11228 Aurora Avenue
Des Moines, Iowa 50322-7905
United States
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Our ref: 12635351-LTR-02

January 21, 2025

Mr. Brian Rath
Solid Waste and Contaminated Sites Section
Iowa Department of Natural Resources
6200 Park Ave, Suite 200
Des Moines, Iowa 50321

MidAmerican Energy Company Louisa Generating Station East CCR Monofill
Operating Permit #70-SDP-16-04P – Cell 4 Geosynthetic Clay Liner Construction
Muscatine, Iowa

Dear Mr. Rath:

GHD Services Inc. (GHD) is submitting this letter on behalf of MidAmerican Energy Company (MidAmerican) to request a permit amendment authorizing construction of Cell 4 with a geosynthetic clay liner (GCL) at the East Coal Combustion Residual (CCR) Monofill at the Louisa Generating Station (LGS) (#70-SDP-16-04P). The construction drawings, specifications, and Construction Quality Assurance Plan for the Cell 4 GCL construction activities are included in Attachments 1, 2, and 3, respectively.

The planned modifications are generally consistent with the previously approved construction of Cell 1 (docDNA #90262) and Cells 2 and 3 (docDNA #94898) with the exception of using GCL instead of the conventional compacted clay liner (CCL). In additions to the Attachments 1 through 3 outlined above, this submission includes the following documents to demonstrate functional equivalency of GCL to CCL:

– Attachment 4 provides compatibility results based on permeability testing using LGS leachate on CETCO coal combustion residue (CCR) compatible GCL products.
– Attachment 5 documents functional equivalency based on Darcy's Law calculations and a Technical Equivalency Assessment of GCLs to CCLs

Please feel free to contact Justin Simon (515-414-3946) or Mike Alowitz (515-414-3934) for questions.

Regards,

Justin Simon, PE
Environmental Engineer

+1 515 414-3946
justin.simon@ghd.com

Mike Alowitz, PE
Environmental Engineer

+1 515 414-3934
michael.alowtiz@ghd.com

JS/lg/LTR-02

Copy to: Josh Love, MidAmerican
Jamie Murphy, MidAmerican

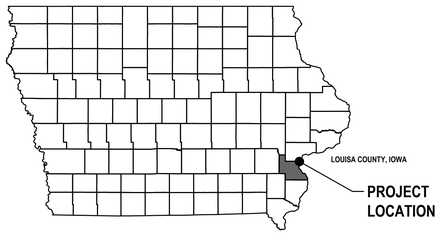
Attachments

Attachment 1

LGS Cell 4 GCL Drawings

MIDAMERICAN ENERGY COMPANY
LOUISA GENERATING STATION
CCR MONOFILL EXPANSION
CELL 4 - GCL

JANUARY 2025
12635351



AREA MAP

LOCATION MAP

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Sheet List Table	
SHEET NO.	SHEET TITLE
GENERAL	
GN-001	COVER SHEET
GN-002	STAMPING PAGE
GN-003	GENERAL ABBREVIATIONS
GN-004	GENERAL SYMBOLS AND LEGEND
GN-005	GENERAL SITE PLAN
GN-006	CONSTRUCTION AREA SITE PLAN
CIVIL	
CI-101	EXISTING BOTTOM OF CLAY LINER GRADING PLAN
CI-102	CELL 4 BOTTOM OF GEOSYNTHETIC CLAY LINER
	GRADING PLAN
CI-103	CELL 4 TOP OF DRAINAGE LAYER GRADING PLAN
CI-104	LEACHATE COLLECTION SYSTEM PLAN
CI-105	STORMWATER PLAN
CI-106	ELECTRICAL SITE PLAN
CI-107	LINER VERIFICATION POINTS
CI-302	PERIMETER BERM SECTIONS
CI-501	DETAILS
CI-502	DETAILS
CI-503	DETAILS
CI-504	DETAILS
CI-505	DETAILS
CI-506	DETAILS
CI-507	DETAILS

No.	Issue	Checked	Approved	Date
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0	ISSUED FOR BID	JS	MA	07/10/24

Author | Drafting Check | Project Manager **J. SIMON**
Designer | Design Check | Project Director **M. ALOWITZ**

Bar is one inch on original size sheet
0 1"

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Client **MIDAMERICAN ENERGY COMPANY**
Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Project No. **12635351** | Date **JUNUARY 2025** | Scale **AS SHOWN**

Title **COVER SHEET**
Size **ARCH D**
Sheet No. **GN-001**

Plot Date: 9 January 2025 - 9:44 AM | Plotted By: Lily Gao | Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Gen\12635351-GHD-00-DRG-00-GN-001.dwg

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

Justin Simon, P.E. — Date: 1-9-2025

License Number: 23766

My license renewal date is: December 31, 2025

Pages or sheets covered by this seal: ALL SHEETS

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Title **STAMPING PAGE**

Size **ARCH D**

Project No. **12635351** Date **JUNUARY 2025** Scale **AS SHOWN**

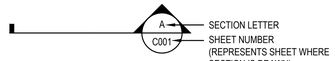
Sheet No. **GN-002**

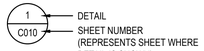
Plot Date: 9 January 2025 - 9:46 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Gen\12635351-GHD-00-DRG-00-GN-002.dwg

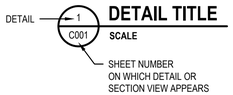
ABBREVIATIONS		
Ø, DIA	=	DIAMETER
AOBE	=	AS ORDERED BY ENGINEER
ASPH	=	ASPHALT
AHD	=	AHEAD
BOB	=	BOTTOM OF BANK
BC	=	BOTTOM OF CURB
BDY	=	BOUNDARY
BV	=	BUTTERFLY VALVE
BLDG	=	BUILDING
BLVD	=	BOULEVARD
BM	=	BENCHMARK
BTD	=	BLACK TOP DRIVE
BK	=	BACK
CL	=	CENTERLINE
CB	=	CATCH BASIN
CATV	=	CABLE TV
C/C	=	CENTER TO CENTER
CIP	=	CAST IRON PIPE
CMP	=	CORRUGATED METAL PIPE
CO	=	CLEANOUT
CONC	=	CONCRETE
CONST	=	CONSTRUCTION
CP	=	CONTROL POINT
CR	=	COUNTY ROAD
CSD	=	CRUSHED STONE DRIVE
CSPA	=	CORRUGATED STEEL PIPE ARCH
CT	=	COPPER TUBING PIPE
CULV	=	CULVERT
DI	=	DRAINAGE INLET
DIP	=	DUCTILE IRON PIPE
DIA, Ø	=	DIAMETER
DN	=	DOWN
E	=	EAST
EL	=	ELEVATION
EP	=	EDGE OF PAVEMENT
EPS	=	EDGE OF PAVED SHOULDER
ES	=	EDGE OF SHOULDER
FND	=	FOUNDATION
FS	=	FAR SIDE
FT	=	FOOT, FEET
GAR	=	GARAGE
GCL	=	GEOSYNTHETIC CLAY LINER
GM	=	GAS METER
GP	=	GUY POLE
GRAV	=	GRAVEL
GSB	=	GAS SERVICE BOX
GV	=	GAS VALVE (MAIN LINE)
GS	=	GATE SERVICE
GW	=	GAS WELL
HC	=	HANDICAP
HDPE	=	HIGH DENSITY POLYETHYLENE PIPE
HP	=	HIGH POINT
HPG	=	HIGH PRESSURE GAS
HSE #	=	HOUSE NUMBER
HW	=	HEADWALL
HWY	=	HIGHWAY
HYD	=	HYDRANT
INV	=	INVERT
IB	=	IRON BAR
IP	=	IRON PIPE OR IRON PIN
LF	=	LINEAR FOOT
LP	=	LIGHT POLE
LPG	=	LOW PRESSURE GAS
LT	=	LEFT
MH	=	MANHOLE
MON	=	MONUMENT

ABBREVIATIONS		
N	=	NORTH
NA	=	NOT APPLICABLE
NE	=	NORTH EAST
NW	=	NORTH WEST
NITC	=	NOT IN THIS CONTRCT
NTS	=	NOT TO SCALE
O/C	=	ON CENTER
OD	=	OUTSIDE DIAMETER
PAVT	=	PAVEMENT
PCCP	=	PRESTRESSED CONCRETE CYLINDER PIPE
PCSP	=	PERFORATED CORRUGATED STEEL PIPE
PS	=	PUMP STATION
PVC	=	POLYVINYL CHLORIDE PIPE
PP	=	POWER POLE
RCP	=	REINFORCED CONCRETE PIPE
RIB	=	RECORDED IRON BAR
RD	=	ROAD
RP	=	REFLECTOR POST
RR	=	RAILROAD
ROW	=	RIGHT OF WAY
RT	=	RIGHT
RTE	=	ROUTE
R	=	RADIUS
STA	=	STATION
SA	=	SANITARY MANHOLE (SYMBOL)
SAN	=	SANITARY SEWER
SSMH	=	SANITARY MANHOLE
SHDR	=	SHOULDER
SIB	=	SET IRON BAR
SH	=	STATE HIGHWAY
S	=	SOUTH
SE	=	SOUTH EAST
SF	=	SILT FECE
SBD	=	STRAW BALE DIKE
SPK	=	SPIKE
STP	=	STEEL PIPE
STM	=	STORM SEWER
STM MH	=	STORM MANHOLE
STK	=	STAKE
ST	=	STREET
STY	=	STORY
SW	=	SIDEWALK
SW	=	SOUTH WEST
TB	=	TEST BORE
TOB	=	TOP OF BANK
TBM	=	TEMPORARY BENCH MARK
TC	=	TOP OF CURB
TEL P	=	TELEPHONE POLE
TGL	=	THEORETICAL GRADE LINE
UP	=	UTILITY POLE
UGE	=	UNDERGROUND ELECTRIC
UGT	=	UNDERGROUND TELEPHONE
VCP	=	VITRIFIED CLAY PIPE
VTP	=	VITRIFIED TILE PIPE
WAT	=	WATER
W	=	WEST
WP	=	WATER PIPE
WM	=	WATER METER
WV	=	WATER VALVE
WS	=	WATER SERVICE (HSE. LINE)

TYPICAL SECTION MARKS (FOR PLANS)







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Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

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Project **CCR MONOFILL EXPANSION CELL 4**
LOUISA GENERATING STATION

Title **GENERAL ABBREVIATIONS**

Size **ARCH D**

Project No. **12635351**

Date **JUNUARY 2025**

Scale

Sheet No. **GN-003**

Plot Date: 9 January 2025 - 10:10 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Gen\12635351-GHD-00-DRG-00-GN-003.dwg

FEATURE	EXISTING	PROPOSED
PROPERTY LINE		
MUNICIPAL BOUNDARY	IOWA / ILLINOIS	
CENTER LINE		
EASEMENT		
ROW & MONUMENT		
CONTOURS MAJOR	625	625
CONTOURS MINOR	624	624
FEMA FLOOD CONTOUR		

UTILITY LINETYPES

FEATURE	EXISTING	PROPOSED
ELECTRIC UNDERGROUND		
ELECTRIC OVERHEAD		
TELEPHONE UNDERGROUND		
TELEPHONE OVERHEAD		
COMMUNICATION UNDERGROUND		
COMMUNICATION OVERHEAD		
GAS		
WATER MAIN		
SANITARY SEWER		
SANITARY SEWER FORCEMAIN		
STORM SEWER		
ABANDONED PIPE		
DEMOLITION		

TOPOGRAPHIC LINETYPES

FEATURE	EXISTING	PROPOSED
FENCE		
GUIDE POSTS GUARD RAIL		
RR TRACKS SMALL SCALE		
SHEET PILING		
SHORE LINE		
WORK LIMIT LINE		

SURVEY

FEATURE	EXISTING	PROPOSED
MONUMENT	MONUMENT	
SIB	SIB	
IB	IB	
RIB	RIB	
IRON PIPE	IP	
CUT-CROSS	CC	
NAIL	NAIL	
DRILL HOLE	DH	
BENCHMARK	BM #	
TEMPORARY BENCHMARK	TBM #	
CONTROL POINT	CP	CP
PERMANENT SURVEY MARKER		

SANITARY

FEATURE	EXISTING	PROPOSED
SANITARY SEWER MH	SAN MH	
CLEAN OUT		
SANITARY SEWER VALVE		
VENT		
LATERAL		
END CAP		
MANHOLE DEMOLITION		X

FEATURE	EXISTING	PROPOSED
STORM MANHOLE	STM MH	
STORM CATCH BASIN	CB	
CULVERT/ENDSECTIONS		
SWALE/DITCH		
YARD DRAIN	YD	YD
FLOW ARROW		
STORM PIPE		

WATER

FEATURE	EXISTING	PROPOSED
WATER GATE VALVE		
WATER BUTTERFLY VALVE		
HYDRANT VALVE		
HYDRANT		
CURB STOP		
WATER METER	WM	
AIR RELIEF VALVE		
WELL	W	
SERVICE		
SERVICE RECONNECT		
BLOWOFF / SAMPLE POINT		
TAPPING SLEEVE		
WATER SERVICE BOX		
SPRINKLER HEAD		
VALVE CHAMBER		
END CAP		

POWER

FEATURE	EXISTING	PROPOSED
UTILITY POLE		
GUY WIRE ANCHOR		
STREET LIGHT		
BURIED CABLE MARKER		
TRANSMISSION TOWERS		
PULL BOX STREET LIGHTS	L	
TERMINAL BOX	T	
UTILITY MANHOLE	UTIL MH	
HANDHOLE	H	H
INSPECTION POST		
UTILITY MARKER		

NATURAL GAS

FEATURE	EXISTING	PROPOSED
GAS VALVE		
GAS METER	GM	
GAS MAIN MARKER		
GAS SERVICE BOX		
GAS WELL	G	
END CAP		

COMMUNICATIONS

FEATURE	EXISTING	PROPOSED
PEDESTAL		
POLICE OR FIRE CALL BOX	CALL	

RAILROAD

FEATURE	EXISTING	PROPOSED
RR SIGNAL		
RR SIGNAL CONTROL BOX		
RR SWITCHSTAND		
RR FROG POINT		
RR BUMPER		

FEATURE	EXISTING	PROPOSED
SPLASH BLOCK		
MAIL BOX		
YARD LIGHT		
STONE FENCE		
TREE LINE		
DECIDUOUS TREE, TRUNK Ø		
CONIFER TREE, TRUNK Ø		
CONIFER TREE, MULTI-TRUNK Ø		
DECIDUOUS TREE, MULTI-TRK Ø		
TREE BORING		B
TREE REMOVAL		R
BORING/RECEIVING PITS		
STUMP		
HEDGE		
BOLLARD		
SPOT ELEVATION	103.00	103.00
WATER ELEVATION	WATER EL	WATER EL
GATE		
POST		
STREAM OR RIVER		
TOP OF SLOPE		
TOE OF SLOPE		
TEST BORE HOLE	BH-1	BH-1

TRAFFIC

FEATURE	EXISTING	PROPOSED
TRAFFIC SIGNAL	SIGNAL	
PULL BOX TRAFFIC SIGNAL		
SIGNAL POLE W/CONTROL		
ROAD SIGNS		
MILE MARKER		
RAISED PAVEMENT MARKER		

EROSION CONTROL

FEATURE	EXISTING	PROPOSED
SILT FENCE		
INLET PROTECTION		

MISC

FEATURE	EXISTING	PROPOSED
CASING PIPE		
TANK FILLER	F	
CLAY DAM		
CONTRACTOR TEST PIT		T
POST INDICATOR VALVE		
PUMP		
VALVE OPERATOR **		
CHECK VALVE		

FEATURE	EXISTING	PROPOSED
CLAY		
APPROVED BACKFILL		
SAND		
SEDIMENT		
COMPACT STONE SUBBASE		
SELECT FILL		
FILL		
RIP-RAP / CRUSHED STONE		
BEDROCK		
SWAMP		
TOPSOIL		
ASPHALT		
CONCRETE		
CONCRETE MASONRY UNIT		
ROCK SURFACE		
EARTH SURFACE		
PIPE BEDDING		
TOP COURSE		
BINDER COURSE		
GRANITE		
PEA GRAVEL		
EASEMENT		
MARSH OR SWAMP		
ROCK OUTCROPPING		

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Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

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0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4**
LOUISA GENERATING STATION

Title **GENERAL SYMBOLS AND LEGEND**

Size **ARCH D**

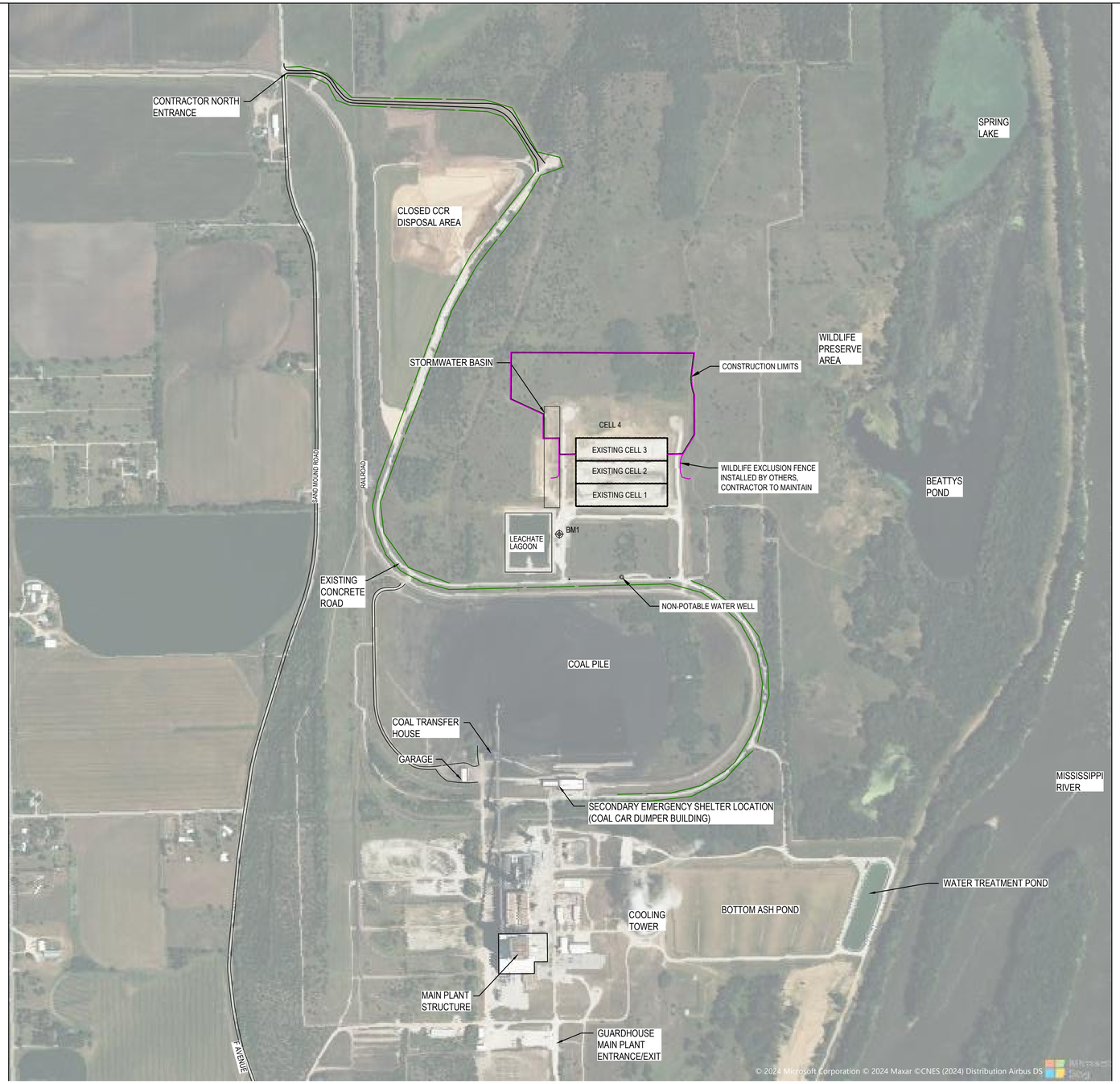
Project No. **12635351**

Date **JUNUARY 2025**

Scale

Sheet No. **GN-004**

Plot Date: 9 January 2025 - 10:11 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Gen\12635351-GHD-00-DRG-00-GN-004.dwg



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PLAN

SCALE 1" = 500'

0 500' 1000'

NOTES:

1. CONTRACTOR SHALL ONLY USE DESIGNATED AREAS SHOWN ON THE DRAWINGS.
2. CONTRACTOR IS RESPONSIBLE FOR ALL CONDITIONS OF THE STORM WATER PERMIT ACTIVITIES INSIDE THE PROJECT AREA. ALL TEMPORARY AND PERMANENT STORM WATER FEATURES SHOWN OR PART OF THIS PROJECT MUST COMPLY WITH THE PERMIT AND SPECIFICATIONS.
3. UTILITY LOCATIONS ARE APPROXIMATE. CONTRACTOR SHALL FIELD LOCATE ALL UNDERGROUND AND ABOVE GROUND UTILITIES INCLUDING NOTIFICATION OF IOWA ONE CALL (1-800-292-8989).
4. ENGINEER SHALL PROVIDE SITE CONTROL DATA PRIOR TO START OF PROJECT. STATE PLANE NORTHING AND EASTING AND ELEVATION IN FEET NGVD88.
5. CONTRACTOR TO PROTECT ALL MONITORING WELLS.
6. THE WILDLIFE PRESERVE AREA IS TO BE PROTECTED THROUGHOUT CONSTRUCTION AND OPERATION OF THE CCR MONOFILL.
7. SEE STORMWATER PLAN (CI-105) FOR INFORMATION PERTAINING TO POLLUTION PREVENTION FOR THIS PROJECT. PUMPED WATER FROM DEWATERING FROM CONSTRUCTION SHALL BE DISCHARGED TO EXISTING FACILITIES.
8. CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION OF SITE SECURITY DURING THE WORK.
9. CONTRACTOR SHALL USE DESIGNATED STOCKPILE AREAS.
10. CONTRACTOR SHALL OVEREXCAVATE AND REPLACE UNSUITABLE SOILS.
11. ALL DISTURBED SOIL AREAS OUTSIDE OF CELL AND PROJECT BOUNDARIES SHALL BE RESTORED AND SEEDED.
12. CONTRACTOR SHALL PROVIDE OWNER CONTINUOUS ACCESS TO ALL AREAS WITHIN THE LIMITS OF CONSTRUCTION.
13. SEE SPECIFICATION AND SEQUENCING REQUIREMENTS FOR KEY FEATURES.
14. CLEARING TREES TO BE COORDINATED WITH OWNER AND ENGINEER PRIOR TO COMMENCEMENT.
15. WILDLIFE EXCLUSION FENCE INSTALLED BY OTHERS AND ALIGNMENT MAY VARY. CONTRACTOR TO MAINTAIN INTEGRITY OF FENCE.

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Title **GENERAL SITE PLAN**

Size **ARCH D**

Project No. **12635351** Date **JUNUARY 2025** Scale **AS SHOWN**

Sheet No. **GN-005**

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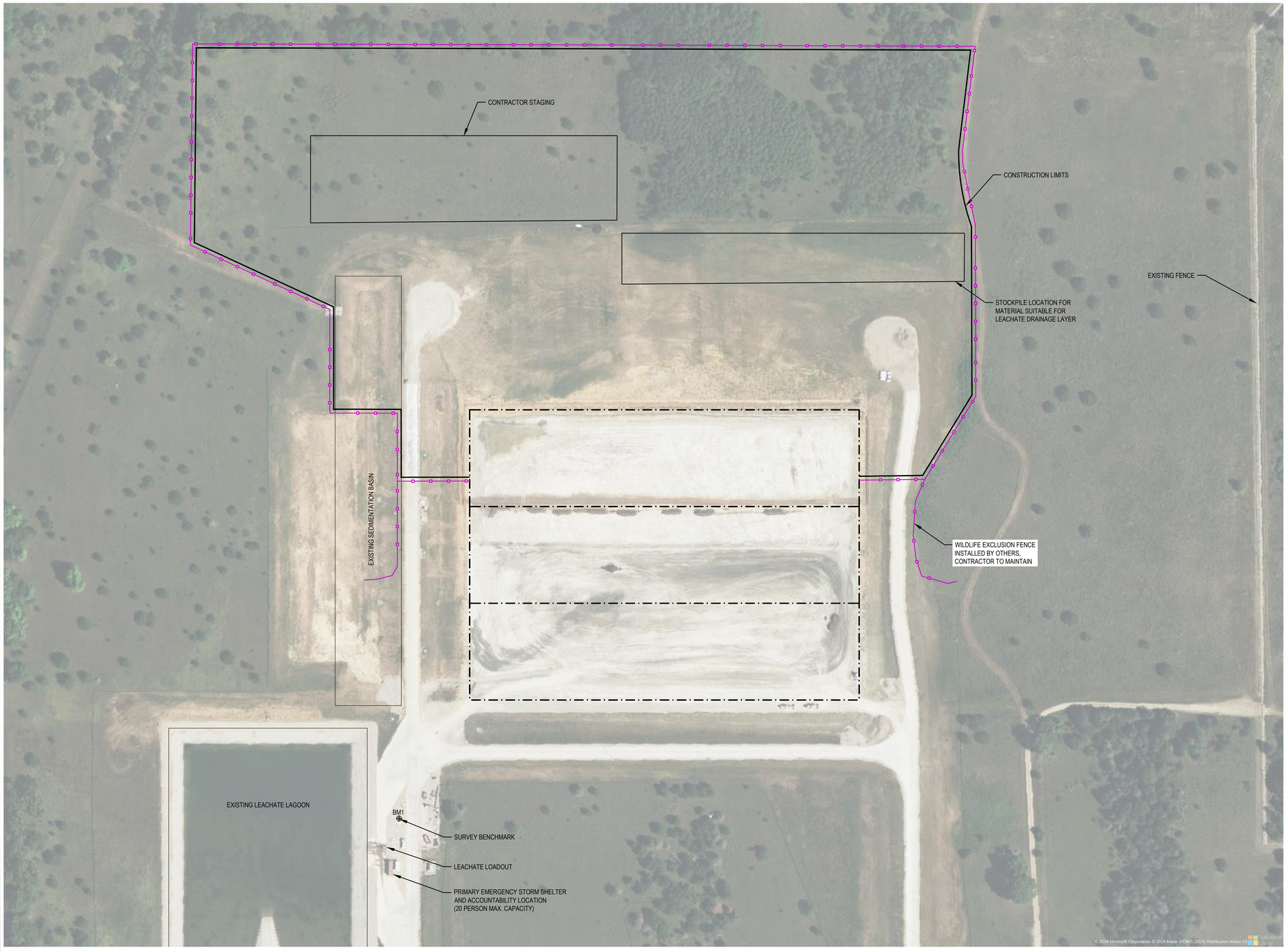

PLAN

SCALE 1" = 100'

0 100' 200'

N

NOTES:

1. CONTRACTOR SHALL ONLY USE DESIGNATED AREAS SHOWN ON THE DRAWINGS.
2. CONTRACTOR IS RESPONSIBLE FOR ALL CONDITIONS OF THE STORM WATER PERMIT ACTIVITIES INSIDE THE PROJECT AREA. ALL TEMPORARY AND PERMANENT STORM WATER FEATURES SHOW OR PART OF THIS PROJECT MUST COMPLY WITH THE PERMIT AND SPECIFICATIONS.
3. UTILITY LOCATIONS ARE APPROXIMATE. CONTRACTOR SHALL FIELD LOCATE ALL UNDERGROUND AND ABOVE GROUND UTILITIES INCLUDING NOTIFICATIONS OF IOWA ONE CALL (1-800-292-8989).
4. CONTRACTOR TO PROTECT ALL MONITORING WELLS.
5. THE WILDLIFE PRESERVE AREA IS TO BE PROTECTED THROUGHOUT CONSTRUCTION AND OPERATION OF THE CCR MONOFILL.
6. SEE STORMWATER (SHEET CI-105) FOR INFORMATION PERTAINING TO POLLUTION PREVENTION FOR THIS PROJECT. PUMPED WATER FROM DEWATERING FROM CONSTRUCTION SHALL BE DISCHARGED TO EXISTING FACILITIES.
7. CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION OF SITE SECURITY DURING THE WORK.
8. CONTRACTOR SHALL USE DESIGNATED STOCKPILE AREAS.
9. CONTRACTOR SHALL OVEREXCAVATE AND REPLACE UNSUITABLE SOILS.
10. ALL DISTURBED SOIL AREAS OUTSIDE OF CELL AND PROJECT BOUNDARIES SHALL BE RESTORED AND SEEDED.
11. CONTRACTOR SHALL PROVIDE OWNER CONTINUOUS ACCESS TO ALL AREAS WITHIN THE LIMITS OF CONSTRUCTION.
12. THERE SHALL BE NO STOCKPILING, FILLING, GRADING, EXCAVATIONS, OR HAUL ROADS WITHIN THE 500 FOOT IDENTIFIED ZONE.
13. CONTRACTOR SHALL MINIMIZE DISTURBED AREAS AS A RESULT OF CONSTRUCTION AND RESTORE ALL DISTURBED AREAS. CONTRACTOR TO PROVIDE AND INSTALL TEMPORARY CULVERTS TO MAINTAIN DRAINAGE PATHS.
14. ALL STOCKPILE SOILS QUANTITIES SHOWN ON THE PLANS ARE LOOSE VOLUMES AND APPROXIMATE. ALL VEGETATION, ROOTS, AND DELTERIOUS MATERIALS MUST BE REMOVED BEFORE USE. EXCESS TOPSOIL SHALL BE PLACED IN DESIGNATED STOCKPILE AREAS.
15. WILDLIFE EXCLUSION FENCE INSTALLED BY OTHERS AND ALIGNMENT MAY VARY. CONTRACTOR TO MAINTAIN INTEGRITY OF FENCE.

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LOUISA GENERATING STATION

Title **CONSTRUCTION AREA SITE PLAN**

Size **ARCH D**

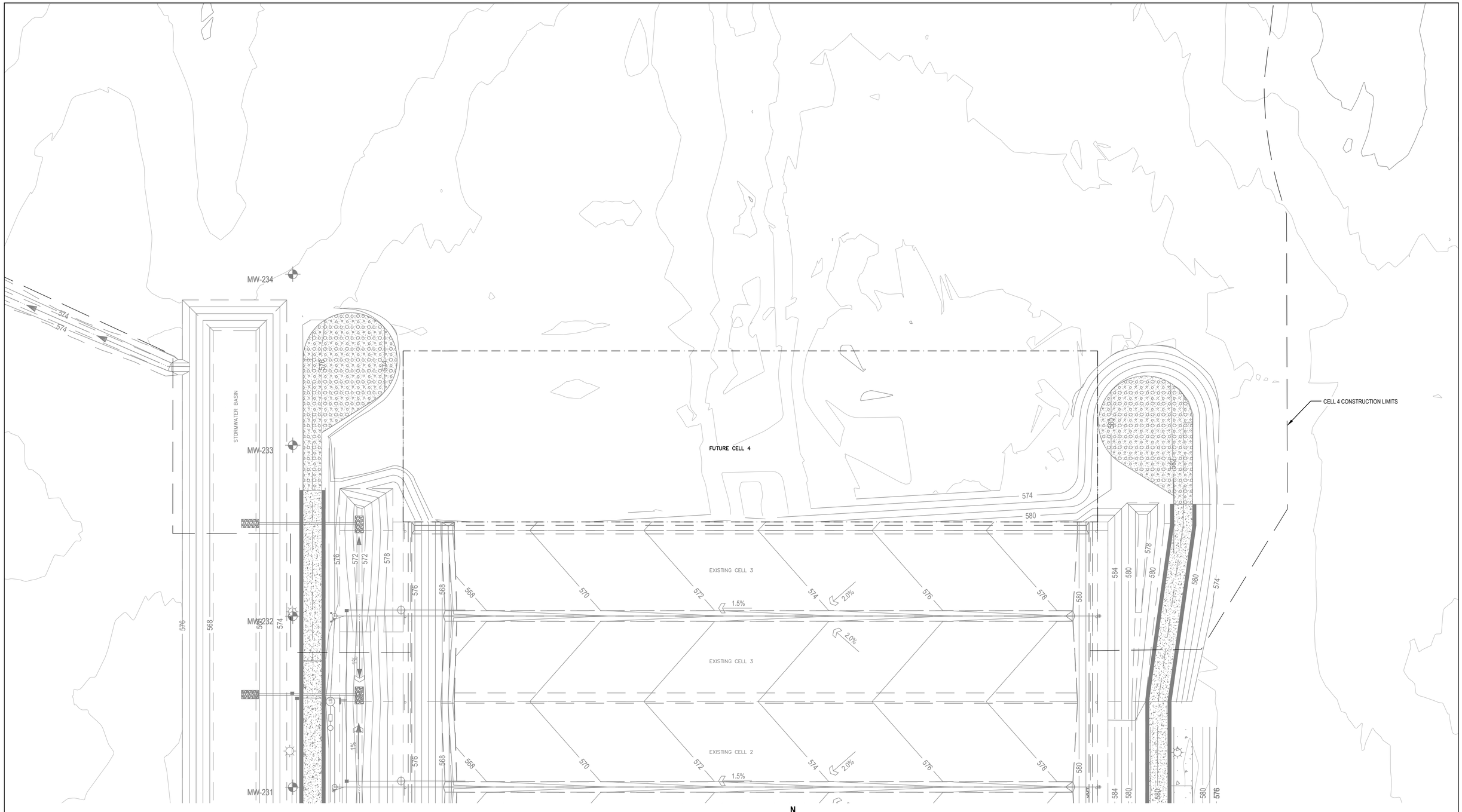
Project No. **12635351**

Date **JUNUARY 2025**

Scale **AS SHOWN**

Sheet No. **GN-006**

Plot Date: 9 January 2025 - 10:13 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Gen\12635351-GHD-00-DRG-00-GN-006.dwg



PLAN

SCALE 1" = 50'

0 50' 100'

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet

0 1"

GHD Inc.
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Des Moines Iowa 50322 USA
T 515 414 3933

www.ghd.com

Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4**
LOUISA GENERATING STATION

Title **EXISTING BOTTOM OF CLAY LINER GRADING PLAN**

Size **ARCH D**

Project No. **12635351**

Date **JUNUARY 2025**

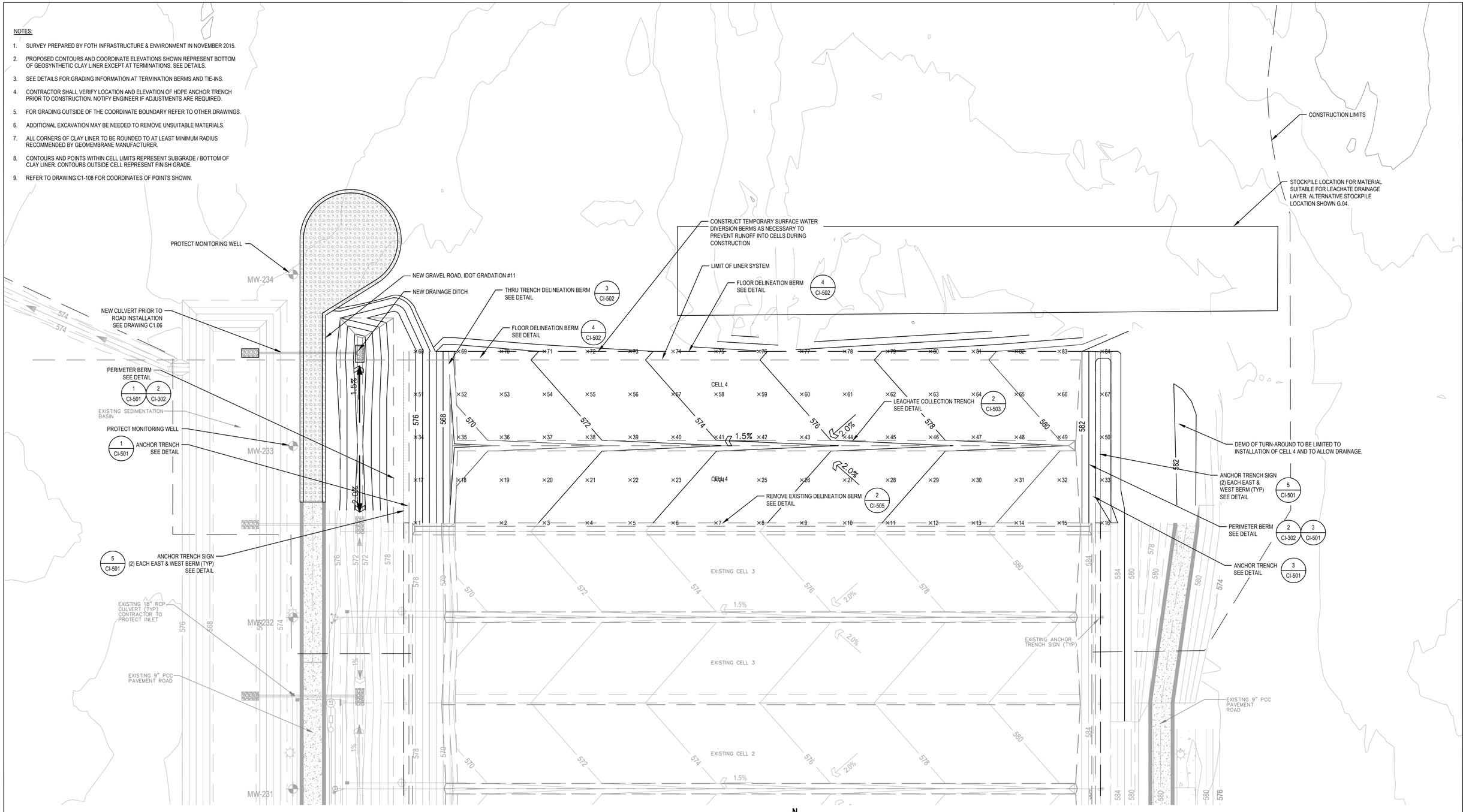
Scale **AS SHOWN**

Sheet No. **CI-101**

Plot Date: 9 January 2025 - 10:14 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-101.dwg

NOTES:

1. SURVEY PREPARED BY FOTH INFRASTRUCTURE & ENVIRONMENT IN NOVEMBER 2015.
2. PROPOSED CONTOURS AND COORDINATE ELEVATIONS SHOWN REPRESENT BOTTOM OF GEOSYNTHETIC CLAY LINER EXCEPT AT TERMINATIONS. SEE DETAILS.
3. SEE DETAILS FOR GRADING INFORMATION AT TERMINATION BERMS AND TIE-INS.
4. CONTRACTOR SHALL VERIFY LOCATION AND ELEVATION OF HDPE ANCHOR TRENCH PRIOR TO CONSTRUCTION. NOTIFY ENGINEER IF ADJUSTMENTS ARE REQUIRED.
5. FOR GRADING OUTSIDE OF THE COORDINATE BOUNDARY REFER TO OTHER DRAWINGS.
6. ADDITIONAL EXCAVATION MAY BE NEEDED TO REMOVE UNSUITABLE MATERIALS.
7. ALL CORNERS OF CLAY LINER TO BE ROUNDED TO AT LEAST MINIMUM RADIUS RECOMMENDED BY GEOMEMBRANE MANUFACTURER.
8. CONTOURS AND POINTS WITHIN CELL LIMITS REPRESENT SUBGRADE / BOTTOM OF CLAY LINER. CONTOURS OUTSIDE CELL REPRESENT FINISH GRADE.
9. REFER TO DRAWING C1-108 FOR COORDINATES OF POINTS SHOWN.



N

PLAN

SCALE 1" = 50'

0 50' 100'

1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24
No.	Issue	Checked	Approved	Date

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

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0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **CELL 4 BOTTOM OF GEOSYNTETIC CLAY LINER LINER GRADING PLAN**

Size **ARCH D**

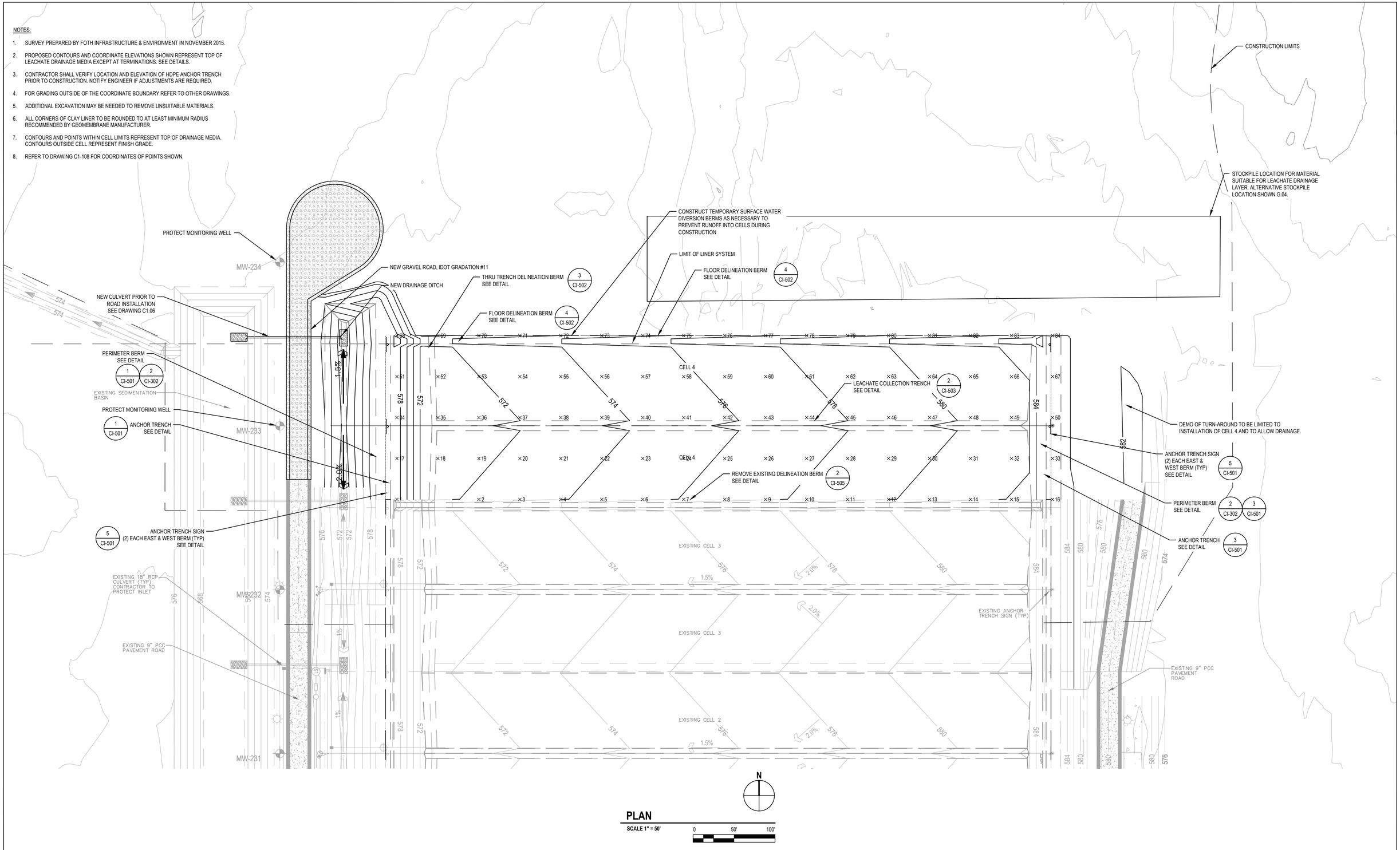
Project No. **12635351** Date **JUNUARY 2025** Scale **AS SHOWN**

Sheet No. **CI-102**

Plot Date: 9 January 2025 - 10:15 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-102.dwg

NOTES:

1. SURVEY PREPARED BY FOTH INFRASTRUCTURE & ENVIRONMENT IN NOVEMBER 2015.
2. PROPOSED CONTOURS AND COORDINATE ELEVATIONS SHOWN REPRESENT TOP OF LEACHATE DRAINAGE MEDIA EXCEPT AT TERMINATIONS. SEE DETAILS.
3. CONTRACTOR SHALL VERIFY LOCATION AND ELEVATION OF HDPE ANCHOR TRENCH PRIOR TO CONSTRUCTION. NOTIFY ENGINEER IF ADJUSTMENTS ARE REQUIRED.
4. FOR GRADING OUTSIDE OF THE COORDINATE BOUNDARY REFER TO OTHER DRAWINGS.
5. ADDITIONAL EXCAVATION MAY BE NEEDED TO REMOVE UNSUITABLE MATERIALS.
6. ALL CORNERS OF CLAY LINER TO BE ROUNDED TO AT LEAST MINIMUM RADIUS RECOMMENDED BY GEOMEMBRANE MANUFACTURER.
7. CONTOURS AND POINTS WITHIN CELL LIMITS REPRESENT TOP OF DRAINAGE MEDIA. CONTOURS OUTSIDE CELL REPRESENT FINISH GRADE.
8. REFER TO DRAWING C1-108 FOR COORDINATES OF POINTS SHOWN.



PLAN

SCALE 1" = 50'

0 50' 100'

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

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0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **CELL 4 TOP OF DRAINAGE LAYER GRADING PLAN**

Size **ARCH D**

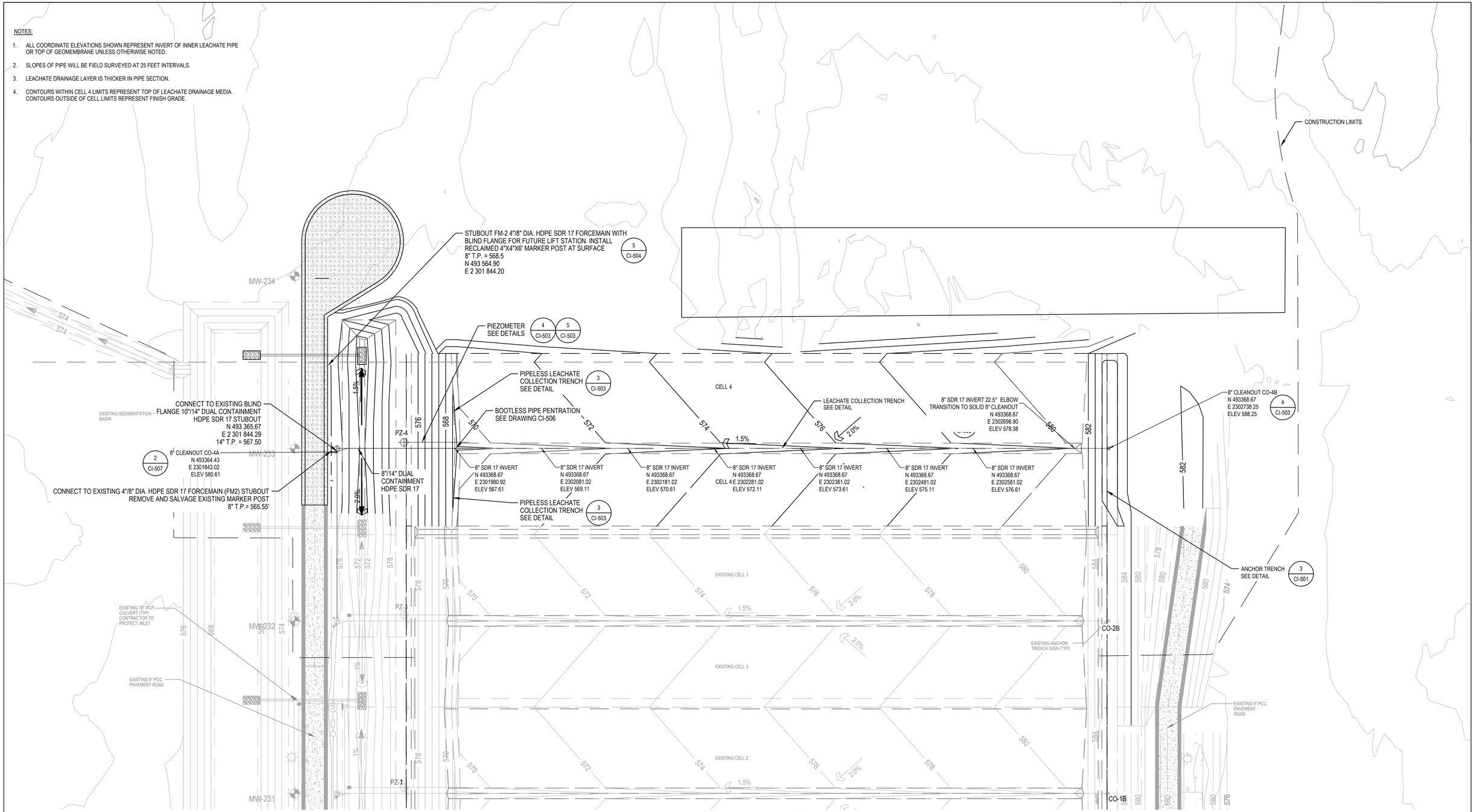
Project No. **12635351** Date **JUNUARY 2025** Scale **AS SHOWN**

Sheet No. **CI-103**

Plot Date: 9 January 2025 - 10:16 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-103.dwg

NOTES:

1. ALL COORDINATE ELEVATIONS SHOWN REPRESENT INVERT OF INNER LEACHATE PIPE OR TOP OF GEOMEMBRANE UNLESS OTHERWISE NOTED.
2. SLOPES OF PIPE WILL BE FIELD SURVEYED AT 25 FEET INTERVALS.
3. LEACHATE DRAINAGE LAYER IS THICKER IN PIPE SECTION.
4. CONTOURS WITHIN CELL 4 LIMITS REPRESENT TOP OF LEACHATE DRAINAGE MEDIA. CONTOURS OUTSIDE OF CELL LIMITS REPRESENT FINISH GRADE.



PLAN

SCALE 1" = 50'

0 50' 100'

1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24
No.	Issue	Checked	Approved	Date

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet
0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **CELL 4 TOP OF DRAINAGE LAYER GRADING PLAN**

Size **ARCH D**

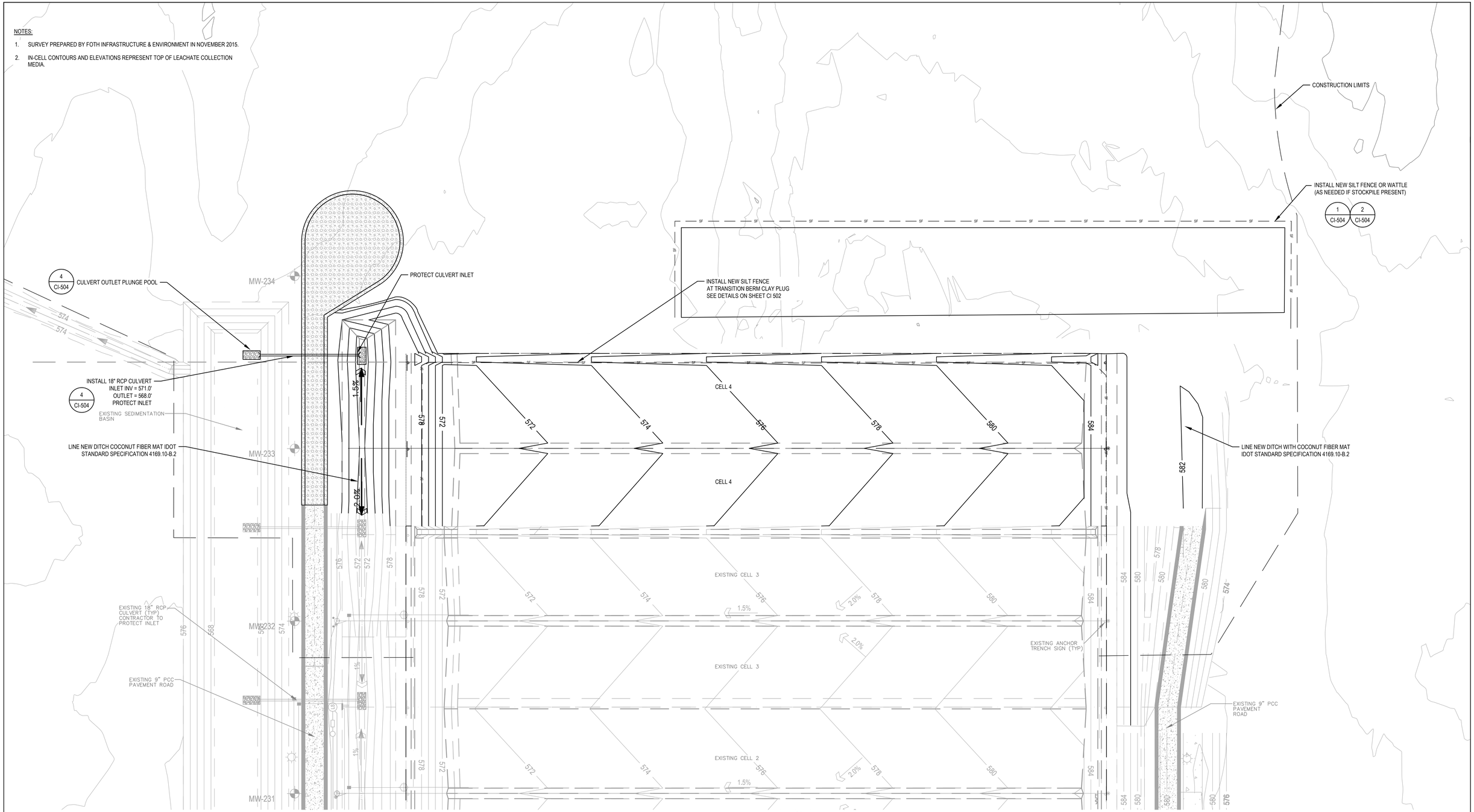
Project No. **12635351** Date **JUNUARY 2025** Scale **AS SHOWN**

Sheet No. **CI-104**

Plot Date: 9 January 2025 - 10:17 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-104.dwg

NOTES:

1. SURVEY PREPARED BY FOTH INFRASTRUCTURE & ENVIRONMENT IN NOVEMBER 2015.
2. IN-CELL CONTOURS AND ELEVATIONS REPRESENT TOP OF LEACHATE COLLECTION MEDIA.



PLAN

SCALE 1" = 50'

0 50' 100'

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet

0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **LEACHATE COLLECTION SYSTEM PLAN**

Size **ARCH D**

Project No. **12635351**

Date **JUNUARY 2025**

Scale **AS SHOWN**

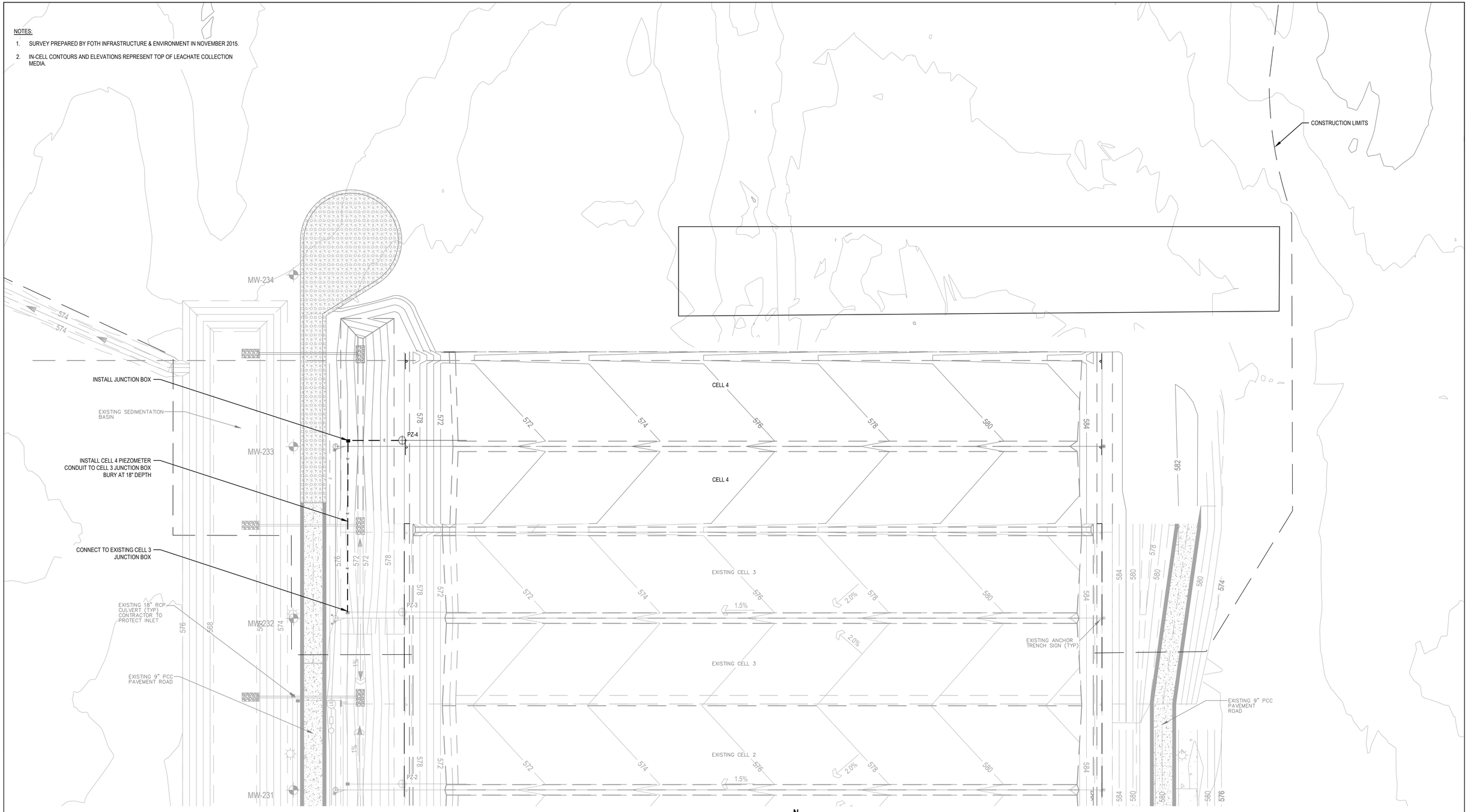
Sheet No. **CI-105**

Plot Date: 9 January 2025 - 10:17 AM Plotted By: Lily Gao

Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-105.dwg

NOTES:

1. SURVEY PREPARED BY FOTH INFRASTRUCTURE & ENVIRONMENT IN NOVEMBER 2015.
2. IN-CELL CONTOURS AND ELEVATIONS REPRESENT TOP OF LEACHATE COLLECTION MEDIA.



PLAN

SCALE 1" = 50'

0 50' 100'

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet

0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **STORMWATER PLAN**

Size **ARCH D**

Project No. **12635351**

Date **JUNUARY 2025**

Scale **AS SHOWN**

Sheet No. **CI-106**

Plot Date: 9 January 2025 - 10:18 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-106.dwg

PT	EASTING	NORTHING	BOTTOM OF GCL	BOTTOM OF GCL AS-BUILT	TOP DRAIN DESIGN	TOP DRAIN AS-BUILT		
1	2301938.115	493278.6675	578.00		579.00			
2	2302038.115	493278.6675	571.12		572.42			
3	2302088.115	493278.6675	572.10		573.32			
4	2302138.115	493278.6675	572.85		574.00			
5	2302188.115	493278.6675	573.60		574.72			
6	2302238.115	493278.6675	574.35		575.63			
7	2302288.115	493278.6675	575.10		576.12			
8	2302338.115	493278.6675	575.85		577.02			
9	2302388.115	493278.6675	576.60		577.93			
10	2302438.115	493278.6675	577.35		578.42			
11	2302488.115	493278.6675	578.10		579.32			
12	2302538.115	493278.6675	578.85		580.00			
13	2302588.115	493278.6675	579.60		580.72			
14	2302638.115	493278.6675	580.46		581.63			
15	2302688.115	493278.6675	581.47		582.47			
16	2302738.115	493278.6675	585.20		586.20			
17	2301938.115	493328.6675	578.00		579.00			
18	2301988.115	493328.6675	569.65		572.00			
19	2302038.115	493328.6675	570.69		572.00			
20	2302088.115	493328.6675	571.15		572.53			
21	2302138.115	493328.6675	572.19		573.19			
22	2302188.115	493328.6675	572.81		573.94			
23	2302238.115	493328.6675	573.45		574.81			
24	2302288.115	493328.6675	574.44		575.44			
25	2302338.115	493328.6675	574.98		576.23			
26	2302388.115	493328.6675	575.84		576.94			
27	2302438.115	493328.6675	576.69		577.69			
28	2302488.115	493328.6675	577.18		578.53			
29	2302538.115	493328.6675	578.19		579.19			
30	2302588.115	493328.6675	578.81		579.94			
31	2302638.115	493328.6675	579.40		580.81			
32	2302688.115	493328.6675	580.89		581.50			
33	2302738.115	493328.6675	586.00		587.00			
34	2301938.115	493378.6675	578.00		579.00			
35	2301988.115	493378.6675	568.40		572.00			
36	2302038.115	493378.6675	570.10		572.00			
37	2302088.115	493378.6675	570.24		572.05			
38	2302138.115	493378.6675	570.93		572.80			
39	2302188.115	493378.6675	572.13		573.55			
40	2302238.115	493378.6675	572.44		574.29			
41	2302288.115	493378.6675	574.04		575.04			
42	2302338.115	493378.6675	574.17		575.79			
43	2302388.115	493378.6675	574.55		576.54			
44	2302438.115	493378.6675	576.11		577.29			
45	2302488.115	493378.6675	576.25		578.04			
46	2302538.115	493378.6675	577.00		578.79			
47	2302588.115	493378.6675	578.14		579.54			
48	2302638.115	493378.6675	578.37		580.36			
49	2302688.115	493378.6675	580.14		581.50			
50	2302738.115	493378.6675	586.00		587.00			
51	2301938.115	493428.6675	578.00		579.00			
52	2301988.115	493428.6675	570.12		572.00			
53	2302038.115	493428.6675	570.95		572.00			
54	2302088.115	493428.6675	571.64		573.02			
55	2302138.115	493428.6675	572.64		573.64			
56	2302188.115	493428.6675	573.20		574.46			
57	2302238.115	493428.6675	573.92		575.13			
58	2302288.115	493428.6675	574.66		575.74			
59	2302338.115	493428.6675	575.41		576.74			
60	2302388.115	493428.6675	576.20		577.24			
61	2302438.115	493428.6675	576.95		577.99			
62	2302488.115	493428.6675	577.59		579.02			
63	2302538.115	493428.6675	578.45		579.49			
64	2302588.115	493428.6675	579.20		580.46			
65	2302638.115	493428.6675	579.92		581.13			
66	2302688.115	493428.6675	581.12		582.12			
67	2302738.115	493428.6675	586.00		587.00			
68	2301938.115	493478.6675	578.00		579.12			
69	2301988.115	493478.6675	570.84		571.84			
70	2302038.115	493478.6675	571.91		572.91			
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72	2302138.115	493478.6675	573.86		574.86			
73	2302188.115	493478.6675	573.96		574.96			
74	2302238.115	493478.6675	575.09		576.09			
75	2302288.115	493478.6675	575.91		576.91			
76	2302338.115	493478.6675	575.99		576.99			
77	2302388.115	493478.6675	576.20		577.20			
78	2302438.115	493478.6675	576.62		577.62			
79	2302488.115	493478.6675	578.04		579.04			
80	2302538.115	493478.6675	578.39		580.02			
81	2302588.115	493478.6675	578.73		579.73			
82	2302638.115	493478.6675	580.10		581.10			
83	2302688.115	493478.6675	580.43		581.43			
84	2302738.115	493478.6675	584.20		585.20			

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

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0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**

Title **ELECTRICAL SITE PLAN**

Size **ARCH D**

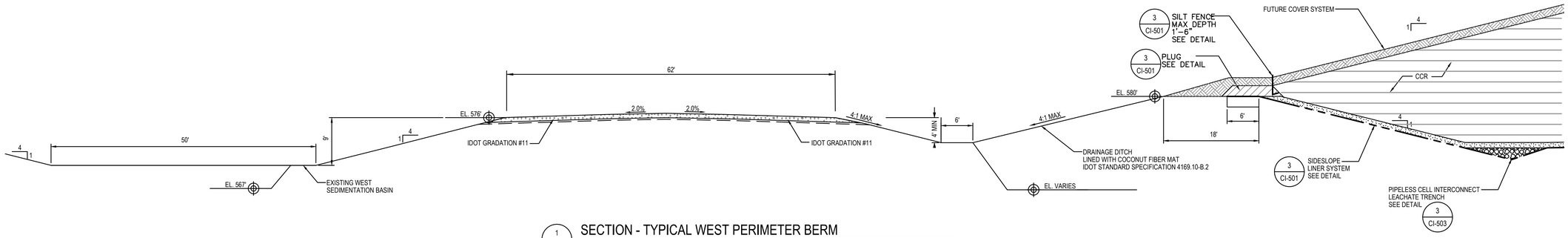
Project No. **12635351**

Date **JUNUARY 2025**

Scale **NTS**

Sheet No. **CI-107**

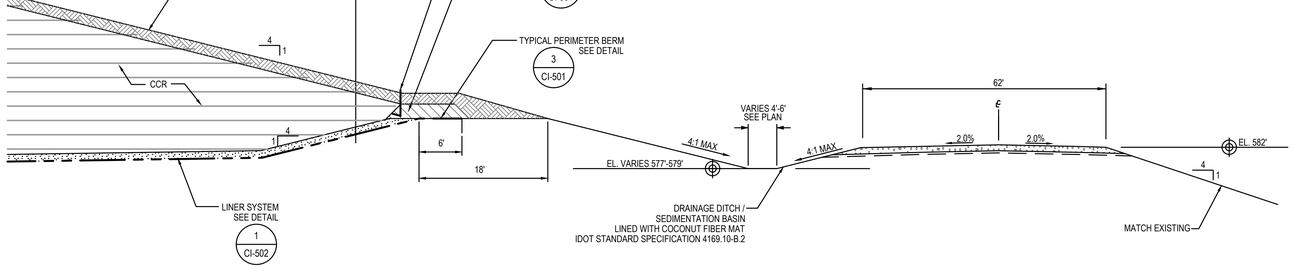
Plot Date: 9 January 2025 - 10:18 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-107.dwg



1 / CI-302 SECTION - TYPICAL WEST PERIMETER BERM

NOTE:

PORTIONS OF AREAS OUTSIDE OF THE CELL CLAY LINER SYSTEM HAVE BEEN CONSTRUCTED. SEE PLANS FOR NEW CONSTRUCTION LIMITS (DRAINAGE, ROADS, ETC)



2 / CI-302 SECTION - TYPICAL EAST PERIMETER BERM

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **S. PIKE** Drafting Check **G. USHIRO** Project Manager **J. SIMON**

Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet

0 1"

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Client **MIDAMERICAN ENERGY COMPANY**

Project **CCR MONOFILL EXPANSION CELL 4**
LOUISA GENERATING STATION

Title **PERIMETER BERM SECTIONS**

Size **ARCH D**

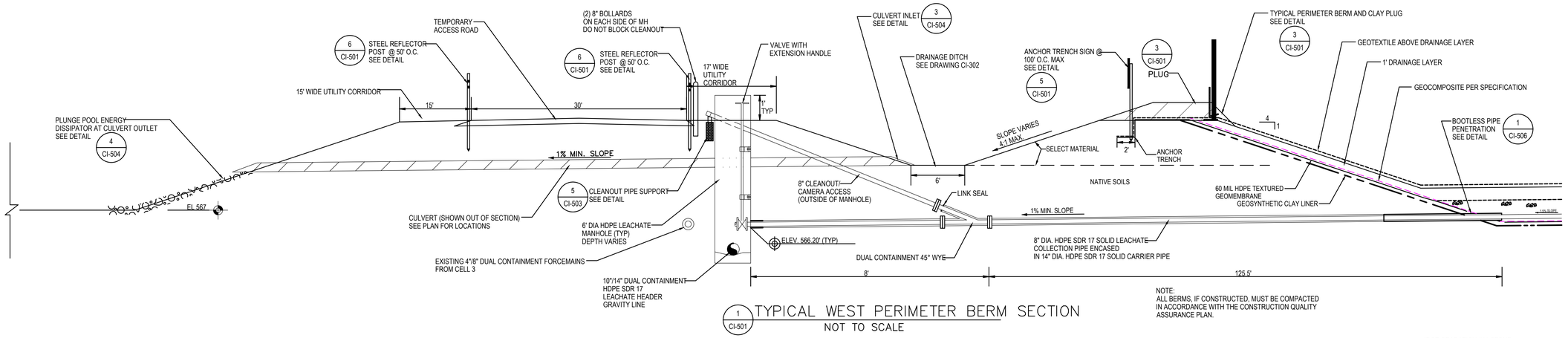
Project No. **12635351**

Date **JUNUARY 2025**

Scale **1" = 10'**

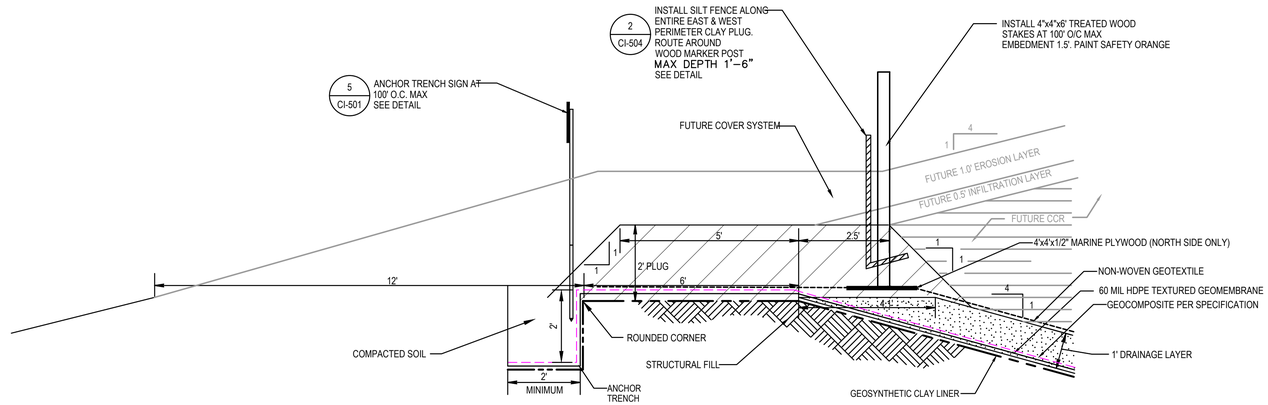
Sheet No. **CI-302**

Plot Date: 9 January 2025 - 10:19 AM Plotted By: Lily Gao Filename: C:\ADISK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-302.dwg

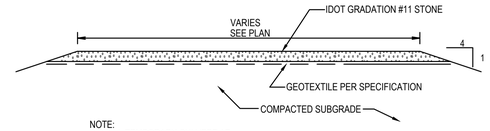


1 CI-501 TYPICAL WEST PERIMETER BERM SECTION
NOT TO SCALE

NOTE:
ALL BERMS, IF CONSTRUCTED, MUST BE COMPACTED IN ACCORDANCE WITH THE CONSTRUCTION QUALITY ASSURANCE PLAN.

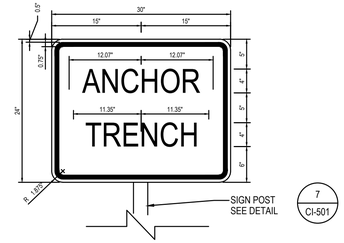


3 CI-501 TYPICAL PERIMETER BERM PLUG DETAIL
NOT TO SCALE

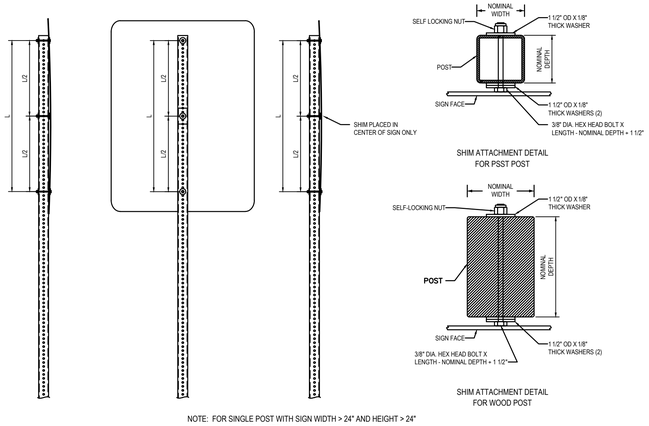


NOTE:
INSTALL TEMPORARY CULVERT AT DRAINAGE CROSSINGS

4 CI-501 TYPICAL TEMPORARY ACCESS ROAD DETAIL
NOT TO SCALE



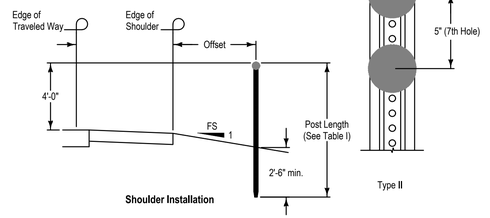
5 CI-501 TYPICAL ANCHOR TRENCH SIGN DETAIL
NOT TO SCALE



NOTE: FOR SINGLE POST WITH SIGN WIDTH > 24" AND HEIGHT > 24" FOR SHEET ALUMINUM SIGNS ONLY

7 CI-501 INSTALLATION - TYPE "A" SIGN SHIM IDOT SI-133 DETAIL
NOT TO SCALE

Post Lengths for Shoulder Installation					
Offset	Foreslope Rate (FS:1)				
ft	10:1	6:1	4:1	3:1	2:1
2	8	8	8	8	8
4	8	8	8	10	10
6	8	8	10	10	10
8	8	10	10	10	12



6 CI-501 TYPICAL REFLECTOR POST DETAIL
NOT TO SCALE

No.	Issue	Checked	Approved	Date
1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
0	ISSUED FOR BID	JS	MA	07/10/24

Author **G. USHIRO** Drafting Check **S. PIKE** Project Manager **J. SIMON**
Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet
0 1"

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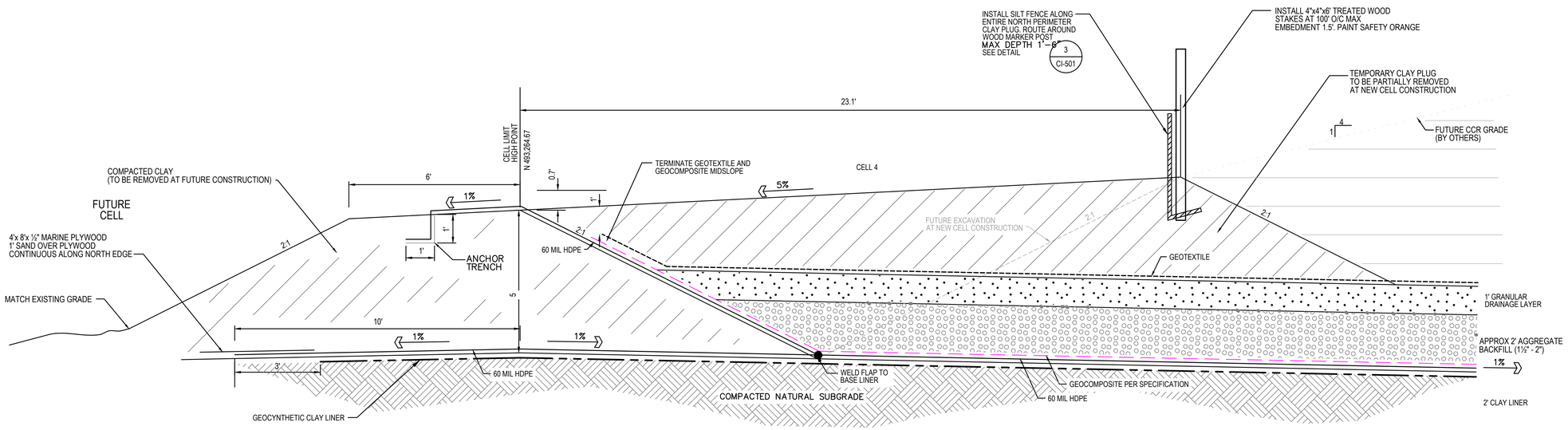
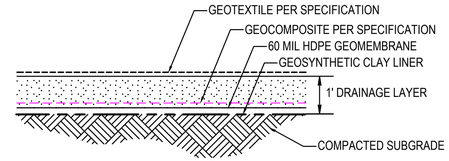
Client **MIDAMERICAN ENERGY COMPANY**
Project **CCR MONOFILL EXPANSION CELL 4 LOUISA GENERATING STATION**
Title **DETAILS**
Size **ARCH D**
Project No. **12635351** Date **JUNUARY 2025** Scale **NTS**
Sheet No. **CI-501**

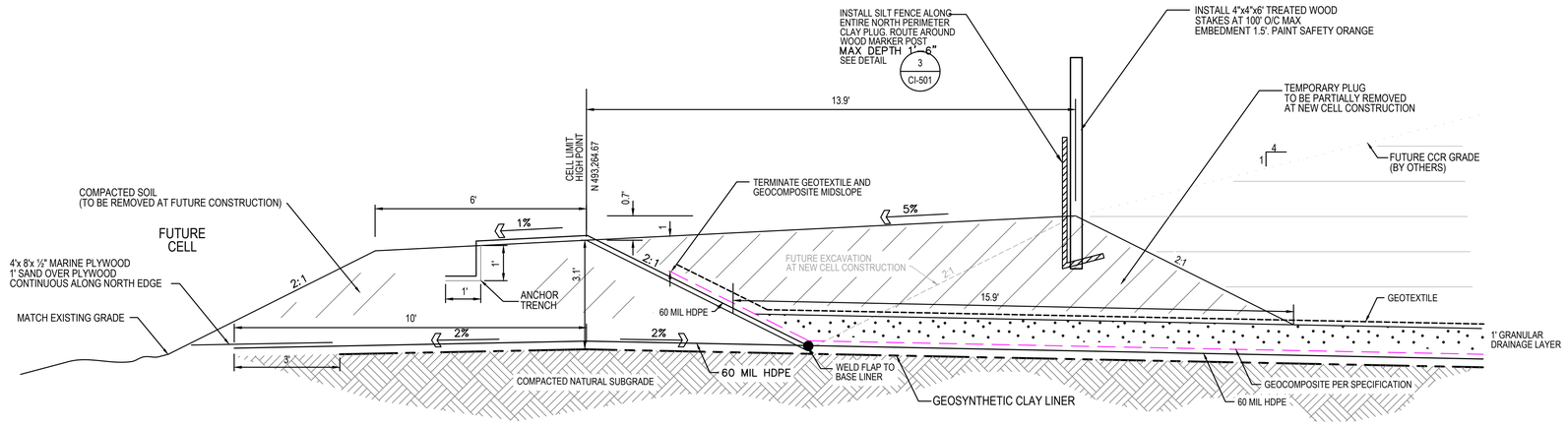
Plot Date: 9 January 2025 - 10:20 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-501.dwg



3 CI-502 CELL 4 FLOOR LINER TRANSITION BERM THROUGH TRENCH (NORTH)



1 CI-502 TYPICAL BOTTOM LINER DETAIL
NOT TO SCALE



4 CI-502 TYPICAL CELL 4 FLOOR LINER TRANSITION BERM DETAIL

NOTE:
THIS DETAIL APPLIES DIRECTLY TO THE TRANSITION BERMS ON 4:1 SLOPES WITH THE EXCEPTION OF THE 2% SLOPE ON BASAL LINER (NO HIGH POINT)

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Date **JUNUARY 2025**
Scale **NTS**
Sheet No. **CI-502**

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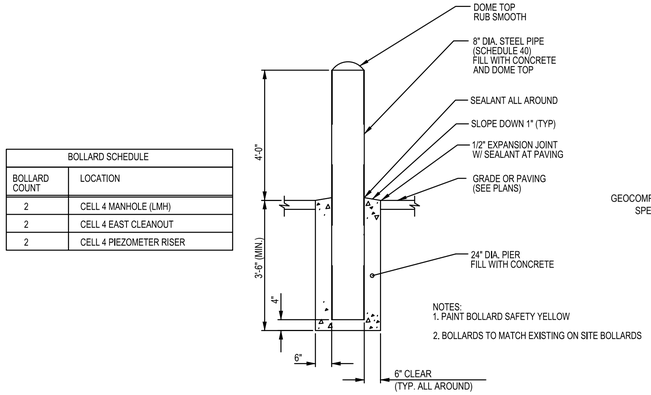
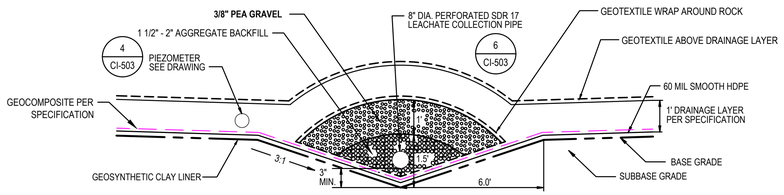
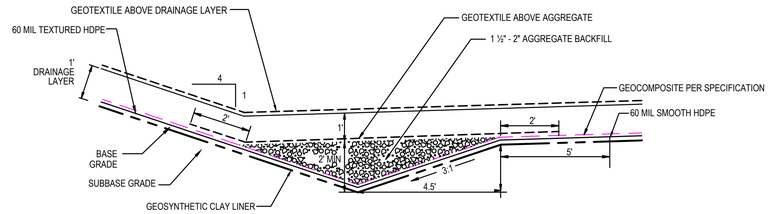
BOLLARD SCHEDULE	
BOLLARD COUNT	LOCATION
2	CELL 4 MANHOLE (LMH)
2	CELL 4 EAST CLEANOUT
2	CELL 4 PIEZOMETER RISER



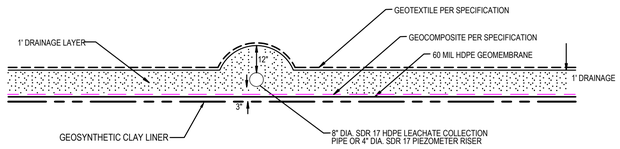
1 / CI-503 TYPICAL PIPE BOLLARD DETAIL
NOT TO SCALE



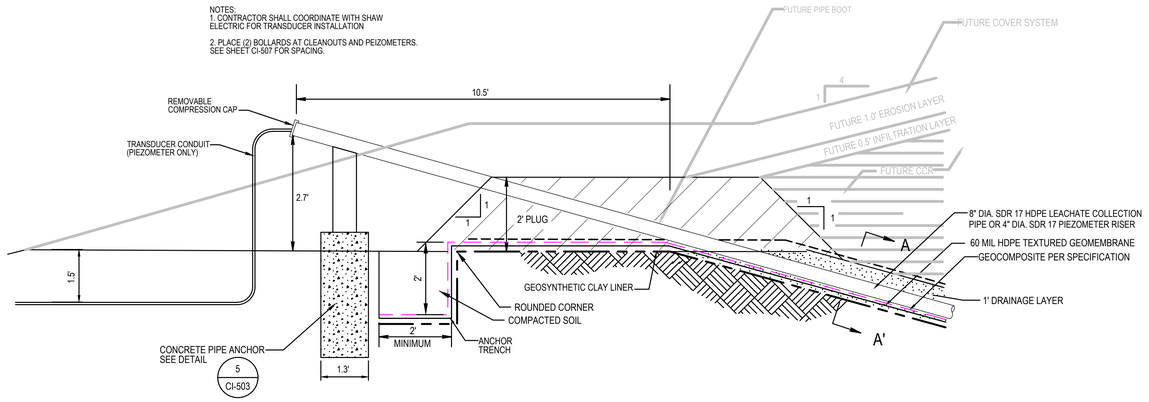
2 / CI-503 TYPICAL LEACHATE COLLECTION TRENCH DETAIL
NOT TO SCALE



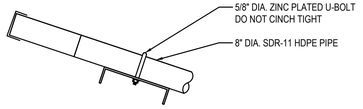
3 / CI-503 TYPICAL PIPELESS CELL INTERCONNECT LEACHATE TRENCH DETAIL
NOT TO SCALE

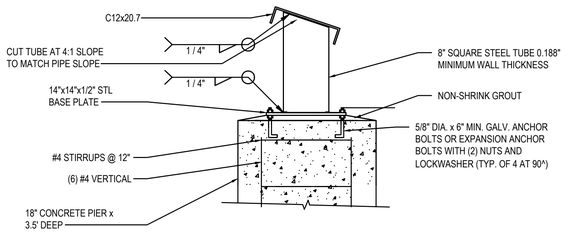


SECTION A-A'
CLEANOUT OR PIEZOMETER RISER

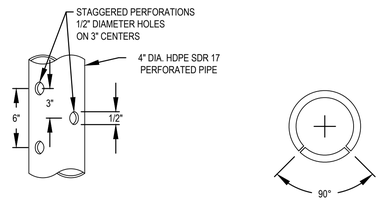


4 / CI-503 TYPICAL EAST CLEANOUT & WEST PIEZOMETER DETAIL
NOT TO SCALE

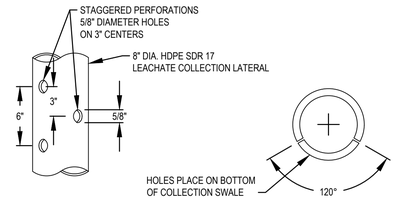




5 / CI-503 PIPE SUPPORT DETAIL
NOT TO SCALE



6 / CI-503 LEACHATE PIEZOMETER PIPE PERFORATIONS
NOT TO SCALE



7 / CI-503 LEACHATE COLLECTION PIPE PERFORATIONS
NOT TO SCALE

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Title **DETAILS**
Size **ARCH D**
Project No. **12635351** Date **JUNUARY 2025** Scale **NTS**
Sheet No. **CI-503**

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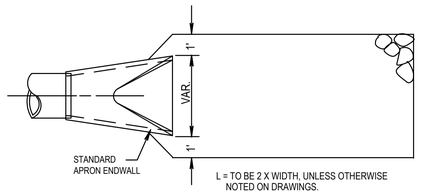
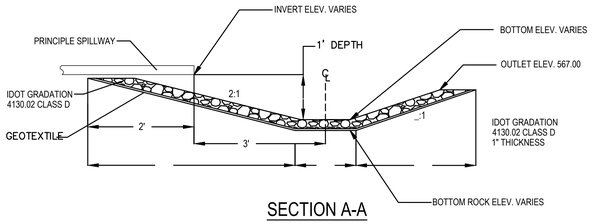
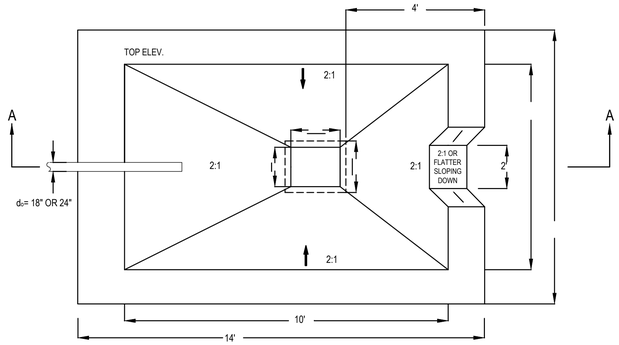
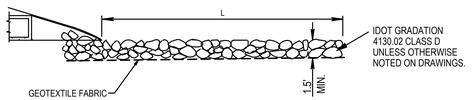




SECTION A-A



PLAN

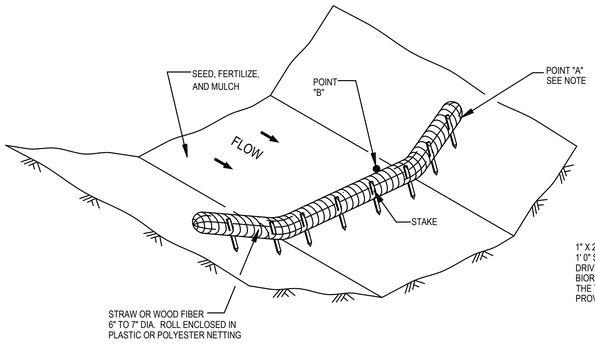


3 CI-504 TYPICAL CULVERT RIPRAP DETAIL

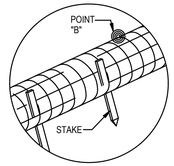
NOT TO SCALE

4 CI-504 PLUNGE POOL ENERGY DISSIPATOR DETAIL

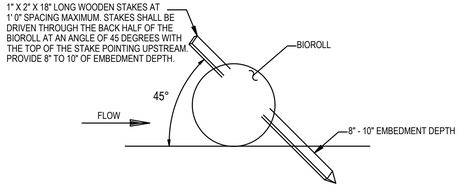
NOT TO SCALE



NOTE:
POINT "A" MUST BE A MINIMUM OF 6 INCHES HIGHER THAN POINT "B" TO ENSURE THAT WATER FLOWS OVER THE DIKE AND NOT AROUND THE ENDS.



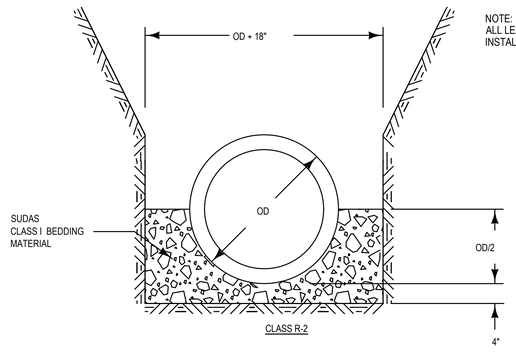
WATTLE INSET A



WATTLE STAKING DETAIL

1 CI-504 WATTLE DITCH CHECK TYPICAL DETAIL

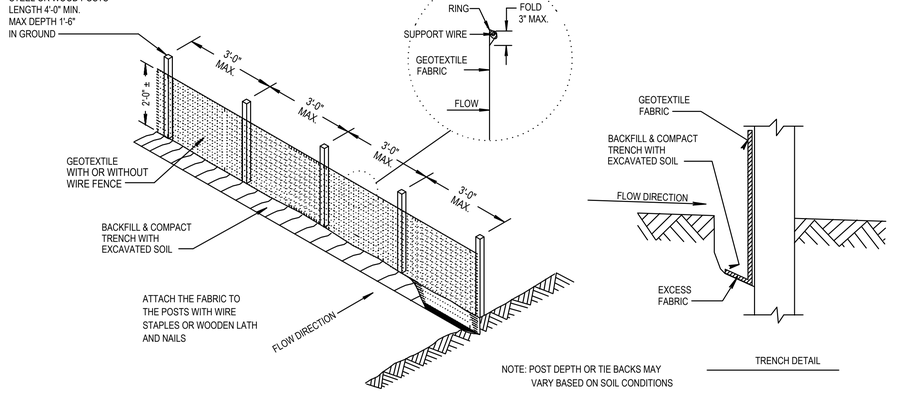
NOT TO SCALE



NOTE:
ALL LEACHATE PIPING SHALL BE
INSTALLED WITH TRACER WIRE.

5 CI-504 RIGID GRAVITY PIPE TRENCH BEDDING FOR AREAS OUTSIDE OF PAVEMENT OR CROSSINGS

NOT TO SCALE



2 CI-504 SILT FENCE AND TYPICAL TRENCH DETAIL

NOT TO SCALE

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Designer **J. SIMON** Design Check **M. ALOWITZ** Project Director **M. ALOWITZ**

Bar is one inch on original size sheet

0 1"

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Project **CCR MONOFILL EXPANSION CELL 4**
LOUISA GENERATING STATION

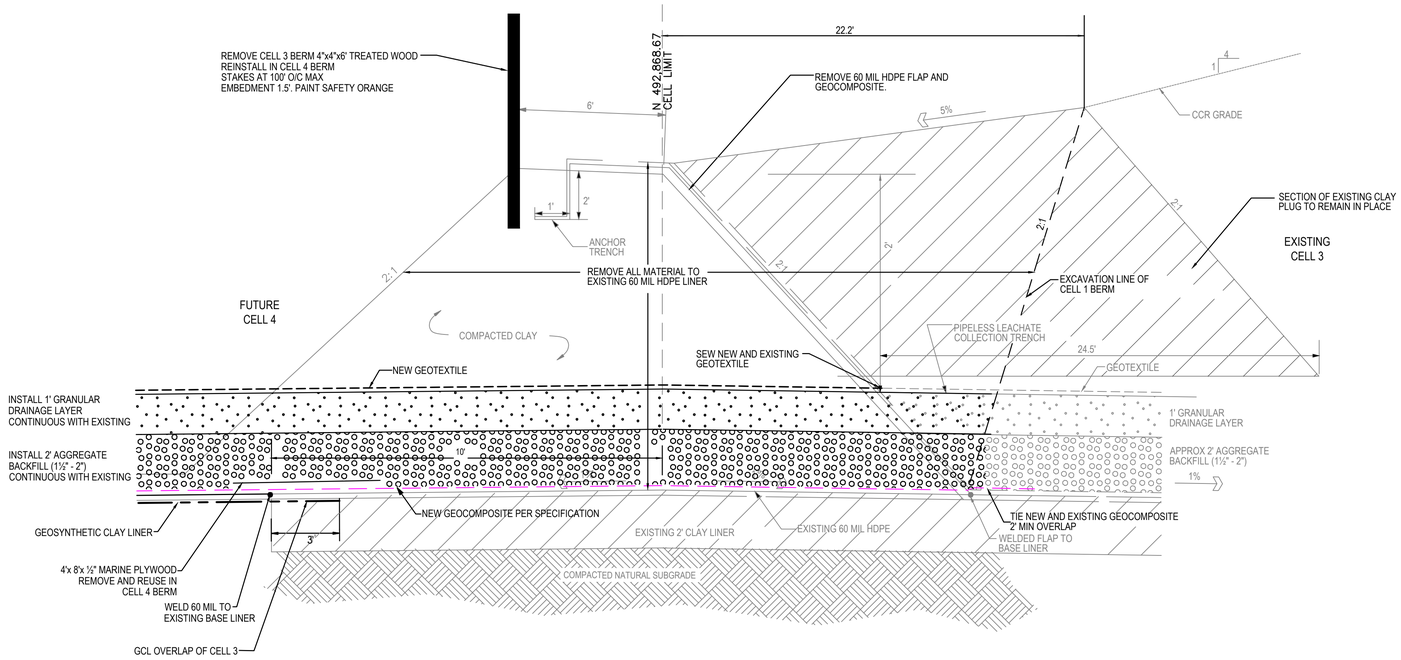
Title **DETAILS**

Size **ARCH D**

Project No. **12635351** Date **JUNUARY 2025** Scale **NTS**

Sheet No. **CI-504**

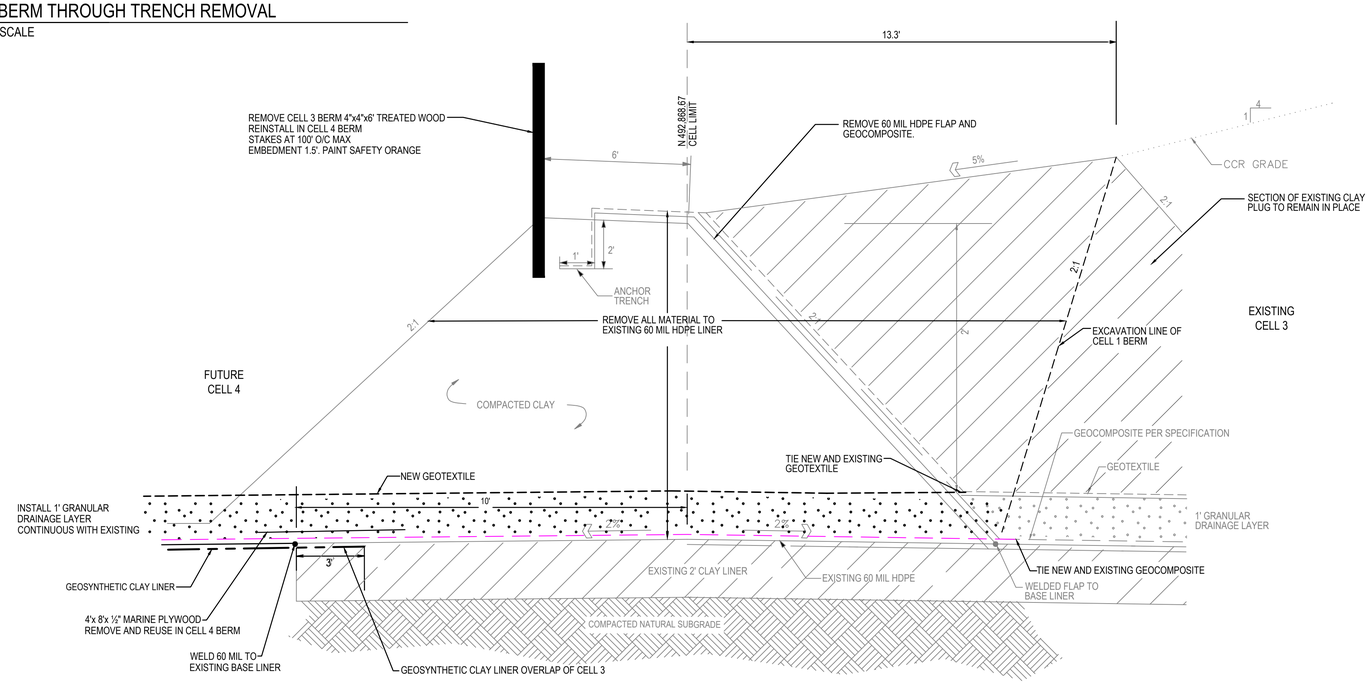
Plot Date: 9 January 2025 - 10:22 AM Plotted By: Lily Gao Filename: C:\ADSK\ACCDocs\GHD Services Pty Ltd\12635351-LGS - Monofill Expansion\Project Files\01 Design\01-GCL Option\Civil\C3D\Sheets\12635351-GHD-00-DRG-00-CI-504.dwg



1 / CI-505 CELL FLOOR LINER TRANSITION BERM THROUGH TRENCH REMOVAL

NOT TO SCALE

NOTE:
CCR MATERIAL REMOVED DURING BERM REMOVAL
TO BE KEPT WITHIN THE LINED MONOFILL AREA (CELL 3)



2 / CI-505 CELL FLOOR AND SLOPE LINER TRANSITION BERM REMOVAL (TYPICAL)

NOT TO SCALE

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1	ISSUED FOR CONSTRUCTION	JS	MA	01/09/25
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Sheet No. **CI-505**

Plot Date: 9 January 2025 - 10:23 AM Plotted By: Lily Gao
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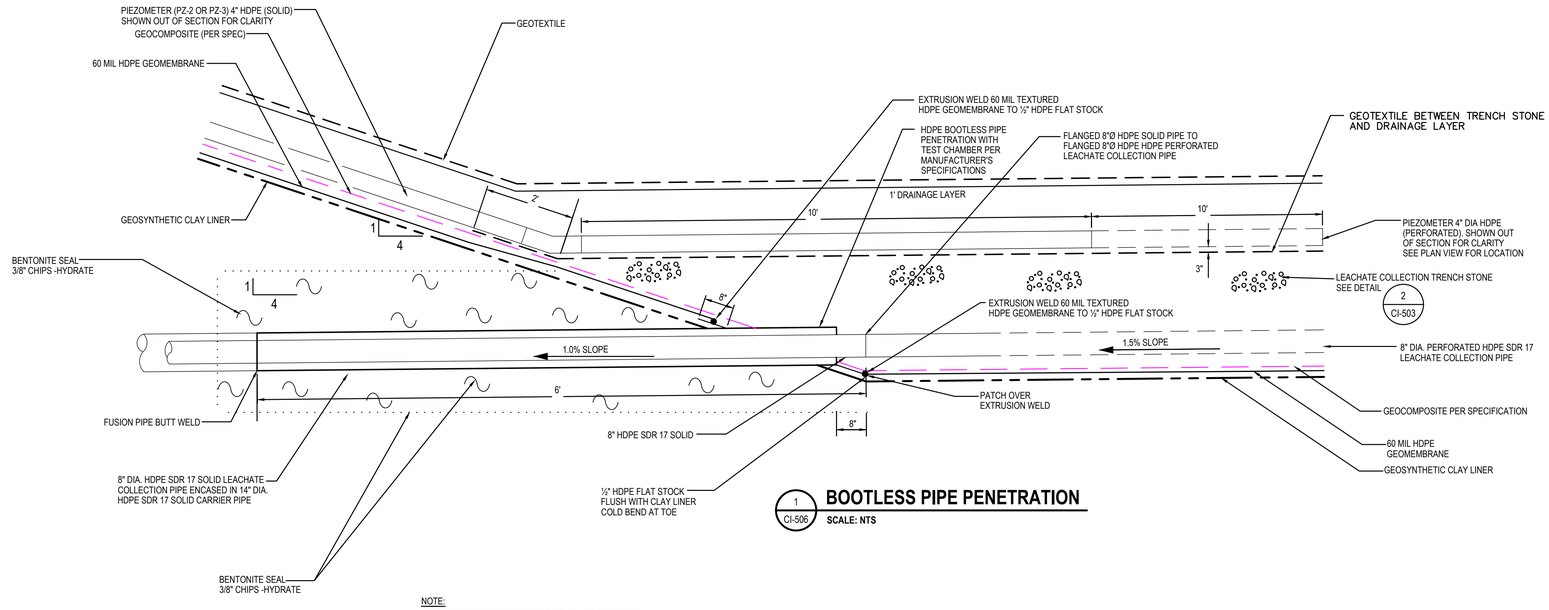
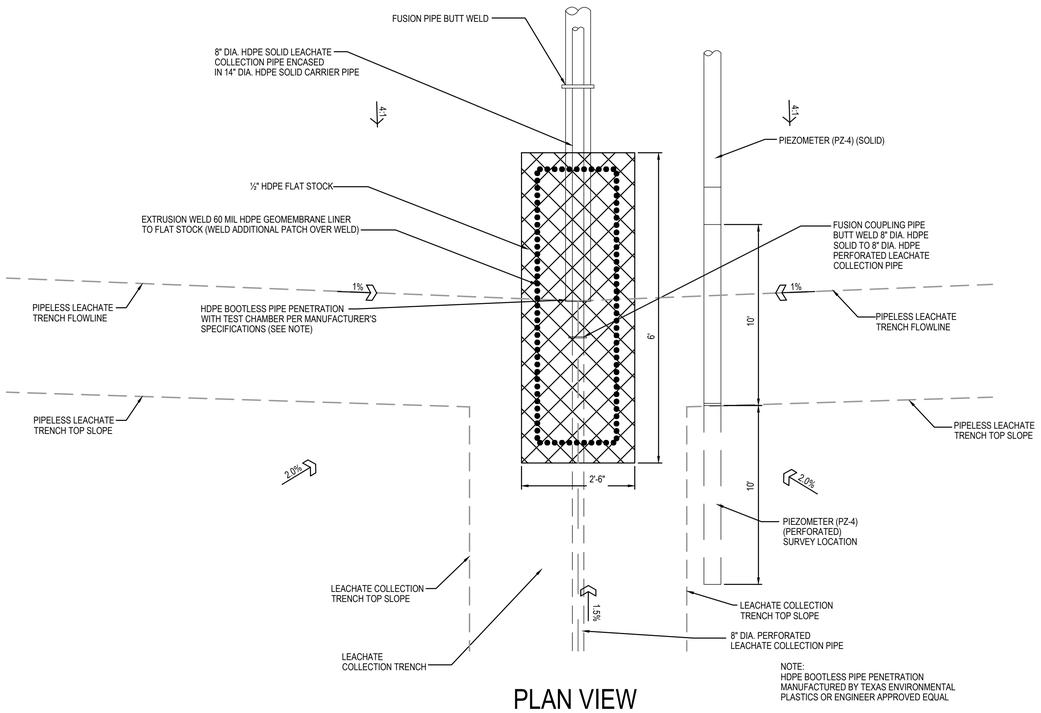


1 CI-506 BOOTLESS PIPE PENETRATION

SCALE: NTS

NOTE:
CONTRACTOR MAY SUBSTITUTE GRANULAR BENTONITE IN LIEU OF CLAY LINER IN AREA OF HDPE FLAT STOCK.



PLAN VIEW

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Scale **NTS**
Sheet No. **CI-506**

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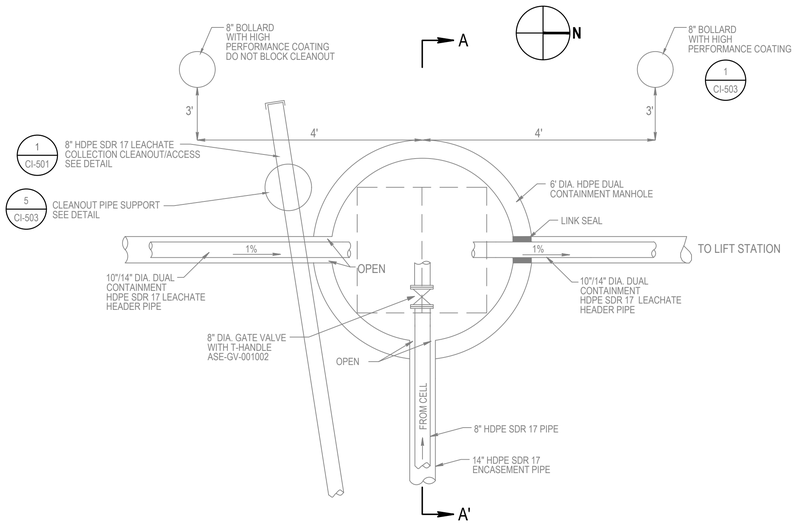
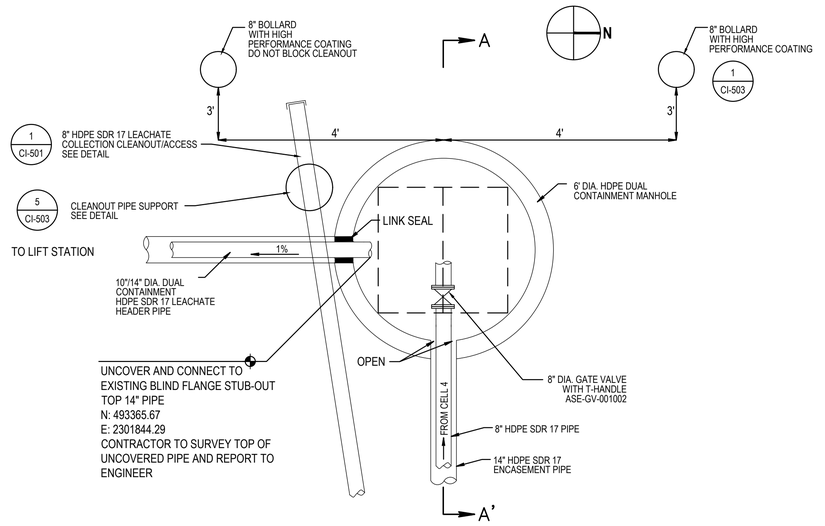
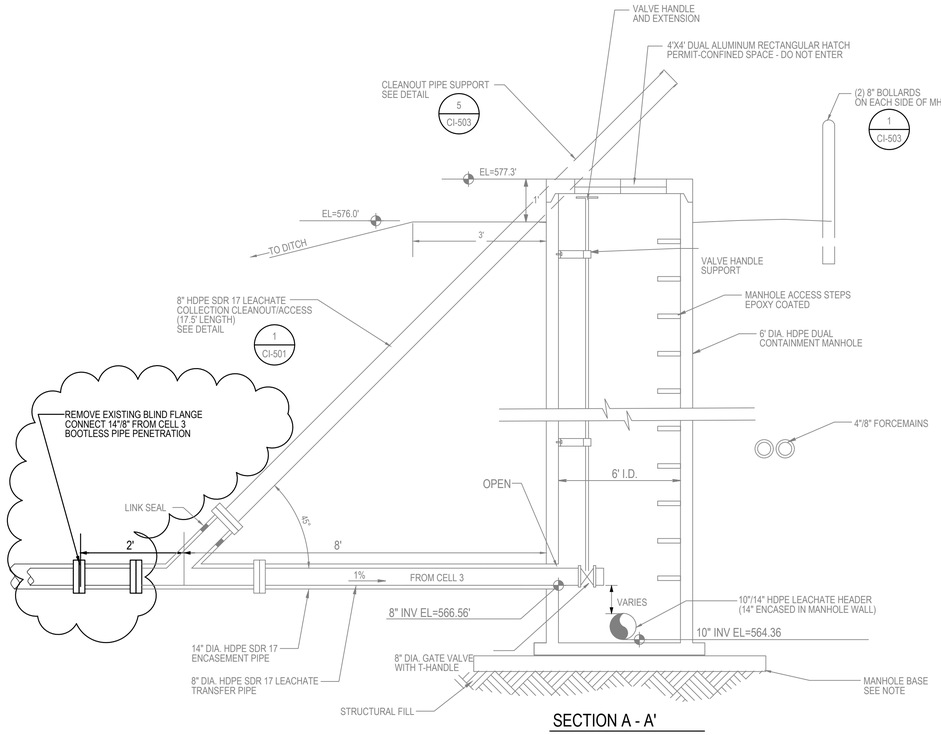


PLAN VIEW



PLAN VIEW

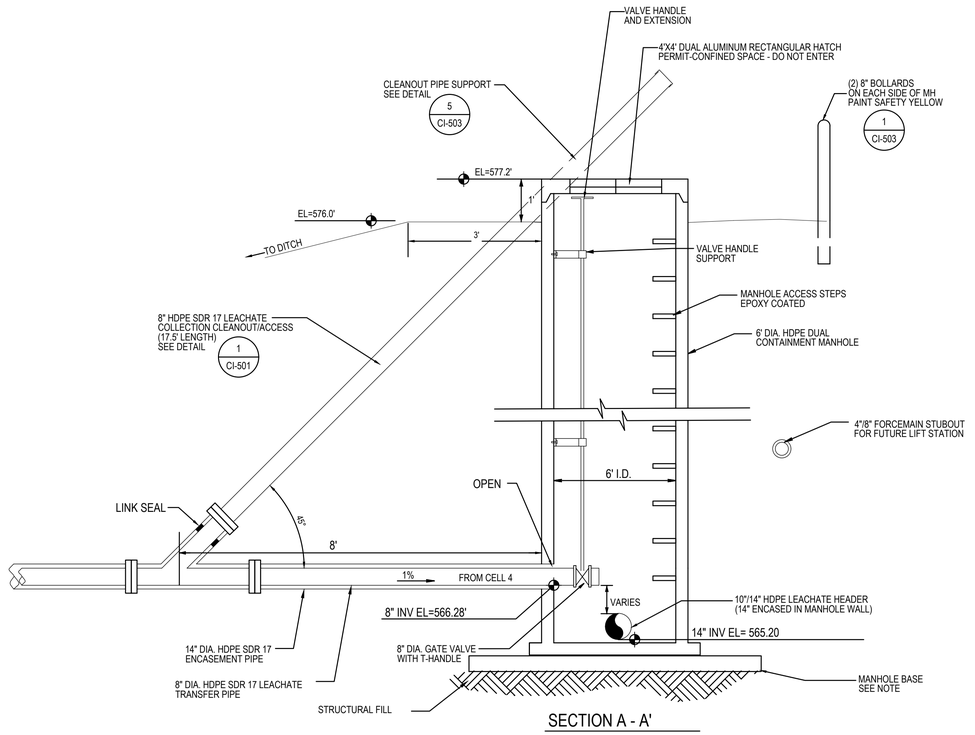


SECTION A - A'

NOTE:
ALL MANHOLES WILL REQUIRE A BASE THAT IS 50% LARGER THAN THE MANHOLE DIAMETER.
PLACE MANHOLE ON A 6" IDOT GRADATION 14 BASE ON TOP OF STRUCTURAL FILL. SAND COMPACTED TO 95% STANDARD PROCTOR.

1 CI-507 EXISTING CELL 3 LEACHATE COLLECTION MANHOLE (LMH-41) DETAIL

NOT TO SCALE



SECTION A - A'

NOTE:
ALL MANHOLES WILL REQUIRE A BASE THAT IS 50% LARGER THAN THE MANHOLE DIAMETER.
PLACE MANHOLE ON A 6" IDOT GRADATION 14 BASE ON TOP OF STRUCTURAL FILL.
SAND COMPACTED TO 95% STANDARD PROCTOR.

2 CI-507 CELL 4 LEACHATE COLLECTION MANHOLE (LMH-42) DETAIL

NOT TO SCALE

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Title **DETAILS**

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Sheet No. **CI-507**

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Attachment 2

LGS Cell 4 GCL Specifications

SECTION 00 80 00

GENERAL NOTES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Definitions
2. Copies of Documents
3. Dust Control
4. Project Coordination

1.2 DEFINITIONS:

A. The following supplemental definitions shall apply:
1. OWNER – The OWNER is MidAmerican Energy Company located at the Louisa Generating Station (LGS), 8602 172nd Street, Muscatine, Iowa 52761.
2. ENGINEER – The ENGINEER is GHD located at 11228 Aurora Avenue, Des Moines, Iowa 50322.
3. CONSTRUCTION QUALITY ASSURANCE (CQA) ENGINEER – The CQA ENGINEER is a third party to be retained by OWNER. The CQA ENGINEER may be the ENGINEER.
4. OWNER'S DESIGNATED REPRESENTATIVE – The OWNER'S DESIGNATED REPRESENTATIVE may be the ENGINEER, CQA ENGINEER or other party identified by OWNER.
5. CONTRACTOR – The CONTRACTOR is selected by the OWNER and is the individual, firm, or corporation undertaking execution of the WORK under the terms of the CONTRACT DOCUMENTS.
6. OTHERS – OTHERS refers to entities contracted by the OWNER who may be on site at the same time as the CONTRACTOR or who may perform work related to the CONTRACTOR's work.
7. CONTRACT DOCUMENTS – CONTRACT DOCUMENTS include contract terms and conditions, exhibits, drawings, and specifications.
8. WORK – WORK is all documentation, testing, construction, and restoration necessary to complete the activities in the CONTRACT DOCUMENTS resulting in closure of the Reclaim Impoundment and construction of a new process water pond at the LGS facility.

1.3 COPIES OF DOCUMENTS

A. Unless otherwise noted, hard copies of CONTRACT documents will not be furnished to the CONTRACTOR.

B. Three sets of full-scale Drawings and one electronic set of computer-aided design drawings will be furnished to the CONTRACTOR.

1.4 DUST CONTROL

A. Throughout completion of all WORK, the CONTRACTOR shall maintain dust control on the WORK area. At a minimum, the CONTRACTOR shall apply water to traveled roads which produce dust on a daily basis when rain is not imminent or ongoing. CONTRACTOR shall maintain a minimum of one water truck on site for dust controls. Costs for dust control are incidental to all other WORK.

1.5 PROJECT COORDINATION

A. OTHERS will be performing work adjacent to the WORK area and will share access roads.

B. CONTRACTOR and OTHERS to coordinate access.

C. Notify ENGINEER or OWNER if problems with coordination arise.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01 10 00

SUMMARY

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Location.
2. Access to the Site.
3. Scope of work.
4. Description of work.
5. Sequence of work.
6. Work by OWNER.
7. Work performed on a Force Account Basis.
8. OWNER-supplied products.
9. Contract Times.
10. Drawings.
11. CONTRACTOR use of the Site.
12. Future work.
13. OWNER occupancy.

1.2 LOCATION

A. Louisa Generating Station (LGS) Coal Residuals (CCR) Expansion Monofill Cell 4 Construction, MidAmerican Energy Company (OWNER), Louisa County, Iowa.

1.3 WORK COVERED BY CONTRACT DOCUMENTS

A. Project Identification
1. Project Name: LGS CCR Expansion Monofill Cell 4 Construction.
2. Project Location: 8602 172nd Street, Muscatine, IA 52761-9066.
3. OWNER: MidAmerican Energy Company (MEC).
4. ENGINEER: GHD Services Inc. (GHD).

B. LGS CCR Expansion Monofill Cell 4 Construction Project
1. General: It is the intent and purpose of these Specifications and accompanying Contract Drawings to describe the Work associated with and included under the LGS CCR Expansion Monofill Cell 4 Construction Project.
2. It is the CONTRACTOR'S responsibility to develop a work plan, sequence of WORK, and schedule detailing, at a minimum, the procedures to be employed, the equipment and materials to be used, the safety plan to be used during the WORK, and a schedule defining the duration of the WORK with milestone subtasks.
3. The work plan, sequence of WORK, and schedule shall be submitted to the OWNER and ENGINEER for approval a minimum of 15 calendar days prior to the scheduled commencement of WORK. Upon review by the OWNER and ENGINEER, the CONTRACTOR shall attend a meeting to finalize the work plan and schedule.
4. The CONTRACTOR shall supply all supervision, oversight, labor, equipment, materials, and incidentals required to complete the WORK outlined in this section unless specified otherwise.

1.4 PROJECT SUMMARY

A summary of the WORK is presented below. The summary is not an exhaustive list of activities but intended to provide an overview of the WORK.

A. GENERAL
1. CONTRACTOR shall mobilize to the site, provide facilities, establish site control throughout the WORK, and shall perform tasks with a focus on safe completion of the WORK in terms of personnel health and safety, equipment safety, and environmental safety.
2. CONTRACTOR shall maintain project documents including redline drawings, records, weekly reports, and quality control records.
3. Coordination with other OWNER'S contractors and operations for site access including trucking and haul routes.
   a. General haul route for fill and routine deliveries is from a gravel access road north of the main facility. OWNER will provide gate security but only on an as-needed basis.
   b. Other deliveries may be coordinated through CONTRACTOR entrance if required.
4. All site personnel must complete OWNER's General Orientation and Coal Plant Orientation training courses, available from gatefeed.com on an annual basis. Past training expires the first of a new calendar year. For those personnel who may take part in Confined Space Entry training as an entrant, attendant, or supervisor, additional Confined Space training is required.
5. Adhere to safe work practices including presence of a Competent Person during all excavation activity when personnel may enter a trench.
6. Maintain dust control and erosion control measures throughout the WORK.
7. Conduct daily tailgate safety and review meetings.
8. Protect existing utilities include but not limited to culverts, electrical lines, piping, and monitoring wells.
9. Provisioning and maintenance of temporary facilities and controls.
10. Complete general housekeeping of project area including trash removal.
11. Maintain erosion controls.
12. Complete construction quality control testing throughout the WORK.
13. Maintain a set of redline drawings with project changes and notes.
14. Maintain Stormwater Pollution Prevention (SWPP) Plan figure and compliance with the SWPP Plan.

B. MOBILIZATION AND PROJECT KICK-OFF
1. Develop project schedule and sequence for review with OWNER and ENGINEER. Coordination with additional site activities by OTHERS may be required.
2. Prepare pre-construction submittals including bond, proof of insurance, site-specific Health and Safety Plan (HASP), analysis of borrow materials and other project materials, and permits necessary to complete the WORK.
3. Mobilize personnel, office trailer, equipment, and initial supplies.
4. Take part in pre-construction meeting with primary subcontractors, OWNER, and ENGINEER.
5. Complete utility locates and assessment of site conditions.
6. Complete site preparation activities:
   a. Mobilize and set up equipment and office trailer at designated location.
   b. Install silt fence as Wildlife Deterrent Fence as described in Contract Documents. Coordinate with ENGINEER prior to relocation of Wildlife Deterrent Fence.

C. CONSTRUCTION SURVEYS
1. The following surveys are required
   a. Preconstruction topographic

b. Subgrade (bottom of clay layer)
c. Top of Compacted Clay Liner
d. Top of pipe, inverts where applicable, and sufficient points to account for pipe grades and bends. Includes leachate system inside and outside cell and stormwater culvert.
e. Top of drainage layer
f. Final site conditions - berms, newly constructed roadways, turnarounds, and laydown or stockpile areas

D. SITE CLEARING AND GRUBBING
1. Site clearing and grubbing of limits of Cell 4 construction.

E. CONSTRUCTION STORMWATER FEATURES AND SPECIES PRESERVATION SYSTEMS
1. Furnish and install construction stormwater features as specified in the NPDES and SWPP Plan documents.
2. Furnish and install species preservation systems as directed by the ENGINEER.

F. LEACHATE SYSTEM CONSTRUCTION INCLUDING MANHOLES
1. Furnish Cell 4 leachate collection manhole and associated HDPE piping including 8-inch conveyance piping and 14-inch containment piping.
2. Install leachate collection manhole and associated piping at locations as specified on the Drawings.
3. Connect Cell 4 leachate collection manhole to Cell 3 leachate collection manhole.

G. CELL EXCAVATION
1. Excavation, filling, compacting, and grading subgrade in preparation for installation of clay.

H. COMPACTED CLAY LINER
1. Loading, hauling, placement, grading and compaction of clay.

I. BOOTLESS PIPE PENETRATION INSTALLATION
1. Furnish bootless pipe penetration.
2. Install bootless pipe penetrations at locations as specified on the Drawings.

J. GEOMEMBRANE INSTALLATION
1. Furnish and install geomembrane liner system.
2. Perform on-site quality control testing for geomembrane installation.

K. DRAINAGE LAYER AND GEOCOMPOSITE FURNISH AND INSTALL
1. Supply, loading, hauling, placing, and grading of drainage layer.
2. Furnish and install geocomposite drainage system.

L. LEACHATE COLLECTION SYSTEM INSTALLATION (INSIDE CELL)
1. Supply and installation of perforated leachate collection pipes in drainage layer on landfill base and solid wall pipe for cleanout.

M. GEOTEXTILE INSTALLATION
1. Supply and installation of non-woven separation geotextile over the granular drainage layer.

N. LEAK LOCATION TESTING
1. Perform leak location testing on the liner system as specified by manufacturer installation guidelines and the Contract documents.
2. Leak surveys are both bare geomembrane (pre geocomposite placement)

and following leachate collection media placement.

O. SITE ROADS CONSTRUCTION
1. Supply, loading, hauling, placing, grading, and compaction of aggregate for access roads and truck turnaround area.
2. Supply and installation of culverts for access road crossings.
3. Supply and installation of riprap for culvert inlet and outlet protection.

P. SITE STABILIZATION AND REMOBILIZATION (IF REQUIRED)
1. If CONTRACTOR'S schedule necessitates construction during two seasons, CONTRACTOR shall develop a written plan, project schedule and sequence for review and approval of OWNER and ENGINEER. The written plan shall detail measures to be completed to stabilize the work, including water management.
2. Coordination with additional site activities by OTHERS may be required.
3. CONTRACTOR shall maintain erosion controls and manage all water during construction shutdown and until final stabilization of disturbed areas.
4. Mobilize personnel, office trailer, equipment, and initial supplies.
5. Take part in pre-construction meeting with primary subcontractors, OWNER, and ENGINEER.
6. Complete utility locates and assessment of site conditions.
7. Complete all other necessary site preparation activities.

Q. RESTORATION
1. Grading perimeter ditches and berms.
2. Revegetate all disturbed areas.
3. Complete as-built survey of all newly installed infrastructure and connections to existing infrastructure.

R. DEMOBILIZATION
1. Demobilization and close out.

1.5 WORK BY OTHERS

A. OTHERS will be performing work under separate contract to OWNER in the vicinity of CONTRACTOR'S WORK area. Activities by OTHERS include:
1. Wildlife Deterrent Fence has been installed around the project area by OTHERS. CONTRACTOR shall preserve the Wildlife Deterrent Fence and coordinate with OWNER and ENGINEER if modifications to the Wildlife Deterrent Fence are proposed.
2. General vehicle and personnel site access by OTHERS will occur throughout the WORK including delivery of CCR to the active Monofill comprising Cells 1, 2, and 3.
3. Monitoring wells around the Monofill may be accessed by OTHERS at any time during the work. Notification of need to access wells will be made at least 48 hours prior to access to allow clearing of obstacles, if applicable.

1.6 MODIFICATION

A. The right is reserved by the OWNER and the ENGINEER to make such changes in the order and execution of the WORK to be done under these Specifications as, in the judgement of the ENGINEER, may be necessary or expedient to carry out the intent of the design of the Contract, and no increase in unit prices, if any, over the Contract rates will be paid the CONTRACTOR on account of such changes.

1.7 AVAILABLE DATA AND PHYSICAL DATA

A. In preparation of the Contract Documents, the ENGINEER relied upon the following information:
   1. Foth. April 2019, SDP Amendment 7. Project Manual. Cell 2 and 3 Construction. Louisa Generating Station (LGS), Coal Combustion Residuals (CCR) Expansion Monofill. MidAmerican Energy Company. Muscatine, Iowa.
   2. Foth. June 2017. MidAmerican Energy Company, Master Development Plan, Lousia Generating Station CCR Monofill, MEC Project Number 53942. Muscatine Iowa.
   3. Dewberry and Davis, LLC. March 2011. Coal Combustion Waste Impoundment Round 7 – Dam Assessment Report. Louisa Generating Station, Bottom Ash Pond. MidAmerican Energy Company. Muscatine, Iowa.
   4. Burns & McDonnell Engineering Company, Inc. July 2016. Subsurface Information for the CCR Impoundment, Louisa Generating Station.
      a. This information is not a part of the Contract Documents.
      b. The above-listed information is available for electronic transfer upon request.
      c. The making available of this information is not intended to relieve bidders from their responsibility to familiarize themselves with the conditions that may in any manner affect cost, progress, or performance of the WORK. The submission of a bid constitutes an agreement by the Bidder that the Bidder shall make no claims against the OWNER, or its agents or employees, and the ENGINEER or its officers, agents, or employees because the data made available to prospective Bidders is not representative of the actual conditions.

B. The CONTRACTOR shall be required to be fully informed concerning the location of facilities and structures on, under, or over the project site, which may interfere with the operations of the CONTRACTOR, and it shall be assumed that the CONTRACTOR has prepared the bid and entered into the Contract in full understanding of the conditions to be encountered, and responsibility of the CONTRACTOR in connection therewith.

C. "Record" information for the existing facilities has been brought to the attention of the ENGINEER and is indicated on the Contract Drawings. However, in some instances, information only from investigations and field surveys has been shown. The location of water, gas, electric, steam, or other utility lines, and the nature of the materials is not guaranteed. The indication on the Drawings of such facilities shall not be assumed to relieve the CONTRACTOR of any responsibility with respect thereto; neither shall the OWNER nor the ENGINEER be held responsible for any omission or failure to give notice to the CONTRACTOR of any other facility or structure on, under, or over the project site.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 01 20 00

PRICE AND PAYMENT PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Price and payment procedures
2. Schedule of Values
3. Applications for Payment
4. Contract modification procedures
5. Bid Form

1.2 PRICE AND PAYMENT PROCEDURES

A. Measurement and Payment
1. CONTRACTOR shall be responsible for providing survey and measurement data throughout the duration of the Work, and for measurement and calculation of quantities for payment. ENGINEER will review and verify the data, measurements, calculations, and approve quantities for payment. Notify ENGINEER sufficiently in advance of operations to permit verification of measurements for payment, and provide necessary equipment, workers, facilities, and survey personnel for making measurements as required.
2. Measurement for Unit Price Work: As specified in individual Sections. Quantities indicated in the Schedule of Prices are for bidding and contract purposes only and are approximate. Quantities of material furnished and/or work performed as provided by CONTRACTOR, accurately substantiated by CONTRACTOR's approved survey and measurement methods, and as verified and approved by ENGINEER, will be used to determine payment(s).
3. Measurement for Lump-Sum Work: ENGINEER will review and verify the amount of work eligible for progress payment purposes. Items will be measured in units such as time, weight, volume, area, or linear means, or combination as appropriate as a completed item or unit of the Work. Such measurements will serve as a basis for estimating percentage payments for partially completed work. Payment for the Work will be made in lump sums according to the General Conditions, PROGRESS PAYMENT for items listed in the Form of Bid: Payment will not be more frequent than monthly.

B. Payment
1. Payment for each Item includes: Full compensation for furnishing labor, supervision, material, tools, equipment, plant, transportation, services, health and safety, included testing, submittals, and incidentals for performance and completion of the Work in complete accordance with the Contract Documents; erection, application, installation, completion, or construction of an item of the Work; overhead and profit; and all other miscellaneous items for which separate payment is not provided under other Items of the Schedule of Prices. All work not specifically set forth as a separate pay Item in the Schedule of Prices shall be considered as a subsidiary obligation of CONTRACTOR and all costs in connection therewith shall be included in the amounts and prices stipulated in the Schedule of Prices. CONTRACTOR shall properly and fairly distribute

indirect costs to each pay Item. Final payment for work governed by unit prices will be made on the basis of the actual measurements and quantities approved by ENGINEER multiplied by the unit price stipulated in the Schedule of Prices. Final payment for work governed by lump-sum prices will be made on the basis of the applicable lump-sum prices stipulated in the Schedule of Prices.

2. Non-payment for Rejected Products: Payment will not be made for any of the following:
3. Products wasted or disposed of in a manner that is not acceptable.
4. Products determined as unacceptable before or after placement.
5. Products not completely unloaded from the transporting vehicle.
6. Products placed beyond the lines and levels of the required Work.
7. Products remaining on hand after completion of the Work.
8. Loading, hauling, and disposing of rejected products.

1.3 SCHEDULES OF VALUES

A. The Schedule of Values is an itemized list included on the Bid Form that establishes the value or cost of each part of the Work. The accepted bid form shall be used as the basis for preparing progress payments and may be used as a basis for negotiations concerning additional work or credits which may arise during construction.

B. Submit the Schedule of Values in the provided Bid Form.

C. Round amounts to the nearest whole dollar. The schedule shall be properly proportioned. The sum of individual values shown on the Schedule of Values shall equal the total for each item bid as well as the total Contract Price. Arrange the Schedule of Values with the following subdivisions, description of work and dollar values for each:
   1. Subcontractor work.
   2. Manufacturer or fabricator.
   3. Supplier.
   4. CONTRACTOR work.

D. Format:
   1. Utilize line items listed in the Bid Form. CONTRACTOR may generate sub-lines to support line items listed in the Bid Form in a supplemental submittal to the required Ariba system response.
   2. Include the following project identification on the Schedule of Values:
      a. Project name and location: Cell 4 Construction for CCR Expansion Monofill, Louisa Generating Station
      b. Name of ENGINEER: *GHD Services, Inc*
      c. ENGINEER’s project number: *12635351*
      d. CONTRACTOR’s name and address.
      e. Date of submittal

E. Provide separate line items in the Schedule of Values for initial cost of materials for each subsequent stage of completion, and for total installed value of that part of the Work.

F. Include in each line item the amount of Allowances specified in this Section. For unit cost Allowances, identify quantities taken from the Contract Documents multiplied by the unit cost to achieve the total for the item.

G. Upon request by ENGINEER, submit supporting documentation to substantiate the correctness of the schedule submitted.

H. Revise the Schedule of Values to list approved Change Orders, with each Application for Payment.

1.4 APPLICATIONS FOR PAYMENT

A. Application Preparation Procedures:
   1. When requested by the CONTRACTOR, the ENGINEER will determine the actual quantities and classifications of Unit Price Work performed.
   2. Preliminary determinations will be reviewed with the CONTRACTOR before completing the Application for Payment.
   3. ENGINEER will complete the Application for Payment based on ENGINEER's decision on actual quantities and classifications.

B. Application for Payment shall be certified by an authorized officer.

C. Use data from approved Schedule of Values. Provide dollar value in each column for each line item for portion of work performed.

D. List each authorized Change Order on the Application for Payment, listing Change Order number and dollar amount as for an original item of the Work.

E. Submit each Application for Payment on an agreed to form to be approved by the ENGINEER. With the Bid Form, provide a breakdown of labor for all personnel to work on the job, material costs and equipment rates for each specific piece of equipment.

F. Submit one signed original of each Application for Payment. Include electronic version with each application.

G. The following administrative actions and submittals shall precede or coincide with submittal of first Application for Payment:
   1. List of subcontractors.
   2. Schedule of Values.
   3. CONTRACTOR's construction schedule.
   4. Copies of building and other permits.
   5. Copies of authorizations and licenses from authorities having jurisdiction for performance of Work.

H. With each Application for Payment, submit waivers of liens from subcontractors and suppliers for the construction period covered by the previous application.
   1. Submit partial waivers on each item for amount requested before deduction for retainage on each item.
   2. When an Application for Payment shows completion for an item, submit final or full waivers.
   3. OWNER reserves the right to designate which entities involved in the Work shall submit waivers.
   4. Submit final Application for Payment with or preceded by final waivers from every entity involved with the performance of the Work covered by the Application for Payment.
   5. Submit waivers of lien on forms executed in a manner acceptable to OWNER.

I. Prepare Application for Final Payment as specified in Section 01 70 00.

J. Submit an updated progress schedule with each Application for Payment.

K. Payment Period: Submit no more than monthly.

1.5 CONTRACT MODIFICATION PROCEDURES

A. Changes in the Work or the requirement for extra work will be made by ENGINEER in accordance with the General Terms and Conditions, and with the change procedures as specified herein.

B. Field Order: ENGINEER will advise of minor changes in the Work not involving an adjustment to the Contract Price or the Contract Times as authorized by the General Conditions, by issuing supplemental instructions in the form of a Field Order. Promptly execute such minor changes and supplemental instructions.

C. Request for Quotation: ENGINEER may issue a Request for Quotation, which includes a detailed description of a proposed change with supplementary or revised information, Drawings, and Specifications, and schedule for executing the change in the Work. Prepare and submit a written itemized cost estimate of changes in the Contract Price and/or the Contract Times that would result from the proposed change in the Work by the due date stipulated in the Request for Quotation.

D. Documentation of Change in Contract Price and Contract Times:
Maintain detailed records of work done on a time and material or Force Account Basis. Provide full information required for evaluation of proposed changes, and to substantiate costs of changes in the Work.

Document each quotation for a change in Contract Price and/or Contract Times with sufficient data to allow evaluation of the quotation by ENGINEER. Each quotation for a change must be approved by ENGINEER prior to CONTRACTOR proceeding with Work associated with the quotation. Allow sufficient time for ENGINEER to review the quotation, without adversely affecting efficiency or production of Work in progress.

On request, provide additional data to support computations including:
1. Quantities of products, labor, and equipment.
2. Taxes and insurance.
3. Overhead and profit.
4. Justification for any change in the Contract Times.
5. Credit for deletions from the Contract, similarly documented.

E. Support each claim for additional costs, and for work done on a time and material or Force Account Basis, with additional information including:
1. Origin and date of claim.
2. Dates and times work was performed, and by whom.
3. Time records and wage rates paid.
4. Invoices and receipts for products, equipment, and subcontracts, similarly documented.

F. CONTRACTOR may propose a change by submitting a request for change to ENGINEER, describing the proposed change and its full effect on the Work, with a statement describing the reason for the change, and the effect on the Contract Price and Contract Times with full documentation (including itemization of costs for labor, material, taxes, subcontracts, bonds, insurance, and overhead and profit) and a statement describing the effect on the Work by Other Contractors, if any.

G. Work Change Directive: ENGINEER may issue a document, signed by OWNER, instructing CONTRACTOR to proceed with a change in the Work, for subsequent inclusion in a Change Order. The document will describe changes in the Work, and will designate method of determining any change in the Contract Price or the Contract Times. Promptly execute the change in the Work.

H. Lump-Sum Price Change Order: Based on Request for Quotation and CONTRACTOR's fixed lump-sum price quotation or CONTRACTOR's request for a Change Order as approved by ENGINEER.

I. Time and Material or Force Account Change Order: Submit itemized account and supporting data after completion of change, within time limits indicated in the Contract Documents. ENGINEER will determine the change allowable in the Contract Price and the Contract Times as provided in the Contract Documents. Maintain detailed records of work done on a time and material or Force Account Basis. Provide full information required for evaluation of proposed changes, and to substantiate costs for changes in the Work.

J. ENGINEER will issue Change Orders for signatures of parties as provided in the Contract Documents.

K. Promptly revise progress schedules to reflect any approved change in the Contract Times (or Milestones), revise sub-schedules to adjust times for other items of work affected by the change, and promptly resubmit to ENGINEER.

L. Promptly enter changes in the Project record documents.

M. Promptly revise Applications for Payment forms and the Schedule of Values to record each authorized Change Order as a separate line item and adjust the Contract Price.

1.6 SCHEDULE OF PAY ITEMS

A. LGS CCR Expansion Monofill Cell 4 Construction Project, MidAmerican Energy Company, Louisa County, Iowa.

1. Item 1 – Performance and Payment Bond and Insurance

Under this item CONTRACTOR shall include all costs for Performance Bond and Payment Bond, in accordance with the CONTRACT DOCUMENTS.

Measurement: No measurement shall be required for this item.

Payment for this item will be made on a lump-sum basis following submittal of proof of completion of the necessary bonds and insurance and shall be full compensation as shown and specified.

2. Item 2 – Mobilization/Demobilization

Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to perform mobilization/demobilization in accordance with all applicable rules and regulations and in accordance with the Contract Documents.

The cost of required permits, work schedule and subsequent updates and any other initiation of the Contract work not specifically identified elsewhere are also included in this Item.

Measurement: No measurement shall be required for this item.

Payment: The lump-sum price bid for this Item shall be full compensation as shown and specified. 60-Percent of the total value shall be paid after mobilization is complete and 40-percent shall be paid after completion of the WORK.

3. Item 3 – Site Clearing and Grubbing

Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to grade the CCR materials to design grades in the Bottom Ash Impoundment including construction quality control testing. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement shall be required for this item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

4. Item 4 – Construction Stormwater Features

Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to supply, installation, inspection, maintenance, and removal (where applicable) of stormwater features and temporary erosion controls in accordance with the Contract Documents.

Measurement: No measurement shall be required for this item.

Payment: The unit price bid for this Item shall be full compensation as shown and specified.

5. Item 5 – Silt Fence (Wildlife Deterrent Fence)

Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to supply, installation, inspection, maintenance and removal of Silt Fence in accordance with the Contract Documents and remove and reinstall existing Wildlife Deterrent Fence in accordance with the Contract Documents.

Measurement: The quantity to be paid for under this Item will be made on the basis of linear feet of silt fence installed or replaced as Wildlife Deterrent Fence.

Payment: The unit price bid for this Item shall be full compensation as shown and specified.

6. Item 6 – Construction Surveys

Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to complete and furnish required surveys include mobilizations, survey control, and data reduction. Work under this Item shall be as in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: The lump-sum price bid per survey for this Item shall be full compensation as shown and specified.

7. Item 7 – Roadway Gravel Surfaces

Under this Item, the CONTRACTOR shall provide all labor, materials, tools and equipment necessary and required to install and place roadway gravel surfaces to design grades.

Measurement: No measurement shall be required for this item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

8. Item 8 – Leachate Collection System Construction Including Manholes
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required install the leachate collection system for the Cell 4 Expansion and connections to the Cell 3 leachate manhole. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement shall be required for this item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

9. Item 9 – Cell Excavation
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary excavate the Cell 4 Expansion and remove the temporary berm at the boundary between Cell 3 and the Cell 4 Expansion in the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

10. Item 10 – Compacted Clay Liner
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to install the compacted clay liner for the Cell 4 Expansion. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

11. Item 11 – Bootless Pipe Penetration Installation
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to install the bootless pipe penetration associated with the leachate collection system within the Cell 4 Expansion. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

12. Item 12 – Geomembrane Installation
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to install the geomembrane liner within the Cell 4 Expansion. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

13. Item 13 – Drainage Layer and Geocomposite Furnish and Install
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to install the drainage layer and geocomposite layer within the Cell 4 Expansion. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

14. Item 14 – Leachate Collection System Installation (Inside Cell)
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to install the leachate collection system within the Cell 4 Expansion. Work under this Item shall be in accordance with the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

15. Item 15 – Geotextile Installation
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to prepare ground surface, install, test, document, and install flexible membrane liner in the Contract Documents. This includes wastage and the anchor trench installation for the flexible membrane liner. Electric leak testing is not included in this item.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

16. Item 16 – Leak Location Testing
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to complete and document an electric leak location survey of the flexible membrane liner in accordance with the Contract Documents.

Measurement: No measurement is required for this item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

17. Item 17 – Site Stabilization and Remobilization (If Required)
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary to stabilize the construction area, including remobilization if required, in the Contract Documents.

Measurement: No measurement is required for this Item.

Payment: Payment under this Item shall be made on a lump-sum basis in proportion to the amount of work completed and shall be full compensation as shown and specified.

18. Item 18 – Restoration
Under this Item, the CONTRACTOR shall provide all labor, materials, tools, and equipment necessary and required to complete seeding in accordance with the Contract Documents including fertilizer application.

Measurement: The quantity to be paid for under this Item will be made on the basis of acres seeded.

Payment: The unit price bid for this Item shall be full compensation as shown and specified.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01 30 00

ADMINSTRATIVE REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Specification language.
2. Mobilization and startup.
3. Coordination.
4. Pre-construction meeting.
5. Progress meetings.
6. Pre-installation meetings.
7. Health and safety.

1.2 SPECIFICATION LANGUAGE

A. These Project Specifications are written in imperative mood and are in abbreviated or streamlined form and include incomplete sentences. This imperative language is directed to CONTRACTOR, unless specifically noted otherwise. Omission of words or phrases such as "CONTRACTOR shall", "shall be", "a", "the", and "all" are intentional. Omitted words or phrases shall be supplied by inference in the same manner as they are when a "note" occurs on the Drawings.

1.3 PRECEDENCE

A. The terms of the "General Terms and Conditions" shall supersede any printed conditions forming a part of CONTRACTOR 's proposal, acknowledgment, invoice, or other form of CONTRACTOR and notwithstanding OWNER‘s act of accepting or paying for any shipment, service, or similar act of CONTRACTOR.

B. CONTRACTOR shall comply with all of the requirements of the OWNER’s General Terms and Conditions.

C. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the Contract Documents shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of the Contract Documents and:
1. The provisions of any standard, specification, manual, or code, or the instruction of any Supplier (whether or not specifically incorporated by reference in the Contract Documents); or
2. The provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

1.4 MOBILIZATION AND STARTUP

A. Do not mobilize to the Site without OWNER's prior written authorization. Ensure bonds and insurance as required by the Contract Documents are in full force.

B. Perform planning and scheduling activities as necessary for the performance of the Works. Contractor should provide a schedule with completed by dates with the bid package. The schedule will become part of the contract documents and if updates are required, the Engineer and OWNER will review all updates. If the schedule is updated and approved, the updated contract supersedes the previously submitted schedules.

C. Purchase materials and mobilize equipment, supplies, and incidentals to the Site.

D. Use the existing Site access roads as defined by the OWNER to the designated work areas during mobilization. Complete improvements to roads as necessary for the performance of the Works.

E. Site temporary utilities and facilities in areas designated by ENGINEER. Obtain OWNER’s and ENGINEER's approval prior to changing locations of temporary construction facilities. Do not use other areas without OWNER’s and ENGINEER's prior approval. Relocate construction equipment or other materials or equipment as required for the performance of the Works.

1.5 COORDINATION

A. Coordinate scheduling, submittals, and work of the various Sections of the Project Specifications and other requirements of the Contract Documents to assure efficient and orderly sequence of the Works with provisions for accommodating items installed later.

B. Coordinate work of various Sections having interdependent responsibilities for installing, connecting to, and placing in service such elements.

C. Coordinate space requirements and installation of mechanical and electrical work which are indicated diagrammatically on the Drawings. Follow routing shown for pipes and conduit as closely as practicable. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

D. In finished areas, except as otherwise indicated, conceal pipes, ducts, and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.

E. Coordinate completion and cleanup of work of separate Sections in preparation for Substantial Completion and for portions of the Works designated for OWNER's utilization.

F. After OWNER's occupancy of the Site or premises, coordinate access to the Site for correction of defective Works and Works not according to the Contract Documents, to minimize disruption of OWNER's activities.

1.6 PRE-CONSTRUCTION MEETING

A. ENGINEER will schedule and administer a pre-construction meeting at the Site after the date of the Notice to Proceed and prior to start of construction at the Site.

B. ENGINEER will make arrangements for meeting, prepare agenda with copies for participants, and preside at meeting. Provide data required to ENGINEER and be prepared to discuss all items on the agenda.

C. Minimum Attendance Required: OWNER, ENGINEER, CONTRACTOR, CONTRACTOR's Health and Safety Officer, CONTRACTOR's Site Supervisor, and major Subcontractors.

D. Agenda will include, but not necessarily be limited to, the following:
1. Designation of responsible personnel.
2. Lines of authority and communication.
3. Health and safety.
4. Endangered and threatened species protection and mitigation.
5. Use of the Site for storage, vehicle parking, access routes, and other Site requirements.
6. OWNER's requirements and partial occupancy.
7. Coordination with Other Contractors and OWNER.
8. Temporary facilities and controls provided by CONTRACTOR.
9. Temporary utilities and services provided by OWNER.
10. Connection to existing utilities.
11. Field offices.
12. Benchmark locations
13. Security and housekeeping procedures.
14. Procedures for processing field decisions, submittals, substitutions, applications for payments, proposal requests, Field Orders, Work Change Directives, Change Orders, and closeout procedures.
15. Progress schedules.
16. Procedures for testing and inspection.
17. Procedures for maintaining Project record documents.
18. Requirements for startup and commissioning.
19. Inspection and acceptance of piping, monofill liner, and stormwater controls put into service during construction period.

E. ENGINEER will record minutes and distribute copies to participants and those affected by decisions made. Identify errors in the minutes, if any, to ENGINEER in writing within 3 days of receipt.

1.7 PROGRESS MEETINGS

A. ENGINEER will schedule and administer progress meetings at the Site throughout the progress of the Works at minimum of two week intervals or more frequently as required.

B. ENGINEER will make arrangements for meetings, prepare agenda with copies for participants, and preside at meetings. Provide data required to ENGINEER and be prepared to discuss all items on the agenda.

C. Attendance Required: CONTRACTOR's Health and Safety Officer, CONTRACTOR's Site Supervisor, Project Manager, major Subcontractors and Suppliers, as appropriate to agenda topics for each meeting.

D. Agenda will include, but not necessarily be limited to, the following:
1. Review of minutes of previous meetings.
2. Review of work progress since last meeting.
3. Field observations, problems, and decisions.

4. Identification of problems which impede planned progress.
5. Review of submittals schedule and status of submittals.
6. Review of off-Site material fabrication/processing and delivery schedules.
7. Review of health and safety concerns and issues.
8. Review of weekly SWPPP inspections.
9. Review of temporary facilities and services.
10. Review of environmental compliance, including protected species management.
11. Maintenance of progress schedule.
12. Corrective measures to regain projected schedules.
13. Planned progress during succeeding work period.
14. Coordination of projected progress.
15. Maintenance of quality and work standards.
16. Effect of proposed changes on progress schedule and coordination.
17. Change Orders.
18. Applications for Payment.
19. Other business relating to the Works.

E. Revise the construction schedule after each progress meeting where revisions to the schedule have been made or recognized. ENGINEER will issue the revised schedule within five days after each meeting.

F. Progress meetings attended by parties other than OWNER, ENGINEER, CONTRACTOR, and CONTRACTOR's major Subcontractors and Suppliers will be split into two meetings. Part A will include all parties at the meeting. Part B will include only OWNER, ENGINEER, CONTRACTOR, and CONTRACTOR's major Subcontractors and Suppliers, and will include discussions related to the Contract.

G. ENGINEER will record minutes and distribute copies to participants and those affected by decisions made. All communication to Subcontractors, Suppliers, or others that CONTRACTOR is responsible for will be made through CONTRACTOR. Identify errors in the minutes, if any, to ENGINEER in writing within 3 days of receipt.

1.8 PRE-INSTALLATION MEETINGS

A. When required, convene a pre-installation meeting at the Site prior to commencing work.

B. Require attendance of parties directly affecting, or affected by, work of the specific Section.

C. Notify ENGINEER, in writing, a minimum of 3 working days in advance of meeting date.

D. Prepare agenda and preside at meeting:
1. Review conditions of installation, preparation, and installation procedures.
2. Review coordination with related Work.

E. ENGINEER will record minutes and distribute copies to participants and those affected by decisions made.

F. Identify errors in the minutes, if any, to ENGINEER in writing within 3 days of receipt.

G. Do not proceed with installation if the meeting cannot be successfully concluded. Initiate whatever action are necessary to resolve impediments to performance of Work and reconvene the conference at the earliest feasible date.

1.9 HEALTH AND SAFETY

A. Comply with OWNER's safety procedures before beginning any activity on the Site, including all on-Site personnel completing GateFeed training.

B. CONTRACTOR shall carefully review the Work to identify safety requirements.

C. CONTRACTOR's Site-specific Health and Safety Plan (HASP):
1. Within 7 days after the date of the Notice to Proceed and prior to mobilization to the Site, submit a HASP. As a minimum, include the following:
   a. A safety and health risk or hazard analysis for each Site task and operation.
   b. Personnel training requirements.
   c. A personal protective equipment (PPE) program.
   d. Site control measures to be employed at the Site.
   e. Emergency procedures.
2. ENGINEER will review CONTRACTOR's Site-specific HASP and provide comments to CONTRACTOR within 7 days after receipt.

D. Conduct all Project activities according to OSHA Standards and Regulations contained in Title 29, Code of Federal Regulations, Parts 1910 and 1926 (29 CFR 1910 and 1926).

E. Be responsible for the safety of persons and property on the Site and for the protection of persons off the Site and the environment to the extent that they may be affected by the conduct of the Works. Comply with and enforce compliance by CONTRACTOR employees and employees of CONTRACTOR's Representatives with safety requirements of the Contract Documents and Laws and Regulations. CONTRACTOR acknowledges that safety and environmental protection obligations are of paramount importance regarding all of the work to be performed under the Contract.

F. Should any unforeseen or Site-specific safety related factor, hazard, or condition become evident during the performance of the Works at the Site, it shall be CONTRACTOR's responsibility to bring such to the attention of ENGINEER, verbally and in writing, as quickly as possible for resolution. In the interim, take prudent action to establish and maintain safe working conditions and to safeguard persons, property, and the environment.

G. Hazardous Waste Requirements:
1. Comply with the requirements of OSHA's "Hazard Communication" rules, 29 CFR 1910.120 and 29 CFR 1926.59.
2. Provide ENGINEER with copies of Material Safety Data Sheets for chemical-containing materials that are brought to the Site. Meet the container labeling provisions in the OSHA standard.

H. Work Stoppage: Give precedence to the safety and health of the public and on-Site personnel and the protection of the environment over cost and schedule considerations for all Project work. CONTRACTOR shall be responsible for decisions regarding when work will be stopped for health or safety considerations. ENGINEER shall have the right to also stop work for health or safety considerations. OWNER has right to stop work per the general terms and conditions of the contract.

I. Contingency and Emergency Response:
1. In the event of injury to on-Site personnel requiring immediate medical attention, implement the following protocol:
   a. Phone Owner’s site emergency number (563-262-2867) and describe injury. The OWNER’s shift supervisor will arrange emergency response.

Additional details of emergency response procedures will be provided to CONTRACTOR upon award of contract.

b. Administer appropriate first aid.
c. Notify the Health and Safety Officer and ENGINEER.
d. Transport personnel to the specified hospital per direction from the shift supervisor.

2. Develop techniques and recommended procedures for immediate first-aid emergency response with local medical facilities.

J. Health and Safety Officer: Employ and assign to the Works a competent and authorized representative herein referred to as the Health and Safety Officer. The Health and Safety Officer shall be on Site during the execution of the Works.

K. Personal Protective Equipment (PPE): Establish levels of protection for each work area based on planned activity and location of activity. Furnish on-Site CONTRACTOR personnel with appropriate PPE. Ensure that safety equipment and protective clothing is kept clean and well maintained. As a minimum, supply each worker with:
1. Steel-toed, steel-shank, chemical-resistant safety boots.
2. Work clothing (full-length pants, long-sleeve shirt).
3. Hard hat.
4. Safety glasses with side shields.

1.10 SUBONCTRACTOR COORDINATION

A. CONTRACTOR is responsible for SUBCONTRACTOR’s work product and compliance with the Contract Documents.

B. CONTRACTOR shall maintain a site superintendent on Site during all SUBCONTRACTOR activity unless otherwise approved by OWNER.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Submittal procedures.
2. Progress schedules.
3. Monthly progress reports.
4. Construction quality control records.
5. Proposed products list.
6. Shop Drawings.
7. Product data.
8. Samples.
9. Manufacturer installation instructions.
10. Manufacturer certificates.
11. Construction photographs.
12. Project organization.
13. Submittals for progress meetings.

1.2 SUBMITTAL PROCEDURES

A. Submittal procedures shall conform to the requirements of the General Conditions, SHOP DRAWINGS and procedures described in this article. Submittals must be approved prior to bringing material to site or doing work. May be returned at cost or work redone if prior approval not received.

B. Unless directed otherwise, transmit submittals to ENGINEER.

C. Transmit each submittal with ENGINEER accepted transmittal form, electronically and follow up with hard copy at the request of the ENGINEER or OWNER.

D. Sequentially number the transmittal form. Revise submittals with original number and a sequential alphabetic suffix.

E. Identify the Project, CONTRACTOR, Subcontractor, or Supplier; pertinent Drawing and detail number and Section number, as appropriate on the submittal. On the transmittal form, or separate sheet, record deviations from Contract Document requirements, including variances, limitations, and justification.

F. Apply CONTRACTOR's approval stamp or signature prior to initial submission to ENGINEER, signed and dated, certifying that CONTRACTOR has satisfied CONTRACTOR's obligations under the Contract Documents including but not limited to review and approval, verification of products required, field dimensions, adjacent construction work, and coordination of information with respect to CONTRACTOR's review and approval of that submittal. Unstamped or unsigned submittals will be returned by ENGINEER without action. Electronic stamps and signatures that still permit ENGINEER to provide comments and update submittal status are acceptable.

G. Except as specified otherwise, for each submittal for review by ENGINEER allow 7 days excluding delivery time to and from CONTRACTOR. Schedule submittals to expedite the Contract and according to specified scheduling. Coordinate submission of related items.

ENGINEER reserves the right to withhold action on a submittal requiring coordination with other submittals until all related submittals are received. No extension of Contract Time will be authorized because of failure to transmit submittals to ENGINEER sufficiently in advance of Work to permit processing.

H. Identify product or system limitations which may be detrimental to successful performance of the completed Works.

I. Provide space for ENGINEER review stamp and comments on submittals.

J. Make corrections to each submittal required by ENGINEER. Promptly revise and resubmit the required number of corrected copies of each submittal and submit new submittals required by such correction; identify changes made since previous submission and changes other than those requested by ENGINEER.

K. Promptly distribute copies of reviewed submittals to Subcontractors, Suppliers, and other concerned parties as appropriate. Instruct parties to promptly report any inability to comply with provisions.

L. Submittals not requested will not be recognized or processed. Submittals received directly from Subcontractors, Suppliers, vendors, or other Representatives or without CONTRACTOR stamp will be returned by ENGINEER without action.

M. Adjustments made on CONTRACTOR's drawings by ENGINEER are not intended to change the Contract Price. If adjustments affect the Contract Price, state such in writing, as specified elsewhere in the Contract, to OWNER and ENGINEER for approval prior to proceeding with the Works.

N. It is the responsibility of CONTRACTOR to review submittals made by Suppliers and Subcontractors before transmitting them to ENGINEER to assure proper coordination of the Works and to determine that each submittal is according to CONTRACTOR's desires and that there is sufficient information about materials and equipment for ENGINEER to determine compliance with the Drawings and Specifications. Incomplete or inadequate submittals will be returned for revision without review.

O. Unless specified otherwise submit one electronic copy of submittals.

P. Requirements of this article shall apply to all required submittals. Failure to meet Submittal requirements to the satisfaction of ENGINEER will constitute unsatisfactory performance of the Work in accordance with the Contract Documents, therefore, the ENGINEER may recommend to the OWNER that all or a portion of the payments requested during the corresponding payment period be withheld until these requirements are met.

1.3 PROGRESS SCHEDULES

A. Submit a draft schedule with the bid. Within 5 days of construction start submit an updated detailed progress schedule as an electronic copy as a PDF and in Microsoft Project Gantt Chart file. Submit updated progress schedules with each Application for Payment, identifying changes since previous version (if applicable) and estimated percentage of completion for each item of the Works. If a schedule remains unchanged from one period to the next, submit a written notice to that effect.

B. Submit a computer generated horizontal bar chart with separate line for each major section of the Works, identifying first work day of each week.

C. Show complete sequence of construction by activity, identifying work of separate stages and other logically grouped activities, and include milestone dates identified in the

Contract Documents. Show coordination of interrelated work activities and items. Indicate the early and late start, early and late finish, float dates, and duration.

D. OWNER controls the float time in the progress schedule, and therefore, without obligation to extend either the overall completion date or any intermediate completion dates set out in the progress schedule, OWNER may initiate changes to the Works that absorb float time only. OWNER-initiated changes that affect the critical path on a critical path methods schedule shall be the sole grounds for extending said completion dates. CONTRACTOR initiated changes that encroach on the float time identified in the progress schedule may be accomplished with OWNER's concurrence. Such changes, however, shall give way to OWNER initiated changes competing for the same float time.

E. Portions of the Works that are listed in the progress schedule with a float time may, at the option of OWNER, be performed using any or no amount of the float time, but in no event shall performance of the Works during the float times entitle CONTRACTOR to an increase in the Contract Price as to such portions of the Works or as to other portions of the Works.

F. Provide sub-schedules to define critical activities which dictate the rate of progress.

G. Show accumulated percentage of completion of each item, and total percentage of the Works completed, as of the first day of each month.

H. Provide separate schedule of submittal dates for Shop Drawings, product data, Samples, factory and field testing dates, and product delivery dates, including those furnished by OWNER and required by Allowances, and dates reviewed submittals will be required from ENGINEER. Indicate decision dates for selection of finishes. Coordinate submittal schedule with the subcontractors, Schedule of Values and list of products as well as CONTRACTOR's progress schedule.

I. If during performance of the Works CONTRACTOR believes it necessary or advantageous to change sequence of activities shown on CONTRACTOR's progress schedule, submit proposed revisions to ENGINEER for approval prior to changing the sequence of work. The schedule will be acceptable to ENGINEER as providing an orderly progression of the Works to completion within any specified dates identified in Section 01 10 00, but such acceptance will neither impose on OWNER or ENGINEER responsibility for the sequencing, scheduling, or progress of the Works nor interfere with or relieve CONTRACTOR from CONTRACTOR's full responsibility therefor.

J. Identify activities modified since previous submittal, major changes in scope, and other identifiable changes. Provide narrative report to define problem areas causing delay, anticipated delays and length, and impact on schedule. Report corrective action taken, or proposed, and its effect including the effect of changes on schedules of Other Contractors.

K. Distribute copies of revised schedules to ENGINEER, OWNER, Subcontractors, Suppliers, and other concerned parties. Post copies in field office. Instruct recipients to promptly report, in writing, problems anticipated by projections indicated in schedules. Delete parties from distribution when they have completed their assigned portion of the work and are no longer involved in construction activities.

L. Prepare and submit to ENGINEER within 10 days after substantial completion a detailed progress schedule for outstanding work and punch list items.

1.4 MONTHLY PROGRESS REPORTS

A. Submit monthly progress report in a form acceptable to OWNER and ENGINEER indicating work accomplished, problems encountered, problems resolved, requests for

changes to the Works, a comparison of the schedule submitted as part of the Contract Documents versus the current status, and work scheduled for the next month.

B. The following documentation shall be part of the monthly progress report:
   1. Items specified in the Request for Proposal for the Project.
   2. Tabulated budget status listing the Contract tasks identified in the progress schedule, and consisting of the following column headings:
      a. Original Budget: Original estimated cost, including direct proportional amount of CONTRACTOR's overhead and profit, to accomplish the tasks. Total cost to complete the tasks shall equal the Contract Price.
      b. Approved Changes: Changes approved by Change Order to the original budget.
      c. Current Budget: Sum of original budget and approved changes.
      d. Percent Complete: Estimated fraction of the work that has been completed.
      e. Achieved Value: Dollar value of the work that has been completed, i.e., current budget multiplied by percent complete.
      f. Amount Spent: Dollar amount that has been spent on the task.
      g. Achieved/Spent Ratio: Comparison of achieved value to amount spent.
   3. Progress Schedule in the form of a Gantt chart with highlighted critical path tasks. The schedule shall show the original schedule and the actual schedule.

1.5 CONSTRUCTION QUALITY CONTROL RECORDS

A. Record daily Construction Quality Control activities in CONTRACTOR's Site log book.

1.6 PROPOSED PRODUCTS LIST

A. Within 20 days prior to products arrival on the Site, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product as applicable.

B. For products specified only by reference standards or description, give name of manufacturer, trade name, model or catalog designation, and reference standards.

C. For products requiring special handling procedures, OWNER approval will be needed prior to bringing on site. At minimum, a Safety Data Sheet (SDS) will be required. Additional information may also be required based on the material.

1.7 SHOP DRAWINGS

A. When specified in individual Sections, prepare detailed drawings of material and structures to be supplied by CONTRACTOR from typical details shown on "Approved for Construction" Drawings and/or from specified requirements.

B. Indicate special utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

C. Indicate materials, methods of construction, attachment or anchorage, erection diagrams, connections, explanatory notes, coordination requirements and other information necessary for completion of the Works.

D. Where articles or equipment attach or connect to other articles or equipment, indicate that such work has been coordinated, regardless of the Section under which the adjacent items will be supplied and installed.

E. Confirm dimensions shown on CONTRACTOR's drawings with actual measurements of existing and/or completed associated structures and affected adjacent work at the Site.

F. Include compliance with specified standards on shop drawings.

G. Highlight, encircle, or otherwise indicate deviations from the Contract Documents.

H. Submit digital copy of CONTRACTOR's drawings via electronic file transfer in PDF file format and in a format compatible for use with Windows 10 and AutoCad 2020. Discuss with ENGINEER if alternative formats are required.

I. After ENGINEER completes its review, Shop Drawings will be stamped or otherwise marked with one of the following notations:
   1. Reviewed.
   2. Reviewed as Noted.
   3. Not Subject to Review.
   4. Revise and Resubmit.

J. If a Shop Drawing is acceptable, it will be marked "Reviewed" or "Reviewed as Noted".

K. Upon return of a Shop Drawing marked "Reviewed" or "Reviewed as Noted", CONTRACTOR may order, ship, or fabricate the materials included on the Shop Drawing, provided it is according to the corrections indicated. Upon receipt of Shop Drawings stamped "Reviewed" or "Reviewed as Noted", produce copies and distribute according to PART 1.2, SUBMITTAL PROCEDURES and for Project record document purposes as described in Section 01 70 00.

L. If a Shop Drawing marked "Reviewed as Noted" has extensive corrections or corrections affecting other drawings or Works, ENGINEER may require that CONTRACTOR make the corrections indicated thereon and resubmit the Shop Drawings for Project record document purposes.

M. Shop Drawings that are for information only will be marked "Not Subject to Review" and returned to CONTRACTOR.

N. If a Shop Drawing is unacceptable, it will be returned to CONTRACTOR marked "Revise and Resubmit".

O. Upon return of a Shop Drawing marked "Revise and Resubmit", CONTRACTOR shall make the corrections indicated and repeat the initial approval procedure.

P. Shop Drawings lacking adequate details or information to allow ENGINEER to determine whether or not the Shop Drawing meets the requirements of the Contract Documents will also be marked "Revise and Resubmit" and returned without further comment.

Q. Shop Drawings not bearing ENGINEER's "Reviewed" or "Reviewed as Noted" notation shall not be issued to Subcontractors nor utilized for construction purposes. No work requiring submission and approval of Shop Drawings shall be performed or equipment requiring submission and approval of Shop Drawings installed without Shop Drawings bearing one of these notations.

R. Submit Shop Drawings well in advance of the need for the material or equipment for construction and with ample allowance for time required to make delivery of material or equipment after data covering such is approved. CONTRACTOR shall assume the risk for all materials or equipment which are fabricated or delivered prior to the approval of Shop Drawings. Shop drawings will not be used and no materials or equipment shall be incorporated into the Works nor included in progress payments until approval thereof has been obtained in the specified manner.

S. ENGINEER will review and process all Shop Drawings promptly, but a reasonable time should be allowed for this, for Shop Drawings being revised and resubmitted, and for time required to return the approved Shop Drawings to CONTRACTOR.

T. Approval of Shop Drawings shall not relieve CONTRACTOR from the responsibility of furnishing materials and equipment of proper dimension, size, quality, quantity, and all performance characteristics to efficiently perform the requirements and intent of the Contract Documents. Approval shall not relieve CONTRACTOR from responsibility for errors of any sort on Shop Drawings. Approval is intended only to assure conformance with the design concept of the Project and compliance with the information given in the Contract Documents. CONTRACTOR is responsible for information that pertains solely to the fabrication processes, to the technique of construction, and for the coordination of the work of all trades.

U. CONTRACTOR shall not be relieved of any part of its responsibilities for correctness of its drawings or adequacy of its design bearing ENGINEER's "Reviewed" or "Reviewed as Noted" notation. ENGINEER's review is for the sole purpose of ascertaining conformance with general design concepts, and in no way constitutes approval of the detail design inherent in CONTRACTOR's drawings, responsibility for which remains solely with CONTRACTOR. Drawings prepared by CONTRACTOR's representatives including Subcontractors, Suppliers, vendors, or other Representatives shall be considered CONTRACTOR's drawings.

1.8 PRODUCT DATA

A. Submit data electronically or in hard copy when requested by ENGINEER or OWNER.

B. Include and identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information unique to the Project.

C. Indicate product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

D. After review, distribute according to PART 1.2, SUBMITTAL PROCEDURES and provide copies for Project record documents as described in Section 01 70 00.

1.9 MANUFACTURER INSTALLATION INSTRUCTIONS

A. When specified in individual Sections, submit manufacturers' printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, to ENGINEER in quantities specified for product data in PART 1.6, PROPOSED PRODUCTS LIST.

B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

C. Whenever the Specifications refer to manufacturer's instructions, such reference shall mean written instructions of the manufacturer.

1.10 MANUFACTURER CERTIFICATES

A. When specified in individual Sections, or when required by reference standards, submit notarized certification and/or test results by manufacturer, in quantities specified for product data in PART 1.6, PROPOSED PRODUCTS LIST.

B. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications, as appropriate.

C. Certificates may be recent or previous test results on material or product, but must be acceptable to ENGINEER.

1.11 CONSTRUCTION PHOTOGRAPHS

A. CONTRACTOR will be responsible for taking construction photographs and will coordinate approval from the ENGINEER and OWNER in order to utilize. CONTRACTOR shall provide any construction photos collected during completion of the Work to the ENGINEER for keeping in the project record.

B. ENGINEER, CQA ENGINEER, and OWNER may document and take construction photographs.

1.12 PROJECT ORGANIZATION

A. Within 7 days after the date of the Notice to Proceed and prior to mobilization to the Site submit an updated Project organization chart identifying major positions and names of persons assigned to these positions, including off-Site project manager, superintendent, certified industrial hygienist, health and safety officer, testing labs, and Subcontractors.

1.13 SUBMITTALS FOR PROGRESS MEETINGS

A. At least 24 hours prior to scheduled progress meetings submit the following:
   1. Updated progress schedule detailing all activities. Include review of progress with respect to previously established dates for starting and stopping the various stages of the Works, major problems and action taken, injury reports, equipment breakdown, and material removal.
   2. Weekly copies of the Site entry and work area logbooks with information on worker and visitor access.
   3. Any other information required by ENGINEER or relevant to the agenda for the upcoming progress meeting.

1.14 SITE LAYOUT

A. Within **7** days after the date of the Notice to Proceed and prior to mobilization to the Site, submit Site layout drawings showing existing conditions, facilities, proposed construction facilities, and temporary controls to be provided by CONTRACTOR including, but not limited to, the following:
   1. Existing property lines, structures, roads, utilities, and other existing Site feature or facility.
   2. Temporary access roads and utilities to be constructed.
   3. Field offices and sheds.
   4. The means of ingress and egress and temporary traffic control facilities.
   5. Proposed location of Site access.
   6. Equipment and material staging areas.
   7. Soil stockpile areas.
   8. Grading, including contours, required to construct temporary construction facilities.
   9. Any other data deemed pertinent by CONTRACTOR or required by ENGINEER.

1.15 SUMMARY OF MAJOR PROJECT SUBMITTALS

A. In addition to the submittals specified in this Section, required submittals include the following:

Name of Submittal	Specification Cross-Reference
Schedule, Pre-Construction (bond, proof of insurance, analysis of borrow materials and other project materials, permitting)	01 10 00
Surveys; top of subgrade, top of clay liner, top of drainage media, leachate pipes, and as-builts	01 10 00; 01 70 00
HASP	01 30 00
Independent Testing Laboratory Documentation	01 40 00
Closeout Requirements	01 70 00
Soils/Aggregates	31 05 16; 31 20 00
Geotextile	31 05 19.13
Excavation Plan	31 23 16.13; 31 25 00
Shoring Plan	31 23 16.13
Soil Erosion and Sediment Control Plan	31 25 00
Leak Location Survey Work Plan	31 35 26.14
HDPE Liner	31 35 26.16
Manholes	33 05 13.19
Test Results	Multiple

1.16 SUBMITTALS SCHEDULES

A. Submit a submittals schedule within 7 days after the date of Notice to Proceed.

B. The submittals schedule shall be in tabular form listing each required submittal by Section and the time for submitting, reviewing, and processing each submittal.

C. The submittals schedule will be reviewed by ENGINEER and ENGINEER will respond in writing listing deficiencies. Do not list submittals not called for in the Contract Documents. The schedule shall include all items for which CONTRACTOR proposes to use substitute or "or-equal" products. Correct deficiencies and resubmit the submittals schedule prior to beginning any work.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01 40 00

QUALITY REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. References.
2. Quality control.
3. Tolerances.
4. Requirements for references.
5. Mockup.
6. Inspecting company and testing laboratory services.
7. Manufacturers' field services and reports.

1.2 REFERENCES

A. Reference Standards:
1. ASTM International:
a. ASTM C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
b. ASTM C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
c. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
d. ASTM C535 – Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
e. ASTM C802 - Standard Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials.
f. ASTM C1077 - Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
g. ASTM C1093 - Standard Practice for Accreditation of Testing Agencies for Masonry.
h. ASTM D422 - Standard Test Method for Particle Size Analysis of Soils.
i. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
j. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
k. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft lbf/ft3 (2,700 kN m/m3)).
l. ASTM D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
m. ASTM D2434 - Standard Test Method for Hydraulic conductivity of Granular Soils (Constant Head).

n. ASTM D2487 – Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
o. ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
p. ASTM D2922 - Standard Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).
q. ASTM D2974 – Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils.
r. ASTM D3740 - Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
s. ASTM D4318 – Standard Test Methods for Liquid, Limit, Plastic Limit, and Plasticity Index of soils.
t. ASTM D4972 - Standard Test Method for pH of Soils.
u. ASTM D5084 – Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
v. ASTM D6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
w. ASTM D6938 – Standard Test Method for In-place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (Shallow Depth).
x. ASTM D7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials.
y. ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

2. Iowa Department of Transportation (Iowa DOT)
   a. Standard Specifications for Highway and Bridge Construction (Iowa DOT Standard Specifications).

B. Construction Quality Assurance Plan:
   1. Construction Quality Assurance Plan prepared by GHD, dated July 2024.

1.3 QUALITY CONTROL

A. CONTRACTOR is solely responsible for establishing and implementing a quality control program to ensure that the Works is in accordance with the Contract Documents.

B. Monitor quality control over Suppliers, products, services, Site conditions, and workmanship, to produce Works of specified quality.

C. Comply with manufacturers' instructions, including each step in sequence.

D. Should manufacturers' instructions conflict with the Contract Documents, request clarification from ENGINEER before proceeding.

E. Comply with specified standards as minimum quality for the Works except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

F. Perform work by persons qualified to produce workmanship of specified quality. Use persons licensed to perform the Works where required by these Specifications or Laws and Regulations.

G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

H. Materials furnished and finished or intermediate stages of the Works shall be sampled, tested, and inspected as specified in individual Sections and as required by reference standards.

1.4 TOLERANCES

A. Monitor tolerance control of installed products to produce acceptable Works. Do not permit tolerances to accumulate.

B. Comply with manufacturers' tolerances. Should manufacturers' tolerances conflict with the Contract Documents, request clarification from ENGINEER before proceeding.

C. Adjust products to appropriate dimensions; position before securing products in place.

D. Vertical tolerances
1. Settlement of soils will not be taken into consideration. Surveyed subgrade and base elevations will be used to verify clay layer thicknesses. Surveys, non-pointed lathe, or cones may be used to document leachate drainage layer thickness.
2. Subbase elevations for the compacted clay layer installation shall be no more than 0.2 foot below the specified elevation. There is zero tolerance above specified elevation. Base elevations for the compacted clay liner shall be no more than 0.2 foot above the specified elevation. There is zero tolerance below the specified elevation. CONTRACTOR is cautioned, design slope grades must be maintained regardless of material thickness.
3. Materials thickness for the granular drainage layer shall have 0.1-foot thickness tolerance above the specified thickness (required thickness is 1.0 foot), and zero thickness tolerance below the specified thickness.
4. All other vertical tolerances shown on plan have a ±0.1-foot tolerance. Pipe slope must be maintained as shown on the plans.

1.5 REQUIREMENTS FOR REFERENCES

A. For products or workmanship specified by association, trade, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable Laws and Regulations.

B. Conform to reference standard by date of issue current as of bid closing date, except where a specific date is established by Laws or Regulations or by an individual Section.

C. Specific provisions of Laws or Regulations may be referenced in the Project Specifications to assist CONTRACTOR and identify options selected by ENGINEER. Such references do not relieve CONTRACTOR from compliance with other applicable provisions of Laws or Regulations not specifically referenced.

D. No inference or provision of any reference document including, but not limited to any standard specification, manual, or code shall be effective to change the relationships, duties, and responsibilities of OWNER, CONTRACTOR, or ENGINEER from those set forth in the Contract Documents, nor shall it be effective to assign to OWNER or ENGINEER any

duty or authority to supervise or direct the furnishing or performance of the Works or any duty or authority to undertake responsibility inconsistent with the provisions of the Contract.

E. Reference standards referred to in these Specifications form part of the Specifications to the extent specified in individual Sections.

F. In case of conflict or discrepancy between a reference standard and the Project Specifications or with another reference standard, the more stringent requirements shall apply.

G. Should specified reference standards conflict with the Contract Documents, request clarification from ENGINEER before proceeding.

1.6 INSPECTING AND TESTING SERVICES

A. CONTRACTOR shall employ and pay for services of an independent testing laboratory to perform inspecting and testing services as specified in individual Sections.

B. Employment of testing laboratory and services performed by such testing laboratory in no way relieves CONTRACTOR of obligation to perform the Works according to requirements of the Contract Documents.

C. Inspection and testing services specific to only some of the Works is further described in their corresponding sections.

D. Quality Assurance:
1. Comply with requirements of the reference standards listed in PART 1.2, REFERENCES.
2. Comply with agencies listed in individual Sections.
3. Inspecting Company and Testing Laboratory: Authorized to operate in Iowa.
4. Inspecting Company and Testing Laboratory Staff: Maintain a full-time registered professional engineer on staff to review services.
5. Testing Equipment: Calibrated at reasonable intervals with devices of an accuracy traceable to either the National Institute of Standards and Technology (NIST) or accepted values of natural physical constants.

E. CONTRACTOR Submittals:
1. Prior to start of the Works, submit independent testing laboratory name(s), address, and telephone number, and names of full-time registered professional engineer and responsible officer.
2. Submit copy of report of testing laboratory facilities inspection made by Construction Materials Reference Laboratory during most recent inspection, with memorandum of remedies of deficiencies reported by the inspection.

F. Testing Laboratory Responsibilities:
1. Test samples of mixes and materials submitted by CONTRACTOR.
2. Provide qualified personnel at the Site. Cooperate with ENGINEER and CONTRACTOR in performance of services.
3. Perform specified inspecting, sampling, and testing of products and methods of construction according to specified standards.
4. Ascertain compliance of materials and mixes with requirements of the Contract Documents.

5. Promptly notify ENGINEER and CONTRACTOR of observed irregularities, deficiencies, or non-conformance of products.
6. Perform additional inspection and tests required by ENGINEER.
7. Attend pre-construction meetings and progress meetings, as required.

G. Testing Laboratory Reports:
1. After each inspection and test promptly submit two copies of reports to ENGINEER and CONTRACTOR. Submit draft on-Site inspection report prior to leaving the Site.
2. As a minimum, reports shall include:
   a. Date issued.
   b. Project title and number.
   c. Name and address of testing laboratory.
   d. Name of inspector.
   e. Date and time of sampling or inspection.
   f. Identification of product and related specification Section.
   g. Location in the Project.
   h. Record of temperature and weather.
   i. Type of inspection or test.
   j. Date of test.
   k. Results of tests and observations.
   l. Conformance with the Contract Documents.
3. When requested by ENGINEER, provide interpretation of test results.

H. Limits on Testing Laboratory Authority:
1. Testing laboratory may not release, revoke, alter, or enlarge upon requirements of the Contract Documents.
2. Testing laboratory may not approve or accept any portion of the Works.
3. Testing laboratory may not assume or perform any duties of CONTRACTOR.
4. Testing laboratory has no authority to stop the Works.

I. CONTRACTOR Responsibilities:
1. Deliver to testing laboratory at designated location, adequate samples of materials proposed to be used which require testing along with proposed mix designs for concrete, and other material mixes that require testing.
2. Cooperate with personnel of independent testing laboratory, and provide safe access to the Works and to manufacturer's operations.
3. Provide incidental labor and facilities:
   a. To provide access to the Works to be tested.
   b. To obtain and handle samples at the Site or at source of products to be tested.
   c. To facilitate tests and inspections.
   d. For testing laboratory's exclusive use for storage and curing of test samples.
   e. Forms for preparing concrete test beams and cylinders.
4. Notify ENGINEER and testing laboratory 24 hours prior to expected time for operations requiring inspecting and testing services to allow for assignment of personnel and scheduling of tests.
5. Furnish copies of product test reports.
6. Promptly notify ENGINEER of all observed irregularities or non-conformance of the Works.
7. Retesting required because of CONTRACTOR negligence or non-conformance to specified requirements shall be performed by the same testing laboratory on instructions by ENGINEER at CONTRACTOR's expense and at no additional cost to OWNER.

8. If defects or deficiencies are revealed during testing or inspecting, correct such defects and deficiencies and retest affected portions of the Works.

1.7 SUPPLIERS' AND MANUFACTURERS' FIELD SERVICES AND REPORTS

A. When specified in individual Sections, require SUPPLIERS to provide qualified personnel to observe Site conditions, conditions of surfaces and installation, quality of workmanship, startup of equipment, testing, adjusting, and balancing of equipment, as applicable, and to initiate instructions when necessary.

B. Submit qualifications of observer to ENGINEER 14 days in advance of required observations. Observer subject to approval of OWNER.

C. Report observations and Site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

D. Submit draft report on same day as the Site visit and final report within 7 days of observation, to ENGINEER for information.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.1 REPAIR and PROTECTION

A. Upon completion of inspection, testing, sample taking and similar services, repair damaged construction and restore substrates and finishes.

B. Protect construction exposed by or for quality-control service activities, and protect repaired construction.

C. Repair and protection is Contractor's responsibility, regardless of the assignment of responsibility for inspection, testing, or similar services.

END OF SECTION

SECTION 01 50 00

TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Summary
2. References
3. Utility Use charges
4. Quality Assurance
5. Removal of Temporary Facilities and Controls
6. Materials and Equipment
7. Temporary Utilities
8. Construction Facilities
9. Vehicular Access and Parking
10. Temporary Protection
11. Existing Utilities
12. Operation, Termination and Removal

1.2 REFERENCES:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. ASTM International:
   a. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
3. National Building Code Part 8 Safety Measures at Construction and Demolition Sites.
4. National Fire Protection Association:
   a. NFPA 10 - Standard for Portable Fire Extinguishers.
   b. NFPA 70 - National Electrical Code.
5. Occupational Safety and Health Administration (OSHA), an agency of the United States Department of Labor, Occupational Safety and Health Standards and Safety and Health Regulations - Code of Federal Regulations:
   a. 29 CFR 1910.141 - Sanitation.
   b. 29 CFR 1910.151 - Medical Services and First Aid.
   c. 29 CFR 1910.157 - Portable Fire Extinguishers.

1.3 UTILITY USE CHARGES

A. Include cost or use charges for temporary facilities in the Contract sum: Allow other entities to use temporary services and facilities without cost, including, but not limited to, the following:
1. OWNER's construction forces.
2. Occupants of Project
3. ENGINEER.
4. Testing agencies.

B. Pay service charges for sewer usage and cleaning (portable toilet), by all parties engaged in construction, at Project site.

C. Provide potable water, whether metered or otherwise, for water used by all entities engaged in construction activities at Project Site.

D. Pay electric power service use charges (if applicable), whether metered or otherwise, for electricity used by all entities engaged in construction activities at Project Site.

1.4 QUALITY ASSURANCE

A. Comply with industry standards and with applicable laws and regulations of authorities having jurisdiction, including but not limited to the following:
   1. Health and safety regulations.
   2. Utility company regulations.
   3. Police, fire department, and rescue squad rules.
   4. Environmental protection regulations.
   5. National Fire Protection Association (NFPA) 241 "Standards for Safeguarding Construction, Alterations and Demolition Operations."
   6. ANSI-AlO Series standards for "Safety Requirements for Construction and Demolition."
   7. National Electrical Contractors Association (NECA) Electrical Design Library "Temporary Electrical Facilities," NFPA 70, and National Electrical Manufacturers Association (NEMA), NECA, and UL, LLC (UL) standards and regulations for temporary electric service.

B. Arrange for authorities having jurisdiction to inspect and test each temporary utility before use. Obtain required certifications and permits.

1.5 REMOVAL OF TEMPORARY FACILITIES AND CONTROLS

A. Remove temporary utilities, equipment, facilities, materials, prior to final Application for Payment inspection.

B. Clean and repair damage caused by installation or use of temporary work.

C. Restore existing and permanent facilities used during construction to specified condition.

PART 2 PRODUCTS

2.1 MATERIALS & EQUIPMENT

A. Provide undamaged materials and equipment in serviceable conditions and suitable for use intended.

B. Provide temporary self-contained toilet units of temporary single-occupant toilet units of the chemical, aerated recirculation, or combustion type for use by all construction personnel. Units shall be properly vented and fully enclosed with a glass-fiber-reinforced polyester shell or similar nonabsorbent material.

PART 3 EXECUTION

3.1 TEMPORARY UTILITIES

A. Electricity:
1. OWNER will allow access to power. Coordinate with OWNER personnel for connection location for specific work progress. However, the Contractor is responsible to provide weatherproof grounded electric power service and distribution system of sufficient size, capacity and power characteristics for construction needs. Additional specifics will be included in pre bid meeting.
2. Provide and utilize portable power generators, if required.

B. Lighting:
1. Install and operate temporary lighting that will fulfill security and protection requirements without operating the entire system.
2. Provide lighting that provides adequate illumination for construction operations and traffic conditions.

C. Water Service:
1. No potable water source is available. Water for dust control is available at production well PW-106.
2. Temporary water service may be provided by MidAmerican Energy Company (MEC). However, the CONTRACTOR is responsible to provide, maintain and pay for suitable quality water service (or provide potable water) required for construction operations. Water used in the compaction/maintenance of the clay liner shall be clean and free of substances which may have a deleterious effect on the liner.
3. The CONTRACTOR shall provide and maintain an adequate supply of potable water for domestic consumption by the CONTRACTOR personnel.
4. Provide drinking water fountains or containerized tap-dispenser bottled-drinking water units, complete with paper cup supplies. Where power is accessible, provide electric water coolers to maintain dispensed water temperature at 45 to 55 degrees Fahrenheit (°F) (7 to 13 degrees Celsius [°C]).

D. Telephone Service:
1. Provide, maintain, and pay for telephone service and equipment.
2. Post emergency numbers including plant emergency response in addition to police, fire, ambulance, hospital, poison control center, and appropriate regulatory agencies in prominent location near each telephone.

E. Portable Radios:
1. If CONTRACTOR uses portable radios for routine Site communications, provide and maintain for ENGINEER's exclusive use, 2 two-way portable radios. Portable radios shall be of the same type and set for the same frequencies as radios used by CONTRACTOR for Site communications.

F. High Speed Internet Service:
1. Provide, maintain, and pay for wireless high speed Internet service for CONTRACTOR's field office.

G. Fire Protection:
1. Take precautions to prevent fires. Provide and maintain temporary fire protection equipment of a type appropriate to the hazard anticipated in accordance with Laws and Regulations and to the satisfaction of ENGINEER and insurance authorities.

2. Bulk storage of flammable liquids and other hazardous materials is not allowed on Site. Handle flammable liquids in approved containers.
3. Open burning of rubbish is not permitted on Site.
4. Deliver, use, and dispose of flammable materials as required by authorities having jurisdiction.
5. With prior OWNER approval, designate an area on Site where smoking is permitted. Provide approved ashtrays in designated smoking areas.
6. Cutting and welding and other hazardous operations capable of starting fires must be performed in accordance with OWNER requirements and only under permit.
7. Portable Fire Extinguishers: NFPA 10; 10-pound capacity, 4A-60B; C UL rating 20-pound ABC type dry chemical.
8. Provide a minimum of one fire extinguisher in every construction trailer and storage shed.
9. Use fireproofed tarpaulins.
10. Include on-Site fire protection specified in CONTRACTOR's Site-specific Health and Safety Plan.

3.2 CONSTRUCTION FACILITIES

A. Do not use existing facilities for field offices or storage.

B. Locate field offices, storage sheds, sanitary facilities and other temporary construction and support facilities for easy access.

C. Provide incombustible construction for offices, shops and sheds located within the construction area or within 30 feet (9 meters [ml) of building lines. Comply with NFPA241.

D. CONTRACTOR's Field Office:
1. Within 2 weeks after the date of the Notice to Proceed, furnish a structurally sound, completely weathertight and insulated office trailer, specifically designed for the purpose required.
2. Provide CONTRACTOR's field office with the minimum facilities specified. Provide all required storage and work sheds.
3. Field Office and Furnishings:
    a. As required by CONTRACTOR and with not less than 240 square feet (sq. ft) (22.5 square meters [sq. m]) for project meetings.
    b. Furnish meeting room with conference table, tack board, and no fewer than 8 chairs.
    c. Lighting suitable for intended use and temperature control to maintain an ambient temperature of 68 to 72 degrees F.
    d. Six protective helmets or hard hates for visitors' use.
    e. Exterior identifying sign.
    f. Other furnishings at CONTRACTOR's option.
4. Remove field office and sheds upon completion unless otherwise approved by ENGINEER.

E. Sanitary Facilities
1. Provide for toilets, wash facilities, and drinking water fixtures in compliance with regulations and health codes for type, number, location, operation, and maintenance of fixtures and facilities.
2. Provide toilet tissue, paper towels, paper cups, and similar disposable materials as appropriate for each facility, and provide covered waste containers for used materials.

3. Install separate self-contained toilet units for male and female personnel shielded to ensure privacy.
4. Install wash facilities supplied with potable water at convenient locations for personnel involved in handling materials that require wash-up for a healthy and sanitary condition.
    a. Dispose of drainage properly.
    b. Supply cleaning compounds appropriate for each condition.
5. Maintain sanitary facilities in a clean an orderly manner. Clean sanitary facilities at a minimum frequency of once per week.

F. Emergency First-Aid Facility:
1. Provide, operate, and maintain an Emergency First-Aid Facility and containing, as a minimum, the following equipment and supplies:
    a. Two fire extinguishers meeting the requirements of 29 CFR 1910.157.
    b. Blankets and towels as required.
    c. First-aid kit containing medications appropriate for the initial treatment of burns, abrasions, fractures, and ingestion or dermal contact with on-Site hazardous waste.
    d. Two hand-held emergency sirens.
    e. Portable emergency eye wash and shower.
2. Locate the Emergency First-Aid Facility within the CONTRACTOR’s Office trailer or other ENGINEER-approved location.

G. Storage/Stockpiling Facilities:
1. Provide, maintain, and operate storage/stockpiling facilities as required. Locations of the stockpile will be directed by the OWNER.
2. Construction of the stockpiles are discussed in Section 31 20 00.

3.3 VEHICULAR ACCESS AND PARKING

A. Access Roads:
1. Existing Roads: Use of existing on-Site roads for construction traffic is permitted subject to the OWNER’s requirements:
    a. Do not interrupt or interfere with traffic on roads at any time.
    b. Utilize and maintain Wildlife Deterrent Fence and gates.
    c. Improve existing roads as CONTRACTOR may require to perform the Works.
    d. Comply with weight and load size restrictions where applicable.
    e. Tracked vehicles are not allowed on paved areas.
2. Avoid traffic loading beyond paving design capacity.
3. Temporary Roads:
    a. Locate roads as approved by ENGINEER. Obtain ENGINEER's prior approval for location and extent of temporary roads.
    b. Construct temporary access roads from Site roadways to serve construction area of a width and load bearing capacity to provide unimpeded traffic for construction purposes as CONTRACTOR requires for performance of the Works.
    c. Construct temporary bridges and culverts to span low areas and allow unimpeded drainage.
    d. Materials:
        1) Paving Base Permanent Construction: As specified in individual Sections.
    e. Preparation: Clear areas, provide surface and storm drainage of road and adjacent areas.

f. Extend and relocate temporary roads as work progress requires. Provide detours as necessary for unimpeded traffic flow.
g. Provide unimpeded access for emergency vehicles. Maintain sufficient width and turning space.
h. Provide and maintain access to fire hydrants and control valves, free of obstructions.

4. Maintenance and Use:
   a. Maintain temporary access roads in a sound condition, properly graded, and free of ruts, washboard, potholes, ponding, ice, snow, mud, soft material, excavated material, construction equipment, and products. Maintain access roads throughout the Contract period to ensure unimpeded access for passenger automobiles as well as construction vehicles.
   b. Maintain existing and permanent paved areas used for construction; promptly remove standing water and repair breaks, potholes, low areas, and other deficiencies, to maintain paving and drainage in original or specified condition.
   c. Remove mud from vehicle wheels before entering public roads.
   d. Prevent contamination of access roads. Immediately scrape up debris or material on access roads which is suspected to be contaminated as determined by ENGINEER; transport and place into designated area approved by ENGINEER.
5. Removal and Repair:
   a. Remove temporary materials and construction at Substantial Completion.
   b. Repair existing facilities damaged by use to original condition at no cost to OWNER.

B. Parking:
1. OWNER will provide temporary gravel surface parking areas to accommodate use of CONTRACTOR’s personnel, resident project representatives, ENGINEER, and OWNER.
2. When space is not adequate, coordinate additional parking with OWNER.
3. Maintain separate parking area for construction equipment.

3.4 TEMPORARY PROTECTION

A. Protection of Street or Roadway Markers
1. The CONTRACTOR shall not destroy, remove, or otherwise disturb any existing survey markers or other existing street or roadway markers without proper authorization by Owner. No pavement breaking or excavation shall be started until all survey or other permanent marker points that will be disturbed by the construction operations have been properly referenced. Survey markers or points disturbed by the CONTRACTOR shall be accurately restored after street or roadway resurfacing has been completed.
2. CONTRACTOR shall maintain vehicle access on all pre-existing facility access roads at all times unless previously approved by OWNER in writing.

B. Barriers, Warning Signs and Lights:
1. Provide barriers to prevent unauthorized entry to construction, Site office, and on-Site parking areas, and to protect existing facilities from damage from CONTRACTOR's operations.
2. Paint with appropriate colors, graphics, and warning signs to inform personnel and the public of the hazard involved.

3. Where appropriate and needed, provide lighting, including flashing red or amber lights.
4. Protect vehicular traffic, stored materials, the Site, and structures from damage.

C. Environmental Protection
1. Provide protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations, and minimize the possibility that air, waterways, and subsoil might be contaminated or polluted or that other undesirable effects might result.
2. Provide protection so that plant life may remain.
3. Trees or Shrubs within Street Right-of Way and Project Limits
   a. The CONTRACTOR shall exercise all necessary precautions so as not to damage or destroy any trees or shrubs, including those lying within street rights-of-way and project limits. Existing trees ·and shrubs which are damaged during construction shall be trimmed or replaced by the CONTRACTOR or a certified tree company under permit from the jurisdictional agency and/or the OWNER. Tree trimming and replacement shall be accomplished in accordance with the following paragraphs. OWNER may designate specific trees for removal within· the scope of the WORK. There are threatened and endangered species present in the project site. Contractor must adhere to the threatened and endangered species plan at all times.
   b. Symmetry of the tree shall be preserved; no stubs or split or torn branches shall be left; clean cuts shall be made close to the trunk or large branch. Spikes shall not be used for climbing live trees. Cuts over 1 ½ inches in diameter shall be coated with a tree paint product that is waterproof, adhesive, and elastic; and free from kerosene, coal tar, creosote; or other material injurious to the life of the tree.
   c. The CONTRACTOR shall immediately notify the jurisdictional agency and/or the OWNER if any tree or shrub is damaged by the CONTRACTOR'S operations. If, in the opinion of said agency' or the OWNER, the damage is such that replacement is necessary, the CONTRACTOR shall replace the tree or shrub at its own expense. The tree or shrub shall be of a like size and variety as the one damaged, or, if of a smaller size, the CONTRACTOR shall pay to the owner of said tree a compensatory payment acceptable to the tree or shrub owner, subject to the approval of the jurisdictional agency or OWNER. The size of the tree or shrub shall be not less than 1 inch in diameter or less than 6 feet in height. Planting of replacement trees and shrubs shall be in accordance with the recommendations of the nursery furnishing the plants. Unless otherwise indicated, the CONTRACTOR shall water and maintain the replacement trees and shrubs for six months after planting.
4. Avoid using tools and equipment that produce harmful noise.
5. Restrict use of noise-making tools and equipment to hours that will minimize complaints from persons near the site.

D. Security:
1. Adhere to OWNER security requirements.
2. Maintain log of workers and visitors and make available to ENGINEER on request. Include date, name, address, company employed by, company/person visited, time in and time out for each person, and record of deliveries and security incidents.

3.5 EXISTING UTILITIES

A. The CONTRACTOR shall protect all existing utilities and improvements not designated for removal or alteration and shall restore damaged or temporarily relocated utilities and improvements to a condition equal to or better than prior to such damage or temporary relocation, all in accordance with the Contract Documents. Such utilities include, but are not limited to, culverts and drainage, leachate transport and management infrastructure, and monitoring wells.

B. The CONTRACTOR shall not do any WORK that would affect electric transmission lines, other utilities, fences, or other structures. The CONTRACTOR shall not enter upon the rights-of-way involved until notified that the OWNER has secured authority from the proper party. After authority has been obtained, the CONTRACTOR shall give said party due notice of its intention to begin WORK, if required by said party; and shall remove, shore, support, or otherwise protect such pipeline; transmission line, ditch, fence, or structure, or replace the same.

C. The CONTRACTOR shall be responsible for exploratory excavations as it deems necessary to determine the exact locations and depths of Utilities which may interfere with the WORK. All such exploratory excavations shall be performed as soon as practicable after Notice to Proceed and, in any event, a sufficient time in advance of construction to avoid possible delays to the CONTRACTOR's progress. When such exploratory excavations show the utility location as shown on the Drawings to be in error, the CONTRACTOR shall so notify the ENGINEER and shall make a record of this on the Record Drawings. The number of exploratory excavations required shall be that number which is sufficient to determine the alignment and grade of the utility.

D. In the event the CONTRACTOR damages existing utility lines that are not indicated or the locations of which are not made known to the CONTRACTOR prior to excavation, a verbal report of such damage shall be made immediately to the OWNER, and a written report thereof shall be made promptly thereafter and submitted to the OWNER and the ENGINEER. The CONTRACTOR will immediately notify the owner of the damaged utility. CONTRACTOR shall also notify Iowa One Call. If directed by the OWNER, repairs shall be made by the CONTRACTOR under the provisions for changes and extra WORK contained in the Contract Documents.

E. All repair to a damaged utility or improvement are subject to inspection and approval by an authorized representative of the utility or improvement owner before being concealed by backfill or other WORK.

F. Unless indicated otherwise, all utilities encountered along the line of the WORK shall remain continuously in service during all the operations under the Contract Documents, unless other arrangements satisfactory to the ENGINEER are made with the owner of said pipelines, ducts, mains, irrigation lines, sewers, storm drains', poles, or wires or cables. The CONTRACTOR shall be responsible for and shall repair all damage due to its operations, and the provisions of this section shall not be abated even in the even such damage occurs after backfilling or is not discovered until after completion of the backfilling.

G. Monitoring Wells
   1. The CONTRACTOR shall exercise all necessary precautions so as not to damage or destroy existing groundwater monitoring wells; as shown on the Drawings. The CONTRACTOR shall immediately notify the OWNER of damage to any monitoring well resulting from the CONTRACTOR's operations. Repair of damaged wells shall be arranged by the OWNER, at the expense of the CONTRACTOR.

3.6 OPERATION, TERMINATION AND REMOVAL

A. Maintenance
1. No signs are allowed without OWNER's prior written permission except those required by law.
2. Keep temporary services and facilities clean and neat.
3. Relocate temporary services and facilities as required by progress of the Work.
4. Maintain markers for underground lines.
5. Protect underground lines from damage during excavation operations

B. Collection and Disposal of Waste
1. Collect waste from construction areas and elsewhere daily. Enforce requirements strictly and dispose of material lawfully.
2. Comply with NFPA 241 for removal of combustible waste materials and debris.
3. Handle and properly containerize hazardous, dangerous, or unsanitary waste materials separately from other waste.

C. Termination and Removal
1. Unless the Owner requests that a temporary facility be maintained longer, each temporary facility shall be removed when the need for its service has ended and can be replaced by authorized use of a permanent facility.
2. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with the temporary facility.
3. Repair damaged Work, clean exposed surfaces, replace construction that cannot be satisfactorily repaired.
4. Restoration of Road Surfaces
    a. Paved Surfaces: All paved, areas including asphaltic concrete berms cut or damaged during construction or during trucking to the site, shall be replaced with similar materials of equal thickness to match the existing adjacent undisturbed areas, except where specific resurfacing requirements have been called for in the Contract Documents or in the requirements of the agency issuing the permit. The pavement restoration requirement shall apply to all components of existing sections, including sub-base, base, and pavement. Temporary and permanent pavement shall conform to the requirements of the affected pavement owner. Pavements which are subject to partial removal shall be neatly saw-cut in straight.
    b. Gravel and Haul Roads: All existing graveled or dirt road surfaces damaged during construction or during trucking to the WORK site shall be repaired to a quality commensurate with conditions prior to initiation of the WORK and existing adjacent undisturbed areas. The restoration requirement shall apply to all components of existing sections including sub-base, base, and surface material.
5. Materials and facilities that constitute temporary facilities are the property of the CONTRACTOR, except the Government reserves the right to take possession of project identification signs.
6. Prior to project completion, replace clean and restore permanent facilities used during the construction period including, but not limited to; the following:
    a. Replace significantly worn parts and parts subject to unusual operating conditions.
    b. Replace lamps burned out or noticeably dimmed by hours of use.

END OF SECTION

SECTION 01 60 00

PRODUCT REQUIREMENTS

1.1 SUMMARY

A. Section Includes:
1. Basic product requirements.
2. Product options.
3. Product substitutions.
4. Product delivery and handling requirements.
5. Product storage and handling requirements.

1.2 BASIC PRODUCT REQUIREMENTS

A. Do not use materials and equipment removed from existing premises, except as specifically permitted by the Contract Documents.

1.3 PRODUCT OPTIONS

A. Products Specified by Reference Standards or by Description Only: Any approved product meeting those standards or descriptions.

B. Products Specified by Naming One or More Manufacturers With a Provision Not Prohibiting Substitutions: Products of manufacturers named and meeting specifications; options or substitutions allowed in accordance with the General Conditions, SUBSTITUTES AND OR-EQUALS. Submit a request for substitution for any manufacturer not named in accordance with the following article.

C. Products Specified by Naming One or More Manufacturers With a Provision Prohibiting Substitutions: Products of manufacturers named and meeting specifications, no options or substitutions allowed.

1.4 PRODUCT SUBSTITUTIONS

A. The General Conditions SUBSTITUTES AND OR-EQUALS specifies requirements and procedures for submitting requests for substitutions after the Notice of Award.

B. Document each request with complete data substantiating compliance of proposed substitution with the Contract Documents.

C. A request for substitution constitutes a representation that CONTRACTOR:
1. Has investigated the proposed product and determined that it meets or exceeds the quality level of the specified product.
2. Will provide the same warranty for the substitution as for the specified product.
3. Will coordinate installation and make changes to other Works which may be required for the Works to be complete at CONTRACTOR's expense and at no additional cost to OWNER.
4. Waives claims for additional costs or time extension which may subsequently become apparent.

5. Will reimburse OWNER for review or redesign services.

D. Substitutions will not be considered unless specific discussion prior to submittal and ENGINEER or OWNER has expressed approval for sending the substitution.

E. Substitution Submittal Procedure after the Notice of Award:
1. Submit request electronically for substitution for consideration. Limit each request to one proposed substitution.
2. Submit Shop Drawings, product data, and certified test results and other data as required by the General Conditions, SUBSTITUTES AND OR-EQUALS, attesting to the proposed product equivalence. Burden of proof is on CONTRACTOR.
3. ENGINEER will notify CONTRACTOR in writing of decision to accept or reject request.
4. ENGINEER will be sole judge as to the acceptance or rejection of CONTRACTOR's request.
5. In the event CONTRACTOR obtains ENGINEER's approval for the use of products other than that shown or specified, CONTRACTOR shall, at CONTRACTOR's own expense and using methods approved by ENGINEER, make all changes to the Works, including structures, piping, electrical, equipment, and controls, that may be necessary to accommodate this product.

1.5 PRODUCT DELIVERY AND HANDLING REQUIREMENTS

A. Arrangements for transportation, delivery, and handling of products required for prosecution and completion of the Works are to be scheduled in advance and are to be made within the Plant’s requirements.

B. Shipments of products to CONTRACTOR or Subcontractors shall be delivered to the Site only during regular working hours. Shipments shall be addressed and consigned to the proper party giving name of Project, street number, and city. Do not deliver shipments to OWNER except where otherwise directed in writing.

C. Provide advance notice of delivery of products to the Site as required in other Sections. Do not deliver products of any kind to the Site until approval in writing has been applied for and obtained by CONTRACTOR from ENGINEER.

D. Arrange delivery of products to the Site in accordance with work sequence and in ample time to facilitate inspection prior to installation. Schedule deliveries to limit requirement for storage at the Site to the practical minimum.

E. Coordinate deliveries to avoid conflict with the Works and conditions at the Site and to accommodate the following:
1. Work of Other Contractors, or OWNER.
2. Limitations of storage space.
3. Availability of equipment and personnel for handling products.
4. OWNER's use of the Site.

F. Do not have products delivered to the Site until approved by ENGINEER.

G. Do not have products delivered to the Site until required storage facilities have been provided.

H. Transport and handle products in accordance with manufacturers' instructions.

I. Immediately on delivery, inspect shipments to ensure that products comply with requirements of the Contract Documents and reviewed submittals, quantities are correct, and products are undamaged.

J. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.6 PRODUCT STORAGE AND HANDLING REQUIREMENTS

A. Limit on-Site storage of products to areas shown on the Drawings or otherwise approved by ENGINEER.

B. Make all arrangements and provisions necessary for storage of materials and equipment.

C. Place all excavated materials, construction equipment, and materials and equipment to be incorporated into the Works so as not to injure any part of the Works or existing facilities and so that free access can be had at all times to all parts of the Works and to all utility service company installations in the vicinity of the Works.

D. Store and protect products in accordance with manufacturers' recommendations and instructions and requirements of Specifications, with seals and labels intact and legible.

E. Store sensitive products in weathertight, climate-controlled enclosures. Protect products subject to ultraviolet degradation from direct exposure to sunlight.

F. For exterior storage of fabricated products, place on sloped supports, above ground.

G. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to avoid condensation or potential degradation of product.

H. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter. Prevent materials from being washed away. Temporary erosion controls shall be implemented to minimize sediment transport.

I. Furnish equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.

J. Arrange storage of products to permit easy access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

K. Store materials and equipment neatly and compactly, and in locations that will cause a minimum of inconvenience to Other Contractors, public travel, adjoining owners, tenants, and occupants.

L. Protect delivered products from contamination or damage.

M. Store materials only in identified and approved locations.

N. CONTRACTOR shall be fully responsible for loss or damage to stored products, materials, and equipment.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01 70 00

EXECUTION AND CLOSEOUT REQUIREMENTS

1.1 SUMMARY

A. Section Includes:
1. References.
2. Examination.
3. Field surveying.
4. Restoration.
5. Alteration Project procedures.
6. Progress cleaning.
7. Final cleaning.
8. Final decontamination.
9. Removal and disposal.
10. Adjusting.
11. Protection.
12. Closeout procedures.
13. Project record documents.
14. Warranties.

1.2 REFERENCES

A. Abbreviations and Acronyms:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. Occupational Safety and Health Administration (OSHA).

1.3 EXAMINATION

A. Prior to commencement of work at the Site, inspect the Site with ENGINEER to review and establish the condition of surface features including existing roads, parking areas, buildings, wells, trees and other plants, grassed areas, fencing, service poles, wires, paving, and survey benchmarks or monuments on or adjacent to the Site which may be affected by the Works. This inventory shall be mutually agreed between ENGINEER and CONTRACTOR and shall not thereafter be subject to dispute. Such inventory, as may be amended from time to time, will be used by ENGINEER to check compliance by CONTRACTOR with the requirements of the Contract Documents.

B. Provide ongoing review, inspection, and attendance during performance of the Works to properly document conditions. Promptly inform ENGINEER of any existing condition at the Site affected by the Works which may require restoration, repair, or replacement. Do not cover up any of the Works without prior approval from ENGINEER.

C. Maintain and protect existing Site structures and facilities from damage which may be affected by the Works while work is in progress. Repair or replace damage resulting from the Works to ENGINEER's approval.

D. Verify that existing Site conditions and substrate surfaces are acceptable for subsequent work. Beginning new work means acceptance by CONTRACTOR of existing conditions.

E. Verify that existing substrate is capable of structural attachment of new work being applied or attached or that existing or previously constructed surfaces are ready to receive subsequent work.

F. Examine and verify specific conditions described in individual Sections.

G. Verify that utility services are available, of the correct characteristics, and in the correct location.

H. Verify that utility requirements and characteristics of operating equipment are compatible with building utilities.

I. The work area completed by Foth Infrastructure & Environmental, LLC and the Project Manual for Cell 2 and 3 Construction CCR Expansion Monofill shall serve as the baseline survey for the project. This survey shall be mutually agreed between OWNER, ENGINEER, and CONTRACTOR and shall not thereafter be subject to dispute. Beginning the Works means acceptance by CONTRACTOR of existing conditions.

1.4 FIELD SURVEYING

A. Quality Assurance:
1. Employ an independent third-party land surveyor registered in the State of Iowa and acceptable to ENGINEER to perform survey work of this article. This registered land surveyor shall complete in progress, final grade, and as-built topographic surveys and other survey activities necessary for design verification, quantity calculations, and Applications for Payment. All surveys shall reference Iowa State Plane, South Zone and NAVD88. Site CONTRACTOR’s land surveyor shall establish additional benchmark locations as shown in Drawings.
2. If subsequent surveys are in part performed by means of GPS equipped construction equipment, perform supplemental control surveys approved by ENGINEER.
3. ENGINEER may, at any time, check CONTRACTOR's survey and layout work but this shall not relieve CONTRACTOR of any of its responsibilities to carry out the Works to the lines and grades set out according to the Drawings and the Project Specifications or as otherwise necessary for performance of the Works according to the Contract Documents.

B. Required Surveys:
1. Preconstruction topographic.
2. Subgrade (bottom of clay layer).
3. Top of Compacted Clay Liner.
4. Top of pipe, inverts where applicable, and sufficient points to account for pipe grades and bends. Includes leachate system inside and outside cell and stormwater culvert.
5. Top of drainage layer.
6. Final site conditions - berms, newly constructed roadways, turnarounds, and laydown or stockpile areas.

C. Submittals:
1. Submit 1 signed paper or electronically sealed document and email digital copies of Site drawing and certificate signed by the land surveyor engaged by CONTRACTOR that the elevations and locations of the Works are in conformance with the Contract Documents. Information shall include surface (xml) files, point

files, CAD drawings, and PDF figures. CAD files shall be compatible for use with Windows 10, 64 bit and AutoCAD 3 D Civil (2020).

2. Final survey reports shall include the following information:
   a. The existing control monuments used in the transfer.
   b. An explanation of how adjustments were performed.
   c. A printout of the initial analysis worksheet.
   d. A listing of map projection transformation.
   e. A listing of loop closures.
   f. Location sketches and descriptions of all azimuth control pairs on control data sheets to include their X, Y, Z coordinate values, scale factor, and GEOID separation.
   g. Vector map.
   h. A spreadsheet with all Project data.
3. On request, submit documentation verifying accuracy of survey work.

D. Record Documents:
1. Maintain a complete and accurate log of control and survey work as it progresses.
2. Prepare a certified survey illustrating dimensions, locations, angles, and elevations of construction and Site work.
3. Submit record documents under the provisions of PART 1.14, PROJECT RECORD DOCUMENTS.

E. Survey Reference Points:
1. Locate, preserve, and protect survey control and reference points.
2. Control datum for survey is that established by OWNER and shown on the Drawings.
3. Promptly report to ENGINEER the loss or destruction of any reference point or relocation required because of changes in grades or other reasons.
4. Make good any errors entering into the Works through CONTRACTOR failure to notify ENGINEER concerning lack of preservation of such survey reference points.
5. Accurately replace or relocate disturbed reference or survey control points based on original survey control. Make no changes without prior written notice to and approval from ENGINEER.

F. Survey Requirements:
1. Utilize recognized engineering survey practices. Locate and lay out the Works using properly calibrated instrumentation.
2. Establish elevations, lines, and levels.
3. Periodically verify layouts by same means and methods.
4. Provide reasonable and necessary opportunities and facilities for setting points and making measurements during construction.
5. Confirm and document locations of all utilities.
6. Develop and make such additional detailed surveys as are needed for construction, such as benchmarks, slope stakes, batterboards, stakes for establishing the design elevations of excavations and final grades, as-builts, and other working points, lines, and elevations. Maintain benchmarks and base lines established by ENGINEER, existing property boundaries, lines and grade hubs, and other references and construction or survey points.

G. Examination:
1. Verify locations of survey control points prior to starting work.
2. Verify set-backs, easements, and clearances, confirm Drawing dimensions and elevations.
3. Promptly notify ENGINEER of any discrepancies discovered.

1.5 RESTORATION

A. As a minimum, restoration shall mean replacement, repairs, or reconstruction to a condition at least as good as or better than the condition prior to commencement of the Works.

B. Except where specifically required otherwise by other Sections, restore areas of the Works and areas affected by the performance of the Works to conditions that existed prior to commencement of the Works and to match condition of similar adjacent, undisturbed areas.

C. Ensure that restored areas match existing grade and surface drainage characteristics, except as otherwise specified, and ensure a smooth transition from restored surfaces to existing surfaces.

D. Do not alter original conditions without prior written approval from ENGINEER.

E. Without limiting the generality of the foregoing or other requirements of the Contract Documents, preserve and protect existing features encountered at the Site during performance of the Works. Contractor shall be responsible for any damage.

F. Utilize construction methods and procedures during performance of the Works which keeps disturbance and damage of whatever nature to existing conditions to the practical minimum. Where work necessitates root or branch cutting, do not proceed without ENGINEER's prior approval.

G. Ensure that quality, grades, elevations, and the extent of bedding, cover, and other backfill materials including subgrades, finish grades, and thickness of pavements for roadways are properly documented during their removal to ensure reconstruction to at least their original and functional condition.

H. Restoration Material: New, except as otherwise specified, not damaged or defective, and of the best quality for the purpose intended. Furnish evidence as to type, source, and quality of materials or products furnished when requested by ENGINEER or specified in other Sections.

I. Should any dispute arise as to the quality or fitness of materials, whether obtained on or off Site, whether previously inspected by ENGINEER prior to use or not, the decision to use any material or product in the finished Works will rest solely with ENGINEER.

J. Remove from the Site clean material not approved for reuse and dispose of at an OWNER approved landfill according to their disposal requirements.

K. Handle and store products and materials in a manner to prevent damage, adulteration, deterioration, and soiling and according to manufacturers' instructions when applicable.

L. Prior to commencement of restoration work, inform ENGINEER of proposed material, methods, and procedures to repair, replace, or reconstruct disturbed, damaged, or suspected damage to the Works.

M. Perform cutting, fitting, remedial, and coordination work to make the several parts of the Works fit together.

N. Except as specified otherwise, repair or replace materials damaged through improper handling or through loss after removal.

O. Store and protect removed material approved for reuse in approved locations. Beginning of restoration work means acceptance of existing conditions.

P. Unless otherwise specified, restore pavement as shown in the Drawings:
1. Removing and replacing the entire portions between joints or scores and not merely refinishing or patching localized areas.
2. Saw cutting surfaces, curbs and gutters, and similar structures or surfaces.
3. Protecting adjacent joints and load transfer devices and underlying granular materials.

1.6 ALTERATION PROJECT PROCEDURES

A. Works:
1. New Materials: As specified in Sections; match existing products and work for patching and extending work.
2. Type and Quality of Existing Products: Determine by inspecting and testing products where necessary, referring to existing Works as a standard.

B. Examination:
1. Verify that demolition is complete and areas are ready for installation of new Works.
2. Beginning of restoration work means acceptance of existing conditions.

C. Preparation:
1. Cut, move, or remove items as necessary for access to alterations and renovation work. Replace and restore at completion.
2. Remove unsuitable material not marked for salvage, such as rotted wood, corroded metals, and deteriorated masonry and concrete. Replace materials as specified for finished Works.
3. Remove debris and abandoned items from area and from concealed spaces.
4. Prepare surface and remove surface finishes to provide for proper installation of new work and finishes.
5. Close openings in exterior surfaces to protect existing work from weather and extremes of temperature and humidity. Insulate ductwork and piping to prevent condensation in exposed areas.

D. Installation:
1. Coordinate work of alterations and renovations to expedite completion sequentially and to accommodate OWNER occupancy.
2. Remove, cut, and patch work in a manner to minimize damage and to provide a means of restoring products and finishes.
3. Refinish visible existing surfaces to remain in renovated rooms and spaces, to specified condition for each material, with a neat transition to adjacent finishes.
4. Recover and refinish Works that exposes mechanical and electrical work exposed accidentally during the Works.
5. Install products as specified in individual Sections.

E. Transitions:
1. Where new Works abuts or aligns with existing, perform a smooth and even transition. Patch the Works to match existing adjacent Works in texture and appearance.
2. When finished surfaces are cut so that a smooth transition with new Works is not possible, terminate existing surface along a straight line at a natural line of division and make recommendation to ENGINEER.

F. Repair of Damaged Surfaces:
1. Repair substrate prior to patching finish.

G. Finishes:
1. Finish surfaces as specified in individual Sections.
2. Finish patches to produce uniform finish and texture over entire area. When finish cannot be matched, refinish entire surface to nearest intersections.

1.7 PROGRESS CLEANING

A. Execute cleaning during progress of the Works and as required by the General Conditions.

B. Requirements of Regulatory Agencies:
1. In addition to the requirements herein, maintain the cleanliness of the Works and surrounding premises within the Works limits to comply with federal, state, and local fire and safety laws, ordinances, codes, and regulations in addition to complying with OWNER policy and procedures.
2. Comply with all federal, state, and local anti-pollution laws, ordinances, codes, and regulations when disposing of waste materials, debris, and rubbish.

C. Coordinate cleaning operations with disposal operations to prevent accumulation of dust, dirt, debris, rubbish, and waste materials on or within the Works or on the premises surrounding the Works. OWNER approval is required prior to all disposal.

1.8 FINAL CLEANING

A. Execute final cleaning prior to Substantial Completion of the Works.

B. Clean equipment and fixtures to a sanitary condition with cleaning materials appropriate to the surface and material being cleaned.

C. Clean the Site; pick up debris and materials from all areas.

D. Repair pavement, roads, seed, and all other areas affected by construction operations and restore them to original condition or to minimum condition specified.

E. Maintain cleaning until acceptance and occupation by OWNER.

1.9 FINAL DECONTAMINATION

A. Perform final decontamination of construction facilities, equipment, and materials which may have come in contact with potentially contaminated materials prior to removal from the Site.

B. Perform decontamination as specified in Section 01 50 00 for equipment to the satisfaction of ENGINEER. ENGINEER will have the right to direct CONTRACTOR to perform additional decontamination if required.

1.10 REMOVAL AND DISPOSAL

A. Remove surplus materials and temporary facilities and controls from the Site.

B. Dispose of all non-contaminated waste materials, litter, debris, and rubbish off Site at an OWNER approved Landfill according to Landfill disposal requirements.

C. Do not burn or bury rubbish and waste materials on Site.

D. Volatile or hazardous wastes materials such as mineral spirits, oil, or paint thinner are not allowed to be brought on site by the CONTRACTOR without specific, material approval from the OWNER.

E. Do not discharge wastes into streams or waterways, anywhere including storm sewers.

F. Dispose of the following materials at an appropriate off-Site facility identified by CONTRACTOR and approved by OWNER according to the Landfill disposal requirements:
1. Debris including excess construction material, non-contaminated litter, and rubbish.
2. Spent disposable personal protective equipment.
3. Wastewater removed from wastewater storage tank, wastewater generated from final decontamination operations including wastewater storage tank cleaning.
4. Volatile or hazardous wastes such as mineral spirits, oil, or paint thinner.

G. Dispose of materials as directed by ENGINEER.

1.11 ADJUSTING

A. Adjust operating products and equipment to ensure smooth and unhindered operation.

1.12 PROTECTION

A. Protect installed work and provide special protection where specified in individual Sections.

B. Provide temporary and removable protection for installed products. Control activity in the immediate work area to prevent damage.

C. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings.

D. Prohibit traffic in areas outside of the Wildlife Deterrent Fence.

E. Maintenance of Flow: Maintain the flow of water in the water distribution system and in existing and temporary sewers, drains, and watercourses. In the event that any emergency or situation should arise which requires interruption of normal operation of any existing systems, restore normal operation as soon as possible even though permission for such planned shutdown was obtained.

F. Flotation: Take necessary precautions against the flotation of any structures during construction. Make good any damage caused by flotation.

1.13 CLOSEOUT PROCEDURES

A. Submit written certification that the Contract Documents have been reviewed, the Works has been inspected, and that the Works is complete according to the Contract Documents and in compliance with Laws and Regulations including, but not limited to, the provision of all applicable federal, state, and local health, safety, and environmental laws and regulations, including OSHA, and ready for ENGINEER's review.

B. Submit final Application for Payment identifying previous payments and amounts remaining due.

C. Prior to final payment by OWNER, the CONTRACTOR will provide a release of lien for all subcontractors and suppliers.

D. Complete and furnish submittals to ENGINEER that are required by governing or other authorities and by the Contract Documents. Payment shall not become due and payable until all submittals have been made acceptable to ENGINEER.

E. OWNER may occupy portions of the Works as specified in Section 01 30 00.

1.14 PROJECT RECORD DOCUMENTS

A. Maintain one set of the following Project record documents on Site; record actual revisions to the Works:
   1. Drawings.
   2. Specifications.
   3. Daily Logs including work performed daily
   4. Time and materials as accumulated.
   5. Change Orders and other modifications to the Contract.
   6. Reviewed Shop Drawings, product data.
   7. Manufacturer's instruction for assembly, installation, and adjusting.

B. Ensure entries are complete and accurate, enabling future reference by OWNER.

C. Store Project record documents separate from documents used for construction.

D. Record information concurrent with construction progress.

E. General:
   1. Do not use Record Documents for construction purposes.
   2. Protect Record Documents from deterioration and loss in a secure, fire-resistant location.
   3. Provide access to Record Documents for Engineer's reference during normal working hours.

F. Record Drawings
   1. Furnish a complete set of Construction Document Drawings to be utilized by Contractor and all Subcontractors for recording all changes and variations from the original Drawings and Shop Drawings.

a. Mark the set to show the actual installation where the installation varies from the work as originally shown.
b. Mark which Drawing is most capable of showing conditions fully and accurately.
c. Where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings.
1) Give particular attention to concealed elements that would be difficult to measure and record at a later date.

2. Mark record sets with red erasable pencil
a. Use other colors to distinguish between variations in separate categories of the work.
3. Mark new information that is important to the Owner but was not shown on Contract Drawings or Shop Drawings.
4. Note related change-order numbers where applicable.
5. Organize Record Drawing sheets into manageable sets:
a. Bind sets with durable-paper cover sheets; print suitable titles, dates, and other identification on the cover of each set.
6. Give particular attention to substitutions and selection of options and information on concealed construction that cannot otherwise be readily discerned later by direct observation.
7. Identify and date each Record Drawing; include designation "PROJECT RECORD DRAWING" in a prominent location.
8. Upon completion of the Work submit Record Drawings to the Engineer for the Owner's records.

G. Record Specifications: Furnish a copy of the Project Manual for recording changes.
1. Mark these documents to show substantial variations in actual work performed in comparison with the text of the Specification and modification.
2. Give particular attention to substitutions and selection of options and information on concealed construction that cannot otherwise be readily discerned later by direct observation.
3. Note related Record Drawing information and product data.
4. Identify and date Record Specification; include 'PRODUCT RECORD SPECIFICATION' in a prominent location.
5. Upon completion of the work, submit record specifications to the Engineer for the Owner's records.

H. Record Product Data: Furnish one copy of each product data submittal. Note related Change Orders and markup of Record Drawings and Record Specifications.
1. Mark these documents to show significant variations in actual work performed in comparison with information submitted.
a. Include variations in products delivered to the site and from the manufacturer's installation instructions and recommendations.
2. Give particular attention to concealed products and portions of the Work that cannot otherwise be readily discerned later by direct observation.
3. Upon completion of markup, submit complete set of Record Product Data to the Engineer for the Owner's records.

I. Record Sample Submitted:
1. Immediately prior to Substantial Completion, the Contractor shall meet with the Engineer and the Owner's personnel at the project site to determine which samples are to be transmitted to the Owner for record purposes.
2. Comply with the Owner's instructions regarding delivery to the Owner's sample storage area.

J. Miscellaneous Record Submittals:
   1. Refer to individual specification sections for requirements of miscellaneous record keeping and submittals in connection with actual performance of the Work.
   2. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records and place in good order.
   3. Identify miscellaneous records properly and bind or file, ready for continued use and reference.
   4. Submit to the Engineer for the Owner's records.

K. Remove ENGINEER title block from all documents generated by CONTRACTOR.

L. Submit documents to ENGINEER with or prior to claim for final Application for Payment.

1.15 WARRANTIES

A. Obtain warranties, executed in duplicate by responsible Subcontractors and Suppliers, within 14 days after completion of the applicable item of work. Except for items put into use with OWNER's permission, leave date of beginning of time of warranty open until the date of Substantial Completion is determined.

B. Verify that documents are in proper form, contain full information, and are notarized.

C. Co-execute submittals when required.

D. Retain warranties until time specified for submittal.

E. Bind in commercial quality 8 1/2- by 11-inch 3-ring binders with durable plastic covers. Identify each binder with typed title WARRANTIES, with title of Project; name, address, and telephone number of CONTRACTOR or equipment SUPPLIER; and name of responsible company principal. Neatly type Table of Contents, in the sequence of the Table of Contents of the Contract Documents, with each item identified with the number and title of the Section in which specified, and the name of the project or work item. Separate each warranty with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List Subcontractor and Supplier, with name, address, and telephone number of responsible principal.

F. For equipment or component parts of equipment put into service during construction with OWNER's permission, submit documents within 10 days after acceptance. Make other submittals within 10 days after the date of Substantial Completion.

G. For items of the Works for which acceptance is delayed beyond the date of Substantial Completion, furnish updated submittal within 10 days after acceptance of the affected item. The date of acceptance of such item shall be the start of the warranty period for that item.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 02 56 13.16

GEOSYNTHETIC CLAY LINER

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. References
2. Submittals
3. Closeout Submittals
4. Quality Assurance
5. Delivery, Storage, and Halding
6. Ambient Conditions
7. Warranty
8. Acceptable GCL Manufacturers
9. Geosynthetic Clay liner Material
10. Overlap Markings
11. Accessory Bentonite
12. Needle Punched and Stitched Bonded GCLs
13. Examination
14. Preparation
15. Installation
16. Field Quality Control

1.2 REFERENCES

A. Definitions:
1. GCL: Geosynthetic clay liner. Factory manufactured hydraulic barrier consisting of granular bentonite clay, sandwiched between and supported and encapsulated by two geotextiles held together by needle punching.
2. Geotextile: Semi-permeable woven or nonwoven fabric used to contain the bentonite used in a GCL.
3. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.
4. Needle Punching: The process of GCL manufacturing whereby barbed needles incorporate the stable fibers from a nonwoven geotextile through a sodium bentonite clay layer into the matrix of a second geotextile layer.
5. Bentonite: High swelling clay consisting primarily of the mineral montmorillonite.
6. Thermal Locking: Needle punching enhancement process utilizing heat to bond needle punched fibers and permanently lock them into a second geotextile to increase the internal shear strength of the GCL.
7. MARV: Minimum Average Roll Value. Average value for a specified parameter less two standard deviations, providing a 95 percent confidence level.

B. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. ASTM International:
a. D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).

b. D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
c. D4354 - Standard Practice for Sampling of Geosynthetics for Testing.
d. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
e. D4643 - Standard Test Methods for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
f. D4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
g. D5084 - Standard Test Method for Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
h. D5889 - Standard Practice for Quality Control of Geosynthetic Clay Liners.
i. D5890 - Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liner.
j. D5891 - Standard Test Method for Fluid Loss of Clay Mineral Component of Geosynthetic Clay Liner.
k. D5993 - Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liner.
l. D6243 - Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method.

1.3 SUBMITTALS

A. Samples: If an alternative to the product specific in Paragraph 2.2.A is proposed, no later than 10 days prior to ordering, submit a representative Sample, at least 12 inches by roll width.

B. Product Data: No later than 10 days prior to ordering, submit GCL manufacturer's product data including installation, handling, storage, and repair instructions.
1. Include statement and certificate of compliance of raw materials.
2. Include statement for basis of property values of raw materials and GCL.

C. Manufacturer's Instructions: Submit manufacturer's installation instructions at least 14 days prior to installation.

D. Manufacturer's Certificates:
1. Deliver each roll to the Site accompanied by manufacturer's certificate.
2. Identify each roll by unique manufacturing number.
3. Include results of at least the following tests: moisture content, swell index, fluid loss of bentonite, grab strength, peel strength, permeability, and mass per unit area of GCL.
4. Quality control certificates signed by manufacturer and notarized.
5. Certificates pertaining to raw materials and manufactured rolls including, but not limited to storage, handling, and shipping of GCL. ENGINEER will review test results for completeness and compliance with required minimum properties for both raw materials and manufactured rolls. Materials and rolls not in compliance with minimum required properties will be rejected.

E. Daily Field Installation Report.
1. Submit no later than 1 day following date covered by the report. Include:
a. Total amount and location of GCL placed.
b. Identifiers of rolls and fabricated blankets.
c. Changes in layout drawings.
d. Record of defects caused during transportation and handling.
e. Observations of weather conditions, and results.

f. Observations of anchor trench excavation, backfilling, and compaction.
g. Observations of seams around appurtenances, and connection to appurtenances.
h. Observations of repairs, including locations and name of repairer.

1.4 CLOSEOUT SUBMITTALS

A. Written warranties by the manufacturer and installer.

1.5 QUALITY ASSURANCE

A. Qualifications
   1. Manufacturer Information:
      a. Corporate background.
      b. Plant capabilities, including:
         1) Size
         2) Equipment
         3) Personnel
         4) Manufacturing capacity.
      c. Quality control program, including testing frequency.
      d. List of 10 (minimum) completed facilities totaling a minimum of 2,000,000 square feet:
         1) Name, location, and purpose of facility.
         2) Date of installation.
         3) Name of owner, project manager, and installer.
         4) Description and surface area of installation.
   2. Installer Information:
      a. Corporate background.
      b. Capabilities, including:
         1) Size
         2) Equipment
         3) Personnel
         4) Anticipated daily production.
      c. Field installation quality control program.
      d. List of 10 (minimum) completed facilities totaling a minimum of 1,000,000 square feet:
         1) Name, location, and purpose of facility.
         2) Date of installation.
         3) Name of owner and project manager.
         4) Name of installation supervisor.

B. Certifications: Prior to shipment to the Site, provide manufacturing quality control documentation on specified rolls of GCL, demonstrating that all quality control test methods, frequency, and acceptance criteria meet the requirements of this Section.

1.6 DELIVERY, STORAGE, AND HANDLING

A. The manufacturer shall assume responsibility for initial loading and shipping of GCL.

B. Prior to shipment, obtain manufacturer's approval for methods of unloading GCL.

C. Lift GCL rolls by inserting a strong iron bar, supplied by manufacturer and sized to limit deflection detrimental to GCL, through the roll core. Attach slings or lifting chains at both ends of bar. Use a spreader bar to support and spread the slings. Ensure bar and support pipe are long enough to prevent damage to liner edges during hoisting.
   1. Do not lift GCL rolls by wrapping straps around the ends of rolls.
   2. Do not drag, lift from one end, lift with forks of a lift truck, or push GCL rolls to the ground from delivery vehicle.

D. Store GCL rolls in a clean, dry area in their original, unopened, wrapped cover. To prevent moisture damage, repair minor rips or tears in plastic packaging with moisture resistant tape prior to placing in storage. Store GCL rolls on pallets and cover with heavy protective tarpaulin, or enclose within a storage facility. Keep GCL blanket clean and free from debris prior to installation. Do not store GCL more than four rolls high or as instructed by manufacturer.

E. Notify ENGINEER 3 days in advance of GCL delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of GCL or of the entire GCL roll at ENGINEER's discretion. Remove rejected material from the Site and replace with new material.

1.7 AMBIENT CONDITIONS

A. Do not install when climatic conditions, as determined by ENGINEER, are unsatisfactory.

B. Install on dry ground.

C. Comply with manufacturer's installation instructions.

1.8 WARRANTY

A. Provide a written warranty by the manufacturer in the Owner’s name guaranteeing the product supplied was manufactured in accordance to industry accepted practices and meets the certified properties required for the project.

B. Provide a written warranty by the installer in the Owner’s name guaranteeing workmanship of the installation. The warranty shall require repair or replacement of any material not installed in compliance with these specifications.

C. The warranty period for the manufacturer shall be five years.

D. The warranty period for the installer shall be one year.

PART 2 PRODUCTS

2.1 ACCEPTABLE GCL MANUFACTUERS

A. CETCO

B. ENGINEER approved equal.

2.2 GEOSYNTHETIC CLAY LINER MATERIAL

A. The GCL material shall be CETCO Resistex 100 or 200 or ENGINEER approved equal.

B. The GCL specified shall be a reinforced if placed on slopes 3:1 or greater.

2.3 OVERLAP MARKINGS

A. A minimum overlap guideline and a construction match-line delineating the overlap zone shall be imprinted with a non-toxic substance on both edges of the GCL.

2.4 ACCESSORY BENTONITE

A. Any accessory bentonite used to seal seams, penetrations, or repairs shall be the same granular bentonite as used in the production of the GCL itself.

2.5 NEEDLE PUNCHED AND STITCHED BONDED GCLs

A. If needle punching or stitch bonding is used in construction of the GCL, the manufacturer shall certify in writing that the GCL has been continuously inspected for broken needles using an in-line metal detector and all broken needles have been removed.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify the GCL meets the requirements of this section and has been approved by the Engineer.

B. Visually inspect the site and remove angular rocks, protrusions and any materials that may impact performance of the GCL.

C. After surface preparation is completed, the installer shall inspect the site and provide a written certification that the subgrade is suitable and acceptable for installation of the material.

3.2 PREPARATION

A. Prior to GCL installation, prepare surface by grading, recompacting and proof rolling.

B. Grade site such that there are not abrupt changes or breaks in grade.

C. Compact subgrade to provide a firm unyielding base for GCL installation.

D. Roll subgrade surface smooth with a drum roller such that base is unyielding.

E. Subgrade surface shall be free from loose earth, rocks, rubble and other foreign material.

F. Correct any defects in subgrade identified by the installer.

3.3 INSTALLATION

A. Placement
1. Place the GCL in accordance with the manufacturer's recommendations and with the direction provided herein. Any deviations from these procedures must be preapproved by the Engineer.
2. Use equipment capable of freely suspending the GCL roll.
3. On sloped areas exceeding a steepness of 4H:1V, the long dimension of all panels shall be oriented parallel to the slope, and the ends of these panels shall be secured in an anchor trench.' Panels should be placed from the highest elevation to the lowest within the area to be lined. Panels shall be placed free of tension or stress yet without wrinkles or folds. Do not stretch the GCL in order to fit a designated area. Do not drag panels across the subgrade into position except where necessary to obtain the correct overlap for adjacent panels.
4. Do not place panels in rain and high wind.
5. Unwrap and install only as much GCL in one working day as can be covered. In no case shall the GCL be exposed to the elements at the end of the day.

B. Seaming
1. GCL seams shall be formed using a bentonite-enhanced overlap. A fillet of granular bentonite shall then be poured in a continuous manner along the overlap, zone (between the edge of the panel and the 6-inch line), at a rate of at least one quarter pound per lineal foot.
2. A 6-inch to 9-inch overlap shall exist at seam locations. Use lap line and match lines printed on the panels. Smooth out any wrinkles, creases, or "fishmouths."
3. Seams may be placed across the slope, overlaps should be "shingled" so as to prevent flow into the seam.
4. Other seaming methods may be submitted to the Engineer for review and approval.

C. Repair
1. Damage in the form offcuts or tears in the GCL shall be identified and repaired by cutting a patch from unused GCL and placing it over the affected area with a minimum 1-foot overlap.
2. Accessory bentonite shall be placed around the perimeter of the affected patch area. An epoxy-based adhesive shall be used to keep the patch in position during backfill operations.

D. Placement of Overlying Materials
1. GCL shall not be covered prior to inspection and approval by the CQA representative.
2. Soil cover shall be placed with low ground pressure equipment. A minimum thickness of 12 inches of cover shall be kept between low ground pressure equipment and the GCL. Vehicles shall not be driven directly on the GCL until the proper thickness of cover has been placed.
3. Initial lift(s) of soil cover shall not be compacted in excess of 85 percent Standard Proctor density.
4. Cover soil shall be pushed upslope to minimize tension on the GCL.
5. If the GCL cover material is a geomembrane or other geosynthetic, precautions shall be taken to prevent damaging the GCL by restricting heavy equipment traffic. Unrolling the geosynthetic can be accomplished through the use of lightweight, rubber-tired equipment such as a 4-wheel all-terrain vehicle (ATV). This vehicle can be driven directly on the GCL, provided the ATV makes no sudden stops, starts, or turns.

6. If a textured geomembrane is placed over the GCL, a slip sheet (such as 20-mil smooth HDPE) shall first be placed over the GCL in order to allow the geomembrane to slide into its proper position.
7. GCL deployed shall be covered with overlying material.
8. If the material overlying the GCL is a geomembrane, the geomembrane shall be covered with an appropriate soil or drainage material within 30 calendar days of GCL deployment.

3.4 FIELD QUALITY CONTROL

A. Owner’s Installation Observation 1
   1. The Owner will provide an experienced and qualified QC observation team during the installation to observe and record installation procedures and quality control procedures and results.
   2. Provide information and assistance to the Owner's QC observation team as required to observe and verify the following:
      a. GCL packaging identification slips.
      b. Subgrade conditions prior to GCL installation.
      c. Handling of GCL package or roll.
      d. Unrolling and deployment of each panel.
      e. Temporary and permanent anchoring of GCL.
      f. Confirm that required overlap distances are met.
      g. Visual observation of the GCL to ensure it is free from detrimental defects.
      h. Visual observation of overlaps and adding of bentonite.
      i. Observation of repairs.
      j. Observation of anchorage.

B. Report of Quality Control Testing and Inspection
   1. Provide written quality control reports for all testing and observations made.
   2. Provide copies of all field laboratory test results within 24 hours of completion of tests.

C. Manufacturer’s/Installer’s Field Services
   1. Installer shall provide a full-time superintendent experienced in the installation of GCL.
   2. Provide an installer's certification the subgrade is suitable and acceptable for installation of the material.
   3. Provide a manufacturer’s installation quality control manual upon delivery of the GCL to the project site.

END OF SECTION

SECTION 31 05 16

AGGREGATES FOR EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Engineered soils and aggregates materials.
2. Iowa Department of Transportation (Iowa DOT) classifications.

1.2 REFERENCES

A. Definitions:
1. MMDD: Modified Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D1557.
2. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.

B. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. ASTM International:
a. ASTM C33 – Standard Specification for Concrete Aggregates.
b. ASTM D75 – Standard Test Method for Sampling Aggregates
c. ASTM C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
d. ASTM C117 – Standard Test Method for Material Finer than No. 200 Sieve in Mineral Aggregate by Washing.
e. ASTM C131 – Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
f. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
g. ASTM C144 – Standard Specification for Aggregate for Masonry Mortar.
h. ASTM C207 – Standard Specification for Hydrated Lime for Masonry Purposes.
i. ASTM C535 – Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angles Machine.
j. ASTM C602 – Standard Specification for Agricultural Liming Materials.
k. ASTM D448 – Standard Specification for Standard Sizes of Coarse Aggregate for Highway Construction.
l. ASTM D1140 – Standard Test Methods for Determining the Amount of Material Finer than 75μm (No. 200) Sieve in Soils by Washing.
m. ASTM D1241 – Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses.
n. ASTM D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures.
o. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

p. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
q. ASTM D6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.

3. Iowa Department of Transportation Standards Specifications for Highway and Bridge Construction (Iowa DOT Standard Specification).

1.3 SUBMITTALS

A. Materials Source: Submit name of proposed imported fill material source at least 14 days prior to commencing transport of materials to the Site.

B. Test Reports: Submit test reports certifying compliance with specified requirements at least 7 days prior to commencing transport to the Site.

C. Suppliers' Certificates: Submit certificate indicating that each type of imported fill material meets or exceeds specified requirements.

D. Weigh Tickets: At the end of each work day, submit delivery weigh tickets of imported fill materials delivered to the Site.

E. Certificates: Certify that products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. An independent testing laboratory to provide testing services required by this section.

PART 2 PRODUCTS

2.1 ENGINEERED SOILS AND AGGREGATES (SOIL CLASS A)

A. General
1. Material shall be clean, sound, hard, dense, durable, field or quarry stone which is free from seams, cracks, or other structural defects. It shall be angular material from shot rock (blasted) or crushed rock having substantially all face of which have resulted from artificial crushing.
2. Loss due to sulfate soundness test shall not exceed 10%.
3. Loss due to abrasion test shall not exceed 40%.
4. Material shall not be frozen.

B. Gradation

1. Soil Class A-1 (Heavy Riprap Rock)

% Total Weight Smaller	
Size of Stone	Than the Given Size
500 lbs.	100
400 lbs.	90
150 lbs.	50
40 lbs.	20

2. Soil Class A-MR (Medium Riprap Rock)

% Total Weight Smaller	
Size of Stone	Than the Given Size
400 lbs.	100
200 lbs.	90
80 lbs.	50
15 lbs.	20

3. Soil Class A-2 (Light Riprap Rock)

% Total Weight Smaller	
Size of Stone	Than the Given Size
150 lbs.	100
60 lbs.	80
20 lbs.	20
2 lbs.	10

4. Soil Class A-3 (Breaker Run Rock or 6” Crushed Rock)

Sieve Size	% Passing by Weight
7-inch	100
6-inch	90
4-inch	75
3-inch	10

5. Soil Class A-4 (3 ½-inch Crushed Rock – ASTM D448-No.1)

Sieve Size	% Passing by Weight
4-inch	100
3½-inch	90-100
2½-inch	25-60
1½-inch	0-15
¾-inch	0-5

6. Soil Class A-5 (2½-inch Crushed Rock – ASTM D448-No.2)

Sieve Size	% Passing by Weight
3-inch	100
2½-inch	90-100
2-inch	35-70
1½-inch	0-15
¾-inch	0-5

7. Soil Class A-6 (1½-inch Crushed Rock – ASTM D448-No.4)

Sieve Size	% Passing by Weight
2-inch	100
1½-inch	90-100
1-inch	20-55
¾-inch	0-15
3/8-inch	0-5

8. Soil Class A-7 (¾-inch Crushed Rock – ASTM D448-No.67)

Sieve Size	% Passing by Weight
1-inch	100
¾-inch	90-100
3/8-inch	20-55
No. 4	0-10
No. 8	0-5

9. Soil Class A-8 (3/8-inch Crushed Rock – ASTM D448-No.8)

Sieve Size	% Passing by Weight
½-inch	100
3/8-inch	85-100
No. 4	10-30
No. 8	0-10
No. 16	0-5

2.2 ENGINEERED SOILS AND AGGREGATES (SOIL CLASS B)

A. General
1. Shall be hard, strong, durable particles free from seams, cracks, and other structural defects.
2. Rounded to subangular.
3. Free from organic impurities and debris.
4. Material shall not be frozen.
5. Loss due to magnesium sulfate soundness test (ASTM-C88) shall not exceed 18% (12% if sodium sulfate is used).
6. Loss due to abrasion/impact in Los Angeles rattler test (ASTM-C535) shall not exceed 10% passing the ½-inch sieve.

B. Gradation

1. Soil Class B-1 (Coarse Aggregate – ASTM C33 – No. 3)

Sieve Size	% Passing by Weight
2½-inch	100
2-inch	90-100
1½-inch	35-70
1-inch	0-15
½-inch	0-5

2. Soil Class B-2 (Coarse Aggregate – ASTM C33 – No. 7)

Sieve Size	% Passing by Weight
¾-inch	100
½-inch	90-100
3/8-inch	40-70
No. 4	0-15
No. 8	0-5

3. Soil Class B-3 (Fine Aggregate – ASTM C33)

Sieve Size	% Passing by Weight
3/8-inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

4. Soil Class B-1 (Masonry Sand – ASTM C144)

Sieve Size	% Passing Natural Sand	Manufactured Sand
No. 4	100	100
No. 8	95-100	95-100
No. 16	70-100	70-100
No. 30	40-75	40-75
No. 50	10-35	20-40
No. 100	2-15	10-25
No. 200	--	0-10

2.3 ENGINEERED SOILS AND AGGREGATES (Soil Class C)

A. General
1. Shall be hard, durable, granular material of uniform quality resulting from crushed rock or crushed bank run sand and gravel.
2. Shall be free from clay lump, organic matter, shale, excess, elongated, or flat pieces, and other deleterious substances.
3. Forty-five percent (45%) of the particles retained on a No. 4 sieve shall have at least one fractured face.
4. Wear shall not exceed 50%.
5. Loss, due to sulfate soundness test shall not exceed 18% by weight.
6. Total moisture content shall not exceed 7%.
7. Filler for blending shall have a maximum liquid limit of 25% and a maximum plasticity index of 6.
8. Material shall not be frozen.

B. Gradation
1. Soil Class C-1 (Crushed Stone)

Sieve Size	% Passing by Weight
1½-inch	100
3/8-inch	30-65
No. 4	25-55
No. 10	15-40
No. 200	2-12

2. Soil Class C-2 (Crushed Stone)

Sieve Size	% Passing by Weight
1-inch	100
3/8-inch	40-75
No. 4	25-60
No. 10	15-45
No. 200	3-12

3. Soil Class C-3 (Crushed Stone)

Sieve Size	% Passing by Weight
1-inch	100
¾-inch	95-100
3/8-inch	50-90
No. 4	35-70
No. 10	15-55
No. 200	5-15

4. Soil Class C-4 (Crushed Gravel)

Sieve Size	% Passing by Weight
1½-inch	100
1-inch	75-100

Sieve Size	% Passing by Weight
3/8-inch	40-75
No. 4	30-60
No. 10	20-45
No. 40	10-30
No. 200	3-10

5. Soil Class C-5 (Crushed Gravel)

Sieve Size	% Passing by Weight
1-inch	100
3/8-inch	50-85
No. 4	35-65
No. 10	25-50
No. 40	10-30
No. 200	3-10

6. Soil Class C-6 (Crushed Gravel)

Sieve Size	% Passing by Weight
1-inch	100
¾-inch	95-100
3/8-inch	50-90
No. 4	35-70
No. 10	20-55
No. 200	8-15

2.4 BANK RUN SOILS

A. Soil Class D-1 and D-2
1. Materials shall be rounded or subangular material resulting from pit run or crushed material.
2. Materials shall be free from clay lumps, organic matter, and deleterious substances.
3. One hundred percent (100%) by weight shall pass a 3-inch sieve.
4. Maximum liquid limit shall be 25% and maximum plasticity index shall be 6.
5. Material shall not be frozen.
6. The portion of material which passes a No. 4 sieve shall conform to the following gradation:

Maximum % Passing by Weight		
Sieve Size	Grade D-1	Grade D-2
No. 4	100	100
No. 40	75	--
No. 100	15	30
No. 200	8	15

B. Soil Class D-3
   1. Well graded, unwashed bank run or crushed bank run which is free from clay lumps, organic matter, and other deleterious substances with gradation as follows:

Sieve Size	% Passing by Weight
¾-inch	100
No. 4	90-100
No. 10	45-90
No. 40	15-45
No. 200	0-10

C. Soil Class E-1 (Clay Soil)
   1. Minimum 50% by weight passing the No. 200 sieve.
   2. For the flection passing the No. 40 sieve, the minimum plasticity index shall be 15.
   3. Minimum Atterberg liquid limit of 30.
   4. Free from organic material, boulders, cobbles, excessive amounts of gravel (greater than %-inch), and other deleterious substances.

D. Soil Class F-1 (Topsoil)
   1. Topsoil shall be defined as the upper soil horizon consisting of mineral layers of maximum humus (organic) accumulation.
   2. Topsoil shall:
      a. Have adequate mineral content to support the growth of the vegetation intended to be established.
      b. Have one of the following SCS (Soil Conservation Service) soil textures: loam, sandy loam, silt loam, silty clay loam, or clay loam.
      c. Be free from herbicides which would be detrimental for the intended use.
      d. Have adequate fertility for quick establishment of vegetation
      e. Shall be neither excessively acid nor excessively alkaline.
      f. Shall be free from deleterious substances.

E. Soil Class G-1 (Clean Earth Fill)
   1. Soil Class G-1 shall be any soil material excavated on the project site or obtained from borrow areas.
   2. Soil materials unsuitable and, therefore, not approved for this classification are:
      a. Soils with high organic contents such as: topsoil, peat, muck,: organic silts, and clays, marls, etc.
      b. Manmade or rubble filled soils containing such materials as: foundry sand, fly ash cinders, asphalt, and concrete rubble, etc.
      c. Silty soils such as: rock flour, loess, etc.
      d. Soils with gravel larger than 3-inch.
      e. Silty clay or clays with a high plasticity (CH soils as defined in ASTM D2487).
      f. All soil contaminated with hazardous waste materials as defined by the EPA.

F. Soil Class G-2 (Clean Earth Fill)
   1. Same as G-1 above except shall not contain gravel larger than 1½-inch.

2.5 MANUFACTURED AND SEPCIFIC SOILS

A. Soil Class H-1 (Polymer Treated and Chemically Treated Bentonite)
   1. Bentonite shall be defined as being largely composed of sodium montmorillonite (a clay mineral).
   2. Contain an optimum level of anionic or non-ionic or organic polymer to maximize wetting, expansion, and dispersing action in all types of soils.
   3. Shall be high swelling which is defined as the ability of 2 grams of the base bentonite, when mechanically reduced to -100 sieve, to swell in water to an apparent volume of 16.0 cc's, or more when added a little at a time to 100 cc's of distilled water in a graduate. Swelling action shall be indefinitely reversible.
   4. Shall have a colloid content exceeding 85% as measured by evaporating the suspended portion of a 2% solution after 24 hours of sedimentation in a graduated beaker.
   5. Shall have a mineralogical composition of 90% minimum montmorillonite with 10% maximum sediments of feldspar, micas, and unaltered volcanic ash.
   6. Material shall not be frozen.

B. Soil Class H-1 (Polymer Treated Bentonite)
   1. Have properties equal to American Colloid Company Volcloy SG-40 Federal Bentonite Fluid Stop 610, or equal.

C. Soil Class H-2 (Chemically Treated Bentonite)
   1. Be chemical treated to resist reaction and degradation from contact with the contaminant being stored.
   2. Have properties and composition equal to America Colloid Company Volcloy Saline Seal -100, Federal Bentonite Marine Seal 123, or equal.

D. Soil Class J-1 (Agricultural Limestone)
   1. Conform to ASTM C602.
   2. Ground or crushed limestone.
   3. Neutralization index of not less than 40 or more than 109.
   4. Meet the following gradation:
      a. Passing a No.4 sieve - 100%
      b. Passing a No. 10 sieve - 90 to 100%
      c. Passing a No. 50 sieve - 50 to 100%.

E. Soil Class J-2 (Hydrated Lime)
   1. Shall consist of essentially calcium, hydroxide or a mixture of calcium hydroxide, magnesium oxide, and magnesium hydroxide.
   2. Dry powder obtained by treating quick lime with enough water to satisfy its chemical affinity for water under the conditions of its hydration.
   3. Hydrated lime shall conform to the requirements of ASTM C207, Type N or S.

2.6 IOWA DEPARTMENT OF TRANSPORTATION CLASSIFICATION

A. Coarse Aggregate for Concrete
   1. Coarse aggregate for concrete shall be in accordance with Iowa DOT Standards, Section 4115, Coarse Aggregate for Portland Cement Concrete. All testing and quality control required by Iowa DOT Standard Specification shall be completed and submitted to the Engineer.
   2. Coarse aggregate fraction size shall be in accordance with the gradation requirements specified and as shown in the Aggregate Gradation Table in the Iowa DOT Standard Specification.

B. Aggregate for Surface or Base Coarse
   1. Aggregate for surface or base coarse shall be in conformance with Iowa DOT Standard Specification, Section 4120. All testing and quality control required by Iowa DOT Standard Specification shall be completed and submitted to the Engineer.
   2. Gradation shall be specified on the Drawings and conform to the gradations in the Aggregate Gradation Table in the Iowa DOT Standard Specification.

C. Graded Aggregate for Flexible Pavement Mixtures
   1. Aggregate for flexible pavement mixtures shall be in accordance with Iowa DOT Standard Specification, Section 4127.: All testing and quality control required by Iowa DOT Standard Specification shall be submitted to the Engineer.
   2. Gradation of material shall be specified on the Drawings and conform to the gradations in the Aggregate Gradation Table of the Iowa DOT Standard Specification.

D. Pipe Backfill
   1. Pipe backfill material is material meeting Iowa DOT Standard Specification Section 4119.
   2. Submit to the Engineer test results verifying the gradation of pipe backfill material if material is shown on Drawings or otherwise specified.

E. Cover Aggregate
   1. Aggregate cover material shall be graded mineral product meeting the gradation requirements 19, 20, or 21 of the Iowa DOT Standard Specification Aggregate Gradation Table.

F. Revetment Stone, Erosion and Gabion Stone
   1. Revetment stone shall be in accordance with Iowa DOT Standard Specification, Section 4130
   2. Gradation
      a. Class A revetment stone shall be in accordance with Iowa DOT Standard Specification Section 4130.02 A.1.
      b. Class B revetment stone shall be in accordance with Iowa DOT Standard Specification Section 4130.02 A.2.
      c. Class C revetment stone shall be in accordance with Iowa DOT Standard Specification Section 4130.02 A.3.
      d. Class D and E revetment stone shall be in accordance with Iowa DOT Standard Specification Section 4130.02 A.4.
      e. Erosion stone gradation shall be in accordance with Iowa DOT Standard Specification Section 4130.04.

f. Gabion stone shall be in accordance with Iowa DOT Standard Specification Section 4130.07.

G. Sand Cover
1. Sand cover material shall consist of sound durable particles of sand and gravel meeting the gradation requirements in the Aggregate Gradation Table No. 36, Iowa DOT Standard Specification.

2.7 SOURCE QUALITY CONTROL

A. To establish acceptability of material, perform tests for each soils class in accordance to the following standards:
1. Soils Class A and C:
a. ASTM c88
b. ASTMC131 (for coarse aggregates smaller than 1½-inches)
c. ASTMC136
d. ASTM C535 (for coarse aggregates 1¼-inches and larger)
e. ASTM Cl 17 (use when aggregate contains materials finer than No. 200 sieve)
2. Soils Class B:
a. ASTMC88
b. ASTM C117 (use when aggregate contains materials finer than No. 200 sieve)
c. ASTMC136
d. ASTM C535 (for coarse aggregates 1 ¼-Inches and larger)
3. Soils Class D:
a. ASTM Cl 17
b. ASTMC136
c. ASTMD1241
d. ASTMD2487
4. Soils Class E:
a. ASTM C136 (test when gravel content is present)
b. ASTM D422
c. ASTM D1140
d. ASTM D2216
e. ASTM D4318
5. Soils Class F:
a. ASTM D2487
6. Soils Class G:
a. ASTM D2487

B. In addition to the above, furnish a soil analysis of Soil Class F:
1. Analyze for the following:
a. pH
b. Phosphorus
c. Potassium
d. Soluble Salts
e. Calcium
f. Magnesium

C. Source sample all soils and aggregates in accordance with ASTM D75.

D. Perform one acceptable test for each type of material at each source. More frequent testing may be required per the construction quality assurance document. Contractor shall perform the maximum amount of testing where specified.

E. For Iowa DOT materials complete all tests as required by Iowa DOT Standard Specifications and submit to Engineer.

PART 3 EXECUTION

3.1 APPLICATION

A. Use the soil classification as specified or stated on Drawings.

B. Place material in accordance with the Drawings and appropriate specification sections for the type of work being performed.

C. If material is not specified on Drawings, submit appropriate recommended material gradation to Engineer.

END OF SECTION

SECTION 31 05 19.13

GEOTEXTILE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Geotextile for earthwork road base.
2. Geotextile for riprap underlining

1.2 REFERENCE STANDARDS

A. Section 01 40 00 - Quality Requirements: Requirements for references.

B. Definitions:
1. AOS: Apparent Opening Size.
2. Geotextile: Synthetic fabric for use in geotechnical filter, separation, stabilization, or erosion control applications.
3. Minimum Average Roll Value: Average value for a specified parameter less 2 standard deviations.

C. American Society for Testing and Materials (ASTM):
1. D4355 - Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon Arc Type Apparatus).
2. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
3. D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
4. D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.
6. D4873 - Standard Guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples.
7. D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.

1.3 PROGRESS SUBMITTALS

A. Section 01 30 00 - Administrative Requirements: Requirements for progress submittals.

B. Product Data: Submit no later than 10 days prior to ordering.

C. Manufacturer's Installation Instructions: Submit at least 14 days prior to installation. Include installation, handling, storage, and repair instructions.

D. Manufacturer's Certificates:
1. Certificates pertaining to the rolls of material delivered to the Site shall accompany the rolls. Each roll shall be identified by a unique manufacturing number.
2. The quality control certificate shall include results of at least the following tests:

a. Unit weight
b. Tensile strength
c. Elongation at break
d. Mullen Burst strength
e. Puncture strength
f. Permittivity
g. Apparent opening size
h. Ultraviolet stability
i. Manufacturer's records for storage, handling, and shipping of geotextile

3. The quality control certificates shall be signed by a responsible party employed by the manufacturer and shall be notarized.
4. Materials and rolls which are in non-compliance with the minimum required properties will be rejected.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver geotextile bearing manufacturer's seals and labels intact. Clearly label each roll to show geotextile identification, date of manufacture, lot number, analysis of contents, and special instructions.

C. Store and handle geotextile in accordance with manufacturer's recommendations and ASTM D4873, in manufacturer's original covers, and protect from moisture, dust, light, and heat.

D. Notify ENGINEER 3 days in advance of delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of geotextile or of the entire geotextile roll at the discretion of ENGINEER. Remove roll from the Site and replace with new material.

PART 2 PRODUCTS

2.1 GEOTEXTILE

A. General:
1. Rot-proof, mildew-proof, and not subject to attack by insects or rodents.
2. One hundred percent polypropylene.
3. Capable of retaining its structure during handling, placement, and long-term service.

B. Geotextile for earthwork road and crushed stone base where noted on Drawings.
1. The non-woven needle punched geotextile specified herein shall be made from staple fiber.
2. The geotextile shall be manufactured from prime quality virgin polymer.
3. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from sun for up to 30 days without any noticeable effect on index or performance properties.
4. Geotextile shall meet or exceed all material properties listed in Table 2.1.

Table 2.1 10 oz/yd Geotextile

Property	Units	Test Method	Value
Unit Weight	ounce per sq yd	ASTM D5261	10
Ultra Violet Degradation	percent retained/number of hours	ASTM 4355	[70/500]
Grab Tensile Strength	pound	ASTM 4632	260
Grab Elongation	%	ASTM 4632	50
CBR Puncture Strength	pound	ASTM D6241	725
Permittivity	sec^{-1}	ASTM D4491	1.0
Water Flow Rate	$gal/min/ft^2$	ASTM 4491	75
Trapezoidal Tear Strength	pound	ASTM D4533	100
Apparent Opening Size (AOS)	U.S. Standard Sieve Size (mm)	ASTM D4751	100 (0.150)

C. Geotextile for riprap underlayment where noted on Drawings.
   1. The non-woven needle punched geotextile specified herein shall be made from staple fiber.
   2. The geotextile shall be manufactured from prime quality virgin polymer.
   3. The geotextile shall be able to withstand direct exposure to ultraviolet radiation from sun for up to 30 days without any noticeable effect on index or performance properties.
   4. Geotextile shall meet or exceed all material properties listed in Table 2.2.

Table 2.2 8 oz/yd Geotextile

Property	Units	Test Method	Value
Unit Weight	ounce per sq yd	ASTM D5261	8
Ultra Violet Degradation	percent retained/number of hours	ASTM 4355	[70/500]
Grab Tensile Strength	pound	ASTM 4632	205
Grab Elongation	%	ASTM 4632	50
CBR Puncture Strength	pound	ASTM D6241	535
Permittivity	sec^{-1}	ASTM D4491	1.0
Water Flow Rate	$gal/min/ft^2$	ASTM 4491	90
Trapezoidal Tear Strength	pound	ASTM D4533	85
Apparent Opening Size (AOS)	U.S. Standard Sieve Size (mm)	ASTM D4751	80 (0.180)

2.2 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Requirements for source testing and analysis of geotextile.

B. All rolls of the geotextile shall be identified with permanent marking on the roll or packaging, with the manufacturers name, product identification, roll number and roll dimensions.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution Requirements: Verification of existing conditions before starting work.

B. Verify that surfaces and the Site conditions are ready to receive work.

3.2 PREPARATION

A. Prior to geotextile placement, provide the necessary equipment and personnel to maintain an acceptable supporting surface during fabric installation.

B. Examine geotextile for defects including rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or handling.

C. Remove defective or damaged geotextile from the Site.

3.3 INSTALLATION

A. Notify ENGINEER at least 24 hours in advance of intention to commence placement of geotextile.

B. Do not permit placement of overlay materials until ENGINEER has inspected and approved installation of geotextile.

C. Obtain approval of ENGINEER prior to installation of geotextile.

D. Place the geotextile on a prepared base in locations as indicated on the Drawings.

E. Unfold or unroll geotextile in accordance with manufacturer's instructions, directly on the prepared base, in conditions which will prevent damage to both the geotextile and the base grade. Unsuitable conditions include, but are not limited to, moderate to high wind conditions.

F. Overlap dimensions and the method of joining adjacent sheets shall, as a minimum, be in conformance with manufacturer's instructions. Secure geotextile to the base grade in accordance with manufacturer's instructions and as shown on the Drawings.

G. During placement of geotextile, do not entrap stones in the geotextile.

H. Position and deploy geotextile to minimize handling. Lay smooth and free of tension, stress, folds, or creases. Protect properly placed geotextile from displacement, contamination by surface runoff, or damage, until and during placement of overlaid materials.

I. Place geotextile on sloping surfaces in one continuous length.

J. Do not permit passage of vehicular traffic directly on geotextile at any time.

K. Place geotextile by unrolling onto graded surface and retain in position as specified.

L. Remove and replace damaged or deteriorated geotextile as directed by ENGINEER.

3.4 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspection and testing.

B. ENGINEER will inspect geotextile in place for tears, overlaps, and consistency before placing materials thereon. Damaged sections, as judged by ENGINEER, will be marked and their removal from the work area recorded. Repair minor damage and minor defects as specified in manufacturer's procedures when approved by ENGINEER to ENGINEER's satisfaction.

C. ENGINEER will verify that weather conditions (air temperature, non-excessive wind, and lack of precipitation) are acceptable for panel placement.

END OF SECTION

SECTION 31 05 19.26

DRAINAGE GEOCOMPOSITE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Drainage geocomposite for Cell 4.

B. Related Requirements:
1. 31 35 26.16 Geomembrane Containment Barriers
2. 31 05 16 Aggregates for Earthwork

1.2 REFERENCES

A. Reference Standards:
1. ASTM International:
a. ASTM D1505 - Standard Test Method for Density of Plastics by the Density -Gradient Technique.
b. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
c. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
d. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
e. ASTM D4716 - Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
f. ASTM D4751 - Standard Test Methods for Determining Apparent Opening Size of a Geotextile.
g. ASTM D4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
h. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
i. ASTM D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
j. ASTM D7005 Test Method for Determining the Bond Strength - (Ply Adhesion) of Geocomposite.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit no later than 14 days prior to delivery to the Site. Include installation, handling, storage, and repair instructions.

C. Layout Drawings: Provide drawings of the proposed drainage geocomposite placement pattern and field seams no later than 14 days prior to installation. Indicate panel configuration and location of seams.

D. Manufacturer's Certificates:
   1. Certificates pertaining to the rolls of material delivered to the Site shall accompany the rolls. Each roll shall be identified by a unique manufacturing number and shall reference the specific rolls of geotextile fabric and gridded HDPE geonet incorporated into the drainage net construction.
   2. Include test data for all parameters specified in PART 2.
   3. The quality control certificates shall be signed by a responsible party employed by drainage geocomposite manufacturer and shall be notarized.
   4. Certificates pertaining to raw materials and manufactured drainage geocomposite rolls shall be provided from drainage geocomposite manufacturer. ENGINEER will review the test results for completeness and for compliance with the required minimum properties for both the raw materials and manufactured drainage geocomposite rolls. Materials and rolls which are in non-compliance with the minimum required properties will be rejected.
   5. Manufacturer’s information shall be complete for determining conformance according to ASTM D4759.

E. Manufacturer's Instructions: Submit manufacturer's installation instructions no later than 14 days prior to installation.

F. Interface Shear Test Reports: Submit no later than 14 days prior to shipping.

G. Transmissivity Testing Reports: Submit no later than 14 days prior to shipping.

1.4 STORAGE, AND HANDLING

A. When transported to the Site, handle drainage geocomposite rolls or blankets according to manufacturer's instructions so that no damage is caused.

B. Protect drainage geocomposite from direct sunlight and heat to prevent degradation of drainage geocomposite material and adhesion of individual whorls of a roll or layers of blanket.

C. Take adequate measures to keep drainage geocomposite materials away from possible deteriorating sources.

D. Use handling equipment approved by manufacturer when moving rolled or folded drainage geocomposite from one place to another.

1.5 AMBIENT CONDITIONS

A. Install drainage geocomposite according to manufacturer's installation instructions.

B. Suspend installation operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing drainage geocomposite to the requirements of this Section.

C. Weather Conditions for Seaming: Comply with manufacturer's installation instructions.

PART 2 PRODUCTS

2.1 GENERAL

A. The geocomposite shall consist of an HDPE drainage net, with extruded or formed high density polyethylene rods, with non-woven or hybrid monolithic woven-nonwoven needle punched geotextile bonded to each side.

B. The Geotextiles shall be insect, rodent, mildew and rot resistant.

C. The drainage net shall be UV stabilized with carbon black.

D. The Contractor shall furnish the Engineer at the time of delivery of the geocomposite a manufacturer's Certificate of Compliance that the geocomposite furnished meets the requirements.

2.2 GEOTEXTILE FABRIC

A. The fabric shall comply with the following physical properties:

Test	Method	Value[1]
Mass Per Unit Area	ASTM D5261	480 g/m^2
Grab Strength	ASTM D4632	890 N
CBR Puncture Strength	ASTM D241	3,447 N
Apparent Opening Size (U.S. Standard Sieve)	ASTM D4751	170
Permittivity	ASTM D4491	0.3 sec
Water Flow Rate	ASTM D4491	814 liters/minute/m^2

Note:
1 – Numerical values represent minimum/maximum average roll values.

2.3 GEONET

A. The geonet shall comply with the following minimum physical properties:

Test	Method	Value
Thickness	ASTM D5199	7.6 mm
Density	ASTM D1505	0.94 g/cm^3
Carbon Black Content	ASTM D4218	2.0%

2.4 GEOCOMPOSITE

A. The geocomposite, (fabric and geonet) shall comply with the following minimum physical properties:

Test	Method	Value
Transmissivity[1]	ASTM D4716	9x10^{-4} m^2/sec
Ply Adhesion	ASTM D7005	89 g/cm
Note: 1 – Gradient of 0.1, load of 10,000 psf, water at 70°F between two steel plants		

2.5 APPROVED PRODUCTS

A. GSE Coal Drain

B. Engineer Approved Equivalent

PART 3 EXECUTION

3.1 GEOCOMPOSITE

A. Prior to placement of the geocomposite, the HDPE liner shall be shaped to required grade with no wrinkles. After the material has been placed, no vehicles will be permitted to travel directly on the geocomposite.

B. The geocomposite shall be rolled out and pulled taut manually to remove wrinkles. Care shall be used when applying the geocomposite to the HDPE to prevent damage to the geocomposite.

C. After placement, the geocomposite shall be exposed to no longer than 7 days prior to covering.

D. Damage areas shall be repaired by removing the damaged area and replacing it with an undamaged piece of geocomposite.

3.2 JOINING SPECIFICATIONS

A. All geonet overlaps shall be joined using light colored fasteners, cord, or polymer braid, unless other fasteners are approved by the Engineer. The joining devices shall not include any metal components and shall have a rated tensile strength greater than or equal to 50 pounds. The devices shall be located in approximately the center of the overlap area. Unless otherwise approved by the Engineer, all joining devices, when installed, shall encompass more than a single strand of each of the overlapped geocomposite panels.

B. All geocomposite panels shall be joined with a side-to-side overlap of nominally four inches. The tie spacing for side-to-side panel overlaps shall consist of a minimum of one row of ties placed on nominally five foot centers along areas of constant grade. In areas of sudden grade change, [nonunally greater than twenty percent difference] the tie spacing shall be reduced to nominally two foot centers.

C. On nearly horizontal surfaces [grades of ten percent or less] geocomposite panels shall be joined with an end-to-end overlap of at least six inches and shall be secured with a minimum one row of ties on one foot centers.

D. Geocomposite panels placed on slopes greater than to ten percent shall have no end-to-end overlaps along the slope length.

E. Geotextile materials shall be sewn with thread as strong as the fabric for the full length. The sewn areas shall then be heat tacked to provide for a smooth surface for placement of other materials on the geocomposite.

F. Geocomposite shall be placed alongside slope comers in an alternating pattern. The comer tie-in shall be secured with a minimum of one row of ties spaced at one foot centers. If necessary, an additional, uncut, full width panel shall be placed down the centerline of the comer and overlapping the staggered end edges or in an equivalent manner as determined by the Engineer. The edges of the overlying comer panel shall be secured with a minimum of one row of ties placed on nominally five foot centers.

END OF SECTION

SECTION 31 20 00

EARTHWORK

PART 1 GENERAL

1.1 SUMMARY

A. The work under this section shall consist of providing all work, materials, labor, equipment, and supervision necessary to complete earthwork required in these specifications and on the drawings. Included are the following topics:
   1. Cutting, grading, filling, rough contouring, compacting, and smooth rolling fill and cohesive soils.
   2. Pipe trenching.
   3. Grading soil and CCR materials.
   4. Procurement of materials not available on Site.
   5. Materials testing.
   6. Placement and grading of compacted clay and/or cohesive soil to meet grades shown on design drawings.
   7. Excavating, trenching, backfilling, and compacting for stormwater sewer piping and structures.

B. Related Requirements:
   1. Section 31 23 16.13 – Trenching
   2. Section 31 35 26.16 – Geomembrane Containment Barriers
   3. Section 33 05 13.19 – Manholes and Structures
   4. Section 33 41 00 – Storm Utility Drainage Piping

1.2 REFERENCES

A. Iowa Department of Transportation (Iowa DOT) Standard Specifications for Highway and Bridge Construction, Series 2015 October 18, 2016.

B. Definitions:
   1. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.

1.3 REFERENCE STANDARDS

A. Section 01 40 00 - Quality Requirements: Requirements for references.

B. ASTM International:
   1. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   3. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   4. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.

5. C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
6. D422 - Standard Test Method for Particle-Size Analysis of Soils.
7. D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
8. D2434 - Standard Test Method for Hydraulic conductivity of Granular Soils (Constant Head).
9. D2487 - Standard Classification of Soils For Engineering Purposes (Unified Soil Classification System).
10. D2922 - Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
11. D2974 – Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils.
12. D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
13. D4972 - Standard Test Method for pH of Soils.
14. D5084 - Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.4 SEQUENCING

A. Section 01 10 00 - Summary: Requirements for sequencing.

B. Coordinate interruptions of utility services to existing facilities which become necessary either directly or indirectly due to work required under the Contract, through ENGINEER. Down time duration and time (weekend, nights, or holidays) for service disruptions may be limited. Perform work of this Section during scheduled times.

C. Coordinate and sequence excavation operations to minimize temporary stockpiling of excavated materials until required for backfilling. Make every effort to balance cut and fill operations and ensure excavated material designated for backfill is immediately placed in the Works. Minimize time excavations remain open.

1.5 SCHEDULING

A. Section 01 30 00 - Administrative Requirements. Requirements for scheduling.

B. Do not allow or cause work performed to be covered up or enclosed prior to required inspections, tests, or approvals.

C. Sampling Data: Submit data at least 7 days prior to commencing transport of material tested from borrow source to the Site.
   1. Soil Materials:
      a. Perform required sampling and analyses as specified in Part 2.5 of this Section and requirements included in Part 1.6 of this Section.

1.6 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Design Data: Provide a proposed schedule of service disruptions to utilities no later than 3 weeks prior to proposed date of disruption. ENGINEER will review schedule with OWNER and respond within 7 days.

C. Materials Source: All material source property shall be investigated for ecological and cultural resources prior to utilization as a borrow source. Approval of the borrow sources shall be required prior to construction start date.
   1. CONTRACTOR shall identify suitable borrow sources, subject to OWNER review and approval. Commercial borrow sources are expected to be acceptable.
   2. OWNER has identified the following borrow sources which are expected to meet project requirements, subject to verification by CONTRACTOR:
      a. Soil Type S2. Acme Materials, 2544 Pettibone Avenue, Muscatine, Iowa 52761. 563-263-1105.
      b. Soil Type S4. Scott Area Landfill, 11555 110th Avenue, Davenport, Iowa 52804. 563-381-1300.

D. Geotechnical Data. Submit geotechnical data in accordance with Section 2.4 testing requirements at least 7 days prior to commencing transport of earthen materials and aggregate to the Site.

E. Analytical Results: Submit chemical analytical results for each imported fill material at least 7 days prior to commencing transport to the Site.

F. Test Reports: Submit test reports certifying compliance with specified requirements at least 7 days prior to commencing transport to the Site.

G. Samples: Submit 100-pound sample of each type of imported fill material in airtight bag or container.

H. Topsoil nutrient analyses: Submit 100 pound sample of each topsoil source in airtight bag or container.
   1. Submit nutrient content testing results as required in Part 2.5 at least 14 days prior to commencing transport to the Site.

I. Suppliers' Certificates: Submit certificate indicating that each type of imported fill material meets or exceeds specified requirements.

J. Field Quality Control: Submit field data on same day testing performed. Submit laboratory data within 24 hours of completion of test.

K. Qualification Statements:
   1. Independent Geotechnical Testing Firm: At least 14 days prior to commencing transport of soil materials to the Site, submit name and qualifications of independent geotechnical testing firm to provide geotechnical testing services for work of this Section.
   2. Independent Analytical Laboratory: At least 14 days prior to commencing transport of soil or aggregate materials to the Site, submit name and qualifications of independent testing laboratory to provide chemical analysis for work of this Section.

L. Certificates: Certify that products meet or exceed specified requirements.

M. Independent Geotechnical and Analytical Testing Firm: At least 14 days prior to commencing transport of aggregate materials to the Site, submit the name and qualifications of the independent testing firm proposed by CONTRACTOR to provide testing services for work of this Section.

N. Material Source Certification: If fill materials will be obtained from a state certified quarry, chemical characterization specified in Part 2.5 may not be required. CONTRACTOR shall be responsible to submit to ENGINEER documentation related to the quarry operations, that includes but is not limited to the following:
1. State certification.
2. Source location and address.
3. Owner's name and state permit/licensing number.
4. Reports of testing in accordance with specified standards, evidencing compliance with specified requirements.
5. Historical report information pertaining to the quarry certification.
6. Source Quality Assurance Plan identifying sampling procedures, sample network, analytical procedures, and analytical laboratory.
7. Statement from the source declaring there is no contamination in the fill materials proposed for the Project, and providing evidence that the source is clean if excavated from the earth. Fill materials will be considered uncontaminated if chemical analysis have been completed by a state-certified laboratory for parameters specified in Part 2.5 and the most recent test results for every earthen fill material proposed for the Project show that every earthen fill material is at or below natural background levels for the region.

1.7 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

B. Materials source control test results and all field quality control test reports.

C. Project Record Documents: Record location of pipes runs, roadways, structures, connections, catch basins, cleanouts, control points, and invert elevations; identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities. Survey roadways at centerline and road edges at each 100 linear feet. Survey piping each 100 linear feet along pipeline, at each change in pipeline alignment and ends of piping.

1.8 QUALITY ASSURANCE

A. All materials, procedures, operations and methods shall be in strict conformance with the Drawings and Specifications and shall be subjected to strict quality control monitoring as detailed herein.

B. The ENGINEER shall conduct sampling, testing, and analysis, as required by this section and elsewhere in the Contract Documents, either by retaining the services of an independent construction materials testing consultant or with internal certified testers. The materials testing personnel shall meet the requirements of ASTM E329.

C. The ENGINEER’s construction materials testing personnel shall complete material testing as outlined in Part 2.1 MATERIALS.

D. Perform work outside of the above, and in this Section in accordance with State of Iowa standards.

1.9 QUALIFICATIONS

A. Geotechnical Testing Firm: Company specializing in performing work of this Section and complying with ASTM D3740 to perform testing of fill materials including density, moisture content, permeability, and particle size analysis for both soil and aggregate samples.

B. Independent Testing Laboratory: Company specializing in performing work of this Section to perform chemical analysis of fill material samples for parameters specified in PART 2.5 SOURCE QUALITY CONTROL.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver, handle, and transport fill materials in a manner and with equipment that will prevent intermixing of soil or aggregate materials and prevent contamination.

1.11 QUANTITIES

A. Finished depths of materials are shown on the Drawings. Excavation depths will be determined by presence of liner materials and verification that all liner materials have been excavated and removed. Soil material layers shall be filled to elevations as shown on the Drawings.

B. CONTRACTOR shall be solely responsible for determining all earthwork quantities based on the existing and proposed elevations provided on the drawings. Any geotechnical investigations provided by the OWNER apply only to those locations that the data was collected, and may not be indicative of conditions elsewhere on the site. The CONTRACTOR is responsible for collecting any additional geotechnical or survey data he deems necessary to complete an accurate estimate of earthwork quantities.

C. If onsite grading, excavation and borrow operations do not provide enough suitable material for fill areas, CONTRACTOR shall coordinate and pay for excavation, transport and placement of imported material meeting the specifications of the contract documents. If excavation results in excess materials, CONTRACTOR shall coordinate and pay for loading, transport and offsite disposal of excess materials.

D. CONTRACTOR shall notify the ENGINEER immediately if geotechnical information, existing grades, or proposed grades shown on the drawings appears to be inaccurate.

PART 2 PRODUCTS

2.1 MATERIALS

A. Imported from the OWNER's pre-approved source if existing soils are unsuitable or more soils are needed with the approval of ENGINEER.

B. Free of unsuitable materials including:
1. Frozen material or material containing snow or ice.
2. Concrete or crushed concrete or other recycled materials unless specifically approved of by OWNER or ENGINEER.
3. Trees, stumps, branches, roots, or other wood or lumber.
4. Wire, steel, cast iron, cans, drums, or other foreign material.
5. Materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

C. Compactable to specified density at specified moisture content.

2.2 SOIL MATERIALS

A. All materials shall be tested prior to use on site and shall meet or exceed the requirements of this Section.

B. AGGREGATE
1. New Stormwater Pipe Bedding – Type A1:
a. Crushed Stone, Graded, Washed.
b. Gradation: Meet the requirements for Gradation No. 3 of the Iowa DOT Aggregate Gradation Table:

Size	% Passing
1 ½"	100
1"	95-100
½"	25-60
No. 4	0-10

c. Quality: The requirements of Coarse Aggregate Quality virgin aggregates: Coarse Aggregate Quality (Virgin Material)

Coarse Aggregate Quality	Maximum Percentage Allowed	Test Method
Abrasion	50	AASHTO T 96

d. Free of organic matter.
e. Uniformity Coefficient of less than 6.
2. Macadam Crushed Stone for Road Base – Type A2
a. IDOT 4122.02.
b. Free of organic matter.
3. 3/4-inch Crushed Stone for Surface Course – Type A3
a. IDOT 4122.02.
b. Free of organic matter.
4. Excavated and regraded CCR bottom ash materials – Type A4:
a. Existing materials stockpiled in the Bottom Ash Impoundment. Grain size analysis indicates variability within bottom ash.
b. CCR mixed with materials excavated from sideslopes or from areas within Bottom Ash Impoundment.

c. CCR materials shall be placed and compacted when uniformly moist.

C. SOILS

1. Excavated soils excavated from Trench suitable for reuse – Type S1:
   a. Existing excavated soils to be placed within the stormwater sewer trench after pipe bedding, pipe are placed according the DRAWINGS.
   b. Backfill shall be placed and compacted when uniformly moist.
   c. If imported material should be required for trench backfill, native sands similar to existing soils excavated should be brought onsite.

2.3 FILL

A. Buffer Zone Material – Type S2

1. Clean imported granular material, not crushed.
2. The material shall contain no angular particles and not more than 30 subangular particles as defined by ASTM D2488. Crushing or other methods which result in sharp edges shall not be used.
3. Iowa DOT Class III materials defined as classified as Coarse-grained soils, borderline clean with fines ASTM D2487 classification of GW-GC, SP-SM:

Size/Sieve Size	% Passing
½"	100
No. 4	Varies
No. 200	10-20

4. Substitutions that are compactable to form a solid base for the LLDPE liner will be considered.

B. Rooting Zone Fill – Type S3

1. Clean imported soil material utilized as fill material as the rooting zone material in the final cover system as shown on the Drawings.
2. Iowa DOT Class II, Class III or Class IVa materials classified as Coarse-grained soils, borderline clean with fines ASTM D2487 classification of GW-GC, SP-SM, SM. These soils should only be inorganic and low plasticity soil materials.

Size/Sieve Size	% Passing
1 ½"	100
No. 4	Varies
No. 200	5-50

C. Cohesive Fill – Type S4:

1. Imported soil materials with cohesive characteristics, and meet all of the following requirements for use in backfill areas along sideslopes:
   a. 45% or less silt size fraction. Silt size particles are 0.074 to 0.002 mm.
   b. 110 pounds per cubic foot or greater density (AASHTO T 99 Proctor Density).
   c. Plasticity index greater than 10.
   1) A-6 or A-7-6 soils of glacial origin.
   2) Hydraulic Conductivity of 1 x 10^{-5} cm/s or lower.

D. Structural Fill – Type S4(a)

1. Imported soil materials with cohesive characteristics, and meet all of the below listed requirements. This material is similar to cohesive soils (S4,) however, no hydraulic conductivity testing is required.
   a. 45% or less silt size fraction. Silt size particles are 110 pounds per cubic foot or greater density (AASHTO T 99 Proctor Density).

b. Plasticity index greater than 10.
c. A-6 or A-7-6 soils of glacial origin.

E. Topsoil – Type S5
1. Remove topsoil (if present) from borrows, cuts, or areas to be excavated or filled. After existing sod has been prepared, remove the topsoil to the depth specified. If not otherwise specified, the depth shall be 6 inches (0.3 m) on flat slopes (less than 5%) and 12 inches on sideslopes greater than 5%. The topsoil may be moved directly to an area where it will be used or may be stockpiled for future use.
2. Imported Topsoil:
a. Organic soils. Class V materials are further described below:

Size	% Passing
3/8”	100
No. 4	90-100
No. 30	20-40

b. pH and organic material shall fall within the ranges stated in Source Control.
c. Use imported topsoil as indicated on the Drawings, unless specified otherwise or allowed by the ENGINEER.
d. Do not use in the pipe embedment zone.

2.4 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing, inspection, and analysis requirements.

B. Testing and Analysis of each source or material type for Cohesive Soil Type S4:
1. For Every 2,500 CY, the following tests will be performed by CONTRACTOR:
a. Particle Size Analysis, ASTM D422.
b. Density/moisture content, ASTM D6938
c. Standard Proctor ASTM D698.
d. Hydraulic conductivity, ASTM D5084.
e. Atterberg Limits – LL, PL and PI, ASTM D4318.

C. Testing and Analysis of each source or material type for Structural Fill Soil Type S4(a):
1. For Every 2,500 CY, the following tests will be performed by CONTRACTOR:
a. Particle Size Analysis, ASTM D422.
b. Standard Proctor ASTM D698.
c. Atterberg Limits – LL, PL and PI, ASTM D4318.

D. Testing and Analysis of Topsoil Type S5:
1. For Every 5,000 CY, the following testing will be performed by the CONTRACTOR:
a. Grain Size, ASTM D422:

Sieve	Percent Passing
1”	100
1/2”	95 to 97
1/4”	40 to 60
No. 100	40 to 60
No. 200	10 to 30

b. pH, ASTM D4972: between 6.0 and 8.0.
c. Organic Matter, ASTM D2974: between 5-12 percent.
d. Phosphorus, Potassium, Calcium, and Magnesium, in accordance with State-Accredited Method.

E. Testing and Analysis of Aggregate Type A1:
1. Grain Size, ASTM C117 and ASTM C136: One sample per 5,000 CY of material required showing 15 percent or less silt and clay.

F. If tests indicate materials do not meet specified requirements, change material or material source and ENGINEER will retest.

G. Provide materials of each type from the same source throughout the Works.

H. In the event of changes to approved sources of materials during performance of the Works, immediately advise ENGINEER of revised locations and obtain ENGINEER’s approval of such locations and materials prior to use in the Works.

I. Acceptance of material at source does not preclude future rejection if it fails to conform to requirements specified, lacks uniformity, or if its field performance is found to be unsatisfactory.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Verification of existing conditions before starting work.

B. Verify that survey bench marks and intended elevations for the Works are as shown on the Drawings.

3.2 PREPARATION

A. Locate, identify, and protect utilities that remain from damage. Confirm locations of buried utilities and structures by careful test excavations or other suitable means. Provide support for aboveground utility poles and lines.

B. Identify required lines, levels, contours, and datum.

C. Notify ENGINEER of unexpected subsurface conditions and discontinue affected work in area until notified by ENGINEER to resume work.

D. Maintain and protect existing utilities designated to remain.

E. Obtain direction from ENGINEER before moving or otherwise disturbing utilities or structures.

F. Protect plant life, lawns, and other features remaining as portion of final landscaping.

G. Protect benchmarks, survey control points, hydrants, existing structures, fences, paving, and curbs from excavating equipment and vehicular traffic.

H. Maintain and protect from damage wells, utilities, and structures encountered. In event of disturbance or damage to well, utility, or structure, immediately notify ENGINEER. Repair or replace well, utility, or structure damaged by CONTRACTOR operations.

I. Protect monitoring wells and other structures and pipelines from uplift and displacement or disturbance during excavation operations.

J. Protect existing structures where temporary unbalanced earth pressures may develop on walls or other structures utilizing bracing, shoring, or other approved method to counteract unbalance.

K. Protect excavations and trenches from contamination.

L. Employ procedures for excavation and trenching that avoid disturbance of utilities and structures.

M. Remove surface features or obstructions including, but not necessarily limited to, trees, shrubs, bush, and other vegetation from surfaces to be excavated, as required to construct the Works. Dispose of such obstructions as directed by ENGINEER. Trees of 4 inches or greater diameter at breast height (dbh) shall not be removed without prior approval of OWNER and ENGINEER.

3.3 EXCAVATING

A. Excavate riprap, sand, clay liner and subgrade from areas designated and shown on the Drawings. Care shall be exercised when stripping or removing soil so as to prevent over-excavation, thus minimizing compaction and placement of cohesive fill.

B. Excavate within proposed grading limits to lines, grades, and elevations shown on the Drawings.

C. Proof roll bearing surfaces. Fill soft spots with rooting clay and compact uniformly to 95 percent SMDD.

D. Correct unauthorized excavation according to Part 3.4 Over-Excavating, at no additional cost to OWNER.

E. Where excavations have been softened or eroded, remove soft and yielding material or otherwise objectionable or damaged areas and replace with fill approved by ENGINEER.

F. Load, transport and segregate excavated materials into unsuitable materials, controlled fill, general fill, and topsoil. Transport excavated materials to embankment or berm areas or to designated stockpiles.

3.4 OVER-EXCAVATING

A. Correct over-excavated areas.

B. Notify ENGINEER when soil at base of excavation appears unsuitable; proceed as directed by ENGINEER. Where, in ENGINEER's opinion, undisturbed condition of soils is inadequate to support installations, over-excavate to provide adequate supporting soils as directed by ENGINEER and refill excavated space with approved material to proper elevation, as specified for backfilling.

C. When directed by ENGINEER, and except as otherwise specified, excavation and removal of inadequate material as specified, and supply and installation of such material in excess of limits shown on the Drawings, Use over-excavated material in the Works or stockpile on Site as approved by ENGINEER.

D. Should unauthorized excavation be carried below lines and grades shown on the Drawings and in excess of specified depth and tolerance because of CONTRACTOR's operations including errors, methods of construction, or to suit its convenience, correct unauthorized excavation as follows:
   1. Fill under concrete structures with concrete.
   2. Fill under unauthorized over-excavation areas by extending indicated bottom elevation of base of material specified to be placed to unauthorized excavation bottom without altering required top elevation and compact as specified unless otherwise directed by ENGINEER.

E. Additional excavation to remove weakened or disturbed soil caused by unsuitable construction methods or procedures or to suit CONTRACTOR's convenience, and subsequent additional backfill and compaction to correct deficiencies will be at no additional cost to OWNER.

3.5 BACKFILLING

A. Obtain ENGINEER's approval for completed excavations and previously placed material prior to placement of successive lifts of fill materials.

B. Do not cause excavations to be backfilled until ENGINEER has approved excavation as complete and completed field measurements for payment purposes, and sampling and testing for quality assurance purposes.

C. Obtain ENGINEER's approval prior to placing fill against structures or around exposed buried utilities.

D. Remove debris or water from areas to be backfilled.

E. Ensure areas to be backfilled are free of debris, snow, ice, water, soft soils, organic materials, or frozen ground.

F. Proof roll subgrade surface to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

G. Cut out soft areas of subgrade not capable of compaction, in place. Backfill with approved native fill and compact to density equal to or greater than density specified for subsequent fill material.

H. Compact subgrade to density specified for subsequent backfill materials.

I. Backfill areas to contours and elevations shown on the Drawings. Use unfrozen and unsaturated materials.

J. Backfill systematically, as early as possible, to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

K. Place fill material in continuous layers and compact earth type for specified density.

L. Maintain optimum moisture content of backfill materials to attain specified compaction density.

M. Backfill around installations as follows:
   1. Place bedding and surround material as specified in this Section.
   2. Place layers simultaneously on both sides of installed work to equalize loading and minimize movement.
   3. Where temporary unbalanced earth pressures may develop on walls or other structures:
      a. Place material under, around, and over installations until 2 feet of cover is provided. Do not dump material directly on installations.

N. Remove sheeting and shoring required during excavation, during backfilling operations. Do not remove bracing until backfilling has reached level of bracing. Pull sheeting in increments to ensure compacted backfill is maintained at appropriate elevation above toe of sheeting.

O. Compact each layer to specified density before placing succeeding layers.

3.6 COMPACTION

A. Fill: As shown on the Drawings.

B. Apply potable water as necessary during compaction to obtain specified density. If material to be compacted is excessively moist, aerate with suitable equipment and method until moisture content is corrected. In areas not accessible to rolling equipment, compact material to specified density using mechanical tamper. Supply and pay for water.

C. When granular material is wetted by sprinkling, do not direct jets of water at fill with such force that finer materials will be washed out. When placing and ensuring density of pipe bedding, the material should be knifed to ensure granular material has not bridged.

D. Compaction Equipment: Use type, size, and efficiency of compaction equipment capable of achieving specified degree of compaction. When operating equipment adjacent to and immediately above structures, avoid causing damage or displacement of structure.

3.7 CCR MATERIAL PLACEMENT

A. CCR subgrade shall be constructed to the grades, slopes, and elevations shown on the Drawings.

B. For granular-sized CCR, placement shall be performed in 12-inch lifts with 7 passes of a 10,000 to 12,000 lbs. mass smooth drum vibratory roller. Moisture content of the CCR at the time of compaction shall be between 8- and 12-percent or a suitable range acceptable to and approved by the Engineer.

C. For silty sand-sized or silt-sized CCR material, (e.g., materials with 30-percent or greater passing 200 sieve) shall be placed in 6-inch lifts and compacted with 5 passes of a 10,000 to 12,000 lbs. mass smooth drum vibratory, with moisture content of the material at the time of compaction between 8- and 12-percent or a suitable range acceptable to and approved by the Engineer. The finer grained materials are expected to be found in the stockpiled CCR materials excavated from the former Reclaim Impoundment and materials excavated from side slopes of the Bottom Ash impoundment.

D. The CCR surface shall be finished with a smooth roller when finished grades are completed so that the surface is smooth to allow placement of the buffer soils.

3.8 COHESIVE SOILS PLACEMENT

A. Cohesive soils subgrade shall be constructed to the grades, slopes and elevations shown on the Drawings.

B. The cohesive soils shall be systematically placed in a compacted lift with an in place 6-inch nominal thickness (or 8-inch uncompacted layer). Work shall be performed expeditiously to ensure proper bonding, uniformity and water content.

C. The water content of the cohesive soil material shall be maintained within the required range of optimum water content, while working the material.

D. Cohesive soils shall be compacted to 95 percent of Standard Proctor.

E. Prior to compaction the cohesive soils may be mixed by disc-harrowing, if directed by the ENGINEER, or an equivalent method to achieve homogenous consistency and each lift shall be compacted to the design density at required moisture content, based on laboratory analysis to achieve the minimum required hydraulic conductivity and maintain the strength and stability of the soil. This may require more effort for some loads of soil material than others.

F. Each 6-inch lift shall be rolled in two orthogonal directions with a sheepsfoot or other appropriate roller until the specific minimum compaction is achieved or exceeded. Each lift shall have a loose pre compaction thickness of no more than 8 inches. The feet of the roller shall be no longer than the compacted thickness after compaction. The compactor shall have a minimum weight of 30,000 lbs. The soil shall be compacted with a minimum of two passes of the roller, or as specified by the ENGINEER.

G. The cohesive surface shall be finished with a smooth roller when finished grades are completed so that the surface is smooth and without indentation or depressions that encourage moisture penetration. The cohesive soil surface shall be smooth prior to placement of HDPE liner to promote full contact between the liner and cohesive soil.

H. Should rain be forecast, the surface of the cohesive soils should be smooth rolled to minimize infiltration and maximize run off. Once the material has dried sufficiently, the surface shall be roughened, or scarified with a disc, sheepsfoot or other efficient and effective means) if additional material is required to reach the design thickness.

I. The CONTRACTOR shall not place, spread or compact soil material during heavy rain or snow, high winds or while the subgrade is frozen. If work is interrupted by heavy rain, operations shall be resumed using soil material which still meets specifications for moisture and density.

J. At the end of each work day, the entire area shall be left in a state that promotes surface drainage off and away from soil barrier materials.

3.9 STRUCTURAL SOILS PLACEMENT

A. Structural soils subgrade shall be constructed to the grades, slopes and elevations shown on the Drawings.

B. The structural soils shall be systematically placed in a compacted lift with an in place 6-inch nominal thickness (or 8-inch uncompacted layer). Work shall be performed expeditiously to ensure proper bonding, uniformity and water content.

C. The water content of the structural soil material shall be maintained within the required range of optimum water content, while working the material.

D. Structural soils shall be compacted to 95 percent of Standard Proctor.

E. Prior to compaction the cohesive soils may be mixed by disc-harrowing, if directed by the ENGINEER, or an equivalent method to achieve homogenous consistency and each lift shall be compacted to the design density at required moisture content, based on laboratory analysis to achieve the minimum required hydraulic conductivity and maintain the strength and stability of the soil. This may require more effort for some loads of soil material than others.

F. Each 6-inch lift shall be rolled in two orthogonal directions with a sheepsfoot or other appropriate roller until the specific minimum compaction is achieved or exceeded. Each lift shall have a loose pre compaction thickness of no more than 8 inches. The feet of the roller shall be no longer than the compacted thickness after compaction. The compactor shall have a minimum weight of 30,000 lbs. The soil shall be compacted with a minimum of two passes of the roller, or as specified by the ENGINEER.

G. The Structural surface shall be finished with a smooth roller when finished grades are completed so that the surface is smooth and without indentation or depressions that encourage moisture penetration. The structural soil surface shall be smooth prior to placement of HDPE liner to promote full contact between the liner and cohesive soil.

H. Should rain be forecast, the surface of the structural soils should be smooth rolled to minimize infiltration and maximize run off. Once the material has dried sufficiently, the surface shall be roughened, or scarified with a disc, sheepsfoot or other efficient and effective means) if additional material is required to reach the design thickness.

I. The CONTRACTOR shall not place, spread or compact soil material during heavy rain or snow, high winds or while the subgrade is frozen. If work is interrupted by heavy rain, operations shall be resumed using soil material which still meets specifications for moisture and density.

J. At the end of each work day, the entire area shall be left in a state that promotes surface drainage off and away from soil barrier materials.

3.10 STOCKPILING

A. Stockpile materials on the Site at locations designated by ENGINEER. Obtain ENGINEER's approval for temporary stockpile locations or propose modifications in stockpile locations, prior to placing material in stockpiles.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Construct stockpile sites so that they are level, well drained, free of foreign materials, and of adequate bearing capacity to support the weight of materials to be placed thereon.

D. Provide and maintain access to stockpiles.

E. Separate differing materials with dividers or stockpile apart to prevent mixing. Stockpile excavated material separately from imported fill materials.

F. Maintain temporary stockpile slopes not steeper than 2 horizontal to 1 vertical. In no instance shall stockpiles be greater than 15 feet in height above original surrounding grade. Place hay bales or soil erosion and sediment control fencing at the base of and around each temporary stockpile to contain soil that may be washed off the stockpile.

G. Prevent intermixing of soil types or contamination.

H. Maintain area surrounding stockpiles in a neat and tidy condition and vegetated if expected not to be utilized for longer than 3 months.

3.11 STOCKPILE CLEANUP

A. Leave unused materials in neat, compact stockpile. Ensure stockpile is out of traffic ways for ongoing operations and during construction.

B. When borrow area is designated, leave area in clean and neat condition. Grade the Site surface to prevent freestanding surface water.

C. Vegetate the stockpile utilizing site appropriate seed mix after construction is complete.

D. Maintain area surrounding stockpiles in neat condition.

3.12 PLACING TOPSOIL

A. Place topsoil in areas shown on Drawings.

B. Fine grade topsoil, eliminating rough or low areas. Maintain levels, profiles, and contours of subgrade.

C. Remove large stone, roots, grass, weeds, debris, and foreign material while spreading.

D. Roll placed topsoil.

E. Leave stockpile area and the Site clean and raked, ready to receive landscaping.

3.13 ROAD AND CRUSHED STONE SURFACE CONSTRUCTION

A. Existing in-place materials shall be used to construct subgrades for roads and other graveled areas. Soil Type S4 shall be used to supplement existing materials to form the subgrade as needed.

B. Areas where roads or other graveled surfaces are to be constructed shall be cleared of all vegetation, roots, and foreign material. Do not remove trees of 4 inches or greater dbh without prior approval of OWNER and ENGINEER. If required, areas shall be excavated to blend with natural slopes and promote drainage as shown on the Drawings. The surface shall be moistened, scarified to a depth of 6 inches, and rolled or otherwise mechanically compacted to achieve 95 percent SMDD. Fill material shall be placed, spread evenly in approximately horizontal layers, and mechanically compacted to achieve 95 percent SMDD. Each layer shall be moistened or aerated, as necessary.

C. The CONTRACTOR shall place Macadam Stone base material and roadway aggregate surfacing, as shown on the Drawings, and in accordance with this Section.

D. Macadam Stone shall be spread on the prepared subgrade following placement of Geotextile Fabric as specified in Section 31 05 19.13 over the entire area to be surfaced. Placement of Macadam Stone shall be performed in such a manner as to not tear, puncture, or, in general, sacrifice the structural integrity of the underlying geotextile fabric. Macadam Stone and Roadway Aggregate shall be evenly graded to depths shown on the Drawings and as specified herein.

E. Roads shall be crowned with a 2 percent slope to the edges to promote drainage. Other crushed stone surface areas shall be graded to promote drainage.

F. Macadam Stone shall be rolled using a vibratory sheep's foot roller. Roadway Aggregate shall be rolled, using either a rubber tire or vibratory roller to achieve 95 percent SMDD.

G. All roads shall be constructed, as shown on the Drawings, to a minimum depth of 12 inches above subgrade. The staging and parking shall be constructed, as shown on the Drawings, to a minimum depth of 12 inches above subgrade.

H. The CONTRACTOR shall conduct quality control testing associated with road construction in accordance with the CQA Plan, at the CONTRACTOR's expense.

3.14 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Requirements for tolerances.

B. All soil layers shall be within 0.1 feet of specified thickness but not uniformly greater or less.

C. Top Surface of Cohesive Soil Liner: Plus 0.1 foot, after each foot or liner completion of compacted cohesive soil is placed; data shall be provided to ENGINEER to verify thicknesses, per Part 1 submittal requirements.

3.15 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting and testing.

B. CONTRACTOR will Perform in place compaction tests according to the following:
Density Tests: ASTM D6938.
Moisture Content: ASTM D6938.

C. CONTRACTOR will obtain samples for placed soils according to the following:
Hydraulic Conductivity Tests ASTM D2434 or ASTM D5084

D. Methods of Testing:
1. Maximum dry density and optimum moisture content will be determined in the field according to ASTM D6938.
2. Bulk wet density will be determined in the field according to ASTM D6938.
3. Moisture content will be determined in the field according to ASTM D6938.
4. Hydraulic conductivity will be determined according to ASTM D2434 or ASTM D5084, whichever is appropriate to the material being tested, on a representative sample compacted in the laboratory to field bulk wet density and moisture.

E. Frequency of Testing:
1. Soil Type S1:
   a. No confirmation testing required.
2. Soil Type S2:
   a. No confirmation testing required.
3. Soil Type S3:
   a. No confirmation testing required.
4. Soil Type S4:
   a. At least one in-place density and moisture for each for each 100 CY of material placed for fill. At least one test required per day S4 material is placed. More frequent testing may be required based on ENGINEER’s interpretation of results, changes in materials, weather, or changes in equipment used to achieve compaction.
   b. At least 1 in place hydraulic conductivity every 3,000 CY material placed for each material source or material type.
5. Soil Type S4(a):
   a. At least one in-place density and moisture for each for each 100 CY of material placed for fill. At least one test required per day S4(a) material is placed. More frequent testing may be required based on ENGINEER’s interpretation of results, changes in materials, weather, or changes in equipment used to achieve compaction.
6. Soil Type S5:
   a. No confirmation testing required.
7. Aggregate Type A1:
   a. A1: One grain size analysis to the #200 for each 750 feet of trench.

b. Minimum requirements for soils must meet the prequalification requirements.

8. Aggregate Type A4:
   a. Daily in situ moisture testing during placement, but prior to compaction, is required.

F. Survey
1. Survey after the excavation of the liner materials and grading of the in-place CCR will be required on a 50-foot by 50-foot grid pattern and along every grade change. The survey grid will be provided by the ENGINEER in a compatible CAD file to the CONTRACTOR. Field survey may require additional points to those provided by the ENGINEER.
2. Record location of pipes runs, roadways, structures, connections, catch basins, cleanouts, control points, and invert elevations; identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities. Survey roadways at centerline and road edges at each 100 linear feet. Survey piping each 100 linear feet along pipeline, at each change in pipeline alignment and ends of piping.

G. Failure to Meet Specified Requirements: If tests indicate that material specifications have not been achieved or cannot be obtained with equipment in use, procedures being followed, or material being incorporated, CONTRACTOR will remove and replace work and modify operations so that equipment, procedure, and material produce required results. CONTRACTOR's removal and replacement of work, resulting from material specification deficiencies, will be at no additional cost to OWNER.

H. Proof roll compacted fill surfaces under slabs on grade and around structures.

3.16 ADJUSTING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for adjusting.

B. Finish compacted soil surfaces to within tolerances included in Part 3.11 for grades shown on the Drawings but not uniformly high or low. Correct surface irregularities by loosening and adding or removing material until surface is within specified grade.

C. Leave work areas in properly graded condition, sloped as required to permit proper drainage, and free of depressions that will pond or collect water or debris and restrict flow.

3.17 CLEANING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning.

B. Clean and reinstate work areas and areas affected by equipment outside areas designated to be excavated, to specified restoration condition.

C. Upon completion of backfilling, remove excess material and debris from work areas and travel routes.

3.18 PROTECTION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protection of installed work.

B. Reshape and recompact fill subjected to vehicular traffic.

END OF SECTION

SECTION 31 23 16.13

TRENCHING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Excavating trenches for utilities.
2. Compacted fill from top of utility bedding to subgrade elevations.
3. Backfilling and compaction.

B. Related Requirements:
1. Section 03 30 00 - Concrete.
2. Section 31 20 00 - Earthwork.
3. Section 31 25 00 - Sediment and Erosion Control.
4. Section 33 05 13.19 - Manholes and Structures.
5. Section 33 41 00 - Storm Utility Drainage Piping.

1.2 REFERENCES

A. Definitions:
1. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.
2. Utility: Buried pipe, duct, conduit, or cable as applicable.

B. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. OSHA Standards and Regulations contained in Title 29, Code of Federal Regulations, Parts 1910 and 1926 (29 CFR 1910 and 1926).
3. Iowa Department of Transportation (Iowa DOT) Standard Specifications for Highway and Bridge Construction, Series 2015, October 18, 2016.
4. Recommended Standards for Wastewater Facilities, Policies for the Design, Review and Approval of Plans and Specifications, “Ten State Standards” 2014 Edition
5. American Association of State Highway and Transportation Officials:
   a. AASHTO T180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
6. ASTM International:
   a. ASTM C117 - Standard Test Method for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing.
   b. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. ASTM D422 - Standard Test Method for Particle Size Analysis of Soils.
   d. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
   e. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 µm) Sieve.
   f. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

g. ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
h. ASTM D3740 - Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
i. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
j. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
k. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 SEQUENCING

A. Section 01 10 00 - Summary: Requirements for sequencing.

B. Coordinate interruptions of utility services to existing facilities which become necessary either directly or indirectly due to work required under the Contract, through ENGINEER. Down time duration and time (weekend, nights, or holidays) for service disruptions may be limited. Perform work of this Section during scheduled times.

C. Coordinate and sequence excavation operations to minimize temporary stockpiling of excavated materials until required for backfilling. Make every effort to balance cut and fill operations and ensure excavated material designated for backfill is immediately placed in the Works. Minimize time excavations remain open.

1.4 SCHEDULING

A. Do not allow or cause work performed to be covered up or enclosed prior to required inspections, tests, or approvals.

B. Unless otherwise specified, advise ENGINEER a minimum of 72 hours in advance of excavation operations to enable ENGINEER to complete pre-excavation surveying.

1.5 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Provide required permits prior to use of sheeting, shoring, trench boxes, or other facilities used for earth support. Provide sheeting, shoring, and trench boxes designed by licensed professional engineer. Submit stamped Shop Drawings for review prior to utilization.

C. Design Data:
1. Shoring Plan and Design: Prior to commencing excavation, submit detailed Shoring Plan and Design. Include existing conditions, written procedures, schedules, design calculations, design assumptions, and design drawings. Provide plan for monitoring movement of adjacent structures and identify maximum acceptable movement of adjacent structure. Provide shoring drawings reviewed and stamped by licensed professional engineer. Provide a copy of required shoring permits.

2. Excavation Plan: Prior to mobilization to the Site, submit a detailed Excavation Plan demonstrating compliance with specified requirements and to permit ENGINEER to schedule testing and measurement activities. Include written procedures, schedules, and drawings as applicable and, at a minimum, address each of the following items:
   a. Methods and procedures to be used to perform excavation and backfilling.
   b. Sequencing and scheduling of excavation and backfilling.
   c. Sequencing and scheduling of shoring installation and removal.
   d. Sequencing and layout of access routes to and from excavation areas.
   e. Methods and procedures to be used to perform additional excavation in open excavations.
   f. Sequencing and scheduling of stockpiling operations.
   g. Anticipated crew sizes, man-hours, types of equipment, and equipment hours on a weekly basis.
   h. Cross-references to demolition, restoration, and shoring plans.
   i. Utilities to be rerouted or protected. Describe methods of rerouting and protecting.
   j. Methods of monitoring movement of adjacent structures.

D. Materials Source: All material source property shall be investigated for environmental and cultural resources as required by applicable regulations prior to utilization as a borrow source. Approval of the borrow sources shall be required prior to construction start date. All materials shall meet the criteria stated in Section 31 20 00.

E. Provide schedule of service disruptions to utilities no later than 21 days prior to proposed date of disruption. ENGINEER will review schedule with OWNER and respond within 7 days.

F. Geotechnical Data: Submit geotechnical data, if backfill materials are required, at least 7 days prior to commencing transport to the Site.
   1. Soil Materials: Submit grain size distribution curves, soil classification, density, and moisture content for each classification of imported soil material and each material source. Show average distribution and minimum and maximum variation in gradation for each grain size distribution curve.
   2. Aggregate Materials: Submit grain size distribution curves, density, and moisture content for each aggregate material. Show average distribution and minimum and maximum variation in gradation for each grain size distribution curve.

G. Analytical Results: Submit chemical analytical results for each soil material at least 7 days prior to commencing transport to the Site.

H. Test Reports: Submit test reports certifying compliance with specified requirements at least 7 days prior to commencing transport to the Site.

I. Suppliers' Certificates: Submit certificate indicating that each type of imported fill material meets or exceeds specified requirements.

J. Field Quality Control: Submit field data on same day testing is performed. Submit laboratory data within 24 hours of completion of test.

K. Qualification Statements:
   1. Independent Geotechnical Testing Firm: At least 14 days prior to commencing transport of soil materials to the Site, submit name and qualifications of independent geotechnical testing firm to provide geotechnical testing services for work of this Section.

2. Independent Analytical Laboratory: At least 14 days prior to commencing transport of soil or aggregate materials to the Site, submit name and qualifications of independent testing laboratory to provide chemical analysis for work of this Section.

L. Certificates: Certify products meet or exceed specified requirements.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

B. Record Documents: Record location of pipes runs, connections, catch basins, cleanouts, control points, and invert elevations; identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.7 QUALITY ASSURANCE

A. Perform work of this Section according to IDOT standard Section 2552 Trench Excavation and Backfill.

1.8 QUALIFICATIONS

A. Licensed Professional: Prepare Shoring Plan and Design under direct supervision of professional engineer experienced in design of work of this Section and licensed in the State of Iowa.

B. Geotechnical Testing Firm: Company specializing in performing work of this Section and complying with ASTM D3740 to perform testing of fill materials including density, moisture content, permeability, and particle size analysis for both soil and aggregate samples.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver, handle, and transport fill materials in a manner and with equipment that will prevent intermixing of soil, aggregate, segregation, or contamination.

C. Minimize stockpiling requirements. Transport material from source directly to final position where possible.

D. Stockpile fill materials in on-Site locations approved by ENGINEER.

1.10 AMBIENT CONDITIONS

A. Suspend operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing fill to the requirements of this Section.

B. Do not operate equipment on approved excavations after heavy rain until material has dried sufficiently to prevent excessive rutting.

PART 2 PRODUCTS

2.1 MATERIALS

A. Imported from approved source as discussed in Part 1.5 D of this Section.

B. Free of unsuitable materials including:
1. Frozen material or material containing snow or ice.
2. Trees, stumps, branches, roots, or other wood or lumber.
3. Wire, steel, cast iron, cans, drums, or other foreign material.
4. Materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

C. Compactable to specified density at specified moisture content.

PART 3 EXECUTION

3.1 LINES AND GRADES

A. Lay pipes to lines and grades shown on the Drawings.
1. ENGINEER and OWNER reserves right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

A. Identify required lines, levels, contours, and datum locations.

B. Locate, identify, and protect utilities designated to remain from damage. Confirm locations of buried utilities and structures by careful test excavations or other suitable means.

C. Arrange for utility company to identify utilities.

D. Protect plant life, trees, lawns, and other features remaining as portion of final landscaping.

E. Protect benchmarks, survey control points, existing structures, fences, paving, and curbs from excavating equipment and vehicular traffic.

F. Maintain and protect above and below grade utilities designated to remain.

G. Maintain and protect from damage wells, utilities, and structures encountered. In event of disturbance or damage to well, utility, or structure, immediately notify ENGINEER. Repair or replace well, utility, or structure damaged by CONTRACTOR operations.

H. Protect monitoring wells and other structures and pipelines from uplift and displacement or disturbance during excavation operations.

I. Protect existing structures where temporary unbalanced earth pressures may develop on walls or other structures utilizing bracing, shoring, or other approved method to counteract unbalance.

J. Protect excavations and trenches from contamination.

K. Employ procedures for excavation and trenching that avoid disturbance of utilities and structures.

L. Remove surface features or obstructions including, but not necessarily limited to, trees, shrubs, bush, and other vegetation from surfaces to be excavated, as required to construct the Works. Dispose of such obstructions as directed by ENGINEER.

M. Remove debris, snow, ice, water, soft soils, organic materials, or frozen ground from areas to be backfilled.

N. Scarify subgrade surface to a depth of 1 inch.

O. Compact subgrade to density requirements for subsequent backfill materials.

P. Proof roll subgrade surface to identify soft spots. Cut out soft areas of subgrade not capable of compaction in place. Backfill with approved native fill and compact to density equal to or greater than requirements for subsequent fill material.

Q. Utilize excavated material suitable for backfill prior to importing fill materials.

3.3 TRENCHING

A. Excavate subsoil required for utilities as required on Drawings.

B. Remove lumped subsoil, boulders, and rocks up of 1/6 cu yd measured by volume.

C. Do not advance open trench more than 200 feet ahead of installed pipe.

D. Cut trenches sufficiently wide to enable installation and allow inspection. Remove water or materials that interfere with work.

E. Excavate bottom of trenches maximum 2 feet wider than outside diameter of pipe.

F. Excavate trenches to depth shown on the Drawings. Provide uniform and continuous bearing and support for bedding material and utilities.

G. Do not interfere with 45-degree bearing splay of foundations where present.

H. When Project conditions permit, slope side walls of excavation starting 2 feet above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this Section.

I. When subsurface materials at bottom of trench are loose or soft, notify ENGINEER, and request instructions.

J. Cut out soft areas of subgrade not capable of compaction in place. Backfill with natural backfill or soil type (S1) and compact to density equal to or greater than requirements for subsequent backfill material.

K. Trim excavation. Remove loose matter.

L. Correct over-excavated areas with compacted backfill as specified for authorized excavation as directed by ENGINEER.

M. Stockpile excavated material in area designated on the Site according to Section 31 20 00 and as shown on the Drawings.

N. Do not disturb soil within the branch spread of trees or shrubs designated to remain. If excavating through roots, excavate by hand and cut roots with sharp axe or saw. Seal cuts with approved tree-wound dressing.

O. Open trenches are CONTRACTOR's sole responsibility.

P. Barricade excavations left open overnight.

3.4 SHEETING AND SHORING

A. Sheet, shore, and brace excavations to prevent danger to persons, structures, and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.

C. Design sheeting and shoring to be removed at completion of excavation work.

D. Repair damage caused by failure of sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

E. Repair damage to new and existing work from settlement, water or earth pressure, or other causes resulting from inadequate sheeting, shoring, or bracing.

3.5 TRENCH BEDDING AND COVER AND COMPACTION

A. Excavate pipe trenches according to Part 3.3 TRENCHING. Hand trim excavation for accurate placement of pipe to elevations shown on the Drawings.

B. Type A1: Place and compact materials in equal continuous layers not exceeding 8-inch thick loose lifts below, and 12-inch thick loose lifts above and adjacent to the pipe. Compact bedding and cover uniformly. Backfill materials should be knifed prior to pipe installation to ensure backfill materials are not bridged.

3.6 BACKFILLING

A. Backfill trenches to contours and elevations with unfrozen fill materials.

B. Existing soils: Excavate soils as shown on Drawings, from Bottom Ash Impoundment locations, grade according to design grades shown on Drawings.

C. Aggregate Type A1: Place and compact materials in equal continuous layers not exceeding 12-inch thick loose lifts.

D. Soil Type S1: Place and compact material in equal continuous layers not exceeding 8-inch loose lifts and keep materials damp to minimize dust, and maximize compaction.

E. Soil Type S4 and S4(a): Place and compact material in equal continuous layers not exceeding 8 inches loose lifts at water contents within 3 percent of optimum. Compact to 95 percent SMDD.

F. Soil Type S5: Place in equal continuous layers not exceeding 8 inch loose lifts. Do not compact.

G. Backfill against supported structures. Do not backfill against unsupported structures.

H. Backfill simultaneously on each side of unsupported foundation walls until supports are in place.

I. Make gradual grade changes. Blend slope into level areas.

J. Fill types according to Section 31 20 00. Completely use select native fill approved for backfilling before using imported fill.

K. Do not use backfill material determined unsuitable by ENGINEER.

L. Backfill around exposed utilities by placing layers simultaneously on all sides to equalize loading. Do not dump directly against monitoring wells, utilities, or foundations.

M. Do not operate heavy compaction equipment closer than 3 feet to foundations, underground utilities, or monitoring wells.

N. Backfill around installations as follows:
   1. Place bedding and surround material as specified in this Section.
   2. Place layers simultaneously on both sides of installed work to equalize loading and minimize movement.
   3. Where temporary unbalanced earth pressures may develop on walls or other structures:
      a. Permit concrete to cure for minimum 7 days or until it has sufficient strength to withstand earth and compaction pressure, and obtain ENGINEER's approval to backfill.
      b. If approved by ENGINEER, erect bracing or shoring to counteract unbalance, and leave in place until removal is approved by ENGINEER.
      c. Place material under, around, and over installations until 2 feet of cover is provided. Do not dump material directly on installations.

O. Do not backfill around or over cast-in-place concrete within 7 days of placement. Backfill after concrete has attained design strength.

P. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.

Q. Place material in continuous layers as follows:
   1. Subsoil Fill: Maximum 12 inches compacted depth.
   2. Structural Fill: Maximum 6 inches compacted depth.
   3. Granular Fill: Maximum 8 inches compacted depth.

R. Employ placement method that does not disturb or damage foundation perimeter drainage, utilities in trench, and existing pond operations.

S. Maintain optimum moisture content of fill materials to attain required compaction density.

T. Do not leave more than 50 feet of trench open at end of working day.

U. Protect open trench to prevent danger to OWNER.

3.7 COMPACTION

A. Excavated Material Suitable for Backfill: Compact to 95 percent SMDD.

B. Apply potable water as necessary during compaction to obtain specified density. If material to be compacted is excessively moist, aerate with suitable equipment and method until moisture content is corrected. In areas not accessible to rolling equipment, compact material to specified density using mechanical tamper. Supply and pay for water.

C. When granular material is wetted by sprinkling, do not direct jets of water at fill with such force that finer materials will be washed out.

D. Compaction Equipment: Use type, size, and efficiency of compaction equipment capable of achieving specified degree of compaction. When operating equipment adjacent to and immediately above structures, avoid causing damage or displacement of structure.

3.8 SHORING

A. Prior to installation of shoring, perform careful test excavations to determine exact extent of foundations to avoid damage to footings.

B. Provide shoring and bracing necessary to safely support soil to prevent movement, loss of soil, or other action that would damage existing on- and off-Site structures. Construct shoring to be rigid and able to prevent movement or damage to supported structure during excavation and following backfilling.

C. Initially install shoring to allow for additional 6 feet of excavation below excavation design limits shown on the Drawings. Install shoring as close to buildings as possible to facilitate maximum removal of contaminated soils.

D. Monitor daily movement of potentially affected on- and off-Site structures. Additional monitoring by ENGINEER does not relieve CONTRACTOR of responsibility to monitor movement, identify excessive movement, identify point at which stabilization should occur, or design and implement corrective or additional measures.

E. Horizontal or vertical movement of more than 0.1 inch of buildings (top of foundation wall) or shoring adjacent to a building is considered excessive and requires immediate stabilization including, but not limited to, backfilling until cause of excess movement is determined and new shoring design measures implemented.

F. Implement and pay for stabilization, consultation to identify and correct problem, and miscellaneous activities associated with correcting problem. Correct or pay for damage caused to a building by movement whether or not movement exceeds 0.1 inch.

3.9 TOLERANCES

A. Section 01 40 00 - Quality Requirements: Requirements for tolerances.

B. Top Surface of Backfilling Under Access Roads: Plus or minus 1 inch from required elevations.

C. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.10 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting and testing.

B. Perform laboratory material tests according to ASTM D698 and AASHTO T180.

C. Perform in place compaction tests according to the following:
   1. Density Tests: ASTM D6938.
   2. Moisture Tests: ASTM D6938.

D. When tests indicate work does not meet specified requirements, remove the work, replace, compact, and retest.

E. Frequency of Tests:
   1. Natural soils or imported Soil Type S1, every 500 linear feet for materials placed in trenches.
   2. For Soil Type S4 and S4(a), two (2) per lift in the pond for backfill.
   3. For Soil Type S4(a), for every 1000 CY placed within berms.

3.11 PROTECTION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protection of installed work.

B. Reshape and re-compact fills subjected to vehicular traffic during construction.

3.12 SCHEDULES

A. Storm and Sanitary Piping:
   1. Cover pipe and bedding with fill as shown on the Drawings.
   2. Compact uniformly to minimum 95 percent SMDD.

END OF SECTION

SECTION 31 23 19

DEWATERING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Dewatering system.
2. Surface water control system.
3. System operation and maintenance.
4. Water disposal.

B. Related Requirements:
1. Section 31 20 00 - Earthwork
2. Section 31 23 16.13 - Trenching
3. Section 31 25 00 - Sediment and Erosion Control
4. Section 33 05 13.19 - Manholes and Structures
5. Section 33 41 00 - Stormwater Utility Drainage Piping

1.2 REFERENCES

A. Definitions:
1. Dewatering: Lowering/removing wastewater, subsurface water, and stormwater from the Bottom Ash Impoundment; lowering of groundwater table as necessary and intercepting horizontal water seepage to prevent groundwater from entering excavations and reducing piezometric pressure within strata to prevent failure or heaving of excavations.
2. Surface Water Control: Removal of surface water within area of work.
3. Filtering: Prior to discharge to the Process Water Pond, all water shall be filtered as necessary to meet discharge criteria of 10 mg/L total suspended solids (TSS).

B. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. SUDAS Design Manual.
   a. Section 3010, 3.04 - Trench Excavation and Backfill, Dewatering.
3. ASTM International:
   a. ASTM C33 - Standard Specification for Concrete Aggregates.

C. Available Project Information: Subsurface Information for the CCR Surface Impoundment (Burns and McDonnell, July 2016), including boring logs and laboratory soils analyses. Existing Survey information included on Drawings.

1.3 SYSTEM DESCRIPTION

A. CONTRACTOR has sole responsibility for determining and implementing dewatering system necessary to complete the Work.

B. Provide dewatering and surface water control systems to remove all water from the monofill in preparation for closure.

C. Provide dewatering and surface water control systems to permit work to be completed on dry and stable subgrade.

D. Remove water from the monofill such that the following may be completed:
   1. Excavation of the liner materials to allow for installation of the final cover.

E. Ground conditions at pumping area will be verified prior to installation.

F. Obtain ENGINEER's prior written consent to allow a rise in water level or to shut down dewatering system.

1.4 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate work to permit the following construction operations to be completed on dry stable substrate.
   1. Grading and final cover construction specified in Section 31 20 00.
   2. Geomembrane Liner installation specified in Section 31 35 26.13.
   3. Trenching specified in Section 31 23 16.13.

C. Coordinate installation and operation of dewatering and filtering system with OWNER/ENGINEER and other CONTRACTORs. Where adjoining Contracts require installation of portions of dewatering system within limits of the Contract, coordinate with Other Contractors regarding access to the Site for installation, operation, and maintenance of the Works.

1.5 PRE-INSTALLATION MEETING

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum 1 week prior to commencing work of this Section.

1.6 SEQUENCING

A. Section 01 10 00 - Summary: Requirements for sequencing.

B. Sequence work to install and test dewatering and surface water control systems minimum seven days before starting excavation.

1.7 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Shop Drawings:
   1. Indicate dewatering and filtration system layout, dewatering pump locations, pipe sizes and capacities, grades, surface water control devices, valves, and water disposal method and location.
   2. Indicate primary power system location and capacity.
   3. Indicate flow measuring devices for system performance measurement.
   4. Indicate filtration system location, capacity.
   5. Include detailed description of dewatering, filtration, and surface water control system installation procedures and maintenance of equipment.
   6. Include description of emergency procedures to follow when problems arise.

C. Product Data: Submit data for each of the following:
   1. Dewatering Pumps: Indicate sizes, capacities, priming method, motor characteristics.
   2. Filtration equipment: Indicate media, estimated media replacement and disposal plan for filtration media.
   3. Pumping equipment for control of surface water within excavation.
   4. Pumping accessories:
      a. Hose/pipe
      b. Valves
      c. Instrumentation
      d. Control panel
      e. Any additional items necessary for the work

D. Design Data:
   1. Indicate design values, analyses, and calculations to support design.

E. Field Reports: Test reports as specified in PART 3, FIELD QUALITY CONTROL.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. CONTRACTOR to accept components on Site
   1. Delivered and unloaded with appropriate procedures and precautions protecting components and inspect for damage.

C. Products are not to be exposed to adverse weather and/or storage conditions while waiting for installation.

1.9 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for warranties.

1.10 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

1.11 QUALIFICATIONS

A. Installer: Company specializing in performing the work of this Section and responsible for design, operation, and maintenance of dewatering system.
   1. Assume sole responsibility for dewatering, filtration and surface water control systems and for loss or damage resulting from partial or complete failure of protective measures and settlement or resultant damage caused by control operations.

PART 2 PRODUCTS

2.1 PERFORMANCE CRITERIA

A. Design dewatering systems to:
   1. Dewater the Bottom Ash Impoundment as necessary to permit the Works to be completed on dry and stable subgrade.
   2. Lower water table within areas of excavation, as necessary to below bottom of excavation to permit the Works to be completed on dry and stable subgrade.
   3. Relieve hydrostatic pressures in confined water bearing strata below excavation to eliminate risk of uplift or other instability of excavation.
   4. Prevent damage to adjacent properties, buildings, structures, utilities, and facilities from construction operations.
   5. Prevent loss of fines, quick condition, or softening of foundation subgrade.
   6. Maintain stability of sides and bottoms of excavations and trenches.
   7. Discharge water must be filtered to have TSS concentrations at or below 10 mg/L. Discharge from the Bottom Ash Impoundment may be discharged to the Process Water Pond, located to the east of the Bottom Ash Impoundment, after filtration.

B. Design surface water control systems to
   1. Collect and remove surface water and seepage entering during excavation, CCR grading and cover installation.
   2. Discharge water to the Process Water Pond located to the east of the Bottom Ash Impoundment. Any water discharged to the Process Water Pond must meet the discharge concentrations identified in the NPDES permit.

2.2 DEWATERING EQUIPMENT

A. Provide Pumps for dewatering Bottom Ash Impoundment:
   1. Portable, skid mounted.
   2. Non-clog, solids handling, centrifugal type.
   3. Self-priming.
   4. Diesel engine driven. No single engine shall have 400 HP or higher. Note: maximum engine size based on air permitting requirements.
   5. Furnish pumps with screened suction hose and discharge hoses as required to suit application.
   6. Design Conditions to be determined by CONTRACTOR to achieve full dewatering of the Bottom Ash Impoundment in an expeditious manner while meeting other criteria established in this Section.

B. Provide Surface Water Control Pumps:
   1. Portable, skid mounted.

2. Non-clog, solids handling, centrifugal type.
3. Self-priming.
4. Diesel engine driven. No single engine shall have 400 HP or higher. Note: maximum engine size based on air permitting requirements.
5. Furnish pumps with screened suction hose and discharge hoses as required to suit application.
6. Design Conditions to be determined by CONTRACTOR.:
7. CONTRACTOR to have additional surface water control pumps readily available for rental/use in case of a 100 year storm event.

C. Suction and discharge pipe:
1. To be designed, furnished and installed by CONTRACTOR and approved by ENGINEER.

D. Select other dewatering equipment to meet specified performance requirements.

2.3 ACCESSORIES

A. Valves and Fittings: Furnish necessary valves and fittings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution Requirements: Verification of existing conditions before starting work.

3.2 PREPARATION

A. Protect existing adjacent buildings, structures, and improvements from damage caused by dewatering operations.

B. Intercept and direct surface water away from excavations using dikes, pipes, sumps, or other means to ENGINEER's acceptance.

3.3 DEWATERING AND FILTRATION SYSTEM

A. Install dewatering and filtration system according to the Shop Drawings. Dewater the various parts of the Works including, without limitation, excavations, structures, foundations, and work areas.

B. Employ construction methods, plant, procedures, and precautions that will ensure the Works, including excavations, are stable, free from disturbance, and dry. Locate system components to allow continuous dewatering operations without interfering with installation of permanent work and adjacent buildings, structures, and improvements.

C. Provide sufficient and appropriate labor, plant, and equipment necessary to keep the Works free of water including standby equipment necessary to ensure continuous operation of dewatering system.

D. Install pumps according to manufacturer's instructions.

E. Connect pumps to discharge header. Install valves to permit pump isolation.

F. Design and operate dewatering systems to:
   1. Remove all remaining water in the existing Bottom Ash Impoundment.

G. Flotation of Structures:
   1. Maintain groundwater at sufficiently low level to prevent damage or displacement of structures by groundwater pressures.
   2. Protect completed structures or parts of completed structures which would suffer displacement or other damage as a result of dewatering equipment failure by providing:
      a. Standby dewatering equipment, connected directly to electrical generators, engaging automatically in event of power failure.
      b. A positive means by which structures may be flooded with water to neutralize exterior hydraulic pressures.
      c. A combination of above.

H. Design and operate dewatering systems to:
   1. Prevent loss of ground as water is removed.
   2. Prevent uplift of any structure or pipeline and protect excavations from flooding and damage due to surface runoff
   3. Avoid inducing settlement or damage to existing facilities, completed work, or adjacent property.
   4. Relieve artesian pressures and resultant uplift of bottom of excavation.

I. CONTRACTOR shall be responsible for determining an appropriate pumping rate that accomplishes the specified dewatering objectives without causing detrimental impacts to the receiving water bodies, structures, or conveyances.

3.4 SURFACE WATER CONTROL SYSTEM

A. Install ditches, berms, and other devices to divert and drain surface water from excavation area.

B. Install ditches, berms, and other devices to divert and drain surface water from excavation area to direct flow from areas being dewatered to local areas where pumps can remove water from the Bottom Ash Impoundment.

C. Divert surface water and seepage water within excavation areas into sumps and pump water to filtration and into the Process Water Pond.

D. Control and remove unanticipated water seepage into excavations.

3.5 SYSTEM OPERATION AND MAINTENANCE

A. Operate dewatering system continuously until all residual water is removed from the Bottom Ash Impoundment.

B. In other areas, operate dewatering system continuously until backfilling is complete.

C. Additional dewatering may be required during excavation, filling and construction of the cover system during construction of the Works. Moving the dewatering system where dewatering is needed to maintain stable areas may be required.

D. Provide supervision of dewatering system by personnel skilled in operation, maintenance, and replacement of system components.

E. Conduct daily observation of dewatering system and monitoring system. Make required repairs and perform scheduled maintenance.

F. Fill fuel tanks before tanks reach 25 percent capacity.

G. When dewatering system cannot control water, notify ENGINEER and stop excavation work.
   1. Supplement or modify dewatering system and provide other remedial measures to control water.
   2. Demonstrate dewatering system operation complies with performance requirements before resuming operations.

H. Modify dewatering and surface water control systems when operation causes or threatens to cause damage to new construction, existing Site improvements, adjacent property, or existing conditions.

I. Correct unanticipated pressure conditions affecting dewatering system performance.

J. Do not discontinue dewatering operations without ENGINEER's approval.

3.6 WATER DISPOSAL

A. Discharge water shall be filtered and discharged into the Process Water Pond.

B. Pipe protection may be required as vehicles will require access between the process pond and the Bottom Ash Impoundment.

3.7 SYSTEM REMOVAL

A. Remove dewatering and surface water control systems after OWNER/ENGINEER approval.

B. Repair damage caused by dewatering and surface water control systems or resulting from failure of systems to protect property.

C. CONTRACTOR responsible for loading all equipment for transport and all equipment necessary to complete this task.

3.8 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting and testing.

B. After dewatering system is installed in the Bottom Ash Impoundment, perform pumping test to determine when selected pumping rate lowers water level in impoundment below pump intake. Adjust pump speed, discharge volume, or both to ensure proper operation of each pump.

C. Monitor and record the following, daily, until dewatering system is discontinued:
   1. Water elevation.
   2. Filter maintenance performed.
   3. TSS test results to ensure that discharge remains below 10 mg/L TSS.
   4. Dewatering flow rates.

END OF SECTION

SECTION 31 25 00

SEDIMENT AND EROSION CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. This WORK shall consist of temporary measures needed to control sediment, soils, and water pollution. These temporary measures shall include, but not be limited to, silt fences, berms, dikes, sediment basins, temporary sedimentation basins, gravel, mulches, grasses, and other erosion control devices or methods. These temporary measures shall be installed at the locations where needed to control erosion and water pollution during the construction of the PROJECT, and as directed by ENGINEER, and as shown on the DRAWINGS.
2. The Erosion Control Plan presented in the DRAWINGS serves as a minimum for the requirements of erosion control during construction. CONTRACTOR has the ultimate responsibility for providing adequate erosion control and water quality throughout the duration of the PROJECT.

B. Related Requirements:
1. Section 31 20 00 - Earthwork
2. Section 32 92 19 - Seeding

1.2 REFERENCES

A. Iowa Department of Transportation (Iowa DOT), Standard Specifications for Highway and Bridge Construction, Series 2015, Section 2602 Water Pollution Control (Soil Erosion).

B. Iowa Department of Natural Resources (Iowa DNR), National Pollutant Discharge Elimination System (NPDES) General Permit No. 2. Effective Dates: March 1, 2023 through February 29, 2028 for Stormwater Discharge Associated with Construction Activities.

C. Iowa DNR, General Permit No. 2 Stormwater Discharge Associated with Construction Activities Summary Guidance, December 2022

D. Definitions:
1. SMDD: Standard Maximum Dry Density and in the context of this Contract means the maximum dry unit weight determined according to ASTM D698.

E. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. ASTM International:
   a. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
   b. ASTM D1388 – Standard Test Method for Stiffness of Fabrics
   c. ASTM D2487 – Standard Test Method for Classification of Soils for Engineering Purposes.

d. ASTM D3776 – Standard Test Method for Mass Per Unit Area (Weight) of Woven Fabric
e. ASTM D4355 – Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
f. ASTM D4491 – Standard Test Method for Water Permeability of Geotextiles by Permittivity
g. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
h. ASTM D4751 – Standard Test Method for Determining Apparent Opening Size of a Geotextile
i. ASTM D5035 – Standard Test Method for Breaking Strength and Elongation of Textile Fabric (Strip Method)
j. ASTM D5338 – Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

1.3 COORDINATION

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate timing of land disturbing activities with provision of erosion control measures to reduce on-Site erosion and off-Site sedimentation.

C. Coordinate installation of temporary erosion control features with construction of permanent erosion control features to ensure effective and continuous control of erosion, pollution, and sediment deposition.

D. Provide additional erosion and sediment control to prevent erosion which may be caused due to selected construction methods.

1.4 SUBMITTALS

A. Section 01 30 00 - Administrative Requirements: Requirements for progress submittals.

B. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

C. Soil Erosion and Sediment Control Plan: Within 7 days after the date of the Notice to Proceed and prior to mobilization to the Site, submit a Soil Erosion and Sediment Control Plan. Address the following:
1. Statement of erosion control and storm water control objectives.
2. Description of temporary and permanent erosion control, storm water control, and air pollution control measures to be implemented on the Site.
3. Description of the type and frequency of maintenance activities required for the chosen erosion control methods.
4. Comparison of proposed post-development storm water runoff conditions with predevelopment conditions.

D. Excavation Plan: as specified in Section 31 23 16.13 Trenching.

E. Product Data: Submit data on items listed in Part 2 of this section. Submit no later than 14 days prior to ordering.

F. Material Source: Inform ENGINEER of proposed source of riprap and aggregate at least 14 days prior to commencing production, including any change in material source during performance of the Works.

1.5 QUALITY ASSURANCE

A. Perform work of this Section in accordance with References stated in Part 1.2 of this section.

1.6 SCHEDULING

A. Sequencing Plan:
   1. CONTRACTOR shall submit a sequencing plan for approval for erosion control in conformance with CONTRACTOR's overall Construction Plan for approval by OWNER.
   2. Changes to the Erosion Control Sequencing Plan may be considered by OWNER only if presented in writing by the CONTRACTOR.

B. Temporary Erosion Control:
   1. When so indicated in the CONTRACT DOCUMENTS, or when directed by ENGINEER, CONTRACTOR shall prepare construction schedules for accomplishing temporary erosion control WORK including all maintenance procedures.
   2. These schedules shall include clearing and grubbing, grading, structural WORK, construction, etc.

PART 2 PRODUCTS

2.1 IOWA DOT

A. Erosion Control Materials, Section 4169, Iowa DOT Standard Specifications.
   1. Mulch per Section 4169.07, Iowa DOT Standard Specifications
   2. Special Ditch Control, Turf Reinforcement Mat, Slope Protection and Outlet or Channel Scour Protection per Section 4169.10 Iowa DOT Standard Specifications.
   3. Filter Fabric per Section 4169.11, Iowa DOT Standard Specifications.
   4. Perimeter and Slope Sediment Control Devises including wattles, sediment logs and filter socks per Section 4169. 12, Iowa DOT Standard Specifications.

2.2 SILT FENCE

A. Geotextile Fabric
   1. Fabric shall be either woven or non-woven polyester, polypropylene, stabilized nylon, polyethylene or polyvinylidene chloride.
   2. Fabric shall have the minimum strength values in the weakest principal direction.
   3. Non-woven fabric may be needle punched, heat bonded, resin bonded, or combination thereof.
   4. Fabric shall meet the following requirements:

a.	Grab Tensile Strength	ASTM D4632	101 lbs. (450 N)
b.	Apparent Opening Size	ASTM D4751	0.3 mm

c.	UV Resistance Strength Retained	ASTM D4355	70 at 500 Hours (%)
d.	Permittivity (per second)	ASTM D4491	0.14

B. Support Posts
1. Wood or steel construction minimum length 4 feet.
2. Wood posts -2-inch by 2-inch or equivalent steel posts.

2.3 EROSION STABILIZATION MAT

A. General
1. Netting, if used, shall not exceed l 5% of the total blanket weight.

B. Types
1. Type A:
   a. Used for slopes 2.5:1 (H:V) or flatter (not to be used in channels).
   b. Minimum shear stress required is 1.0 pounds per square feet (lbs./ft^2) (50 Pascals [Pa]).
2. Type B:
   a. Used for slopes 2:1 or flatter or in channels when design shear stress is less than minimum shear stress of the mat used.
   b. Minimum shear stress required is 1.5 lbs./ft^2 (70 Pa).
   c. Channel mat roll width shall be 6 feet (l.8 meters [m]) or greater.
3. Type Urban:
   a. Used for urban areas and lawn areas where mowing will occur.
   b. Use only 100% organics biodegradable netter products including parent materials, stitching, and netting.
   c. Mats placed on slopes greater than 4:1 and up to 2.5:1 shall be double netted.
   d. Netting and installation shall not pose a safety hazard to pedestrians walking on or crossing the mat.

C. Jute Fabric
1. Uniform, open weave of single jute yarn.
2. Twisted construction having an average twist of not less than one and one-half turns per inch.
3. Furnished in rolled strips 48 inches wide with a minimum of 78 wrapped ends.
4. Fabric shall have a minimum of 41 weft yarns per linear yard of length.
5. Weight of fabric shall be a minimum of 92 lbs per 100 square yards.
6. Non-toxic to vegetation.
7. Smolder resistant.

D. Wood Fiber Blanket
1. Uniform web of interlocking wood excelsior fibers.
2. Uniform thickness.
3. Weight of 78 lbs. per 80 square yards.
4. Have net backing on one side as follows:
   a. Mesh size not exceeding 1 ½ inches by 3 inches.
   b. Woven of twisted paper, cotton cord, or biodegradable plastic.
5. Non-toxic to vegetation.

E. Material Properties
1. Porosity Calculated 85-90%.
2. Stiffness ASTM D1388 2,000 milligrams per centimeter (mg/cm) (maximum).
3. Weight ASTM D3776 18 ounces per square yard (oz/s.y).
4. Tensile Strength ASTM D5035 (2-inch strip).
   a. Length Direction 15 lb.
   b. Width Direction 5 lb.
5. Elongation ASTM D5035 (2-inch strip):
   a. Length Direction 150%
   b. Width Direction 100%
6. Use flexible mat of polyvinylchloride monofilaments bonded together into a three-dimensional web designed exclusively to serve as an erosion control and revegetation mat.

F. Anchoring Devices
1. Anchoring and components for temporary erosion mats shall be completely biodegradable as determined by ASTM D5338.
2. Materials shall be environmentally safe for soil and groundwater.
3. Do not use petroleum based plastics or composites.
4. Do not use materials which may present a hazard from splintering or spearing.
5. Design anchors to hold a minimum of two months and be substantially degraded within four months during the summer (warm soil conditions).

G. Staples
1. Staples for anchoring erosion mat shall meet the following minimum requirements:
   a. U-shaped.
   b. No. 11 gage or larger diameter steel wire.
   c. Width of 1 to 2 inches.
   d. Length:
      1) Not less than 6 inches for firm soil.
      2) Not less than 12 inches for soft or loose soils.
      3) Not less than 8 inches where erosion mat is placed over sod.
2. Pins shall have a 3/16-inch shank diameter with attached 1 1/2-inch washer.
3. Staples shall have a 3/4-inch shank diameter with a l□inch minimum top width.

2.4 TEMPORARY DITCH CHECKS

A. Make temporary ditch checks (TDCs) of materials that are either biodegradable, that can be removed during long term erosion control construction activities, or that will not conflict with long term erosion and sediment control structures if left in-place.

B. Submit a list of TDC materials to the ENGINEER for review.

2.5 SAND BAGS

A. Minimum unfilled size of 16 by 26 inches.

B. Completely filled with a granular soil (P200 <50%).

2.6 FIBER LOG

A. Erosion Bales
1. Tightly compacted bales of grain straw or hay.
2. Use straw, if required to function for more than 15 days.

B. Support Post
1. Wood or steel construction minimum length 4 feet.
2. Wood posts -2-inch by 2-inch or equivalent steel posts.

2.7 GRASS SEED

1. Temporary grass cover (if required) shall be a quick growing species, suitable to the area, in accordance with Iowa DOT Rural Stabilizing Crop Mixture, Section 2601.03, which will provide temporary cover, and not compete with the grasses sown for permanent cover.
2. Hydroseeding – Submit seed mix, application methods and emulsion specification to ENGINEER for approval prior to application.
3. All grass seed or equivalent shall be approved by ENGINEER and in accordance with local regulations prior to installation.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Verification of existing conditions before starting work.

B. Verify surface water drainage pattern to ensure proper locating of soil erosion and sediment control features.

C. Verify that surfaces and the Site conditions are ready to receive work.

3.2 PREPARATION

A. Preserve salient natural features, keep cut-fill operations to a minimum, and ensure conformity with topography so as to create the least erosion and to adequately handle the volume and velocity of surface water runoff.

B. Whenever feasible, retain, protect, and supplement natural vegetation.

C. Do not damage, degrade, or in any way cause harm to existing above-ground structures or appurtenances, below-ground utilities, pipe, conduit, cable, conductor, or structure.

D. Performance of temporary erosion control work does not relieve CONTRACTOR of his responsibility for preventing or minimizing the potential for erosion or siltation.

3.3 WATER CONTROL

A. Maintain excavations free of water.

B. Protect the Site from puddling or running water. Grade the Site to drain. Provide water barriers as necessary to protect the Site from soil erosion.

C. Prevent surface water runoff from leaving work areas.

D. Do not discharge decontamination water, surface water runoff, or groundwater, which may have come in contact with coal combustion residuals (CCR), off Site or to municipal sewers.

E. Any water collected in excavations or ponded within work areas due to precipitation should be collected, pumped and discharged to the Process Water Pond. All stormwater collected from water from CCR shall be filtered prior to discharge to the Process Water Pond.

F. Prevent precipitation from infiltrating or from directly running off stockpiled materials outside footprints of Bottom Ash Impoundment. Cover stockpiled materials with an impermeable liner during periods of work stoppage including at the end of each working day and as directed by ENGINEER.

G. Direct surface waters that have not contacted potentially contaminated materials to existing surface drainage systems.

H. Control surface drainage including ensuring that gutters are kept open, water is not directed across or over pavements or sidewalks except through approved pipes or properly constructed troughs, and runoff from un-stabilized areas is intercepted and diverted to a suitable outlet.

I. Provide, operate, and maintain necessary equipment appropriately sized to keep excavations, staging pads, and other work areas free from water.

J. Have on hand sufficient pumping equipment, machinery, and tankage in good working condition for ordinary emergencies, including power outage, and competent workers for the operation of the pumping equipment.

3.4 EROSION AND SEDIMENT CONTROL

A. Plan and execute construction by methods to control surface drainage from cuts and fills, from borrow and waste disposal areas, from stockpiles, staging areas, and other work areas. Prevent erosion and sedimentation.

B. The OWNER has obtained coverage for the construction NPDES permit; however, the CONTRACTOR is responsible for following all applicable NPDES construction permitting requirements required in Iowa and complying with OWNER requirements.

C. Minimize the amount of bare soil exposed at one time. Stabilize disturbed soils as quickly as practical. Strip vegetation, regrade, or otherwise develop in such a way as to minimize erosion. Remove accumulated sediment resulting from construction activity from adjoining surfaces, drainage systems, and water courses, and repair damage caused by soil erosion and sedimentation as directed by ENGINEER.

D. Provide and maintain temporary measures which may include, but are not limited to, silt fences, hay or straw bales, ditches, geotextiles, drains, berms, terracing, riprap, temporary drainage piping, sedimentation basins, vegetative cover, dikes, and any other construction required to prevent erosion and migration of silt, mud, sediment, and other debris off Site or

to other areas of the Site where damage might result, or that might otherwise be required by the State of Iowa. Make sediment control measures available during construction. Place silt fences and/or hay or straw bales in ditches to prevent sediments from escaping from the ditch terminations.

1. Hay or Straw Bale:
    a. Wire bound or string tied.
    b. Securely anchored by at least two stakes or rebars driven through the bale 12 to 18 inches into the ground.
    c. Chinked (filled by wedging) with hay or straw to prevent water from escaping between the bales.
    d. Entrenched a minimum of 4 inches into the ground.
2. Silt Fence for Erosion Protection:
    a. Geotextile: Uniform in texture and appearance having no defects, flaws, or tears that would affect its physical properties. Contain sufficient ultraviolet ray inhibitor and stabilizers to provide a minimum 2-year service life from outdoor exposure.
    b. Net Backing: Industrial polypropylene mesh joined to the geotextile at both top and bottom with double stitching of heavy-duty cord.
        1) Minimum width of netting: 2 ½ feet.
    c. Posts: Steel posts or sharpened wood approximately 2 inches square protruding below the bottom of geotextile to allow a minimum of 1 ½ feet embedment.
        1) Post spacing: Not to exceed 8 feet.
        2) Securely fasten each post to the geotextile and net backing by staples suitable for such purpose.

E. Plan construction procedures to avoid damage to, or work or equipment encroachment onto water bodies or drainage ditch banks. In the event of damage, promptly take action to mitigate the effects of such damage. Restore affected bank or water body to its existing condition.

F. Installation:
1. Construct temporary erosion control items in accordance with the typical sections of elevation controls shown on the Drawings. Actual alignment and/or location of the various items as directed by ENGINEER.
2. Do not construct bale barriers and silt fence in flowing streams or in swales where there is the possibility of a washout.
3. Check erosion and sediment control measures weekly and after each rainfall. During prolonged rainfall, check daily.
4. Bales and/or silt fence may be removed at the beginning of the work day, but shall be replaced at the end of the work day.
5. Whenever sedimentation is caused by stripping vegetation, regrading, or other development, remove it from adjoining surfaces, drainage systems, and watercourses, and repair damage as quickly as possible.
6. Prior to or during construction, ENGINEER may require installation or construction of improvements to prevent or correct temporary conditions on the Site. Improvements may include berms, mulching, sediment traps, detention and retention basins, grading, planting, retaining walls, culverts, pipes, guardrails, temporary roads, and other measures appropriate to the specific condition. Temporary improvements shall remain in place and in operation as necessary or until otherwise directed by ENGINEER.
7. Pay close attention to the repair of damaged bales, end runs, and undercutting beneath bales.

8. Unless otherwise shown on the Drawings or directed by ENGINEER, remove temporary erosion and sediment control devices upon completion of the Works. Spread accumulated sediments to form a suitable surface for seeding or dispose of, and shape the area to permit natural drainage; all to the satisfaction of ENGINEER. Materials, once removed, become the property of CONTRACTOR.

G. Construct fill and waste areas by selective placement to avoid erosion surface silts or clays.

H. Do not disturb existing embankments or embankment protection.

I. Periodically inspect earthwork to detect evidence or erosion and sedimentation; promptly apply corrective measures.

J. If soil and debris from the Site accumulate in low areas, storm sewers, roadways, gutters, ditches, or other areas where in ENGINEER’s determination it is undesirable, remove the accumulation and restore the area to its original condition.

K. Unless otherwise specified, provide erosion control in accordance with State of Iowa regulations.

3.5 INSTALLATION

A. Install temporary erosion controls in accordance with Iowa DOT Standard Specifications for Highway and Bridge Construction, Section 2601 Erosion Control and Section 2602 Water Pollution Control (Soil Erosion) and in accordance with manufacturer's instructions.

B. Construct temporary erosion control items in accordance with the typical sections and elevation controls shown on the Drawings. Actual alignment and/or location of the various items as directed by ENGINEER.

C. Do not construct bale barriers and silt fence in flowing streams or in swales where there is the possibility of a washout.

D. OWNER shall obtain coverage under the Iowa NPDES General Construction Permit. The CONTRACTOR will be responsible for inspections as discussed in this paragraph and may exceed requirements of the Iowa NPDES General Construction Permit. During prolonged rainfall, daily inspection is necessary. Inspect erosion and sediment control measures monthly during inactive construction including during final vegetation establishment. Inspect erosion and sediment control measures after a 24-hour 0.5-inch rain event and within 7 days following such event. Inspections are necessary until final vegetation has been established and approved by ENGINEER. If soil and debris from the Site accumulate in low areas, storm sewers, roadways, gutters, ditches, or other areas where in ENGINEER's determination it is undesirable, remove the accumulation and restore the area to its original condition.

E. Bales and/or silt fence may be removed at the beginning of the work day, but shall be replaced at the end of the work day.

F. Whenever sedimentation is caused by stripping vegetation, regrading, or other development, remove it from adjoining surfaces, drainage systems, and watercourses, and repair damage as quickly as possible.

G. Prior to or during construction, ENGINEER may require installation or construction of improvements to prevent or correct temporary conditions on the Site. Improvements may include berms, mulching, sediment traps, detention and retention basins, grading, planting, retaining walls, culverts, pipes, guardrails, temporary roads, and other measures appropriate to the specific condition. Temporary improvements shall remain in place and in operation as necessary or until otherwise directed by ENGINEER.

H. Pay close attention to the repair of damaged bales, end runs, and undercutting beneath bales.

I. Unless otherwise shown on the Drawings or directed by ENGINEER, remove temporary erosion and sediment control devices upon completion of the Works. Spread accumulated sediments to form a suitable surface for seeding or dispose of and shape the area to permit natural drainage; all to the satisfaction of ENGINEER. Materials once removed become the property of CONTRACTOR.

J. Construct fill and CCR areas by selective placement to avoid erosive surface silts or clays.

K. Do not disturb existing embankments or embankment protection unless specified in the Works.

L. Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.

M. Whenever sedimentation is caused by stripping vegetation, regrading, or other development, remove it from all adjoining surfaces, drainage systems, and watercourses, and repair damage as quickly as possible.

N. Repair damaged silt fence, end runs, and undercutting beneath silt fence. If fence fabric tears, starts to decompose, or in any way becomes ineffective, replace the affected portion immediately.

O. Unless otherwise shown on Drawings, or directed by ENGINEER, remove all items upon acceptance of established growth by ENGINEER. Spread accumulated sediments to form a suitable surface for seeding or dispose of, and shape the area to permit natural drainage; all to the satisfaction of ENGINEER. All materials once removed become the property of CONTRACTOR.

P. Survey areas and locations where temporary erosion control measures placed.

3.6 DUST AND PARTICULATE CONTROL

A. Execute the Works by methods to minimize raising dust from construction operations.

B. Implement and maintain dust and particulate control measures immediately as determined necessary by ENGINEER during construction and in accordance with State of Iowa regulations.

C. Provide positive means to prevent airborne dust from dispersing into atmosphere. Use potable water for dust and particulate control. Use of water from the CCR impoundments for dust and particulate control is not allowed.

D. Do not use chemical means for a water misting system for dust and particulate control without ENGINEER's prior written approval.

E. As a minimum, use appropriate covers on trucks hauling fine or dusty material and use watertight vehicles to haul wet materials.

F. Prevent visible dust.

G. ENGINEER may stop work at any time when CONTRACTOR's control of dusts and particulates is inadequate for the wind conditions present at the Site, or when air quality monitoring indicates that the release of fugitive dusts and particulates into the atmosphere equals or exceeds the specified levels.

H. In the event that CONTRACTOR's dust and particulate control is not sufficient for controlling dusts and particulates into the atmosphere, work shall be discontinued, and a meeting held between ENGINEER and CONTRACTOR to discuss the procedures that CONTRACTOR proposes to resolve the problem. Make all necessary changes to operations prior to resuming any excavation, handling, processing, or any other work that may cause a release of dusts or particulates.

3.7 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspection and testing.

B. CONTRACTOR shall inspect all temporary erosion control items for proper placement and maintenance.

C. Repairs ordered by ENGINEER caused by circumstances not under CONTRACTOR's control after acceptance will be compensated for at Contract rates or as extra work in the absence of comparable items of work. Material used in restoring any original temporary erosion control installation, after the original installations were accepted, will be measured, and added to the quantities originally installed.

3.8 CLEANING

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for cleaning installed work.

B. Clean silt fences and other measures of excessive sediment accumulation if and when necessary.

C. Remove sediment deposits when the level of deposition reaches approximately one-half the height of the barrier.

END OF SECTION

SECTION 31 35 26.13

CLAY LINER CONSTRUCTION

PART 1 GENERAL

1.1 DESCRIPTION

A. Work in this section specifies the construction of the monofill clay liner including clay encasements for manholes, and collection transfer piping.

B. Contractor shall under this specification locate, test, excavate, haul, place, and compact all clay soils used in construction of the monofill and leachate lagoon.

1.2 PRODUCTS FURNISHED AND INSTALLED BY CONTRACTOR

A. Contractor must provide clay from an Owner approved borrow source that meets the following conditions:
   1. Complete field and laboratory investigations in accordance with Section 01 45 00 Quality Control.
   2. Obtain required approvals for clay removal, transport and use from local and State agencies.

B. The Contractor shall be responsible for:
   1. Required approvals, agreements, contracts, and leases with site owners and regulatory agencies.
   2. Costs for borrow source testing and conformance with the specification.
   3. In-place clay meeting the requirement of this section

1.3 RELATED SECTIONS

A. 01 33 00 Submittal Procedure

B. 01 40 00 Quality Requirements

C. 31 05 16 Aggregates for Earthwork

1.4 REFERENCES

A. Commercial Standards:
   1. ASTM D6898 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft - Ibs/ft3 or 600 KN-m/m3)
   2. ASTM D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
   3. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
   4. ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

5. ASTM D5084 –Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
6. ASTM D6913 –Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
7. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.5 TESTING RESPONSIBILITY

A. Contractor shall perform and pay for all testing including additional testing due to failure and change in material. The Contractor shall provide the following:
   1. Access for testing, inspection, and documentation.
   2. Machinery required to grade density testing locations.
   3. Equipment required to obtain undisturbed samples (i.e., Shelby tubes).
   4. Replace and recompact clay material removed for testing purposes:
      a. Backfill Shelby tube holes in liner with powdered bentonite-voclay-premium gel, or equal and hydrate.

1.6 SUBMITTALS

A. Source sample results of the material identified for the Work by the Contractor in accordance with the Source Testing Requirements for approval by the Owner. The submittal process shall be followed using Section 01 33 00 Submittal Procedures. The samples shall be representative of the material being installed and the sample sizes shall be stated in the test methods. All source testing shall be obtained at the Contractor's expense. The Owner may require a field representative to be present during the sampling.

B. The Contractor shall submit the quality control requirements to the Owner as specified in this section.

C. The Contractor shall perform and submit survey results to the Owner for approval as specified in this section.

1.7 TESTING REQUIREMENTS

A. The following Source Testing will be conducted by the CONTRACTOR.
   1. Standard Proctor: ASTM D698
   2. Grain Size and Hydrometer Analysis: ASTM D6913
   3. Atterberg Limits: ASTM D4318
   4. Hydraulic Conductivity; ASTM D5084 (1 test per 5,000 cubic yards)
   5. Soil Classification: ASTM D2487
   6. Frequency: Minimum of one test for each soil condition encountered and a minimum of one test for every 3,000 cubic yards of liner material borrowed.

B. The following Installation Testing will be conducted by the OWNER.
   1. Owner will perform density testing will performed on a 100-foot grid pattern for each 8-inchTift in accordance with ASTM D6938.
   2. One Shelby tube sample and bulk sample per 12 inches of thickness per acre of liner placement shall be retrieved by the OWNER and analyzed by the CONTRACTOR for the following:
      a. Grain Size and Hydrometer Analysis: ASTM D422

b. Moisture Content: ASTM D2216
c. Dry density. ASTM D698
d. Hydraulic Conductivity: ASTM D5084
e. If any sample fails to meet project requirements (i.e., maximum permeability of 1 X lO-7 cm/sec), a minimum of two adjacent, previously untested bulk samples shall be analyzed.
f. If the additional samples fail, the liner shall be removed and replaced or scarified and recompacted as directed by the OWNER's representative (ENGINEER) at the CONTRACTOR’s expense.

1.8 QUALITY ASSURANCE

A. The Contractor shall perform all quality control requirements specified in this section and Section 01 40 00 Quality Requirements unless it is specified otherwise.

B. All tests shall demonstrate compliance with the specifications and shall be submitted to the Owner by the Contractor prior to accepting any soil or aggregate for use at the Site. Material failing to meet the requirements on this section will not be accepted, the contractor shall perform sufficient sampling and testing to meet the requirements and identify the extent of the nonconforming material. Material not meeting the requirements shall be removed from the Site at no additional expense to the Owner.

C. In place density and moisture compaction requirements shall be conducted by the ENGINEER directed by the OWNER. The Contractor shall facilitate the testing, any tests not conforming to the compaction specifications shall be brought to the Contractors attention. The extent of nonconformance will be delineated by the Engineer and the Contractor shall take appropriate measures as to meet the compaction requirements at no additional expense to the Owner.

D. The Contractor shall facilitate equipment for Shelby tube installation and extraction that will be conducted by the Engineer. The contractor shall be responsible for any work associated with the repair and re-compaction of the Shelby tube locations as directed by the Engineer. Shelby tube testing not meeting the project requirements shall be brought to the Contractors attention, the Engineer shall conduct additional testing to determine the extent of nonconformance at no additional cost to the Owner. The Contractor shall be responsible for all additional costs of testing and re- compaction needed to meet the requirements.

E. The Contractor shall be responsible for conducting any survey work before, during and after clay cap installation as specified in the Drawings and specifications for this project. Survey work shall be conducted by an independent party registered in the State of Iowa and approved by the Owner. The Contractor is responsible for all costs associated with surveying.

F. Additional tests and surveys for compliance with this section along with the Drawings may be made by the Owner, at the expense of the Owner. Nonconformance results with this section and the Drawings shall be brought to the Contractors attention, the survey shall be recertified and re-tested at the Contractor’s expense.

G. Soil referencing shall be made using the Unified Soil Classification System following ASTM D2487. The Contractor shall be bound by the applicable provisions of ASTM D2487 in the interpretation of soil classifications.

PART 2 PRODUCTS

2.1 CLAY LINER MATERIAL

A. Source
1. Contractor shall identify the borrow source location and ownership for clay liner material which has been approved for use by the governing agency at or before the pre-construction meeting.

B. Field and laboratory testing of source clay soils.
1. The Contractor must complete all testing required by and obtained required approvals from the governing agency.

C. Clay materials delivered to the monofill and leachate lagoon site shall meet the following specifications:
1. Unified Soil Classification: CL or CH
2. Liquid Limit (LL): 25 percent or greater
3. Plastic Index (PI): Average 12 percent or greater-
4. Clay Size Fractions (0.005 mm): 25 percent or greater
5. P-200 content of 50 percent or greater.
6. Free from organic material, boulders, cobbles, excessive amounts of gravel (particle size greater than % inch) and other deleterious substances.
7. In-place clay shall have a maximum permeability of 1 x 10'^ cm/sec.
8. 95% of Standard Proctor density
9. 0 to 5 percentage points above Optimal Moisture Content.

D. Unsuitable Material:
1. Any soils that cannot be compacted sufficiently enough to meet the density requirements or performance requirements specified shall be deemed unsuitable material.
2. Any soils that are classified PT, OH, MH, or OL under ASTM D2487 shall be deemed unsuitable material.
3. Any off-site source soils determined to be contaminated by the Owner shall be ; deemed unsuitable material.

PART 3 EXECUTION

3.1 CLAY EXCAVATING, LOADING AND HAULING

A. Perform clearing and grubbing as defined in Section 31 10 00 Site Clearing.

B. Strip and stockpile topsoil.

C. Contractor is responsible for excavating and loading clay at the borrow site.

D. Contractor is responsible for hauling only clay which meets the requirements for clay liner material to the site.

E. Contractor shall obtain any special hauling permits required to transport clay on his chosen haul route. Contractor must access the project site using the north access road. The north access road must be entered from the south along Ogilvie Ave.

F. Contractor shall comply with load limits placed on roads when applicable.

3.2 SUBGRADE PREPARATION

A. Soil materials used for liner support material or for berm construction shall be placed and compacted in accordance with Section 31 05 16 Aggregates for Earthwork.

B. Subgrade shall be graded to the tolerance stated in Section 31 05 16 Aggregates for Earthwork.

3.3 CLAY LINER PLACEMENT

A. General
1. Clay liner placement shall not proceed until liner subgrade, grading, testing, and documentation has been completed.
2. The Owner shall provide a representative on a periodic basis at the clay borrow source to monitor the suitability of clay liner material. This monitoring does not guarantee that all material excavated continuously throughout the project will meet the requirements of this section.
3. The Contractor shall provide quantity surveys required to verify quantities to for unit price contracts. Survey shall be performed prior to beginning and upon completion of each applicable portion of the Work by a registered surveyor in the State of Iowa.
4. Place clay materials so that lift thickness after compaction is not greater than 6 inches.
5. The Contractor shall immediately proceed with the construction of the subsequent clay liner lift after the completion of quality control testing and construction documentation work (field testing and surveying) of the previous lift.
6. Each lift to be kneaded with the previously placed lift.
7. The top surface of the clay liner shall be made smooth by proof rolling after completing compaction of the final lift of clay.
8. All stockpiles shall be properly placed and constructed by the Contractor to maintain a safe access, and not create traffic problems at the Site for the Contractor and any of the Owner's delivery Contractors. Long term stockpile locations shall be approved by the Owner. The maximum height of any stockpile shall be limited to 20 feet above the existing ground surface.
9. The Contractor shall be responsible for installing and maintaining temporary erosion control structures (terraces, sedimentation basins etc.) needed to maintain erosion and sediment runoff to a minimum. The Contractor shall follow the facility's Stormwater Pollution Prevention Plan (SWPPP) requirements and as directed by the Owner or Engineer. Costs for establishing such temporary erosion control measures shall be considered incidental to the Work items in this section.
10. The Contractor shall manage stormwater as necessary to complete the Work
11. Service and maintenance of any machinery will not be allowed within the disturbed excavation areas. Any accidental spills of petroleum products caused by the operation of the machinery within the disturbed excavation area shall require immediate removal. All petroleum products belonging to the Contractor must be properly stored, maintained and disposed of at the Contractor's expense in accordance with applicable laws and regulations. Fueling and maintenance location shall be approved by the Owner.

12. The Contractor shall wet excavated material, backfill areas, traveled portions of the Site, haul roads, arid from borrow areas as necessary to limit dust; At a minimum, water shall be applied to all Work areas daily if rain is not imminent. During all grading and soil Work activities. Contractor shall maintain a minimum of one operational water truck for dust control. Contractor is responsible for all transport, labor, and costs associated with collecting and the application of water for dust control or soil conditioning.
13. Surveying: surveying to determine elevation, lift thicknesses, final grades and quantities for all earthwork shall be performed at the expense of the Contractor. The surveyor shall establish staking points at the minimum frequencies indicated below for pre and post Work survey's such that elevations are measured at the same coordinate.

B. Monofill Base
1. Place clay in a continuous lift across the entire landfill bottom.
2. Clay liner for landfill base shall consist of 6-inch compacted lifts placed to a minimum thickness of 2 feet measured perpendicular to the liner surface.

C. Monofill Sidewall
1. Construct clay liner for landfill sidewall after completion of construction and testing of liner base.
2. Clay liner for landfill sidewall shall consist of 6-inch compacted lifts placed to a minimum thickness of 2 feet measured perpendicular to the liner surface.

D. Moisture Content Adjustment
1. Provide all equipment necessary to adjust clay to the proper moisture content for compaction.
2. Clay liner shall not be placed at a moisture content less than optimum as determined by ASTM D698.
3. Excessively dry or wet clay material shall be replaced prior to placement of additional lifts.

E. Compaction
1. Provide a sheepsfoot roller for clay liner compaction except in confined areas.
2. Compact clay to a minimum of 95 percent of the Standard Proctor maximum density.
3. Upon completion of each 6-inch compacted lift, Contractor shall provide the following:
   a. Machinery required to blade clay liner at density test locations.
   b. Machinery required to obtain undisturbed samples (i.e., Shelby tubes).
   c. Access to clay liner for checking grades after the completion of each lift.

F. Clay Liner Around Structures
1. Place clay liner materials in the manner specified above as required around the following structures:
   a. Leachate pipe cleanout lines.
   b. Leachate pipe trenches.
   c. Leachate manholes.
   d. Other areas shown on the plans.
2. Compact clay as specified above except as follows:
   a. Compact in lifts not to exceed 6 inches after compaction.

G. The maximum permeability of clay samples collected and tested under Part 1.6 C , this section shall be 1 x $l0^{-7}$ cm/sec.

3.4 CONTRACTOR'S RESPONSIBILITY

A. Maintain the integrity of the clay liner until final payment and acceptance.
   1. Clay integrity shall include clay moisture content, density, and hydraulic conductivity.

3.5 RESPONSIBILITY FOR LINER NOT MEETING SPECIFICATION REQUIREMENTS

A. The Owner's representative shall provide the Contractor with a copy of all clay liner quality control results within 48 hours after completion.

B. If the in-place clay liner fails to meet the requirements of this section, the Contractor shall be responsible as follows:
   1. Remove and replace or rework any portion of the clay liner not meeting the project specifications until project specifications are met.
   2. The Contractor shall not be compensated for removing, replacing, or reworking clay not meeting the specification requirements.

END OF SECTION

SECTION 31 35 26.14

GEOMEMBRANE LEAK LOCATION SURVEY

PART 1 GENERAL

1.1 SECTION INCLUDES

A. The CONTRACTOR shall subcontract with an independent Leak Location Contractor to perform electrical leak location surveys of the installed geomembrane liner, as specified herein and in accordance with the requirements of the Contract Documents. Costs for leak location surveys are to be at the sole cost of CONTRACTOR.

B. If necessary, the CONTRACTOR shall be responsible for procuring test water suitable for use in the testing operations. The CONTRACTOR shall also be responsible for disposal of such water following testing procedures.

C. Requirement to perform two geomembrane leak location surveys: the first on the bare geomembrane and the second after protective earth drainage material is placed on the geomembrane.

D. The optimum performance of a geomembrane leak location survey using electrical methods requires the conductive media above and below the geomembrane to be electrically isolated from each other except through the leaks being located in the geomembrane. It is also necessary to have a continuous electrically conducting pathway through an electrically conducting material above the geomembrane, through the leaks, and through an electrically conducting media under the geomembrane.

E. The leak location survey shall be conducted after the earth materials are installed over the geomembrane to detect leaks resulting from construction damage caused during placement of the earth material layer.

1.2 REFERENCES

A. Commercial Standards:
   1. ASTM D 6747 – Standard Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes.
   2. ASTM D 7002 – Standard Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System.
   3. ASTM D 7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials.

1.3 SUBMITTALS

A. The CONTRACTOR shall submit a Leak Location Survey Work Plan to the ENGINEER for approval a minimum of 21 calendar days prior to commencement of the leak location surveys. The Leak Location Survey Work Plan shall include:
   1. Qualification of the proposed Leak Location Contractor, including the number of years the Leak Location Contractor has performed the proposed survey methods

and a list of projects demonstrating the Leak Location Contractor's qualifications and experience.

2. Resumes of proposed on site supervisors, and a list of projects demonstrating the qualifications and experience of the leak location supervisor.
3. A description of the proposed survey methods and procedures, and required site preparations.
4. An estimated duration of each survey.
5. Quality control and field calibration procedures.
6. A sample of a final report (per ASTM D 7002 and ASTM D 7007) provided by the Leak Location Contractor following completion of the survey.

1.4 CONSTRUCTION QUALITY ASSURANCE

A. The Leak Location Contractor shall have tested a minimum of 5,000,000 square feet of geomembrane liner within the previous three years, using the electrical leak location survey methods as described herein. In addition, the leak location survey must be supervised by a professional or technician with a minimum of three years and 1,000,000 square feet of liner testing experience, also using the electrical leak location survey methods as described herein. The leak location supervisor must be on site full time during performance of the leak location survey.

B. The leak location survey shall be observed by the CQA ENGINEER and the CONTRACTOR shall provide a minimum 5 day advance notice of the scheduled commencement of the test.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.1 GENERAL

A. The CONTRACTOR in conjunction with the ENGINEER shall provide the Leak Location Contractor with drawings showing:
   1. All layers constituting the liner system.
   2. Details of all geomembrane liner penetrations.
   3. Peripheral details, including welds to adjacent lining systems.
   4. Structures and obstruction above the geomembrane liner.
   5. Electrical equipment above the geomembrane liner.

3.2 SITE PREPARATION

A. Leak Location Contractor will identify actions required by Contractor to prepare the site for the leak location survey.

B. Contractor shall ensure that the earth materials above and below the geomembrane contains sufficient moisture to conduct a leak location survey. Typically, a moisture content of the earth material layer of more than two percent by weight is sufficient to conduct the survey. If the geomembrane is installed on a desiccated (dusty) subgrade, or on a geotextile, it will be necessary to spray the geomembrane with water prior to the leak

location survey to allow time for the subgrade at the leaks to be wetted. If the moisture content of the earth material layer is not sufficient per the requirements of Leak Location Contractor, then Contractor shall add sufficient water to the earth materials as required.

C. Contractor shall provide electrical isolation around the perimeter of the area being surveyed for leaks. Electrical isolation is achieved by leaving approximately a one-foot-wide area of dry geomembrane exposed around the perimeter of the survey area or leaving a minimum of six-inches of bare geomembrane protruding from the back-filled anchor trench. Any other electrically conducting paths through the geomembrane such as metal pipes, battens, or concrete structures should be likewise isolated.

3.3 EXECUTION

A. Leak Location Contractor shall inspect the site prior to commencing the survey to ensure all site preparations are completed and the site conditions are appropriate for conducting the leak location survey.

B. Any discrepancy in the required site preparations described in the Leak Location Survey Work Plan or site conditions shall be reported to Contractor for corrective or appropriate action.

C. It is recognized that the leak location survey cannot be conducted in areas that are immediately adjacent to the edges of a single geomembrane or immediately adjacent to electrical conducting paths through or around the geomembrane such as earth ramps, metal pipes, battens, or concrete structures.

D. Conduct a leak location survey on the bare geomembrane using the procedures described in the latest version of ASTM Standard D7002.

E. After the earth materials are added above the geomembrane, conduct a leak location survey on the earth materials using the procedures for surveys with earth materials covering the geomembrane described in the latest version of ASTM Standard D7007. The survey data shall be automatically recorded and stored in electronic format at the time of data collection. The data acquisition system shall have digital data transfer from the measurement electronics to a computer to eliminate human error.

F. Leak Location Contractor shall inform CQA Consultant and mark the locations of all identified or indicated leaks with flags, spray paint, or written coordinates.

3.4 REPORTING

A. The Leak Location Contractor shall provide a written report within 14 calendar days of completion of the leak location survey, as applicable, and as described in ASTM D 7007.

END OF SECTION

SECTION 31 35 26.16

GEOMEMBRANE CONTAINMENT BARRIERS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes HDPE geomembrane for Cell 4 Expansion at the Louisa Generating Station.

1.2 REFERENCES

A. Reference Standards:
   1. Section 01 40 00 - Quality Requirements: Requirements for references.
   2. ASTM International:
      a. ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils.
      b. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
      c. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.
      d. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)).
      e. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
      f. ASTM D1004 - Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
      g. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
      h. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
      i. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
      j. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics.
      k. ASTM D3895 – Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry.
      l. ASTM D4437 / D4437M - Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
      m. ASTM D4439 - Standard Terminology for Geosynthetics.
      n. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
      o. ASTM D5199 - Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
      p. ASTM D5321 - Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

q. ASTM D5397 - Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.
r. ASTM D5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
s. ASTM D5721 - Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
t. ASTM D5885 - Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.
u. ASTM D5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
v. ASTM D6391 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

3. Geosynthetic Research Institute:
   a. GRI Test Method GM6 – Pressurized Air Test for Dual Seamed Geomembranes.
   b. GRI Test Method GM9 - Standard Practice for Cold Weather Seaming of Geomembranes.
   c. GRI Test Method GM10 – Standard Guide for The Stress Crack Resistance of HDPE Geomembrane Sheet.
   d. GRI Test Method GM13 – Standard Specification for Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.
   e. GRI Test Method GM29 – Field Integrity Evaluation of Geomembrane Seams (and Sheet) Using Destructive and/or Nondestructive Testing.

1.3 COORDINATION

A. Section 01 30 00 – Administrative Requirements: Requirements for coordination.

B. Coordinate work with surface preparation work and installation of structures that will penetrate geomembrane.

1.4 PRE-INSTALLATION MEETING

A. Section 01 30 00 – Administrative Requirements: Pre-installation meeting.

B. Convene one week prior to commencing installation of geomembrane.

C. Purpose of Meeting:
   1. Define responsibilities of each party.
   2. Establish lines of authority and lines of communication.
   3. Review Site-specific quality assurance, quality control, and monitoring procedures.
   4. Define method of acceptance of completed geomembrane.
   5. Establish protocol for writing on geomembrane (i.e., who is authorized to mark on the geomembrane and in what colors).
   6. Review time schedules.
   7. Review personal protective equipment and applicable regulations.
   8. Review safety plan and procedures.
   9. Review panel layout and numbering system for panels, seams, and test samples.

10. Review methods of measuring production.
11. Review procedures for incremental acceptance.
12. Review procedures for initiating and implementing change orders.
13. Visit the Site to review surface preparation, physical location of the Site, and Site access.
14. Review critical design details.

1.5 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit no later than 10 days prior to ordering.

C. Samples: Submit a representative sample at least 12 inches by the full geomembrane roll width, no later than 10 days prior to ordering.

D. Manufacturer's Instructions: Submit no later than 14 days prior to installation.

E. Manufacturer's Certificates:
1. Deliver each roll to the Site accompanied by manufacturer's certificate.
2. Identify each roll by unique manufacturing number.
3. Include results of at least the following tests: density, carbon black content, thickness, tensile strength, puncture resistance, and tear resistance.
4. Quality control certificates signed by manufacturer.
5. Certificates pertaining to raw materials and manufactured rolls including, but not limited to storage, handling, and shipping of geomembrane. ENGINEER will review test results for completeness and compliance with required minimum properties for both raw materials and manufactured rolls. Materials and rolls not in compliance with minimum required properties will be rejected.

F. Daily Field Installation Report. Submit no later than 1 day following date covered by report and include:
1. Subgrade surface acceptance form signed by manufacturer's representative.
2. Total amount, type, and location of geomembrane placed.
3. Identifiers of rolls and fabricated blankets correlated with manufacturer's number.
4. Quality control tests of materials used during the day.
5. Total amount and location of seams completed, identification of seamer, and welding equipment used.
6. Changes in layout drawings.
7. Observations of test seams, including seaming unit number and identification of names of seamers, weather conditions, speed, temperature setting, and results.
8. Location and results of non-destructive testing.
9. Location and results of destructive testing.
10. Reasons for and observations of repairs and re-testing, including locations, type of repair, name of repairer, and seaming equipment or product used.
11. Observations of anchor trench excavation, backfilling, and compaction.
12. Observations of field seaming operations, including weather conditions, cleaning, overlaps, rate of seaming, names of seamers, and units used.
13. Observations of seams around appurtenances, and connection to appurtenances.

G. Layout Drawings: Submit drawings of the proposed geomembrane placement pattern no later than 14 days prior to installation.

H. Interface Shear Testing: Submit shear test reports no later than 10 days prior to ordering.

I. Qualification Statements:
1. Installer: Submit a copy of manufacturer's approval letter or license no later than 14 days prior to installation.
2. Manufacturer: No later than 14 days prior to ordering, submit:
3. List of previous projects totaling 3 million sq ft of installation.
4. Details of five projects including:
a. Name of project.
b. Description of project.
c. Total area.
d. Client's name, address, contact, and telephone number.
e. Engineer's name, address, contact, and telephone number.
f. Installer's name, address, contact, and telephone number.
g. Date installed.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

B. Project Record Documents: Indicate panel layout including panel identifiers [date placed, installer's name, location of seams, and location and details of repairs].

C. Warranties: Completed original warranty forms filled out in OWNER's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

A. Submit the following information to the Engineer prior to the delivery of materials.
1. Manufacturer/Fabricator Information:
a. Corporate background.
b. Quality control program.
c. List of 10 (minimum) completed facilities totaling a minimum of 2,000,000 square feet:
1) Name, location, and purpose of facility.
2) Date of installation.
3) Name of Owner, project manager, and installer.
4) Description and surface area of liner.
2. Installer Information:
a. Corporate background.
b. Capabilities including:
1) Size - Total installation (in square feet) of HDPE Geomembrane materials over the last five years.
2) Equipment - Total number of fusion and extrusion welders.
3) Personnel - Total number of employees. Total number of field crews.
4) Anticipated daily production - In square feet per day.
c. List of 10 (minimum) completed facilities totaling a minimum of 2,000,000 square feet:
1) Name, location, and purpose of facility.
2) Date of installation.

3) Name of Owner and project manager.
4) Description and surface, area of liner and name of liner manufacturer.
5) Types of seams and seaming equipment used.

d. A master seamer or foreman shall be assigned to this project that has experience seaming a minimum of 1,000,000 square feet of liner using the same type of equipment and material intended for this project. Provide resume.

e. Qualifications of personnel performing seaming operations. Provide resume.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Package and label geomembrane rolls or blankets prior to shipment to the Site. Indicate geomembrane manufacturer, type of geomembrane, thickness, lot number, roll number, and roll dimensions.

C. When transported to the Site, handle geomembrane rolls or blankets as recommended by geomembrane manufacturer.

D. Take adequate measures to protect geomembrane materials during storage.

E. Use appropriate handling equipment when moving rolled or folded geomembrane from one place to another.

F. Notify ENGINEER 3 days in advance of geomembrane delivery to the Site. Perform joint inspection with ENGINEER upon delivery. Defects or damage from shipping and handling will be grounds for rejection of a portion of geomembrane or of the entire geomembrane roll or fabricated blanket at the discretion of ENGINEER. Remove roll from the Site and replace with new material.

1.9 AMBIENT CONDITIONS

A. Do not install when climatic conditions, as determined by ENGINEER, are unsatisfactory.

B. Weather Conditions for Geomembrane Placement:
1. Comply with manufacturer's instructions.
2. Do not unroll, unfold, or place geomembrane at an ambient temperature below 32 degrees F or above 104 degrees F, unless CONTRACTOR obtains written acceptance from geomembrane manufacturer and ENGINEER.
3. Install on dry ground.
4. Take account of Site drainage, wind direction, Site construction layout, access to the Site, and production schedule of the Works.
5. Do not install when subgrade conditions have deteriorated due to moisture, or in the presence of high winds, as determined by ENGINEER.
6. Adequately ballast deployed geomembrane at all times to avoid wind damage.

C. Weather Conditions for Geomembrane Seaming:
1. Comply with manufacturer's instructions.

2. Make no weld below 34 degrees F unless:
   a. Guidelines for field seaming of geomembrane in cold weather, as identified in GRI Test Method GM9 are strictly followed.
   b. CONTRACTOR obtains written approval from geomembrane manufacturer to weld at temperature below 32 degrees F according to GRI Test Method GM9.
   c. Between 34 and 50 degrees F seaming is possible if geomembrane is preheated by either sun or hot air device, and if there is no excessive cooling resulting from wind.
   d. Make no weld below 5 degrees F.
   e. In all cases, keep geomembrane dry while being welded.

1.10 WARRANTY

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for warranties.

B. Provide 20-year manufacturer's warranty against manufacturing defects.

C. Warranty: Include coverage for:
   1. Defective product being not in compliance with the requirements of this Section.
   2. Replacement of geomembrane with new material, including costs associated with geomembrane installation.

PART 2 PRODUCTS

2.1 GEOMEMBRANE

A. Acceptable Manufacturers:
   1. Agru America, Inc.
   2. GSE Environmental
   3. In-Line Plastics LC
   4. An ENGINEER approved equal.

2.2 GEOMEMBRANE PROPERTIES

A. Geomembrane: Conform to the following specifications, in accordance with GRI GM13:

HDPE Geomembrane – Smooth – 60 mils			
Properties	Test Method	Test Value (Minimum Average Value)	Testing Frequency (Minimum)
Thickness – mils • lowest individual of 10 values - percent	ASTM D5199	nominal -10	per roll
Formulated Density - g/cc	ASTM D1505/D792	0.940	200,000 lbs

Tensile Properties(1) • yield strength – pound/inch • break strength – pound/inch • yield elongation – percent • break elongation – percent	ASTM D6693 Type IV	 126 228 12 700	20,000 lbs
Tear Resistance – pound	ASTM D1004	42	45,000 lbs
Puncture Resistance – pound	ASTM D4833/4833M	108	45,000 lbs
Stress Crack Resistance(2) – hour	ASTM D5397 (Appendix)	500	per GRI-GM10
Carbon Black Content (range) - percent	ASTM D4218(3)	2.0 - 3.0	20,000 lbs
Carbon Black Dispersion	ASTM D5596	note (4)	45,000 lbs
Oxidative Induction Time (OIT)(5) a) Standard OIT -or- b) High Pressure OIT	 ASTM D8117 ASTM D5885/D5885M	 100 400	200,000 lbs
Oven Aging at 185 degrees F(5),(6) a) Standard OIT – percent retained after 90 days -or- b) High Pressure OIT – percent retained after 90 days	ASTM D5721 ASTM D8117 ASTM D5885/D5885M	 55 80	per each formulation
UV Resistance(7) a) High Pressure OIT – percent retained after 1600 hours(8)	ASTM D7238 ASTM D5885/D5885M	50	per each formulation

Notes:
(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Yield elongation is calculated using a gage length of 1.3 inches.
- Break elongation is calculated using a gage length of 2.0 inches.
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (TGA) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3.
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) Also evaluate samples at 30 and 60 days to compare with the 90-day response.
(7) The condition of the test should be 20-hour UV cycle at 167 degrees F followed by 4-hour condensation at 140 degrees F.
(8) UV resistance is based on percent retained value regardless of the original HP-OIT value.

****** OR ******

HDPE Geomembrane – Textured – 60 mils			
Properties	Test Method	Test Value (Minimum Average Value)	Testing Frequency (Minimum)
Thickness – mils • lowest individual for 8 out of 10 values – percent • lowest individual for any of the 10 values - percent	ASTM D5994/D5994M	nominal -5 percent -10 -15	per roll
Asperity Height - mils	ASTM D7466/D7466M	16	every 2nd roll(1)
Formulated Density - g/cc	ASTM D1505/D792	0.940	200,000 lbs
Tensile Properties(2) • yield strength – pound/inch • break strength – pound/inch • yield elongation – percent • break elongation – percent	ASTM D6693 Type IV	 126 90 12 100	20,000 lbs
Tear Resistance– pound	ASTM D1004	42	45,000 lbs
Puncture Resistance– pound	ASTM D4833/4833M	90	45,000 lbs
Stress Crack Resistance(3) – hour	ASTM D5397 (Appendix)	500	per GRI-GM10
Carbon Black Content (range) - percent	ASTM D4218(4)	2.0 - 3.0	20,000 lbs
Carbon Black Dispersion	ASTM D5596	note (5)	45,000 lbs
Oxidative Induction Time (OIT)(6) a) Standard OIT -or- b) High Pressure OIT	 ASTM D8117 ASTM D5885/D5885M	 100 400	200,000 lbs
Oven Aging at 185 degrees F(6),(7) a) Standard OIT– percent retained after 90 days -or- b) High Pressure OIT– percent retained after 90 days	ASTM D5721 ASTM D8117 ASTM D5885/D5885M	 55 80	per each formulation
UV Resistance(8) a) High Pressure OIT– percent retained after 1600 hours(9)	ASTM D7238 ASTM D5885/D5885M	 50	per each formulation

Notes:
(1) Alternate the measurement side for double sided textured sheet.
(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Yield elongation is calculated using a gage length of 1.3 inches.
- Break elongation is calculated using a gage length of 2.0 inches.

(3) SP-NCTL per ASTM D5397 Appendix, is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(4) Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (TGA) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established.
(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3.
(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(7) Also evaluate samples at 30 and 60 days to compare with the 90-day response.
(8) The condition of the test should be 20-hour UV cycle at 167 degrees F followed by 4-hour condensation at 140 degrees F.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

2.3 SOURCE QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Testing, inspection, and analysis requirements.

B. Manufacturer shall perform test for parameters shown in PART 2.1, GEOMEMBRANE PROPERTIES at a minimum frequency specified in GRI Test Method GM13.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution Requirements: Verification of existing conditions before starting work.

B. Obtain ENGINEER's and manufacturer's acceptance in writing prior to installing geomembrane and prior to placing subsequent layers on geomembrane.

C. Coordinate activities to allow ENGINEER to observe testing. ENGINEER will observe all testing and collect samples for destructive laboratory testing.

3.2 PREPARATION

A. Surface Preparation:
   1. Do not begin installation of geomembrane until a proper subbase has been prepared and subbase has been accepted by ENGINEER and geomembrane manufacturer.
      a. Prepared Subbase Surface: Free from abrupt changes in grade, water, loose earth, exposed rocks, rubble, protrusions, vegetation, and other foreign matter which may be damaging to geomembrane.
      b. Compact subgrade uniformly to a minimum of 95 percent SMDD according to ASTM D698.
   2. Do not place geomembrane in an area which has become softened by precipitation and which will not support geomembrane installation equipment without rutting.

3.3 PANEL PLACEMENT

A. Place in accordance with manufacturer’s instructions.

B. Designate each roll or blanket with an individual panel number and correlate with manufacturer's identification number.
   1. Mark each designation in each roll as it is deployed.
   2. Position geomembrane as shown on the layout drawings. A panel is the unit area of in-place membrane to be seamed (i.e., one roll may be cut into several panels).
   3. Follow manufacturer's instructions for unwrapping geomembrane materials to ensure panels are unrolled or unfolded in the proper direction for seaming.
   4. Only unroll or unfold panels to be anchored or seamed together that day.
   5. Take care not to damage geomembrane during this operation. Require workers to wear shoes that will not damage geomembrane.

C. Minimize pulling of geomembrane panels to reduce permanent tension.

D. Minimize dragging of textured geomembrane to prevent damage to texturing.

E. Take the following precautions to minimize risk of wind damage during panel placement:
   1. Orientate work according to the direction of prevailing winds if possible, unless otherwise specified.
   2. Provide adequate securement of geomembrane panels using sand bags, tires, or other means that will not damage geomembrane. Ensure loading is continuous along panel edges to avoid possible wind flow under the panels.

F. Replace panels which ENGINEER judges to be seriously damaged (i.e., torn or twisted permanently). Repair less serious damage according to PART 3.6, REPAIR PROCEDURES.

G. Do not place geomembrane when raining or in an area of ponded water.

H. Install geomembrane roll free of corrugations or folds at the average expected temperature of the final use condition.

3.4 INSTALLATION AROUND APPURTENANCES

A. Install geomembrane around wells, vents, or other appurtenances protruding through geomembrane as shown on the Drawings. Unless otherwise specified, initially install geomembrane skirt around each appurtenance prior to geomembrane installation. After geomembrane has been placed and seamed, complete the final field seam connection between the appurtenance skirt and geomembrane. Maintain a sufficient initial overlap of the appurtenance skirt so that shifts in location of geomembrane can be accommodated.

B. Obtain ENGINEER's written acceptance for materials to be used to seal gaps between geomembrane skirt and appurtenances.

C. Install geomembrane carefully on rough surfaces to minimize damage. If accepted by ENGINEER, installer may use additional loosely placed geomembrane sections as protection for geomembrane.

D. Ensure clamps, clips, bolts, nuts, batten strips, or other fasteners used to secure geomembrane around each appurtenance have a lifespan equal to or exceeding geomembrane.

E. Before attaching the geomembrane to appurtenances, ensure that geomembrane is flat and that no wrinkles are trapped by the batten strips or other fasteners.

3.5 FIELD SEAMING

A. Overlap panels a minimum of:
   1. 4 inches for extrusion welds.
   2. 5 inches for hot wedge welds.

B. Panel Preparation: Clean the seam area prior to seaming and verify the absence of moisture, dust, dirt, debris, and foreign material.

C. Seaming Equipment and Products:
   1. Extrusion or hot wedge welding equipment and installation methods recommended by manufacturer.
      a. Extrusion Welding:
         1) Ensure the composition of the extrudate is identical to the geomembrane material, otherwise weld all panels together using the hot wedge welding system.
         2) Equipment shall include thermometers measuring the temperature of extrudate in the machine extruder and at the nozzle.
      b. Wedge Welding: Use equipment capable of continuously monitoring and controlling the wedge temperature.

D. Orient seams downslope to allow unimpeded flow of water over top of geomembrane. Specifically, for hot welded seams overlap the geomembrane on the downslope side of the seam. Extend seaming to outside edge of panels to be placed in anchor trench.

E. If supporting soil is yielding, provide a firm substrate by using a homogeneous board, a conveyor belt, or similar hard surface directly under the seam overlap to effect proper rolling pressure.

F. Seaming Wrinkles: Cut fishmouths and corrugations to effect a flat overlap. Seam the cut fishmouths or corrugations as well as possible, then install a patch of the same generic geomembrane extending a minimum of 6 inches beyond the cut in all directions.

G. Create cross-slope seams a minimum of 5 feet from the toe of slope unless slope is less than 10 percent. Cross-slope seams may be utilized if cut at an angle of approximately 45 degrees.

H. Label each seam with date, seamer, equipment seaming temperature and speed, and time seam started and completed.

I. Seaming Tie-ins: To avoid excessive distortion in the geomembrane due to contraction and expansion, do not proceed with seaming of geomembrane tie-ins unless all panels to be seamed are at a uniform temperature (i.e., early in the morning or late in the day).

3.6 REPAIR PROCEDURES

A. Clean and dry surfaces at time of repair.

B. Repair pinholes by applying a patch; repair defective seams by re-seaming, flap welding, or applying a patch, as accepted by ENGINEER.

C. Patch tears, blisters, larger holes, undispersed raw materials, and contamination by foreign matter, or corrugations determined by ENGINEER to be excessive.

D. Patches:
1. Abrade surfaces as appropriate.
2. Label each patch with date, number, seamer, and equipment.
3. Make patches round or oval.
4. Make patches of the same generic geomembrane. Use textured patches when straddling textured and non-textured geomembranes.
5. Extend patch a minimum of 4 inches beyond the edge of defects.

3.7 INSTALLATION OF MATERIALS IN CONTACT WITH GEOMEMBRANE

A. Place bedding and cover material in a manner to prevent damage to geomembrane.

3.8 FIELD QUALITY CONTROL

A. Section 01 40 00 - Quality Requirements: Field inspecting and testing.

B. Inspect each panel for damage after placement and prior to seaming. Mark damaged panels or portions of damaged panels which have been rejected, as determined by ENGINEER, and record their removal from the work area.

C. Verify that weather conditions (i.e., appropriate air temperature, non-excessive wind, lack of precipitation) are acceptable for panel placement.

D. Field Seaming Operations:
1. Verify that seaming personnel have the specified qualifications.
2. Verify that overlaps meet specified requirements.
3. Verify that seaming area is clean and dry, as specified.
4. Verify that a hard substrate such as a board or piece of conveyor belt is used if supporting soil is soft or uneven.
5. Verify that seaming equipment is available and meets specified requirements.
6. Verify that weather conditions for seaming are acceptable, as specified.
7. Verify that seaming procedures as specified are followed.
8. Verify that panels are properly positioned to prevent wrinkling.
9. Verify that seam testing equipment is available on Site and operational.
10. Verify that field tensiometer is correctly calibrated.

E. Pre-Weld Test Seams:
1. Perform test seams according to ASTM D6392and GM 29 to verify that seaming conditions are adequate. Conduct test seams at the discretion of ENGINEER and at least twice each day, at the beginning of the day and at least every 4 hours thereafter, for each seaming equipment used that day. Perform test seaming under

the same conditions as production seaming. Perform test seams on scrap geomembrane not to be incorporated into the Works.
a. Extrusion Weld Test Seams: Minimum 4 feet long.
b. Hot Wedge Weld Test Seams: Minimum 10 feet long.

2. Cut 1-inch wide coupons from the test seam and assign to peel or shear test alternatively as they are cut across panel. Test coupons in shear and peel using a calibrated field tensiometer.
3. Minimum Strength of Geomembrane Test Seams When Tested in Shear: 120 pounds/inch for both hot wedge welded and extrusion welded seams.
4. Minimum Strength of Geomembrane Test Seams When Tested in Peel: 91 pounds/inch for hot wedge welded seams and 78 pounds/inch for extrusion welded seams.
5. In addition, the test coupons must not delaminate. Passing test results must be obtained from four of five coupons when tested in shear, and four of five coupons when tested in peel. For geomembrane test seams performed using a hot wedge welder, perform peel tests on both the inside and outside welds; both welds must pass the peel test. If a test seam fails, reject the seaming equipment for field seaming until the deficiencies are corrected and a successful test seam is produced.
6. A passing test seam is an indicator of the adequacy of the seaming unit and seamer working under prevailing Site conditions, but is not necessarily an indicator of field seam adequacy.
7. Coordinate completion of test seams to allow ENGINEER to observe all test seams. Retain a sample from each test and label with date, ambient temperature, number of seaming unit, seamer, and pass or fail description. ENGINEER will retain one half of the sample.

F. Non-destructive Seam Testing:
1. Non-destructively test double-wedge weld field seams over their full length by pressure testing the air channel according to GRI Test Method GM6, and test extrusion weld field seams using vacuum box according to ASTM D4437/D4437M. Record test results on geomembrane near seam. Number or otherwise designate each seam. Record location, date, test unit, name of tester, and outcome of all non-destructive testing.
2. Passing non-destructive test of field seams, meeting or exceeding the requirement in GRI Test Method GM6 or ASTM D4437/D4437M, indicates the adequacy of field seams, subject to the results of destructive seam testing as identified in the Destructive Seam Testing Paragraph.
3. Coordinate activities to allow ENGINEER to observe all testing. Conduct testing as the seaming work progresses, not at the completion of all field seaming. Number and mark all defects found during testing immediately after detection. Repair, re-test, and re-mark all defects found to indicate completion and acceptability of the repair. If pressure testing is performed, repair the hole resulting from the pressure needle after testing.

G. Destructive Seam Testing:
1. Collect 3-foot geomembrane field seam samples at a frequency of approximately one sample per 500 linear feet of field seam, or more frequently if requested by ENGINEER, at locations indicated by ENGINEER.
2. Field test five coupons in peel and five coupons in shear from one third of the 3-foot sample according to ASTM D6392, using a calibrated field tensiometer.
3. Perform peel tests on the inside and outside weld. If at least four of each of the five coupons do not delaminate and pass tensile strength requirements based on the field testing, provide to ENGINEER another one-third section of the 3-foot sample

for quality assurance laboratory shear and peel testing (final one-third section of 3-foot sample to be kept for archive and potential re-testing).

a. Minimum Shear Strength of Geomembrane Field Seams When Tested in Shear: 120 pounds/inch for both hot wedge welded and extrusion welded seams, for both field and laboratory tests].
b. Minimum Strength of Geomembrane Field Seams When Tested in Peel: pounds/inch for hot wedge welded seams and 78 pounds/inch for extrusion welded seams, for both field and laboratory tests.
c. If either field or laboratory tests fail, isolate the defective seam and re-test as follows:
    1) Collect additional 3-foot samples from the field seam for testing using a field tensiometer, within 10 feet of each side of the failing sample as determined by ENGINEER, until passing test locations are identified.
    2) Repair the field seam between the passing test locations (based on field tensiometer results) by extrusion welding or patching.
    3) Non-destructively test the patch or extrusion weld and repair as required until non-destructive test standards are achieved.
    4) If the additional laboratory shear or peel tests fail, collect additional destructive seam field samples and field test to isolate the failing seam, then laboratory test.
    5) Repeat the above-noted procedure until passing field and laboratory test results are achieved, thereby delineating extent of defective seam.

H. Verification of Seams in Special Locations:
1. Non-destructively test seams in special locations (i.e., appurtenances) if the seam is accessible to testing equipment. Coordinate activities to allow ENGINEER to observe all testing.
2. If a seam cannot be tested in place, ENGINEER and CONTRACTOR will visually observe for uniformity and completeness.
    a. Record seam number, date of inspection, name of tester, and outcome of the inspection.
3. Promptly repair, re-test, and re-mark defective seams to indicate completion of the repair.

I. Defects and Repairs:
1. Identification: Inspect seams and non-seam areas of geomembrane to identify defects, holes, blisters, undispersed raw materials, and signs of contamination by foreign matter.
2. Evaluation: Non-destructively test each suspect location, both in seam and non-seam, using methods described in Non-destructive Seam Testing Paragraph. Mark and repair each location which fails non-destructive testing.
3. Verification of Repairs: Non-destructively test each repair using the method described in Non-destructive Seam Testing Paragraph. Tests which pass the non-destructive test standards will serve as an indication of an adequate repair. Re-repair and test failed test locations until a passing test results. Record the number of each repair, date, location, repair personnel initials, and test outcome. ENGINEER will observe non-destructive testing of repairs.

J. Geomembrane Acceptance:
1. Geomembrane will be accepted by ENGINEER when:
    a. Installation is finished.
    b. Documentation of installation is completed and submitted to ENGINEER.

c. Verification of the adequacy of field seams and repairs, and associated testing, is complete.

K. Quality Assurance Testing by ENGINEER: Quality assurance laboratory engaged by OWNER will perform laboratory tests on geomembrane samples as identified in this Section to determine if geomembrane seams meet specified requirements. Copies of test reports will be supplied to CONTRACTOR on request. Re-testing of previously failed geomembrane seams will be at no additional cost to OWNER.

3.9 PROTECTION

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for protection of installed work.

B. Protect finished work from damage.

C. Do not permit traffic over unfinished geomembrane installation.

END OF SECTION

SECTION 31 35 28

LEACHAGE COLLECTION SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section includes leachate collection pipes (perforated) within the Cell 4.

B. Related Requirements:
1. Section 31 35 26.16 – Geomembrane Containment Barriers
2. Section 31 05 16 – Aggregates for Earthwork
3. Section 31 05 19.13 – Geotextile
4. Section 31 05 19.26 – Drainage Geocomposite
5. Section 33 00 10 – HDPE Pipe and Fittings

1.2 REFERENCES

A. Reference Standards:
1. ASTM International:
a. ASTM C88 – Standard Test Method for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
b. ASTM C535 – Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
c. ASTM 2487 – Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
d. ASTM D5084 – Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
e. ASTM D6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.

PART 2 PRODUCTS

2.1 LEACHATE COLLECTION PIPES (PERFORATED) WITHIN COMPOSITE LINED AREA

A. Pipe sizes and perforations as shown on the drawings.

B. HDPE pipe in accordance with Section 33 00 10 HDPE Pipe and Fittings.

2.2 BACKFILL AND BEDDING MATERIAL

A. Leachate collection pipe bedding stone will be supplied by the Contractor from an offsite stockpile and shall conform to the following:

1. Shall be hard, strong, durable particles free from seams, cracks and other structural defects, no limestone.
2. Washed and free from organic impurities and debris.
3. Rounded to subangular.
4. Free from organic impurities and debris.
5. Material shall not be frozen.
6. Material shall be washed.
7. Hydraulic Conductivity greater than or equal to 1 cm/sec.
8. Contractor is responsible for providing source testing results on all aggregates to Engineer. Testing frequency is one per source per material.
9. Gradation for bedding stone shall conform to the following:
   a. Coarse aggregate - 100% passing 1.5", 0% passing 3/4"
   b. Pea gravel - 85-95% passing 3/8", 5-15% passing #4, 0-2% passing #8

2.3 GEOTEXTILE

A. Provide geotextile in accordance with Section 31 05 19.13 Geotextile.

PART 3 EXECUTION

3.1 LEACHATE COLLECTION PIPES (PERFORATED)

A. Install geotextile as shown on the plans.
   1. Overlap geotextile according to the manufacturer's requirements.

B. Perforated pipe shall be laid with perforations down, oriented symmetrically about vertical centerline.

C. Bed and backfill pipe with bedding stone as shown on the plans and specified in 2.2 of this section.
   1. Compact bedding by hand around the lower 180° arc of pipe.
   2. Lightly hand tamp remainder of backfill.

D. Contractor to collect samples of delivered in-place filter layer and coarse aggregate and analyze for particle size analysis in accordance with ASTM D6913 at the Contractor’s expense.

3.2 PIPELINE DEBURRING AND CLEANING

A. All interior of HDPE pipe welds shall be deburred prior to cleaning. Where double-walled pipe is installed, the inner pipe shall be deburred prior to cleaning. Deburring shall be made part of the Contractor’s bid.

B. All leachate collection and transfer pipelines shall be cleaned after the pipelines are installed. Pipelines shall be jet cleaned in the direction from the pipes low point to high point. Contractor shall remove any debris from pipelines or manholes and dispose of all such material. Jetter truck shall provide a minimum pressure of 1800 psi at a minimum flow rate of 65 gpm. Contractor to submit a cleaning report to the Owner within 15 days of cleaning. Payment for pipeline cleaning shall be incidental and made part of the Contractor’s bid.

3.3 FIELD QUALITY CONTROL

A. Tests-Pipe Bedding
   1. A minimum of one sample per source of each bedding and filter material will be tested for Grain Size (ASTM D6913) and Classification (ASTM D2487).
   2. A minimum of one sample per source of each bedding or filter material shall be tested for hydraulic conductivity (ASTM D5084).
   3. A minimum of one sample per source of each bedding or filter material shall be tested for loss due to abrasion/impact in Los Angeles Rattler Test (ASTM C535).
   4. A minimum of one sample per source of each bedding or filter material shall be tested for loss due to Magnesium Sulfate Soundness Test (ASTM C88).
   5. Contractor shall pay for all retesting necessitated by failure of the as-installed bedding material to meet these specifications.

3.4 TOLERANCES

A. The elevation of the pipe shall not vary from the design elevation by more than +0,05 feet at each 25 foot interval. Positive drainage must be maintained at all locations.

END OF SECTION

SECTION 31 37 00

RIPRAP, ROCK LINING, AND EROSION CONTROL MATTING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Riprap

B. Related Requirements:
1. Section 31 20 00 – Earthworks
2. Section 31 23 16.13 – Trenching
3. Section 31 05 19.13- Geotextile
4. Section 31 25 00 – Sediment and Erosion Control

1.2 REFERENCES

A. Section 01 40 00 - Quality Requirements: Requirements for references.

B. American Society for Testing and Materials (ASTM):
1. C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
2. C127 - Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.
3. C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

1.3 SUBMITTALS

A. Section 01 30 00 - Administrative Requirements: Requirements for progress submittals.

B. Material Source: Inform ENGINEER of proposed source of riprap at least 14 days prior to commencing production, including any change in material source during performance of the Works.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

1.5 QUALITY ASSURANCE

A. Perform work of this Section in accordance with State of Iowa standards.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Section 01 50 00 - Temporary Facilities and Controls: Requirements for temporary controls.

B. Suspend operations whenever climatic conditions, as determined by ENGINEER, are unsatisfactory for placing riprap to the requirements of this Section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver, handle, and transport riprap at all times in a manner and with equipment that will prevent intermixing of riprap types, segregation, or contamination.

C. Stockpile riprap on the Site in locations approved by ENGINEER.

D. Minimize stockpiling requirements. Transport riprap from source directly to final position where possible.

E. Exercise care in loading, hauling, and unloading riprap to prevent crushing and splitting that would lead to rejection.

1.8 SEQUENCING AND SCHEDULING

A. Section 01 30 00 - Administrative Requirements: Requirements for coordination.

B. Riprap Ditch Lining: Place within two days of ditch excavation.

C. Riprap Slope Protection: Place within fourteen days geotextile placement.

PART 2 PRODUCTS

2.1 RIPRAP

A. Un-weathered, durable crushed or blasted igneous, metamorphic, or sedimentary rock.

B. Free from organic, mica, shale, or other unsuitable material.

C. Individual Rock Fragments: Hard, dense, sound, and resistant to abrasion and free of cracks, seams, and other structural defects that would tend to increase unduly their destruction by water and frost action and handling.

D. Do not use rock exhibiting marked deterioration by water or weather.

E. Bulk Specific Gravity of Rock Fragments: ASTM C127, minimum 2.6.

F. Maximum aspect ratio (greatest to least dimension) of any piece of riprap shall not be greater than 2.5 when measured on mutually perpendicular axes.

G. Gradation limits for riprap are in-place requirements. Make adjustment in production, transportation, and placement as necessary to ensure that placed materials are within specified range.

H. Iowa DOT Class D or E Revetment with the following gradation:

1.

Stone Size	Total Weight Larger
250 lbs.	0 %
90 lbs.	50% - 100%
50 lbs.	90% - 100%
1/2" Sieve	95% - 100%

I. Consist of sound and durable limestone, dolomite, or quartzite in accordance with AASHTO T 96.

J. Broken concrete rubble is not acceptable.

2.2 CONCRETE BLOCK EROSION CONTROL MATTING

A. Acceptable Products:
1. Concrete block Erosion Control Matting - Flexamat manufactured by Motz Enterprises, Inc. to be used as slope erosion protection and as permanent check dams as shown on Drawings.
2. Approved Equal.

2.3 BIODEGRADABLE EROSION CONTROL MATTING

A. Biodegradable erosion control matting underlay shall be a 12- to 18-month degradable excelsior blanket such as Curlex.

B. Approved Equal.

2.4 TURF REINFORCEMENT MAT (TRM):

A. Acceptable Products: North American Green (NAG) C350.

B. Approved Equal.

PART 3 EXECUTION

3.1 EXAMINATION

A. Execution Requirements: Verification of existing conditions before starting work.

B. Do not place riprap over frozen or spongy subgrade surfaces.

C. Confirm geotextile placed in conformance with Section 31 05 19.13.

3.2 PLACEMENT OF RIPRAP

A. Place riprap by suitable methods to ensure minimum breakage of individual pieces during placing.

B. Ensure riprap does not mix with or damage foundation material, including geotextile fabric.

C. Place riprap in a uniform layer, thickness shall be as indicated on the Contract Drawings. Minimum thickness shall be 12 inches, unless otherwise indicated by the ENGINEER.

D. Place riprap in an approved manner to secure the surface and to provide a stable mass.

E. Uniformly distribute larger rock over the entire area and distribute the remainder uniformly with smaller pieces filling voids between larger pieces.

F. Finish surfaces in such a manner so as to ensure they are stable, reasonably uniform, free from bumps or depressions, with no excessively large cavities below or individual rock pieces projecting above the general surface.

G. Where riprap is to be placed on slopes, excavate a trench at toe of slope in accordance with dimensions shown on the Drawings.

H. Where riprap is to be placed on slopes, install toe protection first and continue upslope. Toe protection shall be installed by the following actions:
   1. Excavate at the base of slope in accordance with Drawing dimensions
   2. Place geotextile with enough extra to wrap around the entire toe stone
   3. Lay half of riprap into excavation
   4. Wrap geotextile around placed stone
   5. Place remaining riprap on top of geotextile end section
   6. Continue placing stone upslope

I. Riprap may be placed in location by equipment; however, take care in placing to obtain a good gradation of materials so that the riprap will be firm and solid. Level surfaces to the required alignment and slopes by hand placing the stone so as to fill large voids and to make the surface even.

J. Place riprap as shown on the Drawings.

3.3 PLACEMENT OF EROSION CONTROL MATTING

A. Subgrade Preparation
   1. Subgrade surface shall be free of any debris, protrusions, rocks, sticks, roots or other hindrances which would result in an individual block being raised more than 3/4 inch above the adjoining blocks. With the exception of the anchor trench, subgrade underneath matting shall be three inches lower than any adjacent surface grade for smooth flow transition.

B. Panel Seaming
   1. Panel seams (Channel and Slopes) perpendicular to the hydraulic flow must be overlapped. The downstream panels will be placed under the upstream panel by overlapping 18 inches. If no hydraulic or overland flow is expected, butting the seams together is acceptable.

C. Anchoring
1. Erosion control matting shall have an 18 inch toe-in at edges perpendicular to concentrated hydraulic flow. For areas exposed to surface sheet flow, recess the mat 12 inches.

D. Maintenance
1. Inspect at regular intervals and after storm events. Mow and fertilize vegetation. Do not maintain with grass killing chemicals. Remove sediment buildups in any swales or outlets.

3.4 PLACEMENT OF TURF REINFORCEMENT MAT (TRM)

A. Subgrade Preparation:
1. Prepare soil before installing rolled TRM including any necessary application of lime, fertilizer, and seed.

B. Installation:
1. Begin at the top of the channel. Roll center TRM in direction of water flow in the bottom of channel. TRM will unroll with appropriate side against soil surface. TRM must be securely fastened to soil surface by placing staples/stakes in appropriate locations as shown in the manufacturer's installation guide.
2. Place consecutive TRM end over end (shingle style) with a 4-6 inch overlap. Use a double row of staples staggered 4-inches apart and 4 inch on center to secure the TRM.
3. Adjacent TRM must be overlapped 2-5 inches and stapled.

C. Anchoring:
1. The terminal end of the TRMs must be anchored with a row of staples/stakes approximately 12 inches apart in a 6-inch deep by 6-inch wide trench. Backfill and compact the trench after stapling.

3.5 TOLERANCES

A. Maximum Variation from Finished Elevation: Plus or minus 0.1 foot.

B. Maximum Variation from True Position: Plus or minus 0.5 foot.

END OF SECTION

SECTION 32 31 56

WILDLIFE DETERRENT FENCE

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. Application/Installation of Measures.

B. Removal/Replacement of Measures.

1.2 DESCRIPTION OF WORK:

A. Relocate existing wildlife deterrent fence as described in Contract Documents. Coordinate with ENGINEER minimum of one week prior to initiating work to allow for clearance of sensitive species.

B. Reuse existing materials where possible and furnish all other materials necessary; install, construct, and remove specified wildlife deterrent devices at locations specified in the Contract Documents, or where specified by the ENGINEER. The objective is to deter the entry of threatened and endangered species into the construction area and provide for escape from the construction area via one-way funnels. Protected species documented in the area include the Yellow Mud Turtle (*Kinosternon flavescens*), Western Hognose Snake (*Heterodon nasicus*), and Ornate Box Turtle (*Terrapene ornata*).

C. Prior to removal and subsequent relocation of wildlife deterrent fence, mow a minimum 10-foot wide strip for placement of wildlife deterrent fence shown on the Drawings to a height of 6 inches or less.

D. Carefully remove existing wildlife deterrent fence and fasteners for reuse during reinstallation of the wildlife deterrent fence. Backfill and compact trench following removal of wildlife deterrent fence.

E. Complete the required construction work on this project, while minimizing soil erosion and controlling water pollution.

F. CONTRACTOR shall reuse existing materials to the extent possible. OWNER will provide up to an additional four 150-foot rolls of ERTEC EF30 black wildlife deterrent fence and necessary fasteners if additional material is needed. T-posts shall be provided by CONTRACTOR.

1.3 SUBMITTALS

CONTRACTOR shall submit manufacturer’s information on the physical properties of the wildlife deterrent fence and appurtenances and the geotextile fabric if new materials are supplied by CONTRACTOR.

1.4 SUBSTITUTIONS

Contractor shall submit for ENGINEER's approval information on any proposed substitutes. Substitutes shall be subject to review and approval or denial by ENGINEER. Substitutes shall be approved by ENGINEER prior to use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. During all periods of shipment and storage, the fabric shall be maintained by wrapping in a heavy duty protective covering to protect the fabric from damage including from direct sunlight, ultraviolet rays, mud, dirt, dust, and debris.

B. Materials shall be inspected by Contractor upon delivery and accepted for use only if free of defects or flaws which significantly affect its physical properties.

C. The Contractor shall be responsible for care and storage of materials delivered to the work site or purchased for use. Material delivered to the work site and damaged before actual incorporation in the work may be rejected by the ENGINEER even though it may have been previously acceptable. Stored materials shall be located to facilitate thorough inspections, to minimize environmental damage, and not interfere with operations.

D. All materials not conforming to the requirements of the specifications at the time they are to be used shall be considered unacceptable, and all such materials will be rejected and shall be removed immediately from the work site unless otherwise instructed by the ENGINEER. No rejected material, the defects of which have been corrected, shall be used until approval has been given by the ENGINEER.

1.6 SCHEDULING AND CONFLICTS

A. Timing of wildlife deterrent fence installation:
   1. Fencing must be installed prior to any ground disturbing activities (including clearing and grubbing) and typically during the species' inactive period.
   2. Preferred Installation Schedule: between November 1 and April 1, during unfrozen soil conditions.
      a. The specific installation dates shall be coordinated with the ENGINEER and wildlife deterrent fence alignment and details shall be inspected and approved by ENGINEER prior to installation.
   3. Between April 1 and November 1, with the installation schedule to be approved by ENGINEER and subject to soil temperature and site conditions prior to start of work.
      a. The specific installation dates shall be coordinated with the ENGINEER and wildlife deterrent fence alignment and details shall be inspected and approved by ENGINEER prior to installation.
      b. Wildlife deterrent fence installation shall only be completed after a preconstruction survey of the construction zone for sensitive species has been performed by ENGINEER.

1.7 SPECIAL REQUIREMENTS

A. Protection of Property: Prevent accumulation of soil, sediment, or debris from project site onto adjoining public or private property. Remove any accumulation of soil or debris immediately, and take remedial actions for prevention.

B. Permit Compliance: Conduct all operations in compliance with the Iowa DNR NPDES General Permit No. 2.

PART 2 PRODUCTS

2.1 WILDLIFE DETERRENT FENCE

A. Fabric: ERTEC 30-inch E-Fence™ Polymer Matrix (black) or equivalent as pre-approved by ENGINEER.

B. Posts: 5-foot minimum steel (t-section) weighing at least 0.95 pounds per foot, exclusive of anchor plate. Painted posts are not required.

C. Fasteners:
1. 14-gauge galvanized guide wire.
2. 18-gauge galvanized wire, or black UV-rated plastic ties with a minimum tensile strength of 50 pounds and a minimum length of 8 inches.
3. E-Fence™ guide wire crimp ties or equivalent as pre-approved by ENGINEER.

2.2 SWING GATE EXCLUSION PANELS

A. Fabrics:
1. Barrier Panel: ERTEC High Visibility Orange 30-inch E-Fence™ Polymer Matrix or equivalent as pre-approved by ENGINEER.
2. Ground Sweep: Heavy geotextile continuously attached to exclusion panel.

B. Posts: 5-foot minimum steel (t-section) weighing at least 1.25 pounds per foot, exclusive of anchor plate. Painted posts are not required.

C. Fasteners: 18-gauge galvanized wire, or black UV-rated plastic ties with a minimum tensile strength of 50 pounds and a minimum length of 8 inches.

D. Weights: 4x4-inch #2 pressure-treated timber.

2.3 INTEGRATED SEDIMENT CONTROL PANELS

A. Filter Materials: ERTEC Sediment Control Filter (SF12) or equivalent as pre-approved by ENGINEER.

B. Posts: Wooden stakes (1x2x18-inch).

C. Fasteners:
1. 18-gauge galvanized wire, or black UV-rated plastic ties with a minimum tensile strength of 50 pounds and a minimum length of 8 inches.
2. 1-inch drywall screws.

2.4 ONE-WAY FUNNELS

A. Dimensions:
1. Entrance: 8.5x8.5-inch
2. Exit: 2.5x2.5-inch
3. Exit Door: Mylar: 2.5x3.5-inch

B. Fasteners: 18-gauge galvanized wire, or black UV-rated plastic ties with a minimum tensile strength of 50 pounds and a minimum length of 8 inches.

PART 3 EXECUTION

3.1 PRE-INSTALLATION PREPARATION

A. Mowing:
1. Prior to installation of wildlife deterrent fence, mow the area shown on the Drawings to a height of 6 inches or less.

3.2 WILDLIFE DETERRENT FENCES

A. Installation:
1. Install material along the contour of the ground, as specified in the contract documents, or as directed by the ENGINEER.
2. Install wildlife deterrent fence with a mechanical soil slicing machine that creates a slit in the ground while simultaneously installing the fabric or excavate a trench of a minimum 4 inches wide and a minimum of 6 inches deep. In areas specified by ENGINEER, attach wildlife deterrent fence to existing chain-link fence.
3. Drive 5-foot-length steel t-posts (0.95 pounds per foot minimum) into the ground along the center of the trench, to a minimum depth of 18 inches (with 12 inches below the bottom of trench), at 8-foot on center (OC) spacing or more frequently as required to adequately support fence.
4. Insert barrier material into trench and tie off to posts. Fencing to be installed with 24 inches of material above grade and 6 inches below grade; at least 4 inches shall be trenched into the soil and at least 20 inches shall extend above grade. In areas where the wildlife deterrent fence is to be attached to existing chain-link fence, remove loose gravel for burial of wildlife deterrent fence a minimum of 4 inches below gravel surface. Add additional gravel as needed to achieve 4-inch burial depth. Compact gravel against the wildlife deterrent fence for its entire length to prevent animals from passing under the fence.
5. Fencing must be installed with the fence stakes placed on the construction side of the fence (this is typically opposite the normal requirement for sediment control) to prevent animals from using the stakes to maneuver over the fencing and into the disturbance area. Zip tie (8-inch) or wire tie fence to every post with two ties, one at the top and one at mid-height.

6. Wildlife deterrent fence must be installed in continuous lengths (150-foot rolls). Do not cut segments into shorter lengths unless necessary due to sudden changes in elevation or to accommodate gate locations. Overlap sections 8 inches minimum. Sew sections together vertically with 18-gauge galvanized wire or black UV-rated plastic ties to eliminate all possible gaps.
7. Guide Wire: Using 14-gauge galvanized wire, wrap once around each t-post 3 to 4 inches from top of fence and hand-tension from post to post. Crimp E-Fence™ ties to guide wire at least every 3.3 feet.
8. Construct a “turn-around” at the ends and at any access openings needed in the fencing, in order to redirect animals away from openings. “Turn-arounds” shall be approximately 10 feet in length with 12-inch to 18-inch openings.
9. Backfill trench with trench spoils. Soils must be carefully compacted against both sides of the fence for its entire length to prevent animals from passing under the fence. Backfill on sensitive habitat side first to push wildlife deterrent fence against t-posts, then backfill construction side.

B. Removal:
1. Remove the wildlife deterrent fence and posts as directed by ENGINEER.
2. Roll undamaged segments of wildlife deterrent fence for future use of OWNER. Rolls shall not exceed 150 linear feet of fencing each. Move to OWNER-designated location on site.
3. As directed by ENGINEER, recycle or dispose offsite of wildlife deterrent fence not designated for re-use.
4. Remove sediment or spread to match finished grade; ensure proper drainage.
5. Stabilize the area disturbed by removal operations.

3.3 SWING GATE EXCLUSION PANELS

A. Installation:
1. Panel Alignment (view towards construction site):
   a. The left side panel length is equal to the left gate panel length plus 2 feet. Align the hard edge side of panel with the center of the gate such that all of the 2-foot overlap extends over the hinge. Align hard edge bottom of panel with bottom of gate.
   b. The right side panel length is equal to the right gate panel length plus 4 feet. Center the panel on the gate such that a 2-foot overlap occurs at both the hinge and the latch side of the gate. Align hard edge of panel bottom with bottom of gate.
   c. Attach panels to gates using black UV-rated zip ties (8-inch) or 18-gauge galvanized wire.
2. Ground Sweep:
   a. Attach heavy geotextile to the bottom of the barrier panel using black UV-rated zip ties (8-inch) or 18-gauge galvanized wire.
   b. Ground Sweep shall lie horizontal on-grade at least 10 inches.
   c. Secured to ground when gates are closed using weights (e.g., lumber, UV-rated sand bags). Contractor to provide 4x4-inch #2 pressure-treated timbers (or ENGINEER-approved substitute) as weights for continuous coverage of swing gate ground sweeps with 1 foot of extension past each end of ground sweep.
   d. Add road gravel as needed at swing gate to provide level surface for proper placement of ground sweep. Gravel to be compacted by repeated tracking with vehicles to provide proper compaction.

B. Removal:
1. Remove the swing gate exclusion panel as directed by ENGINEER.
2. Remove and dispose of swing gate exclusion panel and posts.
3. Remove sediment or spread to match finished grade; ensure proper drainage.
4. Stabilize the area disturbed by removal operations.

3.4 INTEGRATED SEDIMENT CONTROL PANEL

A. Installation:
1. May be installed at the same time as wildlife deterrent fence. Sediment control is not required everywhere wildlife deterrent fence is installed. Install on downstream side of project only or at low points where water could flow towards the perimeter.
2. Always install sediment control panel on side away from sensitive habitat (on construction side).
3. Insert sediment control panel at base of fence. Wooden stakes (1x2x18-inch) are to be used to support the sediment control panels in between wildlife deterrent fence posts. Place stakes in between t-posts.
4. Attach with zip tie (8-inch) at t-posts through the sediment control panel, and attach with drywall screws (1-inch) at wood stakes. Using 16-gauge galvanized wire, tie the sediment control panel to the wildlife deterrent fence on 4-foot centers, minimum.
5. Backfill trench with trench spoils. Soils must be carefully compacted against both sides of the fence for its entire length to prevent animals from passing under the fence. Backfill on sensitive habitat side first to push wildlife deterrent fence against t-posts, then backfill other side.

B. Removal:
1. Remove the integrated sediment control panel as directed by ENGINEER.
2. Remove and dispose of integrated sediment control panel and posts.
3. Remove sediment or spread to match finished grade; ensure proper drainage.
4. Stabilize the area disturbed by removal operations.

3.5 ONE-WAY FUNNEL

A. Installation:
1. Install one-way funnels as shown on Drawings or as otherwise specified by ENGINEER.
2. Install funnels with entrance on construction side and exit on non-construction side.
3. Where possible, locate funnels near segment ends to minimize waste during re-use.
4. Attach funnel to wildlife deterrent fence with black UV-rated zip ties or 18-gauge galvanized wire. Close all gaps. Funnel entrance at ground level. Exit ground clearance 1-inch minimum.

B. Removal:
   1. Remove the one-way funnel upon as directed by ENGINEER.
   2. Remove and dispose of one-way funnel.
   3. Remove sediment or spread to match finished grade; ensure proper drainage.
   4. Stabilize the area disturbed by removal operations.

END OF SECTION

SECTION 32 92 19

SEEDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Seeding.
   2. Hydroseeding.
   3. Mulching.

B. Related Requirements:
   1. Section 31 20 00 - Earthwork.
   2. Section 31 23 16.13 - Trenching.
   3. Section 31 25 00 - Sediment and Erosion Control.

1.2 REFERENCES

A. Definitions:
   1. Weeds: vegetative species other than specified species to be established in given area.

B. Reference Standards:
   1. Section 01 40 00 - Quality Requirements: Requirements for references.

1.3 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data for seed mix, mulch, and other accessories. Provide fresh, clean, new crop, certified seed complying with tolerance for germination and purity and free of poa annua, bent grass, and noxious weed seed. Furnish all seeds, including grass, legume, forbs, and cereal crop seeds, from an established seed dealer or certified seed grower. All materials and suppliers are to follow Iowa Seed Law and Iowa Department of Agriculture and Land Stewardship regulations, and be labeled accordingly. Provide native grass and forbs that are source-identified as G0-Iowa certified "yellow tag," when available. If G0-Iowa certified "yellow tag" sourced seed is unavailable, or is only available from a single source, a substitution may be approved by the Engineer. Submit a mechanically printed “yellow tag” for all seed mixes.

C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for closeout submittals.

1.5 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Documentation for origin certification of native seeds shall accompany all shipments and shall be identified on the tags as well. Origin shall be clearly identified on the seed label for all native grass and forb seed.

C. Mulch must be certified as specified in this Section to be free of noxious weed seeds, seed bearing stalks, and/or other reproductive propagules in accordance with the North American Invasive Species Management Association (NAISMA) standards.

1.6 QUALIFICATIONS

A. Seed Supplier: Company specializing in manufacturing products specified in this Section with minimum 3 years of experience.

B. Installer: Company specializing in performing the work of this Section with minimum 3 years of experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Supplier List:
   1. Shooting Star Native Seeds, 20740 County Road 33, Spring Grove, MN 55974. Phone: 1 (888) 983-3670
   2. Substitutions: Contractor shall submit for ENGINEER’s approval information on any proposed substitutes. Substitutes shall be subject to review and approval or denial by ENGINEER. Substitutes shall be approved by ENGINEER prior to use.

B. **Seed Mixture A**: Cover and other areas designated for dry prairie establishment on disturbed areas with sandy soils.

Guild	Scientific Name	Common Name	Seeds/sq ft	Rate (lbs/ac)	% Mix (by sf)	% Mix (by wt)
Cover	Triticum aestivum	Winter Wheat	25.70	100.00		
Total Guild			25.70	100.00	28.48%	91.04%
Forb	Asclepias verticillata	Whorled Milkweed	0.10	0.02		
	Coreopsis palmata	Bird's Foot Coreopsis	0.21	0.06		
	Geum triflorum	Prairie Smoke	0.10	0.01		
	Liatris aspera	Rough Blazing Star	0.25	0.04		
	Monarda punctata	Horsemint	1.42	0.04		
	Oligoneuron rigidum	Stiff Goldenrod	0.83	0.06		
	Penstemon grandiflorus	Large-flowered Beard Tongue	0.32	0.06		
	Rudbeckia hirta	Black-eyed Susan	10.32	0.31		
	Solidago speciosa	Showy Goldenrod	2.00	0.06		
	Symphyotrichum ericoides	Heath Aster	2.58	0.04		
	Symphyotrichum oolentangiense	Skyblue Aster	1.26	0.04		
	Viola pedatifida	Bearded Birdfoot Violet	0.14	0.01		
	Zizia aptera	Heart-leaved Alexanders	0.20	0.05		
Total Guild:			19.83	0.86	21.98%	0.78%
Graminoid	Bouteloua curtipendula	Side-oats Grama	4.00	1.82		
	Bromus kalmii	Kalm's Brome	4.00	1.36		
	Koeleria macrantha	Junegrass	6.00	0.08		
	Panicum virgatum	Switchgrass	8.00	1.56		
	Schizachyrium scoparium	Little Bluestem	18.00	3.27		
	Sporobolus cryptandrus	Sand Dropseed	1.80	0.02		
	Sporobolus heterolepis	Prairie Dropseed	1.00	0.17		
Total Guild			42.80	8.28	47.43%	7.54%
Legume	Astragalus canadensis	Canada Milk Vetch	0.40	0.06		
	Chamaecrista fasciculata	Partridge Pea	0.39	0.39		
	Dalea purpurea	Purple Prairie Clover	1.10	0.20		
	Lupinus perennis	Wild Lupine	0.02	0.04		
Total Guild:			1.91	0.70	2.11%	0.64%
Total Seed Mix:			90.24	109.84		

C. **Seed Mixture B.** Stormwater pond floor and interior berms, temporarily flooded dry ponds and temporarily flooded ditch bottoms.

Guild	Scientific Name	Common Name	Seeds/sq ft	Rate (lbs/ac)	% Mix (by sf)	% Mix (by wt)
Cover	Triticum aestivum	Winter Wheat	12.85	50.00		
Total Guild			12.85	50.00	7.04%	82.70%
Forb	Anemone canadesis	Canada Anemone	0.20	0.07		
	Asclepias incarnata	Marsh Milkweed	0.20	0.11		
	Bidens frondosa	Leafy Beggarticks	0.20	0.11		
	Doellingeria umbellata	Flat-topped Aster	1.50	0.06		
	Eutrochium maculatum	Spotted Joe Pye Weed	2.19	0.06		
	Helenium autumnale	Autumn Sneezeweed	5.97	0.13		
	Physostegia virginiana	Obedient Plant	0.30	0.07		
	Rudbeckia laciniata	Tall Coneflower	0.37	0.07		
	Symphyotrichum novae-angliae	New England Aster	1.56	0.07		
	Verbena hastata	Blue Vervain	1.85	0.05		
	Zizia aurea	Golden Alexanders	0.79	0.20		
Total Guild:			15.13	1.00	8.29%	1.65%
Graminoid	Andropogon gerardii	Big Bluestem	7.35	2.00		
	Bromus ciliatus	Fringed Brome	8.10	2.21		
	Calamagrostis canadensis	Bluejoint	6.40	0.06		
	Elymus trachycaulus	Slender Wheatgrass	2.53	1.25		
	Elymus virginicus	Virginia Wild Rye	2.31	1.50		
	Panicum virgatum	Switchgrass	1.93	0.38		
	Poa palustris	Fowl Bluegrass	50.70	1.06		
	Sorghastrum nutans	Indian Grass	0.55	0.12		
	Spartina pectinata	Prairie Cordgrass	0.91	0.38		
Total Guild			80.78	8.96	44.25%	14.82%
Sedge	Carex stipata	Common Fox Sedge	3.10	0.25		
	Scirpus atrovirens	Dark Green Bulrush	31.70	0.19		
	Scirpus cyperinus	Woolgrass	39.00	0.06		
Total Guild			73.80	0.50	40.43%	0.83%
Total Seed Mix:			182.56	60.46		

D. **Seed Mixture C.** Areas requiring temporary soil stabilization.

Guild	Scientific Name	Common Name	Seeds/ sq ft	Rate (lbs/ac)	% Mix (by sf)	% Mix (by wt)
Cover	Avena sativa	Oats	7.1	16	12.18	40
	Lolium italicum	Annual Rye	44.1	8	75.64	20
	Regreen©	Regreen©	7.1	16	12.18	40
Total Seed Mix:			58.3	40	100.00	100

Note:
PLS = Pure Live Seed

E. Cover Crop
1. Cover crops are included as a component of the seed mixes. Oats and winter wheat shall be selected based on the time of year that the mix is being used. Oats shall be included in mixes during spring and summer. Winter wheat shall be used for fall seeding.

F. Hydroseeding
1. Apply seed at twice the manufacturer's recommended application rate.

2.2 ACCESSORIES

A. Mulching Material: Oat, wheat, or native grass straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

B. Herbicide: Appropriate herbicide for weeds, if present.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 70 00 - Execution and Closeout Requirements: Verification of existing conditions before starting work.

B. Verify that prepared soil base is ready to receive the work of this Section.

3.2 SEEDING AND MULCHING

A. Inspect for noxious weeds – if present apply appropriate herbicide to weed-infested areas.

B. Lightly rake to remove any remaining thatch or debris on the soil surface.

C. Lightly harrow to expose mineral soil.

D. Broadcast seed over site with a gravity seeder, endgate, or cyclone seeder.

E. For small areas, a hand-operated cyclone seeder may be used.

F. Following placement of seed, make at least one pass over the seeded area with a roller or cultipacker to firm the soil.

G. Mulch all seeded areas the same day the seed is sown. Uniformly distribute the mulch over the seeded area at a rate of 1.5 tons/acre of clean, weed-free dry cereal straw, or native grass straw.

H. Use a mulch crimper, or an equivalent disk-type mulch-anchoring tool with cutaway straight disks that are weighted sufficiently, so as to be capable of punching the mulch vertically 2 to 3 inches into the seedbed. Hand methods of crimping may be used on small areas, or where equipment cannot safely operate to perform the work required.

I. Do not seed areas in excess of that which can be mulched on the same day.

J. Planting Season: Native grass/forb and cover crop seed shall be dormant seeded after soil temperatures are 40 degrees Fahrenheit or lower (approximately November 1) and before soil freeze-up and/or snow cover.

K. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 miles per hour.

3.3 HYDROSEEDING

A. Measure and stake area.

B. Mix seed at twice recommended rate and apply seed according to recommended methods.

C. Do not leave seeded surfaces unprotected, especially if precipitation is imminent.

END OF SECTION

SECTION 33 00 10

HDPE PIPE AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Piping, fittings, and cleanouts for leachate collection system.
2. Piping and fittings for leachate collection system pump risers.
3. Piping, fittings, and cleanouts for leachate forcemain.

1.2 REFERENCES

A. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. American Society for Testing and Materials:
a. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
b. ASTM D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
c. ASTM D1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique.
d. ASTM D1598 – Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
e. ASTM D1599 - Standard Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
f. ASTM D2122 - Standard Test Method for Determining Dimension so Thermoplastic Pipe and Fitting.
g. ASTM D2290 – Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe.
h. ASTM D2274 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
i. ASTM D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
j. ASTM D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
k. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

1.3 SUBMITTALS

A. Product Data:
1. Piping and fitting dimensions including test reports and material property sheets.
2. Copies of pressure test results on solid wall pipe.
3. Acknowledgement that products submitted meet requirements of standard referenced.

B. Manufacturer's Instructions: Indicate special procedures required to install products specified.

C. Manufacturer's Certificate: Quality control certificates pertaining to each lot of pipe produced.

D. Qualification Statements: Submit manufacturer experience qualifications.

E. Quality Assurance/Control Submittals
   1. Certification that the tests required by this specification section were performed and meet the stated minimum requirements.
   2. Evidence from the pipe manufacturer that the personnel completing joints are qualified to perform the thermal butt fusion.
   3. Manufacturer’s written instructions regarding handling, delivery, storage, jointing, pipe fittings, and installation.

1.4 QUALITY ASSURANCE

A. Pipe shall be available to Owner’s representative for inspection.

B. Material manufacturer, pipe diameters, and pressure classes shall not be mixed.

C. Personnel completing the joints shall be certified by the pipe manufacturer as being qualified to perform the thermal butt fusion.

D. Coordinate flange dimensions, couplings, and drilling between piping and equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Upon delivery, inspect pipe and fittings for damage, cracks, holes, or foreign inclusions.

B. Deliver and store piping with labeling in place. Store pipe and accessories on flat, level ground with no rocks or other objects under the pipe.

C. Check date of production to verify the pipe will be installed withing six months of date of production.

D. Deliver, store, and handle pipe according to applicable requirements of specified references, manufacturer's instructions, and as specified herein.

E. Use every precaution to prevent damage to the pipe. Do not permit metal tools or heavy objects to unnecessarily come in contact with pipe.

PART 2 PRODUCTS

2.1 MATERIALS

A. Pipe Sizes 4 inch and Larger
   1. Pipe and fittings shall be high density polyethylene (HDPE) meeting AWWA C906 standards.

2. Materials used for the manufacture of the HDPE pipe and fittings shall be made from a PE 3408 resin compound meeting the minimum cell classification of PE 345434C in accordance with ASTM D3350 and the hydrostatic design basis of 1,600 psi determined in accordance with ASTMD2837.
3. Provide outside diameter of nominal size shown on the Drawings or stated in the Bid Schedule.
4. Provide pipe with a dimension ratio (DR) of 17, pressure class 160 unless stated otherwise on the Drawings or in the Bid Schedule.
5. Pipe shall be installed within 6 months of the production date.

B. Pipe Sizes 1.5 inches Through 3 inches
1. Pipe and fittings shall be high density polyethylene (HDPE) meeting AWWA C901 standards.
2. Materials used for the manufacture of the HDPE pipe and fittings shall be made from a PE 3408 resin compound meeting the minimum cell classification of PE 345434C in accordance with ASTM D3350 and the hydrostatic design basis of 1,600 psi determined in accordance with ASTM D2837.
3. Provide outside diameter based straight pipe of nominal size shown on the Drawings or stated in the Bid Schedule.
4. Provide pipe with a dimension ratio (DR) of 17, pressure class 160 unless stated otherwise on the Drawings or in the Bid Schedule.
5. Pipe shall be installed within 6 months of the production date.

C. Fittings
1. Fittings shall meet the requirements of AWWA C901 or AWWA C906 whichever applies.
2. Fittings for pipe greater than 3 inches diameter shall be HDPE molded fittings and HDPE fabricated fittings of the same equivalent dimension ratio, pressure rating and outside diameter as the connecting pipe.
    a. The pipe manufacturer shall mold or fabricate and supply all HDPE molded fittings, fabricated fittings, accessories and adapters required to perform the Work. No Contractor fabricated fittings shall be used.
    b. Molded fittings shall be manufactured with thermal butt-fused joints meeting the requirements of ASTM D3261.
    c. Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings.
3. Fittings for pipe 3 inches diameter or less shall be capable of restraining PE pipe from pullout with the same pressure class as the connecting pipe,
    a. Provide metal compression connections with ferrule and compression nut.
    b. Provide a stainless steel insert stiffener to insert inside the tube.
    c. Insert fittings shall not be used.

2.2 Pipe Identification

A. Mark the pipe and fittings with the appropriate standard AWWA C901 or AWWA C906 whichever is applicable to affirm the product was manufactured, inspected, sampled, and tested in accordance with the standard.

B. Pipe and fittings shall be marked with the following at intervals between markings of no greater than 5 feet:
1. Nominal size and OD base of DIOD.
2. Standard material code designation of PE 3408.
3. Dimension ratio.

4. Pressure class.
5. AWWA C901 or AWWA C906, whichever is applicable.
6. Manufacturer's production code to include day, month, year produced.

2.3 Joints

A. HDPE Pipe and Pipe Fittings Greater than 3 inches Diameter
1. Pipe and pipe fittings shall be designed for joining by thermal butt fusion.
2. Joining method shall be capable of conveying water at the pressure designated by the pressure class.
3. Joints shall be pipe end to pipe end and pipe end to fitting.

B. HDPE Pipe 3 inches Diameter and Less.
1. Provide compression connection to the HDPE pipe to metal fitting.
2. Provide threaded adaptor fittings with joint tape for connection from HDPE pipe to threaded fittings of different material.

C. Transition from HDPE to Steel Pipe or PVC Pipe
1. Provide a molded flange connector adapter with a ductile iron back-up flange for making flange to flange connection. If the connecting pipe is plain end then use an EBAA Iron Inc. Megaflange 2100 Restrained Flange Adaptor on the connecting pipe.
2. For buried connections use a mechanical joint connection adaptor with a mechanical joint flange backup connecting to a mechanical joint pipe ductile iron pipe and when connecting to a plain end PVC pipe provide ah EBAA Iron Inc. use the series 15PF00 for Restraint for C900 PVC Pipe.
   a. Provide extended T-bolts for the connection.
   b. Provide stainless steel stiffener inserted in the pipe.
3. From the transition joint pipe restrains shall be provided at all joints within the following distances of the transition joint:
   a. 6 inch diameter pipe – 15 linear feet.
   b. 8 inch diameter pipe – 19 linear feet.
   c. 10 inch diameter pipe – 24 linear feet.
   d. 12 inch diameter pipe – 28 linear feet.
   e. 14 inch diameter pipe – 33 linear feet.
   f. 16 inch diameter pipe – 36 linear feet.

2.4 SOURCE QUALITY CONTROL

A. Contractor shall submit manufacturing test data performed on the production pipe:
1. Measurement of pipe dimensions in accordance with ASTM D2122.
   a. Pipe dimensions shall be within the tolerances stated in AWWA C906 or AWWA C901 whichever is applicable.
   b. Wall thickness variability in any diametrical cross section of the pipe shall not exceed 12%.
   c. The outside diameter measured at the cut-end of the pipe length shall not be more than 1.5% smaller than the average outside diameter specified in AWWA C906 or AWWA C901, whichever is applicable, when measured at any point not closer than 12 inches to the squarely cut-end of the pipe length.

2. Thermal stability of a pipe specimen from mid-wall area in accordance with the method described in ASTM D3350. The minimum induction temperature shall be 220°C.
3. Ring-tensile strength test of pipe specimens tested in accordance with ASTM D2290. Tensile strength shall be not less than 2,900 psi.
4. Quick burst test of pipe specimens in accordance with ASTM D1599. The test pressure at failure shall not be less than that which results from the minimum hoop stress value of 2,900 psi.
5. Elongation at break test of five pipe specimens cut equally spaced around the circumference of the pipe in the longitudinal direction tested in accordance with ASTM D638 using a cross-head separation of 2 inches per minute. The elongation at break for each test specimen shall not exceed 400%.
6. Five-second pressure test of a section of pipe tested in accordance with ASTM D1598. The pipe shall not burst, crack, spit, or otherwise fail a test pressure four times the pipe pressure class applied for five seconds. This test is also required for fittings.
7. Melt index of pipe specimens tested in accordance with ASTM D1238. The resultant index shall be less than 0.15.
8. Density of pipe specimens tested in accordance with ASTM D2839. The result shall be minimum 0.955 grams per cubic centimeter.
9. Bend-back test in accordance with AWWA C901 or AWWA C906 whichever is applicable. Any indication of cracking or crazing shall reject the pipe.

B. Test the PE compounds by an accredited testing agency in accordance with the applicable requirements of NSF No. 14 to demonstrate the materials are suitable for use with potable water.

PART 3 EXECUTION

3.1 HDPE PIPE INSTALLATION

A. In addition to the applicable sections for installing piping, conform to the following:
1. Thermal butt fuse all joints as per ASTM D3261.
2. Utilize certified personnel for jointing operation.

B. Provide, install, and connect pipe and fittings at locations shown on Drawings and according to manufacturer's directions.

C. Place warning tape in trench directly over buried piping.

D. Inside of pipes shall be thoroughly cleaned to remove all accumulated debris.
1. For fabricated HDPE pipe ensure all grindings are completely removed; removal includes cutting attached to pipe.
2. Remove beads greater than 1/8 inch on inside of 18 inch leachate extraction riser and perforated leachate collection lines.

END OF SECTION

SECTION 33 05 13.19

HIGH DENSITY POLYETHYLENE (HDPE) MANHOLES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. CONTRACTOR shall furnish all labor, materials, equipment, and incidentals required to furnish and install all precast concrete manholes and structures as shown, specified and otherwise required to complete the Work.
2. The Work includes, but is not limited to the following:
a. HDPE manholes.
b. Bedding and cover materials.

B. Structures shall conform in shape, size, dimension, material, and other respects to the details shown or as ordered by the ENGINEER.

C. Related Requirements:
1. Section 31 05 16 - Aggregates for Earthwork: Bedding fill type.
2. Section 31 23 16.13 - Excavation: Excavation requirements for manholes.

1.2 REFERENCES

A. Definitions:
1. Bedding: Specialized material placed under manhole prior to subsequent backfill operations.

B. Reference Standards:
1. Section 01 40 00 - Quality Requirements: Requirements for references.
2. ASTM International:
a. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
b. ASTM A536 - Standard Specification for Ductile Iron Castings.
c. ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
d. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

1.3 SUBMITTALS

A. Provide detailed shop drawings, product data, and other information as required to demonstrate compliance with the specifications.

B. Submittals for the HDPE manhole must include, at a minimum:
1. Certification that the HDPE meets the material specification.
2. Drawings showing inlets, outlets, and overall dimensions along with all special features (manways, ladders, etc.).

3. Design values and calculations for:
   a. Ring compressive strain
   b. Combined ring compressive and ring bending strain
   c. Ring buckling
   d. Axial strain
   e. Axial buckling
4. Thickness at the bottom of the manhole section based on stress deflection.
5. Written quality assurance program for fabricating thermoplastic structures.
6. Testing documentation the manhole is leak free. Include date of test, testing personnel, testing methods used, and results.

PART 2 PRODUCTS

2.1 HDPE MANHOLES

A. The HDPE materials should conform to ASTM D3350 with a minimum cell classification of 345464C.

B. HDPE density shall be no less than 0.955 grams/cubic centimeter as tested using ASTM D1505.

C. Melt index should be no greater than 0.154 grams/10 minutes using ASTM D1235 condition 3.2.3.

D. Flexural Modulus shall be between 110,000 and 160,000 pounds per square inch using ASTM D790.

E. Tensile Strength at yield shall be between 3,200 to less than 3,500 psi using ASTM D638.

F. Slow crack growth resistance would be greater than 100 hours per ASTM F1473.

G. Hydrostatic Design Basis shall be 1600 psi at 23°C in accordance with ASTM D2837.

H. The manhole diameter, length, and DR shall be as shown on the drawings (minimum DR shall be 17).

I. The thickness of the bottom of the manhole shall be determined by the manufacturer using ASTM F1759. The bottom of the manhole shall have a diameter 50% larger than the manhole diameter.

J. Manhole inlets and outlets shall be as shown on the Drawings. All inlets and outlets shall be extrusion welded inside and outside of the structure using good welding practices. Gussets shall be attached at 90, 180, 270, and 360 degrees around inlets and outlets unless impractical.

K. All connections equal to or larger than 4 inches shall be butt fusion welded, electrofusion welded, or flanged. Connection less than 4 inches shall use threaded transition fittings.

L. If anti-floatation devices are required, connection of such devices shall be integral to the manhole.

PART 3 EXECUTION

3.1 UNLOADING

A. Unloading and storage of HDPE manholes shall be in accordance with manufacturer's requirements.

3.2 INSTALLATION

A. Base and embedment materials for the manhole shall be as shown on the Drawings. Manhole base materials shall be compacted and unyielding. A visual inspection of the base where the manhole is to be set shall be conducted by the Engineer.

B. Embedment materials shall be native materials.

C. For manholes in traffic areas, reinforced concrete pads spanning the manhole are required. A traffic rated frame and cover are required.

D. Watertightness test shall be conducted in the presence of the Engineer.

END OF SECTION

Attachment 3

LGS Cell 4 GCL CQAP

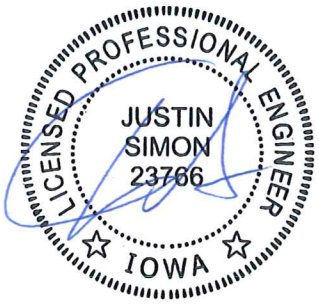
Construction Quality Assurance Plan

Cell 4 GCL Expansion Project
Louisa Generating Station

MidAmerican Energy Company

January 09, 2025

The Power of Commitment



SEAL

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

1-9-2025

(signature) (date)

Printed or typed name: Justin Simon

License number: 23766

My license renewal date is December 31, 2025

Pages or sheets covered by this seal:

Original document dated January 9, 2025.

Project name	LGS - Monofill Expansion						
Document title	Construction Quality Assurance Plan | Cell 4 GCL Expansion Project						
Project number	12635351						
File name	12635351-RPT-02-LGS-Cell4-GCL-CQAP						
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**
S3	0	Justin Simon	M. Alowitz		K. Armstrong		

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1. Introduction

This Construction Quality Assurance (CQA) Plan for the Louisa Generating Station Coal Combustion Residue (CCR) Impoundment Cell 4 Geosynthetic Clay Liner (GCL) Expansion Project (Project) addresses CQA for the components of the monofill liner and leachate management systems at the MidAmerican Energy Company (MidAmerican) Louisa Generating Station (LGS). These systems include: structural fill material, GCL, drainage layer, leachate collection system soils, high-density polyethylene (HDPE) geomembrane, geotextile, and HDPE leachate collection piping. This CQA Plan specifies the CQA program to be implemented for materials selection and evaluation, laboratory test requirements, field test requirements, and problem resolution. The CQA program provides a framework for organization, operations, policies, and designation of responsibility. This framework is required to ensure a verifiable level of construction quality. A construction certification report will be prepared upon completion of the Project elements addressed by this CQA Plan.

The Iowa Department of Natural Resources (IDNR) will be notified at least seven days prior to commencement of construction of critical facility components under their review. Samples of construction materials used for physical testing will be retained until construction certification has been approved. The following sections present CQA requirements for various key elements of the Project construction. These requirements will be set forth in construction documents and are to be reviewed and understood by all parties involved.

1.1 Definition of Personnel

1.1.1 Owner

In this CQA Plan, the Owner is MidAmerican Energy Company. The Owner may designate a representative to liaison with the Contractor and oversee construction of the Project.

1.1.2 Engineer

The Engineer is GHD, 11228 Aurora Avenue, Des Moines, Iowa. The Engineer will be copied on all progress reports and will periodically visit the work site. The Engineer will provide clarifications on the design Drawings and Specifications as required by the Contractor or CQA Engineer. The Engineer may be the same firm as the CQA Engineer. The Engineer may designate the CQA Engineer to perform some responsibilities designated for the Engineer.

1.1.3 CQA Engineer

The CQA Engineer is an individual, firm, or corporation, independent from the Owner, Contractor, and Manufacturer, that observes and documents activities related to the CQA of the earthen and geosynthetic components of the liner system. The CQA Engineer must provide a field representative who manages CQA activities under the direct supervision of a Professional Engineer registered in the State of Iowa. The CQA Engineer may be the same as the Engineer, but must be independent from the Contractor. The CQA Engineer will report to the Engineer and Owner and be paid solely by the Owner. Responsibilities of the CQA Engineer may be performed by the Engineer.

1.1.4 Contractor

The Contractor is the individual, firm, or corporation undertaking execution of the work under the terms of the Contract Documents. The Contractor is responsible for quality control (QC) sampling and testing, from manufacturing through installation, in accordance with the CQA Plan, Drawings, and Specifications. Actual sampling and testing must be conducted by a party and laboratory independent from the Owner, Contractor, Engineer, and CQA Engineer; retained by the Contractor at the Contractor's sole expense; and approved by the Engineer and the Owner. The geomembrane testing laboratory must also be independent from the Manufacturer and must have provided quality assurance (QA)

testing for installation of the proposed geomembrane material for at least five completed projects having a total minimum area of 2 million square feet.

1.1.5 Inspector

The Inspector is a QA/QC employee of the Contractor or subcontractor retained by the Contractor to inspect and document materials and installation of materials as required in the Contract Documents.

1.1.6 Manufacturer

The Manufacturer manufactures a specific component of the Project and delivers the component to the Contractor at the site. The geomembrane Manufacturer must have produced the specified geomembrane material for at least five continuous years and must have produced a total minimum area of 20 million square feet.

1.1.7 Geosynthetics Installer

The Installer is responsible for field handling, deploying, seaming, anchoring, and field QC testing of geosynthetics. The Installer must have installed and tested the specified geosynthetic material for the following criteria:

– Installed a minimum of 1 million square feet of GCL.
– Installed the specified geomembrane at least five completed projects having a total minimum area of 5 million square feet.

The geomembrane Installer shall designate a Master Seamer. The Master Seamer shall be present during all seaming operations and shall have minimum field seaming experience as specified in the Specifications using the same type of seaming apparatus in use at the site and hold an International Association of Geosynthetic Installers (IAGI) Certified Welding Technician (CWT) certification in both extrusion welding and fusion welding. The Master Seamer shall provide direct oversight of the other Seamers. Seamers having less than 1 million square feet of high-density polyethylene (HDPE) geomembrane experience shall be qualified prior to performing actual field seams by successfully passing on-site field seaming tests as detailed in the Specifications.

1.1.8 Pipe Installer

The Pipe Installer shall provide all materials, equipment, and labor necessary to complete the installation of the piping which, at a minimum, meets the specifications of the Contract Documents. The Pipe Installer shall provide the required documentation, including the certifications for material and workmanship, and perform the QA/QC procedures as detailed in the Contract Documents, this CQA Plan, and the Pipe Installer's quality control plan.

The Pipe Installer shall be responsible for the proper installation of the piping for the leachate collection system. The work shall include the installing, joining, repairing, and field testing of any or all the pipe materials. The Pipe Installer may also be responsible for obtaining, handling, transporting, and properly storing the piping materials as required by the Contract Documents. The work shall also include preparation of documentation (for example, a record drawing) which indicates the location of buried pipe, repairs, and other pertinent features and data concerning the installation of the piping. The Pipe Installer is responsible for completing the pipe installation and coordinating with a Licensed Land Surveyor or a P.E. to verify pipe installation line and grade prior to pipe burial. The Pipe Installer shall report directly to the Contractor.

1.1.9 Soils CQA Laboratory

The Soils CQA Laboratory is independent from the Owner, Gravel Supplier, Granular Material Supplier, and Contractor. The Soils CQA Laboratory conducts tests in the laboratory (which may be on site or off site) on samples of soil taken from the borrow areas, stockpiles, liner system, or other subgrade and backfill areas. The Soils CQA Laboratory is retained by the Contractor and solely paid by the Contractor.

1.1.10 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is independent from the Owner, Resin Supplier, Manufacturer, Contractor, and Installer. The Geosynthetics CQA Laboratory shall be a laboratory accredited in the applicable tests methods by the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP). The Geosynthetics CQA Laboratory conducts tests on samples of geosynthetics taken from the site. The Geosynthetics CQA Laboratory may also conduct tests on pipes or other liner system components. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture or installation of any of the geosynthetic components. All work required from the Geosynthetics CQA Laboratory shall be paid for solely by the Contractor.

1.1.11 Tester

The Tester is an independent third-party subcontractor retained by the Contractor to test materials required to complete the Project.

1.1.12 Surveyor

The Surveyor completes QC and project documentation surveying, is registered in the State of Iowa, and is independent from the Owner, Contractor, and CQA Engineer. The Surveyor is retained by the Contractor at the Contractor's sole expense and approved by the Engineer or the Owner.

2. Pre-Construction Meeting

A pre-construction meeting will be held to discuss Project activities, safety procedures, and assignment of CQA responsibilities, site survey control, schedule, and any other issues notable to the Project as a whole. The Owner, Engineer, Surveyor, Contractor, and any necessary subcontractors shall be required to attend this meeting. As necessary, additional meetings may be held during construction at the request of the Owner, Engineer, or Contractor in order to discuss work progress and resolve potential problems. Inspections and tests as outlined in this CQA Plan, Drawings, and Specifications (Contract Documents) will be discussed and responsibilities of personnel performing the work, inspection, and documentation will be discussed. The intent of this CQA Plan is to ensure the construction meets Project requirements. Periodically, the process will be refined based on worker-identified quality problems, test data, inspection results, audits, and the Owner’s satisfaction with the Project.

2.1 Responsibilities

The Contractor is responsible for performing the work in accordance with all aspects of the Contract Documents. At minimum, the Contractor shall construct the Project in accordance with the Contract Documents including testing and inspection in accordance with the CQA Plan.

The Engineer is responsible for oversight, documentation, and inspection by ensuring the Contractor’s staff is performing required observation inspection and documentation required. If during oversight and inspection the Owner’s representative observes potential non-conformance with the Contract Documents, the Engineer shall discuss with the Contractor to determine corrective action. The Owner shall be kept apprised of corrective actions and the Engineer is responsible for communicating with the Owner regarding corrective actions.

3. Site Survey Control and Records

Horizontal and vertical control will be maintained throughout construction so that survey data can be obtained as necessary. Benchmark locations are available on site and shall be used to reference survey data. Survey information shall be supplied in Iowa State Plane, North American Datum of 1983 (NAD 83), and North American Vertical Datum of 1988 (NAVD 88). Such controls will be used to document test locations, layer thicknesses, and appurtenance locations. Survey accuracy and tolerances are specified in the Specifications.

3.1 Survey Verification

At a minimum, the record survey shall document the following:

– GCL Subbase
  - Subbase of GCL on 50-foot grid and at grade breaks.
  - Trench elevations every 25 feet.
  - Geosynthetic location information for panels, repairs, destructive tests, anchor trench, and splices to existing liners/covers.

– Leachate Extraction System
  - Collection pipe locations and elevations every 25 feet.
  - Header pipe locations and elevations every 25 feet.
  - Locations and elevations of manholes, cleanouts, and sumps.
  - Top of leachate collection drainage layer on 50-foot gride and at grade breaks.

– General Construction
  - Edges and centerlines of new roads at 50 foot intervals and at sufficient frequency to capture curve radii.
  - Culvert inverts and outlets.
  - Corners of rip rap areas to properly identify extents.

3.2 Survey Tolerances

Tolerances for each phase of construction are listed in Table 1. Areas which do not meet the tolerances listed in Table 1 will be re-graded, or removed and replaced, until the tolerances are met and are verified by resurvey.

Table 1 Summary of Survey Tolerances

Item	Tolerance
GCL – Subbase Grade	0.0 to 0.1 foot
Clay Liner – Top of Clay Liner (if applicable)	0.0 to +0.1 foot
Leachate Extraction System – Collection Piping	±0.05 foot/100 feet
Leachate Extraction System – Header Piping	±0.05 foot/100 feet
Leachate Extraction System – Top of Drainage Layer	0.0 to +0.1 foot

3.3 Thickness Verification

The Contractor shall verify the thickness of the soil components indicated in Table 2. The method of verification may include survey, hand augers, hand shoveling, or other QC&A Officer-approved method.

Table 2 Summary of Minimum Thicknesses

Item	Frequency	Minimum Thickness	Tolerance
Clay Liner (if applicable)	50-foot grid	2.0 feet	0.0 to +0.1 feet
Leachate Collection Drainage Layer	100-foot grid	1.0 feet	0.0 to +0.1 feet

4. Products and Materials

Quality tests and inspections will be performed during the production of the materials, as materials arrive on the Project site, and as they are incorporated into the construction. Tests and inspections will be performed by a combination of Contractor staff, Testers and Inspectors, and subcontractor and Supplier quality personnel.

Suppliers will perform tests on materials as they are produced. Prior to the material arriving on the Project site, testing information will be forwarded to the Engineer demonstrating the material meets requirements. The Supplier's quality management system will be reviewed, along with test records from previous production and reporting of quality data during production will be established.

Products and materials are identified from receipt and storage through installation. The Owner's representative will either record or require the Contractor to submit the documentation for shipment, storage, and installation, as required in the Specifications.

4.1 Handling

Products and materials should be handled on site in accordance with the Supplier's recommendations, Project requirements, and good construction practice. When materials arrive at the Project site, receiving personnel will document receipt of the material in accordance with the appropriate procedure. QC will check material for conformance to Project requirements. Any damage or deficiency will be noted. The materials will be used or stored as appropriate for the material.

Some materials, such as concrete, will require physical tests as received and will be sampled to determine their conformance. The work will be conducted following the proper test procedure and documented as required.

Packing slips, mill certificates, or other documents from the supplier showing conformance to requirements will be reviewed by QC and QA personnel and retained by QA. Three-ring binders will be used to compile certificates and will include an updated log of accepted shipments.

4.2 Storage

Products or materials not immediately used will be stored. Material for indoor storage will be placed in bins, shelving, racks, or pallets and positioned in neat and orderly condition for ease of retrieval. Material stored outdoors will be placed on adequate dunnage and protected as required by the Supplier.

4.3 Protection

Some products and materials will require special measures to protect them from degradation. The Supplier's requirements will be followed in providing the proper environment for the products and materials. The Contractor will be responsible for providing proper conditions.

5. Construction Monitoring/Oversight

This section includes a summary of work that requires observation, verification, and documentation. The work for the Project includes site clearing and grubbing, placement of construction stormwater features and species prevention systems, placement and grading of cohesive soils, stormwater conveyance system piping, geosynthetic materials installation, leachate collection system including manhole and appurtenances installation, and site stabilization and restoration. This work will be observed, documented, and reported. Documentation will consist of daily logs, soil testing, Manufacturer testing documentation, material testing results, and surveying as required in the Contract Documents.

5.1 Soils and Aggregates

All soil materials shall be prequalified prior to being brought on site to stockpile or install at the site. All soil materials shall be free of debris, contamination, and meet Specifications outlined in the Contract Documents. Cohesive soils and structural fill shall be placed at a maximum 6-inch installed thickness. Density testing shall be required. Documentation shall include the following:

– Fill for the design grades shall be placed and verified as reaching the design grades. Survey of the excavation grades and design fill grades shall be performed according to the survey requirement details in the Specifications.
– Structural fill, common fill, and cohesive soil shall be compacted to the density detailed in the Specifications. Performing the density testing is the responsibility of the Contractor and results shall be submitted to the Owner's representative for verification.
– Installation of pipe bedding and compactive effort required shall be performed by the Contractor and observed by the CQA Engineer.
– Adequate spreading of soil material to obtain complete coverage and specific lift thickness.

5.1.1 Recompacted Subgrade

Fill material placed for liner and support construction (subgrade, berms, etc.) shall be tested in accordance with the schedule presented in Table 3.

Table 3 Recompacted Subgrade Quality Testing

Test	Test Method	Minimum Frequency	Acceptance Test Values
Compaction Characteristics	ASTM D698	1 each representative material in the subgrade	Not Applicable
In-Place Density and Percent Compaction	ASTM D6938	50-foot grid/1 foot	Minimum 90% of Standard Proctor maximum dry density, as identified by ASTM D698
Firmness Proof Rolls with CAT 627 or Equivalent	Not Applicable	Periodic	No rutting>1/2-inch (or Engineer Approval)

– The CQA Engineer shall perform the following functions during subgrade preparation:
  - Verify that all trees, stumps, roots, boulders, and debris are removed.
  - Verify that placement of frozen soil, or soil onto frozen ground does not occur.
  - Verify that the foundation is constructed and graded to provide a smooth, workable surface on which to construct the liner.

5.1.2 Compacted Clay Liner (If Applicable)

The Contractor shall perform the installation of the cohesive soils according to the Specifications including in-situ and laboratory testing. The following is a summary of the placement requirements for cohesive soils:

- Adequate spreading of soil material to obtain complete coverage and specified maximum lift thickness.
- Adequate clod-size reduction for clayey soils.
- Adequate spreading and incorporation of water to obtain full penetration through clods and uniform distribution of the specified water content.
- Adjustment of the soil moisture content to meet project specifications.
- Adjustment of the soil moisture content in the event of precipitation or drought during construction.
- Prevention of significant water loss and desiccation-cracking before and after compaction.
- Uniformity of coverage by compaction equipment, especially at compacted fill edges, in equipment turnaround areas, and at the tops and bottoms of slopes.
- Repair of penetrations or holes resulting from the collection of undisturbed soil samples or the use of density or moisture probes, using the same materials and methods used for repairs on the test fill.
- Adequate blending together of repaired and undisturbed sections of the soil layer.
- Excavation and stabilization of materials around outlet structures during excavation.

The compaction process can be affected by weather. The Specifications restrict the moisture content during compaction of the cohesive soil liner. Care must be taken when performing work during and after a rainfall, during very hot or windy conditions, or during freezing weather. Atmospheric conditions should be observed by the Contractor and recorded by the Engineer, and the Contractor shall take appropriate actions when unsuitable weather conditions exist.

5.1.3 Compacted Clay Borrow Material (If Applicable)

Prior to placement of clay for the compacted clay portion of the liner system, the contractor is responsible for receiving approval of the Owner. Borrow material shall be tested in accordance with the schedule presented in Table 4.

Table 4 Compacted Clay Borrow Material Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Standard Proctor	ASTM D698	1 for each soil condition encountered and 1 per 5,000 cubic yards of liner material borrowed.	Not Applicable.
Grain Size and Hydrometer Analysis	ASTM D6913 and D7928	1 for each soil condition encountered and 1 per 5,000 cubic yards of liner material borrowed.	Particle size < ½-inch
Dry Density	ASTM D698	1 per foot-acre	95% Modified Proctor
Atterberg Limits	ASDM D4318	1 for each soil condition encountered and 1 per 5,000 cubic yards of liner material borrowed.	Liquid Limit > 25% Plastic Index > 12%

Clay layers (liner) construction shall meet the specifications and be tested in accordance with the schedule presented in Table 5.

Table 5 Compacted Clay Quality Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Hydraulic Conductivity	ASTM D5084	1 per foot-acre	Maximum $1x10^{-7}$ centimeters per second
In-Place Density/Moisture	ASTM D6938	100-foot grid each 6-inch lift on 1-foot horizontal offset, and at each Shelby Tube/bulk sample location (1 per foot-acre)	Density and moisture must meet the compaction requirements to achieve the necessary permeability specified in the geotechnical laboratory analysis (Compaction Curve) and is equal to or greater than 95% of Standard Proctor (ASTM D698) maximum dry density. Moisture content optimum to 5% of optimum.
Moisture Content	ASTM D2216	1 per foot-acre	0 to 5% above optimum
Atterberg Limits	ASTM D4318	1 per foot-acre	Liquid Limit > 25% Plastic Index > 12%

Thin-walled tubes (Shelby Tubes) will be accompanied with a bulk sample. Shelby Tubes will be in accordance with Table 6. All test holes shall be filled with bentonite and hydrated by the Contractor.

Table 6 Shelby Tube Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Grain Size and Hydrometer Analysis	ASTM D6913 and D7928.	1 per foot-acre	No less than 50% by weight passing the #200 sieve
Moisture Content	ASTM D2216	1 per foot-acre	0 to 5% above optimum
Dry Density	ASTM D698	1 per foot-acre	Must achieve 95% compaction
Atterberg Limits	ASTM 4318	1 per foot-acre	Liquid Limit > 25% Plastic Index > 12%
In-Place Density/Moisture	ASTM D6938	At each Shelby Tube/bulk sample location (1 per foot-acre)	Density and moisture must meet the compaction requirements to achieve the necessary permeability specified in the geotechnical laboratory analysis (Compaction Curve) and is equal to or greater than 95% of Standard Proctor (ASTM D698) maximum dry density. Moisture content optimum to 5% of optimum.

5.2 Drainage Layer

The drainage layer construction for the leachate collection system shall be tested in accordance with the schedule presented in Table 7. In addition, the CQA Engineer shall inspect pipe bedding and granular layer material for undesirable objects. Coarse aggregate will be of non-calcareous material.

Table 7 Drainage Layer Quality Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Grain Size	ASTM D6918	1 per 1,000 (5,000 for washed stone) cubic yards and at least 1 per source	IDOT Gradation 36
Hydraulic Conductivity	ASTM D2434	1 per 2,500 cubic yards of material (sand only) and at least 1 per source.	Minimum $1x10^{-1}$ centimeters per second without geosynthetic drainage media

5.3 Pipe Bedding

Pipe bedding used in leachate collection trenches shall be tested in accordance with the schedule presented in Table 8 and Table 9. In addition, the CQA Engineer shall inspect all pipe bedding and granular layer material for undesirable objects. Coarse aggregate will be of non-calcareous material.

Table 8 1½ to 2-inch Coarse Aggregate Pipe Bedding Quality Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Grain Size	ASTM D6918	A per 1,000 lineal feet of trench, minimum 3	Stone meeting Specification 31 05 16, soil class B-1 requirements
Soil Classification	ASTM 2487	A per 1,000 lineal feet of trench, minimum 3	Stone meeting Specification 31 05 16, soil class B-1 requirements
Hydraulic Conductivity	ASTM 2434	Every third sample	Minimum 1 centimeter per second

Table 9 Pea Gravel Filter Quality Testing

Test Description	Test Method	Minimum Frequency	Acceptance Criteria
Grain Size	ASTM D6918	A per 1,000 lineal feet of trench, minimum 3	Stone meeting Specification 31 05 16, soil class B-3 requirements
Soil Classification	ASTM 2487	A per 1,000 lineal feet of trench, minimum 3	Stone meeting Specification 31 05 16, soil class B-3 requirements
Hydraulic Conductivity	ASTM 2434	Every third sample	Minimum 1 centimeter per second

5.4 Geosynthetics

The Cell 4 Expansion includes GCL overlayed by 60-mil high-density polyethylene (HDPE) texted geomembrane liner, a geocomposite, 1-foot drainage layer, and a geotextile as well as tie-ins to existing lined areas.

The GCL liner shall be handled in accordance with manufacturer's instructions. For additional guidance, refer to ASTM D5888 (Standard Guide for Storage and Handling of Geosynthetic Clay Liners) and ASTM D 6102 (Standard Guide for Installation of Geosynthetic Clay Liners). The subgrade surface must be prepared in accordance with the project specifications. The engineer’s approval of the subgrade must be obtained prior to installation. The finished surface should be firm and unyielding, without abrupt elevation changes, voids, cracks, ice, or standing water. The subgrade surface must be smooth and free of vegetation, sharp edged rocks, stones, sticks, construction debris, and other foreign matter that could contact the GCL. The subgrade should be rolled with a smooth-drum compactor to remove any wheel ruts greater than 1 inch in depth, footprints, or other abrupt grade changes. Furthermore, all protrusions extending more than 0.5 inch (12 mm) from the subgrade surface shall be removed, crushed, or pushed into the surface with a smooth-drum compactor. The GCL may be installed on a frozen subgrade, but the subgrade soil in the unfrozen state should meet the above requirements.

5.4.1 Engineer and CQA Engineer Requirements

The following inspection activities will be performed and documented by the Owner’s representatives:

– Checking of delivery tickets and Manufacturer’s QC documentation provided by the Contractor to verify that the geosynthetic clay and geomembrane liner rolls received on site meet the Specifications.
– Verifying storage of the geosynthetics meets Manufacturer’s requirements.

– Observation and measurements of the anchor trench to ensure that it is constructed as specified in the design Drawings. Backfilling of the trench should be performed as soon as possible and completed with care so as not to damage the geosynthetics.
– Observation and tests to confirm that all designed geosynthetics penetrations and connections are installed as specified. Penetrations should be inspected to verify the use of appropriate clamps and caulking, for appropriate material, for good seaming, and for good housekeeping practices.
– Measurements to confirm that required overlaps of adjacent geosynthetic clay and geomembrane liner sheets were achieved, proper temporary anchorage was used (e.g., sand bags), and specified temporary and final seaming materials and techniques were used.

As each geosynthetic clay and geomembrane liner panel is placed, it will be visually inspected for creases, tears, punctures, and thin spots. To accomplish this, the panels will be traversed by the CQA Engineer in such a way that the entire surface, including factory seams, is inspected. Any defects will be marked on the geosynthetic clay or geomembrane liner for repair and then tested to ensure the repair meets minimum standards.

The overall quality of geosynthetic clay and geomembrane liner installation can be affected by the weather conditions at the time of installation. The CQA Engineer or Engineer will take into account these factors and the effects they may have on the specific geosynthetic type and seaming procedures in use. If the weather becomes unacceptable for installation of the geosynthetic, the Owner's representative will recommend suspending the geosynthetic installation until conditions again become favorable, thus minimizing the potential for unacceptable installation.

The following inspection activities are necessary and will be documented during field seaming operations:

– Observations to ensure that the geosynthetic clay and geomembrane liner is free from dirt, dust, and moisture.
– Collect documentation of daily subgrade acceptance by the Installer and include in the Project documentation file.
– Daily documentation of weather conditions (i.e., temperature, humidity, and wind) to ensure that they are acceptable for seaming.
– Measurements of temperatures, pressures, and speed of seaming, when applicable, to ensure that they are as specified (e.g., gauges and dials should be checked and readings recorded).
– Measurements of the curing time between seaming and seam testing to ensure that it is as specified (when applicable).
– Observations to ensure that the membrane is not damaged by equipment or personnel during the seaming process.

5.4.1.1 Contractor Requirements

Installation of the geosynthetic clay liner and the 60-mil HDPE geomembrane liner will be performed by a subcontractor meeting the qualification standards listed in the Specifications. The personnel performing seaming operations will be qualified by experience or by successfully passing seaming tests. The experience record of each of the Installer's technicians will be given to the Engineer prior to the start of the geomembrane liner placement. A pre-construction meeting will be held prior to geosynthetic placement to discuss schedule, responsibilities, testing frequencies, and to review the Installer's panel layout drawings.

The Manufacturer will provide QC certification forms with results of plant testing of the geosynthetic. These forms shall certify that the geosynthetic rolls shipped to the site meet or exceed the material property requirements of the Specifications. These certification forms shall be received by the Engineer prior to any geosynthetic clay or geomembrane liner installation.

The geosynthetic rolls shall be inspected upon arrival to ensure that the materials meet the Specifications. The CQA Engineer shall record all roll numbers to verify rolls as shipped and note in the daily field report any damage to the rolls.

Prior to the placement of the geosynthetic, both the Installer and the CQA Engineer will inspect the subgrade for uneven areas, rocks, or foreign objects that may damage the geosynthetic clay liner. The Installer is required to sign an acceptance form accepting the subgrade condition prior to geosynthetic clay liner placement.

During placement of the each geosynthetic liner, the CQA Engineer will be present to observe deployment, record roll numbers and panel numbers, and to mark any areas with visible damage to the geosynthetic clay or geomembrane liner. A panel placement form shall be filled out by the CQA Engineer to document weather conditions during placement. The Contractor is responsible for sequentially numbering panels and repairs to support tracking of seams and testing.

Before seaming begins, trial welds will be taken, tested, and recorded. The frequency of trial welds is included in the Specifications. If a trial weld fails, the Seamer will be required to make another complete trial seam. If this additional test fails, the seaming apparatus or Seamer will not be accepted until deficiencies are corrected and two consecutive passing trial seams are made.

Continuity (non-destructive) testing will be performed using a vacuum box unit over the entire length of each seam. Alternately, when the dual hot wedge weld machine is used, the air channel formed in the seaming process will be pressurized to detect leaks. These processes will be witnessed by the Inspector and CQA Engineer and any leaks will be noted, repaired, retested, and recorded. This testing will follow concurrently with the seaming process, not at the completion of all seaming. Test results are to be recorded directly on the geomembrane and recorded in field notes.

Destructive test samples will be taken according to the frequency and schedule outlined in the Specifications and sent to an independent laboratory for testing. The locations of these tests shall be determined by the CQA Engineer and will be recorded and included on the as-built panel placement drawing.

5.4.2 Geotextile

Prior to the installation of any geotextile, the Manufacturer or Installer shall provide the Engineer with the following information:

- The origins (resin suppliers' names) and identifications (brand names and numbers) of the resins used to manufacture the geotextile.
- All required manufacturer documentation as stated in the Specifications reviewed by the Engineer prior to installation.
- Installer requirements as required in the Specifications to be reviewed by the Engineer prior to installation.
- Installation of the geotextile shall be performed by the Contractor or Subcontractor and conform to Project Specifications. The CQA Engineer will observe installation.

The CQA Engineer shall verify that:

- Property values certified by the Manufacturers meet all of their guaranteed specifications.
- Measurements of properties by the Manufacturers are properly documented and that the test methods used are acceptable.
- Quality control certificates have been provided at the specified frequency for all rolls, and that each roll is identified on a certificate. However, it is not necessary that every roll be individually tested.
- The correct materials have been delivered to the Project Site and document the material installation.
- Rolls are appropriately labeled.
- Certified minimum average roll properties meet the project specifications.

5.4.3 Geocomposite

Prior to the installation of any geocomposite, the Contractor shall provide the Engineer with the required manufacturer data detailing quality control certificates, reports, and written certifications from the manufacturer as required in the

Project Specifications. The CQA Engineer shall review these documents and shall report any discrepancies with Project Specifications. The CQA Engineer shall verify that:

- Property values certified by the Manufacturers meet all of their guaranteed specifications.
- Measurements of properties by the Manufacturers are properly documented and that the test methods used are acceptable.
- Quality control certificates have been provided at the specified frequency for all rolls, and that each roll is identified on a certificate. However, it is not necessary that every roll be individually tested.
- The correct materials have been delivered to the Project Site and document the material installation.
- Rolls are appropriately labeled.
- Certified minimum average roll properties meet the project specifications.

Table 10 summarizes testing requirements and required frequency for quality control for the Project work.

Table 10 HDPE Liner Test Summary

Test Description	Test Method	Minimum Frequency
Defects/Punctures	Visual Inspection	Upon delivery to site; 100% of all seams and liner surface after placement and prior to seaming
Weather Conditions	Verification	Prior to panel placement
Qualified Personnel	Verification	Prior to start of installation and verify prior to new crew members starting work
Seam Overlap	Verification	Every seam prior to welding
Seaming Area is Clean and Dry	Verification	Every seam prior to welding
Use of Hard Substrate	Verification	Where supporting soil is soft or uneven
Seaming Equipment is Available and Meets Required Specifications	Verification	Every morning and after lunch break of every working day
Seaming Procedures are Followed	Verification	Every seam for duration of weld
FML Panels are Properly Positioned	Verification	Every seam prior to welding
Seam Testing Equipment is Available, with Current Calibration, on the Site and Operational	Verification	Prior to start of installation
Field Tensiometer has been Correctly Calibrated	Verification	Prior to start of installation
Extrusion and Hot Wedge Weld Test Seams	ASTM D6392 and GM 29	At least 2 times per day (at the beginning of the day, and at least 4 hours thereafter)
Peel and Shear	ASTM 6392	5 of each per each field sample
Vacuum Pressure	ASTM D4437/D4437M and GRI GM6	100% of all seams
Air Pressure	GRI GM6	100% of all wedge weld seams
Destructive Seam Testing	GRI GM20, GRI GM29	The initial seam sample interval shall be 500 linear feet for the first 10 samples unless seam failure rate (SFR) exceeds limits

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Attachment 4

CETCO Tier I, Tier II, and Tier III Compatibility Testing Results

CETCO 2870 Forbs Avenue Hoffman Estates, IL 60192
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August 13, 2024

Justin Simon, PE,
GHD,
11228 Aurora Ave,
Des Moines, IA 50322-7904

RE: MidAmerican Energy Center Louisa Generating Station CCR LF ('24)
Summary of Tier I, Tier II, and Tier III Testing

Dear Mr. Simon,

The purpose of this letter is to present the final Tier III results of the compatibility testing of the CETCO® Resistex® geosynthetic clay liners for the above-mentioned project. Initial findings were previously conveyed for the Tier I and Tier II testing (and are attached) for this project. All testing was performed at the CETCO in-house GAI-LAP accredited laboratory located in Hoffman Estates, Illinois.

CETCO initiated a geosynthetic clay liner (GCL) chemical compatibility evaluation as outlined in our Technical Reference (TR-345, attached) after receiving representative sample of site leachate. Completion of Tier I & II evaluations indicated that a standard GCL (such as Bentomat®) in the presence of the leachate would not likely provide suitable performance as defined by permeability. CETCO initiated Tier III testing of Resistex® 100 and Resistex® 200 after finishing Tier I & II.

Permeability testing is performing in general accordance with ASTM D6766, Scenario II with the leachate. For this testing, a cell pressure of 80 pounds per square inch (psi), 77 psi headwater pressure and 75 psi tailwater pressure were utilized and represent test conditions that CETCO utilizes in evaluating our GCL products. It should be noted that testing utilizing field condition pressures could yield different results.

The Resistex® 100 permeability for the site leachate is 2.63×10^{-9} cm/sec after 11.28 pore volumes and 2563 hours.
The Resistex® 200 permeability for the site leachate is 1.54×10^{-9} cm/sec after 8.25 pore volumes and 2619 hours.

Please feel free to contact me for further information.

Sincerely,

M. Reza. Gorakhki, Ph.D.
Reza Gorakhki
Director - Environmental Products
Minerals Technologies Inc.
2870 Forbs Ave.
Hoffman Estates, IL 60192 USA
C 970.691.4135
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CETCO EP Project Information ASTM D6766 Perm Test Results		
Project	MidAmerican Energy Company Louisa	MidAmerican Energy Company Louisa
Product Tested for Hydraulic Conductivity	Resistex 100	Resistex 200
Product Lot #	LO2018 Roll 4	20GCL001 Roll 46
Leachate Code#	LT24-2	LT24-2
Leachate EC (uS/cm)	11260	11260
Ionic Strength Estimated by ICP (mol/L)	0.1785	0.1785
RMD Estimated by ICP (M^0.5)	1.0481	1.0481
Sulfate/Chloride Ratio	0.56	0.56
Hydration Liquid	LT24-2	LT24-2
Permeation Liquid	LT24-2	LT24-2
Pressure Difference (PSI) =	2	2
Max. Effective Stress (PSI) =	5	5
Hydraulic Gradient	157	182
Actual Hydraulic Conductivity k (cm/sec)	2.63×10^{-9}	1.54×10^{-9}
PVF	11.28	8.25

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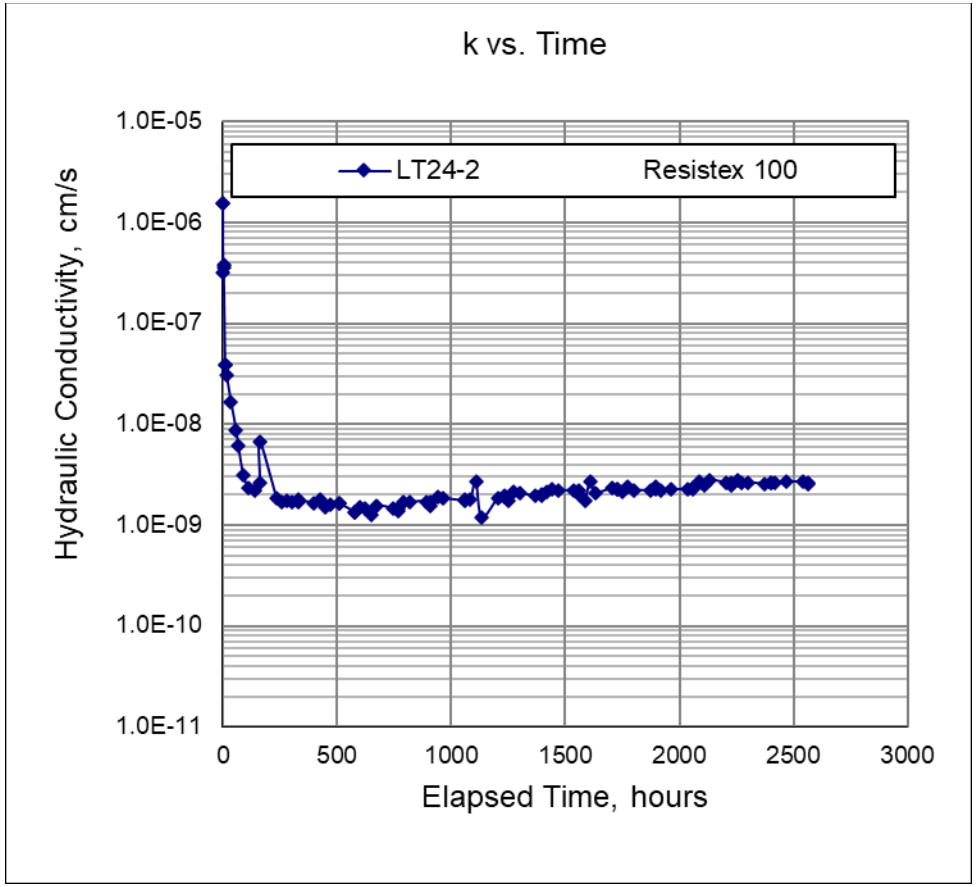

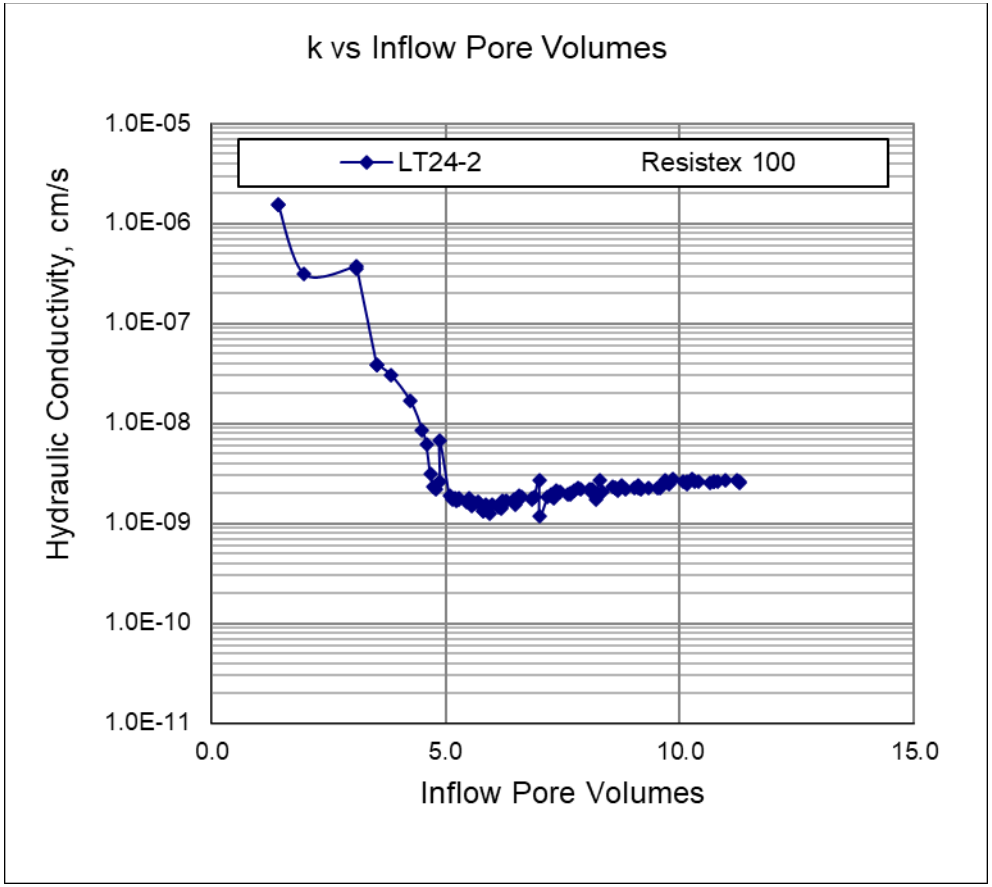

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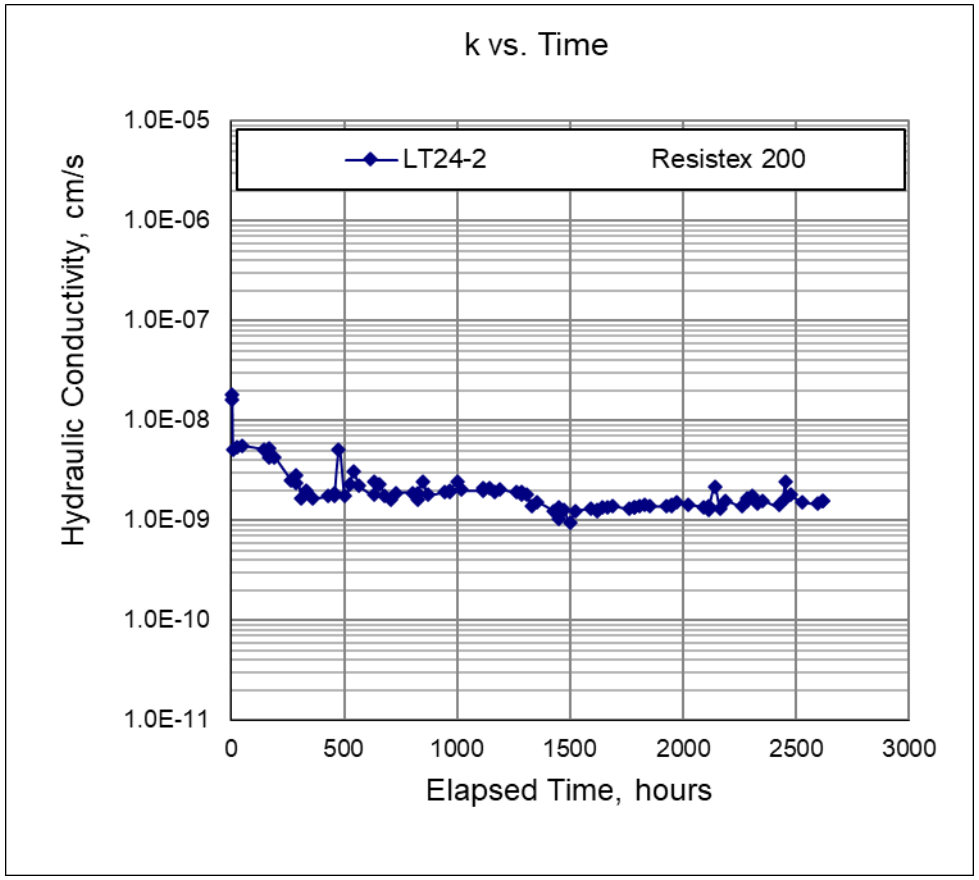

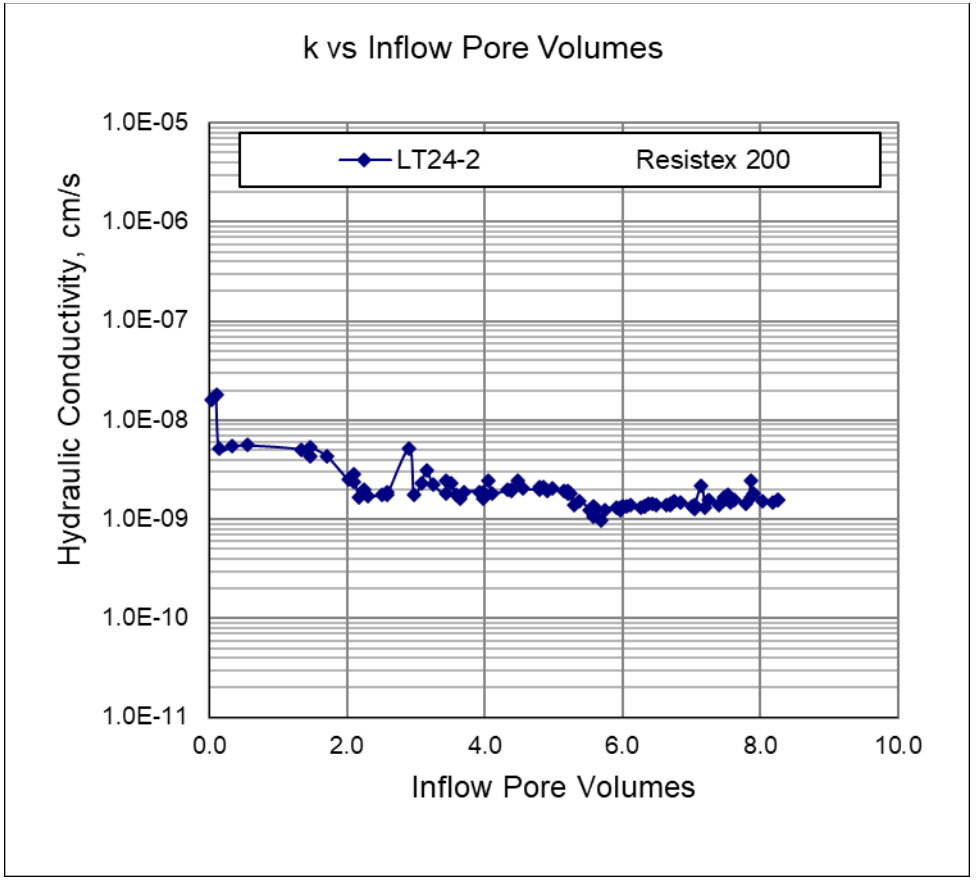

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GEOSYNTHETIC CLAY LINER COMPATIBILITY ANALYSIS

ASTM D6141 - 09

Project:	MidAmerican Energy Company Louisa	Date:	3/21/2024
Location:	Iowa	Project Type and Citation:	Liner Compatibility BMG/LT-RD-HE-597
Requested By:	Kevin Armstrong, GHD Services, Inc.	Sample ID:	LT24-2
Sample Type(s)[1]:	Leachate		

Test Results:

Leachate Used for Testing	Site Leachate		
Bentonite/Product	Resistex 100	Resistex 200	U40
Fluid Loss (mL), ASTM D5891 modified[1]	18.52	8.92	12.12
Free Swell (mL/2g), ASTM D5890 modified[1]	20	20	20
Conductivity (µS/cm)	11260		
pH	5.53		
Chloride (ppm)	2256		

Note:

1) Test method modified for use with site specific hydration fluid in place of deionized water.

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ICP Elemental Analysis

Element	ppm
Silver	ND
Aluminum	4.969
Arsenic*	ND
Boron	2.735
Barium	0.713
Calcium	287.411
Cadmium	1.752
Chromium	0.257
Copper	2.017
Iron*	3.475
Potassium	163.182
Magnesium	23.779
Manganese	3.562
Molybdenum	1.798
Sodium	2144.73
Nickel	1.54
Phosphorus	62.074
Lead*	3.578
Sulfur	1136.69
Antimony	1.985
Selenium*	1.383
Titanium	0.099
Zinc	1.805
Zircon	0.425

1) Accuracy is ±0.005 ppm except for arsenic, iron, mercury, lead and selenium which have accuracy limits of 0.02 ppm.
2) The sample was diluted 1:99 prior to testing and the results were scaled up by 100x.

Analyst: DW

EVALUATING GCL CHEMICAL COMPATIBILITY

Sodium bentonite is an effective barrier primarily because it can absorb water (i.e., hydrate and swell), producing a dense, uniform layer with extremely low hydraulic conductivity, on the order of 10^{-9} cm/sec. Water absorption occurs because of the unique physical structure of bentonite and the complementary presence of sodium ions in the interlayer region between the bentonite platelets. Sodium bentonite's exceptional hydraulic properties allow GCLs to be used in place of much thicker soil layers in composite liner systems.

Sodium bentonite which is hydrated and permeated with relatively "clean" water will perform as an effective barrier indefinitely. In addition, past testing and experience have shown that sodium bentonite is chemically compatible with many common waste streams, including Subtitle D municipal solid waste landfill leachate (TR-101 and TR-254), some petroleum hydrocarbons (TR-103), deicing fluids (TR-109), livestock waste (TR-107), and dilute sodium cyanide mine wastes (TR-105).

In certain chemical environments, the interlayer sodium ions in bentonite can be replaced with cations dissolved in the water that comes in contact with the GCL, a process referred to as ion exchange. This type of exchange reaction can reduce the amount of water that can be held in the interlayer, resulting in decreased swell. The loss of swell usually causes increased porosity and increased GCL hydraulic conductivity. Experience and research have shown that calcium and magnesium are the most common source of compatibility problems for GCLs (Jo et al, 2001, Shackelford et al, 2000, Meer and Benson, 2004, Kolstad et al, 2004/2006). Examples of liquids with potentially high calcium and magnesium concentrations include: leachates from lime-stabilized sludge, soil, or fly ash; extremely hard water; unusually harsh landfill leachates; and acidic drainage from calcareous soil or stone. Other cations (ammonium, potassium, and sodium) may contribute to compatibility problems, but they are generally not as prevalent or as concentrated as calcium (Alther et al, 1985), with the exception of brines and seawater. Even though these highly concentrated solutions do not necessarily contain high levels of calcium, their high ionic strength can reduce the amount of bentonite swelling, resulting in increased GCL hydraulic conductivity.

This reference discusses the tools that can be used by a design engineer to evaluate GCL chemical compatibility with a site-specific leachate or other liquid.

HOW IS GCL CHEMICAL COMPATIBILITY EVALUATED?

Ideally, concentration-based guidelines would be available for determining GCL compatibility with a site-specific waste. Unfortunately, considering the variety and chemical complexity of the liquids that may be evaluated, as well as the many variables that influence chemical compatibility (e.g., prehydration with subgrade moisture [TR-222], confining stress [TR-321], and repeated wet-dry cycling [TR-341]), it is not possible to establish such guidelines. Instead, a three-tiered approach to evaluating GCL chemical compatibility is recommended, as outlined below.

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Tier I

The first tier is a simple review of existing analytical data. The topic of GCL chemical compatibility has been the subject of much study in recent years, with several important references available in the literature. One of these references, Kolstad et al (2004/2006), reported the results of several long-term hydraulic conductivity tests involving GCLs in contact with various multivalent (i.e., containing both sodium and calcium) salt solutions. Based on the results of these tests, the researchers found that a GCL's long-term hydraulic conductivity (as determined by ASTM D6766) can be estimated if the ionic strength (I) and the ratio of monovalent to divalent ions (RMD) in the permeant solution are both known, using the following empirical expression:

$$\frac{\log K_c}{\log K_{DI}} = 0.965 - 0.976 \times I + 0.0797 \times RMD + 0.251 \times I^2 \times RMD$$

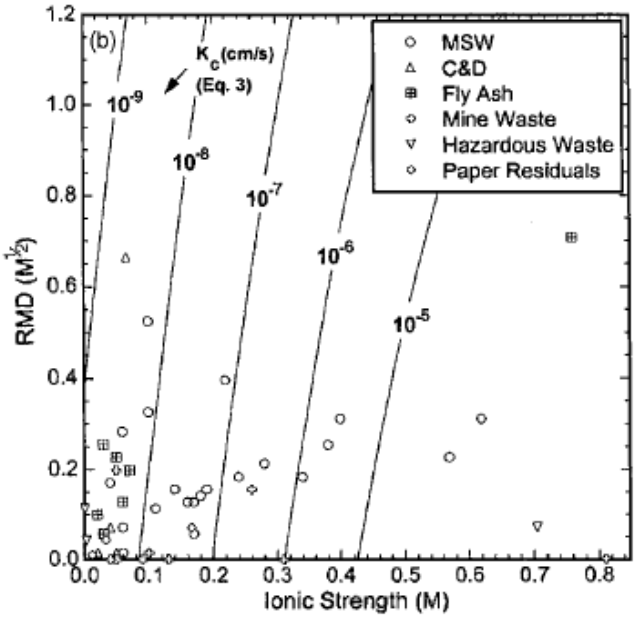
where:

I = ionic strength (M) of the site-specific leachate.

RMD = ratio of monovalent cation concentration to the square root of the divalent cation concentration ($M^{1/2}$) in the site-specific leachate.

K_c = GCL hydraulic conductivity when hydrated and permeated with site-specific leachate (cm/sec).

K_{DI} = GCL hydraulic conductivity with deionized water (cm/sec).



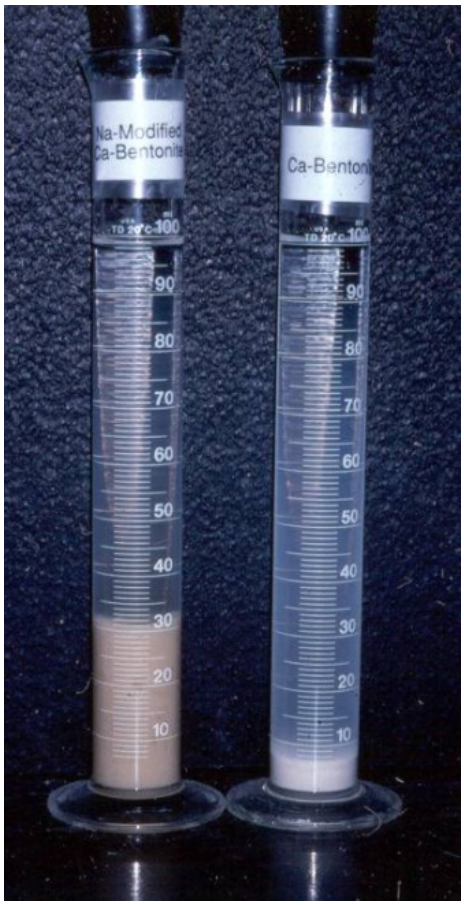
Using this tool, a Tier I compatibility evaluation can be performed if the major ion concentrations (typically, calcium, magnesium, sodium, and potassium) and ionic strength (estimated from either the total dissolved solids [TDS], or electrical conductivity [EC]) of the site leachate are known. For example, using the relationship above and MSW leachate data available in the literature, Kolstad et al. were able to conclude that high hydraulic conductivities (i.e., $>10^{-7}$ cm/sec) are unlikely for GCLs in base liners in many solid waste containment facilities.

In many cases, the Tier I evaluation is sufficient to show that a site-specific leachate should not pose compatibility problems. However, if the analytical data indicate a potential impact to GCL hydraulic performance, or if there is no analytical data available, then it is necessary to proceed to the second tier, involving bentonite "screening" tests, which are described below.

Tier II

The next tier of compatibility testing involves bentonite screening tests, performed in accordance with ASTM Method D6141. These tests are fairly straightforward, and can be performed at one of CETCO's R&D laboratories or at most commercial geosynthetics testing laboratories.

Liquid samples should be obtained very early in the project, such as during the site hydrogeological investigation. It is important that the sample collected is representative of actual site conditions. Synthetic leachate samples may also be considered for use in the compatibility tests. The objective is to create a liquid representative of that which will come in contact with the GCL. At least 1-gallon (4-Liter) of each sample should be submitted for testing. Samples should be accompanied by a chain-of-custody or information form. When a sample is received at the CETCO laboratory, the following screening tests are performed to assess compatibility:



- Fluid Loss (ASTM D5890) – A mixture of sodium bentonite and the site water/leachate is tested for fluid loss, an indicator of the bentonite's sealing ability.
- Swell Index (ASTM D5891) – Two grams of sodium bentonite are added to the site water/leachate and tested for swell index, the volumetric swelling of the bentonite.
- Water quality – The pH and EC of the site water/leachate are measured using bench-top water quality probes. pH will indicate if any strong acids (pH < 2) or bases (pH > 12) are present which might damage the bentonite clay. EC indicates the strength of dissolved salts in the water, which can hamper the swelling and sealing properties of bentonite if present at high concentrations.
- Chemistry – The site water/leachate is analyzed for major dissolved cations using ICP. The analytical results can then be used to perform a Tier I assessment, if one has not already been done.

As part of this testing, fluid loss and free swell tests are also performed on clean, deionized, or "DI" water for comparison to the results obtained with the site water/leachate sample. Sodium bentonite tested with DI water is expected to have a free swell of at least 24 mL/2g and a fluid loss less than 18 mL. Changes in bentonite swell and fluid loss indicate that the constituents dissolved in the site water may have an impact on GCL hydraulic conductivity. However, since it is only a screening tool, there are no specific values for the fluid loss and swell index tests that the clay must meet in order to be considered chemically compatible with the test liquid in question. Differences between the results of the baseline tests and those conducted with the site leachate may warrant further hydraulic testing.

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A major drawback of the D6141 tests is the potential for a false "negative" result, meaning that the bentonite swell index or fluid loss might predict no impact to hydraulic performance, where in reality, there may be a long-term adverse effect. This is primarily a concern with dilute calcium or magnesium solutions, which may slowly affect GCL hydraulic performance over months or years. Short-term (2-day) bentonite screening tests would not be able to capture this type of long-term effect. This is not expected to be a concern with strong calcium or magnesium or high ionic strength solutions, which have been shown to impact GCL hydraulic conductivity almost immediately, and whose effects would therefore be captured by the short-term bentonite screening tests. Another limitation of the bentonite screening tests is their inability to simulate site conditions, such as clean water prehydration, increased confining pressure, and wet/dry cycling. These limitations can be in part addressed by moving to the third tier, a long-term GCL hydraulic conductivity test, discussed below.

Tier III

The third-tier compatibility evaluation consists of an extended GCL hydraulic conductivity test performed in accordance with ASTM D6766. This test method is essentially a hydraulic conductivity test, but instead of permeating the GCL sample with DI water, the site-specific leachate is used. Since leachates can often be hazardous, corrosive, or volatile, the testing laboratory must have permeant interface devices, such as bladder accumulators, to contain the test liquid in a closed chamber, and prevent contamination of the flow measurement and pressure systems, or release of chemicals to the ambient air.

Method D6766 provides some flexibility in specifying the testing conditions so that certain site conditions can be simulated. For example, in situations where the GCL will be deployed on a subgrade soil that is compacted wet of optimum, the GCL will very likely hydrate from the relatively clean moisture in the subgrade (TR-222), long before it comes in contact with the potentially aggressive site leachate. Lee and Shackelford (2005) showed that a GCL which is pre-hydrated with clean water before being exposed to a harsh solution is expected to exhibit a lower hydraulic conductivity than one hydrated directly with the solution. Depending on the expected site conditions, the D6766 test can be specified to pre-hydrate the GCL with either water (Scenario 1) or the site liquid (Scenario 2).

Another site-specific consideration is confining pressure. Certain applications, such as landfill bottom liners and mine heap leach pads, involve up to several hundred feet of waste, resulting in high compressive loads on the liner systems. Although the standard confining pressure for

the ASTM D6766 test is 5 psi (representing less than 10 feet of waste), the test method is flexible enough to allow greater confining pressures, thus mimicking conditions in a landfill bottom liner or heap leach pad. Petrov et al (1997) showed that higher confining pressures will decrease bentonite porosity, and tend to decrease GCL permeability. TR-321 shows that higher confining pressures will improve hydraulic conductivity even when the GCL is permeated with aggressive calcium solutions.

ASTM D6766 has two sets of termination criteria: hydraulic and chemical. To meet the hydraulic termination criterion, the ratio of inflow rate to outflow rate from the last three readings must be between 0.75 and 1.25. It normally takes between one week and one month to reach the hydraulic termination criterion. To meet the chemical termination criterion, the test must continue until at least two pore volumes of flow have passed through the sample and chemical equilibrium is established between the effluent and influent. The test method defines chemical equilibrium as effluent electrical conductivity within ±10% of the influent electrical conductivity. This requirement was put in place to ensure that a large enough volume of site liquid passes through the sample to allow slow ion exchange reactions to occur. Two pore volumes can take approximately a month to permeate through the GCL sample. However, reaching chemical equilibrium (effluent EC within 10% of influent EC), may take more than a year of testing, depending on the leachate characteristics.

ASTM D6766 is a very useful tool which provides a fairly conclusive assessment of GCL chemical compatibility with a site-specific leachate. However, the major drawback of the D6766 test is the potentially long period of time required to reach chemical equilibrium. This limitation reinforces the need for upfront compatibility testing early in the project. Clearly, requiring the contractor to perform this testing during the construction phase is not recommended.

WHAT DO THE ASTM D6766 COMPATIBILITY TEST RESULTS MEAN?

ASTM D6766 is currently the state-of-the-practice in the geosynthetics industry for evaluating long-term chemical compatibility of a GCL with a particular site waste stream. An ASTM D6766 test that is properly run until both the hydraulic (inflow and outflow within ±25% over three consecutive readings) and chemical (effluent EC within ±10% of influent EC) termination criteria are achieved, provides a good approximation of the GCL's long-term hydraulic conductivity when exposed to the site leachate. Jo et al (2005) conducted several GCL compatibility tests with weak calcium and magnesium solutions, with some tests running longer than 2.5 years, representing several hundred pore volumes of flow. The intent of this study was to run the tests until complete ion exchange had occurred, which required even stricter chemical equilibrium termination criteria than the D6766 test. The study found that the final GCL hydraulic conductivity values measured after complete ion exchange were fairly close to (within 2 to 13 times) the hydraulic conductivity values determined by ASTM D6766 tests, which took much less time to complete.

The laboratory that performs the chemical compatibility test, whether it is the CETCO R&D laboratory or an independent third-party laboratory, is only reporting the test results under the specified testing conditions, and is not making any guarantees about actual field performance or the suitability of a GCL for a particular project. It is the design engineer's responsibility to incorporate the D6766 results into their design to determine whether the GCL will meet the

overall project objectives. Neither the testing laboratory nor the GCL manufacturer can make this determination.

Also, it is important to note that the results of D6766 testing for a particular project are only applicable for that site, for the specific waste stream that is tested, and only for the specific conditions replicated by the test. For instance, D6766 testing performed at high normal loads representative of a landfill bottom liner should not be applied to a situation where the GCL will only be placed under a modest normal load, such as a landfill cover or pond. Similarly, the results of a D6766 test where the GCL was pre-hydrated with clean water should not be applied to sites located in extremely arid climates where little subgrade moisture is expected, unless water will be applied manually to the subgrade prior to deployment. And finally, since D6766 tests are normally performed on continuously hydrated GCL samples, the test results should not be applied to situations where repeated cycles of wetting and drying of the GCL are likely to occur, such as in some GCL-only landfill covers, as desiccation can worsen compatibility effects.

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Attachment 5

CETCO Functional Equivalency

CETCO 2870 Forbs Avenue Hoffman Estates, IL 60192
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September 17, 2024

Justin Simon, PE.,
GHD
11228 Aurora Ave
Des Moines, IA 50322-7904

Subject: MidAmerican Energy Center Louisa Generating Station CCR LF

Dear Justin Simon,

CETCO received a question about comparing the contaminant flux performance of compacted clay liner (CCL) and geosynthetic clay liner (GCL). Generally, GCL is a thinner material (thickness of GCL is approximately 7 mm) but provides approximately 20 to 50 times lower permeability. To combine the effects of thickness and permeability, industry typically uses darcy's law equivalency. A copy of darcy's law spreadsheet (attached to this letter) provided and shows that the flux of contaminant going through the GCL layer is 23% less than a CCL with 2 ft of clay with permeability of 1×10^{-7} cm/s. CETCO TR-208 (attached) which provides additional information about calculation methods and ease of construction and quality control for GCL lined waste containment in compare with CCL lines facilities.

Should you have any further questions or require additional information, please do not hesitate to contact me.

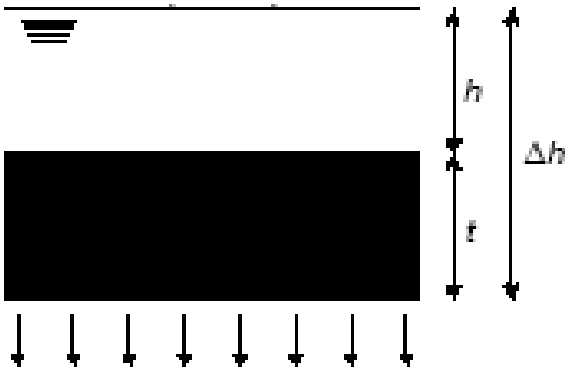
Sincerely,

M. Reza. Gorakhki, Ph.D.
Reza Gorakhki
Director of Environmental Products.
Minerals Technologies Inc.
2870 Forbs Ave.
Hoffman Estates, IL 60192 USA
C 952.334.8530
Email: Reza.gorakhki@mineralstech.com

Liner Leakage Calculations

Darcy's Law: $q = Q/A = k\ i$

K = hydraulic conductivity
i = (head + thickness)/thickness = (H + T)/T



	Bentonite-Soil Mix	Resistex 100 GCL
k (cm/sec)	1.00E-07	2.63E-09
thickness (cm)	60.96	0.70
head (cm)	30	30
hydraulic gradient	1.492125984	43.85714286
flux (m3/m2/sec)	1.49E-09	1.15E-09
Flux (L/ha/day)	1289	997
flux (gal/acre/day)	**138**	**106**

TECHNICAL EQUIVALENCY ASSESSMENT OF GCLs TO CCLs

This paper was presented at the 7th Geosynthetic Research Institute Seminar in 1993. It contains a comprehensive comparison of geosynthetic clay liners (GCLs) to compacted clay liners (CCLs). The authors begin with an overview of the various types of GCLs available on the market at that time. They make a detailed comparison of GCLs to CCLs in the following three areas:

- hydraulic properties
- physical/mechanical properties
- construction issues

The more important points or comparisons are highlighted below.

Hydraulic Properties
The authors conclude that a GCL is at least equivalent to a CCL with respect to the steady state flow of water, even though a GCL is much thinner. The GCL's effectiveness is due to its extremely low permeability.

In the short term, a CCL probably has better Cation Exchange Capacity (CEC) than a GCL. However, this advantage makes no difference over the life of the landfill because the full adsorptive capacity of the CCL will be exhausted relatively quickly. Consequently, CEC will make no difference in the performance of the liners in the long run.

The authors draw a similar conclusion about break-out time. Break-out time is not an important factor because all liners leak to some extent. What is more important is the total volume of leakage through a given liner over a given period of time.

Physical/Mechanical Properties
The authors looked at several properties in this section and determined that GCLs are equivalent or superior to CCLs with respect to freeze/thaw, wet/dry cycles and total and differential settlement. GCLs are not permanently damaged by either freezing or desiccation due to the bentonite's self-healing nature. Also, GCLs perform better under differential settlement than CCLs because their geotextiles allow the GCLs to withstand larger stains. CCLs will crack severely after only 0.85% strain.

Slope stability is a very site specific issue because of the many different factors involved. However, the authors' point out that slope stability is also very product dependent. Different GCLs have by nature of their reinforcing mechanisms, different stability characteristics.

The authors do note that GCLs are not equivalent to CCLs with regard to bearing capacity. Heavy equipment, such as that used at most landfills, cannot drive directly on top of a GCL. A soil cover of 1 to 3 feet is required to protect a GCL from heavy equipment. This type of protection is not required for a CCL.

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Construction Issues

The authors point out that GCLs are more susceptible to puncture than CCLs. However, they also mention, "Although the GCLs can be punctured during construction, careful CQC/CQA should be capable of addressing this potential problem. Further, for final covers, an occasional small puncture may be of little consequence."

GCLs do have several advantages over CCLs when it comes to construction. GCLs can be deployed much more quickly and do not require any water. This last point is important because a large CCL can require several hundred thousand gallons of water just to raise the water content a few percent.

The Quality Assurance of a manufactured GCL is relatively simple and straightforward. In contrast, "The proper construction of a low-permeability CCL is a relatively challenging task." Extensive testing of the finished liner must accompany careful selection and placement of the soils. All of these factors substantially increase the time and cost of constructing a CCL without any increase in the performance of the liner.

Conclusions

The conclusions reached by the authors state, "While no general conclusion can be reached about GCL equivalency to a CCL at all sites (either for liner or cover applications), it is expected that GCLs can be shown to provide better or equivalent performance at many sites."

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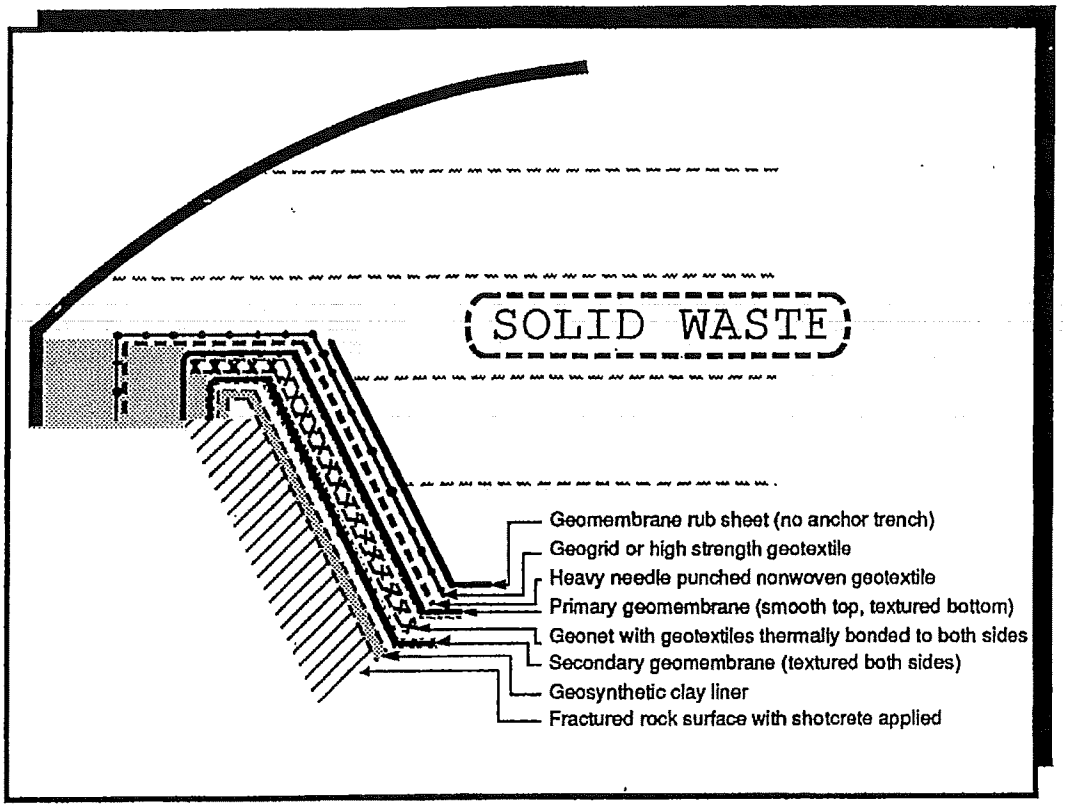
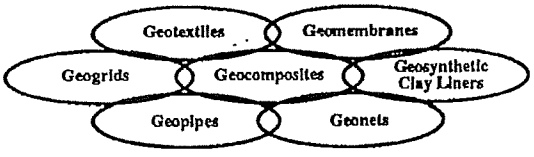
PROCEEDINGS OF THE 7TH GRI SEMINAR

GEOSYNTHETIC LINER SYSTEMS: INNOVATIONS, CONCERNS AND DESIGNS

DECEMBER 14-15, 1993
PHILADELPHIA, PA





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TECHNICAL EQUIVALENCY ASSESSMENT OF GCLs TO CCLs

R. M. KOERNER
GEOSYNTHETIC RESEARCH INSTITUTE, DREXEL UNIVERSITY, USA
D. E. DANIEL
UNIVERSITY OF TEXAS AT AUSTIN, USA

ABSTRACT

Since their introduction as barrier materials in waste containment systems in 1986, geosynthetic clay liners (GCLs) have been installed in a variety of applications. Perhaps the major applications have been as leachate containment barriers beneath landfills and surface impoundments, and as infiltration water barriers in landfill covers. When one considers that the traditional barrier material in these applications is a compacted clay liner (CCL), it is only logical that the two materials should be compared and contrasted to one another in such a way so as to assess technical equivalency. This paper provides the salient features for providing such an assessment. It is primarily based on technical issues and results in a framework that can possibly be used for assessment of both liner and cover barrier materials.

In this assessment it is seen that other than issues of puncture resistance and product thinning due to abutting objects and uneven subgrades (both of which can be avoided by proper CQC/CQA procedures), GCLs can generally be used on an equivalent basis as CCLs. However, site specific conditions like long term slope stability may provide unique situations calling for specific products or alternate designs.

Needed to further this assessment of GCLs to CCLs is a continued dialogue with respect to technical issues, close monitoring of GCL installations, and involvement of regulatory agencies in the decision making process.

INTRODUCTION AND SCOPE

The traditional hydraulic barrier material used to contain solids and liquids in a variety of applications is clearly one made from natural soils, typically clays. Such clay barriers can occur via a natural clay stratum, a compacted soil liner or an amended clay liner. These natural soil materials will be called by the collective term of "compacted clay liners", or "CCLs", in this paper.

Clearly, CCLs are the basic material required by regulatory agencies in the containment of solid waste. A recent study for municipal solid waste liner systems has shown the following, Fahim and Koerner (1993):

- CCLs are used as a single liner beneath waste in 19 states
- CCLs are used as a composite liner beneath a geomembrane in 20 states
- CCLs are used as a single cover in 36 states
- CCLs are used as a composite cover beneath a geomembrane in 6 states

The minimum U. S. EPA requirements are generally for the CCL to be from 300 to 900 mm thick with a maximum hydraulic conductivity of 1×10^{-7} cm/sec in the liner and 1×10^{-5} cm/sec in

the cover. Note, however, that current municipal solid waste regulations (Subtitle "D") call for a geomembrane to be placed above the CCL in both situations of a liner beneath the waste and a cover above the waste.

A tremendous data base is available on CCLs for waste containment applications. This is evidenced by major research efforts, U.S. EPA SW-869 (1983), Goldman, et. al. (1988) and Daniel, (1987), development of specialized laboratory test equipment, U.S. EPA (1986), development of unique construction procedures and equipment, Rogowski, (1990) and an entire CQC/CQA monitoring protocol, Daniel and Koerner (1993). Thus any new liner material intended to challenge the status of CCLs must necessarily be compared and contrasted to the existing situation.

One such competing material that might be considered for a single liner (not a composite) replacement of a CCL is a geomembrane (GM). Indeed, 8 states have selected this option for liners beneath the waste and 17 have for covers above the waste. Both strategies, however, do not meet the minimum technology guidance of U.S. EPA regulations which, as mentioned previously, require composite GM/CCL systems. For this paper it will be assumed that the GM (if used at all) will be used in a complimentary manner to the underlying clay liner as a composite liner.

A second, and more recent, competing material to a CCL is a geosynthetic clay liner, or GCL. Geosynthetic clay liners are defined in ASTM D4439 as follows:

"Geosynthetic clay liners are factory manufactured hydraulic barriers typically consisting of bentonite clay or other very lower permeability material, supported by geotextiles and/or geomembranes, which are held together by needling, stitching, or chemical adhesives."

Bentonite panels (the forerunner to GCLs) were first manufactured in the early 1980's and were initially used for foundation waterproofing and for sealing water retention structures. The panels were subsequently modified to be flexible rolls incorporating either geotextiles or geomembranes, i.e., GCLs, and were first used for landfill liners in 1986. Since then, GCLs have been used for a variety of lining applications and final cover systems for municipal and hazardous solid wastes.

The realization that GCLs are new, however, is evidenced by the survey mentioned earlier, Fahim and Koerner (1993), where no Federal regulations and only two State regulations even mention GCLs as a possible replacement of, or augmentation to, CCLs. In Colorado, GCLs are possible to use in the liner system and in Michigan in the cover system.

Interestingly, replacement of any natural material with a synthetic alternative (via technical equivalency) is usually a possibility. If one wishes to substitute a GCL for a CCL, one must demonstrate that the GCL will be equivalent in terms of meeting performance objectives. However, neither Federal nor State regulations mention the criteria by which equivalency should be evaluated. At the present time equivalency must be evaluated on a case-by-case basis using criteria that have not yet been defined. The lack of equivalency accepted criteria is perhaps the single greatest problem that the designer and/or owner of a waste facility face in seeking regulatory approval for substitution of a CCL by a GCL.

Importantly, one should not think of a GCL as being totally equivalent to a CCL. Indeed, there is no possibility that a 10 mm thick layer of bentonite could possibly be equivalent to a 300 to 900 mm thick layer of compacted clay in all respects. The critical issue is whether substituting an alternative material such as a GCL for the more traditional CCL will meet or exceed the performance objectives of the site specific situation. If the GCL will meet or exceed the performance objectives, then it should be considered that equivalency has been established.

This paper is intended to establish a framework for assessing such equivalency for waste containment liners and covers. In so doing, many generalities must be taken since no two site performance objectives, or set of demands, are identical. Even further (and with respect to solid waste landfills), liner systems beneath the waste will have very different objectives than covers above the waste. With these concepts in mind, and for the purposes of this paper, GCLs will be contrasted to CCLs in both liners and covers from a generic and widely encompassing perspective.

OVERVIEW OF GCLs

Since compacted clay liners (CCLs) are historically known, clearly established and well documented, e.g., U.S. EPA SW-869 (1983), Goldman, et. al. (1988), and Daniel, (1987), we will only focus on a description of geosynthetic clay liners (GCLs). The description will be brief, however, since more complete descriptions are available in the open literature, Daniel and Boardman (1993) and Estornell and Daniel (1992), and can be regularly updated from manufacturers of the various GCL products.

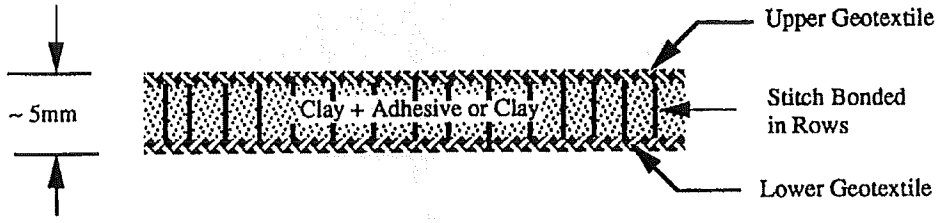
The essence of a GCL, of course, is the layer of bentonite which is held between or on carrier layers of geotextiles or a geomembrane. Bentonite is a unique clay mineral with very high swelling potential and water absorption capacity. When wetted, bentonite is the least permeable of all naturally occurring, soil-like minerals. Bentonite is a chemically stable mineral that has undergone complete weathering and will last, in effect, forever.

GCLs are manufactured by placing powdered or granulated bentonite (with or without an adhesive mixed into the bentonite) on a geotextile or geomembrane substrate. The bentonite layer is typically 7 to 10 mm thick and is placed at a unit weight of approximately 5.0 kg/m^2. Those GCLs with a geotextile substrate (4 of the 5 available types) have covering geotextiles as well, see Figure 1(a). The product (with or without adhesives) is often stitch bonded as in Figure 1(b), or needle punched as in Figure 1(c), thereby gaining considerable structural integrity. For one GCL, the substrate is a geomembrane where an adhesive mixed with the bentonite results in the final product, see Figure 1(d).

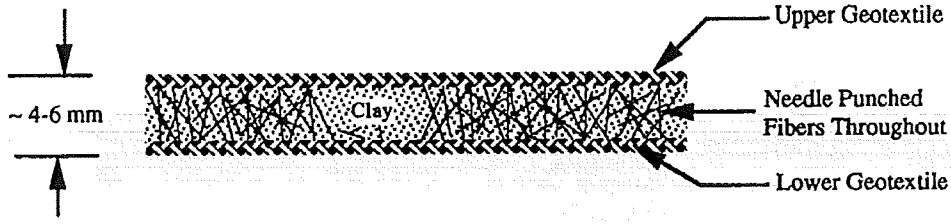
One particular style of each of the commercially available GCL products is shown in the upper photograph of Figure 2. This photograph shows the products stacked upon each other in dry (lower) and hydrated (upper) pairs. The lower photograph shows greater detail of one of the products in the hydrated (left) and dry (right) states.

As one can surmise from these photographs, there exists very real differences between GCLs and a 300 to 900 mm thick layer of clay-soil. In addition to the obvious thickness issue, Table 1 counterpoints many of the relevant features. Daniel (1993) further elaborates on these differing features.

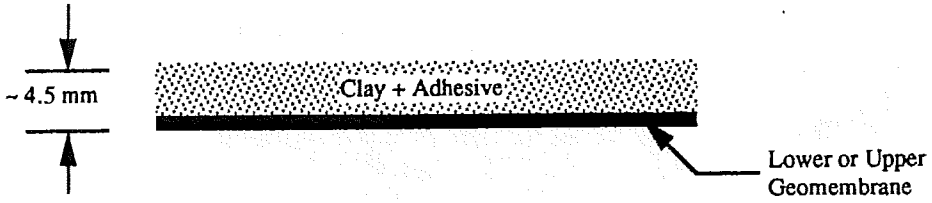
(a) Adhesive Bound Clay to Upper and Lower Geotextiles



(b) Stitch Bonded Clay Between Upper and Lower Geotextiles

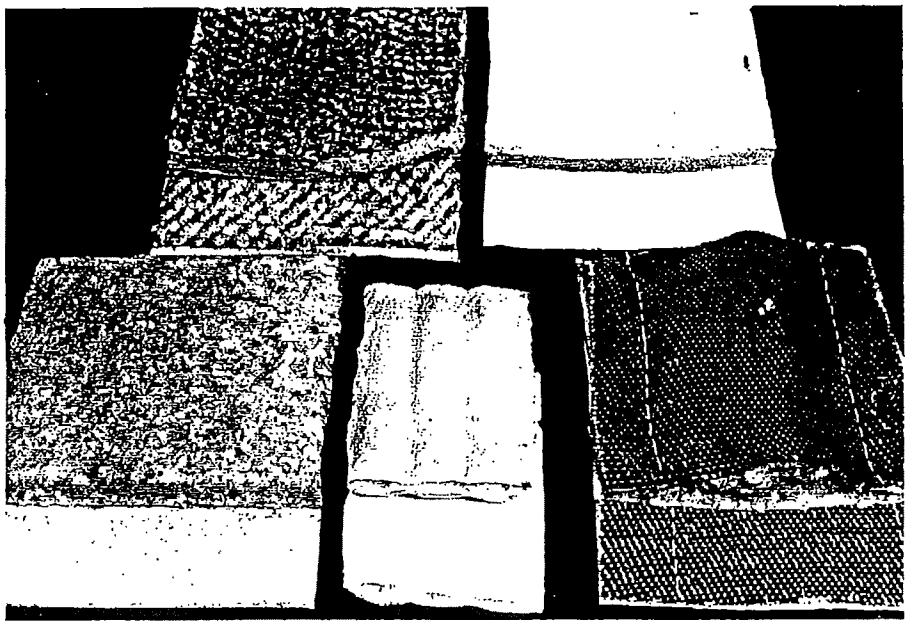


(c) Needle Punched Clay Through Upper and Lower Geotextiles

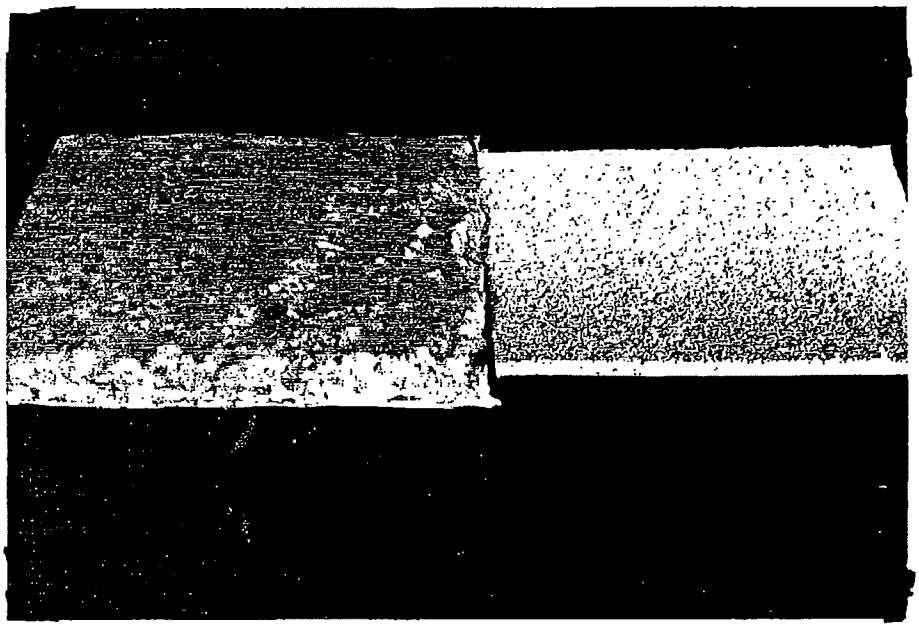


(d) Adhesive Bound Clay to a Geomembrane

Figure 1 - Cross section sketches of currently available geosynthetic clay liners (GCLs).



(a) Different Products in Dry versus Hydrated Conditions



(b) A GCL Hydrated (Left) vs. Dry (Right)

Figure 2. Commercially Available Geosynthetic Clay Liners (GCLs)

Table 1. Some selected differences between GCLs and CCLs.

Characteristic	Geosynthetic clay liner	Compacted clay liner
Materials	Bentonite, adhesives, geotextiles, and geomembranes	Native soils or blends of native soils and bentonite
Thickness	Typically 7 to 10 mm (when hydrated)	Typically 300 to 900 mm
Hydraulic conductivity	$\leq (1 \text{ to } 5) \times 10^{-9}$ cm/s	$\leq 1 \times 10^{-7}$ cm/s
Speed of construction	Rapid, simple installation	Slow, complicated construction
Need for MQC and MQA	Factory manufacturing requires constant monitoring	Naturally found materials or mineral layers requiring no monitoring
Status of CQC and CQA	Relatively simple, straight-forward, common-sense procedures	Complex procedures requiring highly skilled and knowledgeable people
Field desiccation sensitivity	GCLs cannot desiccate during construction unless prematurely hydrated	CCLs are nearly saturated; can desiccate during construction
Available of materials	Materials readily shipped to any site	Varies widely from readily available to not available at all
Installed Cost	Typically $6.00 to $8.00 per square meter for a large site	Highly variable -- estimated range: $6.00 to $30.00 per square meter
Experience	Limited due to newness and nonfamiliarity	Has been used for many decades with great confidence as a liner material

Note:
MQC = manufacturing quality control
MQA = manufacturing quality assurance
CQC = construction quality control
CQA = construction quality assurance

TECHNICAL EQUIVALENCY ISSUES

In this section as many issues as felt to be typically encountered in comparing GCLs to CCLs are presented. They are arranged in three somewhat arbitrary categories (hydraulic, physical/mechanical and construction) and are listed for liners as well as covers. Each of the issues in Table 2 will be discussed individually in the text to follow.

Table 2. Technical equivalency categories and specific issues to be addressed.

Category	Criterion for evaluation	Possibly relevant for: Liners	Covers
Hydraulic Issues	Steady flux of water	X	X
	Steady solute flux	X	
	Chemical adsorption capacity	X	
	Breakout time:		
	- Water	X	X
	- Solute	X	
	Horiz. flow in seams or lifts	X	X
	Horiz. flow beneath geomembranes	X	X
	Generation of consolidation water	X	X
	Permeability to gases		X
Physical/ Mechanical Issues	Freeze-thaw behavior	X[1]	X
	Wet-dry behavior		X
	Total settlement response	X[2]	X
	Differential settlement response	X[2]	X
	Slope stability considerations	X	X
	Vulnerability to erosion		X
	Bearing capacity (squeezing)	X	X
Construction Issues	Puncture resistance and resealing	X	X
	Subgrade condition considerations	X	X
	Ease of placement or construction	X	X
	Speed of construction	X	X
	Availability of materials	X	X
	Requirements for water	X	X
	Air pollution concerns	X	X
	Weather constraints	X	X
	Quality assurance considerations	X	X

notes:

[1]Relevant only until liner is covered sufficiently to prevent freezing

[2]Settlement of liners usually of concern only in certain circumstances, e.g., vertical or lateral expansions

HYDRAULIC ISSUES

The essence of any barrier material is its ability to contain the targeted liquids. The usual liquids are leachate, i.e., the solute, for liner systems beneath the waste and water for the cover system above the waste.

Steady Flux of Water. Water flux is defined as the volume of water flowing across a unit area in a unit time. The steady downward flux of water (v) through an individual layer of porous material with zero water pressure at the base of the layer is defined from Darcy's law as:

$$v = k \frac{H + T}{T} \quad (1)$$

where k is the hydraulic conductivity, H is the depth of liquid ponded on the layer, and T is the

thickness of the layer.

Equation 1 is applicable only for flow through the bentonite component of a GCL; if the GCL contains a geomembrane, water flux will be controlled by water vapor diffusion through the geomembrane component. The geomembrane component, if present, should be included in the equivalency analysis, e.g., by using appropriate water vapor transmission rates. Also, Eq. 1 applies to a CCL or GCL liner alone and not to composite liners. Composite action with a geomembrane is considered later.

In order to estimate the required hydraulic conductivity of the GCL for equivalency assessment, assume that the water flux through the GCL is equal to the water flux through the CCL:

$$V_{GCL} = V_{CCL} \tag{2}$$

or:

$$k_{GCL} \frac{H + T_{GCL}}{T_{GCL}} = k_{CCL} \frac{H + T_{CCL}}{T_{CCL}} \tag{3}$$

If the hydraulic conductivity and thickness of the compacted clay liner are known, and the thickness of the GCL is known, the required hydraulic conductivity of the GCL to ensure equivalent performance in terms of steady flux of water is:

$$(k_{GCL})_{Required} = k_{CCL} \frac{T_{GCL}}{T_{CCL}} \frac{H + T_{CCL}}{H + T_{GCL}} \tag{4}$$

The required hydraulic conductivity of the compacted clay liner (k_{CCL}) is usually 1×10^{-7} cm/s. The thickness of GCLs (T_{GCL}) varies from product to product, but is typically about 7 mm after hydration at low overburden stress. The head of water (H) on the CCL or GCL is assumed to be 300 mm for purposes of illustration. The required hydraulic conductivity of the GCL, based on Eq. 4 and these conditions, is therefore:

- For equivalence to a 300-mm-thick compacted clay liner:
$$(k_{GCL})_{Required} = 4.6 \times 10^{-9} \text{ cm/sec}$$
- For equivalence to a 600-mm-thick compacted clay liner:
$$(k_{GCL})_{Required} = 3.4 \times 10^{-9} \text{ cm/sec}$$

As see in Table 1, the hydraulic conductivity of the bentonite component of commercially-produced GCLs is typically ≤ 1 to 5×10^{-9} cm/s. Thus, it is seen that equivalency of a GCL to a CCL, in terms of the steady water flux, can be established for most, if not all, GCLs in their manufactured condition.

Steady Solute Flux. Long-term, steady flux of solute in leachate may be analyzed on the basis of advection alone, diffusion alone, or advection plus diffusion. It is assumed that the concentration of a solute of concern in the leachate remains constant. Regarding advection, the advective mass flux, $v_{m,A}$, is:

$$v_{m,A} = c_{leachate} k \frac{H + T}{T} = c_{leachate} v \tag{5}$$

where $c_{leachate}$ is the concentration of the solute of interest in the leachate and, as before, v is the water flux. The advective mass flux ratio, $F_{m,A}$, is defined as the mass flux of solute through a GCL divided by the mass flux of solute through a CCL:

$$F_{m,A} = \frac{v_{m,A(GCL)}}{v_{m,A(CCL)}} \tag{6}$$

or:

$$F_{m,A} = \frac{c_{leachate}\, k_{GCL}\, \dfrac{H + T_{GCL}}{T_{GCL}}}{c_{leachate}\, k_{CCL}\, \dfrac{H + T_{CCL}}{T_{CCL}}} = \frac{c_{leachate}\, v_{GCL}}{c_{leachate}\, v_{CCL}} = \frac{v_{GCL}}{v_{CCL}} \tag{7}$$

Thus, the ratio of solute flux is the same as the ratio of water flux. Therefore, if one has demonstrated equivalency in terms of steady water flux, one has necessarily also demonstrated equivalency in terms of steady mass flux of solute.

Chemicals can also migrate through liners via diffusion. Two cases are considered:

1. Single Liner or Bottom Liner in Double Liner System. Theoretically, steady-state diffusion is never reached with a clay liner resting on native soil, unless there is a boundary condition, e.g., water table with uncontaminated water at a shallow depth below the liner. Conditions at a particular site must be considered in order to determine the pattern of diffusion through a liner resting on native soil. However, in nearly all cases essentially equivalent performance is anticipated from a GCL if the native soils are included in the assessment, as they should be.

2. Upper Liner in Double Liner System. Over time, the solute of interest in the leachate will diffuse to the base of the upper liner and into the underlying leak detection layer. The concentration at the base of the liner will eventually equal the concentration on top of the liner. Thus, the diffusion-driving concentration gradient will become zero and diffusive transport will cease. The issue of steady diffusion through an upper liner in a double liner system is moot.

Solutes can also migrate through soil liners by advection plus diffusion. However, since advective and diffusive mass fluxes are additive, and since the advective mass flux dominates, demonstration of equivalency in terms of water flux will generally ensure equivalency in terms of total mass flux.

Chemical Adsorption Capacity. Regulations generally have no specific adsorption requirements. Adsorption of organics tends to be different from adsorption of inorganics. Adsorption of inorganics is controlled by cation exchange reactions and geochemical processes such as precipitation. Adsorption of organic solutes is generally assumed to be controlled by the amount of organic carbon in the soil and a partition coefficient for the solute (which is characterized by the octanol-water partition coefficient or water solubility of the organic species).

For inorganics, the maximum adsorbed mass per unit cross-sectional area of liner (M) resulting from cation exchange processes may be defined as follows:

$$M = C\, \rho_d T \tag{8}$$

where C is the cation adsorption capacity (maximum mass of solute sorbed per unit mass of dry soil), ρ_d is the dry mass density of the soil, and T is the thickness of the liner. The ratio of thickness of a typical GCL to a CCL is small (on the order of 0.01). Thus, in order for a GCL to

have equivalent cation adsorption capacity, the adsorption coefficient of the GCL would have to be at least 100 times that of the CCL.

The cation exchange capacity of bentonite clay is typically on the order of 100 to 150 meq/100g. Natural soil materials used to construct CCLs have typical CECs in the range of 3 to 30 meq/100g. The ratio of cation adsorption capacities, denoted F_{CEC}, is:

$$F_{CEC} = \frac{C_{GCL}}{C_{CCL}} = \frac{C_{GCL}}{C_{CCL}\frac{\rho_{dGCL}}{\rho_{dCCL}}}\frac{T_{GCL}}{T_{CCL}} \qquad (9)$$

For the typical range of values, F_{CEC} would be expected to be in the range of 0.03 to 0.75. It appears unlikely that equivalency can be demonstrated for cation adsorption capacity using the expressions just presented. However, cation exchange is just one of several processes that can affect adsorption. Precipitation of inorganic solutes can be a far more important mechanism than cation exchange, and pH is often a dominant variable controlling precipitation processes in many geochemical environments. Thus, site-specific factors, and not just simple comparisons of CECs and relative soil masses, will often need to be considered when relative adsorption capacities are compared.

Non-polar organic solutes are sorbed by carbon present in the soil. The carbon content of bentonite in GCLs is capable of estimation, but CCLs will be highly variable in their organic carbon content. Although site-specific assessments would be required (due to variability of CCLs), equivalency of a GCL to a CCL probably cannot be demonstrated in terms of capacity to adsorb non-polar constituents in leachate because the mass of bentonite present in a GCL is far less than the mass of soil present in a CCL.

Adsorption, however, is only relevant in the short term. When steady state mass transport is reached, adsorption capacity is exhausted. Equivalency in terms of adsorption, if evaluated at all, should be evaluated in terms of a specified performance period.

Breakout Time of Water or Solute. Neither GCLs, nor CCLs, are initially saturated with water. GCLs contain essentially dry bentonite, but CCLs are often close to being saturated at the time of construction. When liquid first enters the upper surface of an unsaturated liner, no liquid discharges from the base of the liner until the liner absorbs enough water to reach field capacity at the base of the liner.

The time to discharge water from the base of the liner is difficult to analyze in a simple way. For CCLs, the time depends greatly upon the hydraulic conductivity, initial water content, tendency to swell, and rate of water infiltration into the top of the liner. For GCLs, the time to initiate discharge of water from the base is usually fairly short (a few weeks) if the liner is continuously flooded with solute or may be extremely long if solute is slowly absorbed by the bentonite. For GCLs that contain a geomembrane, the time may be much greater. A comparison of time to initiate discharge of solute from the base of the liner would have to be performed on a site and product specific basis.

Regarding a landfill cover, a GCL might be compared to a CCL in terms of the time to discharge water from its base on the assumption that leachate production within the underlying waste would not begin until water is discharged from the base of the barrier layer. However, many would consider the "breakout time" of water from the barrier layer to be essentially irrelevant because over the long term, the time to initiate discharge water from the barrier layer is not important. Over the long term, the flux of water through the barrier layer is the important issue. A liner with a hydraulic conductivity of 1×10^{-9} cm/s allows only about 0.25 mm (0.01 inch) of water to flow through it per year under continuous exposure to a water

source and unit hydraulic gradient. For those GCLs that contain a geomembrane, the presence of the geomembrane should be taken into account in the evaluation of breakout time.

In general, it is not believed that breakout time should be an important issue in an equivalency assessment. Other factors seem far more important.

Horizontal Flow in Seams or Lifts. The liquid flow just described is considered to be, and is laboratory measured as, the vertical flow through the clay matrix. Concerns are raised as to horizontal flow which might be more rapid and tend to increase the water or solute flux over a large area. For GCLs, the concern is clearly in the overlap seam area. Yet, large scale experiments tend to substantiate manufacturers recommendations that the overlap areas either self-seal or, by adding bentonite, co-mingle with the abutting geotextiles to form an adequate seal, LaGatta, (1992). For CCLs, the concern is between individual lifts with inadequate bonding from one surface to the next, Rogowski (1990). This issue, as with the GCLs, is clearly related to CQC/CQA monitoring which will be discussed later. If properly constructed, neither material should be a major concern with respect to horizontal liquid flow.

Horizontal Flow Beneath Geomembranes. When used as the lower component of a composite liner, both GCLs and CCLs must achieve "intimate contact" with the overlying geomembrane. The reason being that liquid (water or solute) passing through a hole in the geomembrane should not be able to spread horizontally attacking the underlying clay over an enlarged area.

Using a radial transmissivity device, laboratory test results on five different GCLs placed beneath a geomembrane with a small centrally located hole has been reported by Harpur, et al. (1993). Transmissivity test results at two different normal stresses were evaluated, see Table 3.

Table 3. Apparent transmissivities of various GM/GCL combinations compared to theoretical GM/CCLs.

Clay Beneath Geomembrane	Type of Bentonite	Type of Upper Geotextile Against Geomembrane	Apparent Transmissivity in Units of m^2/sec	
			7 kPa	70 kPa
GCL-A	adhesive/granules	none	3×10^{-12}	3×10^{-12}
GCL-B	power	woven-slit film	3×10^{-11}	9×10^{-12}
GCL-C	adhesive/granules	woven-spunlaced	8×10^{-11}	6×10^{-12}
GCL-D	granules	woven-slit film	2×10^{-10}	1×10^{-10}
GCL-E	powder	nonwoven-needled	1×10^{-10}	8×10^{-11}
theoretical best CCL lab conditions		none	6.4×10^{-10}	
theoretical best CCL field conditions		none	6.4×10^{-9}	

Comparing the GCL group with CCLs is difficult due to lack of data with GM/CCLs. However, theoretical data also shown in Table 3 indicates that all GM/GCL combinations evaluated are significantly lower in transmissivity than the anticipated GM/CCL transmissivity. Bentonite extruding through covering geotextiles, or intruding into them gives rise to these lower GM/GCL transmissivity values. While actual GM/CCL data needs to be developed it appears as though GCLs are superior to CCLs with respect to transmissivity.

For both GCLs and CCLs, the intimate contact issue can be challenged when the covering geomembrane has waves in it due to high temperature expansion. This is an equal concern for both GCLs and CCLs with no preference for one material over the other.

Generation of Consolidation Water. Application of normal stress to a CCL tends to squeeze water out of the clay matrix. If this were to occur in a landfill cover, the water migrating into the underlying waste would eventually become leachate. Dry GCLs have no capability to produce consolidation water upon loading. In general, the GCL should be viewed as superior to a CCL in terms of minimizing production of consolidation water. However, because the applied loads in final covers are so small, the entire issue of production of consolidation water is usually moot for covers. This issue is far more important for clay liners located above leak detection layers in double liner systems beneath landfills.

In double lined waste containment facilities at least six states require a composite primary liner located above a leak detection system for MSW, Fahim and Koerner (1993). For hazardous waste, the number is considerably higher. When the clay liner component is a CCL placed at, or near, saturation, each lift of solid waste placed in the facility causes consolidation to occur. The expelled water enters the leak detection system and invariably causes confusion. Is the liquid consolidation water or leachate passing through the entire primary composite liner? Only through chemical analysis (MS/GC testing) and comparison with the primary leachate can a definitive answer be given. Additionally, this generation of expelled pore water occurs with each lift of additional waste that is placed in the facility. It has been very troublesome (and difficult to interpret) at a number of facilities. Dry GCLs do not have this problem and can be considered superior in this regard.

Permeability to Gases. The permeability of a barrier layer to various gases may be very important if the barrier layer is expected to restrict the movement of gas through the cover of a MSW landfill. Decomposing MSW landfills produce methane, carbon dioxide and trace amounts of numerous other gases. For clay soils, the gas permeability is extremely sensitive to the water content of the soil. Dry clay materials are highly permeable to gases, but water-saturated clay materials are practically impermeable to gases.

Compacted clay liners are compacted at a water content that is wet of optimum. The volume of air present in the CCL tends to be very low. Conversely, the gas permeability of GCLs depends greatly on how much moisture has been absorbed by the bentonite. The gas permeability is high for dry bentonite sandwiched between two geotextiles. For GCLs that contain a geomembrane, the geomembrane dominates the material's gas permeability and gives it a very low permeability. Equivalency in terms of gas permeability probably can be demonstrated for GCLs that contain a geomembrane or for GCLs that are sufficiently hydrated to attain a low permeability to gages. The bentonite in the GCL can be forced to hydrate quickly either by placing the GCL in contact with a moist soil or by applying water to the overlying soil after the GCL is placed and covered. Laboratory tests indicate that absorption of water by the bentonite occurs within a few weeks, Daniel, et al. (1993). The hydration of the bentonite can be forced to occur if gas permeability is a critical issue.

While this discussion tends to favor CCLs, it must be mentioned that if the CCL cracks due to desiccation or differential settlement the preferred pathways will bypass the intact soil mass causing the CCL to become high in its gas permeability.

PHYSICAL/MECHANICAL ISSUES

A number of physical/mechanical issues must be addressed since an inadequate structural performance of either a CCL or a GCL could result in an inadequate hydraulic performance, or even result in a failed system.

Freeze/Thaw Behavior. CCLs are known to be vulnerable to large increases in hydraulic conductivity from freeze/thaw cycling, e.g., Kim and Daniel (1992), although compacted soil-bentonite mixtures may not be as vulnerable to damage. Limited laboratory data indicate that GCLs do not undergo increases in hydraulic conductivity as a result of freeze/thaw. Thus,

from the available data, GCLs appear to be superior to CCLs in terms of freeze/thaw resistance.

Wet-Dry Behavior. Wetting and drying of CCLs and GCLs can cause the respective materials to swell or shrink. The main concern with CCLs is that desiccation can lead to cracking and to an increase in hydraulic conductivity.

Available laboratory data indicate that desiccation of wet GCLs does cause cracking, but rehydration of the GCL causes the bentonite to swell and the material to self heal, Kim and Daniel (1992). Thus, GCLs appear to be superior to CCLs in terms of ability to self-heal if the material is wetted, dried, and then rewetted.

Total Settlement Response. Total settlement refers to large scale settlement without significant bending or distortion of the liner system. Clearly, such settlement can be anticipated with MSW landfill covers. Hazardous solid waste (HSW) should be considerably more stable in this regard. Large scale (mass) settlement might also occur in liner systems placed as lateral or vertical expansions. It is believed that GCLs and CCLs would both respond similarly to total settlement and that neither would be damaged if there is no significant bending or distortion.

Differential Settlement Response. LaGatta (1992) studied the effects of differential settlement on the hydraulic conductivity of GCLs. He placed a water-filled bladder in a "false bottom" located beneath the GCL. The GCL was placed over the bladder and was then covered with 600 mm of gravel to simulate cover material. The GCL was flooded with 300 mm of water, and water draining out the bottom of the experimental apparatus was collected for 2 to 4 months, until the flow rate became steady. Then the bladder was incrementally deflated to produce a differential settlement. Boardman (1993) performed similar tests but subjected dry (rather than hydrated) GCLs to differential settlement; the GCLs were hydrated and permeated after the distortion took place in the dry material. The extreme differential settlement caused by the deflated bladders did not produce large increases in hydraulic conductivity for most of the GCLs tested.

Distortion is defined as the differential settlement, Δ, divided by the horizontal distance over which that settlement occurs, L, as shown in Figure 3. Distortion produces tension, which can lead to cracking. It appears from LaGatta's and Boardman's tests that many GCLs can withstand large distortion (Δ/L up to 0.5) and tensile strain (up to 10 to 15%) without undergoing significant increases in hydraulic conductivity. This finding is in sharp contrast to the results for compacted clay, which are summarized in Table 4 as compiled by LaGatta (1992). Normal compacted clay materials cannot withstand tensile strains greater than approximately 0.85% without failing by cracking. Pure bentonite, on the other hand, is reported to have a tensile strain at failure of 3.4%, but LaGatta measured much greater tensile strains without cracking in many GCLs, probably due to the beneficial reinforcing and/or confining effects from the geotextiles or geomembrane of the GCLs. In any case, the available data indicate that GCLs can withstand much greater tensile deformation than CCLs without cracking, which is a favorable characteristic for final covers. GCLs are considered to be superior to CCLs in terms of resistance to damage from differential settlement.

While this same discussion can be applied to the liner system beneath the solid or liquid waste the general situation is not as compelling since soil subgrades should be far more competent than with a body of solid waste. The notable exception, of course, is for vertical and lateral expansions of landfills over existing facilities. Here the situation described above for covers is even further exacerbated due to the high magnitudes of the applied normal stresses.

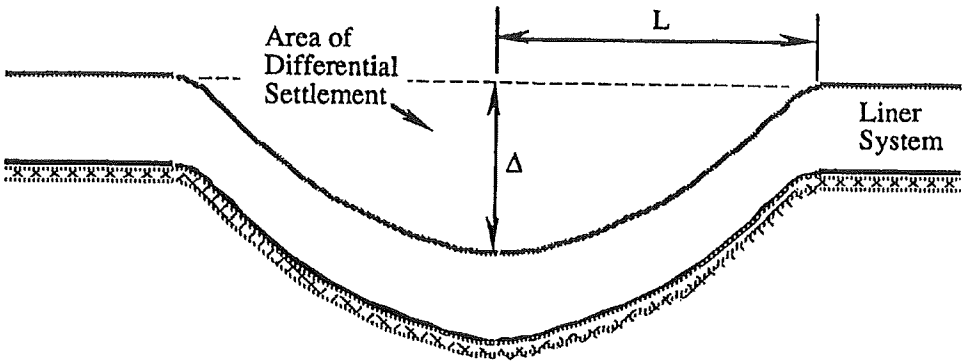


Figure 3. Definition of Liner Distortion "ΔL"

Table 4. Data on tensile strain at failure for compacted clay, LaGatta (1992).

Type or Source of Soil	Water Content (%)	Plasticity Index* (%)	Failure Tensile Strain (%)
Natural Clayey Soil	19.9	7	0.80
Bentonite	101	487	3.4
Illite	31.5	34	0.84
Kaolinite	37.6	38	0.16
Portland Dam	16.3	8	0.14
Rector Creek Dam	19.8	16	0.1
Woodcrest Dam	10.2	Non-plastic	0.18
Shell Oil Dam	11.2	Non-plastic	0.07
Willard Test Embankment	16.4	11	0.20

*Defined as the liquid limit minus the plastic limit per ASTM D4318

Slope Stability Considerations. The mid-plane shear strength of GCLs is obviously sensitive to the water content and type of GCL. Water-saturated GCLs that contain unreinforced, adhesive-bonded bentonite have angles of internal friction for consolidated-drained conditions of approximately 10 degrees. Dry or damp materials are 2 to 3 times higher than water-saturated GCLs. Also, needle-punched and stitch-bonded GCLs have higher strengths, at least in the short term. On-going creep studies of some types of hydrated needle punched GCLs, however, show that linear creep may occur at shear stresses of less than 50% of the short term strength. Whether these trends continue for all needle punched products at all normal stresses is not known. Note that it is possible to lock the needled fibers in place by adhesives or thermal fusion, and thus long term stability is possible. This same study shows that stitch bonded GCLs are very stable under similar conditions. Furthermore, the interface shear strength at the upper and/or lower surfaces of a GCL may be an issue depending on the type of surfaces of the GCL and the nature of the abutting material.

The shear strength of CCLs varies widely. Major factors include type of clay, percentage of clay, water content, density, etc. Thus no comparative conclusions with GCLs can be made.

For stability analyses involving composite liners, one often must consider interfacial shear with an adjacent layer, e.g., a geomembrane. No general statement can be made about

equivalency of a GCL to a CCL in terms of interface shear strength because the assessment depends on the specific materials involved, degree to which the bentonite or clay can wet, slope angle, and other site-specific conditions. Even further, slope stability must sometimes be assured against seismic conditions. Again site specific or product specific conditions will be required to make an equivalency assessment.

Vulnerability to Erosion. Erosion resistance may be of concern in final covers if adequate cover soil is not present. With a well-designed and properly maintained cover system, the barrier layer should never be subjected to forces of erosion after the construction phase is over and equivalency should not be an issue. In some cases, however, there may be insufficient cover soil to guarantee that the barrier layer will not be exposed. Because of the presence of erosion-resistant geosynthetic materials in GCLs, most GCLs can potentially be more resistant to erosion than CCLs. However, if a GCL is exposed to erosive forces, the bentonite may be washed out of some products. Thus, equivalency depends upon the specific materials being considered. For many sites, erosion will not be of any concern, e.g., situations with adequate cover soil or for a GCL or CCL underlying a geomembrane.

In general, erosion is not a consideration for either GCLs or CCLs placed as a liner system beneath the waste.

Bearing Capacity (Squeezing). Both CCLs and GCLs must have adequate bearing capacity to support the applied normal stresses. The clay must not squeeze laterally becoming thinner in localized areas under concentrated loads, e.g., wheel loads from construction equipment or maintenance vehicles. Both static and dynamic loads must be resisted depending on the local situation. Even further, if a leak detection system is located beneath the CCL or GCL, fugative particles could clog the drainage layer rendering it ineffective.

Hydrated bentonite in GCLs is not as strong as the typical soils used in constructing CCLs hence GCLs are probably not equivalent to CCLs. However, under most circumstances, a GCL will provide adequate bearing capacity if the material is buried under sufficient soil overburden. Equivalency is heavily dependent upon site-specific conditions and the situation is essentially a design and CQC/CQA consideration and must be viewed as such.

CONSTRUCTION ISSUES

There are a host of construction issues which must be addressed in assessing equivalency of GCLs to CCLs. The best of designs can be defeated if installation is not possible, or is made so difficult so as to engender long term problems.

Puncture Resistance and Resealing. Geosynthetic clay liners are thin and, like all thin geosynthetic materials, are vulnerable to damage from accidental puncture during or after construction. In contrast, thick CCLs cannot be accidentally punctured. Some GCLs have the capability to self-seal around certain punctures, e.g., penetration of the GCL with a sharp object such as a nail. The swelling capacity of bentonite gives GCLs this self-healing capability. Of perhaps greater concern than penetration of the GCL by an object after construction is accidental puncture during construction. For example, if the blade of a bulldozer accidentally punctures the GCL during spreading of cover material, the GCL would probably not self seal in the vicinity of the puncture.

Geosynthetic clay liners will generally not have equivalent puncture resistance to CCLs. However, this does not mean that a GCL cannot meet or exceed the performance objectives of a compacted clay liner. Proper CQC/CQA procedures can be established and implemented to make the probability of puncture during construction extremely low. In final covers, one or two accidental punctures would probably not have a major impact on the overall performance of the barrier layer. In a bottom liner system subjected to a continuous head of leachate, a

different conclusion would be drawn about the significance of undetected and unrepaired damage to a GCL from puncture. Ultimately, site-specific conditions and quality assurance procedures will be critical in dealing with the puncture issue and in establishing equivalency of a GCL to CCL for a particular project.

Subgrade Condition Considerations. Compacted clay liners are constructed with heavy equipment. If the subgrade is uneven a CCL can be placed and compacted in a straightforward manner. On the other hand, stones and rocks can cause localized thinning or even puncture of a GCL. If the subgrade contains stones or rocks, the integrity of the GCL will be compromised. Also, in order for the overlapped seams in a GCL to self seal properly, the overlapped panels must be placed on a very smooth and even subgrade. Subgrades with frozen ruts can be particularly troublesome for GCLs and their potential to thin out over the raised ridges is very high. Thus, equivalency of a GCL to a CCL in terms of the effect of subgrade clearly depends on the conditions of the subgrade. This, in turn, depends upon subgrade restrictions placed in the plans and specifications and on the level of CQC/CQA monitoring.

Subgrades must be very carefully prepared for the successful placement o a GCL. It is of significantly less concern when placing a CCL.

Ease of Placement or Construction. A GCL will always be easier to place than a CCL, unless weather conditions are adverse (e.g., constant rain), in which case even a GCL will also be difficult to construct. In general, GCLs are superior to CCLs in terms of ease of placement or construction.

Speed of Construction. GCLs can be placed much more quickly than CCLs. GCLs are superior to CCLs in terms of speed of construction.

Availability of Materials. Suitable clays for construction of a CCL may or may not be available locally, depending on the location of the site. Because GCLs are manufactured materials, they are readily available and can be shipped to a site quickly. The cost of shipment is usually not a large percentage of the total cost of a GCL. Thus, GCLs will always be at least equivalent to CCLs in terms of availability of materials and will be superior to CCLs at sites lacking local sources of suitable clay.

Requirements for Water. Construction water is necessary for many compacted clay soils in order to make a CCL. They are usually placed at a moisture content wet of optimum to achieve the desired low hydraulic conductivity. The total amount of water required to moisten a clay liner can be very large. For example, if a 600 mm thick compacted clay liner were to be constructed over a 5 ha site, and the natural water content of the soil had to be increased 5% to achieve the required moisture conditions, the total amount of water necessary would be approximately 1,500,000 liter. In arid regions, this water may represent a valuable resource, and in some remote locations, it may be very expensive to provide the water. Furthermore, if the only water available is from a local stream which is polluted, the expelled water during consolidation could be a concern in generating leachate or in masking leak detection liquids in double lined systems.

Geosynthetic clay liners do not require construction water and are superior to CCLs in this regard.

Air Pollution Concerns. Air pollution is a subject of great concern in some areas. Construction of CCLs liners tend to be an energy intensive activity with heavy equipment excavating, hauling, processing, spreading, and compacting the soil with repeated passes of heavy compactors. All of this activity adds to air pollution in terms of hydrocarbon emissions from the equipment and air-borne particulate matter (dust). GCLs are factory fabricated, shipped to

the site, moved into position by machinery, and then unrolled (sometimes by hand). Air pollution at the factory during GCL manufacturing is generally carefully controlled and monitored. Relatively speaking, the impacts to air quality are less with a GCL than a CCL.

Weather Constraints. Compacted clay liners are difficult to construct when soils are wet, heavy precipitation is occurring, the weather is extremely dry (clay desiccates), the soil is frozen, or the temperature is below freezing. GCLs are difficult to construct during precipitation. Weather constraints during placement generally favor GCLs.

Some, if not all, GCLs must be covered before they hydrate. If a geomembrane will be placed over a GCL, the GCL must be covered almost immediately with the geomembrane. Construction should proceed downgradient with the geomembrane shingled over the edge of the GCL upon the completion of each day's work. If soil is placed over the GCL, backfilling must be kept as close as possible to the exposed edge. Furthermore, the exposed edge should be protected by a temporary membrane at the end of each day's work. The fact that many GCLs must be covered before they are hydrated can be a significant weather constraint for GCLs. CCLs also have weather constraints after placement. CCLs must not be allowed to freeze or desiccate, and wet weather often creates rutting and damage to the surface.

Equivalency in terms of weather constraints must be considered on a site-specific basis, but weather constraints generally favor GCLs over CCLs.

Quality Assurance Considerations. The proper construction of a low-permeability, CCL is a very challenging task. Careful control must exist over materials, moisture conditions, clod size, maximum particle size, surface preparation for a lift of soil, lift thickness, compaction coverage and energy, and protection of each completed lift. Comparatively, CQC/CQA requirements are much less rigorous for GCLs compared to CCLs, but no less critical. In general, while CQC/CQA for a CCL requires a number of relatively sophisticated tests and points of control by very experienced and capable personnel, CQC/CQA for GCLs is more nearly the application of common sense. Far fewer things can go wrong with the installation of a GCL compared to placement and compaction of a CCL. However, testing procedures and observational techniques are well established for CCLs but are not for GCLs. There are major ongoing efforts to establish testing methods for GCLs. ASTM Committee D-35 has recently dedicated an entire subcommittee to this particular material. While it would appear that GCLs are superior to CCLs in terms of ease of quality control, more work needs to be done to establish standard test methods and procedures for GCLs.

SUMMARY OF EQUIVALENCY ASSESSMENT

Clearly an equivalency analysis of GCLs to CCLs will be needed on a site-specific basis. Any broad conclusions that can be drawn will tend to be fairly general. However, a generalized summary of the technical equivalency issues just discussed will be attempted. Tables 5(a) and 5(b) are arranged to parallel the issues in Table 2 and just discussed. Table 5(a) is for liner systems beneath waste materials and Table 5(b) is for cover systems above the waste. Each table is arranged so as to counterpoint GCLs to CCLs in the following manner:

- the GCL is probably superior
- the GCL is probably equivalent
- the GCL is probably not equivalent
- equivalency depends on site specific or product specific conditions

Clearly, the "not equivalent" category of GCLs to CCLs in each table is most important. These issues will be discussed separately. Unfortunately, many issues fall into the "equivalency depends on site specific or product specific conditions" category. They, of course, remain unanswered at least in the generalized sense of this paper.

Table 5(a). Generalized technical equivalency assessment for liners beneath landfills and surface impoundments.

Category	Criterion for evaluation	GCL is probably superior	GCL is probably equivalent	GCL is probably not equivalent	Equivalency depends on site or product
Hydraulic Issues	Steady flux of water		X		
	Steady solute flux		X		
	Chemical adsorption capacity			X	
	Breakout time				
	Water				X
	Solute				X
	Horiz. flow in seams or lifts		X		
	Horiz. flow beneath geomembrane	X			
	Generation of consolidation water	X			
Physical/ Mechanical Issues	Freeze-thaw behavior	X			
	Total settlement		X		
	Differential settlement	X			
	Slope stability				X
	Bearing capacity			X	
Construction Issues	Puncture resistance			X	
	Subgrade condition			X	
	Ease of placement	X			
	Speed of construction	X			
	Availability of materials	X			
	Requirements for water	X			
	Air pollution concerns	X			
	Weather constraints				X
	Quality assurance considerations		X		

Regarding "chemical adsorption capacity" of GCLs in liner systems, equivalency cannot be shown. More of concern, however, is what impact does this issue have on the performance of a given facility. For example, if the liner is a GM/GCL composite the issue might be moot for a properly installed geomembrane. In the short term, absorption by the GCL may be adequate due to very low water flux. In the long term, the adsorption capacity of all liners may eventually be exhausted and is therefore not relevant. If the composite is the primary liner of a double liner system, the leak detection system will handle the liquid and adsorption is not relevant. Thus only when the GCL is used by itself can real concern be expressed, and even then, site-specific conditions are very important.

Regarding "bearing capacity", or squeezing, of hydrated GCLs there is concern for both liners and covers. The hydration of GCLs can be quite rapid. Within a few days, Daniel, et al. (1993) show that 40% moisture content can be attained from soil suction considerations. Concentrated loads from construction equipment and/or maintenance equipment can readily

Table 5(b). Generalized technical equivalency assessment for covers above landfills.

Category	Criterion for evaluation	GCL is probably superior	GCL is probably equivalent	GCL is probably not equivalent	Equivalency depends on site or product
Hydraulic Issues	Steady flux of water		X		
	Breakout time of water				X
	Horiz. flow in seams or lifts		X		
	Horiz. flow beneath geomembranes	X			
	Generation of consolidation water	X			
	Permeability to gases				X
Physical/ Mechanical Issues	Freeze-thaw behavior	X			
	Wet-dry behavior	X			
	Total settlement		X		
	Differential settlement	X			
	Slope stability				X
	Vulnerability to erosion				X
	Bearing capacity			X	
Construction Issues	Puncture resistance			X	
	Subgrade condition			X	
	Ease of placement	X			
	Speed of construction	X			
	Availability of materials	X			
	Requirements for water	X			
	Air pollution concerns	X			
	Weather constraints				X
	Quality assurance considerations		X		

cause squeezing and lateral migration of the hydrated bentonite in some GCL products. GCLs, thin to begin with, can further decrease in their thickness, to the point where the geotextiles are possibly touching one another. This issue must be addressed in design (e.g., to provide suitable thickness for haul roads and access roads) and in strict CQC/CQA procedures during construction.

Regarding "puncture resistance", thin GCLs do not have the same resistance as much thicker CCLs. Although the GCLs can be punctured during construction, careful CQC/CQA should be capable of addressing this potential problem. Further, for final covers, an occasional small puncture may be of little consequence. Indeed, puncture is probably of much greater concern for a bottom liner than for a final cover and of much more concern for single liner systems than for the upper liner in a double liner system. Also, if puncture is of concern, a layer of relatively low permeability soil or waste material may be placed below the GCL to provide a back-up should puncture occur at an isolated location. It should be stated, however, that GCLs enjoy several important advantages over a compacted clay liner which may more than offset its greater vulnerability to puncture.

Regarding "subgrade conditions", the thinness of GCLs is again at issue. With only 7 to 10 mm of thickness of a GCL to begin with, no amount of thinning is tolerable without negatively affecting the water or solute flux calculations provided earlier. Subgrade conditions must be specified as being free from stones, gravel, ruts (particularly when frozen) and all other perturbations in the subgrade material. When placed over the geonet of a leak detection system, rib indentation can cause GCL thinning. This is readily prevented by using the proper separation geotextile between the GCL and geonet, but must be designed accordingly. Thus adverse subgrade conditions can be eliminated as a issue of non-equivalency, but only with proper design and rigorous CQC/CQA procedures.

CONCLUSIONS AND RECOMMENDATIONS

Presented in this paper was an overview of geosynthetic clay liners (GCLs), with the intention of comparing and contrasting them to traditional soil liners. When used for waste containment, such soil liners are usually compacted clay liners (CCLs). However, instead of basing potential equivalency on non-quantifiable issues (like a lack of endorsement by regulatory agencies), three categories of technical issues were evaluated. They were hydraulic, physical/mechanical, and construction categories, each of which had numerous specific issues.

It was seen that there are numerous advantages of GCLs over CCLs. These include better resistance to freeze-thaw, better self healing characteristics in wet-dry conditions, less vulnerability to damage from differential settlement, less consumption of landfill space, easier placement, faster placement, lack of need for local clay materials, less need for construction water (relevant for arid areas), and greater ease of good quality assurance. Geosynthetic clay liners will probably cost less than compacted clay liners for many, and perhaps most, sites. The major disadvantages of GCLs are greater vulnerability to damage from puncture, poor subgrade conditions, lateral squeezing and subsequent thinning of the product. All are potentially controllable by proper design procedures and by rigorous CQC/CQA procedures. While not generally a critical issue, the chemical adsorption capacity of a GCL is lower than a CCL.

As suggested by Tables 5(a) and 5(b), many equivalency issues depend on the particular GCL product selected and the unique site specific conditions. In general, equivalency will have to be evaluated on a case-by-case basis. An important site-specific issue is likely to be slope stability. It may be difficult to provide adequate factors of safety against slope failure on relatively steep slopes that contain certain GCLs. However, designers have a choice of products and, as an option, a variety of reinforcement materials (such as geogrids and geotextiles) available for use, if necessary.

While no general conclusion can be reached about GCL equivalency to a CCL at all sites (either for liner or cover applications) it is expected that GCLs can be shown to provide better or equivalent performance at many sites.

Although GCLs are not without limitations, their favorable properties are sufficiently advantageous that owners, designers, and regulatory officials could give serious consideration to expanded use of GCLs as containment barrier materials. There is a need to reach agreement about the criteria upon which GCLs will be evaluated, and it is hoped that this paper will help to continue the dialogue that will ultimately lead to establishment of agreed upon and appropriate criteria to assess technical equivalency.

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