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 G	**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 G.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)	895.68					
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)	**6.44**	**6.44**	**7.64**	**21.82**	**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)	**10.44**	**10.44**	**11.64**	**25.82**	**NA**	**NA**
Uplift @ TW (ft)	**10.23**	**10.23**	**11.38**	**25.82**	**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 G		

Monolith Structure

ITEM		UNIT	QUANITY	UNIT COST	TOTAL Cost
FURNISH HP14x73 WALL PILING		LF	1,800	0	$0
INSTALL HP14x73 WALL PILING		LF	1,800	0	$0
PILE TEST, 60.0 ft	Long	EA	4	0	$0
FOOTING CONCRETE		CY	212	0	$0
	Forming	SF	842		
STEM CONCRETE		CY	268	0	$0
	Forming	SF	3,840		
STEEL REINFORCEMENT		LB	96,328	0	$0
WALL RAILING		LF	83	0	$0
SHEET PILE CUT-OFF WALL		SF	1,660	0	$0
					$0

Structure Length = 83 ft

No. piles = 36 Each

Length = 50 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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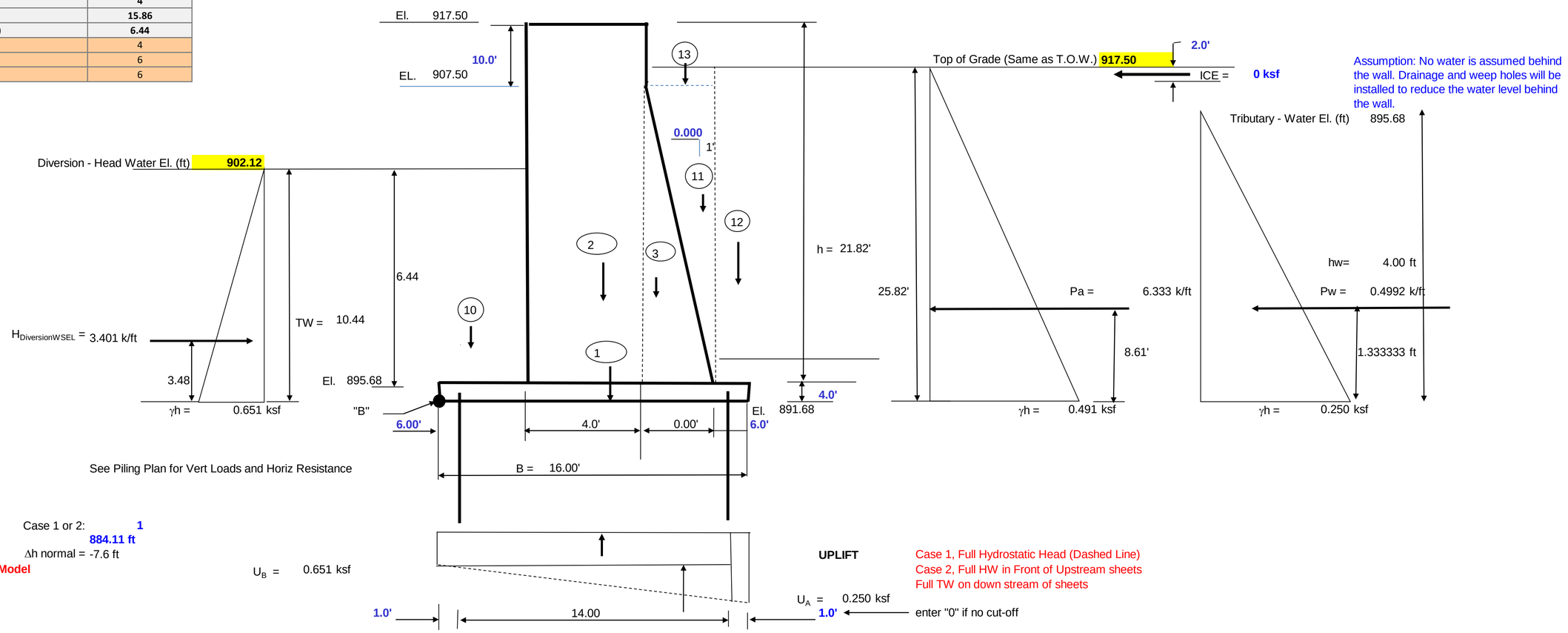
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 1 100 yr. flood	Panel G

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)	895.68
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)	6.44
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

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 = 83.0 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 = -7.6 ft
See Geotechnical seepage Model

U_B = 0.651 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	83	16.00	4.00	0.15	rec	796.8	8.00	6,374.4
Stem	2	83	4.00	21.82	0.15	rec	1086.6	8.00	8,693.1
Batter	3	83	0.00	11.82	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	83	6.00	6.44	0.0624	rec	200.1	3.00	600.4
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**880.4**	ΣM_V =	**9,443.4**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	83	16.00	0.651	rec	-865.1	8.00	-6,921
	U_A	83	16.00	-0.402	tri	266.8	10.67	2,846
					ΣU =	**-598.3**	ΣM_U =	**-4,075**

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

Horizontal Loads

	L	H	Pressure		ICE	arm	Mu
	ft	ft	ksf		K	ft	ft-k
ICE	83	2.00	0.00	rec	0.0	24.82	0.0

	L	Force		H	arm	Mw
	ft	k/ft		K	ft	ft-k
SOIL	83	-6.333		-525.67	8.61	-4524.28
Water Loads						
H_{TW}	83	3.401	tri	282.25	3.48	982.23
H_{HW}	83	-0.499	tri	-41.43	1.33	-55.24
			ΣWater =	**240.82**	ΣM_W =	**-3597.3**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-7672	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	24511	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**16,839**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,165**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-285**	kips

Location of Resultant	Xr = ΣM / P =	7.78	ft from Toe
	e = B/2 - Xr =	0.22	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	201	cy (includes stepped)	842	sf
Stem Conc:	268	cy	3840	sf
Total =	470			

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	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
Bot mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
								cy	**LB/cy**
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24,066.02	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24,123.00	
Top Face	Transverse:	9	6	3.40	3.5	166	1,975		
	Longitudinal:	9	6	3.40	82.5	8	2,244		
Dowels	Vertical I.F.	9	6	3.40	21.3	166	12,033		
	Vertical O.F.	9	6	3.40	21.3	166	12,033		
								cy	**LB/cy**
							52,380	268	195.2251648
						Σ =	**88,685**		
	Lap Splices (long. Bars)	9		3.40	8	281	7,643		
						Σ Bar Wt=	96,328	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	V	arm	Mv
	ft	kcf		K	ft	ft-k
Diversion WSEL	6.44	0.0624	0.401856	1.294	2.147	2.777736
Tributary SEL =	21.82	0.019	0.41458	4.523	7.273	32.89778
Tributary WSEL =	0.00	0.0624	0	0.000	0.000	0
Sum				4.523		32.89778
Net Forces				3.229		30.12004

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

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
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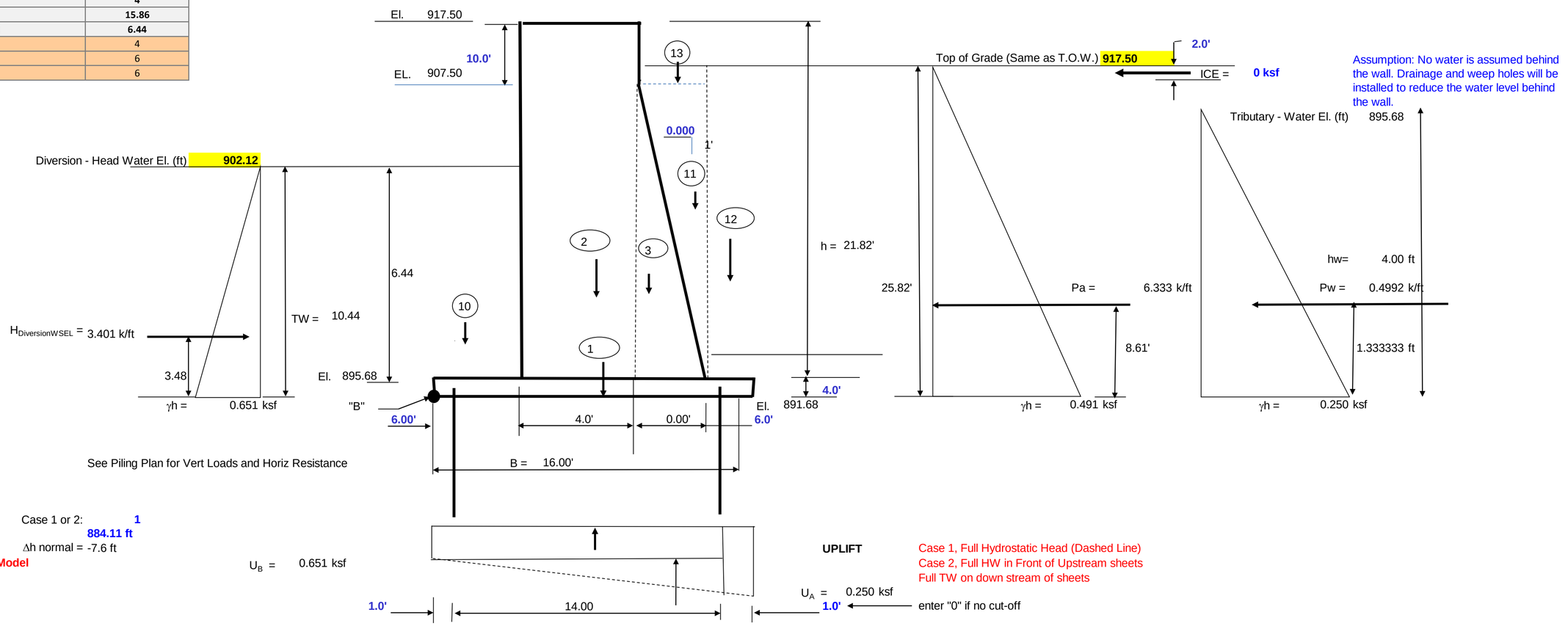
Tibutary - Water height (ft)	15.86
Diversion - Head Water height (ft)	6.44
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

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 = 83.0 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 = -7.6 ft
See Geotechnical seepage Model

U_B = 0.651 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	83	16.00	4.00	0.15	rec	796.8	8.00	6,374.4
Stem	2	83	4.00	21.82	0.15	rec	1086.6	8.00	8,693.1
Batter	3	83	0.00	11.82	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	83	6.00	6.44	0.0624	rec	200.1	3.00	600.4
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**880.4**	ΣM_V =	**9,443.4**

Uplift Loads		L ft	W ft	Pressure ksf		**U** K	arm ft	**Mu** ft-k
	U_B	83	16.00	0.651	rec	-865.1	8.00	-6,921
	U_A	83	16.00	-0.402	tri	266.8	10.67	2,846
					ΣU =	**-598.3**	ΣM_U =	**-4,075**

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

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

ICE	83	2.00	0.00	rec	0.0	24.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	83		-6.333		-525.67	8.61	-4524.28	
Water Loads								
H_{TW}	83		3.401	tri	282.25	3.48	982.23	
H_{HW}	83		-0.499	tri	-41.43	1.33	-55.24	
				ΣWater =	**240.82**	ΣM_W =	**-3597.3**	

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Sum of Horizontal Forces	H = Σhorizontal	**-285**	kips

Location of Resultant	Xr = ΣM / P =	7.78	ft from Toe
	e = B/2 - Xr =	0.22	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
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Stem Conc:	268	cy	3840	sf
Total =	470			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing in	LB /ft	Length ft	# of bars ea	Total wt lb		
a) Footing									
Top mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
								cy	**LB/cy**
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24066.016	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24123	
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FORCES AT THE BOTTOM OF THE STEM

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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
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Tributary - Deck Slab thickness @ H.P. (ft)	4
Diversion - Mat Slab thickness (ft)	4
Tibutary - Water height (ft)	15.97
Diversion - Head Water height (ft)	7.64
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

File:

MN State Building Codes
Frost Depth = **5.0 ft** provide min frost ftg protection during Dec, Jan, Feb, March
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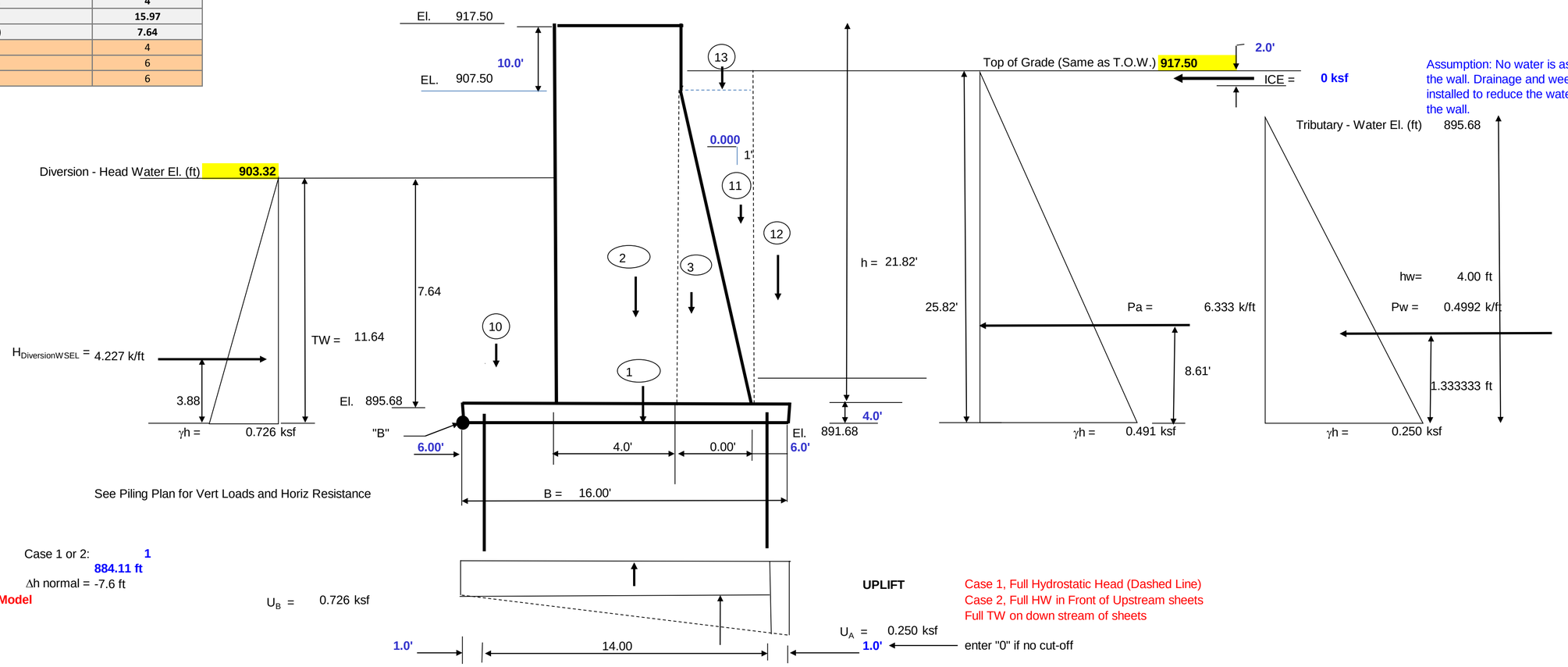

Case 1, Full Hydrostatic Head (Dashed Line)
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					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**
T.W on ftg Stem	10	83	6.00	7.64	0.0624	rec	237.4	3.00	712.2
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**917.6**	ΣM_V =	**9,555.3**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	83	16.00	0.726	rec	-964.6	8.00	-7,717
	U_A	83	16.00	-0.477	tri	316.6	10.67	3,377
					ΣU =	**-648.0**	ΣM_U =	**-4,340**

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

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				Load Cases: Case 3 500 yr. flood — Panel G	

ICE	83	2.00	0.00	rec	0.0	24.82	0.0
	L		Force		**H**	arm	**Mw**
	ft		k/ft		K	ft	ft-k
SOIL	83		-6.333		-525.67	8.61'	-4524.28
Water Loads							
H_{TW}	83		4.227	tri	350.86	3.88	1361.35
H_{HW}	83		-0.499	tri	-41.43	1.33	-55.24
				ΣWater =	**309.43**	ΣM_W =	**-3218.2**

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-7558	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	24623	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**17,065**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,153**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-216**	kips

Location of Resultant	Xr = ΣM / P =	7.93	ft from Toe
	e = B/2 - Xr =	0.07	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	201	cy (includes stepped)	842	sf
Stem Conc:	268	cy	3840	sf
Total =	470			

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	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
Bot mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
								cy	**LB/cy**
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24066.016	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24123	
Top Face	Transverse:	9	6	3.40	3.5	166	1,975		
	Longitudinal:	9	6	3.40	82.5	8	2,244		
Dowels	Vertical I.F.	9	6	3.40	21.3	166	12,033		
	Vertical O.F.	9	6	3.40	21.3	166	12,033		
								cy	**LB/cy**
							52,380	268	195.2251648
						Σ =	**88,685**		
	Lap Splices (long. Bars)	9		3.40	8	281	7,643		
						Σ Bar Wt=	96,328	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	7.64	**0.0624**	0.476736	1.821	2.547	4.637815
Tributary SEL =	21.82	**0.019**	0.41458	4.523	7.273	32.89778
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				4.523		32.89778
Net Forces				2.702		28.25996

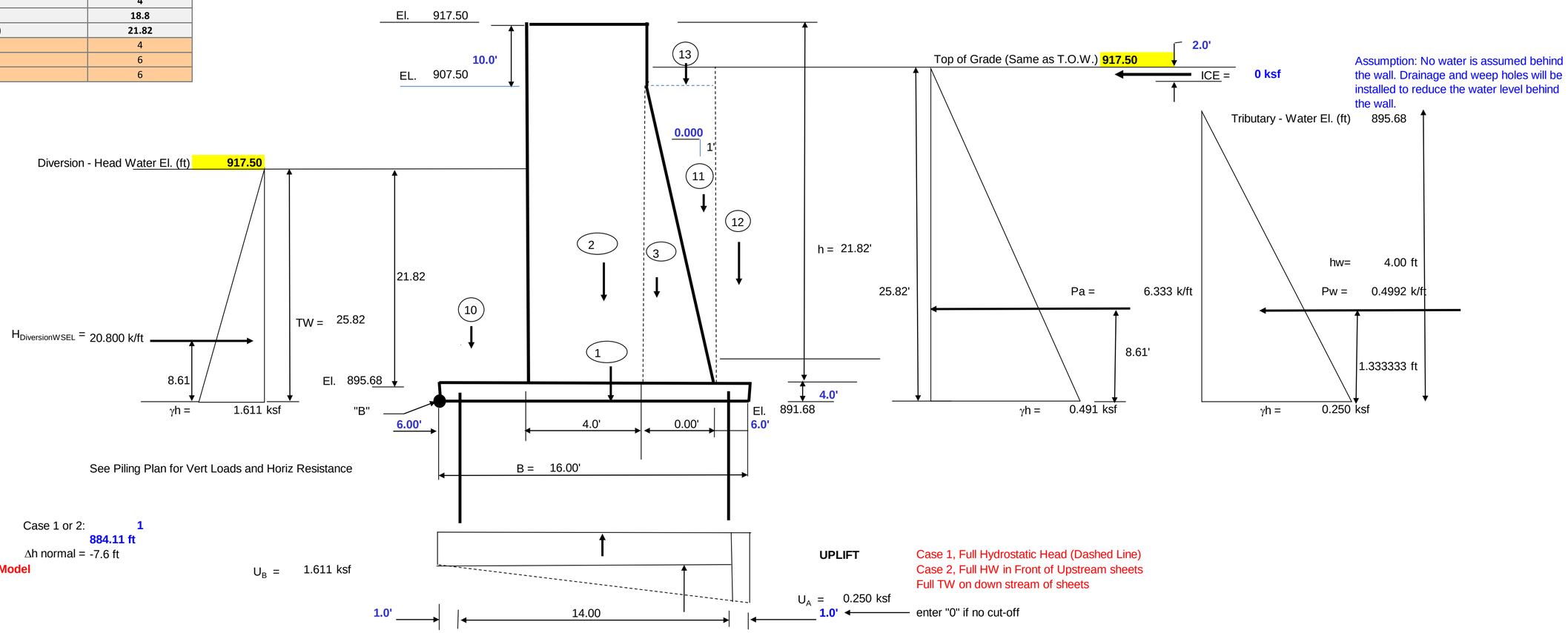
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 4 T.O. Levee Panel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

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)	895.68
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)	21.82
Wall Thickness (ft)	4
Toe (Ft)	6
Heel (ft)	6

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 = 83.0 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 = -7.6 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
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	83	16.00	4.00	0.15	rec	796.8	8.00	6,374.4
Stem	2	83	4.00	21.82	0.15	rec	1086.6	8.00	8,693.1
Batter	3	83	0.00	11.82	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**
T.W on ftg Stem	10	83	6.00	21.82	0.0624	rec	678.1	3.00	2,034.2
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**1358.3**	ΣM_V =	**10,877.2**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	83	16.00	1.611	rec	-2139.6	8.00	-17,117
	U_A	83	16.00	-1.362	tri	904.1	10.67	9,644
					ΣU =	**-1235.5**	ΣM_U =	**-7,474**

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 G	

ICE	83	2.00	0.00	rec	0.0	24.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	83		-6.333		-525.67	8.61'	-4524.28	
Water Loads								
H_{TW}	83		20.800	tri	1726.41	8.61	14858.68	
H_{HW}	83		-0.499	tri	-41.43	1.33	-55.24	
				ΣWater =	**1684.98**	ΣM_W =	**10279.2**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	2806	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	25945	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**28,750**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,006**	kips
Sum of Horizontal Forces	H = Σhorizontal	**1,159**	kips

Location of Resultant	Xr = ΣM / P =	14.33	ft from Toe
	e = B/2 - Xr =	(6.33)	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	201	cy (includes stepped)	842	sf
Stem Conc:	268	cy	3840	sf
Total =	470			

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	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
Bot mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
								cy	**LB/cy**
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24066.016	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24123	
Top Face	Transverse:	9	6	3.40	3.5	166	1,975		
	Longitudinal:	9	6	3.40	82.5	8	2,244		
Dowels	Vertical I.F.	9	6	3.40	21.3	166	12,033		
	Vertical O.F.	9	6	3.40	21.3	166	12,033		
								cy	**LB/cy**
							52,380	268	195.2251648
						Σ =	**88,685**		
	Lap Splices (long. Bars)	9		3.40	8	281	7,643		
						Σ Bar Wt=	96,328	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H	γ	Pbase	**V**	arm	**Mv**
	ft	kcf		K	ft	ft-k
Diversion WSEL	21.82	**0.0624**	1.361568	14.855	7.273	108.0432
Tributary SEL =	21.82	**0.019**	0.41458	4.523	7.273	32.89778
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				4.523		32.89778
Net Forces				-10.332		-75.1455

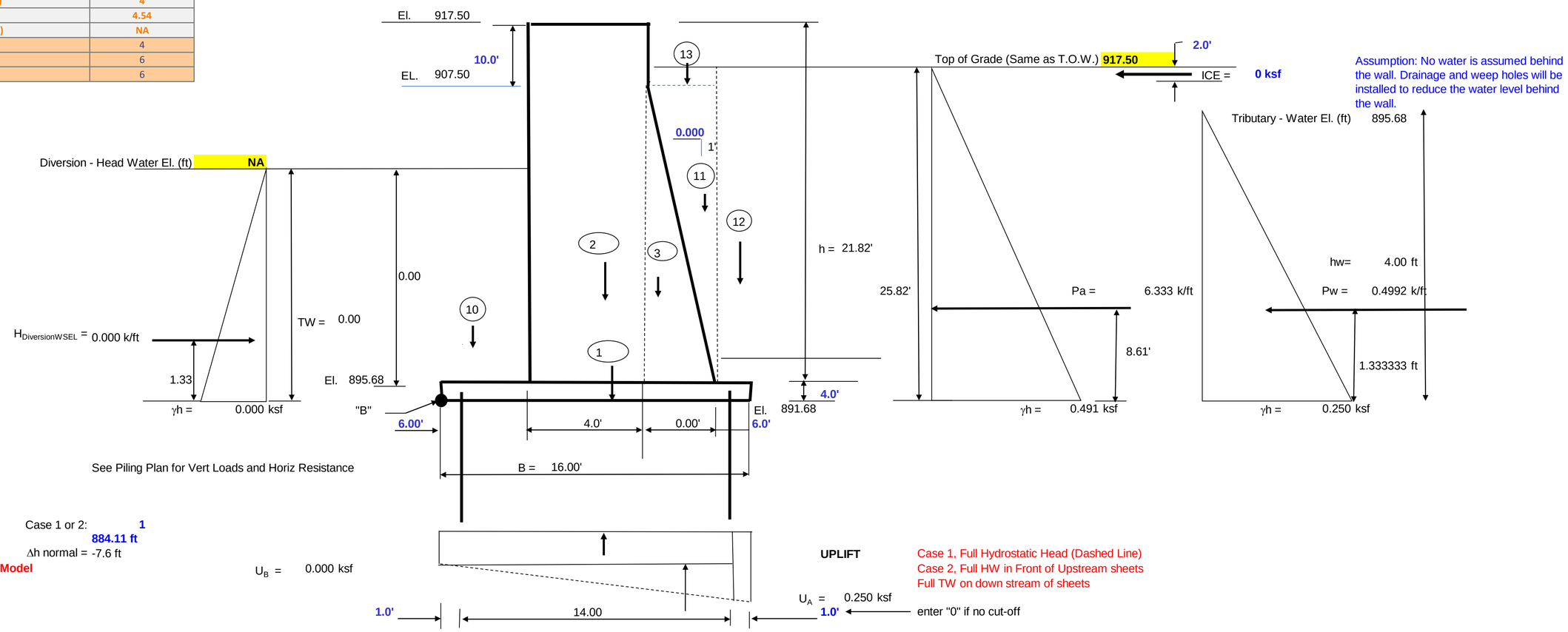
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Load Cases: Case 5 Normal flow + ice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

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)	895.68
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)	6
Heel (ft)	6

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 = 83.0 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 = -7.6 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
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	83	16.00	4.00	0.15	rec	796.8	8.00	6,374.4
Stem	2	83	4.00	21.82	0.15	rec	1086.6	8.00	8,693.1
Batter	3	83	0.00	11.82	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**

← CONSTANT FOR ALL LOAD CASES

T.W on ftg Stem	10	83	6.00	0.00	0.0624	rec	0.0	3.00	0.0
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**680.2**	ΣM_V =	**8,843.0**

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	83	16.00	0.000	rec	0.0	8.00	0
	U_A	83	16.00	0.250	tri	-165.7	10.67	-1,768
					ΣU =	**-165.7**	ΣM_U =	**-1,768**

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 G

ICE	83	2.00	0.00	rec	0.0	24.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	83		-6.333		-525.67	8.61'	-4524.28	
Water Loads								
H_{TW}	83		0.000	tri	0.00	1.33	0.00	
H_{HW}	83		-0.499	tri	-41.43	0.00	0.00	
				ΣWater =	**-41.43**	ΣM_W =	**-4524.3**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-6292	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	23911	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**17,618**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,398**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-567**	kips

Location of Resultant	Xr = ΣM / P =	7.35	ft from Toe
	e = B/2 - Xr =	0.65	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	201	cy (includes stepped)	842	sf
Stem Conc:	268	cy	3840	sf
Total =	470			

STEEL REINFORCEMENT: (assumed)

		Bar #	Spacing in	LB /ft	Length ft	# of bars ea	Total wt lb		
a) Footing									
Top mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
								cy	**LB/cy**
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24066.016	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24123	
Top Face	Transverse:	9	6	3.40	3.5	166	1,975		
	Longitudinal:	9	6	3.40	82.5	8	2,244		
Dowels	Vertical I.F.	9	6	3.40	21.3	166	12,033		
	Vertical O.F.	9	6	3.40	21.3	166	12,033		
								cy	**LB/cy**
							52,380	268	195.2251648
						Σ =	**88,685**		
	Lap Splices (long. Bars)	9		3.40	8	281	7,643		
						Σ Bar Wt=	96,328	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H ft	γ kcf	Pbase	**V** K	arm ft	**Mv** ft-k
Diversion WSEL	0.00	**0.0624**	0	0.000	0.000	0
Tributary SEL =	21.82	**0.019**	0.41458	4.523	7.273	32.89778
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				4.523		32.89778
Net Forces				4.523		32.89778

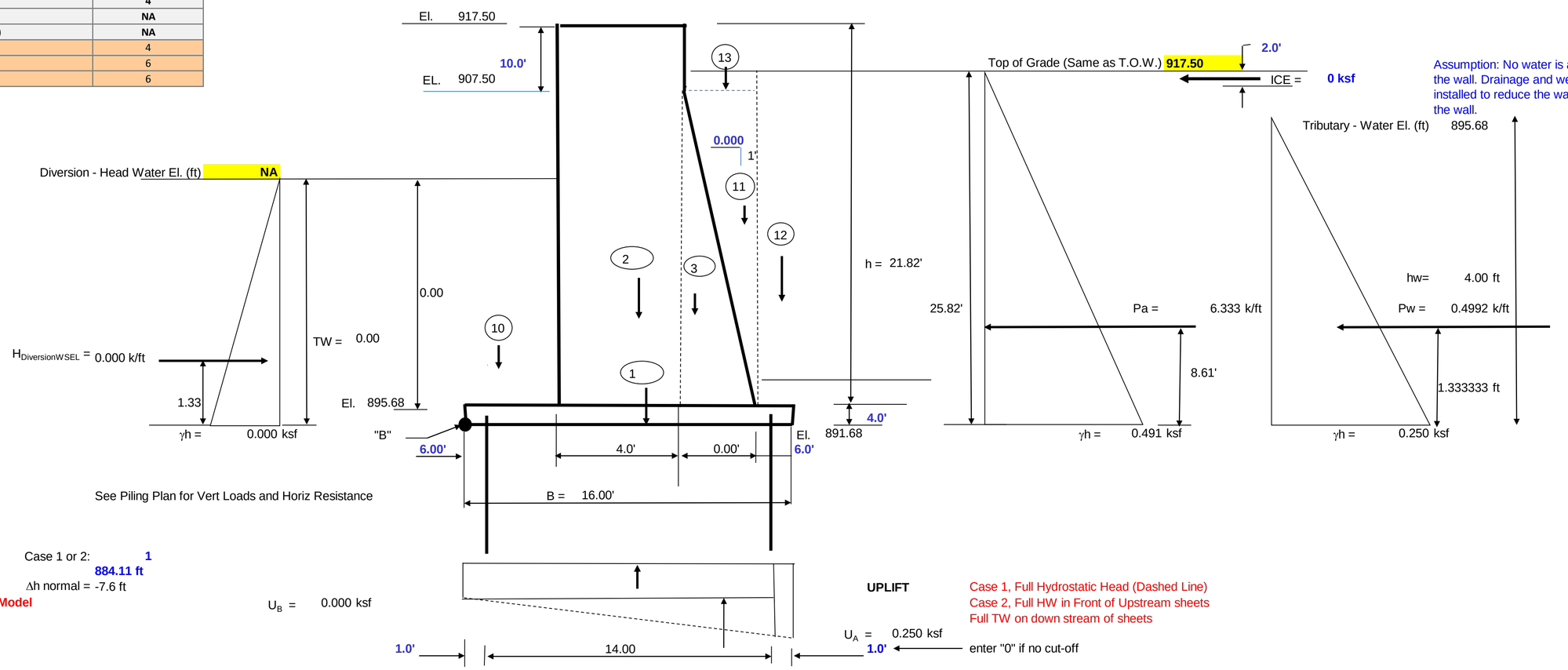
BARR ENGINEERING			DATE	2/11/2011	SHEET NO.
			PROJECT NAME	FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4	
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
				Load Cases: Case 6 Construction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

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)	895.68
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)	6
Heel (ft)	6

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 = 83.0 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 = -7.6 ft
See Geotechnical seepage Model

UPLIFT
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	83	16.00	4.00	0.15	rec	796.8	8.00	6,374.4
Stem	2	83	4.00	21.82	0.15	rec	1086.6	8.00	8,693.1
Batter	3	83	0.00	11.82	0.15	tri	0.0	10.00	0.0
					D.L. Concrete	ΣVc =	**1883.4**	ΣM_V =	**15,067.5**
T.W on ftg Stem	10	83	6.00	0.00	0.0624	rec	0.0	3.00	0.0
H.W. on Stem Slope	11	83	0.00	11.82	0.12	tri	0.0	10.00	0.0
H.W. Above Slope	13	83	0.00	10.00	0.12	rec	0.0	10.00	0.0
Soil on Footing	12s	83	6.00	21.82	0.0626	rec	680.2	13.00	8,843.0
H.W. on Footing	12w	83	6.00	0.00	0.0624	rec	0.0	13.00	0.0
					D.L. Water	ΣVw =	**680.2**	ΣM_V =	**8,843.0**

← CONSTANT FOR ALL LOAD CASES

Uplift Loads		L ft	W ft	Pressure ksf		U K	arm ft	Mu ft-k
	U_B	83	16.00	0.000	rec	0.0	8.00	0
	U_A	83	16.00	0.250	tri	-165.7	10.67	-1,768
					ΣU =	**-165.7**	ΣM_U =	**-1,768**

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 G

ICE	83	2.00	0.00	rec	0.0	24.82	0.0	
	L		Force		**H**	arm	**Mw**	
	ft		k/ft		K	ft	ft-k	
SOIL	83		-6.333		-525.67	8.61'	-4524.28	
Water Loads								
H_{TW}	83		0.000	tri	0.00	1.33	0.00	
H_{HW}	83		-0.499	tri	-41.43	1.33	-55.24	
				ΣWater =	**-41.43**	ΣM_W =	**-4579.5**	

Overturning Moments	$\Sigma M_{OT} = M_U + M_W + M_{ICE}$ =	-6347	kip-ft
Resisting Moments	$\Sigma M_R = M_V$ =	23911	kip-ft
Sum of Moments	$\Sigma Mnet = M_R + M_{OT}$ =	**17,563**	kip-ft
Sum of Vertical Forces	P = Conc + Water + Uplift =	**2,398**	kips
Sum of Horizontal Forces	H = Σhorizontal	**-567**	kips

Location of Resultant	Xr = ΣM / P =	7.32	ft from Toe
	e = B/2 - Xr =	0.68	ft
	B/6 =	2.667	ft

CONCRETE QUANTITIES

			forming	
Ftg conc:	201	cy (includes stepped)	842	sf
Stem Conc:	268	cy	3840	sf
Total =	470			

STEEL REINFORCEMENT: (assumed)

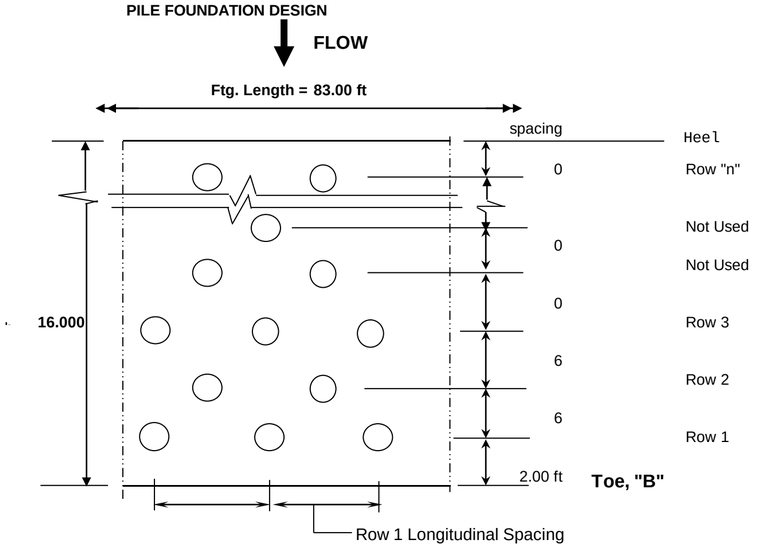
		Bar #	Spacing in	LB /ft	Length ft	# of bars ea	Total wt lb		
a) Footing								**cy**	**LB/cy**
Top mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
Bot mat	Transverse:	9	6	3.40	15.5	170	8,959		
	Longitudinal:	9	6	3.40	84.5	32	9,194		
							36,305	201	180.19125
b) Skin Reinf. On Monolith									
Vert Face	Vertical	9	6	3.40	21.32	166	12,033	24066.016	
	Longitudinal:	9	6	3.40	82.5	43	12,062	24123	
Top Face	Transverse:	9	6	3.40	3.5	166	1,975		
	Longitudinal:	9	6	3.40	82.5	8	2,244		
Dowels	Vertical I.F.	9	6	3.40	21.3	166	12,033		
	Vertical O.F.	9	6	3.40	21.3	166	12,033		
								cy	**LB/cy**
							52,380	268	195.2251648
						Σ =	**88,685**		
	Lap Splices (long. Bars)	9		3.40	8	281	7,643		
						Σ Bar Wt=	96,328	lb	

FORCES AT THE BOTTOM OF THE STEM

Diversion Face	H ft	γ kcf	Pbase	**V** K	arm ft	**Mv** ft-k
Diversion WSEL	0.00	**0.0624**	0	0.000	0.000	0
Tributary SEL =	21.82	**0.019**	0.41458	4.523	7.273	32.89778
Tributary WSEL =	0.00	**0.0624**	0	0.000	0.000	0
Sum				4.523		32.89778
Net Forces				4.523		32.89778

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 G	

PILE FOUNDATION DESIGN



L = 83.00 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"	12	27.75	1	34
Row 1 to Row 2	6.00 ft	8.0 ft	5.00 ft	0 "/12"	15	6.50	2	17
Row 2 to Row 3	6.00 ft	14.0 ft	5.00 ft	0 "/12"	9	21.50	3	17
Row 3 to Row 4	0.00 ft	0.0 ft	5.00 ft	0 "/12"	0	44.00	0	0
Row 4 to Row 5	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 5 to Row 6	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 6 to Row 7	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 7 to Row 8	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 8 to Row 9	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 9 to Row 10	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 10 to Row 11	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 11 to Row 12	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 12 to Row 13	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 13 to Row 14	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Row 14 to Row 15	0.00 ft	0.0 ft	0.00 ft	0 "/12"	0	41.50	0	0
Last Row to Heel	2.00 ft							
	16.00 ft				ΣN =	36		68

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

Pile Properties: Pile Type: **HP** (C.I.P or HP) Pile Length = **50.0 ft**

HP Nominal Depth, h = **14.0 in**

Wt. per ft, plf **73**

Ftg EL. 891.68

Pile Tip El. 842.68

Pile Cap Embed = **1.00 ft**

Total pile Length = 1,800 LF

Pile Group Properties

N.A. of Pile Group to Toe

$X_{NA} = (\Sigma N * d_{toe}) / \Sigma N =$ **7.50 ft**

	Dist. From N.A. to Pile Row	d	N	$I = N * d^2$
1	Dist. To Row 1	5.50 ft	12	363.0
2	Dist. To Row 2	-0.50 ft	15	3.8
3	Dist. Row 3	-6.50 ft	9	380.3
0	Row 4 (not used)	0.00 ft	0	0.0
0	Row 5 (not used)	0.00 ft	0	0.0
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
			36	$\Sigma I =$ **747.0**

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**	27.9	30.3	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.7	1,296	**OK**
Case 2	**82.6 tons**	27.9	30.3	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.7	1,476	**OK**
Case 3	**82.6 tons**	26.5	30.2	33.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.9	1,476	**OK**
Case 4	**107.7 tons**	-22.6	32.4	87.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.5	1,728	**OK**
Case 5	**36.5 tons**	34.7	33.2	31.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.7	828	**OK**
Case 6	**82.6 tons**	34.9	33.2	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.9	828	**OK**

Max Service : P = **87.5**

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:

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

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

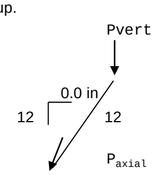
$$e_{NA} = X_{NA} - e_{toe}$$

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-	$e_{toe} = M_{toe} / P$	$e_{NA} = X_{NA} - e_{toe}$	$M_{NA} = P * e_{NA}$

Case 1	**100 yr. flood**	**Usual**	2,165	285	16,839	7.78	-0.28	-598
Case 2	**100 yr. flood + ice**	**Unusual**	2,165	285	16,839	7.78	-0.28	-598
Case 3	**500 yr. flood**	**Unusual**	2,153	216	17,065	7.93	-0.43	-917
Case 4	**T.O. Levee**	**Extreme**	2,006	-1,159	28,750	14.33	-6.83	-13704
Case 5	**Normal flow + ice**	**Usual**	2,398	567	17,618	7.35	0.15	366
Case 6	**Construction**	**Unusual**	2,398	567	17,563	7.32	0.18	421

SERVICE

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

Vertical Load, P = 2165 kips
Horizontal Load, H = 285 kips
M_{NA} = -598 kip-ft

36

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads			**Axial Pile Load**
1	Row 1	60.2		-4.4	55.8 kips/pile		27.9 tons/pile	27.9 tons/pile
2	Row 2	60.2		0.4	60.6 kips/pile		30.3 tons/pile	30.3 tons/pile
3	Row 3	60.2		5.2	65.4 kips/pile		32.7 tons/pile	32.7 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 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:	**32.7 tons/pile**	**max: 32.7 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	12	0.0	432	1.000	432 kips
2	Row 2	0	15	0.0	540	1.000	540 kips
3	Row 3	0	9	0.0	324	1.000	324 kips
4	Row 4	0	0	0.0	0	1.000	0 kips
5	Row 5	0	0	0.0	0	1.000	0 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
			36		1296		**1296 kips**

OK

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

Vertical Load, P = 2165 kips
Horizontal Load, H = 285 kips
M_{NA} = -598 kip-ft

36

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads			**Axial Pile Load**
1	Row 1	60.2		-4.4	55.8 kips/pile		27.9 tons/pile	27.9 tons/pile
2	Row 2	60.2		0.4	60.6 kips/pile		30.3 tons/pile	30.3 tons/pile
3	Row 3	60.2		5.2	65.4 kips/pile		32.7 tons/pile	32.7 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile		0.0 tons/pile	0.0 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:	**32.7 tons/pile**	**max: 32.7 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	12	0.0	492	1.000	492 kips
2	Row 2	0	15	0.0	615	1.000	615 kips
3	Row 3	0	9	0.0	369	1.000	369 kips

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		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls	
2/11/11				Panel G	

4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 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	
			36		1476		**1476 kips**	**OK**

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

Vertical Load, P = 2153 kips
Horizontal Load, H = 216 kips
M_{NA} = -917 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	59.8		-6.7	53.1 kips/pile	26.5 tons/pile	26.5 tons/pile
2	Row 2	59.8		0.6	60.4 kips/pile	30.2 tons/pile	30.2 tons/pile
3	Row 3	59.8		8.0	67.8 kips/pile	33.9 tons/pile	33.9 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 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: **33.9 tons/pile**	**max:** **33.9 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	12	0.0	492	1.000	492 kips	
2	Row 2	0	15	0.0	615	1.000	615 kips	
3	Row 3	0	9	0.0	369	1.000	369 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 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	
			36		1476		**1476 kips**	**OK**

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

Vertical Load, P = 2006 kips
Horizontal Load, H = -1159 kips
M_{NA} = -13704 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		**Axial Pile Load**
1	Row 1	55.7		-100.9	-45.2 kips/pile	-22.6 tons/pile	-22.6 tons/pile
2	Row 2	55.7		9.2	64.9 kips/pile	32.4 tons/pile	32.4 tons/pile
3	Row 3	55.7		119.2	175.0 kips/pile	87.5 tons/pile	87.5 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 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: **87.5 tons/pile**	**max:** **87.5 tons/pile**

Assumed lateral Capacity: 48.0 kips/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 G**	

	Horizontal Pile Capacity	Batter "/ft	N	Resistance due to Batter, kips	Resitance due to Bending, kips	Group Efficiency	Lateral Resitance	
1	Row 1	0	12	0.0	576	1.000	576 kips	
2	Row 2	0	15	0.0	720	1.000	720 kips	
3	Row 3	0	9	0.0	432	1.000	432 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 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	
			36		1728		**1728 kips**	**OK**

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

Vertical Load, P = 2398 kips
Horizontal Load, H = 567 kips
M_{NA} = 366 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	66.6		2.7	69.3 kips/pile	34.7 tons/pile	34.7 tons/pile
2	Row 2	66.6		-0.2	66.4 kips/pile	33.2 tons/pile	33.2 tons/pile
3	Row 3	66.6		-3.2	63.4 kips/pile	31.7 tons/pile	31.7 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 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:	**34.7 tons/pile**	**max: 34.7 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	12	0.0	276	1.000	276 kips	
2	Row 2	0	15	0.0	345	1.000	345 kips	
3	Row 3	0	9	0.0	207	1.000	207 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 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	
			36		828		**828 kips**	**OK**

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

Vertical Load, P = 2398 kips
Horizontal Load, H = 567 kips
M_{NA} = 421 kip-ft

	Vertical Pile Loading	P / N	+	M_{NA}* d / Σ I	= Pile Loads		Axial Pile Load
1	Row 1	66.6		3.1	69.7 kips/pile	34.9 tons/pile	34.9 tons/pile
2	Row 2	66.6		-0.3	66.3 kips/pile	33.2 tons/pile	33.2 tons/pile
3	Row 3	66.6		-3.7	62.9 kips/pile	31.5 tons/pile	31.5 tons/pile
4	Row 4	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 tons/pile
5	Row 5	0.0		0.0	0.0 kips/pile	0.0 tons/pile	0.0 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

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 G	

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:	**34.9 tons/pile**	**max:**	**34.9 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	12	0.0	276	1.000	276 kips	
2	Row 2	0	15	0.0	345	1.000	345 kips	
3	Row 3	0	9	0.0	207	1.000	207 kips	
4	Row 4	0	0	0.0	0	1.000	0 kips	
5	Row 5	0	0	0.0	0	1.000	0 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	
			36		828		**828 kips**	**OK**

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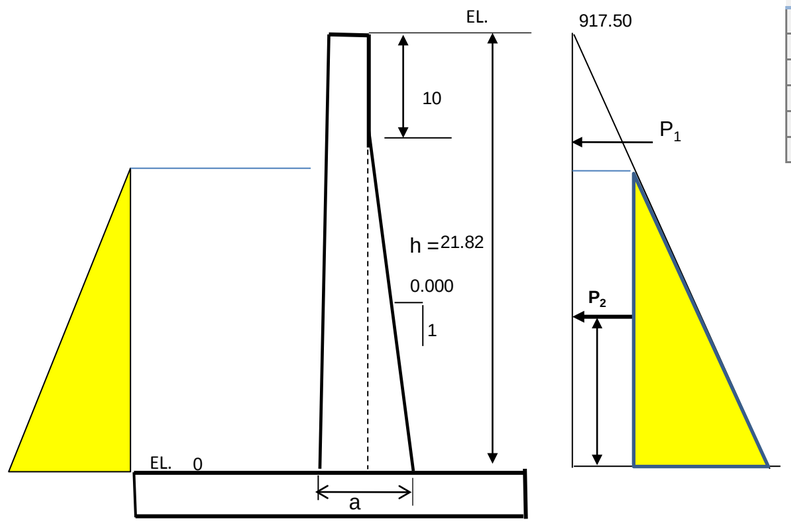
COMPUTED	CHECKED	SUBMITTED	PROJECT NUMBER	34091004	
MBI 2/11/11		MBI	SUBJECT	Sheyenne Aquaduct Structure - Retaining Walls Panel G 0	



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	3.23	30.120	7.14	66.57
Case 2	100 yr. flood + ice	Unusual	0.75	3.23	30.120	5.35	49.92
Case 3	500 yr. flood	Unusual	0.75	2.70	28.260	4.48	46.84
Case 4	T.O. Levee	Extreme	0.75	-10.33	-75.145	17.12	124.55
Case 5	Normal flow + ice	Usual	1	4.52	32.898	10.00	72.70
Case 6	Construction	Unusual	0.75	4.52	32.898	7.50	54.53

STEM DESIGN VALUES

MU, k-ft/ft	124.55	k-ft/ft
VU, k/ft	17.12	k/ft

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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 =	125	k-ft /ft	Includes: hf = 1.3
Vuh=	17.12	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 = 73.137

REQ'D p= 0.0012 **O.K.**

p= 0.0016

As (REQ'D)= 0.86 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 0.0016

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 =	423.5	**a**	1) p = **0.25** pb Recommended limit
a= T/C =	0.283	in	2) p = **0.375** pb Max. permitted upper limit not requiring special study
Mn= T(d - a/2)/12 =	432.7	ft-k	3) p = **0.5** pb Max. permitted upper limit when excessive deflections are not predicted In ACI 318
ϕ Mn=	389.4	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 O.K.

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

Vuh =	17.1	k		NO SHEAR REINF. REQUIRED
Vn = Vuh / ϕ =	22.8	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=		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=	**10.86**	in		
Vs = (Av * Fy * d) / s =	0.0	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 = 0.40 * s

but not less than 50bw*s/ fy = 13.33333333 * 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