Attachment F

Dewatering Discharge Calculations (Item G.2.)

DEWATERING DISCHARGE ESTIMATE

Project:	Kaipapau Stream Bridge Replacement		
Prepared for:	State Department of Transportation, Highways Division		
Consultant:	R. M. Towill Corporation	Prepared by:	RSY
Date:	9/19/19	Checked by:	WC

1.0 PURPOSE

Determine the estimated dewatering discharge flow rate that will occur during construction of the new bridge and relocation of a 12-inch waterline.

Note: these calculations are intended for NPDES-NOI permit purposes only.

2.0 DESCRIPTION OF CONDITIONS

The dewatering discharge requirement is the amount of water entering the excavation through the portion of the earthen walls below the groundwater elevation. The amount of water flowing through the earthen walls is assumed to be equal to the rate of water moving through the groundwater aquifer, which can be estimated using Darcy's Law.

3.0 REFERENCES

3.1 *Pre-Conceptual Design Report, Kamehameha Highway, Kaipapau Stream Bridge Replacement,* R. M. Towill Corporation, January 2006

3.2 *Principles of Engineering Geology and Geotechnics* , Krynine and Judd, McGraw-Hill Book Company Inc., New York, 1957.

3.3 *Civil Engineering Handbook, Fourth Edition* , Urquhart, McGraw-Hill, 1959

3.4 *Civil Engineering Reference Manual* , Lindeburg, Professional Publications, California, 1992.

3.5 *Geotechnical Engineering Exploration* , Geolabs, August 6, 2014.

4.0 CRITERIA & ASSUMPTIONS

4.1 Assume groundwater elevation will vary with tidal fluctuations. The worst-case (maximum) groundwater elevation is assumed to be 2 feet.

4.2 The top excavation elevation is assumed to range from +0 feet (stream bed) to +10 feet (north abutment) mean sea level (msl).

4.3 Per the structural plan S8.1, shaft excavation will be a drilled shaft with diameter of 4 feet to a depth of:

Abutment 1	(-)79.6	ft msl
Abutment 2	(-)64.5	ft msl
Test Shaft	(-)92.0	ft msl

4.4 Per the civil plan sheet C-21, the 12-inch waterline excavation below the water table is about 80 LF, with assumed bottom trench elevation of (-)5 ft msl (1 foot below bottom of concrete jacket).

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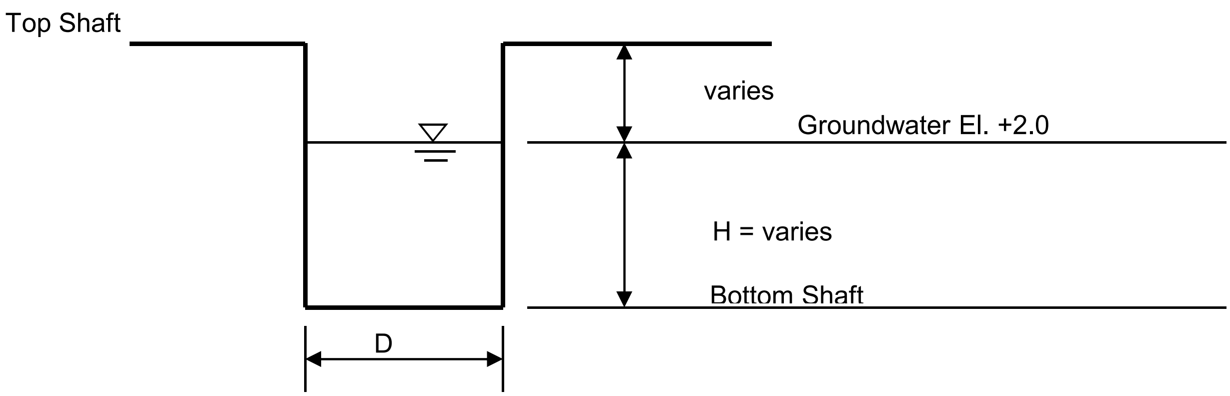
5.0 CALCULATIONS

5.1 Shaft Excavation

5.1.1 Sketch of shaft excavation (not to scale)



5.1.2 Darcy's Law can be expressed as Q = AKJ (adapted from Ref. 3.4, pg. 6-6), where:

Q = Discharge flow rate, ft^3/day
A = Seepage flow area, ft^2
K = Hydraulic conductivity, ft/day
J = Hydraulic gradient, ft/ft

5.1.3 Determine A

A is the area of the earthen walls below the groundwater elevation, where:

Abutment 1

D = 4 ft (shaft diameter)
H = 81.6 ft (height of groundwater above shaft bottom)
A = Area of the shaft bottom + Area of the shaft sides
A = $(\pi * D^2 / 4) + (\pi * D * H)$
A = 1038 ft^2

Abutment 2

D = 4 ft (shaft diameter)
H = 66.5 ft (height of groundwater above shaft bottom)
A = Area of the shaft bottom + Area of the shaft sides
A = $(\pi * D^2 / 4) + (\pi * D * H)$
A = 848 ft^2

Test Shaft

D = 4 ft (shaft diameter)
H = 94 ft (height of groundwater above shaft bottom)
A = Area of the shaft bottom + Area of the shaft sides
A = $(\pi * D^2 / 4) + (\pi * D * H)$
A = 1194 ft^2

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5.1.4 Determine K

From the geotechnical report (Ref. 3.5), pg. 8:

Abutment 1 (Boring No. 1)	0.038 ft/min	54.7 ft/day
Abutment 2 (Boring No. 3)	0.042 ft/min	60.5 ft/day
Test Shaft (Boring No. 3)	0.042 ft/min	60.5 ft/day

K was measured at two different depths and using the constant head and falling head methods. The hydraulic conductivity at the lower depth and the constant head method was used.

5.1.5 Determine J

The hydraulic gradient in flat areas is typically 1%+ (Ref. 3.2, pg. 181).

J = 0.01 ft/ft (assumed)

5.1.6 Calculate Q for each shaft

Abutment 1 shafts

Q = A * K * J

Q = 568.0 ft^3/day

Q = 4,249 gal/day 2.95 gpm

Abutment 2 shafts

Q = A * K * J

Q = 513.0 ft^3/day

Q = 3,837 gal/day 2.66 gpm

Test Shaft

Q = A * K * J

Q = 722.0 ft^3/day

Q = 5,401 gal/day 3.75 gpm

5.1.7 Calculate Shaft Volume

Abutment 1
4 ft diameter
81.6 ft depth

V = 1,025 ft^3 = 7,671 gal

Abutment 2
4 ft diameter
66.5 ft depth

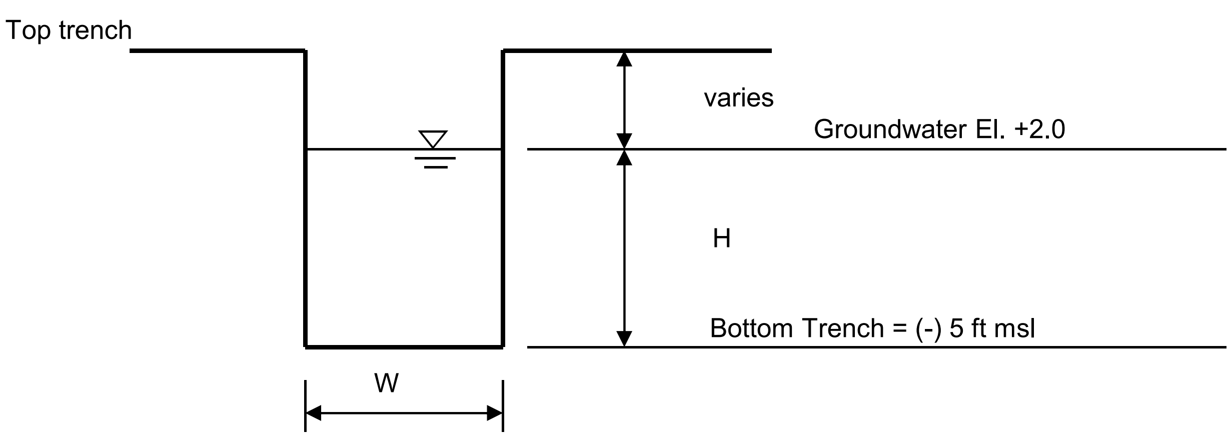
V = 836 ft^3 = 6,251 gal

Test Shaft
4 ft diameter
94 ft depth

V = 1,181 ft^3 = 8,836 gal

5.2 Waterline Trench Excavation

5.2.1 Sketch of waterline trench excavation (not to scale)



5.2.2 Similar to the calcs for the shaft excvation, use Darcy's Law, Q = AKJ, where:

Q = Discharge flow rate, ft^3/day
A = Seepage flow area, ft^2
K = Hydraulic conductivity, ft/day
J = Hydraulic gradient, ft/ft

5.2.3 Determine A

A is the area of the earthen walls below the groundwater elevation, where:

W = 3 ft (trench width)
H = 7 ft (height of groundwater above trench bottom)
L = 80 ft (length of trench under groundwater)
A = Area of the trench bottom + Area of the ternch sides
A = L * W + 2 * (W * H) + 2 * L * H)
A = 1,402 ft^2

5.2.4 Determine K

Similar to the calcs for the shaft excvation, K is obtained from the geotechnical report (Ref. 3.5), pg. 8: Boring No. 3 is the closest to the waterline trench location.

Boring No. 3	0.078 ft/min	112.3 ft/day

K was measured at two different depths and using the constant head and falling head methods. The hydraulic conductivity at the higher depth and the constant head method was used.

K = 0.001 cm/sec — Ranges from 10-3 to 10-7, assume high end of range as worst case
2.83 ft/day

5.2.5 Determine J

The hydraulic gradient in flat areas is typically 1%+ (Ref. 3.2, pg. 181).

J = 0.01 ft/ft (assumed)

5.2.6 Calculate Q for the waterline trench

Q = A * K * J
Q = 1,574.7 ft^3/day
Q = 11,779 gal/day 8.18 gpm

5.3 Calculate Total Dewatering Volume

Shaft Assumptions:

1. Construction Period = 5 days per shaft
2. Dewatering during construction & once during concrete pouring into steel casing
3. 4 shafts per abutment

Trench Assumptions:
1. Construction Period = 5 days

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DEWATERING VOLUME

Abutment 1				
Volume during shaft drilling	=	4 shafts x 5 days x 21,243 gpd =	84,970	gallons
Volume during concrete pour	=	4 shafts x 7671 gallons =	30,683	gallons
TOTAL VOLUME, ABUTMENT 1	=		115,653	gallons
Abutment 2				
Volume during shaft drilling	=	4 shafts x 5 days x 19,187 gpd =	76,746	gallons
Volume during concrete pour	=	4 shafts x 6251 gallons =	25,005	gallons
TOTAL VOLUME, ABUTMENT 2	=		101,751	gallons
Test Shaft				
Volume during shaft drilling	=	1 shaft x 5 days x 27,003 gpd =	27,003	gallons
Volume during concrete pour	=	1 shaft x 8836 gallons =	8,836	gallons
TOTAL VOLUME, TEST SHAFT	=		35,840	gallons
Waterline Trench				
Volume during waterline construction	**=**	5 days x 58,595 gpd =	58,895	gallons
GRAND TOTAL VOLUME	=		312,138	gallons

5.9 Calculate Dewatering Basin Capacity

Dewatering Basin Dimensions (from civil plan sheet C-18)

Length	20	ft
Width	15	ft
Depth	8	ft

Dewatering Basin Volume	2400	CF	
Dewatering Basin Floor Area	300	SF	
Percolation Rate	0.0052	ft/min	from Geotechnical Report, page 8, Boring No.3,
	1.56	CF/min	Falling Head, at depth of 17 ft
	2,246	CF/day	
	16,803	gpd	

Compare to the required dewatering rates for the different areas of construction:

Area	Dewatering Rate	
Abutment 1 shafts	4,249	gpd
Abutment 2 shafts	3,837	gpd
Test shaft	5,401	gpd
Waterline trench	11,779	gpd

There is sufficient percolation for each individual area.