SHEYENE AQUADUCT STRUCTURE

Client Name:	**U.S. ARMY CORPS OF ENGINEERS**	**Design By:**	**MBI**
Project Name:	**FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4**	**Review By:**	
Work Describtion:	**Sheyenne Aquaduct Structure - Retaining Walls**	**Date:**	**2/10/2011**
	Panel E	**Job #:**	**34091004**
File Path:	P:\Mpls\34 ND\09\34091004 Fargo Moorhead Metropolitan Feas. Study\WorkFiles_Phase4\070 Structural\Aqueducts\Sheyene\[34091004 PH4 Sheyene Retaining Walls Panel E.xlsx]Load Cases		
REF.	**1**		
	2		

ID#	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Name	100 yr. flood	100 yr. flood + ice	500 yr. flood	T.O. Levee	Normal flow + ice	Construction
Load Category	Usual	Unusual	Unusual	Extreme	Usual	Unusual
Tributary - Water El. (ft)	914.56	914.56	914.67	917.5	903.24	**NA**
Diversion - Head Water El. (ft)	902.12	902.12	903.32	917.5	**NA**	**NA**
Diversion - Tail Water El. (ft)	901.91	901.91	903.06	917.5	**NA**	**NA**
Tributary - T.O. Wall El. (ft)	917.5					
Tributary - T.O. Deck L.P. El.(ft)	898.7					
Tributary - T.O. Deck H.P. El.(ft)	900.7					
Diversion - T.O. Mat El. (ft)	883.68					
Tributary - Deck Slab thickness @ L.P. (ft)	2					
Tributary - Deck Slab thickness @ H.P. (ft)	4					
Diversion - Mat Slab thickness (ft)	4					
Tibutary - Water height (ft)	**15.86**	**15.86**	**15.97**	**18.8**	**4.54**	**NA**
Diversion - Head Water height (ft)	**18.44**	**18.44**	**19.64**	**33.82**	**NA**	**NA**
Ice	**NA**	2ft Ice	**NA**	**NA**	2ft Ice	**NA**
Ice Load	**NA**	10 kips/ft	**NA**	**NA**	10 kips/ft	**NA**
Ice Laod El. (ft)	**NA**	**914.56**	**NA**	**NA**	**903.24**	**NA**
Uplift @ HW (ft)	**22.44**	**22.44**	**23.64**	**37.82**	**NA**	**NA**
Uplift @ TW (ft)	**22.23**	**22.23**	**23.38**	**37.82**	**NA**	**NA**
Pile Condition	**Undrained**	**Undrained**	**Undrained**	**Undrained**	**Drained**	**Undrained**
Load Category	**Usual**	**Unusual**	**Unusual**	**Extreme**	**Usual**	**Unusual**
Safety Factors	2	1.5	1.5	1.15	2	1.5
Allwable Lateral Capacity (tons)	**18**	**20.5**	**20.5**	**24**	**11.5**	**20.5**
Allowable Pile Capacity (tons) - Axial	**61.95**	**82.60**	**82.60**	**107.74**	**36.525**	**82.60**
Allowable Pile Capacity (tons) - Uplift	**38.65**	**51.53**	**51.53**	**67.22**	**5.9**	**51.53**

Pile Capacity	**Ultimate Axial Capacity (kips)**	**Allowable Lateral Capacity (kips)**		
		0.5" (Usual)	**0.67" (Unusual)**	**0.875" (Extreme)**
Undrained - Axial	247.8	36	41	48
Undrained - Uplift	154.6			
Drained - Axial	146.1	23	29	36
Drained - Uplift	23.6			

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COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004		
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Panel E		

Monolith Structure

ITEM		UNIT	QUANITY	UNIT COST	TOTAL Cost
FURNISH HP14x73 WALL PILING		LF	4,370	0	$0
INSTALL HP14x73 WALL PILING		LF	4,370	0	$0
PILE TEST, 48.0 ft	Long	EA	6	0	$0
FOOTING CONCRETE		CY	618	0	$0
	Forming	SF	1,428		
STEM CONCRETE		CY	701	0	$0
	Forming	SF	9,812		
STEEL REINFORCEMENT		LB	253,760	0	$0
WALL RAILING		LF	140	0	$0
SHEET PILE CUT-OFF WALL		SF	2,800	0	$0
					$0

Structure Length = 140 ft

No. piles = 115 Each

Length = 38 ft

Note: HP14x73 pile used for design, use HP14x73 to allow for corrosion

LENGTH

(FRONT & Back FACE) 10 FT

Native Soil has low permeability assume cut-off minimal to prevent scour

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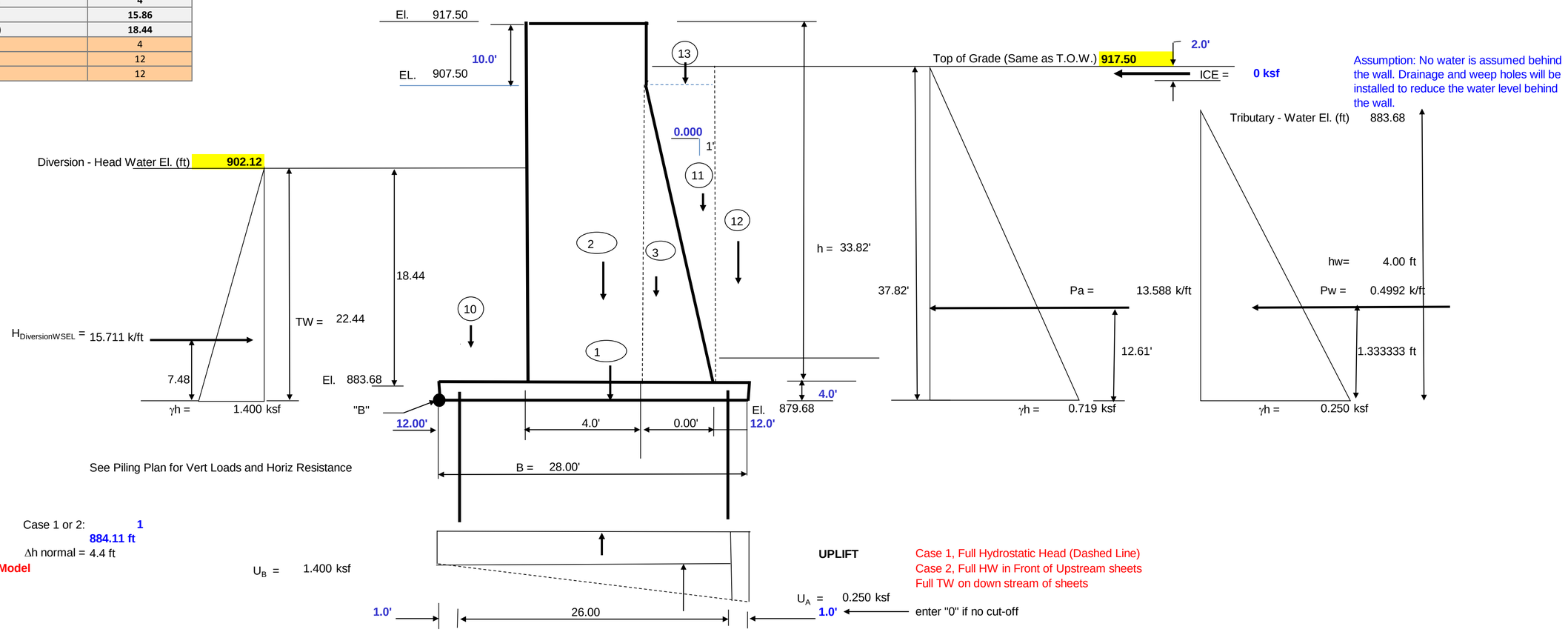
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 1 100 yr. flood	Panel E

ID#	Case 1
Name	100 yr. flood
Load Category	Usual
Tributary - Water El. (ft)	914.56
Diversion - Head Water El. (ft)	902.12
Diversion - Tail Water El. (ft)	901.91
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	883.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.86
Diversion - Head Water height (ft)	18.44
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = 4.4 ft
See Geotechnical seepage Model

U_B = 1.400 ksf

UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets

U_A = 0.250 ksf
enter "0" if no cut-off

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	140	28.00	4.00	0.15	rec	2352.0	14.00	32,928.0
Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	140	12.00	18.44	0.0624	rec	1933.1	6.00	11,598.6
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**5489.9**	ΣM_V =	**89,847.8**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	140	28.00	1.400	rec	-5489.0	14.00	-76,846
	U_A	140	28.00	-1.151	tri	2255.3	18.67	42,099
					ΣU =	**-3233.7**	ΣM_U =	**-34,747**

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MBI		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls		
2/11/11				Load Cases: Case 1 100 yr. flood	Panel E	

Horizontal Loads

	L	H	Pressure		ICE	arm	Mu
	ft	ft	ksf		K	ft	ft-k
ICE	140	2.00	0.00	rec	0.0	36.82	0.0

	L	Force		H	arm	Mw
	ft	k/ft		K	ft	ft-k
SOIL	140	-13.588		-1902.37	12.61	-23982.53
Water Loads						
H_{TW}	140	15.711	tri	2199.52	7.48	16452.43
H_{HW}	140	-0.499	tri	-69.89	1.33	-93.18
			ΣWater =	**2129.63**	ΣM_W =	**-7623.3**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-42371	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	162548	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**120,177**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**7,449**	kips
Sum of Horizontal Forces	H = Σhorizontal	**227**	kips

Location of Resultant	Xr = ΣM / P =	16.13	ft from Toe
	e = B/2 - Xr =	(2.13)	ft
	B/6 =	4.667	ft

CONCRETE QUANTITIES

				forming	
Ftg conc:	589	cy (includes stepped)		1428	sf
Stem Conc:	701	cy		9812	sf
Total =	1,290				

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
Bot mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
								cy	**LB/cy**
							106,991	589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63,441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63,556.20	
Top Face	Transverse:	9	6	3.40	3.5	280	3,332		
	Longitudinal:	9	6	3.40	139.5	8	3,794		
Dowels	Vertical I.F.	9	6	3.40	33.3	280	31,721		
	Vertical O.F.	9	6	3.40	33.3	280	31,721		
								cy	**LB/cy**
							134,066	701	191.1270455
						Σ =	**241,058**		
	Lap Splices (long. Bars)	9		3.40	8	467	12,702		
						Σ Bar Wt=	253,760	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	18.44	**0.0624**	1.150656	10.609	6.147	65.21028
Tributary SEL =	33.82	**0.019**	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				0.257		57.28607

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MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 2 100 yr. flood + ice Panel E	

ID#	Case 2
Name	100 yr. flood + ice
Load Category	Unusual
Tributary - Water El. (ft)	914.56
Diversion - Head Water El. (ft)	902.12
Diversion - Tail Water El. (ft)	901.91
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	883.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.86
Diversion - Head Water height (ft)	18.44
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

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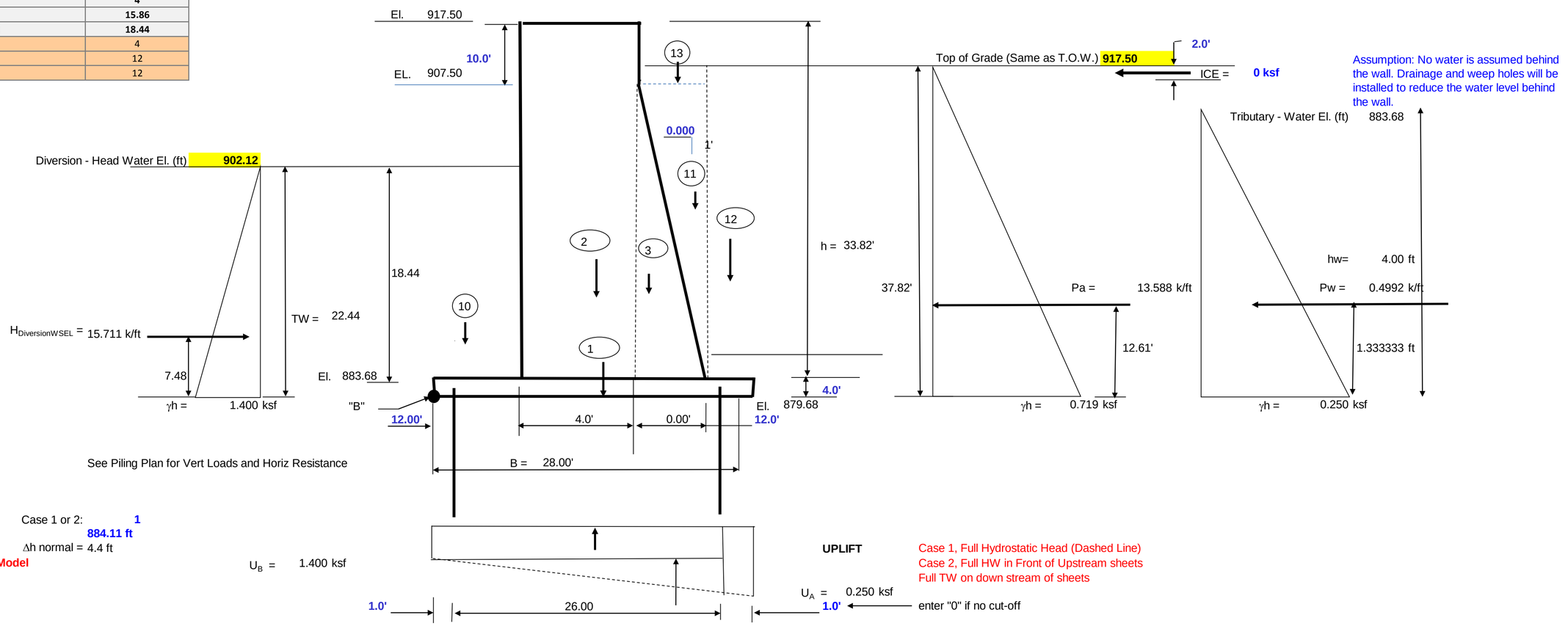
MN State Building Codes
Frost Depth = 5.0 ft provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = 903.24 ft DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
Stepped Ftg Ls = 2.0 ft overlap distance at stepped ftg



See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: 1
Normal Water Level, El. 884.11 ft
Δh normal = 4.4 ft
See Geotechnical seepage Model

U_B = 1.400 ksf

UPLIFT
U_A = 0.250 ksf
enter "0" if no cut-off

Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	140	28.00	4.00	0.15	rec	2352.0	14.00	32,928.0
Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	140	12.00	18.44	0.0624	rec	1933.1	6.00	11,598.6
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**5489.9**	ΣM_V =	**89,847.8**

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	140	28.00	1.400	rec	-5489.0	14.00	-76,846
	U_A	140	28.00	-1.151	tri	2255.3	18.67	42,099
					ΣU =	**-3233.7**	ΣM_U =	**-34,747**

Horizontal Loads	L ft	H ft	Pressure ksf	**ICE** K	arm ft	**Mu** ft-k

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2/11/11				Load Cases: Case 2 100 yr. flood + ice	Panel E

ICE	140	2.00	0.00	rec	0.0	36.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	140		-13.588		-1902.37	12.61	-23982.53	
Water Loads								
H_{TW}	140		15.711	tri	2199.52	7.48	16452.43	
H_{HW}	140		-0.499	tri	-69.89	1.33	-93.18	
				ΣWater =	**2129.63**	ΣM_W =	**-7623.3**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-42371	kip-ft
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Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**120,177**	kip-ft
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Location of Resultant	Xr = ΣM / P =	16.13	ft from Toe
	e = B/2 - Xr =	(2.13)	ft
	B/6 =	4.667	ft

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			forming	
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Stem Conc:	701	cy	9812	sf
Total =	1,290			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
							106,991	cy	LB/cy
								589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63556.2	
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FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	18.44	0.0624	1.150656	10.609	6.147	65.21028
Tributary SEL =	33.82	0.019	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	0.0624	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				0.257		57.28607

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ID#	Case 3
Name	500 yr. flood
Load Category	Unusual
Tributary - Water El. (ft)	914.67
Diversion - Head Water El. (ft)	903.32
Diversion - Tail Water El. (ft)	903.06
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
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Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.97
Diversion - Head Water height (ft)	19.64
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

File:

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Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
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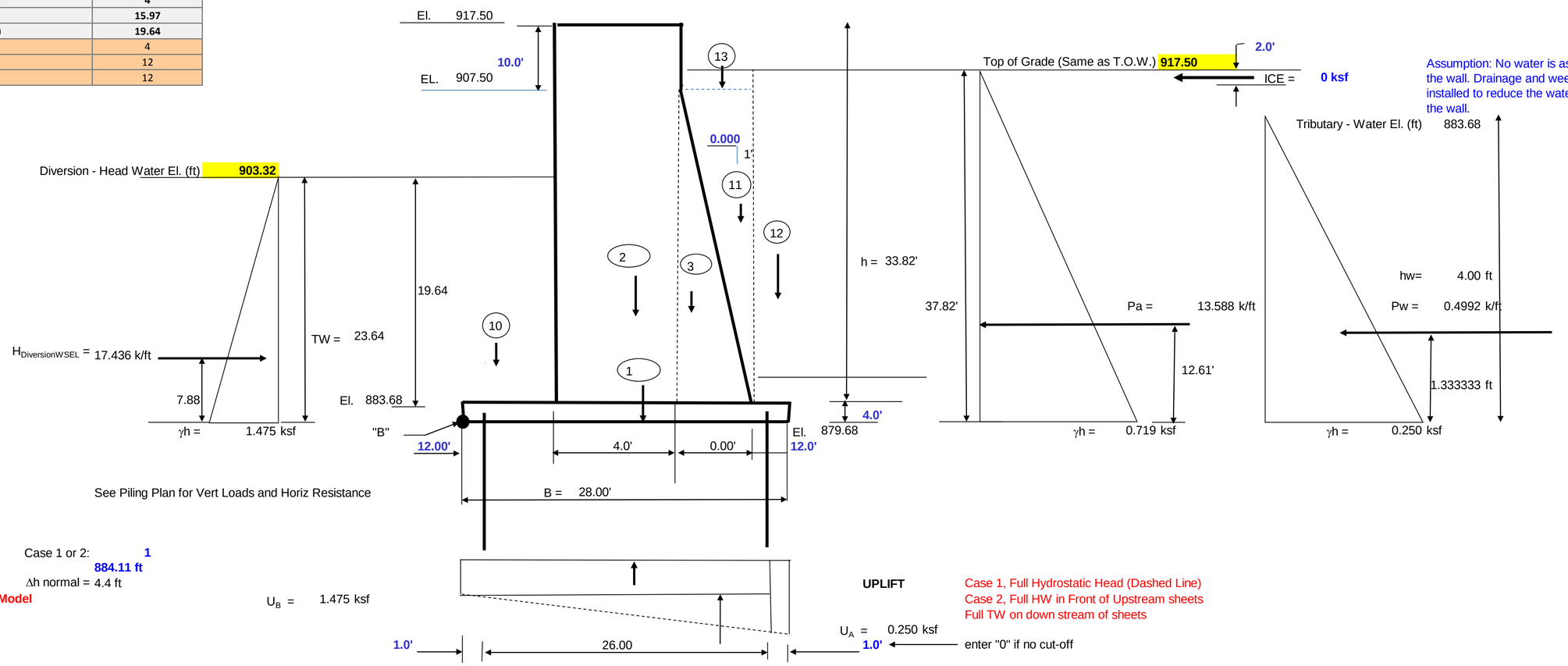

See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = 4.4 ft
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UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
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Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**
T.W on ftg Stem	10	140	12.00	19.64	0.0624	rec	2058.9	6.00	12,353.4
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**5615.7**	ΣM_V =	**90,602.6**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	140	28.00	1.475	rec	-5782.5	14.00	-80,955
	U_A	140	28.00	-1.226	tri	2402.1	18.67	44,838
					ΣU =	**-3380.5**	ΣM_U =	**-36,117**

Horizontal Loads		L ft	H ft	Pressure ksf		ICE K	arm ft	Mu ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 3 500 yr. flood	Panel E

ICE	140	2.00	0.00	rec	0.0	36.82	0.0
	L		Force		**H**	arm	**Mw**
	ft		k/ft		K	ft	ft-k
SOIL	140		-13.588		-1902.37	12.61'	-23982.53
Water Loads							
H_{TW}	140		17.436	tri	2441.06	7.88	19235.51
H_{HW}	140		-0.499	tri	-69.89	1.33	-93.18
				ΣWater =	**2371.17**	ΣM_W =	**-4840.2**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-40957	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	163303	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**122,346**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**7,428**	kips
Sum of Horizontal Forces	H = Σhorizontal	**469**	kips

Location of Resultant	Xr = ΣM / P =	16.47	ft from Toe
	e = B/2 - Xr =	(2.47)	ft
	B/6 =	4.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	589	cy (includes stepped)	1428	sf
Stem Conc:	701	cy	9812	sf
Total =	1,290			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
Bot mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
								cy	**LB/cy**
							106,991	589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63556.2	
Top Face	Transverse:	9	6	3.40	3.5	280	3,332		
	Longitudinal:	9	6	3.40	139.5	8	3,794		
Dowels	Vertical I.F.	9	6	3.40	33.3	280	31,721		
	Vertical O.F.	9	6	3.40	33.3	280	31,721		
								cy	**LB/cy**
							134,066	701	191.1270455
						Σ =	**241,058**		
	Lap Splices (long. Bars)	9		3.40	8	467	12,702		
						Σ Bar Wt=	253,760	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	19.64	0.0624	1.225536	12.035	6.547	78.78759
Tributary SEL =	33.82	0.019	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	0.0624	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				-1.169		43.70877

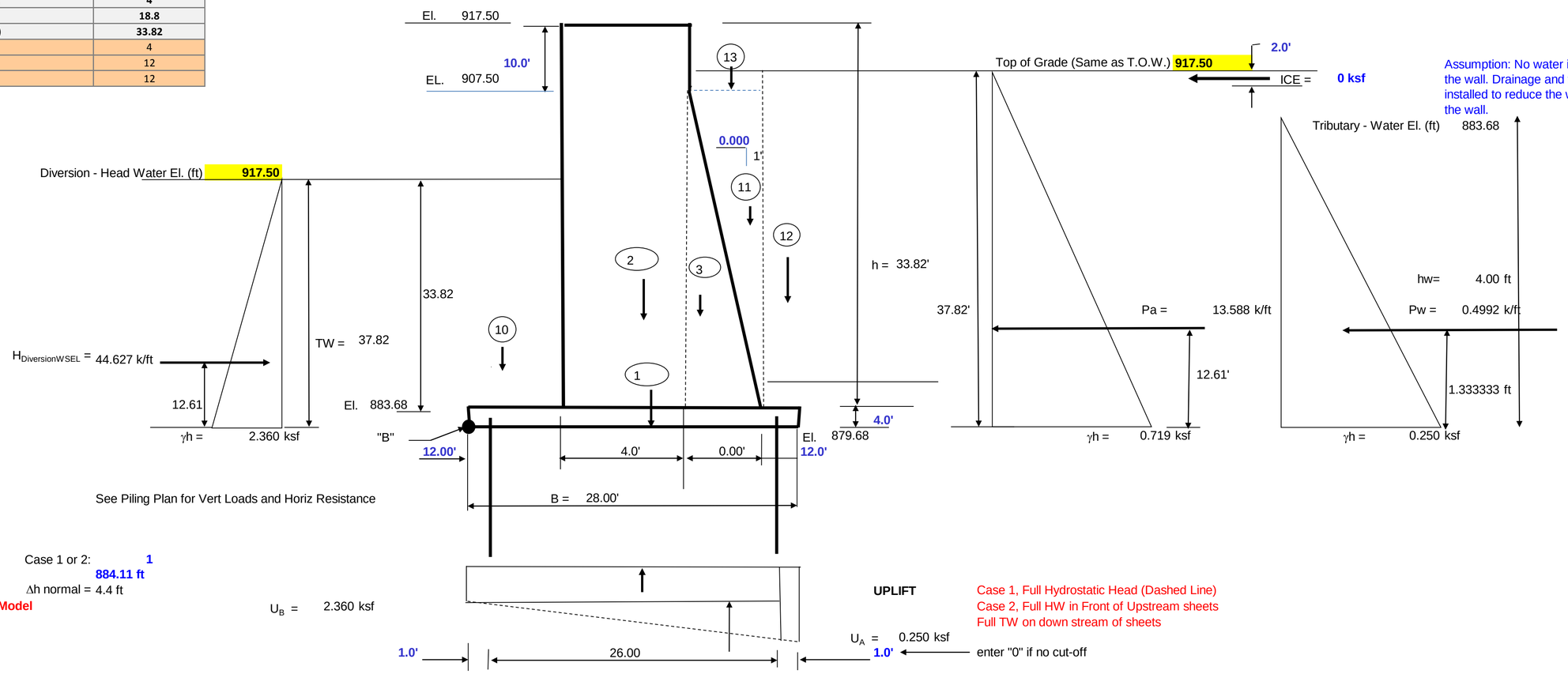
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 4 T.O. Levee Panel E	

ID#	Case 4
Name	T.O. Levee
Load Category	Extreme
Tributary - Water El. (ft)	NA
Diversion - Head Water El. (ft)	917.5
Diversion - Tail Water El. (ft)	917.5
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	883.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	18.8
Diversion - Head Water height (ft)	33.82
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



See Piling Plan for Vert Loads and Horiz Resistance

Case 1 or 2: **1**
Normal Water Level, El. **884.11 ft**
Δh normal = 4.4 ft
See Geotechnical seepage Model

U_B = 2.360 ksf

U_A = 0.250 ksf

UPLIFT
Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets
enter "0" if no cut-off

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	140	28.00	4.00	0.15	rec	2352.0	14.00	32,928.0
Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	140	12.00	33.82	0.0624	rec	3545.4	6.00	21,272.5
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**7102.2**	ΣM_V =	**99,521.7**

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	140	28.00	2.360	rec	-9251.1	14.00	-129,515
	U_A	140	28.00	-2.110	tri	4136.3	18.67	77,211
					ΣU =	**-5114.8**	ΣM_U =	**-52,304**

Horizontal Loads	L ft	H ft	Pressure ksf	**ICE** K	arm ft	**Mu** ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 4 T.O. Levee Panel E	

ICE	140	2.00	0.00	rec	0.0	36.82	0.0
	L		Force		**H**	arm	**Mw**
	ft		k/ft		K	ft	ft-k
SOIL	140		-13.588		-1902.37	12.61'	-23982.53
Water Loads							
H_{TW}	140		44.627	tri	6247.78	12.61	78763.67
H_{HW}	140		-0.499	tri	-69.89	1.33	-93.18
				ΣWater =	**6177.89**	ΣM_W =	**54688.0**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	2384	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	172222	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**174,606**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**7,180**	kips
Sum of Horizontal Forces	H = Σhorizontal	**4,276**	kips

Location of Resultant	Xr = ΣM / P =	24.32	ft from Toe
	e = B/2 - Xr =	(10.32)	ft
	B/6 =	4.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	589	cy (includes stepped)	1428	sf
Stem Conc:	701	cy	9812	sf
Total =	1,290			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
Bot mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
								cy	**LB/cy**
							106,991	589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63556.2	
Top Face	Transverse:	9	6	3.40	3.5	280	3,332		
	Longitudinal:	9	6	3.40	139.5	8	3,794		
Dowels	Vertical I.F.	9	6	3.40	33.3	280	31,721		
	Vertical O.F.	9	6	3.40	33.3	280	31,721		
								cy	**LB/cy**
							134,066	701	191.1270455
						Σ =	**241,058**		
	Lap Splices (long. Bars)	9		3.40	8	467	12,702		
						Σ Bar Wt=	253,760	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	33.82	**0.0624**	2.110368	35.686	11.273	402.3038
Tributary SEL =	33.82	**0.019**	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				-24.820		-279.807

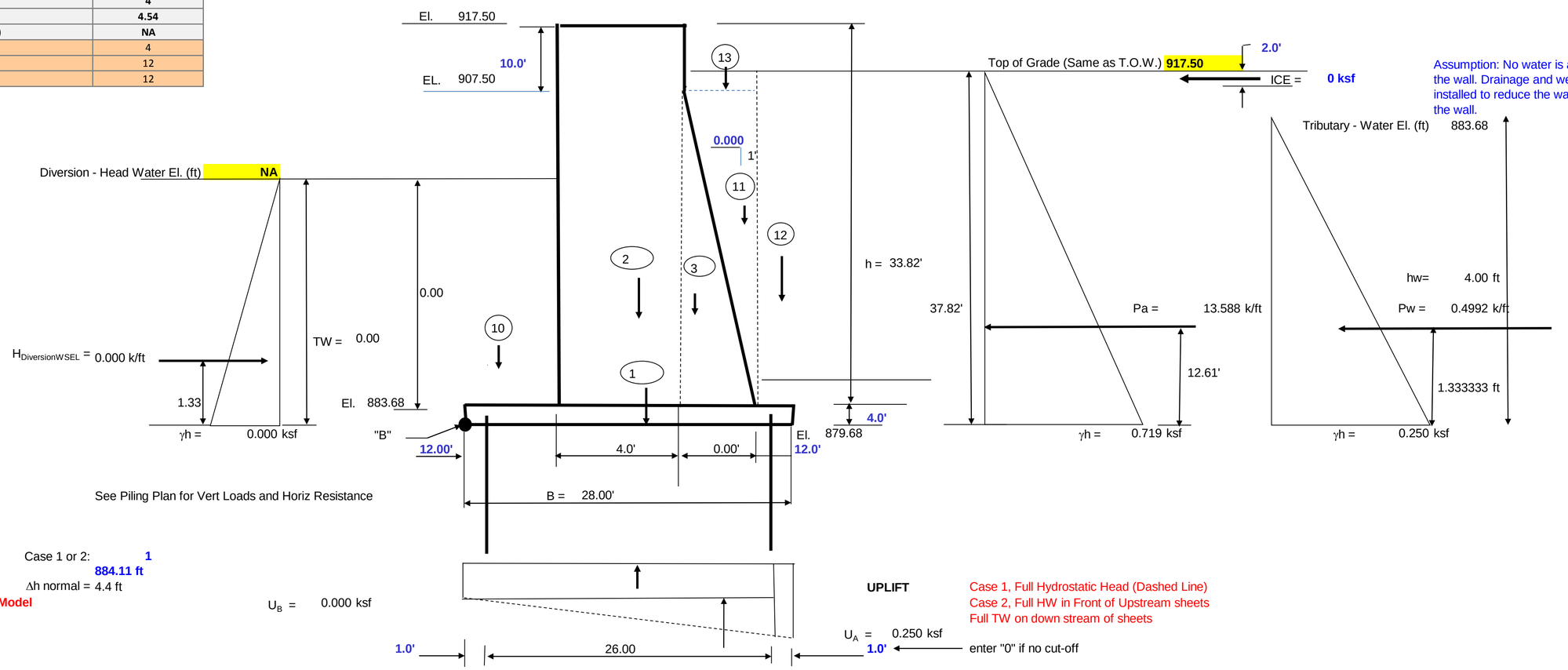
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 5 Normal flow + ice Panel E	

ID#	Case 5
Name	Normal flow + ice
Load Category	Usual
Tributary - Water El. (ft)	903.24
Diversion - Head Water El. (ft)	NA
Diversion - Tail Water El. (ft)	NA
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	883.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	4.54
Diversion - Head Water height (ft)	NA
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

File:

MN State Building Codes
Frost Depth = 5.0 ft provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = 903.24 ft DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
Stepped Ftg Ls = 2.0 ft overlap distance at stepped ftg



Case 1 or 2: 1
Normal Water Level, El. 884.11 ft
Δh normal = 4.4 ft
See Geotechnical seepage Model

Case 1, Full Hydrostatic Head (Dashed Line)
Case 2, Full HW in Front of Upstream sheets
Full TW on down stream of sheets

Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	140	28.00	4.00	0.15	rec	2352.0	14.00	32,928.0
Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**
T.W on ftg Stem	10	140	12.00	0.00	0.0624	rec	0.0	6.00	0.0
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**3556.8**	ΣM_V =	**78,249.2**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	140	28.00	0.000	rec	0.0	14.00	0
	U_A	140	28.00	0.250	tri	-489.2	18.67	-9,132
					ΣU =	**-489.2**	ΣM_U =	**-9,132**

Horizontal Loads	L ft	H ft	Pressure ksf	**ICE** K	arm ft	**Mu** ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 5 Normal flow + ice	Panel E

ICE	140	2.00	0.00	rec	0.0	36.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	140		-13.588		-1902.37	12.61'	-23982.53	
Water Loads								
H_{TW}	140		0.000	tri	0.00	1.33	0.00	
H_{HW}	140		-0.499	tri	-69.89	0.00	0.00	
				ΣWater =	**-69.89**	ΣM_W =	**-23982.5**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-33115	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	150950	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**117,835**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**8,260**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-1,972**	kips

Location of Resultant	Xr = ΣM / P =	14.26	ft from Toe
	e = B/2 - Xr =	(0.26)	ft
	B/6 =	4.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	589	cy (includes stepped)	1428	sf
Stem Conc:	701	cy	9812	sf
Total =	1,290			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
Bot mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
								cy	**LB/cy**
							106,991	589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63556.2	
Top Face	Transverse:	9	6	3.40	3.5	280	3,332		
	Longitudinal:	9	6	3.40	139.5	8	3,794		
Dowels	Vertical I.F.	9	6	3.40	33.3	280	31,721		
	Vertical O.F.	9	6	3.40	33.3	280	31,721		
								cy	**LB/cy**
							134,066	701	191.1270455
						Σ =	**241,058**		
	Lap Splices (long. Bars)	9		3.40	8	467	12,702		
						Σ Bar Wt=	253,760	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	V	arm	Mv
	ft	kcf		K	ft	ft-k
Diversion WSEL	0.00	0.0624	0	0.000	0.000	0
Tributary SEL =	33.82	0.019	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	0.0624	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				10.866		122.4964

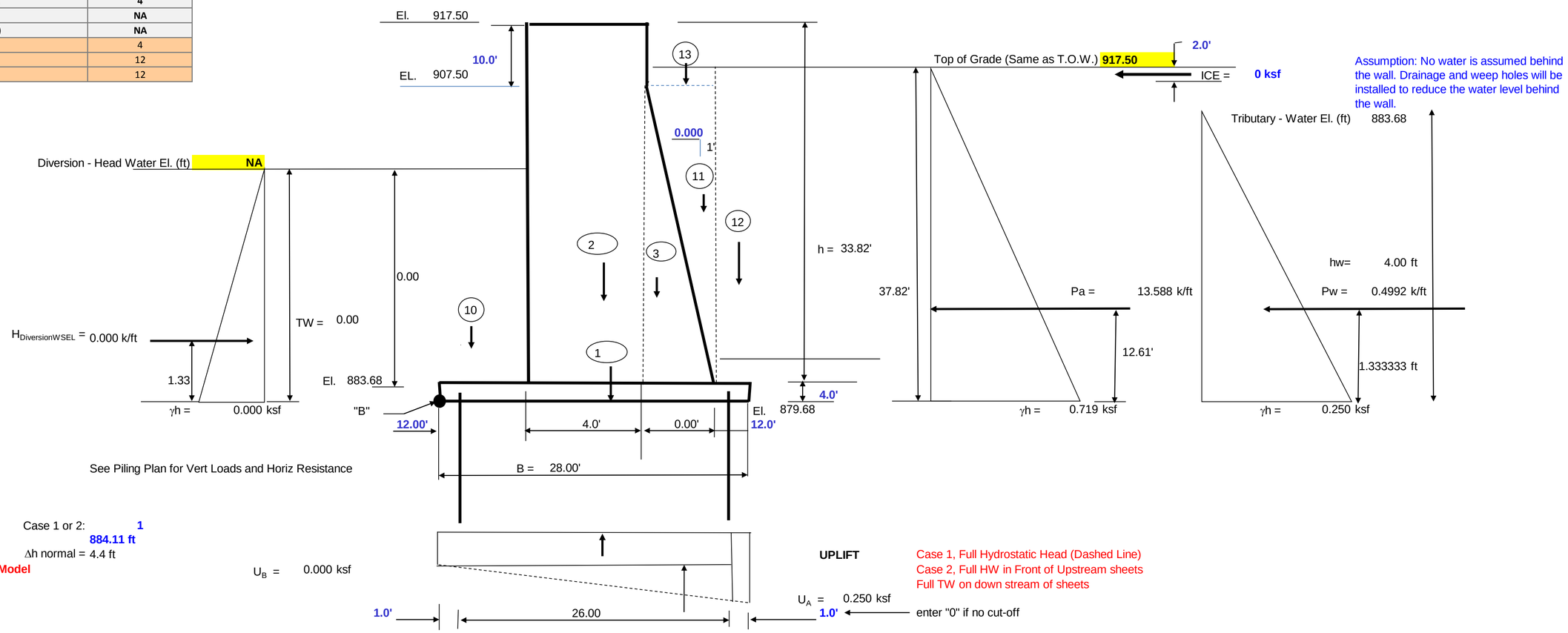
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 6 Construction Panel E	

ID#	Case 6
Name	Construction
Load Category	Unusual
Tributary - Water El. (ft)	NA
Diversion - Head Water El. (ft)	NA
Diversion - Tail Water El. (ft)	NA
Tributary - T.O. Wall El. (ft)	917.5
Tributary - T.O. Deck L.P. El.(ft)	898.7
Tributary - T.O. Deck H.P. El.(ft)	900.7
Diversion - T.O. Mat El. (ft)	883.68
Tributary - Deck Slab thickness @ L.P. (ft)	2
Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	NA
Diversion - Head Water height (ft)	NA
Wall Thickness (ft)	4
Toe (Ft)	12
Heel (ft)	12

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
Water El. = **903.24 ft** DEC, JAN, FEB Mean Water Elevation

Non-Overflow Section **Length = 140.0 ft**
Stepped Ftg Ls = **2.0 ft** overlap distance at stepped ftg



Vertical Loads	Section	L ft	W ft	H ft	γ kcf	shape	V K	arm ft	Mv ft-k
Ftg concrete	1	140	28.00	4.00	0.15	rec	2352.0	14.00	32,928.0
Stem	2	140	4.00	33.82	0.15	rec	2840.9	14.00	39,772.3
Batter	3	140	0.00	23.82	0.15	tri	0.0	16.00	0.0
					D.L. Concrete	ΣVc =	**5192.9**	ΣM_V =	**72,700.3**
T.W on ftg Stem	10	140	12.00	0.00	0.0624	rec	0.0	6.00	0.0
H.W. on Stem Slope	11	140	0.00	23.82	0.12	tri	0.0	16.00	0.0
H.W. Above Slope	13	140	0.00	10.00	0.12	rec	0.0	16.00	0.0
Soil on Footing	12s	140	12.00	33.82	0.0626	rec	3556.8	22.00	78,249.2
H.W. on Footing	12w	140	12.00	0.00	0.0624	rec	0.0	22.00	0.0
					D.L. Water	ΣVw =	**3556.8**	ΣM_V =	**78,249.2**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	140	28.00	0.000	rec	0.0	14.00	0
	U_A	140	28.00	0.250	tri	-489.2	18.67	-9,132
					ΣU =	**-489.2**	ΣM_U =	**-9,132**

Horizontal Loads		L ft	H ft	Pressure ksf		**ICE** K	arm ft	**Mu** ft-k

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 6 Construction	Panel E

ICE	140	2.00	0.00	rec	0.0	36.82	0.0
	L		Force		**H**	arm	**Mw**
	ft		k/ft		K	ft	ft-k
SOIL	140		-13.588		-1902.37	12.61'	-23982.53
Water Loads							
H_{TW}	140		0.000	tri	0.00	1.33	0.00
H_{HW}	140		-0.499	tri	-69.89	1.33	-93.18
				ΣWater =	**-69.89**	ΣM_W =	**-24075.7**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-33208	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	150950	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**117,742**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**8,260**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-1,972**	kips

Location of Resultant	Xr = ΣM / P =	14.25	ft from Toe
	e = B/2 - Xr =	(0.25)	ft
	B/6 =	4.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	589	cy (includes stepped)	1428	sf
Stem Conc:	701	cy	9812	sf
Total =	1,290			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing		Length	# of bars	Total wt		
a) Footing			in	LB /ft	ft	ea	lb		
Top mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
Bot mat	Transverse:	9	6	3.40	27.5	284	26,554		
	Longitudinal:	9	6	3.40	141.5	56	26,942		
								cy	**LB/cy**
							106,991	589	181.6374748
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	33.32	280	31,721	63441.28	
	Longitudinal:	9	6	3.40	139.5	67	31,778	63556.2	
Top Face	Transverse:	9	6	3.40	3.5	280	3,332		
	Longitudinal:	9	6	3.40	139.5	8	3,794		
Dowels	Vertical I.F.	9	6	3.40	33.3	280	31,721		
	Vertical O.F.	9	6	3.40	33.3	280	31,721		
								cy	**LB/cy**
							134,066	701	191.1270455
						Σ =	**241,058**		
	Lap Splices (long. Bars)	9		3.40	8	467	12,702		
						Σ Bar Wt=	253,760	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	0.00	**0.0624**	0	0.000	0.000	0
Tributary SEL =	33.82	**0.019**	0.64258	10.866	11.273	122.4964
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				10.866		122.4964
Net Forces				10.866		122.4964

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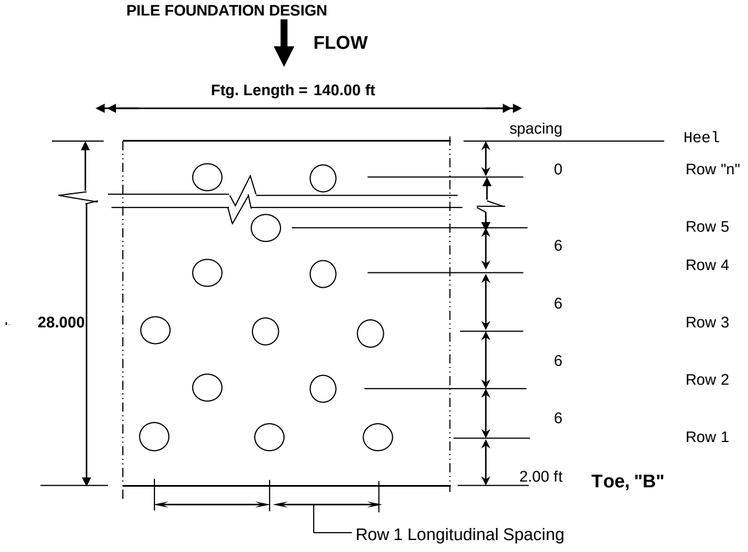
				Panel E	

PILE FOUNDATION DESIGN



L = 140.00 ft

PILE PATTERN GEOMETRY

Transverse Spacing		Distance to Toe, d_{toe}	Longitudinal Spacing	Batter	Piles per Row (N)	Edge Dist (ft)		Trial N
Row 1 to Toe	2.00 ft	2.0 ft	2.50 ft	0 "/12"	23	42.50	1	57
Row 1 to Row 2	6.00 ft	8.0 ft	5.00 ft	0 "/12"	22	17.50	2	29
Row 2 to Row 3	6.00 ft	14.0 ft	5.00 ft	0 "/12"	22	17.50	3	29
Row 3 to Row 4	6.00 ft	20.0 ft	5.00 ft	0 "/12"	24	12.50	4	29
Row 4 to Row 5	6.00 ft	26.0 ft	5.00 ft	0 "/12"	24	12.50	5	29
Row 5 to Row 6	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 6 to Row 7	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 7 to Row 8	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 8 to Row 9	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 9 to Row 10	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 10 to Row 11	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 11 to Row 12	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 12 to Row 13	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 13 to Row 14	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Row 14 to Row 15	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	70.00	0	0
Last Row to Heel	2.00 ft							
	28.00 ft				ΣN =	115		173

Note: Enter 0 for Longitudinal Spacing for Rows Not Used)

Pile Properties: Pile Type: **HP** (C.I.P or HP) Pile Length = **38.0 ft**
HP Nominal Depth, h = **14.0 in**
Wt. per ft, plf **73**

Ftg EL. 879.68
Pile Tip El. 842.68
Pile Cap Embed = **1.00 ft**
Total pile Length = 4,370 LF

Pile Group Properties

N.A. of Pile Group to Toe
X_{NA} = (ΣN * d_{toe}) / ΣN = **14.21 ft**

	Dist. From N.A. to Pile Row	d	N	I = N * d^2
1	Dist. To Row 1	12.21 ft	23	3428.2
2	Dist. To Row 2	6.21 ft	22	848.1
3	Dist. Row 3	0.21 ft	22	1.0
4	Dist. Row 4	-5.79 ft	24	804.9
5	Dist. Row 5	-11.79 ft	24	3336.8
0	Row 6 (not used)	0.00 ft	0	0.0
0	Row 7 (not used)	0.00 ft	0	0.0
0	Row 8 (not used)	0.00 ft	0	0.0
0	Row 9 (not used)	0.00 ft	0	0.0
0	Row 10 (not used)	0.00 ft	0	0.0
0	Row 11 (not used)	0.00 ft	0	0.0
0	Row 12 (not used)	0.00 ft	0	0.0
0	Row 13 (not used)	0.00 ft	0	0.0
0	Row 14 (not used)	0.00 ft	0	0.0
0	Row 15 (not used)	0.00 ft	0	0.0
			115	Σ I = **8419.0**

ALLOWABLE LOADS (from Geotechnical)

	Service	Allowable Pile Loads					
	ID#	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	Name	100 yr. flood	100 yr. flood + ice	500 yr. flood	T.O. Levee	Normal flow + ice	Construction
	Load Category	Usual	Unusual	Unusual	Extreme	Usual	Unusual
Allwable Lateral Capacity (tons)		18.0 tons	20.5 tons	20.5 tons	24.0 tons	11.5 tons	20.5 tons
Allowable Pile Capacity (tons) - Axial		62.0 tons	82.6 tons	82.6 tons	107.7 tons	36.5 tons	82.6 tons
Safety Factors		2.00	1.50	1.50	1.15	2.00	1.50

w/o Group effects

Summary Pile Reactions

Load Combinations	Allowable Pile Capacity (tons) - Axial	Pile Loads (tons/pile) 1	2	3	4	5	6	7	8	9	10	11	12	Max. Vertical Load (Tons)	Horiz Pile Group Capacity (k)	Check
Case 1	**62.0 tons**	22.0	27.1	32.2	37.3	42.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.4	4,140	**OK**
Case 2	**82.6 tons**	22.0	27.1	32.2	37.3	42.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.4	4,715	**OK**
Case 3	**82.6 tons**	20.1	26.1	32.1	38.1	44.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.1	4,715	**OK**
Case 4	**107.7 tons**	-21.4	4.5	30.3	56.2	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.0	5,520	**OK**
Case 5	**36.5 tons**	35.6	35.7	35.9	36.1	36.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.2	2,645	**OK**
Case 6	**82.6 tons**	35.6	35.8	35.9	36.0	36.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.2	2,645	**OK**

Max Service : P = **82.0**

Using solid mechanics equations adapted for discrete elements, the forces in the pile rows for different load combinations are determined.
The force in each pile row is found using:

Pile Load = P / N + M_{NA} / I

First, the moment about the toe must be translated to get the moment about the neutral axis of the pile group.

$e_{toe} = M_{toe} / P$

Then the eccentricity about the neutral axis of the pile group is

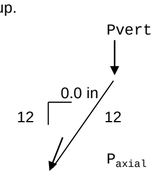
$e_{NA} = X_{NA} - e_{toe}$

The moment about the neutral axis of the pile group becomes

$M_{NA} = P * e_{NA}$

For battered pile, the Vertical pile load needs to be transformed to the axial load along the pile axis

Paxial = 1.000 Pvert



FORCE RESULTANT (see Stability Analysis)

CASE	Event		Vertical Load P (kips)	Horizontal	ΣM toe (kip-	$e_{toe} = M_{toe} / P$	$e_{NA} = X_{NA} - e_{toe}$	$M_{NA} = P * e_{NA}$

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Case 1	**100 yr. flood**	**Usual**	7,449	-227	120,177	16.13	-1.92	-14336
Case 2	**100 yr. flood + ice**	**Unusual**	7,449	-227	120,177	16.13	-1.92	-14336
Case 3	**500 yr. flood**	**Unusual**	7,428	-469	122,346	16.47	-2.26	-16802
Case 4	**T.O. Levee**	**Extreme**	7,180	-4,276	174,606	24.32	-10.11	-72583
Case 5	**Normal flow + ice**	**Usual**	8,260	1,972	117,835	14.26	-0.06	-465
Case 6	**Construction**	**Unusual**	8,260	1,972	117,742	14.25	-0.04	-372

SERVICE

Case **Case 1**
Flood Event **100 yr. flood**
Usual

Vertical Load, P = 7449 kips
Horizontal Load, H = -227 kips
M_{NA} = -14336 kip-ft

115

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads			**Axial Pile Load**
1	Row 1	64.8		-20.8	44.0 kips/pile		22.0 tons/pile	22.0 tons/pile
2	Row 2	64.8		-10.6	54.2 kips/pile		27.1 tons/pile	27.1 tons/pile
3	Row 3	64.8		-0.4	64.4 kips/pile		32.2 tons/pile	32.2 tons/pile
4	Row 4	64.8		9.9	74.6 kips/pile		37.3 tons/pile	37.3 tons/pile
5	Row 5	64.8		20.1	84.9 kips/pile		42.4 tons/pile	42.4 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
						max:	**42.4 tons/pile**	**max: 42.4 tons/pile**

Assumed lateral Capacity: 36.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance
1	Row 1	0	23	0.0	828	1.000	828 kips
2	Row 2	0	22	0.0	792	1.000	792 kips
3	Row 3	0	22	0.0	792	1.000	792 kips
4	Row 4	0	24	0.0	864	1.000	864 kips
5	Row 5	0	24	0.0	864	1.000	864 kips
6	Row 6	0	0	0.0	0	1.000	0 kips
7	Row 7	0	0	0.0	0	1.000	0 kips
8	Row 8	0	0	0.0	0	1.000	0 kips
9	Row 9	0	0	0.0	0	1.000	0 kips
10	Row 10	0	0	0.0	0	1.000	0 kips
11	Row 11	0	0	0.0	0	1.000	0 kips
12	Row 12	0	0	0.0	0	1.000	0 kips
13	Row 13	0	0	0.0	0	1.000	0 kips
14	Row 14	0	0	0.0	0	1.000	0 kips
15	Row 15	0	0	0.0	0	1.000	0 kips
			115		4140		**4140 kips**

OK

Case **Case 2**
Flood Event **100 yr. flood + ice**
Unusual

Vertical Load, P = 7449 kips
Horizontal Load, H = -227 kips
M_{NA} = -14336 kip-ft

115

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads			**Axial Pile Load**
1	Row 1	64.8		-20.8	44.0 kips/pile		22.0 tons/pile	22.0 tons/pile
2	Row 2	64.8		-10.6	54.2 kips/pile		27.1 tons/pile	27.1 tons/pile
3	Row 3	64.8		-0.4	64.4 kips/pile		32.2 tons/pile	32.2 tons/pile
4	Row 4	64.8		9.9	74.6 kips/pile		37.3 tons/pile	37.3 tons/pile
5	Row 5	64.8		20.1	84.9 kips/pile		42.4 tons/pile	42.4 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
						max:	**42.4 tons/pile**	**max: 42.4 tons/pile**

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance
1	Row 1	0	23	0.0	943	1.000	943 kips
2	Row 2	0	22	0.0	902	1.000	902 kips
3	Row 3	0	22	0.0	902	1.000	902 kips

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4	Row 4	0	24	0.0	984	1.000	984 kips	
5	Row 5	0	24	0.0	984	1.000	984 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			115		4715		**4715 kips**	**OK**

Case **Case 3**
Flood Event **500 yr. flood**
Unusual

Vertical Load, P = 7428 kips
Horizontal Load, H = -469 kips
M_{NA} = -16802 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	64.6		-24.4	40.2 kips/pile	20.1 tons/pile	20.1 tons/pile
2	Row 2	64.6		-12.4	52.2 kips/pile	26.1 tons/pile	26.1 tons/pile
3	Row 3	64.6		-0.4	64.2 kips/pile	32.1 tons/pile	32.1 tons/pile
4	Row 4	64.6		11.6	76.2 kips/pile	38.1 tons/pile	38.1 tons/pile
5	Row 5	64.6		23.5	88.1 kips/pile	44.1 tons/pile	44.1 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
						max: 44.1 tons/pile	**max: 44.1 tons/pile**

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	23	0.0	943	1.000	943 kips	
2	Row 2	0	22	0.0	902	1.000	902 kips	
3	Row 3	0	22	0.0	902	1.000	902 kips	
4	Row 4	0	24	0.0	984	1.000	984 kips	
5	Row 5	0	24	0.0	984	1.000	984 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			115		4715		**4715 kips**	**OK**

Case **Case 4**
Flood Event **T.O. Levee**
Extreme

Vertical Load, P = 7180 kips
Horizontal Load, H = -4276 kips
M_{NA} = -72583 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	62.4		-105.3	-42.8 kips/pile	-21.4 tons/pile	-21.4 tons/pile
2	Row 2	62.4		-53.5	8.9 kips/pile	4.5 tons/pile	4.5 tons/pile
3	Row 3	62.4		-1.8	60.6 kips/pile	30.3 tons/pile	30.3 tons/pile
4	Row 4	62.4		49.9	112.4 kips/pile	56.2 tons/pile	56.2 tons/pile
5	Row 5	62.4		101.7	164.1 kips/pile	82.0 tons/pile	82.0 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
						max: 82.0 tons/pile	**max: 82.0 tons/pile**

Assumed lateral Capacity: 48.0 kips/pile

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	Horizontal Pile Capacity	Batter "/ft	N	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	23	0.0	1104	1.000	1104 kips	
2	Row 2	0	22	0.0	1056	1.000	1056 kips	
3	Row 3	0	22	0.0	1056	1.000	1056 kips	
4	Row 4	0	24	0.0	1152	1.000	1152 kips	
5	Row 5	0	24	0.0	1152	1.000	1152 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			115		5520		**5520 kips**	**OK**

Case **Case 5**
Flood Event **Normal flow + ice**
Usual

Vertical Load, P = 8260 kips
Horizontal Load, H = 1972 kips
M_{NA} = -465 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	71.8		-0.7	71.2 kips/pile	35.6 tons/pile	35.6 tons/pile
2	Row 2	71.8		-0.3	71.5 kips/pile	35.7 tons/pile	35.7 tons/pile
3	Row 3	71.8		0.0	71.8 kips/pile	35.9 tons/pile	35.9 tons/pile
4	Row 4	71.8		0.3	72.1 kips/pile	36.1 tons/pile	36.1 tons/pile
5	Row 5	71.8		0.7	72.5 kips/pile	36.2 tons/pile	36.2 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
11	Row 11	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
12	Row 12	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
13	Row 13	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
14	Row 14	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
15	Row 15	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
					max:	**36.2 tons/pile**	**max: 36.2 tons/pile**

Assumed lateral Capacity: 23.0 kips/pile

	Horizontal Pile Capacity	Batter "/ft	N	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	23	0.0	529	1.000	529 kips	
2	Row 2	0	22	0.0	506	1.000	506 kips	
3	Row 3	0	22	0.0	506	1.000	506 kips	
4	Row 4	0	24	0.0	552	1.000	552 kips	
5	Row 5	0	24	0.0	552	1.000	552 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			115		2645		**2645 kips**	**OK**

Case **Case 6**
Flood Event **Construction**
Unusual

Vertical Load, P = 8260 kips
Horizontal Load, H = 1972 kips
M_{NA} = -372 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	71.8		-0.5	71.3 kips/pile	35.6 tons/pile	35.6 tons/pile
2	Row 2	71.8		-0.3	71.6 kips/pile	35.8 tons/pile	35.8 tons/pile
3	Row 3	71.8		0.0	71.8 kips/pile	35.9 tons/pile	35.9 tons/pile
4	Row 4	71.8		0.3	72.1 kips/pile	36.0 tons/pile	36.0 tons/pile
5	Row 5	71.8		0.5	72.4 kips/pile	36.2 tons/pile	36.2 tons/pile
6	Row 6	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
7	Row 7	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
8	Row 8	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
9	Row 9	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
10	Row 10	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls **Panel E**	

11	Row 11	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
12	Row 12	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
13	Row 13	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
14	Row 14	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
15	Row 15	0.0	0.0	0.0 kips/pile		0.0 tons/pile		0.0 tons/pile	
					max:	**36.2 tons/pile**	**max:**	**36.2 tons/pile**	

Assumed lateral Capacity: 41.0 kips/pile

	Horizontal Pile Capacity	**Batter "/ft**	**N**	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	23	0.0	529	1.000	529 kips	
2	Row 2	0	22	0.0	506	1.000	506 kips	
3	Row 3	0	22	0.0	506	1.000	506 kips	
4	Row 4	0	24	0.0	552	1.000	552 kips	
5	Row 5	0	24	0.0	552	1.000	552 kips	
6	Row 6	0	0	0.0	0	1.000	0 kips	
7	Row 7	0	0	0.0	0	1.000	0 kips	
8	Row 8	0	0	0.0	0	1.000	0 kips	
9	Row 9	0	0	0.0	0	1.000	0 kips	
10	Row 10	0	0	0.0	0	1.000	0 kips	
11	Row 11	0	0	0.0	0	1.000	0 kips	
12	Row 12	0	0	0.0	0	1.000	0 kips	
13	Row 13	0	0	0.0	0	1.000	0 kips	
14	Row 14	0	0	0.0	0	1.000	0 kips	
15	Row 15	0	0	0.0	0	1.000	0 kips	
			115		2645		**2645 kips**	**OK**

BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
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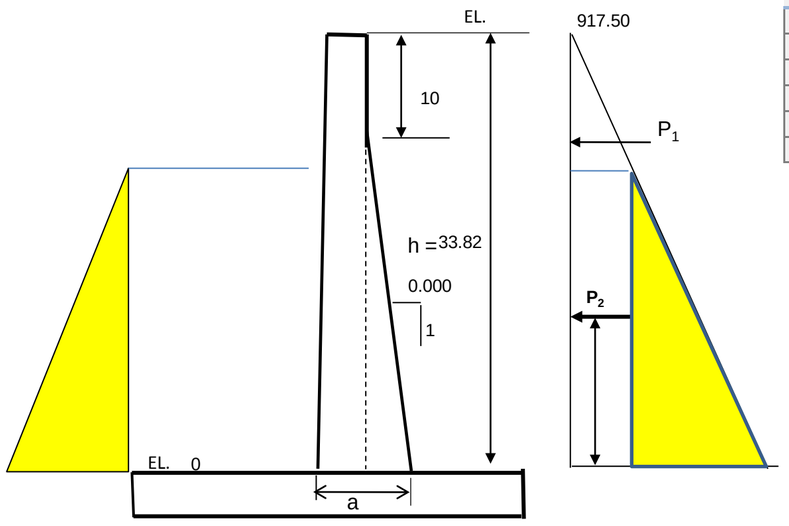
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Panel E 0	



CASE	Event		HW	TW	Dh	TW -ftg
Case 1	100 yr. flood	Usual	902.12	901.91	0.21	901.91
Case 2	100 yr. flood + ice	Unusual	902.12	901.91	0.21	901.91
Case 3	500 yr. flood	Unusual	914.670	903.06	11.61	903.06
Case 4	T.O. Levee	Extreme	917.500	917.50	0.00	917.50
Case 5	Normal flow + ice	Usual	0.000	0.000	0.00	0.00
Case 6	Construction	Unusual	0.000	0.000	0.00	0.00

LOAD FACTORS

Hf =	1.30	hydraulic Factor
LF =	1.70	
Unsual & Extreme =	0.75	
TOP THICK =	4.0 ft	48.0 in
Batter at Base =	0.00 ft	0.0 in
a =	4.00 ft	48.0 in

Load Factors - Hydraulic Structures	
live load, LL =	1.7
dead load, DL =	1.4
flood level , FL =	1
Fluid, F =	1.7
hydraulic, Hf =	1.3
direct tension hydraulic, Hf =	1.65
ICE =	1.7

WALL DESIGN:

Horizontal Load Components and Moments about Bottom of Stem (Service)

CASE	Event	Condition	Load Factor	H (kips/ft)	Moment (kip-ft/ ft)	Vu (kips/ft)	Mu (kip-ft/ ft)
Case 1	100 yr. flood	Usual	1	0.26	57.286	0.57	126.60
Case 2	100 yr. flood + ice	Unusual	0.75	0.26	57.286	0.43	94.95
Case 3	500 yr. flood	Unusual	0.75	-1.17	43.709	-1.94	72.45
Case 4	T.O. Levee	Extreme	0.75	-24.82	-279.807	41.14	463.78
Case 5	Normal flow + ice	Usual	1	10.87	122.496	24.01	270.72
Case 6	Construction	Unusual	0.75	10.87	122.496	18.01	203.04

STEM DESIGN VALUES

MU, k-ft/ft	463.78	k-ft/ft
VU, k/ft	41.14	k/ft

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COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Panel E 0	

ACI 318-05 w/ Modifications per EM 1110-2-2104 ref. EM 110-2-2104

9.3 - Design Strength

ϕ = **0.9** 9.3.2.1 - Tension Controlled sections

0.75 9.3.2.3 - Shear and torsion

FLEXURAL STEEL FOR RECTANGULAR CONCRETE SECTIONS

fy=	60	ksi	
Fc'=	4	ksi	
B1=	0.85		
Muh =	464	k-ft /ft	Includes: hf = 1.3
Vuh=	41.14	k / ft	
bw=	12	in.	
h=	48	in	
cover=	4	in (include correct stirrup bar dia.)	
d=	43.50	in	
pb=	0.0285		pb=0.85*B1*Fc'/ fy*(87 / (87+fy))
.75*pb=	0.0214		
m=fy / 0.85*Fc'=	17.647		

TRIAL

Ru=Mn/bd^2 = 272.328

REQ'D p= 0.0047 **O.K.**

p= FALSE N.G.

As (REQ'D)= 0.81 in^2

ACI 10.5.1

p(min)= 3*SQRT(Fc')/fy 0.00316

200* / fy 0.00333

ACI 10.5.3

4/3*p 0.0063

EM 110-2-2104 2-8 c. (not less than Temp & Shrinkage, half in each face)

p(min)= 0.0028 /2 ▶ As =0.5*$p_{T\&S}$bh = 0.8064 in^2

As = #9 @ 12 = 1.00 in^2

SELECT STEEL

bar #=	9		
spacing, s=	6	in	
# OF BAR=	1	(ENTER 1 IF PER FT, b=12")	a
As=	1.999	in^2	
d=	43.4375	in	
p = As/bd =	0.0038	**O.K. < 0.375pb**	**EM 110-2-2104**
p =	**0.135**	**pb**	**MAXIMUM TENSILE REINFORCEMENT**
T= As*fy =	119.9	k	a) For singly reinforced flexural members
C= B1*Fc' *b*a =	1576.9	**a**	1) p = **0.25** pb Recommended limit
a= T/C =	0.076	in	2) p = **0.375** pb Max. permitted upper limit not requiring special study
Mn= T(d - a/2)/12 =	433.7	ft-k	3) p = **0.5** pb Max. permitted upper limit when excessive deflections are not predicted In ACI 318
ϕ Mn=	390.3	ft-k	4) p = >**0.5** pb but ≤ 0.375 pb permitted only if detailed serviceability analysis incl. deflect. Calc.
			b) Use of compression reinf. shall be per ACI 318
			< Mu N.G.

CHECK SHEAR REINFORCEMENT (ACI 11.3 & EM 110-2-2104 3-3a)

Vuh =	41.1	k		NO SHEAR REINF. REQUIRED
Vn = Vuh / ϕ =	54.9	k		
Vc = 2*sqrt(Fc') bw * d =	65.9	k		**11.3.1.1**
Vs =Vuh / f - 1.3Vc =	No Shear Reinf. Req.	k	NG	Vs(max) ≤ 8*sqrt(fc')bd = 263.7 k

Trial Stirrup Sizes:

# of stirrup legs =	2	(single stirrup = 2, Dbl stirrup = 4……..)
Stirrup bar size =	4	
Av=	0.393	in^2
s=	0.000	in s = Av * fy * d / (Vu / f - Vc)

11.5.5 - Spacing limits for shear reinforcement

s = d/2 =	21.719	in	OR 24	in
s(max)=	10.859	in		
4*sqrt(Fc')*bw*d=	131.9	k	< Vs Reduce Spacing	
USE s=	**0.00**	in		
Vs = (Av * Fy * d) / s =	#DIV/0!	k		

11.5.6 - MINIMUM SHEAR REINFORCEMENT

A minimum area of shear reinforcement, Av,min shall be provided in all reinforced concrete flexural members where **Vu** exceeds **0.5 f Vc**

NOT REQUIRED IF:

a) SLAB OR FOOTING, vc>vn **O.K.**

b) CONCRETE JOIST ACI 8.11

c) BEAMS W/ h <= 10"

h <= 2.5*Bf

h <= 0.5*tw

d) WALLS (SEE ACI 11.10.1); vc>vn **O.K.**

11.5.6.3

Av,min = 0.75 sqrt(fc') bw*s/fy = 0.70 * s

but not less than 50bw*s/ fy = 23.33333333 * s

s max = Av fy / 0.75 sqrt(fc') bw = 0.00 in

s max = Av fy /50 bw = 0.00 in

11.5.5.3

Where Vs exceeds 4*sqrt(Fc')*bw*d maximum spacings shall be reduced by one-half