in the 2011 Fargo-Moorhead Metropolitan Area Flood Risk Management Final Feasibility Report and Environmental Impact Statement. A supplemental environmental assessment and supplemental 404(b)1 analysis was prepared in July 2013 to address changes that were made since the 2011 EIS, to include constructing a Ring Levee around the communities of Oxbow, Hickson, and Bakke.

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Appendix L: Quality Control

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

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Attachments will be provided in future submittals.

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Attachment L-10	BCOE Sponsor Review Comments and Responses
Attachment L-11	BCOE IEPR Comments and Responses

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Appendix L: Quality Control

L.1 GENERAL

As stated by EC 1165-2-214, all planning, engineering and scientific work will undergo a vigorous review process. Technical, scientific, and engineering information that is relied upon to support recommendations in decision documents or form the basis of designs , specifications, and/or O&M requirements will be reviewed to ensure technical quality and practical application.

L.2 REVIEWS TO BE CONDUCTED FOR WP-43B

L.2.1 District Quality Control (DQC) Review

District Quality Control Reviews will be performed on all engineering and design products for WP-43B as required by EC-1165-2-214.

L.2.2 Agency Technical Review (ATR)

Agency Technical Reviews will be performed on the engineering and design products associated with the WP-43B as required by EC-1165-2-214.

L.2.3 Independent External Peer Review (IEPR)

Since WP-43B will be designed to P&S level for the OHB Ring Levee Project, a Type II IEPR will be conducted.

L.2.4 Lessons Learned and After Action Reviews

Prior to start of designs, Design Engineers will review lessons learned from available databases and files that are pertinent and will assure they are considered for incorporation into the engineering and design products being prepared.

L.2.5 Final Product Quality Review Certifications

Upon completion of each design product or deliverable, the Project Engineer will perform a final product quality review and prepare a quality review certificate.

L.3 REVIEW DOCUMENTATION

The attachments at the end of this Appendix document the status of the reviews that have occurred and will be updated as reviews are completed and closed out.

Public/SBU/FOUO | AGENCY: USACE-ProjNet | USER: Richard Femrite (Logout)

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Project: (FMM-PED-L1) Fargo-Moorhead Metro - OHB

DrChecks(4)   Search:

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Pinned?	RPT	ID/Edit	Add Comments	Edit All/Note/Yours	Evaluate Pend/Concur/Other	My BackCheck Pend/Opn/Clsd	All BackCheck Pend/Opn/Clsd
		00003	PER-OHB-WP43B-ATR Review (Jan 03/14 to Jan 17/14) Closed for comments	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
		00004	PER-OHB-WP43B-Sponsor Review (Jan 03/14 to Jan 17/14) Closed for comments	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
		00002	PER - OHB-WP43B - DQC (Nov 25/13 to Dec 09/13) Closed for comments	0 / 0 / 0	0 / 15 / 0	0 / 0 / 0	15 / 0 / 0
		00001	OHB-wave analysis (Oct 15/13 to Nov 25/13) Not Assigned	0 / 0 / 0	0 / 1 / 0	0 / 0 / 0	0 / 0 / 1

Showing 1 to 4 of 4 entries

Project Memo   Search:

To change your access to this project, please contact a **manager** listed below.   Search:

First Name	Last Name	Site	Email	Voice
Brett	Coleman	MVP St. Paul Distric...	brett.r.coleman@usace.army.mil...	6512905452

Showing 1 to 1 of 1 entries

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Comment Report: All Comments
Project: (FMM-PED-L1) Fargo-Moorhead Metro - OHB Review: PER - OHB-WP43B - DQC
Displaying 15 comments for the criteria specified in this report.
343 ms to run this page

Id	Discipline	DocType	Spec	Sheet	Detail
5444719	CAD-BIM	Plans	n/a	n/a	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
Drawings with written comments are provided to designer. These contain spelling errors, etc.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** Thank you for your review. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

Id	Discipline	DocType	Spec	Sheet	Detail
5444724	CAD-BIM	Plans	n/a	G-001	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
Cover sheet missing Solication/contract/month text in lower left. The 4th line of text doesn't match the 4th line of the title block text.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** Solicitation,Contract and Month text have been added in lower left. Title blocks have been changed to match the text. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

Id	Discipline	DocType	Spec	Sheet	Detail
5444728	CAD-BIM	Plans	n/a	G-003	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
work limit line in gegend doesn't seem to be plotting correctly.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** Work limit line has been fixed to plot correctly. Submitted By: Edith Pang (651-290-5552) Submitted On: Jan 02 2014
	Backcheck not conducted
	Current Comment Status: **Comment Open**

Id	Discipline	DocType	Spec	Sheet	Detail
5444730	CAD-BIM	Plans	n/a	C-101	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
For control points located outside of the plan area, identify an approximate distance to location.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** Distance to location of control point has been added. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted

	Current Comment Status: **Comment Open**				
5444739	CAD-BIM	Plans	n/a	CS101	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
There are 2 solid lines that cross in plan view near coordainte D2. They seem to ve the highway or township. Please clarify.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** The level that the solid lines are on has been turned off. (These lines are only shown on ROW drawings). Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5444742	CAD-BIM	Plans	n/a	CS101	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
Define the screened dashed line in the profile.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** The screened dashed line has been removed. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5444771	CAD-BIM	Plans	n/a	CS105 & CS106	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
work limits extend outside of the plan area. Please clarify.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** A new sheet (CS114) has been added to drawing set showing the borrow site and future retention pond (location to be detirmined at future date). Match lines have been added to sheets CS105 & CS106. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5444779	CAD-BIM	Plans	n/a	CS109	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
I believe that section F Bubble should be Section E. There doesn't seem to be a Section F symbol.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** All section bubbles have been checked to correspond with cross sections sheets. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5444787	CAD-BIM	Plans	n/a	CS113	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
WP-43D is called out on the profile. Is the levee being built as part of this project or that project? Please clarify.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** At the time of ATR Submittal the design and construction phasing of 43D is unknown. Submitted By: Edith Pang (651-290-5552) Submitted On: Jan 02 2014				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
5444970	CAD-BIM	Plans	n/a	CS501	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): CAD-BIM
Scale bars and scales are missing. Or add "not to scale".

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 03 2013

1-0	Evaluation **Concurred** "NOT TO SCALE" has been added to drawing. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
5445582	CAD-BIM	Plans	n/a	n/a	n/a

Comment Classification: For Official Use Only (FOUO)

Coordinating Discipline(s): Real Estate
Real Estate drawings are not included.

Submitted By: Chris Afdahl (651-290-5712). Submitted On: Dec 04 2013

1-0	Evaluation **Concurred** The Real Estate drawing are not included in this submittal. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
5450980	Civil	Plans	n/a	n/a	n/a

Comment Classification: Public (Public)

FMM43B_DTR_DQC.pdf documents were reviewed and courtesy comments were provided to the PDT for consideration in preparing the 65% DTR documents.

Submitted By: Christine Moss ((651) 290-5025). Submitted On: Dec 09 2013

1-0	Evaluation **Concurred** Thank you for your review. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013				
	Backcheck not conducted				
	Current Comment Status: **Comment Open**				
5450981	Civil	Plans	n/a	CS106	n/a

Comment Classification: Public (Public)

It appears that the inside drainage ditch has a low point at STA IB 51+66.98 per CS207 at Field Access Road 1 (51st Street). A 145 l.f. 64"x43" CSPA culvert is identified however, the profile indicates a low point with drainage meeting at the access road. It is not clear where the drainage goes.

Submitted By: Christine Moss ((651) 290-5025). Submitted On: Dec 09 2013

1-0	Evaluation **Concurred** Callout has be added stating "INSIDE DRAINAGE DITCH AND CULVERT WILL OUTLET INTO RETENTION POND" AT THE TIME OF ATR SUBMITTAL THE DESIGN AND LOCATION OF RETENTION POND HAS NOT BEEN DETIRMINED Submitted By: Edith Pang (651-290-5552) Submitted On: Jan 02 2014
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5450982	Civil	Plans	n/a	CS111	n/a

Comment Classification: Public (Public)

It is not clear where the 100 LF 35"x24" CSPA culvert on the inside drainage ditch under Access Road (Main Street) flows to since the ditch appears to end and CS112 and CS113 do not indicate an inside drainage ditch.

Submitted By: Christine Moss ((651) 290-5025). Submitted On: Dec 09 2013

1-0	Evaluation **Concurred** Callout has been added stating "CULVERT WILL OUTLET INTO FUTURE RETENTION POND DESIGNED AND CONSTRUCTED BY OTHERS". Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

5451649	Geotechnical	Plans and Specs	n/a	n/a	n/a

Comment Classification: For Official Use Only (FOUO)

The provided documents were reviewed and I have no significant comments.

Submitted By: Gregory Wachman (651-290-5192). Submitted On: Dec 10 2013

1-0	Evaluation **Concurred** Thank you for your review. Submitted By: Edith Pang (651-290-5552) Submitted On: Dec 31 2013
	Backcheck not conducted
	Current Comment Status: **Comment Open**

US Army Corps of Engineers®
St. Paul District

Appendix M: Memos for Record and Guidance Memos

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

Doc Version: 35% Review Submittal

P2#

03 January 2014

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Appendix M: Memos for Record and Guidance Memos

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Attachment M-1 MFR-019 Oxbow, Hickson, Bakke Ring Levee Utility Relocation Requirements

Attachment M-2 MFR-020 Landscape Enhancements and Golf Course Layout along the Oxbow, Hickson, Bakke Ring Levee

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Appendix M: Memos for Record and Guidance Memos

M.1 GENERAL

This appendix contains the Memos for Record and Guidance Memos that are referenced within the Design Documentation Report and Appendices. This is not a complete listing of Memos for Record and Guidance Memos associated with the Oxbow, Hickson, Bakke Ring Levee Project.

Additional information will be provided in future submittals.

MEMORANDUM FOR RECORD

SUBJECT

Oxbow, Hickson, Bakke Ring Levee – MFR-019, Utility Relocation Requirements

REFERENCE

EM 1110-2-1913, Design and Construction of Levees
EM 1110-2-2902, Conduits, Culverts and Pipes

PURPOSE OF THIS MFR

This memorandum discusses general requirements for utility relocations within the Oxbow, Hickson, Bakke (OHB) Ring Levee Project. These requirements will aid impacted utility owners in developing a relocation plan. These requirements are general; each proposed utility relocation shall be reviewed by the Corps of Engineers (COE) on a case-by-case basis.

The OHB Ring Levee is required to mitigate and reduce the flood risk for the three communities from flooding caused by the staging area of the FM Diversion Project. The proposed project consists of a ring levee surrounding all three communities, local drainage ditches on the interior and exterior (as needed) and road raises. As a result of this project, a variety of existing utilities will have to be relocated from within the project footprint. In addition, utilities will have to cross the levee to provide service to the residents on the inside.

RESPONSIBILITIES

The Local Sponsor shall be responsible for:

- Coordination with utility owners impacted by the proposed project.
- Development of draft and final demolition and relocation plans that will be submitted to the COE for review and comment.
- Evaluate COE comments and coordinate with COE reviewers to close out comments.
- Depending on the type and location of proposed utilities within the project limits, some relocations may need to be constructed prior to levee construction while others at the time of levee construction (i.e. freeboard crossings). If utility relocations and/or crossings need to be included in the levee design packages, final approved relocation plans must be submitted to the appropriate levee design team no later than 30 days prior to the 65% submittal date.

The COE shall be responsible for:

- Timely review of draft and final demolition and relocation plans, and submittal of review comments.
- Incorporating necessary demolition and relocation plans into the COE levee design package (currently WP-43B).

EXISTING UTILITY PIPELINES CROSSING THE LEVEE

EM 1110-2-1913 outlines requirements for pipelines and other utility lines crossing levees. In general, existing utilities that cross the proposed ring levee alignment should be removed unless a site specific engineering evaluation is developed showing that the utility can remain in place. Criteria for the engineering evaluation can be found in Chapter 8 of the EM.

PROPOSED UTILITY PIPELINES CROSSING THE LEVEE

In general, new pipelines should cross the levee above the design still water pool of 922.5 ft and should not cross beneath the embankment. The number of crossings should be limited, and the use of utility corridors where multiple lines cross at the same location is encouraged. If possible, crossings should be located where the existing ground is at its highest elevation. The presence of local drainage ditches inside and outside of the levee may complicate the freeboard crossing design and should be taken into account when crossing locations are evaluated.

There may be instances where certain pipelines may be allowed to cross under the levee. There are many factors that must be considered and addressed in a site specific engineering evaluation before any such crossing would be approved. Chapter 8 of EM 1110-2-1913 discusses these factors and concerns. Pressure pipelines are of particular concern because of the damage that can occur to the levee if a line fails in the foundation of the levee.

EXISTING UTILITY ABANDONMENT AND REMOVAL

Existing above and below ground utilities within the project limits shall be removed by the demolition and relocation contractor prior to levee construction, unless identified as better suited for removal by the OHB ring levee contractor. In the latter case, the demolition and relocation contractor shall disconnect, cap and abandon existing underground utility lines in place for future removal. Removal includes but is not limited to utility piping, piping appurtenances, and bedding materials. Trenches shall be backfilled with impervious fill and compacted to 95% of maximum density. The laboratory tests for moisture-density relations shall be made in accordance with ASTM D698 (Standard Proctor); and field density tests be determined in accordance with ASTM D 2167 (Rubber Balloon Method) or ASTM D 6938 (Nuclear Method). The density test results shall be verified by performing an ASTM D 1556 density test at the start of the job and for every 10 ASTM D 6938 density tests.

PROPOSED UTILITY PIPELINE DESIGN AND CONSTRUCTION

Proposed pipeline crossings in the levee above the design still pool elevation will be evaluated on a case by case basis, and calculations shall be submitted to fully document the design. The following are provided as guidelines for pipeline crossings in the levee above the design still pool elevation:

1. If possible, proposed utility crossings shall be aligned to cross perpendicular to the levee

centerline at the crossing location. Variations to the crossing angle may be dictated by field conditions and the location of connecting utilities. Final crossing location and orientation relative to the proposed levee alignment shall be approved by the COE during project design stages.

2. To provide frost protection, additional levee fill will be required to meet local requirements for 7.5’ minimum cover. Earthen fill is the preferred alternative for frost protection, as it is more reliable than insulation.
3. The new pipelines shall be designed in accordance with EM 1110-2-2902. It is recommended that ductile iron pipe be used. If plastic pipe (ABS, HDPE, PVC) is desired, approval is required from USACE Headquarters (HQUSACE).
4. Pipeline material and joints shall be pressure rated to withstand all fluid pressures that may be encountered. Specifications shall be written to require hydrostatic pressure testing after installation.
5. Pipelines crossing levees will be televised once every five years minimum by levee safety inspection personnel. Design of pipelines shall allow this televising to occur by providing entrance and exit points and a way to evacuate the line if necessary. The exception to this will be potable water lines, where hydrostatic pressure testing once every five years will be required to evaluate the condition of the pipeline.
6. Positive shut-off valves shall be installed on either side of the embankment. This will provide a means to isolate the utility line in the event that it fails, repairs are needed, or relocation is to occur.
7. Calculations are required to show that each utility line has adequate strength/flexibility to withstand the expected loading/settlement.

Proposed pipeline crossings under the levee will be considered if justification is provided that shows why it is necessary instead of a crossing above the design still pool elevation. These crossings will also be evaluated on a case by case basis, and calculations shall be submitted to fully document the design. The guidelines above will also apply to crossings under the levee. The following additional guidelines also apply:

8. The pipeline must be laid so that the crown is at least 3’ below the levee inspection trench and local drainage ditches so it will not be damaged during construction of these features.

9. If open cut is utilized, the trench shall extend under and 20’ beyond the proposed levee prism. At the COE’s discretion, the utility pipeline may be required to be encased in Controlled Low-Strength Material (CLSM) (specification attached). When CLSM is required, the new pipeline shall be placed on firm ground at the bottom of the trench and CLSM shall be placed in the trench to 1 foot above the crown of the pipe. Trenches shall be backfilled with impervious fill and compacted to 95% maximum density. The laboratory tests for moisture-density relations shall be made in accordance with ASTM D698 (Standard Proctor); and field density tests be determined in accordance with ASTM D 2167 (Rubber Balloon Method) or ASTM D 6938 (Nuclear Method), the density test results shall be verified by performing an ASTM D 1556 density test at the start of the job and for every 10 ASTM D 6938 density tests.

10. If horizontal directional drilling is utilized, it shall be accomplished pursuant to the

attached "Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling", June 2002 and the St. Paul District's "Guidance Pertaining to Horizontal Directional Drilling Under a Flood Barrier/Channel." There shall be no pipe entry/exit locations (pits) within 50' of either toe of the proposed levee.

11. It is recommended that all pressurized utility lines (sewer, water and gas) crossing under the channel and levee be cased. The use of casing pipe should also be considered for other utility crossings. In general, casing pipe material shall be limited to one that can be joined together continuously, while maintaining sufficient strength to resist the high tensile stresses imposed during the pullback operation. When used, the COE recommends the use of HDPE or steel pipe. All casing specifications shall be submitted to the COE for review and comment.

RAPID CLOSURE VALVES

The need for rapid closure valves is dependent upon the type of utility relocation. Generally, rapid closure valves will be required on each side of utility pipeline crossings. The purpose of the valves is to provide pipeline isolation in the event of leakage, rupture, repairs or relocation. The rapid closure valves shall be located a minimum of 20 feet beyond the outermost project feature (i.e., levee, berm or drainage ditch).

NON-PIPELINE UTILITY CROSSINGS

Cable TV, Telecommunications and Underground Power lines are typically trenched into the ground at depths ranging from 3 to 4 feet below the ground surface. The existing utilities shall be removed from the footprint of the proposed ring levee and relocated in the levee above the design still pool elevation.

UTILITY RELOCATIONS NOT CROSSING THE LEVEE BUT WITHIN PROJECT WORK LIMITS

Utility relocations within project work limits but not crossing the levee shall be designed to meet all federal, state and local requirements. Relocations shall be designed to withstand heavy loading from construction equipment and shall meet minimum frost protection depths as required.

Utilities running parallel to the project alignment must be located a minimum of 20 feet outside the outer most toe of levee/ditch as applicable.

DESIGN SUBMITTAL REQUIREMENTS

Complete submittal of plans, specifications, Design Documentation Report and all other supporting information.

POST CONSTRUCTION SUBMITTAL REQUIREMENTS

a. Testing reports.
b. Product Data-Materials: Pipe, joints, valves, fittings & appurtenances.
c. As-Built Drawings: Submit As-Built drawings for the complete utility line relocation showing complete detail, including trench dimensions, pipe profile, pipe alignment, valve locations, connection box locations, manholes, etc.
d. Letter from designer of record verifying that project design meets all applicable governmental, COE and industry design standards.

MAINTENANCE AND ABANDONMENT PLAN

Responsible utility owners shall prepare a maintenance and abandonment plan for all utilities located within the limits of the subject project. The plan shall address applicable facility maintenance, periodic valve testing, leakage, repair (if applicable) and abandonment. All piping shall be provided with metallic marking tape or other applicable passive marking system to facilitate utility location by field personnel for future maintenance and repair.

CROSSING IDENTIFICATION

Color coded fiberglass service line marker posts shall be provided for all underground utilities at each crossing point (inside and outside side). Markers (Length 72”; width 1”.) shall identify service lines, valves & underground property

AS BUILT REQUIREMENTS

Utility owner shall provide As-Built plans and As-Built survey data to COE for all relocations within the limits of the subject project. As-Built drawings shall be submitted in electronic format (Microstation is preferred). SDSFIE-compliant survey point data shall be submitted in ASCII text or shape file format. FGDC-compliant metadata files shall be submitted which describes, in general, when the as-built survey was conducted, who conducted the survey, how it was conducted, and the accuracy of the survey data. Surveys should be done in the project spatial reference system:

NAD83 (NSRS2007), North Dakota State Plane Coordinate System, South Zone
NAVD 88 (GEOID09)
US Survey Feet

SIGNATURES:

____

Brett Coleman Date
Project Manager, MVP
USACE

____

Marsha Mose Date
Chief, Design Branch, MVP
USACE

____

Renee McGarvey Date
OHB Technical Manager, MVP
USACE

____

Bruce Spiller Date
CH2MHill
Sponsor’s Program Management Consultant

ATTACHMENT 1

Guidance Pertaining to Horizontal Directional Drilling Under a Flood Barrier/Channel

GUIDANCE

Pertaining to

Horizontal Directional Drilling Under a Flood Barrier/Channel

The following information and guidance pertains to horizontal directional drilling (HDD) under an engineered flood barrier (i.e floodwall, levee embankment, diversion channel).

The two primary concerns with horizontal directional drilling (HDD) beneath a levee or floodwall are:

1. Hydrofracturing (drilling fluid pressure exceeding the tensile strength of the soil) the foundation soils beneath the flood barrier during drilling operations.

2. Development of a preferential seepage path along the pipeline/utility after installation.

Generally, the COE would require the following information in the permit application for any utilities installed by HDD that pass beneath a flood barrier.

1. Proposed drill path alignment (both plan and profile views).

2. Location of entry and exit points.

3. Proposed depth of cover.

4. Diameter of the borehole, diameter of pipe and type of pipe to be installed, if used, or diameter of utility.

5. Proposed method to fill annulus.

6. Location, elevations, and clearances of all utility crossings and structures.

Based on our recent experience, we feel comfortable with the following recommendations/guidelines:

- Allow the Contractor to proceed without actively monitoring the drill pressures. Suggest that only fresh drilling mud be used. It may not be necessary to insist on this provision depending on the length of flood barrier to be traversed, however it will be easier to maintain a proper viscosity if clean mud is used.

- If “mud motor” HDD technology is used, hold the density of the drilling fluid as close as possible to 8.4 lbs/gallon (or 45seconds/quart in a Marsh Funnel).

- Bentonite can be used to fill the annulus.

- Generally, depth of burial should be at least 10 feet below grade where the utility passes under the flood barrier.

- Fluid jetting methods should not be used as a means of cutting beneath a flood protection project.

- The Contractor will be responsible for repairing any soil fracturing, drilling fluid reaching the surface, etc. as well as any slope failure resulting from the drilling process. The Contractor should note any spots where fluid loss occurs, and the COE should get a record of the amount of fluid loss as well as the location.

- Prior to commencing, the Contractor should explain their method for maintaining directional control during drilling operations. In other words, how will he/she verify where the bit is horizontally and vertically so that it does not accidentally wander beneath the levee foundation any more than absolutely necessary?

- The Contractor should provide an “as-built” drawing upon completion of the directional drilling and installation of the line. This drawing should include alignment & profile data.

- It should be plainly stated that any foundation or flood barrier damage resulting from the directional drilling will be repaired by the Contractor to City/Gov’t. specifications at Contractor expense.

- The Contractor should be informed that the suspension of the requirement to actively monitor downhole pressures does not relieve them of the ultimate responsibility of leaving the flood barrier foundation in the same condition, as it was before the horizontal drilling procedure was undertaken.

ATTACHMENT 2

Draft Controlled Low-Strength Material (CLSM) Specification

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CONTROLLED LOW-STRENGTH MATERIAL (CLSM)

04/12

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-

SECTION 03 22 70.01 13

CONTROLLED LOW-STRENGTH MATERIAL (CLSM)
04/12

PART 1 GENERAL

1.1 REFERENCES

All publications referenced shall be the most current version, edition, standard, latest revision, or reapproval unless otherwise stated. The following publications and standards listed below will be referred to only by the basic designation thereafter, and shall form a part of this specification to the extent indicated by the references thereto:

ASTM INTERNATIONAL (ASTM)

ASTM C 33/C 33M	(2011a) Standard Specification for Concrete Aggregates
ASTM C 94	(2011b) Ready-Mixed Concrete
ASTM C 150	(2011) Standard Specification for Portland Cement
ASTM C 220	(1991; R 2009) Standard Specification for Flat Asbestos-Cement Sheets
ASTM C 618	(2008) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 685	(2010) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 940	(2010a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM D 4832	(2010) Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5971	(2007) Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material
ASTM D 6023	(2007) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)
ASTM D 6103	(2004) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

1.2 DESIGN REQUIREMENTS

Controlled Low-Strength Material (CLSM) mixture proportion shall consist of 100 pounds or less of portland cement plus fly ash per cubic yard; pozzolan; sand; water; and a fluidifier, if required to obtain the required slump. The CLSM fill mixture proportion shall have a flow consistency of more than 8 inches. The flow consistency shall be determined in accordance with ASTM D 6103. CLSM fill shall have a compressive strength of 100 psi at 28 days. The compressive strength of the CLSM shall be determined in accordance with ASTM D 4832 after being made and cured in accordance with ASTM D 4832. The mixture proportions shall be reported in accordance with ASTM C 94. If the CLSM is to be placed using a concrete pump, the mixture proportions shall be designed so that it will not segregate in the pump line under pressure or when there is an interruption in flow.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Data

On-Site Batching and Mixing

Water Reducing

Concrete Mixture Proportions

The Contractor shall submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for all equipment and materials.

SD-07 Schedules

Placing

The methods and equipment for transporting, handling, and depositing the CLSM backfill and CLSM fill shall be submitted to the Contracting Officer prior to the first placement.

SD-08 Statements

Concrete Mixture Proportions

CLSM mixture proportions shall be the responsibility of the Contractor and shall be designed in accordance with the criteria in paragraph DESIGN REQUIREMENTS. Ten days prior to placement of CLSM, the Contractor shall submit to the Contracting Officer the mixture proportions that will produce CLSM of the qualities required. Mixture proportions shall include the dry weights of cementitious material(s); and saturated surface-dry weights of the fine aggregate; the quantities, types, and names of admixtures; and quantity of water per cubic yard of concrete. All materials included in the mixture proportions shall be of the same type and from the same source as will be used on the project.

SD-09 Reports

CLSM Mixture Proportions Tests

Applicable test reports shall be submitted to verify that the CLSM mixture proportions selected will produce CLSM of the quality specified. The results of all tests and inspections conducted at the project site shall be reported informally at the end of each shift and in writing weekly and shall be delivered to the Contracting Officer within 3 days after the end of each weekly reporting period.

SD-13 Certificates

Cement

Cementitious Material will be accepted on the basis of a manufacturer's certificate of compliance.

Aggregates

Aggregates will be accepted on the basis of certificate of compliance that the aggregates meet the requirements of the specifications under which it is furnished.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Ready-Mixed Concrete

Ready-mixed concrete shall conform to ASTM C 94, except as otherwise specified.

2.1.1.1 Volumetric Batching and Continuous Mixing

Volumetric batching and continuous mixing shall conform to ASTM C 685.

2.1.1.2 On-Site Batching and Mixing

The Contractor shall have the option of using an on-site batching and mixing facility. The method of measuring materials, batching operation, and mixer shall be submitted for review by the Contracting Officer. On-site plant shall conform to the requirements of either ASTM C 94 or ASTM C 685.

2.1.2 Portland Cement

Portland Cement shall conform to ASTM C 150, Type I or II, low alkali.

2.1.3 Pozzolan

Pozzolan shall be Class F or C fly ash conforming to ASTM C 618.

2.1.4 Sand

Sand shall meet the requirements of fine aggregate of ASTM C 33/C 33M.

2.1.5 Fluidifier

The fluidifier shall give the CLSM fill the following salient characteristics:

a. must have less than 1 percent bleed water in accordance with ASTM C 940

b. have an initial set time of more than 5 hours in accordance with ASTM C 220 modified by using a Ferioli apparatus

c. have a flow consistency equal to or more than 8 inches in accordance with ASTM D 6103

d. have a compressive strength of 100 psi at 28 days in accordance with ASTM D 4832

e. maintain a homogeneous mixture during pumping

1. Quantity of admixture(s) required in the mixture proportion is governed by the salient characteristics specified.

2. The admixture shall be added as directed by the manufacturer, in most cases it added to the CLSM at the job site and mixed for a minimum of 5 minutes at mixing speed.

2.1.6 Water

Water shall be potable water that is fresh, clean, and free from sewage, oil, acid, alkali, salts, or organic matter.

2.2 MIXING AND TRANSPORTING

The CLSM shall be mixed and transported in accordance with ASTM C 94.

PART 3 EXECUTION

3.1 TRENCH PREPARATION

Once the trench has been dug it shall be cleaned of all loose material and debris to the satisfaction of the Contracting Officer before any CLMS fill is placed. The new utility pipeline shall be placed on firm ground at the bottom of the trench and a minimum of 1 foot of CLSM fill shall be placed above the top of the pipeline. The pipeline shall be securely anchored to maintain its position and prevent it from any movement during placement of the CLSM.

3.2 PLACEMENT

3.2.1 General

CLSM placement shall not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement. When CLSM is mixed and/or transported by a truck mixer, the CLSM shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours (or 45 minutes when the placing temperature is 85 degrees F or greater unless a retarding admixture is used). The fluidifier shall not be added to the Ready Mix trucks until they have arrived onsite. The fluidifier shall be added to each truck at the proper dosage rate and mixed for 5 minutes and no more than 15 minutes before it is placed. CLSM shall be conveyed from the mixer to point of placement as rapidly as practicable by methods which prevent segregation or loss of ingredients.

3.2.2 Consolidation

Consolidation of the CLSM will not be required.

3.3 TESTS

3.3.1 General

The individuals who sample and test CLSM as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to ACI minimum guidelines for certification of concrete Field Testing Technicians, Grade I.

3.3.2 Inspection Details and Frequency of Testing

3.3.2.1 Flow Consistency

Flow consistency shall be checked once during each shift that CLSM is produced for each class of concrete required. Samples shall be obtained in accordance with ASTM D 5971 and tested in accordance with ASTM D 6103. Whenever a test result is outside the specifications limits, the CLSM shall not be delivered to the placement and an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the water-cement ratio does not exceed that specified in the submitted CLSM mixture proportion.

3.3.2.2 Compressive-Strength Specimens

At least one set of test specimens shall be made each day on CLSM placed during the day or every 10 cubic yards placed. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths are detected. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is accomplished in a completely random and unbiased manner. A set of test specimens for concrete with strength as specified in paragraph DESIGN REQUIREMENTS shall consist of six cylinders, one tested at 7 days, one tested at 14 days, and two tested at 28 days. Two cylinders shall be tested as directed. Test specimens shall be molded and cured in accordance with ASTM D 4832 and tested in accordance with ASTM D 4832. All compressive strength tests shall be reported immediately to the Contracting Officer.

3.3.3 Density

At least one set of test specimens shall be made each day on CLSM placed during the day or every 20 cubic yards placed. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is accomplished in a completely random and unbiased manner. Test procedures and calculations shall be in accordance with ASTM D 6023.

3.3.4 Reports

The Contractor shall prepare reports of all tests and inspections conducted at the project site.

-- End of Section --

ATTACHMENT 3

Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling

ERDC/GSL TR-02-9

Geotechnical and Structures Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling

Carlos A. Latorre, Lillian D. Wakeley, and Patrick J. Conroy

June 2002

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Preface

The work documented in this report was performed during May through October 2001 as part of the technology transfer component of the Geotechnical Engineering Research Program (GTERP), specifically in the work unit entitled Applications of Trenchless Technology to Civil Works. Funding for preparation and publication of this report was provided by the U.S. Army Corps of Engineers as part of its ongoing support of civil works research. Mr. Carlos Latorre, U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), is principal investigator for this work unit. The research team also includes Dr. Lillian D. Wakeley, GTERP Manager (ERDC, GSL), Mr. Patrick J. Conroy, U.S. Army Engineer District (USAED), St. Louis (MVS), and Mrs. Nalini Torres (ERDC, GSL). Mr. Jim Chang, CECW, is GTERP Technical Monitor.

The guidelines and specifications provided in this report are based on work completed previously by Dr. R. David Bennett, formerly GSL, ERDC; and Mr. Joseph M. Morones, State of California, Department of Transportation; and modified with their cooperation by Mr. Latorre. This report was prepared by Messrs. Latorre and Conroy and Dr. Wakeley. The authors gratefully acknowledge technical review of this document by Mr. George Sills, USAED, Vicksburg, Mr. Pete Cali, USAED, New Orleans; and Mr. John Wise, USAED, Fort Worth.

This report was completed at ERDC under the general supervision of Dr. Wakeley, Chief, Engineering Geology and Geophysics Branch, Dr. Robert L. Hall, Chief, Geosciences and Structures Division, GSL, and Dr. Michael J. O'Connor, Director, GSL.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

1 Introduction

Background

Early methods of installing pipelines and utilities across rivers and streams involved excavation of trenches. After the placement of the pipeline, the trenches were backfilled to protect the pipeline from hazards. These early dredged crossings were generally sited at the channel crossing of the thalweg between bends of the river. Here the river is generally a wide, shallow rectangle. This location is chosen because of its hydraulic stability and the economic limitation of the dredging equipment.

In and across the U.S. Army Engineer Division, Mississippi Valley (MVD), lies the heart of the pipeline transmission network of the United States. Hundreds of individual pipelines traverse from Texas and out of the Gulf of Mexico across the numerous rivers, bayous, and wetlands of Louisiana to service the northeast population centers on the Atlantic coast. Along the leveed banks of the lower Mississippi River, pipeline crossings exist between almost every bendway. The crossings of these earthen flood control structures present a difficult and expensive construction problem resulting from concerns about the integrity of the levee which may be subjected to sliding, piping, and erosion failures.

Horizontal Directional Drilling Method

In the early 1970s, a new process was introduced to install pipelines by use of horizontal directional drilling (HDD) techniques acquired from the oil and gas industry. The method has steadily grown to achieve worldwide acceptance and has been used in over 3,000 installations totaling over 1,288 km (800 miles) of pipelines. Today pipeline installations increasingly rely upon HDD technology as the primary method for crossings of watercourses, wetlands, utility corridors, roads, railroads, shorelines, environmental areas, and urban areas.

The placement of pipelines by the HDD method requires the drilling of a guided pilot bore, generally using a 7.3- to 11.43-cm- (2-7/8- to 4-1/2-in.-) diam drill pipe. At the lead, or downhole, end of the pilot string is a fluid powered cutting tool. The cutting tool is either a drill motor to which a bit is connected or a jet bit with nozzles. Drilling fluid is pumped through the string, and fluid causes the motor to rotate which turns the bit to cut the hole. With jet bits, the velocity from the jet nozzle erodes the hole in front of the drill pipe. Located behind the drill head is a section of the drill pipe with a small bend or angular deviation. This section, known as a bent sub or bent housing, allows the motor or jet nozzle to be directed. A steering tool is latched onto a locking tool on the drill pipe. In this steering tool are a magnetometer and other devices to determine the azimuth, inclination, and orientation of the tool or tool face. Position determinations are made, and the data from the steering tool are plotted in the field to determine the profile and alignment of the bore. Analysis of this position plot is then used to determine drilling progress and path. At a desired location, the pilot drill pipe exits the ground. The pilot bore is then enlarged by pulling reaming tools back through the bore. Once this operation is completed, the pipeline or conduit is attached to the drill pipe and pulled back through the predrilled bore. This is accomplished as the drill pipe is removed, joint by joint, from the drilled path until the pipeline reaches the ground surface at the entry end of the bore.

One of the primary parameters in horizontal directional drilling is the drilling fluid or mud. The drilling mud is usually comprised of a bentonite and water mixture with the main function to power the downhole cutting tool used to open the bore. Secondary functions of the drilling mud are to serve as a lubricant for the pipeline during installation and, in cases of rock or hard ground bores, to remove cuttings from the bore.

The use of HDD has been restricted, in part, by major misunderstandings of how the HDD process actually functions. It is assumed by many that it is similar to well drilling or tunneling in that an open bore is required. This is true only in hard geologic materials such as rock. The majority of HDD pipeline crossings installed to date have been performed in soft ground comprised chiefly of alluvial deposits of silts, sand, and clay. In these types of soils, the process begins with a small pilot bore from which various cutters are inserted to loosen the soil as it is mixed into a slurry by injection of the drilling mud. Once this slurry pathway has been made large enough, generally 25.4 to 30.5 cm (10 to 12 in.) greater than the diameter of the pipeline, the installation of the pipeline commences by pulling the pipeline back through the soft slurry pathway. Some of the in situ soil and fluid are then compressed into the formation, and the remainder of the soil is actually pumped out of the path.

The information in this report represents some of the experiences of the Corps of Engineer (CE) Districts involving HDD for installation of utilities under levees. The experience of the U.S. Army Engineer District (USAED), St. Louis, in dealing with installation of communications systems was identified as having wide applicability to the Corps. Engineering documentation from two St. Louis District projects, the set of guidelines presented in “Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling” (Staheli et al. 1998), Engineer Manual (EM) 1110-2-1913 (Headquarters, Department of the Army (HQDOA) 2000), and the State of California Department of Transportation (CalTrans) Encroachment Permits, “Guidelines and Specifications for Horizontal Directional Drilling Installations” (Morones 2000), provided the basis for this report. A paper on the subject was presented at the Corps Infrastructure Systems Conference in August 2001.

Problem Identification

Although horizontal directional drilling could offer cost-effective, safe alternatives to installing pipelines with open trenching, the CE has no standard guidelines allowing the installation of pipelines with this construction method. As a result, permitting policies are extremely varied and some districts strictly prohibit the use of this technique. While recommended guidelines for pipeline installation using HDD were developed for use by the CE Districts through this work unit back in 1998, as part of a lengthy and detailed EM, the guidelines were not readily recognized by permitting offices as applicable to the questions they face. Also, there is growing pressure on Corps offices particularly by communications companies to install cables under levees.

Objectives

The objectives are to provide and distribute this information to targeted potential users like the CE District permitting offices and engineers that receive applications from utility companies to install utilities under levees. This report addresses those questions and helps CE offices with the growing pressure they are receiving from private companies to allow them to install cables/pipelines under levees. These guidelines are presented in a quick and organized manner that will provide criteria by which to evaluate proposals (e.g., application review, approving, disapproving, and/or making recommendations) for levee crossings, beneath rivers, and within levee rights-of-way using HDD techniques without endangering the levees; and the use of HDD for pipeline installation in areas where the installation technique might be applicable and capable of providing a tremendous cost savings to the Corps of Engineers and the pipeline industry. These guidelines will also help to demonstrate that, very often, these techniques offer substantial economic and operational advantages over current practices. Last but not least, these guidelines will help us stay involved in the development of this fast and fairly new emerging technology.

Potential Benefits

The pipeline industry would realize a tremendous benefit from the use of HDD in crossing of flood control levees. This benefit would include significant cost reduction in construction and maintenance presently required for levees and adjacent road crossings such as bridges, concrete boxes, earthen cover, and ramps. The use of the technique could also benefit the Corps of Engineers by: (a) eliminating blockage of levee crown from buried pipelines, pipeline bridges, or conduit boxes, (b) eliminating differential settlement imposed on levees by the construction of buried pipelines, pipeline bridges, or conduit boxes, (c) improving the operation and safety of grass cutting and other maintenance equipment on the levees, and (d) reducing risk of rupture of pipelines located above or near ground surface on levee slopes, (e) reducing disruption in urban areas, and (f) providing better public acceptance and increasing environmental consciousness.

Potential Problem

While considering any alteration request, the District's prime objective is to protect the integrity of the flood protection systems. In the case of HDD, designers must be aware and take into account during the design stage the following:

a. Hydrofracture during installation.

b. Preferred seepage path after construction.

To allow third parties to utilize HDD techniques, the District needed methods and processes to prevent these problems from occurring.

2 HDD Guidelines and Specifications

Permit Application Submittal

The permit application package should contain the following information in support of the permit application.

a. Location of entry and exit point.

b. Equipment and pipe layout areas.

c. Proposed drill path alignment (both plan and profile view).

d. Location, elevations, and proposed clearances of all utility crossings and structures.

e. Proposed depth of cover.

f. Soil analysis.

g. Product material (HDPE/steel), length, diameter-wall thickness, reamer diameter.

h. Detailed pipe calculations, confirming ability of product pipe to withstand installation loads, and long-term operational loads.

i. Proposed composition of drilling fluid (based on soil analysis) viscosity and density.

j. Drilling fluid pumping capacity, pressures, and flow rates proposed.

k. State right-of-way lines, property, and other utility right-of-way or easement lines.

l. Elevations.

m. Type of tracking method/system.

n. Survey grid establishment for monitoring ground surface movement (settlement or heave) because of the drilling operation.

o. Contractor's work plan (see page 11 in this document).

All additional permit conditions shall be set forth in the special provisions of the permit.

Table 1 outlines recommended depths for various pipe diameters:

Table 1
Recommended Minimum Depth of Cover[1]

Diameter	Depth of Cover
50 mm (2 in.) to 150 mm (6 in.)	1.2 m (4 ft)
200 mm (8 in.) to 350 mm (14 in.)	1.8 m (6 ft)
375 mm (15 in.) to 600 mm (24 in.)	3.0 m (10 ft)
625 mm (25 in.) to 1,200 mm (48 in.)	4.5 m (15 ft)

[1] These depths do not apply for crossing under flood protection projects.
(Permission to reprint granted by California Department of Transportation, Office of Encroachment Permits, January 10, 2001).

The permittee/contractor shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring.

Upon completion of the work, the permittee shall provide an accurate as-built drawing of the installed pipe.

Soil Investigations

A soil investigation should be undertaken. This investigation must be suitable for the proposed complexity of the installation to confirm ground conditions.

Soil analysis

Common sense must be utilized when requiring the extensiveness of the soil analysis. A soil analysis is required in order to obtain information on the ground conditions that the contractor will encounter during the HDD operation.

If the contractor can go to the project site and complete an excavation with a backhoe to 0.03 m (1 ft) below the proposed depth of the bore, that is a soil investigation. In all cases when an excavation is made in creating an entrance and exit pit for an HDD project, that is also an example of a soil investigation. The HDD process is in itself a continual and extensive soil analysis as the pilot bore is made. As the varying soils and formations are encountered, the drilling slurry will change colors, therefore providing the contractor with continual additional information.

The purpose and intent of the soil analysis is to assist the contractor in developing the proper drilling fluid mixture and to ensure the CE and the Levee Board that the contractor is aware of the conditions that do exist in the area of the proposed project. This prepares the contractor in the event they should encounter a zone of pretectonics and that they would need additives or preventive measures in dealing with inadvertent returns (hydrofractures).

The discretion on the extensiveness of the soil analysis is left to each individual CE District permitting office and/or Levee Board, respectfully, for their respective areas. The HDD inspector/geotechnical engineer plays a large role in assisting the District Permitting Office and Levee Board in making decisions on the extensiveness. Each individual HDD inspector/geotechnical engineer has a general knowledge of the soil conditions in their area of responsibility.

In many circumstances, the soil information has already been prepared, either by the CE District, Levee Board, or by City and County Entities. This information, if available, should be provided to the requesting permittee.

Determination of soil investigations

The CE District Geotechnical Engineer (DGE) should determine the extensiveness of the Soil Investigation to be performed based on the complexity of the HDD operation. DGE may recommend, according to the guidelines listed below, a combination of or modification to the guideline to fit the following respective areas:

a. Projects less than 152 mm (500 ft) in length, where the product or casing is 20 cm (8 in.) or less in diameter.[1]

(1) A field soil sampling investigation to a depth of 0.3 m (1 ft) below the proposed drilling.

(2) Subsurface strata, fill, debris, and material.

b. Projects less than 244 m (800 ft) in length, where the product or casing is 36 cm (14 in.) or less in diameter.[1]

(1) A field soil sampling investigation to a depth of 0.3 m (1 ft) below the proposed drilling.

(2) Subsurface strata, fill, debris, and material.

(3) Particle size distribution (particularly, percent gravel and cobble).

c. Projects where the product or casing is 41 cm (16 in.) or greater in diameter. A geotechnical evaluation by a qualified soil engineer is necessary to determine the following:[1]

---

[1] Does not apply when crossing a flood protection project.

(1) Subsurface strata, fill, debris, and material.

(2) Particle size distribution (particularly percent gravel and cobble).

(3) Cohesion index, internal angle of friction, and soil classification.

(4) Plastic and liquid limits (clays), expansion index (clays), soil density.

(5) Water table levels and soil permeability.

d. Projects where the product or casing is 61 cm (24 in.) or greater in diameter, or when project crosses flood control projects. A geotechnical evaluation by a qualified soil engineer is required to determine the following:

(1) Subsurface strata, fill, debris, and material.

(2) Particle size distribution (particularly, percent gravel and cobble).

(3) Cohesion index, internal angle of friction, and soil classification.

(4) Plastic and liquid limits (clays), expansion index (clays), soil density, and standard penetration tests.

(5) Rock strength, rock joint fracture and orientation, water table levels, and soil permeability.

(6) Areas of suspected and known contamination should also be noted and characterized.

Boreholes or test pits should be undertaken at approximately 75- to 125-m (250- to 410-ft) intervals where a proposed installations greater than 305 m (1,000 ft) in length and parallel to an existing road. Additional boreholes or test pits should be considered if substantial variations in soil conditions are encountered.

Should the soil investigation determine the presence of gravel, cobble, and/or boulders, care should be exercised in the selection of drilling equipment and drilling fluids. In such ground conditions, the use of casing pipes or washover pipes may be required or specialized drilling fluids utilized. Fluid jetting methods used as a means of cutting **should only be considered** where soils have a high cohesion such as stiff clays. Jetting should not be allowed when crossing under a flood protection project.

Preconstruction and Site Evaluation

The following steps should be undertaken by the permittee/contractor in order to ensure safe and efficient construction with minimum interruption of normal, everyday activities at the site:

a. Notify owners of subsurface utilities along and on either side of the proposed drill path of the impending work through USA alert (the one-call program). All utilities along and on either side of the proposed drill path are to be located.

b. Obtain all necessary permits or authorizations to carry construction activities near or across all such buried obstructions.

c. Expose all utility crossings using a hydroexcavation, hand excavation, or other approved method (potholing) to confirm depth.

d. Arrange construction schedule to minimize disruption (e.g., drilling under major highways and/or river crossings).

e. Determine and document the proposed drill path, including horizontal and vertical alignments and location of buried utilities and substructures along the path.

The size of excavations for entrance and exit pits should be of sufficient size to avoid a sudden radius change of the pipe and consequent excessive deformation at these locations. Sizing the pits is a function of the pipe depth, diameter, and material. All pits, over 1.52 m (5 ft) in depth must abide by Occupational, Safety, and Health Administration (OSHA) regulations.

Prior to commencement of the project, the area should be physically walked over and visually inspected by District Geotechnical Engineer, the driller, and members of the Levee Board for potential entry/exit sites. The following should be addressed:

a. When on CE/Levee Board property, it should be established whether or not there is sufficient room at the site for: entrance and exit pits; HDD equipment and its safe unimpeded operation; support vehicles; fusion machines; aligning the pipe to be pulled back in a single continuous operation.

b. Suitability of soil conditions should be established for HDD operations. (The HDD method is ideally suited for soft subsoils such as clays and compacted sands. Subgrade soils consisting of large grain materials like gravel, cobble, and boulders make HDD difficult to use and may contribute to pipe damage.)

c. The site should be checked for evidence of substructures, such as manhole covers, valve box covers, meter boxes, electrical transformers, conduits or drop lines from utility poles, and pavement patches. HDD may be a suitable method in areas where the substructure density is relatively high.

Installation Requirements

The permittee shall ensure that appropriate equipment is provided to facilitate the installation: in particular, the drill rig shall have sufficient pulling capacity to meet the required installation loads determined by the detailed pipe calculations. The drill rig should have the ability to provide pull loads, push loads, torque, and the permittee shall ensure that they are monitored during the drilling operation. The permittee shall ensure the drill rod can meet the bend radii required for the proposed installation (a general rule of thumb is 100 times, in feet, the diameter of the installed pipe in inches).

During construction, continuous monitoring and plotting of pilot drill progress shall be undertaken. This is necessary to ensure compliance with the proposed installation alignment and allow for the undertaking of appropriate course corrections that would minimize "dog legs," should the bore begin to deviate from the intended bore path. The actual path of the pilot hole should be plotted against the design drill path.

Monitoring shall be accomplished by manual plotting based on location and depth readings provided by the onboard locating/tracking system or by hand-held walkover tracking systems. These readings map the bore path based on information provided by the locating/tracking system. Readings or plot points shall be undertaken on every drill rod.

For installations where tight control of alignment and grade is required, readings shall be undertaken every 1.0 to 1.5 m (3 to 5 ft). At the completion of the bore, an as-built drawing shall be provided. Prior to commencement of a directional drilling operation, proper calibration of the sonde equipment shall be undertaken.

Monitoring of the drilling fluids such as the pumping rate, pressures at the drill rig and pressures in the annular space behind the drill bit (when drilling under flood control projects), viscosity, and density during the pilot bore, back reaming, and/or pipe installation stages shall be undertaken to ensure adequate removal of soil cuttings and the stability of the borehole is maintained. Excess drilling fluids shall be contained at entry and exit points until recycled or removed from the site. Entry and exit pits should be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The permittee shall ensure that all drilling fluids are disposed of in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in contaminated ground, the drilling fluid shall be tested for contamination and disposed of appropriately. Restoration of damage to a levee caused by hydrofracture or any other aspect of the directional drilling operation shall be the responsibility of the permittee. Plans for all restoration or repair work shall be submitted for approval by the Levee District or Corps of Engineers District.

To minimize heaving during pullback, the pullback rate shall be determined by which maximizes the removal of soil cuttings and which minimizes compaction of the ground surrounding the borehole. The pullback rate shall also minimize overcutting of the borehole during the back reaming operation to ensure that excessive voids are not created and result in postinstallation settlement.

The permittee shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring as outlined in their submitted detailed monitoring plan. Subsurface monitoring points shall be established along the HDD centerline and along any flood protection project that the HDD crosses under to provide early indications of settlement, since large voids may not materialize during drilling as a result of pavement bridging.

Should settlement occur, all repairs would be the responsibility of the permittee. To prevent future settlement should the drilling operation be unsuccessful, the permittee shall ensure the backfill of any void(s) with grout or backfilled by other means. Plans for all restoration or repair work shall be submitted for approval.

Considerations

The following considerations must be taken into account.

a. *Different ground conditions:* The availability of adequate geotechnical information is invaluable in underground construction; it acts to reduce the risk born by the permittee/contractor. However, even in the presence of good geotechnical data, unexpected ground conditions may be encountered. The Contractor's plan should describe the response to different ground conditions.

b. *Turbidity of water and inadvertent returns:* During construction, events like drill bit lockup or being off the design drill path may lead to work stoppage. The permittee/contractor should offer a mechanism to mutually address and mitigate these problems if and when they should arise. For example, contingency plans for containment and disposal of inadvertent returns or hydrofractures.

Permittee/contractor responsibilities

The permittee/contractor should provide the following items: construction plan, site layout plan, project schedule, communication plan, safety procedures, emergency procedures, company experience record, contingencies plan, and drilling fluid management plan.

Construction plan requirements. The permittee shall identify in the construction plan:

a. Location of entry and exit pits.

b. Working areas and their approximate size.

c. Proposed pipe fabrication and layout areas.

d. State right-of-way lines, property lines.

e. Other utility right-of way and easement lines.

f. Pipe material and wall thickness.

g. Location of test pits or boreholes undertaken during the soil investigation.

h. Identify the proposed drilling alignment (both plan and profile view) from entry to exit.

i. Identify all grades and curvature radii.

j. All utilities (both horizontal and vertical).

k. Structures with their clearances from the proposed drill alignment.

l. Confirm the minimum clearance requirements of affected utilities and structures.

m. Required minimum clearances from existing utilities and structures.

n. Diameter of pilot hole, and number and size of prereams/backreams.

o. Access requirements to site (if required).

p. Crew experience.

q. Type of tracking equipment.

Locating and tracking. The permittee shall describe the method of locating and tracking the drillhead during the pilot bore. Systems include walkover, wire-line, or wireline with wire surface grid. The locating and tracking system shall be capable of ensuring the proposed installation can be installed as intended.

Typical walkover sondes have an effective range of 10 to 15 m, depending on the Electro-magnetic properties of the soil and the extent of local magnetic interference. Depending on the profile of the borehole, the driller may lose contact with the sondes over certain sections of the alignment. As much as practically possible, the sonde should maintain contact with the drill bit. If the “blind” section is expected to be too long or in the vicinity of a buried object, the project engineer may specify the use of a wire-line system or a magnetic navigation tool.

The locating and tracking system shall provide the following information:

a. Clock and pitch information.

b. Depth.

c. Beacon temperature.

d. Battery status.

e. Position (x,y).

f. Azimuth: Where direct overhead readings (walkover) are not possible.

Figure 1 shows a universal housing that will work with any drill-string on all HDD rigs. The placement of the sonde should be before the backreamer. This housing can be utilized in the initial pilot bore. After exiting, the cutting head can be removed and the reamer installed. This housing chamber can utilize any of the sonde batteries manufactured, regardless of manufacturer. There is also a 6-cm (2.5 in.) mini-sonde combination available for smaller rigs.

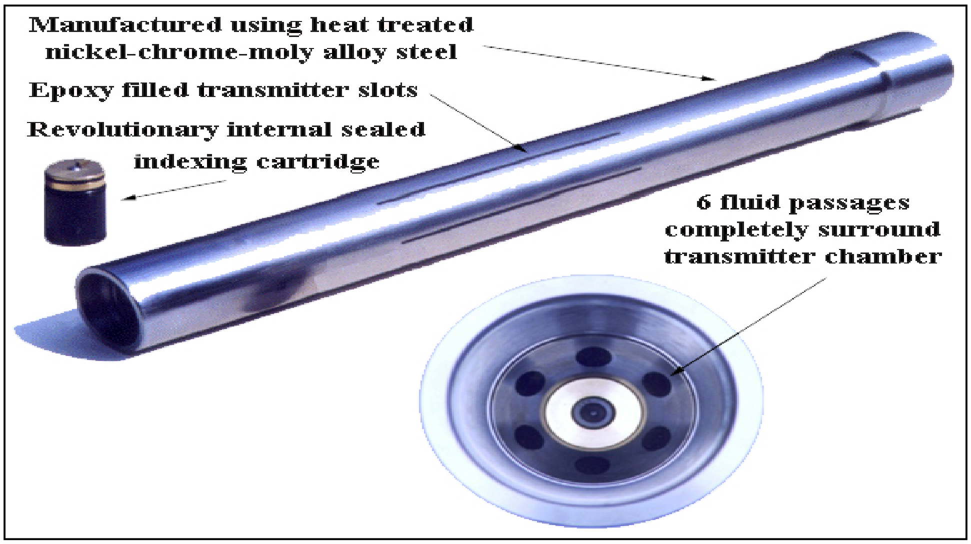

Figure 1. Universal housing for drill-string on HDD rigs (Permission to reprint granted by California Department of Transportation, Office of Encroachment Permits, January 10, 2001)

Drilling fluids management plan. The following information should be provided as part of the drilling fluid management plan. The proposed viscosities for soil transportation to the entry and exit pits are:

a. Pumping capacity and pressures must be estimated.

b. Source of fresh water for mixing the drilling mud must be identified. (Necessary approvals and permits are required for sources such as streams, rivers, ponds, or fire hydrants.)

c. Method of slurry containment must be described and detailed.

d. Method of recycling drilling fluid and spoils (if applicable) must be explained.

e. Method of transporting drilling fluids and spoils offsite must be described.

Drilling fluid pressures in the borehole should not exceed that which can be supported by the foundation soils. Calculation of maximum allowable pressures shall be done for all points along the drill path, taking into account the shear strength of the foundation soils, the depth of the drill path, the bore diameter, and the elevation of the groundwater table. Drilling fluids serve the following functions:

a. Remove cuttings from the bottom of the hole and transport them to the surface.

b. Hold cuttings in suspension when circulation is interrupted.

c. Release cuttings at the surface.

d. Stabilize the hole with an impermeable cake.

e. Cool and lubricate the drill bit and drill string.

f. Control subsurface pressures.

g. Transmit hydraulic horsepower.

h. Cool the locating transmitter sonde preventing burnout.

Previous experience. The permittee's contractor should provide a list of projects completed by his company, location, project environment (e.g., urban work, river crossing), product diameter, and length of installation. The permittee's contractor should also provide a list of key personnel.

Safety. The drilling unit should be equipped with an electrical strike safety package. The package should include warning sound alarm, grounding mats (if required), and protective gear. The permittee/contractor should have a copy of the company safety manual that includes:

a. Operating procedures that comply with applicable regulations, including shoring of pits and excavations when required.

b. Emergency procedures for inadvertently boring into a natural gas line, live power cable, water main, sewer lines, or a fiber-optic cable, which comply with applicable regulations.

c. Emergency evacuation plan in case of an injury.

Contingency plans. The Contingency plan should address the following:

a. Inadvertent return, spill (e.g., drilling fluids, and hydraulic fluids), including measures to contain, clean, and repair the affected area.

b. Cleanup of surface seepage of drilling fluids and spoils (i.e., hydrofracture).

Communication plan. The communication plan should address the following:

a. The phone numbers for communication with owner or his representative on the site.

b. Identification of key person(s) who will be responsible for ensuring that the communications plan is followed.

c. Issues to be communicated including safety, progress, and unexpected technical difficulties.

Traffic control.

a. When required, the permittee/contractor is responsible for supplying and placing warning signs, barricades, safety lights, and flags or flagmen, as required for the protection of pedestrians and vehicle traffic.

b. Obstruction of the roadway, on major road, should be limited to off-peak hours.

Additional Requirements

Information that may be required, include other permits, bonding, and certification as listed in the following sections.

Additional permits

a. Obtaining water (i.e., hydrants, streams, etc.)

b. Storage, piling, and disposal of material.

c. Water/bentonite disposal.

d. Any other permits required carrying out the work.

Bonding and certification requirements

a. Payment bond (if required).

b. Performance bond (if required).

c. Certificate of insurance.

d. WCB certificate letter.

e. ACSA certificate of recognition.

Drilling Operations

The following points provide general remarks and rules of thumb related to the directional boring method.

a. Only operators who have “Proof of Training” by the North American Society of Trenchless Technology (NASTT) should be permitted to operate the drilling equipment in CE/Levee Board property.

b. Drilling mud pressure in the borehole should not exceed that which can be supported by the foundation soils to prevent heaving or a hydraulic fracturing of the soil (i.e., hydrofracture). Allowing for a sufficient cover depth does not necessarily guarantee against hydrofracture. Sound, cautious drilling practice minimizes the chance of hydrofracture occurrence. Also, measuring mud pressures in the annular space behind the drill bit and comparing these mud pressures with the calculated maximum allowable pressures help minimize the occurrence of hydrofracture. Typical bore depth of 0.75 to 1.0 m gives pipes with an Outside Diameter (O.D.) of 50-200 mm a minimum cover of 0.65 m. While circumstances may dictate greater depths, shallower depths are not recommended.

c. The drill path alignment should be as straight as possible to minimize the fractional resistance during pullback and to maximize the length of the pipe that can be installed during a single pull.

d. It is preferable that straight tangent sections be drilled before the introduction of a long radius curve. Under all circumstances, a minimum of one complete length of drill rod should be utilized before starting to level out the borehole path.

e. The radius of curvature is determined by the bending characteristics of the product line, and it is increasing with diameter.

f. Entrance angle of the drill string should be between 8 and 20 deg, with 12 deg being considered optimal. Shallower angles may reduce the penetrating capabilities of the drilling rig, while steeper angles may result in steering difficulties, particularly in soft soils. A recommended value for the exit angle of the drill string is within the range of 5 to 10 deg.

g. Whenever possible, HDD installation should be planned so that back reaming and pulling for a leg can be completed on the same day. If necessary, it is permissible to drill the pilot hole and preream one day, and complete both the final ream and the pullback on the following day.

h. If a drill hole beneath a levee must be abandoned, the hole should be backfilled with grout or bentonite to prevent future subsidence.

i. Pipe installation should be performed in a manner that minimizes the over-stressing and straining of the pipe. This is of particular importance in the case of a polyethylene pipe.

Equipment setup and site layout

a. Sufficient space is required on the rig side to safely set up and operate the equipment. The workspace required depends on the type of rig to be used. A small rig may require as little as 3- by 3-m working space, while a large river crossing unit requires a minimum of 30- by 50-m working area. A working space of similar dimensions to that on the rig side should be allocated on the pipe side, in case there is a need to move the rig and attempt drilling from this end of the crossing.

b. If at all possible, the crossing should be planned to ensure that drilling proceed downhill, allowing the drilling mud to remain in the hole, minimizing inadvertent return.

c. Sufficient space should be allocated to fabricate the product pipeline into one string, thus enabling the pullback to be conducted in a single continuous operation. Tie-ins of successive strings during pullback may considerably increase the risk of an unsuccessful installation.

Drilling and back-reaming

a. Drilling mud should be used during drilling and back reaming operations. Using water exclusively may cause collapse of the borehole in unconsolidated soils. While in clays, the use of water may cause swelling and subsequent jamming of the product.

b. Heaving may occur when attempting to back-ream a hole that is too large. This can be avoided by using several prereams to gradually enlarge the hole to the desired diameter.

c. A swivel should be included between the reamer and the product pipe to prevent the transfer of rotational torque to the pipe during pullback.

d. In order to prevent over stressing of the product during pullback, a weak link, or break-away pulling head, may be used between the swivel and the leading end of the pipe. More details regarding breakaway pulling heads can be found in paragraph entitled “Break-away Pulling Head.”

e. The pilot hole must be back-reamed to accommodate and permit free sliding of the product inside the borehole. A rule of thumb is to have a borehole 1.5 times the outer diameter of the product. This rule of thumb should be observed particularly with the larger diameter installations (≥ 250-mm O.D.). Some recommended values for final preream diameter as a function of the product O.D. are given in Table 2. These values should be increased by 25 percent if excessive swelling of the soil is expected to occur or the presence of boulders/cobbles is suspected.

f. The conduit must be sealed at either end with a cap or a plug to prevent water, drilling fluids, and other foreign materials from entering the pipe as it is being pulled back.

g. Pipe rollers, skates, or other protective devices should be used to prevent damage to the pipe from the edges of the pit during pullback, eliminate ground drag, or reduce pulling force and subsequently reduce the stress on the product.

h. The drilling mud in the annular region should not be removed after installation but permitted to solidify and provide support for the pipe and neighboring soil.

Table 2
Recommended Back-Ream Hole Diameter (after Popelar et al. 1997)

Nominal Pipe Diameter, mm	Back-Ream Hole Diameter, mm
50	75 to 100
75	100 to 150
100	150 to 200
150	250 to 300
200	300 to 350
250	350 to 400
≥300	At least 1.5 times product OD

Drilling Fluid - Collection and Disposal Practices

The collection and handling of drilling fluids and inadvertent returns, along with the need to keep drilling fluids out of streams, streets, and municipal sewer lines, have been among the most debated topics. These points include:

a. Drilling mud and additives to be used on a particular job should be identified in the permit package, and their Material Safety Data Sheets (MSDS) should be provided to the Permit Office.

b. Excess drilling mud slurry shall be contained in a lined pit or containment pound at exit and entry points, until recycled or removed from the site. Entrance and exit pits should be of sufficient size to contain the expected return of drilling mud and spoils.

c. Methods to be used in the collections, transportation, and disposal of drilling fluids, spoils, and excess drilling fluids should be in compliance with local ordinances, regulations, and environmentally sound practices in an approved disposal site.

d. The slurry should be tested for contamination and disposed of in a manner which meets government requirements when working in an area of contaminated ground.

e. Precautions should be taken to keep drilling fluids out of the streets, manholes, sanitary and storm sewers, and other drainage systems, including streams and rivers.

f. Recycling drilling fluids is an acceptable alternative to disposal.

g. All diligent efforts should be made by contractor to minimize the amount of drilling fluids and cuttings spilled during the drilling operation, and complete cleanup of all drilling mud overflows or spills shall be provided.

There are legitimate concerns associated with the fluid pressures used for excavation during the horizontal directional drilling process and the risk of hydraulic fracturing. Reasonable limits must be placed on maximum fluid pressures in the annular space of the bore to prevent inadvertent drilling fluid returns to the ground surface. However, it is equally important that drilling pressures remain sufficiently high to maintain borehole stability, since the ease in which the pipe will be inserted into the borehole is dependent upon borehole stability. Limiting borehole pressures are a function of pore pressure, the pressure required to counterbalance the effective normal stresses acting around the bore (depth), and the undrained shear strength of the soil.

Tie-Ins and Connections

Trenching may be used to join sections of conduits installed by the directional boring method. An additional pipe length, sufficient for joining to the next segment, should be pulled into the entrance pit. This length of the pipe should not be damaged or interfere with the subsequent drilling of the next leg. The contractor should leave a minimum of 1 m of conduit above the ground on both sides of the borehole.

Alignment and Minimum Separation

The product should be installed to the alignment and elevations shown on the drawings within the prespecified tolerances (tolerance values are application dependent, for example, in a major river crossing, a tolerance of ±4 m from the exit location along the drill path center line may be an acceptable value). This tolerance is not acceptable when installing a product line between manholes. Similarly, grade requirements for a water forcemain are significantly different from those on a gravity sewer project.

When a product line is installed in a crowded right-of-way, the issue of safe minimum separation distance arises. Many utility companies have established regulations for minimum separation distances between various utilities. These distances needed to be adjusted to account for possible minor deviation when a line product is installed using HDD technology. As a rule of thumb, if the separation distance between the proposed alignment and the existing line is 5 m or more, normal installation procedures can be followed. If the separation is 1.5 m or less, special measures, such as observation boreholes are required. The range between 1.5 and 5 m is a "gray" area, typically subject to engineering judgment (a natural gas transmission line is likely to be treated more cautiously than a storm water drainage line).

Break-Away Pulling Head

Recent reports from several natural gas utility companies reveal concerns regarding failure experienced on HDPE pipes installed by horizontal directional drilling. These failures were attributed to deformation of the pipe due to the use of excessive pulling force during installation. A mitigation measure adopted by some gas companies involves the use of break-away swivels to limit the amount of force used when pulling HDPE products. Some details regarding these devices and their applications are given below.

a. The weak link used can be either a small diameter pipe (but same SDR) or specially manufactured break-away link. The latter consists of a breaking pin with a defined tensile strength incorporated in a swivel. When the strength of the pin is exceeded it will break, causing the swivel to separate. A summary of pulling head specifications is given in Table 3 (all products are SDR 11). Note that the values provided in Table 3 could be considered conservative.

Table 3
Pulling Head Specifications

Pipe Diameter (in.)[1]	Diameter of Break-Away Swivel (in.)	Maximum Allowable Pulling Force (lb)[2]
1-1/4	7/8	850
2	1-1/4	1,500
4	1 3/8	5,500
6	2-1/2	12,000
8	3	18,500

[1]To convert inches to centimeters, multiply by 2.54.
[2]To convert pounds to kilograms, multiply by 0.4535.

b. The use of break-away swivels is particularly warranted when installing small diameter HDPE pipes (up to 10-cm (4 in.) O.D.). Application of such devices in the installation of larger diameter products is not currently a common practice.

c. If the drilling equipment-rated pulling capacity is less than the safe load, the use of a weak link may not be required.

d. Exceeding the product elastic limit can be avoided simply by following good drilling practices, namely: regulating pulling force; regulating pulling speed; proper ream sizing; and using appropriate amounts of drilling slurry fluid.

Protective Coatings

In an HDD installation, the product may be exposed to extra abrasion during pullback. When installing a steel pipe, a form of coating which provides a corrosion barrier as well as an abrasion barrier is recommended during the operation, the coating should be well bonded and have a hard smooth surface to resist soil stresses and reduce friction, respectively. A recommended type of coating for steel pipes is mill applied Fusion Bonded Epoxy.

Site Restoration and Postconstruction Evaluation

All surfaces affected by the work shall be restored to their preconstruction conditions. Performance criteria for restoration work will be similar to those employed in traditional open excavation work. If required, the permittee/contractor shall provide a set of as-built drawings including both alignment and profile. Drawings should be constructed from actual field readings. Raw data should be available for submission at any time upon request. As part of the "As-Built" document, the contractor shall specify the tracking equipment used, including method or confirmatory procedure used to ensure the data were captured.

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14. ABSTRACT

Applications for permits to drill beneath levees are increasing in permitting offices of the U.S. Army Corps of Engineer Districts. This report provides a basis for consistent and science-based consideration of these permit applications. It describes methods of horizontal directional drilling (HDD) beneath levees and lists the types of geotechnical and other data that are essential to judging the safety of proposed drilling for infrastructure modifications and installation of utilities. Critical considerations include setback distances, levee toe stability, thickness and integrity of the top stratum, and other geotechnical parameters. Data provided for vertical and horizontal permeabilities, top stratum thickness, hydraulic gradient at levee toe, and other parameters are based on experience in the U.S. Army Engineer Districts, Vicksburg and St. Louis, and the California Department of Transportation. In appropriate geotechnical settings with appropriate operational care, utilities can be installed beneath flood-control levees using HDD without compromising the integrity and function of the levee.

15. SUBJECT TERMS

Annular space	Fiber-optic cables	Hydrofracture
Directional drilling	Geotechnical engineering	Residual pressure
	HDD	Trenchless technology

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2 January 2014

MEMORANDUM FOR RECORD – DRAFT 1/2/14

SUBJECT: Fargo-Moorhead Metro Flood Risk Management (FMMFRM) Project – MFR 020- Landscape Enhancements and Golf Course Layout along the Oxbow-Hickson-Bakke Ring Levee

PURPOSE

1. This memorandum for record (MFR) defines the extent to which the City of Oxbow and the Oxbow Country Club will be allowed to construct landscaping and golf features adjacent to the Oxbow-Hickson-Bakke levee. Requirements for levees will be discussed, along with the impacts of the Vegetation-Free Zone requirements needed for the levees.

BACKGROUND

2. The design for the Fargo-Moorhead Metropolitan Flood Risk Management (FMMFRM) Project is ongoing. As part of the mitigation for impacts created through the staging of flood water upstream of the diversion project, a levee will be constructed around the Oxbow-Hickson-Bakke community. The construction of the levee will result in the removal of a number of homes in the City of Oxbow as well as disruption and segmentation of the Oxbow Country Club. These impacts are being mitigated through the construction of replacement residential lots and replacement holes for the Oxbow Country Club. The City of Oxbow and the Oxbow Country Club desire to incorporate the topography created by the construction of the levee into the golf facilities.

3. The project features will include:

- A ring levee surrounding portions of the communities of Oxbow, Hickson, and Bakke.
- Replacement residential lots to mitigate for the loss of residential lots due to the construction of the ring levee.
- Replacement golf holes, clubhouse, and other golf features to mitigate for the loss of existing golf facilities.

LEVEE REQUIREMENTS

4. The levee will need to be designed, constructed, and maintained so that it is a reliable feature of the project. Many different factors must be considered when designing the levee; they are detailed below. The project delivery teams (PDTs) will complete the final design of the levee.

Levee Crest Elevation

5. The levee is an essential component of the flood risk management system for the communities of Oxbow, Hickson, and Bakke. The primary access into the communities of Oxbow, Hickson, and Bakke during large floods will be sections of Cass County Highways 81 and 18 and Interstate Highway 29. These access roads will be raised to an elevation that will allow access to be maintained up to a 0.2% chance flood. To provide adequate risk reduction up until the point at which access will be unavailable, the levee will be built to the 0.2% chance elevation plus overbuild to account for risk and uncertainty, wave run-up, and estimated settlement.

Levee Typical Cross Section

6. The typical cross section for the Oxbow-Hickson-Bakke levee is a compacted clay levee with a 10-foot top width and 1V:5H side slopes on the interior of the levee and 1V:4H side slopes on the exterior of the levee. The interior levee side slope could be as steep as 1V:3H, barring it satisfies slope stability requirements, but the Local Sponsor has determined that 1V:5H will be used to provide a less obtrusive visual appearance. Because of the impervious nature of the levee fill and the foundation, seepage has not been an issue on existing levees, nor has stability been an issue for levees constructed away from the river channel. These levees have performed well under flood conditions.

Levee Construction Requirements

7. The levee section will be constructed to the following requirements to ensure the integrity of the levee. These requirements are the minimum and may require further evaluation by the PDT during design.

a. Fill Material: Alluvium or Sherack materials shall be used as fill material. These formations will be located in the upper portion of the diversion channel excavation.

b. Stripping: All organic materials beneath the footprint of the levee shall be removed.

c. Inspection Trench: An inspection trench will be required. If any pervious layers are encountered during excavation, an analysis should be completed to determine if a cut-off trench will be needed.

d. Utilities and Drain Tile: If utilities and drain tile are encountered within the inspection trench or they are known to be beneath the footprint of the levee, at a minimum, the utilities and drain tile shall be removed from beneath the footprint of the levee and extending out 15 feet from the both toes of the levee. The exception would be utilities relocated as part of this project in compliance with MVP MFR for Utility Relocations.

e. Overbuild: The placement of the excavated material will cause the foundation to settle and consolidate. The levee section will be overbuilt to accommodate the estimated settlement.

f. Placement: The material shall be placed in lifts of 9 inches or less.

g. Compaction: The fill material will be required to be compacted to a minimum 95 percent of maximum dry density as determined by the standard proctor.

h. Moisture Control: The moisture content of the fill material when compacted shall fall within the range of 2 percentage points below optimum moisture content and 3 percentage points above optimum moisture content as determined by the standard proctor.

i. Testing: More testing will be required than for the embedded levee associated with the diversion channel project. Final quantity will be determined by PDTs.

j. Topsoil and Seeding: A minimum of 4 inches of topsoil shall be placed and seeded on any exposed surface of the levee.

GOLF COURSE FEATURE REQUIREMENTS

8. Incorporation of golf course features adjacent to the levee section as desired by the Oxbow Country Club will be done in accordance with requirements for planting berms outlined in ETL 110-2-571"Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures." Beyond the minimum levee section needed to satisfy stability requirements, additional fill (planting berm) may be added to the interior side slope of the levee to better accommodate differing types of public use and related landscape planting approaches. In these planting berm areas, the Vegetation Free Zone (VFZ) on the interior side shall extend a minimum of 15' from the landside crest of the levee or intersection between the levee slope and the additional fill, whichever is greater. Within the VFZ, the only acceptable vegetative ground cover is perennial grasses. In addition, a 3' root free zone runs along the interior side slope of the levee. Any landscape plantings outside of the VFZ must take into account this 3' root free zone.

Golf Course Feature Location

9. The placement of any additional earth fill for golf course features along the landside of the levee shall be done in accordance with guidance related to planting berms outlined in Section 4 of ETL 1110-2-571.

10. All proposed golf course features will be located a minimum of 15 feet from the landside edge of the crown of the levee or the intersection between the levee slope and the additional fill, whichever is greater, and the VFZ shall be kept clear of obstructions so that access is always provided. Planting plans shall consider the requirements of vegetation free zones, including the root free zone.

11. All geotechnical stability and seepage requirements for levee design shall be met in areas where additional fill is placed adjacent to the levee section.

12. Root free zones shall be based on the minimum required embedded interior side slope of the levee, based on geotechnical analysis, beneath the surface of the additional fill. This embedded side slope shall begin at the protected side crest of the levee or at the intersection of the protected side levee slope and the top of the additional fill.

13. Irrigation systems adjacent to the levee pose two potential threats to system reliability: pressurize waterlines may fail, resulting in damage to the engineered levee section; and irrigation water may impair visual inspection by obscuring wet areas that are actually due to seepage. To minimize threats to the levee, any irrigation system installed as part of the golf course infrastructures shall be located a minimum of 20 feet from the landside edge of the levee crown or intersection between the levee slope and the additional fill, whichever is greater. Irrigation systems installed as described shall spray towards the golf course and not in the VFZ.

<u>Golf Course Feature Construction Requirements</u>

14. The construction requirements for additional fill placed for golf course features can be less stringent than the levee. Some considerations for construction requirements are listed below.

   a. Stripping: Adequate topsoil beneath the footprint of the additional fill for golf course features should be stripped to conserve enough topsoil to allow for long term viability of vegetation. Additional topsoil can be left in place.

   b. Placement: The specified lift thickness should be based on how dense the additional fill for golf course features needs to be to accommodate the end use. The thicker the lifts, the less dense the additional fill will be, which could lead to more settlement and less bearing capacity.

   c. Compaction: The material placed as additional fill for golf course features should be compacted to accommodate the end use. Moisture Control: There will be no moisture control requirements.

   d. Testing: The testing requirements for the additional fill for golf course features will be similar to that required for the levee but at less frequent intervals and will depend on what density is required for the additional fill.

   e. Topsoil and Seeding: Topsoil thickness will be determined based on the end-use of the additional fill for golf course features. At a minimum, 4 inches of topsoil shall be placed and seeded on any exposed surface of additional fill.

RIGHT OF WAY REQUIREMENTS

15. The minimum requirements for right of way for the Oxbow Hickson Bakke levee are outlined below. Typical right of way requirements are also shown in Figure 1.

a. The real estate required for construction, operating and maintaining the levee will be purchased and owned by the Diversion Authority. This area will include all area under the levee and any adjacent parallel drainage ditches plus a minimum of 50 feet beyond the toe of the levee or daylight point of drainage ditches.

b. For areas in which the City of Oxbow and the Oxbow Country Club desire to incorporate golf features including additional fill, the real estate required will be a minimum of 20 feet on the interior side of the point where the levee section intersects existing ground.

c. The Diversion Authority will allow the City of Oxbow and the Oxbow Country Club, through an easement, to utilize the area between the interior edge of the levee crown and the landside limits of the Diversion Authority's right of way for the purpose of operating and maintaining a golf course. All golf course operation and maintenance within this area shall be subject to the requirements outlined in this document.

VEGETATION FREE ZONE AND VEGETATION MANAGEMENT ZONE

16. The requirements for vegetation-free zones and vegetation-management zones are outlined in the USACE Technical Letter ETL 1110-2-571, "Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures." The primary purpose of the vegetation-free zone (VFZ) is to provide reliable, unobstructed access to the dam or levee for surveillance, maintenance, and flood-fighting purposes. A secondary purpose of the VFZ is to provide distance between root systems and levees, which moderates the risk of potential piping and seepage due to root penetration and structural damage resulting from a wind-driven tree overturning. In addition to the VFZ, a vegetation-management zone (VMZ) can be specified in which vegetation is less stringently managed.

17. In the context of the FMMFRM project, the VFZ will require periodic maintenance and control of the vegetation within that zone. The control of the vegetation would require mowing or burning (if permitted) at least once each year for inspection. No woody vegetation or trees would be allowed within the VFZ.

O&M AND COE INSPECTION REQUIREMENTS

VFZ O&M and Inspection Requirements

18. Mowing or burning of the VFZ will be required at least every year for inspection. Additional mowing or burning may be necessary to ensure health and vigor of the species providing erosion protection, and in anticipation of flood conditions and flood fighting activities. All requirements outlined in ETL 1110-2-571 will be adhered to.

REVIEW

CONTACT

19. Any questions concerning this MFR should be directed to

SIGNATURES

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Project Manager
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St. Paul District

Appendix N: Engineering Considerations

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Oxbow, Hickson, Bakke Ring Levee Phase WP-43B

Engineering and Design Phase

Doc Version: 35% Review Submittal

P2#

03 January 2014

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Appendix N: Engineering Considerations

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Appendix N: Engineering Considerations

N.1 INTRODUCTION

WP-43B is the levee portion on the west side of County Road 81 and around the Bakke Subdivision. The west boundary of WP-43B runs through an existing agricultural field beginning at the intersection of County Roads 18 and 81 to the west side of the Bakke Subdivision. The north boundary of WP-43B runs parallel on the north side of the Bakke Subdivision until it intersects County Road 81. The total length of levee is approximately 12,983 feet. The USACE is designing this portion of the OHB Ring Levee Project.

Major work items include the following:

- Levees
- Ditches
- Access Roads
- Vegetation

N.2 HYDRAULICS

Additional information will be provided in future submittals.

N.3 GEOTECHNICAL

Additional information will be provided in future submittals.

N.3.1 Diversion Channel Excavation

N.3.1.1 Topsoil

N.3.1.2 Excavation

N.3.1.3 Muck Excavation

N.3.1.4 Groundwater and Seepage

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N.3.2 Placement of Excavated Materials

N.3.2.1 Levee

N.3.2.2 Road Subgrade

N.3.2.3 Topsoil

N.3.2.4 Swell / Shrink

N.3.2.5 Materials

N.3.3 Instrumentation

N.3.4 Hazardous, Toxic, and Radioactive Wastes

N.4 CIVIL

N.4.1 Existing Conditions

Existing topographic data utilized for the design and drawings is from Aerial Light Detection and Ranging (LIDAR) and ground survey campaigns performed in May 2011 by Merrick and Company through contract with the local sponsors. Additional topographic surveys have been conducted by HMG for use in conjunction with the LiDAR data and this information will be incorporated into the base map by the USACE. The coordinate system and projection of the existing condition data is NAD83 (2007), North Dakota State Plane Coordinate System, South Zone (U.S. Survey Feet). The elevation datum of the existing condition data is NAVD88 (U.S. Survey Feet).

N.4.2 Existing Utilities

All utility relocations will be performed prior to construction. Utility relocation plans will be provided to the contractor as a plan reference document.

The following table lists identified utilities within the construction limits of WP-43B and will be updated and provided in future submittals:

Utilities WP-43B

UTILITY	CROSSING STATION	DESCRIPTION
ELECTRIC		
Cass County Electric		
Minnkota Power		
COMMUNICATION		

UTILITY	CROSSING STATION	DESCRIPTION
Century Link		
WATER		
Cass Rural Water Users, Inc.		

N.5 CULTURAL RESOURCES

N.5.1 Archaeological

Additional information will be provided in future submittals.

N.6 MECHANICAL

No Considerations Provided

N.7 ELECTRICAL

No Considerations Provided