



Client Name Florida Power and Light (FPL) Page 1 of 29 24 Brk 2/19/17
 Project Name Dania Beach Project No. 195190
 Calculation Title Excavation Dewatering System Design and Flow Rate Estimate
 Calculation No./File No. 58.4300.1101
 Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective: To estimate the flow rate, number of wells and wellpoint spacing for excavations to construct Unit 7.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

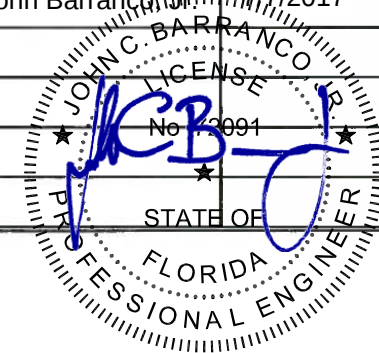
Refer to Page ____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number MS Excel Version 2007
 Standard B&V Application Used? ☐ Yes ☐ No
 If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	Girma Mergia	07/05/17	Brandon Gomer	07/06/17	John Barranco, Jr.	7/7/2017
1	Girma Mergia	02/17/17	Brandon Gomer	02/19/17		
	B/S for Mergia	02/19/17				



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1.0 Objective

Preliminary design of dewatering systems for excavations of the Auxiliary Cooling System Pump Pit, the Oil-Water Separator (OWS) and the Waste Water Sump, the Storm Sewer Pipe Corridor, and Underground Utility Corridor.

2.0 References

1. Ardaman & Associates, Inc., Subsurface Exploration, Dania Beach Clean Energy Center, June 9, 2017.
2. Email communications with John Brrancco
3. Florida Geological Survey, Report of Investigations No. 17, Biscayne Aquifer of Dade and Broward Counties, Florida, 1958
4. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10932 , Excavations, Sloping and Benching, 1926 Subpart P App B, OSHA.
5. Dewatering and Groundwater Control. Unified Facilities Criteria UFC 3-220-05. 16 January 2004.

3.0 Design Basis

1. Approximate drawdown to be 1 foot below excavation.
2. Top of well screen at minimum 3 feet depth below excavation to account for head loss and improve performance of the system.
3. For calculation purposes, the excavations and dewatering in each calculation are assumed not to occur at the same time.
4. For long trenches, two lines of wellpoints along each side of the excavation will be used to dewater the excavation area.
5. Reduced permeability due to screens being placed in the organic/peat layers are not considered.
6. Greater pumping rates and less drawdown near the ends of the two lines of wellpoints are not included in this estimate.
7. Pumps and header systems are not designed or assumed in this analysis.
8. The filter pack is not designed in this analysis, but the hydraulic conductivity of the filter pack is assumed to be greater than the natural formation based on previous experience and engineering judgment.
9. Wellpoint diameter will be 2 inch.
10. The site is surrounded by constant head boundaries including canals and water bodies. Because of potential recharge that may occur during the excavation dewatering from the water bodies, the estimated radius of influences may be conservative.
11. The canals and the water bodies surrounding the site include saline water. As a result of potential recharge from the boundaries, the pumped water for excavation dewatering may be water with some saline content. Therefore discharge of dewatered water to the canals around the site may not cause any impact.

4.0 Definition of Units & Constants

in =inch

ft = feet

n = required number of wellpoints,

Q = flow rate per wellpoint in gpm,



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gpm= gallons per minute

ho = the total head of the dewatered
aquifer in feet,

s = wellpoint spacing in feet,

Ro = radius of influence in feet,

k = hydraulic conductivity,

b = wellpoint diameter in inches,

D = Aquifer depth in feet

H = Aquifer thickness in feet,

5.0 Analysis

Subsurface Conditions

Subsurface lithology was established from subsurface investigation boring logs and geotechnical report (Ref 1). The investigation boring and piezometer location are shown in Figure 1 below.

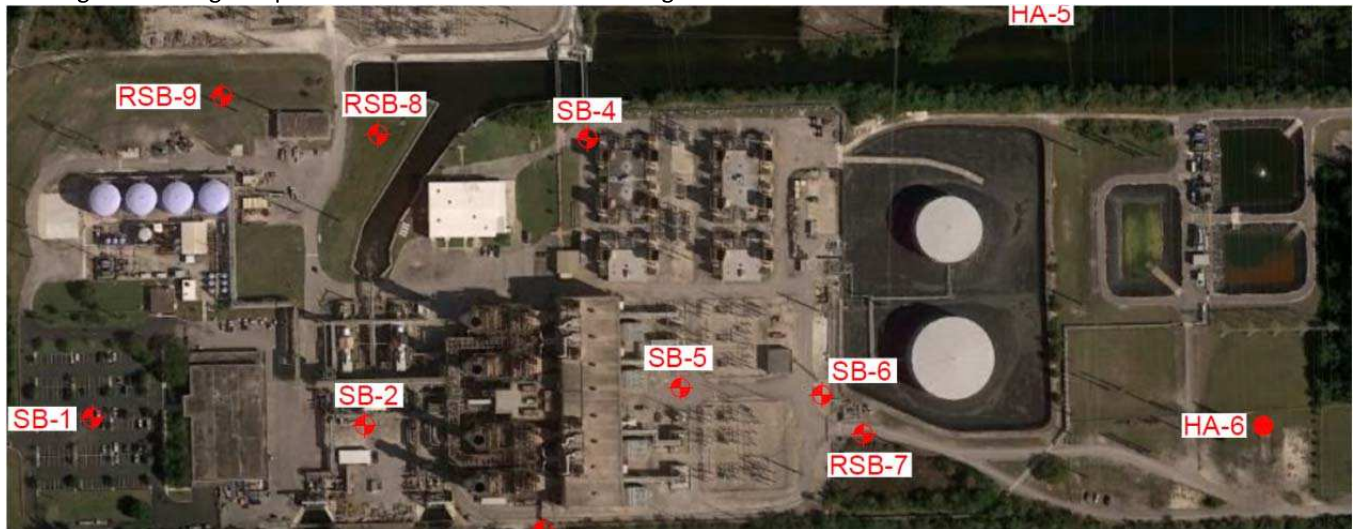


Figure 1: Investigation Boring Locations

Existing ground elevation at the power block area is approximately 7 feet NAVD88 (Ref 1). The soil profile consists of approximate 5 to 7 feet of sandy material underlain by 4 to 5 feet of brown organic soft silty clay layer underlain by sand. The maximum depth of boring investigation was 60 feet below the current ground surface. The depth to water table varied between 2 and 5 feet below ground surface. Shallower water table was noted at borings close to the water impoundments where the ground surface elevation is about 3 feet NAVD88. The average water table within the power block area is at 5 feet below current ground surface which is elevation of 2 feet NAVD88 (Ref 2).

Dewatering Required

The excavations highlighted on Figure 2 are planned within the power block area. The depths of excavations stated on Figure 2 are from the final grade elevation of 10 feet NAVD88 (Ref 2). Several of the long trench excavations required are planned for construction of underground utilities and sumps. Deeper excavations are planned to construct sump foundations at the Auxiliary Cooling System and the Waste Water sumps shown on Figure 2.

The shallow trench excavations including the 10 foot wide by 6 feet deep Underground corridor and the Circulating water pipe corridor excavation are assumed not to require dewatering since the bottom of the excavations will be above the water table (Ref 2). This dewatering calculation is prepared for all other excavations listed on Figure 2.

- 10' wide x 6' deep U/G Utility Corridor
- 20' wide x 12' deep U/G Utility Corridor
- 6' wide x 10' deep Storm Sewer Pipe Corridor
- Circ Water Pipe Corridor - Varies (See Plan)

Note: Foundation and Powerblock Bathtub
Excavations to be above water table unless noted
otherwise in plan.

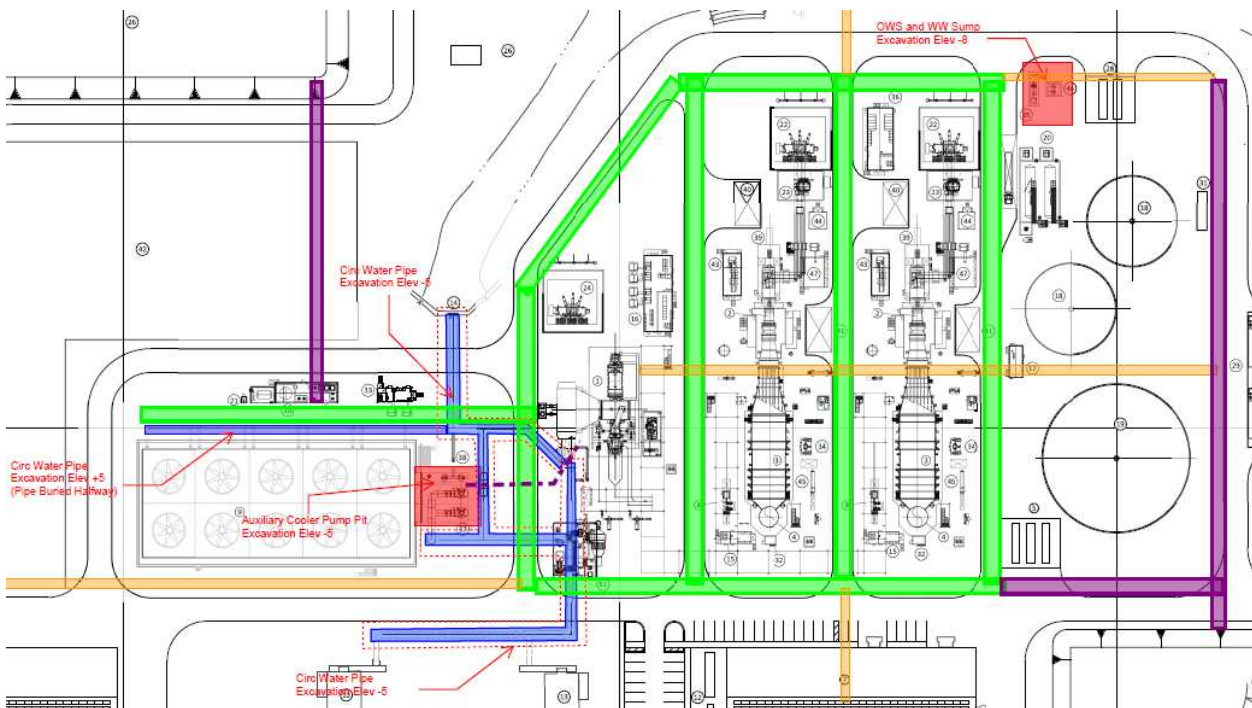


Figure 2: Excavation Areas

Site Aquifer characteristics and Subsurface Condition

The site soils consist of 5 to 7 ft of loose to medium dense granular and sandy lime rock fill material followed by 4 to 5 ft soft compressible organics, underlain by soft, slightly silty sandy fragmented limestone to depths of 43 to 48 feet. Hard limestone was encountered at depths of 53 to 58 feet and extended to the deepest boring depth of 60 feet (Ref 1).

The water table at the power block area is the top of the unconfined aquifer. The Biscayne Aquifer is the highly permeable water table aquifer in Broward and Dade Counties in Florida (Ref-3). The aquifer is the thickest in the Atlantic Coastal areas and wedges out in the western Dade and Broward counties. From the aquifer thickness provided in Ref 3, the aquifer thickness may be up to 120 feet. An aquifer thickness of 60 feet is used based on the anticipated use of wellpoints and the depth to hard limestone (53 to 58 feet) encountered in the borings (Ref 1).

At piezometers installed on site the water table was at approximately 2 to 5 feet depths. Shallower water table was noted at borings close to the water impoundments where the ground surface elevation is about 3 feet NAVD88. The average water table within the power block area is at 5 feet below current ground surface which is elevation of 2 feet NAVD88 (Ref

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2). As indicated in Ref 2, the mapped seasonal high water table is anticipated to be closer to 0.5 feet NAVD88 and elevation 2 feet NAVD88 is considered conservative. The higher observed groundwater may be due to the drilling methods, proximity of stormwater ponds, and the water content of the organic/peat layer.

Horizontal hydraulic conductivity of the aquifer (K_h) at the site was evaluated from site slug test results at 3 piezometers (Ref -1). The slug tested piezometers were screened between 5 ft and 15 ft depth range which is a good representative range of the upper zone of the aquifer to be dewatered. The horizontal hydraulic conductivities from the test results ranged between 17.4 and 212 feet/day. Average $k_h = (67.1+212.2+17.4)/3 = 98.9$ feet/day (use 99 feet/day).

Dewatering Design for 20 foot wide x 12' Deep U/G Utility Corridor

This U/G utility corridor excavation occurs between and surrounding the power units and over the northern part of the Auxiliary Cooling System area. The excavation is expected to take place in sequences of 500 feet lengths. A typical 500 foot excavation is designed for dewatering.

Bottom of excavation elevation = -2 ft NAVD88, 9 feet from existing grade during excavation.

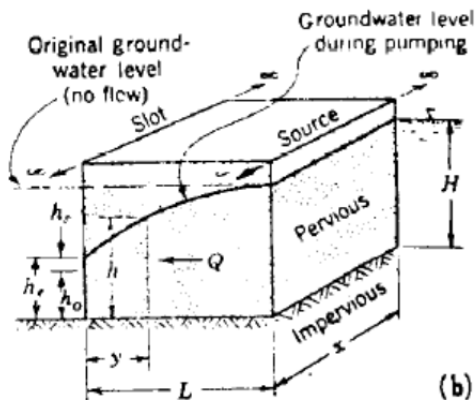
Soil from boring logs consists of fine sand and silty lime rock (Ref 1). Soil is Type C based on OSHA classification (Ref 4). For short-term excavation a slope of 1 ½ :1 is allowed by OSHA.

Excavation width at top = $20 + 2 \times 9 \times 1.5 = 47$ ft

Assume header pipes at 2 feet distance from excavation edge,

Distance between well point lines = $47 + 2 \times 2 = 51$ feet.

Use the average k_h value of 99 feet/day for design. This gives 0.06875 feet/minute (= 99 ft/day * 1 day/24 hr * 1 hr/60 min).



FLOW

$$Q = \frac{kx}{2L} (H^2 - h_o^2)$$

Where

Q = pumping rate in cu-ft/day

H = static (no pumping) ground water head in feet

h_o = pumping water level within the pumping well

kx = horizontal hydraulic conductivity in feet/day

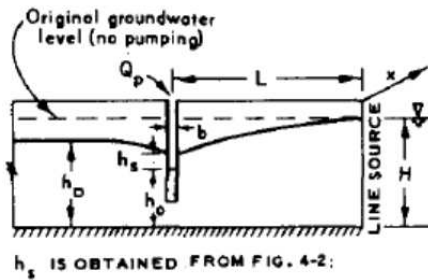
L = Distance from the pumping well to the point of no drawdown (radius of influence) in feet

The flow to a partially penetrating wellpoint is described by the following equation (Ref 5):

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(c)

$$Q_p = \left(0.73 + 0.27 \frac{H - h_0}{H} \right) \frac{kx}{2L} (H^2 - h_0^2) \quad (3)$$

WHERE $L \geq 3H$

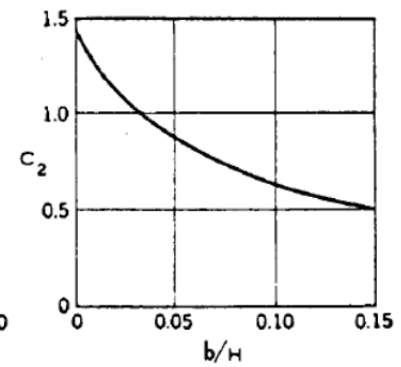
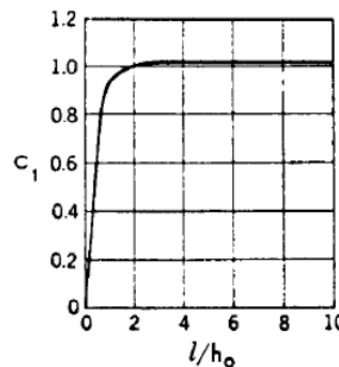
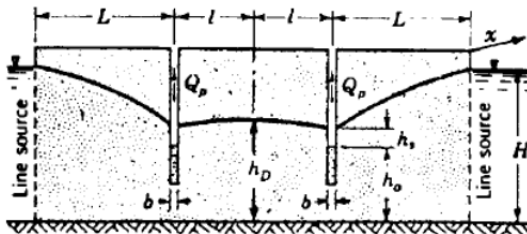
GRAVITY FLOW

Where,

 Q_p = pumping rate at the wellpoint H = The static water table aquifer head in feet h_0 = pumping water level head inside the wellpoint kx = horizontal hydraulic conductivity of the aquifer L = radius of influence of a pumping well (distance from wellpoint to point of zero drawdown)

When two lines of partially penetrating wellpoints along each side of a long excavation are used, the flow for one slot with one line source in a water table aquifer is described with the following equation.

$$h_D = h_0 \left[\frac{C_1 C_2}{L} (H - h_0) + 1 \right]$$

The values of C_1 and C_2 are obtained from the following:

Where

 h_D = head at midpoint of the trench in feet b = wellpoint diameter in feet l = half the distance between the wellpoints on each side of the trench L = distance to a line source or radius of influence in feet

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The Radius of Influence of a well is estimated using the following equation (Ref 5)

RADIUS OF INFLUENCE, R, CAN BE ESTIMATED FOR
BOTH ARTESIAN AND GRAVITY FLOWS BY

$$R = C (H - h_w) \sqrt{k} \quad (1)$$

WHERE R, H, AND h_w ARE DEFINED PREVIOUSLY
AND EXPRESSED IN FEET. COEFFICIENT
OF PERMEABILITY, k, IS EXPRESSED IN
 10^{-4} CM/SEC.

AND C = 3 FOR ARTESIAN AND GRAVITY FLOWS
TO A WELL.

C = 1.5 TO 2.0 FOR A SINGLE LINE OF
WELLPOINTS.

The value of h_w is set equal to the required drawdown at the wellpoint, which is appropriate for small drawdowns (Ref 5).

A spreadsheet program was used for design. Two lines wellpoints (64 wells on each side at 8 foot spacing) should be used for the excavation. Wellpoint should be 20 feet deep with 6 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 802gpm. The estimated daily discharge is about 1.2 million gallons.

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MODEL DATA

500 feet long, 20 feet wide, 12 feet deep UG Utility Corridor

Excavation Area	a' Width	ft	51
	b' Length	ft	500
Excavation Time Length	t = 7 days	months	0.2333
Time of excavation	t	min	10080
Ground Surface Elevation		ft	7
Groundwater Depth		ft	5
Groundwater Elevation	H	ft	2
Elev. Bottom of Excavation		ft	-2
Required Drawdown at Mid Excavation	H-hd	ft	5
Required Lowered Water Table Elev.		ft	-3
Estimated Required Drawdown at Wellpoint	H-ho	ft	7
Estimated Water Level at Wellpoint	ho	ft	53.0
Elevation of bottom of Unconfined Aquifer		ft	-58
Aquifer Depth	B	ft	65
Aquifer Thickness	H	ft	60
	hd required mid-excavation	ft	55
Coefficient of Permeability	kh=kv=	ft/min	0.0688
	kh=kv=	cm/s	0.03493
Transmissivity	T=kH	ft ² /min	4.125
	T=kH	gpd/ft	44431

Estimate flow and drawdown at mid-excavation with two lines of slots

Estimate Influence distance from wellpoint line Sichardt Form	$L=1.5(H-h)\text{SQRT}(k \text{ in microns/sec})$	ft	196
Estimate l/ho	l=	ft	26
	l/ho=		0.5
Determine C1 from Graph c, fig 4-5, Ref. #4	C1=		0.6
Estimate b/H	b = wellpoint diameter	ft	0.167
	b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4	C2=		1.40
Estimate Excavation drawdown due to one line WP	$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	54.59
Excavation drawdown		ft	5.4

Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation

Well spacing	s	ft	8
Estimate flow/wellpoint	$Qp=(0.73+0.27(H-ho)/H)*(ks(H^2-ho^2)/2)$	ft ³ /mi	0.8
Estimate flow/wellpoint	Qp=	gpm	6.31
Estimate Limiting flow rate per foot of well screen	$qc = 2*PI*rw*SQRT(kh)*7.48/1.07$	gpm	1.92
Minimum wellpoint screen length required		ft	3.29
Depth of well point required		ft	15.29
Approximate suction lift with wellpoint required		ft	13

Single stage wellpoint has practical maximum suction lift of 22 feet

Use 20 feet deep well point with 6 foot screen at the bottom

Required number of wellpoints on each side of excavation	n		64
Estimated total flow from two wellpoint lines	Qt	gpm	802
Estimated daily total flow		gpd	1,154,754

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Dewatering Design for 6 foot wide x 10' Deep Storm Sewer Pipe Corridor

Three trench excavations are required for the storm sewer corridor. The excavations consist of 500, 212 feet segments on the east side of the power block area and a 330 feet segment on the west side of the power block area. Two lines of well points on each side of the excavations are evaluated.

Bottom of excavation elevation = 0 ft NAVD88, 7 feet from existing grade.

Using a slope of 1 ½ :1 is allowed by OSHA.

Excavation width at top = $6 + 2 \times 7 \times 1.5 = 27$ ft

Assume header pipes at 2 feet distance from excavation edge,

Distance between well point lines = $27 + 2 \times 2 = 31$ feet.

Average K_h value = 99 feet/day

Results of the wellpoint system analyses using spreadsheet program are outlined below for the three excavations.

For a 500 foot segment, two lines wellpoints (51 wells on each side at 10 foot spacing) should be used. Wellpoint should be 18 feet deep with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 810 gpm. The estimated daily discharge is about 1.2 million gallons.

For a 212 foot segment, two lines wellpoints (25 wells on each side at 9 foot spacing) should be used. Wellpoint should be 18 feet deep with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 351 gpm. The estimated daily discharge is about 510,000 gallons.

For a 330 foot segment, two lines wellpoints (38 wells on each side at 9 foot spacing) should be used. Wellpoint should be 18 feet deep with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 538 gpm. The estimated daily discharge is about 780,000 gallons.

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MODEL DATA

500' long 6' wide x 10' deep Storm Sewer Pipe Corridor

Excavation Area	a' Width	ft	31
	b' Length	ft	500
Excavation Time Length	t = 7 days	months	0.2333
Time of excavation	t	min	10080
Ground Surface Elevation		ft	7
Groundwater Depth		ft	5
Groundwater Elevation	H	ft	2
Elev. Bottom of Excavation		ft	0
Required Drawdown at Mid Excavation	H-hd	ft	3
Required Lowered Water Table Elev.		ft	-1
Estimated Required Drawdown at Wellpoint	H-ho	ft	5
Estimated Water Level at Wellpoint	ho	ft	55.0
Elevation of bottom of Unconfined Aquifer		ft	-58
Aquifer Depth	B	ft	65
Aquifer Thickness	H	ft	60
	hd required mid-excavation	ft	57
Coefficient of Permeability	kh=kv=	ft/min	0.0688
	kh=kv=	cm/s	0.03493
Transmissivity	T=kH	ft ² /min	4.125
	T=kH	gpd/ft	44431

Estimate flow and drawdown at mid-excavation with two lines of slots

Estimate Influence distance from wellpoint line Sichardt Form	$L=1.5(H-h)\text{SQRT}(k \text{ in microns/sec})$	ft	140
Estimate l/ho	l=	ft	16
	l/ho=		0.3
Determine C1 from Graph c, fig 4-5, Ref. #4	C1=		0.5
Estimate b/H	b = wellpoint diameter	ft	0.167
	b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4	C2=		1.35
Estimate Excavation drawdown due to one line WP	$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	56.32
Excavation drawdown		ft	3.7

Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation

Well spacing	s	ft	10
Estimate flow/wellpoint	$Qp=(0.73+0.27(H-ho)/H)*(ks(H^2-ho^2)/2)$	ft ³ /mi	1.1
Estimate flow/wellpoint	Qp=	gpm	7.94
Estimate Limiting flow rate per foot of well screen	$qc = 2*PI*rw*SQRT(kh)*7.48/1.07$	gpm	1.92
Minimum wellpoint screen length required		ft	4.14
Depth of well point required		ft	14.14
Approximate suction lift with wellpoint required		ft	11

Single stage wellpoint has practical maximum suction lift of 22 feet

Use 18 feet deep well point with 5 foot screen at the bottom

Required number of wellpoints on each side of excavation	n		51
Estimated total flow from two wellpoint lines	Qt	gpm	810
Estimated daily total flow		gpd	1,165,875

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MODEL DATA

212' long 6' wide x 10' deep Storm Sewer Pipe Corridor

Excavation Area	a' Width	ft	31
	b' Length	ft	212
Excavation Time Length	t = 7 days	months	0.2333
Time of excavation	t	min	10080
Ground Surface Elevation		ft	7
Groundwater Depth		ft	5
Groundwater Elevation	H	ft	2
Elev. Bottom of Excavation		ft	0
Required Drawdown at Mid Excavation	H-hd	ft	3
Required Lowered Water Table Elev.		ft	-1
Estimated Required Drawdown at Wellpoint	H-ho	ft	5
Estimated Water Level at Wellpoint	ho	ft	55.0
Elevation of bottom of Unconfined Aquifer		ft	-58
Aquifer Depth	B	ft	65
Aquifer Thickness	H	ft	60
	hd required mid-excavation	ft	57
Coefficient of Permeability	kh=kv=	ft/min	0.0688
	kh=kv=	cm/s	0.03493
Transmissivity	T=kH	ft ² /min	4.125
	T=kH	gpd/ft	44431

Estimate flow and drawdown at mid-excavation with two lines of slots

Estimate Influence distance from wellpoint line Sichardt Form	$L=1.5(H-h)\text{SQRT}(k \text{ in microns/sec})$	ft	140
Estimate l/ho	l=	ft	16
	l/ho=		0.3
Determine C1 from Graph c, fig 4-5, Ref. #4	C1=		0.5
Estimate b/H	b = wellpoint diameter	ft	0.167
	b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4	C2=		1.40
Estimate Excavation drawdown due to one line WP	$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	56.37
Excavation drawdown		ft	3.6

Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation

Well spacing	s	ft	9
Estimate flow/wellpoint	$Qp=(0.73+0.27(H-ho)/H)*(ks(H^2-ho^2)/2)$	ft ³ /mi	1.0
Estimate flow/wellpoint	Qp=	gpm	7.14
Estimate Limiting flow rate per foot of well screen	$qc = 2*PI*rw*SQRT(kh)*7.48/1.07$	gpm	1.92
Minimum wellpoint screen length required		ft	3.72
Depth of well point required		ft	13.72
Approximate suction lift with wellpoint required		ft	11

Single stage wellpoint has practical maximum suction lift of 22 feet

Use 18 feet deep well point with 5 foot screen at the bottom

Required number of wellpoints on each side of excavation	n		25
Estimated total flow from two wellpoint lines	Qt	gpm	351
Estimated daily total flow		gpd	505,212

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330' long 6' wide x 10' deep Storm Sewer Pipe Corridor

Excavation Area	a' Width	ft	31
	b' Length	ft	330
Excavation Time Length	t = 7 days	months	0.2333
Time of excavation	t	min	10080
Ground Surface Elevation		ft	7
Groundwater Depth		ft	5
Groundwater Elevation	H	ft	2
Elev. Bottom of Excavation		ft	0
Required Drawdown at Mid Excavation	H-hd	ft	3
Required Lowered Water Table Elev.		ft	-1
Estimated Required Drawdown at Wellpoint	H-ho	ft	5
Estimated Water Level at Wellpoint	ho	ft	55.0
Elevation of bottom of Unconfined Aquifer		ft	-58
Aquifer Depth	B	ft	65
Aquifer Thickness	H	ft	60
	hd required mid-excavation	ft	57
Coefficient of Permeability	kh=kv=	ft/min	0.0688
	kh=kv=	cm/s	0.03493
Transmissivity	T=kH	ft ² /min	4.125
	T=kH	gpd/ft	44431

Estimate flow and drawdown at mid-excavation with two lines of slots

Estimate Influence distance from wellpoint line Sichardt Form	$L=1.5(H-h)\text{SQRT}(k \text{ in microns/sec})$	ft	140
Estimate l/ho	l=	ft	16
	l/ho=		0.3
Determine C1 from Graph c, fig 4-5, Ref. #4	C1=		0.5
Estimate b/H	b = wellpoint diameter	ft	0.167
	b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4	C2=		1.35
Estimate Excavation drawdown due to one line WP	$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	56.32
Excavation drawdown		ft	3.7
Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation			
Well spacing	s	ft	9
Estimate flow/wellpoint	$Qp=(0.73+0.27((H-ho)/H))*(ks(H^2-ho^2)/2)$	ft ³ /min	1.0
Estimate flow/wellpoint	Qp=	gpm	7.14
Estimate Limiting flow rate per foot of well screen	$qc = 2*PI*rw*SQRT(kh)*7.48/1.07$	gpm	1.92
Minimum wellpoint screen length required		ft	3.72
Depth of well point required		ft	13.72
Approximate suction lift with wellpoint required		ft	11
Single stage wellpoint has practical maximum suction lift of 22 feet			
Use 18 feet deep well point with 5 foot screen at the bottom			
Required number of wellpoints on each side of excavation	n		38
Estimated total flow from two wellpoint lines	Qt	gpm	538
Estimated daily total flow		gpd	774,964

Dewatering Design for 16' Wide x 15' Deep Circ Water Pipe Trench

**BLACK & VEATCH****Client** FPL**Project** Dania Beach**Unit** 7**Project No.** 195190**File No.** 58.4300.1101**Title** Dewatering System Design and Flow Rate**Estimate****Computed By** G. Mergia**Date** 07/05/2017**Verified By** B. Gomer**Date** 07/06/2017**Page** 14

Two Trench systems are required to install the Circ Water Pipe System, one on the south side of intake (620 feet long) and another on the north side of the intake (380 feet long) trench excavations will be required for the storm sewer corridor. The trenches will be 16 feet wide at the bottom.

Bottom of excavation elevation = -5 ft NAVD88, 12 feet from existing grade.

Using a slope of 1 ½ :1 is allowed by OSHA.

Excavation width at top = $16 + 2 \times 12 \times 1.5 = 52$ ft

Assume header pipes at 2 feet distance from excavation edge,

Distance between well point lines = $52 + 2 \times 2 = 56$ feet.

Average K_h value = 99 feet/day

Results of the wellpoint system analyses using spreadsheet program for the two excavation systems are outlined below

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MODEL DATA

620 feet long, 16 feet wide, 15 feet deep Circ. Water Pipe Corridor				
Excavation Area		a' Width	ft	56
		b' Length	ft	620
Excavation Time Length		t = 42 days	months	1.4000
Time of excavation		t	min	60480
Ground Surface Elevation			ft	7
Groundwater Depth			ft	5
Groundwater Elevation		H	ft	2
Elev. Bottom of Excavation			ft	-5
Required Drawdown at Mid Excavation		H-hd	ft	8
Required Lowered Water Table Elev.			ft	-6
Estimated Required Drawdown at Wellpoint		H-ho	ft	11
Estimated Water Level at Wellpoint		ho	ft	49.0
Elevation of bottom of Unconfined Aquifer			ft	-58
Aquifer Depth		B	ft	65
Aquifer Thickness		H	ft	60
		hd required mid-excavation	ft	52
Coefficient of Permeability		kh=kv=	ft/min	0.0688
		kh=kv=	cm/s	0.03493
Transmissivity		T=kH	ft ² /min	4.125
		T=kH	gpd/ft	44431
Estimate flow and drawdown at mid-excavation with two lines of slots				
Estimate Influence distance from wellpoint line Sichardt Formula		$L=1.5(H+h)\sqrt{K}$ (k in microns/sec)	ft	308
Estimate l/ho		l=	ft	28
		l/ho=		0.6
Determine C1 from Graph c, fig 4-5, Ref. #4		C1=		0.7
Estimate b/H		b = wellpoint diameter	ft	0.167
		b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4		C2=		1.40
Estimate Excavation drawdown due to one line WP		$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	50.71
Excavation drawdown			ft	9.3
Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation				
Well spacing		s	ft	8
Estimate flow/wellpoint		$Qp=(0.73+0.27(H-ho)/H)*(ks(H^2-ho^2)/2L)$	ft ³ /min	0.8
Estimate flow/wellpoint		Qp=	gpm	6.23
Estimate Limiting flow rate per foot of well screen		$qc = 2*PI*rw*\sqrt{K}*(H-ho)/L$	gpm	1.92
Minimum wellpoint screen length required			ft	3.25
Depth of well point required			ft	19.25
Approximate suction lift with wellpoint required			ft	17
Single stage wellpoint has practical maximum suction lift of 22 feet				
Use 20 feet deep well point with 6 foot screen at the bottom				
Required number of wellpoints on each side of excavation		n		79
Estimated total flow from two wellpoint lines		Qt	gpm	979
Estimated daily total flow			gpd	1,409,547

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MODEL DATA				
380 feet long, 16 feet wide, 15 feet deep Circ Water Pipe Corridor				
Excavation Area		a' Width	ft	56
		b' Length	ft	380
Excavation Time Length		t = 42 days	months	1.4000
Time of excavation		t	min	60480
Ground Surface Elevation			ft	7
Groundwater Depth			ft	5
Groundwater Elevation		H	ft	2
Elev. Bottom of Excavation			ft	-5
Required Drawdown at Mid Excavation		H-hd	ft	8
Required Lowered Water Table Elev.			ft	-6
Estimated Required Drawdown at Wellpoint		H-ho	ft	11
Estimated Water Level at Wellpoint		ho	ft	49.0
Elevation of bottom of Unconfined Aquifer			ft	-58
Aquifer Depth		B	ft	65
Aquifer Thickness		H	ft	60
		hd required mid-excavation	ft	52
Coefficient of Permeability		kh=kv=	ft/min	0.0688
		kh=kv=	cm/s	0.03493
Transmissivity		T=kH	ft ² /min	4.125
		T=kH	gpd/ft	44431
Estimate flow and drawdown at mid-excavation with two lines of slots				
Estimate Influence distance from wellpoint line Sichardt Formula		$L=1.5(H-h)\sqrt{K}$ (k in microns/sec)	ft	308
Estimate l/ho		l=	ft	28
		l/ho=		0.6
Determine C1 from Graph c, fig 4-5, Ref. #4		C1=		0.7
Estimate b/H		b = wellpoint diameter	ft	0.167
		b/H=		0.003
Determine C2 from Graph d, fig 4-5, Ref. #4		C2=		1.40
Estimate Excavation drawdown due to one line WP		$hd=ho*(C1*C2*(H-ho)/L+1)$	ft	50.71
Excavation drawdown			ft	9.3
Note within the excavation the combined drawdown of well points is expected to dewater the area to below the depth of excavation				
Well spacing		s	ft	8
Estimate flow/wellpoint		$Qp=(0.73+0.27(H-ho)/H)*(ks(H^2-ho^2)/2L)$	ft ³ /mi	0.8
Estimate flow/wellpoint		Qp=	gpm	6.23
Estimate Limiting flow rate per foot of well screen		$qc = 2*PI*rw*\sqrt{K(h)}$	gpm	1.92
Minimum wellpoint screen length required			ft	3.25
Depth of well point required			ft	19.25
Approximate suction lift with wellpoint required			ft	17
Single stage wellpoint has practical maximum suction lift of 22 feet				
Use 20 feet deep well point with 6 foot screen at the bottom				
Required number of wellpoints on each side of excavation		n		49
Estimated total flow from two wellpoint lines		Qt	gpm	605
Estimated daily total flow			gpd	870,867

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Auxiliary Cooling System Pump Pit Dewatering Design for 64' x 66' excavation to -5 foot elevation,

Bottom of excavation elevation = -5 ft NAVD88, 12 feet from existing grade.

Using a slope of 1 ½ :1 allowed by OSHA.

Excavation width at top = 64 + 2*12*1.5 = 100 ft

Excavation length at top = 66 + 2*12*1.5 = 102 ft

Assume 104' x 106' excavation (add 2' on each side of the excavation to reach the wells)

Average Kh value = 99 feet/day

Because of the large width of excavation, wellpoints with relatively short radius of influence will not work to lower the water level to below excavation desired depth. A few equally spaced larger wells will be analyzed. Since the wells are not expected to be as deep as the aquifer, partially penetrating wells should be evaluated.

The pumping rate and drawdown of partially penetrating well in unconfined aquifer can be established with the following equations:

FULLY OR PARTIALLY PENETRATING WELL

FLOW, Q_w , FOR ANY GRAVITY WELL WITH A CIRCULAR SOURCE

$$Q_w = \frac{\pi k [(H - s)^2 - t^2]}{\ln (R/r_w)} \left[1 + \left(0.30 + \frac{10r_w}{H} \right) \sin \frac{1.8s}{H} \right] \quad (3)$$

DRAWDOWN, $H - h$ OR $H^2 - h^2$, WHERE h' IS ACCOUNTED FOR (OBTAIN Q_w FROM EQ 3)

WHERE $r > 1.5H$,
$$H^2 - h^2 = \frac{Q_w}{\pi k} \ln \frac{R}{r} \quad (4)$$

WHERE $r < 1.5H$,
 FOR $r/h > 1.5$,
 FOR $r/h < 1.5$,
 USE EQ 4

$$H - h = \frac{Q_w P \ln (10R/H)}{\pi k H [1 - 0.8(s/H)^{1.5}]} \quad (5)$$

FOR $0.3 < r/h < 1.5$,
$$P = 0.13 \ln R/r \quad (6)$$

FOR $r/h < 0.3$,
$$P = \bar{C}_x + \Delta C \quad (7)$$

WHERE
$$\bar{C}_x = 0.13 \ln \frac{R}{r} - 0.0123 \ln^2 \frac{R}{10r} \quad (8)$$

AND
$$\Delta C = \frac{s}{h} \left[\left(\frac{1}{2.3} \ln \frac{R}{10r} \right) \left(1.2 \frac{s}{H} - 0.48 \right) + 0.113 \ln \frac{2.4H}{R} \ln \frac{R}{34r} \right] \quad (9)$$

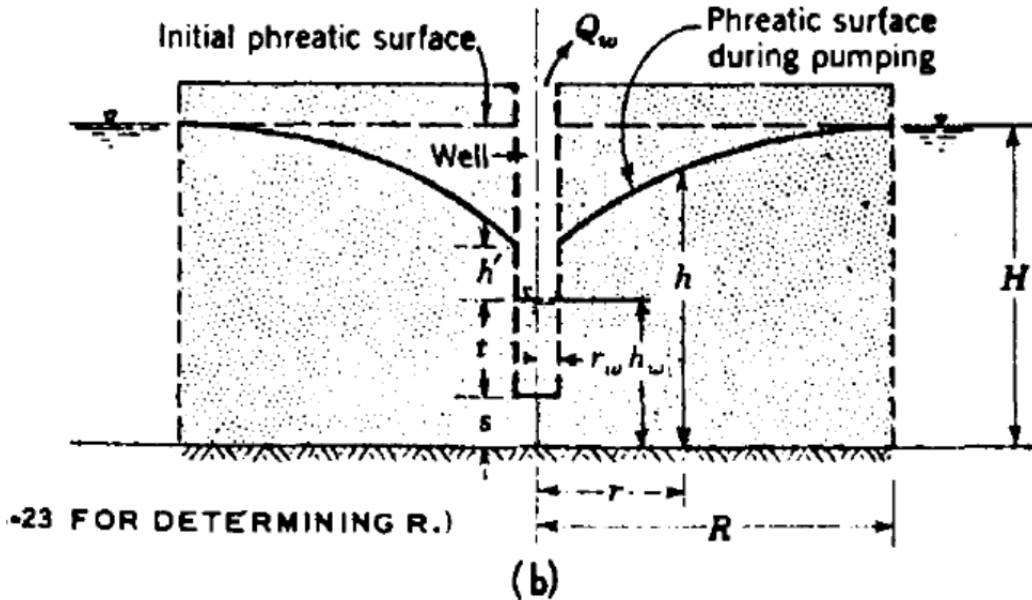
The dimensions in the equations are shown in the below figure.



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A spreadsheet program solution is shown below.

Four dewatering wells can be used at each corner of the approximate 105 x 103 feet excavation. Each well will be 10-inch ID, 55 feet deep, with 35 feet, continuous 20-slot screen. 2-inch gravel pack over the bottom 40 feet of the well should be used. A pumping rate of 170 gpm at each well will result in about 14 feet of drawdown that is greater than the 13 feet of required drawdown at the excavation. Daily pumping rate from the pit will be about 1.0mgd.

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MODEL DATA**Aux Cooling System Pit**

Excavation,	Length L	66	ft
	Width B	64	ft
GROUND SURFACE ELEVATION		7	ft
GROUNDWATER DEPTH		5	ft
ELEV. BOTTOM OF EXCAVATION		-5	ft
Assume groundwater 1 feet below excavation			
Excavation Time Length	t	42	days
DEPTH TO CONFINING LAYER		65	ft
ESTIMATED REQ'D DRAWDOWN AT EXCAVATION	H-ho	13	ft
COEFFICIENT OF PERMEABILITY	kh-kv	0.0688	ft/min
Dewatered Excavation Area			
Aquifer thickness at excavation	ho	46	ft
EXCAVATION AREA Length (Assumed 1.5:1 side slope)	L'	102	ft
EXCAVATION AREA Width (Assumed 1.5:1 side slope)	B'	100	ft
Time of excavation	t	60,480	min
GROUNDWATER ELEVATION		2	ft
Estimated drawdown at pumping well		20	ft
REQ'D LOWERED GROUNDWATER LEVEL ELEV.		-6	ft
Bottom confining layer elevation		-58	ft
Aquifer thickness before dewatering	H	60	ft
Hydraulic conductivity	kh-kv	99	ft/day
	kh-kv	741	gpd/ft ²
	kh-kv	0.0349	cm/s
ASSUME UNCONFINED AQUIFER			
Storage Coefficient (Specific Yield)		0.18	
TRANSMISSIVITY	T-kH	4.1	ft ² /min
	T-kH	44,431	gpd/ft

Estimate drawdown at mid-excitation and total flow assuming multiple partially penetrating pumping wells

Estimate Radius of influence for pumping time	$R = \text{SQRT}(0.3 \cdot T \cdot t / S)$	1,764	ft
Pumping time required to influence R -	$t = S \cdot R^2 / (0.3 \cdot T)$	42.0	days
Well Screen Length		37.0	ft
Unconfined Aquifer			
Equivalent radius for multiple wells r -		57.0	ft
Planned Well Depth below existing ground		55.0	ft
Height of water in well	S =	10.0	ft
Initial estimate total dewatering pumping (single well), use $r = L/2$	$Q_p = \frac{\pi k [(H-S)^2 - r^2]}{\ln \left(\frac{R}{r_w} \right)} \cdot \frac{1}{\ln \left(\frac{R}{r_w} \right)}$	243	gpm
Assumed pumping well radius		0.416666667	ft
Required Number of wells	n	4	
Pumping rate per well		161	gpm
Increased pumping to get desired excavation drawdown		100	gpm
Daily pumping rate		925,490	gpd
Dewatering Well spacing		104	ft
Excavation Perimeter		404	ft
Equivalent radius		57	
	r/H =	0.95	
	$P = 0.13 \ln R/r$	0.45	
Excavation Drawdown	Drawdown at distance r from 4 wells	17.78	
use 4, 10-inch ID, 55 feet deep wells on each corner of the excavation with 35 feet 20 slot screen, continuous slot			
use 2 inch sand pack around screen			
A pumping rate of 170 gpm at each well will result in more than the 13 feet drawdown at the excavation			

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OWS and WW Sump Dewatering Design for 52' x 64' excavation to -8 foot elevation,

Bottom of excavation elevation = -8 ft NAVD88, 15 feet from existing grade.

Using a slope of 1 ½ :1 allowed by OSHA.

Excavation width at top = $52 + 2 \times 15 \times 1.5 = 97$ ft

Excavation length at top = $64 + 2 \times 15 \times 1.5 = 109$ ft

Assume 101' x 113' excavation

Average Kh value = 99 feet/day

Because of the large width of excavation, wellpoints with relatively short radius of influence will not work to lower the water level to below excavation desired depth. A few equally spaced larger wells will be analyzed. Since the wells are not expected to be as deep as the aquifer, partially penetrating wells are evaluated using a spreadsheet program.

Four dewatering wells can be used at each corner an approximate 112 x 101 feet excavation. Each well will be 10-inch ID, 55 feet deep, with 35 feet, 20-slot continuous slot screen. 2-inch gravel pack over the bottom 40 feet of the well should be used. A pumping rate of 210 gpm at each well will result in about 17 feet of drawdown that is greater than the 16 feet of required drawdown at the excavation. Daily pumping rate from the pit will be about 1.2mgd.

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MODEL DATA**OUS and VW Sump**

Excavation,	Length L	64	ft
	Width B	52	ft
GROUND SURFACE ELEVATION		7	ft
GROUNDWATER DEPTH		5	ft
ELEV. BOTTOM OF EXCAVATION		-8	ft
Assume groundwater 1 feet below excavation			
Excavation Time Length	t	15	days
DEPTH TO CONFINING LAYER		65	ft
ESTIMATED REQ'D DRAWDOWN AT EXCAVATION	H-ho	16	ft
COEFFICIENT OF PERMEABILITY	kh-kv	0.069	ft/min
Dewatered Excavation Area			
Aquifer thickness at excavation	ho	43	ft
EXCAVATION AREA Length (Assumed 1.5:1 side slope)	L'	112	ft
EXCAVATION AREA Width (Assumed 1.5:1 side slope)	B'	100	ft
Time of excavation	t	21,600	min
GROUNDWATER ELEVATION		2	ft
Estimated drawdown at pumping well		20	ft
REQ'D LOWERED GROUNDWATER LEVEL ELEV.		-9	ft
Bottom confining layer elevation		-58	ft
Aquifer thickness before dewatering	H	60	ft
Hydraulic conductivity			
	kh-kv	99	ft/day
	kh-kv	741	gpd/ft ²
	kh-kv	0.03	cm/s
ASSUME UNCONFINED AQUIFER			
Storage Coefficient (Specific Yield)		0.18	
TRANSMISSIVITY	T-kH	4.1	ft ² /min
	T-kH	44,431	gpd/ft

Estimate drawdown at mid-excitation and total flow assuming multiple partially penetrating pumping wells

Estimate Radius of influence for pumping time	$R = \text{SQRT}(0.3 * T * t / S)$	1,054	ft
Pumping time required to influence R =	$t = S * R^2 / (0.3 * T)$	15.0	days
Approx Max Well Screen Length		34.0	ft
Unconfined Aquifer			
Equivalent radius for multiple wells r =		59.7	ft
Planned Well Depth below existing ground		55.0	ft
Height of water in well	S =	10.0	ft
Initial estimate total dewatering pumping (single well), use r = L/2	$Q_s = \frac{P * K [(H/S)^2 - t^2] * [1 + (0.3 * 10 * w / H) * \sin 1.8^\circ S / H]}{(\ln(R / r_w))}$	307	gpm
Assumed pumping well radius		0.416666667	ft
Required Number of wells	n	4	
Pumping rate per well		202	gpm
Increased pumping to get desired excavation drawdown		125	gpm
Daily pumping rate		1,162,595	gpd
Dewatering Well spacing		104	ft
Excavation Perimeter		424	ft
Equivalent radius		60	
	r/H =	1.00	
	$P = 0.13 \ln R / r$	0.37	
Excavation Drawdown	Drawdown at distance r from 4 wells	16.99	
	$H - h = \frac{4 * Q_w P \ln(10R / H)}{0.8 (s / H)^{1.5}}$		
use 4, 10-inch ID, 55 feet deep wells on each corner of the excavation with 35 feet 20 slot screen, continuous slot			
use 2 inch sand pack around screen			
A pumping rate of 210 gpm at each well will result in more than the required 16 feet of drawdown at excavation			

6.0 Conclusions

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Dewatering of 500 ft long, 20 foot wide x 12' Deep U/G Utility Corridor

Two lines wellpoints (64 wells on each side at 8 foot spacing). Wellpoint should be 20 feet deep from existing grade with 6 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 802 gpm. The estimated daily discharge is 1.2 million gallons.

Dewatering of 500 ft long, 6 foot wide x 10' Deep Storm Sewer Utility Corridor

Two lines wellpoints (51 wells on each side at 10 foot spacing). Wellpoint should be 18 feet deep from existing grade with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 810 gpm. The estimated daily discharge is about 1.2 million gallons.

Dewatering of 212 ft long, 6 foot wide x 10' Deep Storm Sewer Utility Corridor

Two lines wellpoints (25 wells on each side at 9 foot spacing). Wellpoint should be 18 feet deep from existing grade with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 351 gpm. The estimated daily discharge is 510,000 gallons.

Dewatering of 330 ft long, 6 foot wide x 10' Deep Storm Sewer Utility Corridor

Two lines wellpoints (38 wells on each side at 9 foot spacing). Wellpoint should be 18 feet deep from existing grade with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 538 gpm. The estimated daily discharge is 780,000 gallons.

Dewatering of 620 ft long, 16 foot wide x 15' Deep Circ Water Pipe Corridor

Two lines wellpoints (79 wells on each side at 8 foot spacing). Wellpoint should be 20 feet deep from existing grade with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 979 gpm. The estimated daily discharge is 1,409,600 gallons.

Dewatering of 380 ft long, 16 foot wide x 15' Deep Circ Water Pipe Corridor

Two lines wellpoints (49 wells on each side at 8 foot spacing). Wellpoint should be 20 feet deep from existing grade with 5 foot long screen zone at the bottom. Total estimated pumping rate for the excavation is approximately 605 gpm. The estimated daily discharge is 870,900 gallons.

Dewatering of Auxiliary Cooling System Pit

Four dewatering wells to be used at each corner an approximate 105 x 103 feet excavation. Each will be 10-inch ID, 55 feet deep, with 35 feet, 20-slot continuous slot screen. 2-inch gravel pack over the bottom 40 feet of the well should be used. A pumping rate of 170 gpm at each well will result in more than the 13 feet required drawdown at the excavation. Daily pumping rate from the pit will be about 1.0mgd.

OUS and WW Sump

Four dewatering wells to be used at each corner an approximate 112 x 101 feet excavation. Each will be 10-inch ID, 55 feet deep, with 35 feet, 20-slot continuous slot screen. 2-inch gravel pack over the bottom 40 feet of the well should be used. A pumping rate of 210 gpm at each well will result in more than the 16 feet required drawdown at the excavation. Daily pumping rate from the pit will be 1.2mgd.

The estimated radius of influence during dewatering pumping of the OUS and WW Sump is about 1504 feet. The Auxiliary Cooling System Pit dewatering is expected to last 6 weeks and the estimated radius of influence is 1764 feet. Additional well points may be needed at select locations if constant head water bodies at the site reduce the radius of influence during excavation dewatering.

About 6 weeks dewatering period is estimated to dewater each Circ. Water Pipe System trench. All other trench excavation periods are estimated to take about a week.

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Even though the excavations in the calculation are assumed to occur at different times, the contractor may choose to combine some of excavations and dewatering. Under those circumstances the combined pumping rate may be less to dewater areas because of drawdown interferences.

Note:

For proper header and discharge pipes and fittings should be used to minimize head losses. Install wellpoint header pipes as close as practical to prevailing groundwater elevation and in accessible locations. Locate wellpoint pumps centrally so that head losses to ends of system are balanced. Install valves to permit isolation of a portion of the system. Size discharge lines so that the head losses do not create excessive back pressure on the pump.



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7.0 List of Attachments

None