February 4, 2025

Mr. Mick Leat
Land Quality Bureau
Iowa Department of Natural Resources
6200 Park Ave Suite 200
Des Moines, Iowa 50321

HLW Engineering Group
Engineering Management

RE: Response to IDNR Letter dated January 24, 2025 (Doc #111960)
Conceptual Development Plan
Marshall County Sanitary Landfill
Permit No. 64-SDP-02-75P

Dear Mr. Leat:

This letter contains responses and information requested in the January 24, 2025 IDNR letter related to IDNR review of the Conceptual Development Plan (CDP, Doc #111541) for the Marshall County SLF. Our responses are formatted according to the numbered items in the referenced letter (Doc #111960).

Item 1.

Several of the abutment liners shown on Sheet 6A of the 2006 Permit Renewal/Development and Operational Plans referenced in the IDNR letter have been constructed. The constructed abutment liners are labelled "Abutment Liner" and "Subarea B4-3,4,5" on Figure 13 of the CDP. Abutment liners constructed to date are Subtitle D composite liners in compliance with IAC 567-113.7(5)"a"(1).

Regarding the future abutment lined areas, Section 113.7(7) of the "Design Plans and Specifications, Quality Control and Assurance Plan" section of the CDP states:

> *These "abutment" areas will be constructed with a Subtitle D composite liner in accordance with 113.7(5)"a"(1). A geotechnical engineer will be retained to do stability and settlement calculations for the abutment lined areas prior to the final design of the abutment areas being completed. The geotechnical documentation will be submitted to IDNR for review when the plans and specifications for each abutment area are submitted.*

Figure 16 of the CDP represents the method of construction of the Subtitle D composite liners, including the abutment liners. Since construction of some of the abutment lined areas may not occur for at least 10 years it seems prudent to analyze the geotechnical requirements of each abutment lined area at the time of construction rather than at this time.

Item 2.

The construction of the proposed abutment liners over the unlined B-1, B-2, and C&D areas will effectively cap these areas with a Subtitle D composite abutment liner. The proposed liner system will eliminate surface water infiltration into the waste mass under the abutment liner and should

lead to a drastic reduction in the volume of leachate collected from Areas B-1 and B-2, and Area C/D by the existing infrastructure.

As noted in your letter, it is the intent of the Marshall County SLF to have the leachate header, lateral, and conveyance piping continue to operate as landfill development at the site continues. Additional discussion on the maintenance of the existing leachate piping is also included under Item 3 (pipe strength calculations) and Item 4 (manholes) below.

Groundwater collected in Subareas B-4-1 through B-4-7 is combined with the leachate collected in these areas and conveyed to the leachate storage lagoons in the temporary leachate conveyance pipe. This practice will continue for the Mid Area Development as collected leachate and groundwater will be combined and conveyed to the leachate storage lagoons. Perforated groundwater diversion piping in the Mid Area Development will be installed at the same approximate location and at similar elevations as the existing temporary leachate conveyance piping. Figure 15A is included in Attachment A showing the elevation of the existing temporary leachate conveyance pipe, existing leachate header and conveyance pipes associated with Areas B-1 and B-2, existing leachate header and conveyance pipes associated with Area C/D, and proposed elevations of the perforated groundwater diversion piping that will be installed under the Mid Area Development. As shown on the figure the future groundwater diversion piping is lower in elevation than the existing leachate infrastructure. So, in the event that the existing leachate infrastructure were to be compromised the future groundwater diversion piping is located to intercept leachate migration from Areas B-1 and B-2 and Area C/D for conveyance to the leachate storage lagoons.

Item 3.

The existing leachate piping associated with Areas B-1 and B-2 and Area C/D consists of 8" and 10" diameter SDR 7 HDPE piping bedded in clean rock backfill. Based on the proposed cap elevations shown in the CDP, the maximum height of fill over the existing piping will be less than 160 feet. Pipe strength calculations for the 8" diameter and 10" diameter piping assuming the closure cap is 200 feet over the piping are included in Attachment B. These calculations demonstrate that the existing piping meets manufacturer's recommendations for ring thrust stress, ring deflection and wall buckling at the assumed maximum waste depth.

Item 4.

MH-8, MH-9, and MH-6-2 are located within the proposed Mid Area Development. These manholes will be removed to the concrete bases during the construction of the Mid Area Development and solid walled piping will be installed to connect the piping runs currently separated by the manholes to maintain the leachate collection and conveyance. MH-7 and MH-6-2 are located outside of the Mid Area Development and will remain to provide access at the downgradient ends of the existing collection systems.

Item 5.

Groundwater diversion piping will be installed on the base of the future disposal areas parallel to the leachate collection piping. The proposed location of the groundwater diversion piping in each

area is shown on revised Figures 6, 7 (South Development Plan), 10 (North Development Plan), and 15 (Mid Area Development Plan) in Attachment A.

The elevations of the manholes and leachate conveyance piping for the North Development Area (except for MH NE-8 and MH NE-9) have been lowered by approximately 6' from the elevations shown in the CDP to allow the groundwater collected in the attenuation zone shown in the "2019 Amendment #1 to the 2017 Assessment of Corrective Measures Report" (Doc #95276) to either be routed to the leachate collection system and conveyed to the leachate storage lagoons (as shown on Figure10) or, if future testing warrants, to be discharged to the surface. MH NE-8 and MH NE-9 were not lowered as the groundwater collected in areas that drain to these manholes is outside of the attenuation zone. Construction in the North Development Area will proceed from south to north so these two manholes could be modified prior to construction to allow the groundwater piping to be connected to the leachate collection system at these manhholes if deemed necessary by future water quality testing.

Item 6.

Revisions to the location of future monitoring wells are made and are illustrated on revised Figure 20 (included in Attachment C) of the December 20, 2024 Hydrologic Monitoring System Plan (HMSP) included in Attachment E of the CDP (Doc #111541).

MW-124 was moved to the southwest corner of the North Development Area. The remaining wells along the downgradient edge (MW-122 and MW-123) were shifted south accordingly. There are two (2) additional monitoring wells (MW-136 and MW-137) illustrated along the remaining downgradient edge to satisfied the 300 ft spacing requirement of 113.10(2)"e"(2).

MW-138 has been added to revised Figure 20 on the north side of the central drainage channel of the Mid Area Development.

The following is anticipated (*HMSP Modifications in **bold italicized text***):

*North Expansion Area Development (**amended herein**)*
Add Background Wells MW-201, MW-102, MW-104, MW-106, and ***MW-136.***
Add Downgradient Monitoring Wells ***MW-137***, MW-122, MW-123, and MW-124.

During development of the North Expansion Area the following wells are anticipated to be abandoned (as development progression requires): MW-94, MW-54, MW-49, MW-89, and MW-91.

*South Expansion Area Development **(no changes)***
Add Background Wells MW-108, MW-110, and MW-112.
Add Downgradient Monitoring Wells MW-126 through MW135.

During development of the South Expansion Area the following wells are anticipated to be abandoned (as development progression requires): MW-66.

Mid Expansion Area Development ***(amended herein)***
Add No Background Wells.
Add Downgradient Monitoring Wells MW-125 ***and MW-138***.

During development of the Mid Expansion Area the following wells are anticipated to be abandoned (as development progression requires): MW-95, ***MW-120,*** MW-96R, ***and MW-121.***

Note that water elevation data will conclusively demonstrate whether the existing and/or future monitoring wells will continue to demonstrate an upgradient or downgradient position as the future cells are constructed in the North Expansion Area and the South Expansion Area.

Item 7.

Understood.

We trust that the above adequately address your review comments on the CDP.

Respectfully,
HLW Engineering Group

Douglas J. Luzbetak, P.E.
Project Manager

cc: Don Ballalatak, Manager, Marshall County SLF

ATTACHMENT A

SCALE

0 — 300 — 600

Legend

- Existing 2' Contours
- Existing 10' Contours
- Design 10' Contours
- Design 2' Contours
- Waste Boundary (Existing)
- Waste Boundary (Proposed)
- Existing Groundwater Diversion Pipe
- Existing Leachate Pipe
- Design Leachate Piping
- Design Groundwater piping
- Property Line
- Storm Water Pipe
- Fence
- Leachate Manhole (Existing)
- Gravel Surface

NOTE:

1. GROUND CONTOURS AERIAL DRONE SURVEY DATED SEPTEMBER 25, 2017
2. FORCE MAIN ONLY APPROXIMATELY LOCATED. FOR PRECISE LOCATIONS, SEE AS-BUILT PLANS FROM 1991, "LEACHATE CONTROL SYSTEM – PHASE II"
3. RECYCLING AREAS WILL BE RELOCATED AS NEEDED.

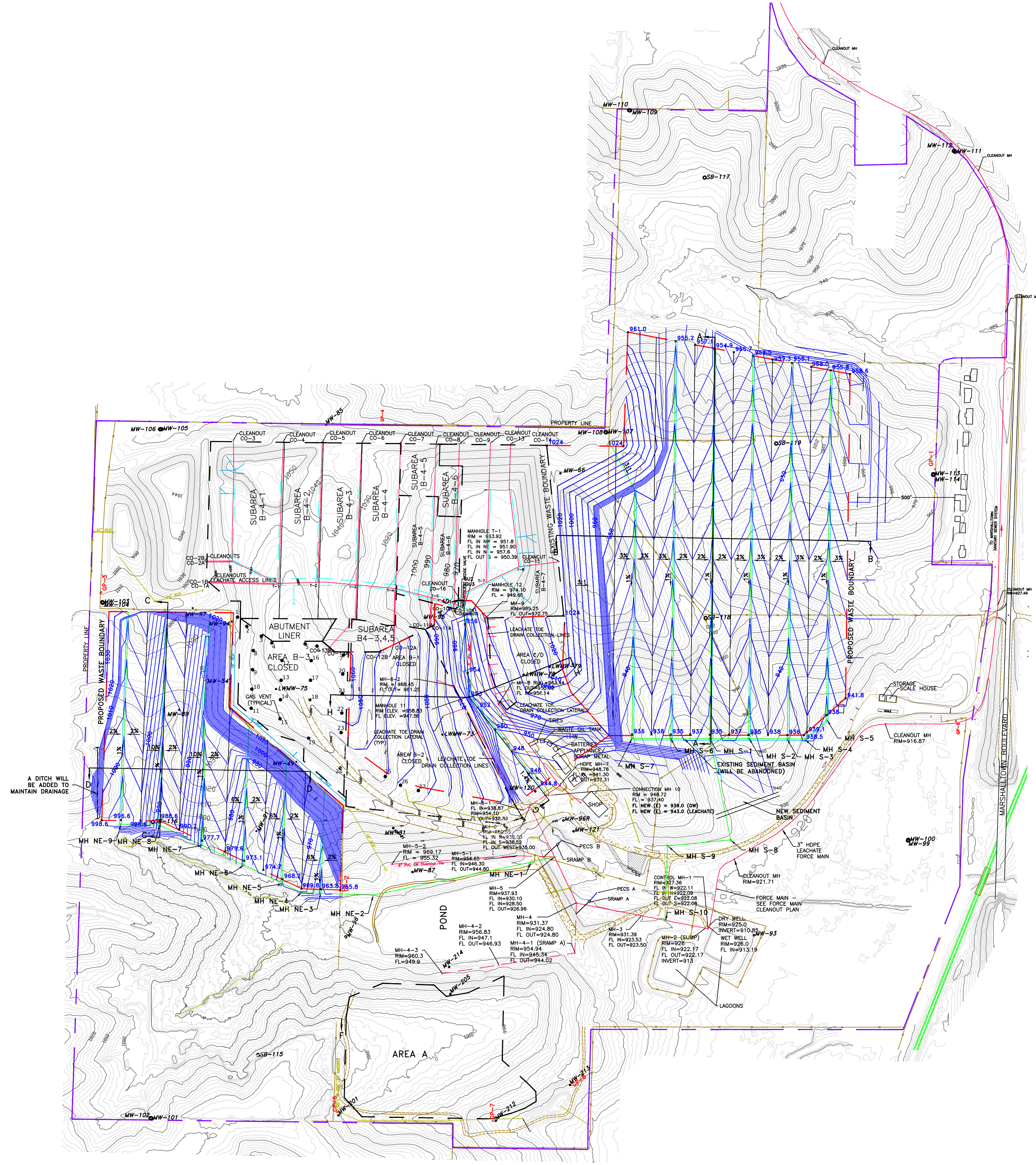

FIGURE: 6

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003-21A	DATE 01/31/25

OVERALL DEVELOPMENT PLAN
CONCEPTUAL DEVELOPMENT PLAN
MARSHALL COUNTY SANITARY LANDFILL
MARSHALL COUNTY, IOWA

HLW Engineering Group
204 West Broad Street, P.O. Box 314
Story City, Iowa 50248
Phone: (515) 733-4144
FAX: (515) 733-4146

HLW Engineering Group

SCALE
0 150 300

NOTE:

1. GROUND CONTOURS AERIAL DRONE SURVEY DATED SEPTEMBER 25, 2017.
2. RECYCLING WILL BE RELOCATED AS NEEDED.
3. FILL WILL BE ADDED TO CROSSING BETWEEN MH 5-9 AND MH 5-10 TO MAINTAIN COVER OVER LEACHATE PIPE.

Legend

- Existing 2' Contours
- Existing 10' Contours
- Design 10' Contours
- Design 2' Contours
- Waste Boundary (Existing)
- Waste Boundary (Proposed)
- Existing Groundwater Diversion Pipe
- Existing Leachate Pipe
- Design Leachate Piping
- Design Groundwater piping
- Property Line
- Storm Water Pipe
- Fence
- Leachate Manhole (Existing)
- Gravel Surface

MH	FL IN	FL OUT	CONVEYANCE PIPE SIZE	SLOPE
S-5	936.8 (E)	936.7 (N)		
			8"x12"	0.8%
S-4	935.5 (S)	935.4 (N)		
			8"x12"	0.7%
S-3	934.8 (E/S)	934.7 (N)		
			8"x12"	0.5%
S-2	933.8 (E/S)	933.7 (N)		
			8"x12"	0.5%
S-1	933.8 (E)	932.6 (W)		
	932.7 (N/S)		8"x12"	0.5%
S-6	933.8 (E/N)	933.7 (S)		
			8"x12"	0.5%
S-7	934.8 (E)	934.7 (S)		

S-1	933.8 (E)	932.6 (W)		
	932.7 (N/S)		10"x14"	0.5%
S-8	930.5 (E)	930.4 (N)		
			10"x14"	0.5%
S-9	928.9 (S)	928.8 (W)		
			10"x14"	1.0%
S-10	925.0 (E)	923.0 (S)*		
	923.0 (N)*			

* VERIFY EXISTING PIPE FLOWLINE

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SOUTH DEVELOPMENT PLAN
CONCEPTUAL DEVELOPMENT PLAN

MARSHALL COUNTY SANITARY LANDFILL
MARSHALL COUNTY, IOWA

FIGURE: 7

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003-21A	DATE 01/31/25

NOTE:

1. GROUND CONTOURS AERIAL DRONE SURVEY DATED SEPTEMBER 25, 2017.
2. FILL WILL BE ADDED TO MAINTAIN A MINIMUM OF 5' OF COVER OVER LEACHATE CONVEYANCE PIPE AS NEEDED.

SCALE
0 150 300

Legend
- Existing 2' Contours
- Existing 10' Contours
- Design 10' Contours
- Design 2' Contours
- Waste Boundary (Existing)
- Waste Boundary (Proposed)
- Existing Groundwater Diversion Pipe
- Existing Leachate Pipe
- Design Leachate Piping
- Design Groundwater piping
- Property Line
- Storm Water Pipe
- Fence
- Leachate Manhole (Existing)
- Gravel Surface

MH	FL IN	FL OUT	CONVEYANCE PIPE SIZE	SLOPE
NE-9	995.35 (E)25	995.0 (S)		
			8"x12"	4.0%
NE-8	987.35 (E/N)	987.25 (S)		
			8"x12"	7.0%
NE-7	976.45 (E)	970.35 (S)		
	970.45 (N)		8"x12"	1.9%
NE-6	971.85 (E)	965.75 (N)		
	965.85 (N)		8"x12"	2.2%
NE-5	966.95 (E)	960.85 (S)		
	960.95 (N)		10"x14"	2.1%
NE-4	958.75 (N)	958.65 (S)		
			10"x14"	2.1%
NE-3	962.55 (E)	956.45 (S)		
	956.55 (N)		10"x14"	2.85%
NE-2	948.75 (N)	948.65 (S)		
			10"x14"	0.8%
NE-1	941.75 (N)	939.75 (S)		
			10"x14"	6.9%
MH-5*	930.1 (E) *	926.95 (SW)*		
	928.5 (NE)*			
	930.75 (N)			

* EXISTING

A DITCH WILL BE ADDED TO MAINTAIN DRAINAGE

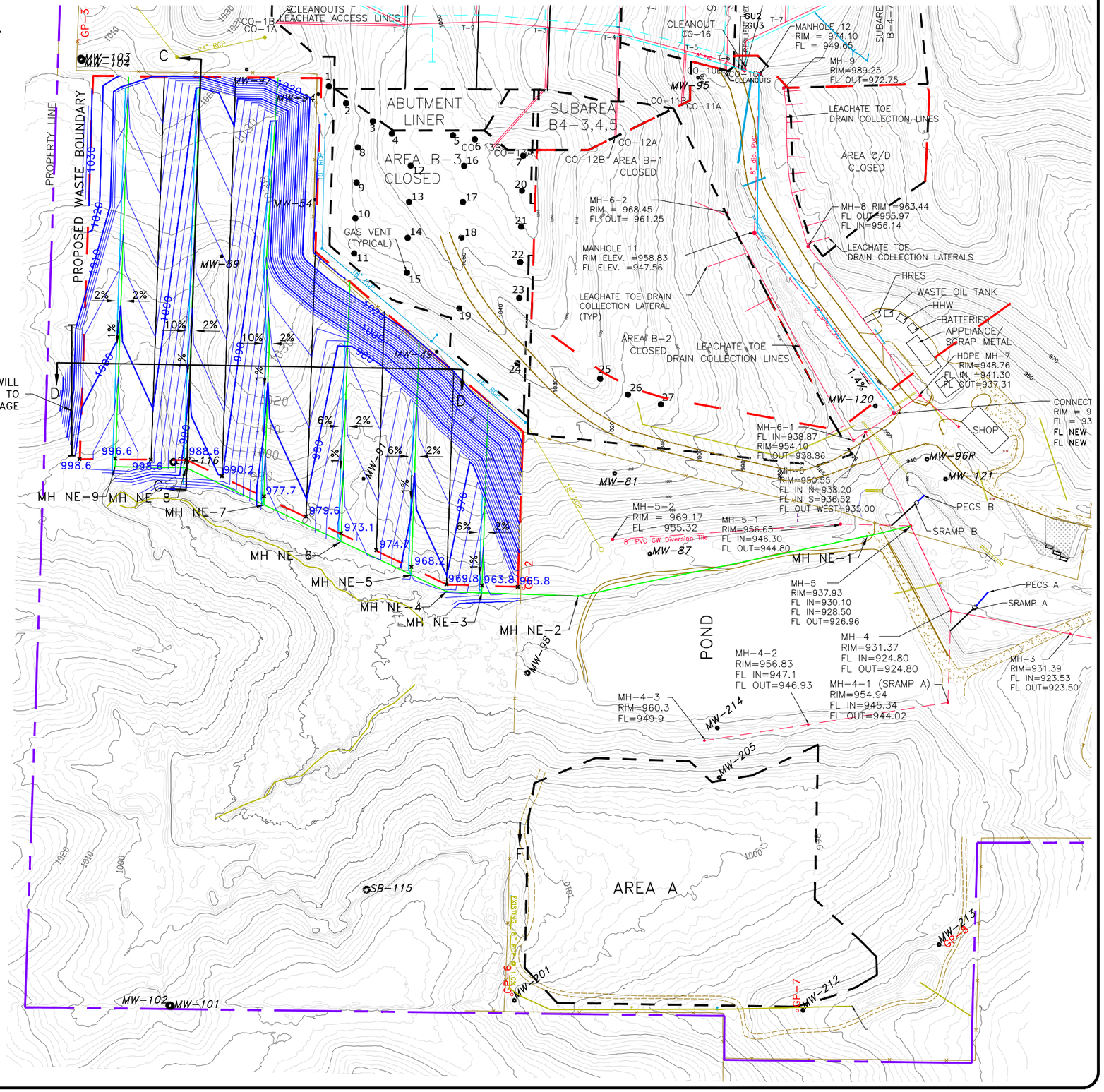

FIGURE: 10

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003-21A	DATE 02/03/25

NORTH DEVELOPMENT PLAN
CONCEPTUALL DEVELOPMENT PLAN

MARSHALL COUNTY SANITARY LANDFILL
MARSHALL COUNTY, IOWA

HLW Engineering Group
204 West Broad Street, P.O. Box 314
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HLW Engineering Group

SCALE
0 100 200

Legend

- Existing 2' Contours
- Existing 10' Contours
- Design 10' Contours
- Design 2' Contours
- Waste Boundary (Existing)
- Waste Boundary (Proposed)
- Existing Groundwater Diversion Pipe
- Existing Leachate Pipe
- Design Leachate Piping
- Design Groundwater piping
- Property Line
- Storm Water Pipe
- Fence
- Leachate Manhole (Existing)
- Gravel Surface

NOTE:

1. GROUND CONTOURS AERIAL DRONE SURVEY DATED SEPTEMBER 25, 2017.
2. RECYCLING AREAS TO BE RELOCATED AS NECESSARY.
3. MANHOLES T-1, 11, AND 12 WILL BE REMOVED AS LANDFILLING PROGRESSES.
4. MANHOLES 6-2, 8, AND 9 WILL BE PARTIALLY REMOVED/ABANDONED AS LANDFILLING PROGRESSES.
5. THE EXISTING LEACHATE TOE DRAIN TILES WILL BE LEFT IN PLACE AND WILL CONTINUE TO OPERATE AFTER THE LINER IS INSTALLED.
6. LEACHATE LINES AT CO-10A, CO-10B, CO-11A, CO-12A AND CO-12B WILL BE EXTENDED DURING ABUTMENT LINER CONSTRUCTION TO MAINTAIN ACCESS TO LEACHATE PIPING. DETAILS WILL BE PROVIDED WITH BIDDING REQUIREMENTS FOR THE ABUTMENT LINER PROJECT(S).
7. ADDITIONAL LEACHATE COLLECTION PIPING MAY BE ADDED TO THE ABUTMENT LINERS DEPENDING ON FINAL DESIGN OF LINER BASED ON GEOTECHNICAL ENGINEER'S RECOMMENDATION. DETAILS WILL BE PROVIDED WITH BIDDING REQUIREMENTS FOR THE ABUTMENT LINER PROJECT(S).

FIGURE: 15

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003-21A	DATE 01/31/25

MID AREA DEVELOPMENT PLAN
CONCEPTUAL DEVELOPMENT PLAN
MARSHALL COUNTY SANITARY LANDFILL
MARSHALL COUNTY, IOWA

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PIPES ASSOCIATED WITH AREA 'B' AND AREA 'C/D' ARE OUT OF SECTION BUT INCLUDED TO SHOW ELEVATIONS IN COMPARISON TO PROPOSED PERFORATED GROUNDWATER DIVERSION PIPE

980
970
960
950
940
935

PROPOSED EDGE OF LINER

AREA C/D – LEACHATE HEADER PIPE

AREA C/D – LEACHATE CONVEYANCE PIPE

AREA B – LEACHATE HEADER PIPE

PROPOSED TOP OF LINER @ LOCATION OF GROUNDWATER DIVERSION PIPE

EXISTING TEMPORARY LEACHATE CONVEYANCE PIPE

PROPOSED PERFORATED GROUNDWATER DIVERSION PIPE

EXISTING PIPE
MH 6–1 TO MH 6–2
MH 7 TO MH 9
MH 10 TO MH 12

PROPOSED PIPE
NEW MH 10 TO MH 12

SCALE
HORIZ. 1"=100'
VERT. 1"=5'

0+00 WEST
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00 EAST

FIGURE: 15A

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003–21A	DATE 2/03/25

MID AREA DEVELOPMENT PLAN
LEACHATE/GROUNDWATER COLLECTION
MARSHALL COUNTY SANITARY LANDFILL
MARSHALL COUNTY, IOWA

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HLW Engineering Group

ATTACHMENT B

PIPE STRENGTH CALCULATIONS

Note: All equations and references are from Chapter 6 of the the Plastics Pipe Institute® Handbook of Polyethylene Pipe unless otherwise stated.

Analyze three aspects of potential failure of the pipe. The three aspects are:

1. Compressive Ring Thrust Stress
2. Ring Deflection
3. Constrained Pipe Wall Buckling

Due to the depth of waste over the pipe, use the methodology listed in the Section titled "Installation Category #3: Deep Fill Installation" in Chapter 6.

Compressive Ring Thrust Stress

Calculate the compressive stress on the pipe to determine if the pipe can withstand the applied vertical load due to the waste and cover at final closure elevations.

$S = (P_E+P_L)DR/288$ Eqn. 3-13

S - Pipe wall compressive stress, psi

P_E - Vertical soil pressure due to earth load, psf

P_L - Vertical soil pressure due to live load, psf

DR - Dimension ratio of pipe

However, for deep fills (fills > 50 feet), the vertical load can be reduced by a "Vertical Arching Factor", VAF.

$P_{RD} = (P_E)(VAF)$ Eqn. 3-23

P_{RD} - Radial directed earth pressure, psf

VAF - Vertical Arching Factor

$VAF = 0.88-0.71((S_A-1)/(S_A+2.5))$ Eqn. 3-21

S_A - Hoop Thrust Stiffness Ratio

$S_A = (1.43)(M_S)(r_{CENT})/EA$ Eqn. 3-22

M_S - one-dimensional modulus of soil, psi

r_{CENT} - radius to centroidal axis of pipe, in

E - Apparent modulus of elasticity of pipe material, psi

A - Profile wall average cross section (in^2/in) or pipe wall thickness (in)

The existing piping is 8" and 10" diameter, SDR 7 HDPE pipe placed in clean rock backfill. 8" HDPE pipe has the following typical characteristics:

DR =	7		
r_{CENT} =	3.6225	in	
E =	28,000	psi	Table B.1.1 (Chapter 3)
A =	1.232	in	

Ultimate waste heights in future design areas will be less than 200 feet based on site layout. This analysis assumes a design cap height of 200 feet over liner. Assume loading on pipe due to landfill at final grade is:

Layer	Thickness (ft)	Unit Weight (pcf)	Load (psf)
Final Cap	4	120	480
MSW + Cover *	195	64	12,480
Drainage Layer Material	1	120	120
Rock Pipe Bedding	1	125	125
Total Thickness =	201	Total Load =	13,205

* Assume "MSW + Cover" consists of 1/5 cover at 120 pcf and 4/5 MSW at 50 pcf

M_S =	3,080		Table 3-12
P_E =	13,205	psf	
P_L =	0		Assume no live load due to depth of fill over pipe
S_A =	0.46		
VAF =	1.01		
P_{RD} =	13,321	psf	

S = 324 psf

which is less than the allowable long term compressive stress for PE pipe (1,000 psi - Table C.1, Chapter 3) typically used in landfill applications.

Ring Deflection

Calculate the deflection of the pipe to determine if pipe deflection due to the vertical load is within acceptable limits.

% deflection = $D_F E_S$ x100 Eqn. 3-28

D_F - Deformation Factor

E_S - Soil Strain

D_F is determined using Figure 3-6 using the pipe rigidity factor, R_F

$R_F = 12E_S(DR-1)^3/E$ Eqn. 3-24

E_S - Secant modulus of the soil, psi

DR - Dimension Ratio of Pipe

E - Apparent modulus of pipe material, psi

$E_S = M_S((1+◆)(1-2◆)/(1-◆))$ Eqn. 3-26

M_S - One-dimensional modulus of soil, psi

◆ - Poisson's Ratio

E_S = Vertical Soil Pressure/$144E_S$ Eqn. 3-27

Vertical Soil Pressure = Load on pipe due to earth loading. Do not adjust for Vertical Arching (do not use Vertical Arching Factor to reduce load).

M_S =	3,080 psi	Table 3-12
◆ =	0.2	Table 3-13
E_S =	2,772 psi	
R_F =	257	
D_F =	1.5	Figure 3-6
E_S =	0.03	

Defl = 5.0 %

which is less than the 7.5% deflection limit for HDPE pipe used in non-pressure applications as per Page 218 of the Handbook of Polyethylene Pipe.

Constrained Pipe Wall Buckling

Calculate the constrained wall buckling pressure to determine if the pipe has satisfactory resistance to constrained pipe buckling.

$P_{WC} = (5.65/N)*((R*B'*E'*E)/(12(DR-1)^3))^1/2$ Eqn. 3-15

P_{WC} - Allowable constrained buckling pressure, psi
N - Factor of Safety
R - Buoyancy reduction factor
B' - Constant
E' - Soil reaction modulus, psi
E - Apparent modulus of elasticity of pipe material, psi

$R = 1 - 0.33*(H_{GW}/H)$ Eqn. 3-17

H_{GW} - Height of groundwater above pipe, ft
H - Depth of cover, ft

H_{GW} =	2.33	ft	(assumes 2' head on liner)
H =	201	ft	
R =	1.0		

$B' = 1/(1+4*e^{(-0.065H)})$ Eqn. 3-18

B' =	1.0		
N =	2		
E' =	3,000	psi	Table 3-7

P_{WC} =	506.7	psi
	72,962	psf

Since the calculated constrained buckling pressure exceeds the earth load calculation the pipe has satisfactory resistance to constrained pipe buckling.

PIPE STRENGTH CALCULATIONS

Note: All equations and references are from Chapter 6 of the the Plastics Pipe Institute® Handbook of Polyethylene Pipe unless otherwise stated.

Analyze three aspects of potential failure of the pipe. The three aspects are:

1. Compressive Ring Thrust Stress
2. Ring Deflection
3. Constrained Pipe Wall Buckling

Due to the depth of waste over the pipe, use the methodology listed in the Section titled "Installation Category #3: Deep Fill Installation" in Chapter 6.

Compressive Ring Thrust Stress

Calculate the compressive stress on the pipe to determine if the pipe can withstand the applied vertical load due to the waste and cover at final closure elevations.

$S = (P_E+P_L)DR/288$ Eqn. 3-13

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P_L - Vertical soil pressure due to live load, psf

DR - Dimension ratio of pipe

However, for deep fills (fills > 50 feet), the vertical load can be reduced by a "Vertical Arching Factor", VAF.

$P_{RD} = (P_E)(VAF)$ Eqn. 3-23

P_{RD} - Radial directed earth pressure, psf

VAF - Vertical Arching Factor

$VAF = 0.88-0.71((S_A-1)/(S_A+2.5))$ Eqn. 3-21

S_A - Hoop Thrust Stiffness Ratio

$S_A = (1.43)(M_S)(r_{CENT})/EA$ Eqn. 3-22

M_S - one-dimensional modulus of soil, psi

r_{CENT} - radius to centroidal axis of pipe, in

E - Apparent modulus of elasticity of pipe material, psi

A - Profile wall average cross section (in^2/in) or pipe wall thickness (in)

The existing piping is 8" and 10" diameter, SDR 7 HDPE pipe placed in clean rock backfill. 10" HDPE pipe has the following typical characteristics:

DR =	7		
r_{CENT} =	4.508	in	
E =	28,000	psi	Table B.1.1 (Chapter 3)
A =	1.536	in	

Ultimate waste heights in future design areas will be less than 200 feet based on site layout. This analysis assumes a design cap height of 200 feet over liner. Assume loading on pipe due to landfill at final grade is:

Layer	Thickness (ft)	Unit Weight (pcf)	Load (psf)
Final Cap	4	120	480
MSW + Cover *	195	64	12,480
Drainage Layer Material	1	120	120
Rock Pipe Bedding	1	125	125
Total Thickness =	201	Total Load =	13,205

* Assume "MSW + Cover" consists of 1/5 cover at 120 pcf and 4/5 MSW at 50 pcf

M_S =	3,080		Table 3-12
P_E =	13,205	psf	
P_L =	0		Assume no live load due to depth of fill over pipe
S_A =	0.46		
VAF =	1.01		
P_{RD} =	13,325	psf	

S = 324 psf

which is less than the allowable long term compressive stress for PE pipe (1,000 psi - Table C.1, Chapter 3) typically used in landfill applications.

Ring Deflection

Calculate the deflection of the pipe to determine if pipe deflection due to the vertical load is within acceptable limits.

% deflection = $D_F E_S$ x100 Eqn. 3-28

D_F - Deformation Factor

E_S - Soil Strain

D_F is determined using Figure 3-6 using the pipe rigidity factor, R_F

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E - Apparent modulus of pipe material, psi

$E_S = M_S((1+◆)(1-2◆)/(1-◆))$ Eqn. 3-26

M_S - One-dimensional modulus of soil, psi

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◆ =	0.2		Table 3-13
E_S =	2,772	psi	
R_F =	257		
D_F =	1.5		Figure 3-6
E_S =	0.03		

Defl = 5.0 %

which is less than the 7.5% deflection limit for HDPE pipe used in non-pressure applications as per Page 218 of the Handbook of Polyethylene Pipe.

Constrained Pipe Wall Buckling

Calculate the constrained wall buckling pressure to determine if the pipe has satisfactory resistance to constrained pipe buckling.

$P_{WC} = (5.65/N)*((R*B'*E'*E)/(12(DR-1)^3))^1/2$ Eqn. 3-15

P_{WC} - Allowable constrained buckling pressure, psi
N - Factor of Safety
R - Buoyancy reduction factor
B' - Constant
E' - Soil reaction modulus, psi
E - Apparent modulus of elasticity of pipe material, psi

$R = 1 - 0.33*(H_{GW}/H)$ Eqn. 3-17

H_{GW} - Height of groundwater above pipe, ft
H - Depth of cover, ft

H_{GW} =	2.33	ft	(assumes 2' head on liner)
H =	201	ft	
R =	1.0		

$B' = 1/(1+4*e^{(-0.065H)})$ Eqn. 3-18

B' =	1.0		
N =	2		
E' =	3,000	psi	Table 3-7

P_{WC} =	506.7	psi
	72,962	psf

Since the calculated constrained buckling pressure exceeds the earth load calculation the pipe has satisfactory resistance to constrained pipe buckling.

ATTACHMENT C

SCALE
0 300 600

Legend

- Existing 2' Contours
- Existing 10' Contours
- Design 10' Contours
- Design 2' Contours
- Waste Boundary (Existing)
- Waste Boundary (Proposed)
- Existing Groundwater Diversion Pipe
- Existing Leachate Pipe
- Design Leachate Piping
- Design Groundwater piping
- Property Line
- Storm Water Pipe
- Fence
- Leachate Manhole (Existing)
- Gravel Surface

NOTE:

1. GROUND CONTOURS AERIAL DRONE SURVEY DATED SEPTEMBER 25, 2017.
2. FORCE MAIN ONLY APPROXIMATELY LOCATED. FOR PRECISE LOCATIONS, SEE AS-BUILT PLANS FROM 1991, "LEACHATE CONTROL SYSTEM – PHASE II".
3. RECYCLING AREAS WILL BE RELOCATED AS NEEDED.

● MW – PERMANENT MONITORING WELL

ORIGINAL LANDFILLS
(AREA A, B-1, B-2, B-3, AREA C/D)

AREA B-4
(RCRA SUBTITLE D)

MIDDLE EXPANSION AREA
(FUTURE)

NORTH EXPANSION AREA
(FUTURE)

SOUTH EXPANSION AREA
(FUTURE)

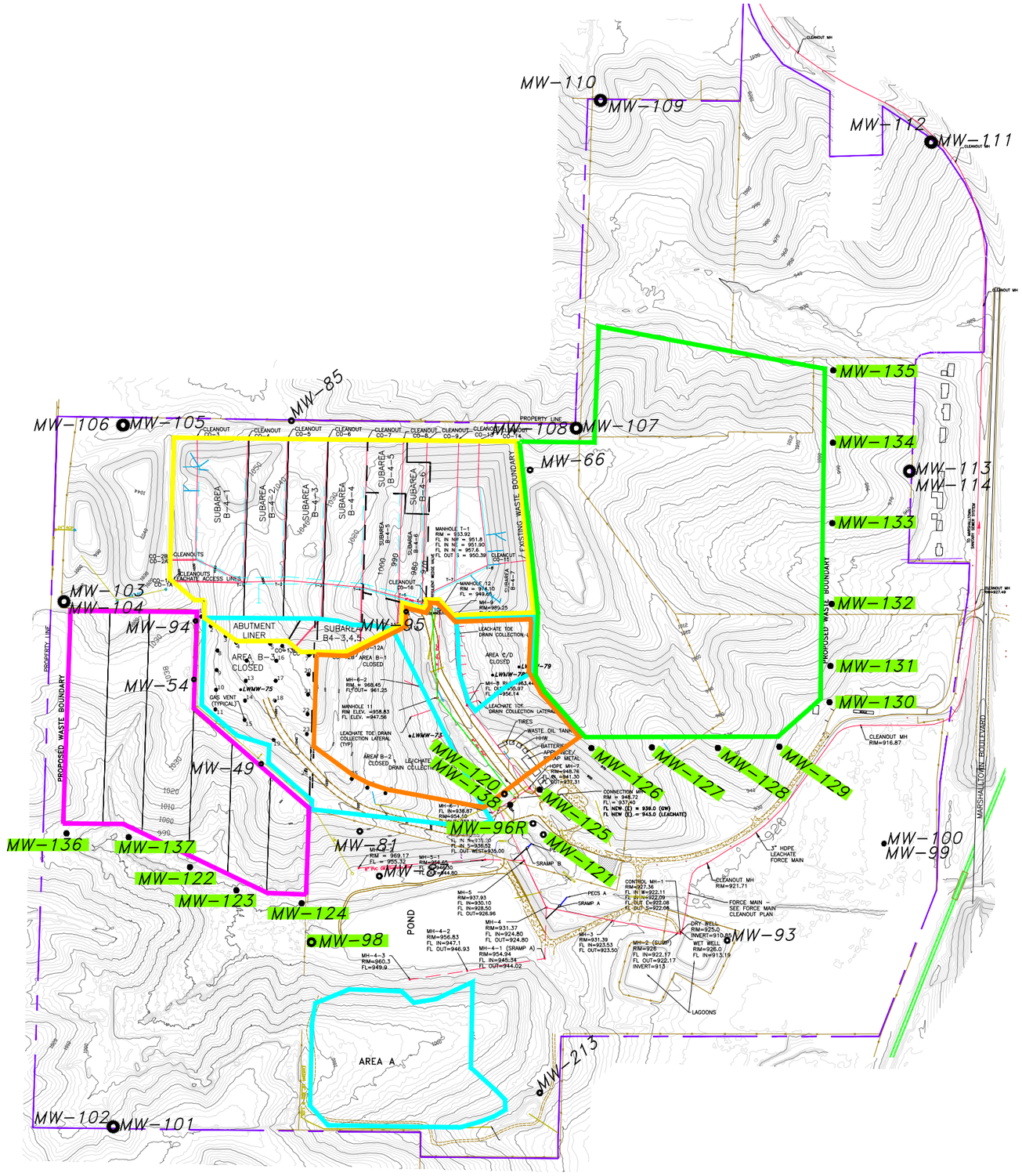

FIGURE: 20

REVISION	NO.	DATE
DRAWN JGH	PROJECT NO. 6003-21A	DATE 2/03/25

FUTURE HMSP MONITORING WELL LOCATIONS

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MARSHALL COUNTY, IOWA

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