MORGAN SINDALL

ENGINEERING SOLUTIONS

Project: Garnswllt

Section: De-watering Preliminary Assessment

Design No.: 300392-DEL-GRN01-CA-00002 C01

Revisions:

Revision	*Date*	*Description*
C01	13/01/2021	First Issue

Engineer: E. Spencer

100% Safe

Morgan Sindall Engineering Solutions
Corporation Street, Rugby, Warwickshire, CV21 2DW
T 01788 534669 W morgansindall.com

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Document Control

Design Brief Reference	GRN01

Engineering Solutions Checks

	Name	Signed	Date
Numerical	N. Darbyshire	Neil Darbyshire	13/01/2021
Design Parameters, Methods & Standards	N. Darbyshire	Neil Darbyshire	13/01/2021
Output	N. Darbyshire	Neil Darbyshire	13/01/2021

Engineering Solutions Review

	Name	Signed	Date
Project Design Engineer	S. Moore	S. Moore	14/01/2021
Approved By	P. Trafford	[signature]	15/01/2021

Innovation

Are the solutions proposed in this design Innovative?			~~Yes~~/No
Why are the solutions proposed in this design regarded as innovative and potentially qualify for RDEC?			
Proposed By			
Approved By			

Related Design Output

Document Reference	Description
TW2 GRN01 De-watering Part B	

1. RISK ASSESSMENT

The Designer's Risk Assessment below identifies all risks associated with this design. Residual risks that need to be actively managed by the construction, maintenance, operation and decommissioning personnel are to be communicated on the drawings and TW2 forms associated with this design.

DESIGNER'S RISK ASSESSMENT HEALTH, SAFETY AND THE ENVIRONMENT Residual Risks Associated With The Types Of Works Detailed On This Drawing	
General 1. Generic Hazards and Risks, such as working at height, confined spaces, working with hazardous materials etc. have **not** been identified. 2. Significant residual risks have been identified. These are not necessarily those that involve the greatest risks but those (including health risks) that are not likely to be obvious, are unusual, or are likely to be difficult to manage effectively. 3. It is assumed that all personnel are competent to undertake the works shown on this drawing. 4. It is assumed that appropriate PPE will be worn as identified in the risk assessment of the construction method statement for these works. 5. It is assumed that proprietary equipment, plant, products and materials will be used in accordance with the manufacturer's / suppliers instructions and Materials Safety Data Sheets.	
Construction	
C1	Assessment made on basis of 10^-4 to 10^-5m/s permeability. Full assessment and design required before any construction. Soil permeability based on the descriptions only.
C2	Final design calculation must be completed before any construction. Specialist dewatering contractor to provide final proposals.
C3	Falling head tests to be completed before construction of any dewatering. Specialist dewatering contractor to provide final proposals.
C4	Site team to be aware of any high voltage lines in the area.
C5	Wellpoints to be installed by the water jetting method, and will need account for potentially dense and cobbly soil.
Use and Maintenance	
M1	Discharge calculated between 2 and 8.5 l/s for wellpoint dewatering around 2No. tanks. Should permeability of the ground be higher, then discharge will be higher.
M2	
Decommissioning and Demolition	
D1	
Hold Points (to be implemented before construction can commence)	
Does the Designer require a constructability review meeting to be held?	No
Does the Designer need to review the construction method statement?	No
Other?	N/A

Design Calculation

Design Risk Assessment

Ref	Risk Description	Pre-Mitigation Risk			Control / Mitigation	Post Mitigation Risk		
		Severity	Likelihood	Risk		Severity	Likelihood	Residual Risk
1	Failure due to more permeable ground then used in assessment	Major	Frequent / likely	HIGH	Assessment made on basis of 10^-5 to 10^-4 permeability. Full assessment and design required before any construction. Soil permeability has been calculated based on the descriptions only.	Major	Infrequent / rarely	MEDIUM
2	Failure due to assessmnet being used as final design	Major	Frequent / likely	HIGH	Final design calculation must be completed before any construction. Specialist dewatering contractor to provide final proposals.	Major	Infrequent / rarely	MEDIUM
3	GWL different than assumed	Major	Frequent / likely	HIGH	Falling head tests to be completed before construction of any dewatering. Specialist dewatering contractor to provide final proposals.	Major	Infrequent / rarely	MEDIUM
4	FST below high voltage lines	Major	Occasional / uncommon	HIGH	Site team to be aware of any high voltage lines in the area.	Major	Infrequent / rarely	MEDIUM
5								
6								
7								
8								
9								

2. CONTENTS

3. SCOPE

This calculation is required to provide site with information regarding any dewatering methods required for to prevent floatation of tanks when drained.

Site have requested that the groundwater is to be modelled at ground level (16.764mAOD) and reduced to the top of the base slab for the tank (13.259m). The required drawdown would be 3.505m.

The tanks in question are indicated in figure 1 below.

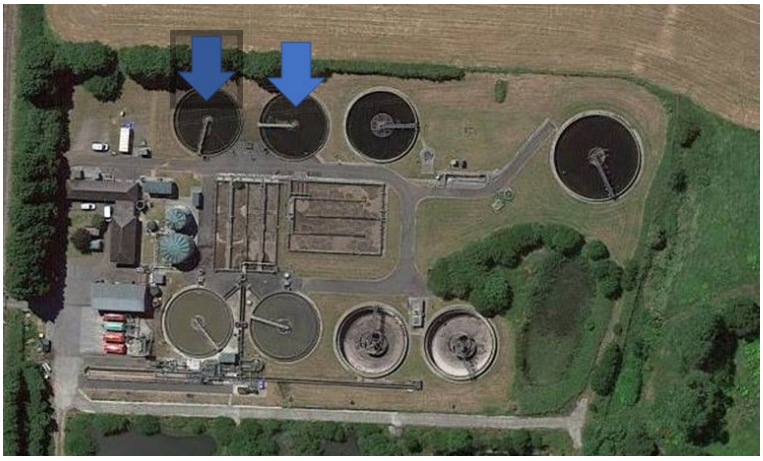


Figure 1 – Location of tanks in question

This calculation is required for a preliminary assessment to calculate an approximate volume of groundwater removed from the ground. This is not a final design.

4. BASIS OF DESIGN

The following support information has been used.

- Ground conditions (Report_10629)

The following standard has been followed for a method.

- Processes – (CIRIA C750 Groundwater Control)

5. GROUND CONDITIONS

5.1. Design Borehole

Figure 2 below shows the locations of the tanks and boreholes

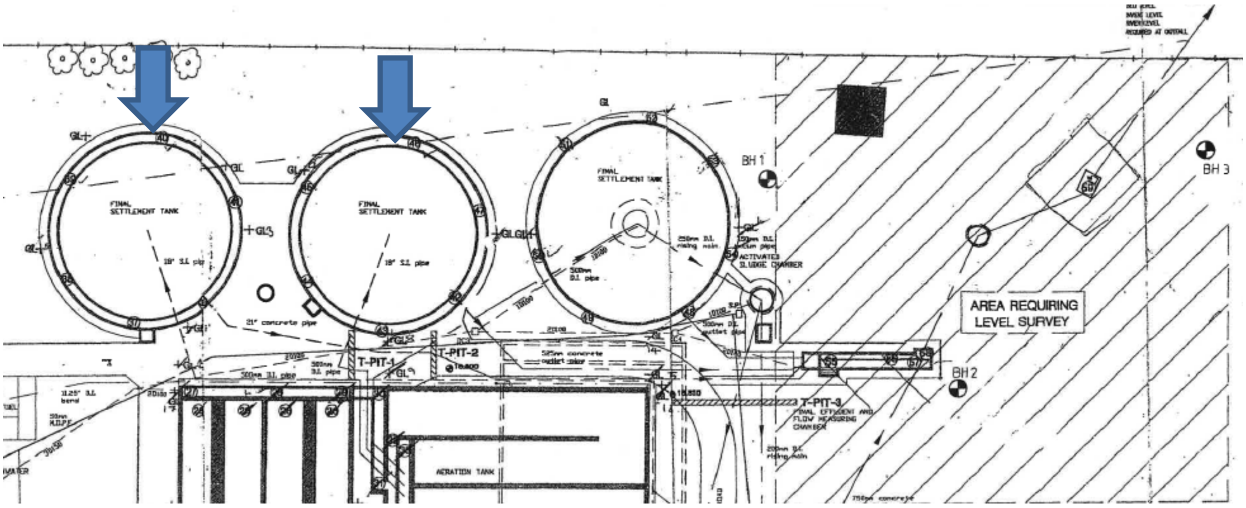


Figure 2 – Tank and boreholes

The long section in figure 3 below shows the geology of all three boreholes. Borehole logs have been included in the appendix.

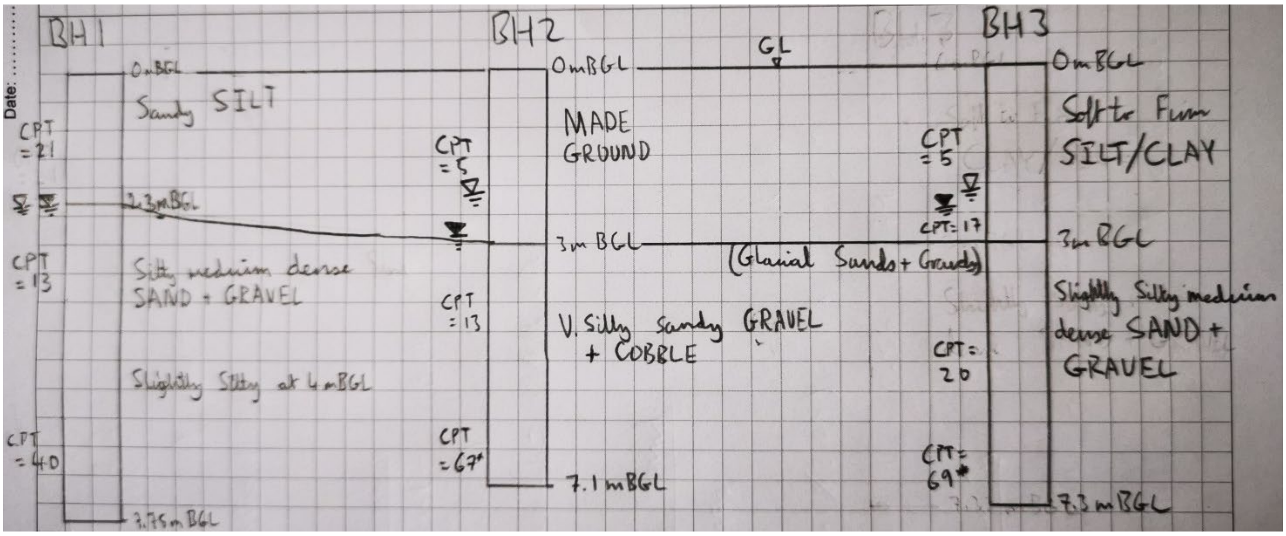


Figure 3 – Long Section showing BH1, BH2 and BH3

The descriptions of the ground materials concerned in which the groundwater control methods will be calculated from are as follows:

Borehole 1: Silty medium dense SAND and GRAVEL becoming slightly silty at 4mbgl.

Borehole 2: Medium dense very silty sandy GRAVEL and COBBLE. Grading changing to silty sandy gravel at approximately 4mbgl.

Borehole 3: Medium dense brown slightly silty SAND and GRAVEL.

Varying ranges of silt between all the boreholes. Silty SAND and GRAVEL will be used as the design geology.

A grading curve (figure 4) has been plotted of the following design ground material.

Design ground material: Slightly Silty SAND and GRAVEL.

Silt content: 5% to 20% Silt

50 – 50 split of the remaining material between sand and gravels. The two possible gradings at each end of the possibilities are as follows.

- Ground Material 1 - 47.5% SAND, 47.5% GRAVEL and 5% Silt
- Ground Material 2 – 40% SAND, 40% GRAVEL and 20% Silt

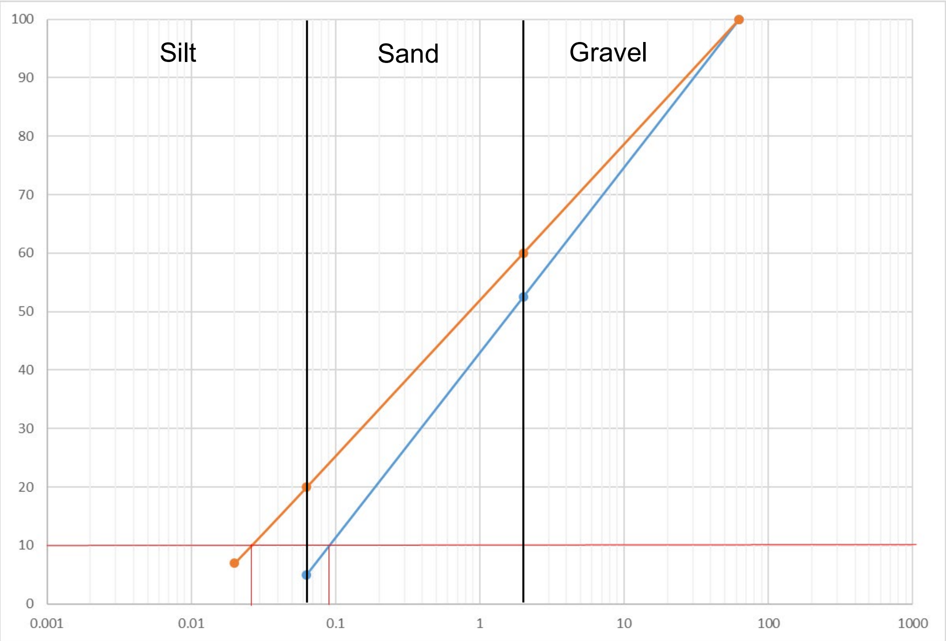


Figure 4 – Grading Curve

An approximation using Hazens Formula has been used this requires checking the D_{60} and D_{10} values and is as follows.

Permeability, k; $=(C/10^4) \times (D_{10})^2$ m/s

Ground Material 1

Size of material passing at 10%, D_{10}; 0.095

Size of material passing at 60%, D_{60}; 3.5

Uniformity Coeficient, C; 100

Permeability, k; $(100/10^4) \times 0.095^2 = 9.03\times10^{-5}$m/s

Ground Material 2

Size of material passing at 10%, D_{10}; 0.028

Size of material passing at 60%, D_{60}; 2

Uniformity Coeficient, C; 100

Permeability, k; $(100/10^4) \times 0.028^2 = 7.84\times10^{-6}$m/s

A permeability of 10^{-5} to 10^{-4} will be used4

The design borehole is below.

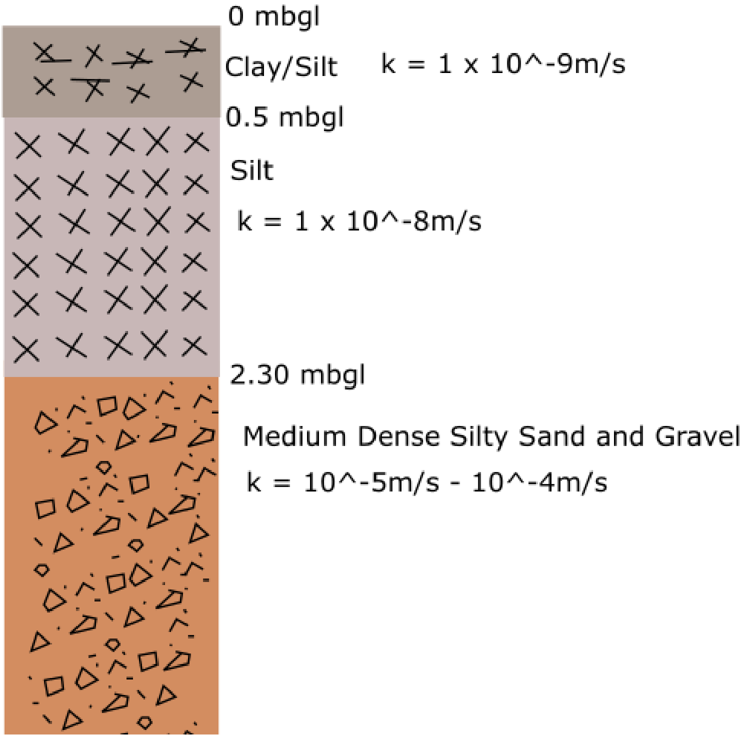


Figure 5 – Design Borehole

The ground levels of the have been taken from BH1.

5.2. Groundwater

Site have requested that the groundwater is to be modelled at ground level (16.764mAOD) and reduced to the top of the base slab for the tank (13.259m). The required drawdown would be 3.505m.

5.2.1. Assumptions made

- Groundwater level – 16.764mAOD
- Drawdown level – 13.259mAOD
- Base of aquifer – 9.014mAOD, As the base of the aquifer is unknown it has been taken as the base of the borehole (7.75mBGL).

6. ANALYSIS

C750 – Groundwater Control has been used as guidance to determine whether groundwater control is needed and if so what type.

Figure 2 below has been used to assess the dewatering requirements for the attenuation tank excavation and installation.

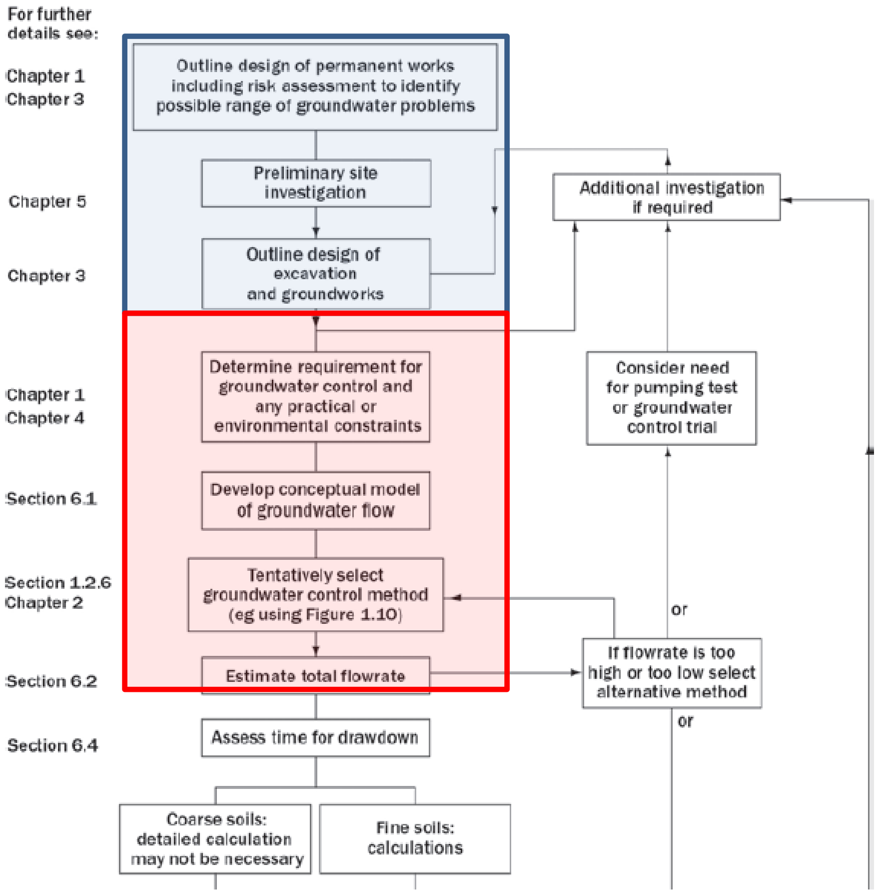


Figure 6 – Flow chart of process followed to analyse groundwater flow and control – Taken from CIRIA C750 Groundwater Control - section 1.1 – figure 1.1.

Blue Shading indicates areas already covered prior to this calculation. Areas shaded in red show areas covered by this calculation.

6.1. Determining requirements for groundwater control

Site have requested groundwater levels are modelled at on site being 16.8mAOD and the required drawdown depth to prevent floatation of the tank being 13.3mAODm (3.5m of drawdown). The groundwater sits in the gravels and sands with a value for permeability of k = 10^{-5}m/s to 10^{-4} m/s.

6.2. Conceptual Groundwater flow model

A model of the required groundwater flow can be seen in figure 7 below showing the excavation and the alterations to the groundwater flow regime needed.

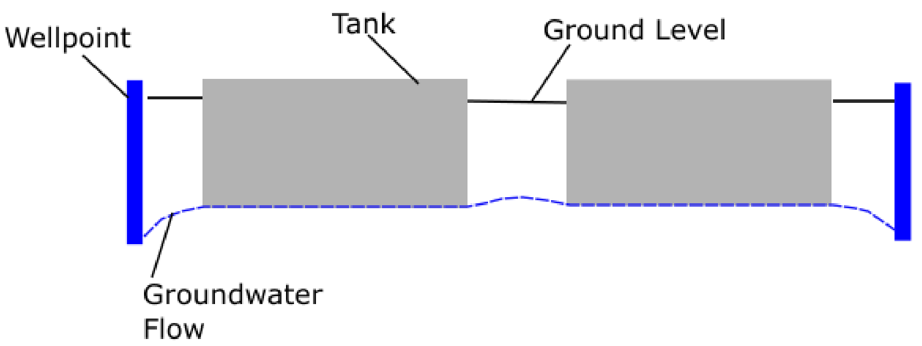


Figure 7 – Conceptual groundwater flow

6.3. Groundwater control method

Using figure 8 taken from C750 and the characteristic permeability estimate can be made as to what method of dewatering would be best suited to the ground properties of the site.

The highest design permeability is 10^{-5} m/s to 10^{-4} m/s and a required draw down of 3.5m it is shown that single stage wellpoints would be best suited.

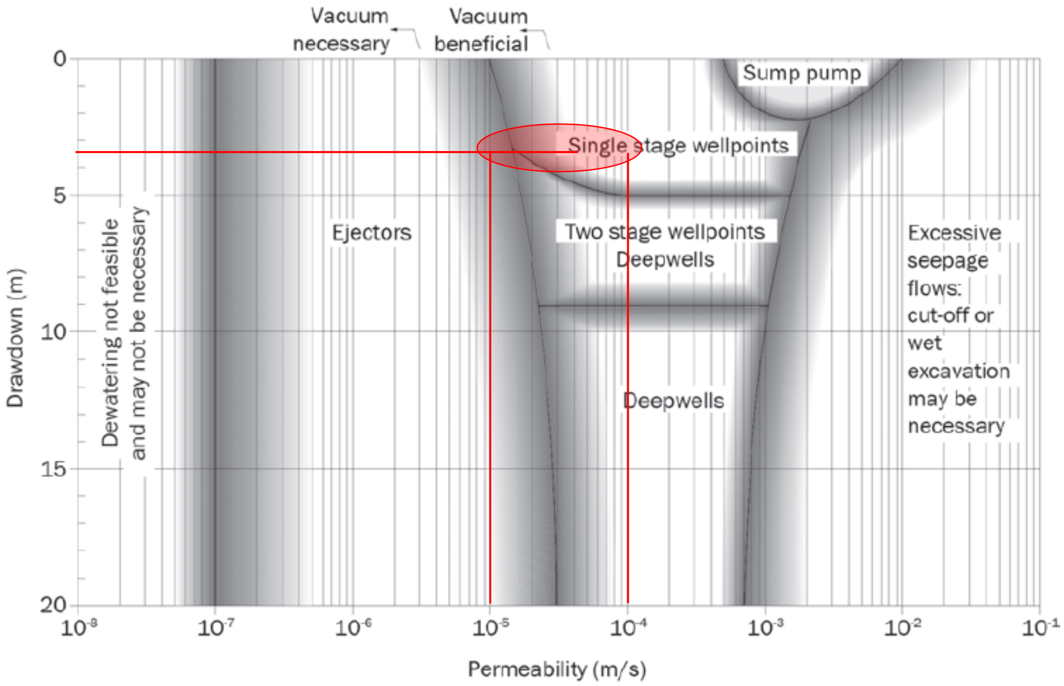


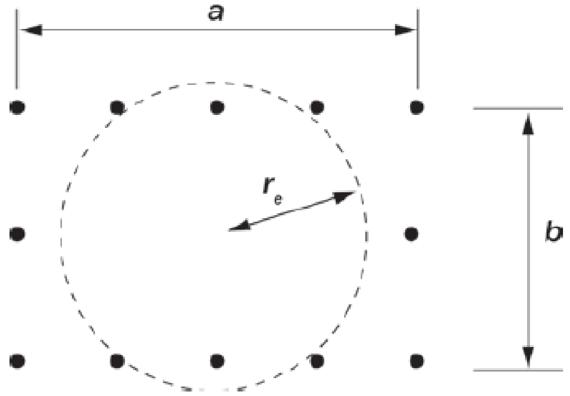
Figure 8 – Required control method

6.4. Estimate of total flowrate

Section 6.2 of CIRIA C750 gives equations to calculate the flow rate of the ground (Q).

$$\text{Unconfined conditions: } Q = \frac{\pi k\left(H^2 - h_w^2\right)}{\ln\left[R_o/r_e\right]}$$

Inputs for the equation can be found in the following figures, 5, 6 and 7.



b) Rectangular system modelled as equivalent well of radius, r_e

Figure 9 – Rectangular system modelled as equivalent well of radius, r_e

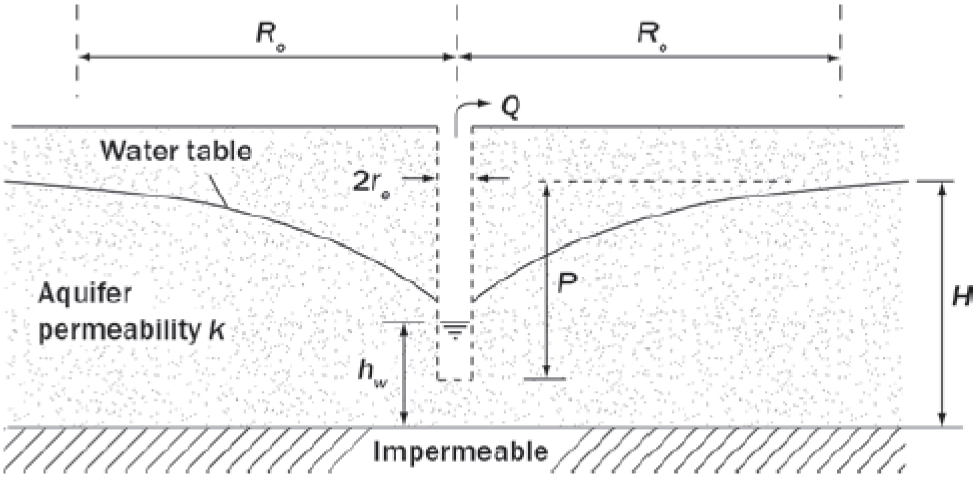


Figure 10 – Idealised radial flow to wells

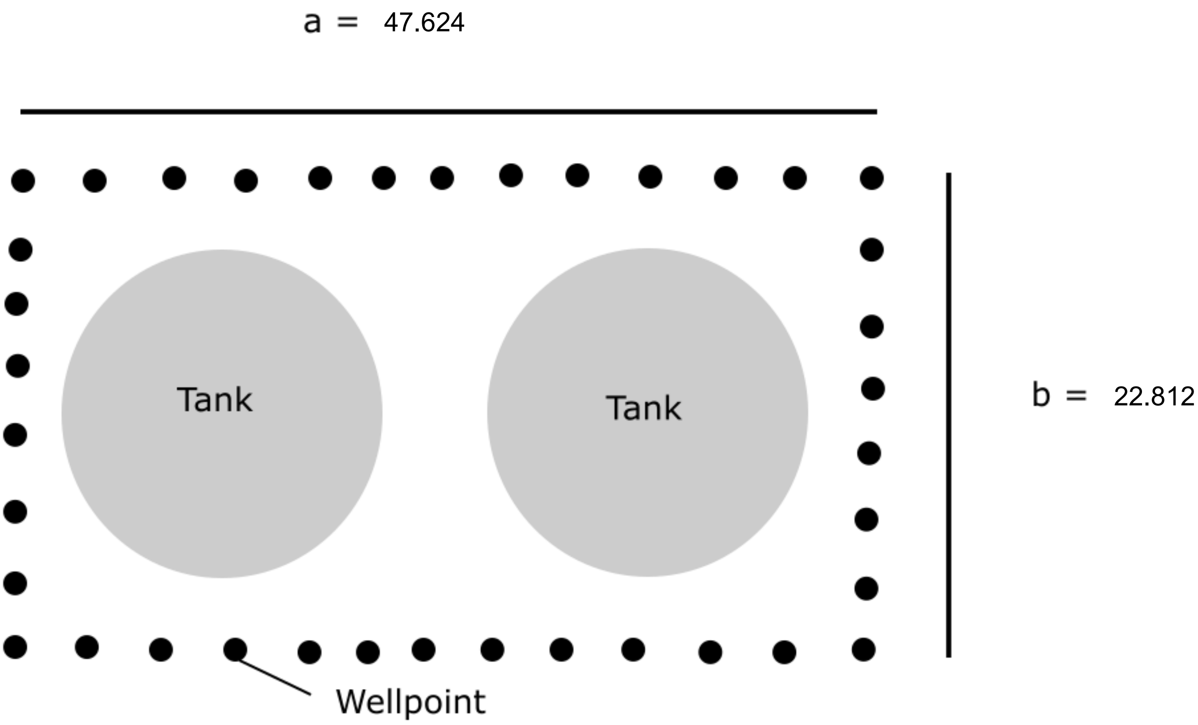


Figure 11 – Plane view of excavation showing approximate well arrangement 1.5m spacing's between wellpoints.

ID of tank = 19.812m

Space between approximately 5m

a = (19.812 x 2) + 5 + (1.5 x 2) = 47.624

b= 19.812 + (1.5 x 2) = 22.812

No. of well points = ((31.112m x 2) + (25.112m x 2)) / 3m = 38 well points

Equations for both r_e and R_o taken from CIRIA C750 section 6.2.1 can be found below:-

Equivalent well of radius; $\mathbf{r_e} = (a + b) / \pi$

If:

a = 47.624m

b = 22.812m

Then:

$\mathbf{r_e} = (a + b) / \pi$

$= (47.624 + 22.812) / \pi = (70.436) / \pi = 22.4m$

Design Calculation

Radius of influence $\mathbf{R_o} = C (H - h_w) \sqrt{(k)}$

If:

C = 3000

H = Base of aquifer (taken as base of the borehole) – GWL (ground water level mBGL)

= 7.75 – 0 = 7.75m

$\mathbf{h_w}$ = Base of aquifer – reduced GWL (taken as 1.5m below required drawdown level) = 7.75 – 6 = 1.75m

k = 9.03×10^{-5} m/s to 7.83×10^{-6} m/s

Then:

$\mathbf{R_o} = 3000 (7.75 - 1.75) \times \sqrt{10^{-5}} = 57$m

$\mathbf{R_o} = 3000 (7.75 - 1.75) \times \sqrt{10^{-4}} = 180$m

As groundwater level has been modelled at the surface the conditions have been assessed as unconfined.

Therefore:

Flow Rate

$$\text{Unconfined conditions: } Q = \frac{\pi k \left(H^2 - h_w^2\right)}{\ln\left[R_o / r_e\right]}$$

Q1 = $(\pi \times 10^{-5} (7.75^2 - 1.75^2)) / \ln((57 / 22.4))$

= 1.92×10^{-3} m/s = approximately 2 l/s

Q2 = $(\pi \times 10^{-4} (7.75^2 - 1.75^2)) / \ln((180/ 22.4))$

= 8.59×10^{-3} m/s = approximately 8.5l/s

Flow rate = 2 l/s – 8.5 l/s

7. SUMMARY

Findings of this preliminary assessment are

1. For 3.5m of drawdown of the water table, a single stage wellpoint system will be required to e installed around the two FST.
2. Estimated Discharge calculated to be approximately 2 – 8.5 l/s
3. Ground permeability estimated from soil descriptions only .
4. Wellpoints expected to be installed to approximately 6m depth at 1.5m spacings.

APPENDIX A – BOREHOLE LOGS

STRUCTURAL SOILS

BOREHOLE LOG

Contract	Client	Borehole No
Garnswllt WWTW, Ammanford	Montgomery Watson Ltd	BH1

Job No	Start / End	Ground Level (m AOD)	Co-Ordinates	Sheet
01629	Start 01.08.01 End 01.08.01			1 of 1

Depth	No	Type	Blows	Water	Instrumentation	Description of Strata	Depth (Thickness)
						Grass over brown clay TOPSOIL with frequent thin roots and some fine and medium sandstone gravel.	0.15
0.50	1	D				Firm brown sandy CLAY/SILT with much fine and medium subrounded to angular sandstone and limestone gravel. (Superficial Deposits)	0.50
1.00-1.45	2	CPT	21			Firm brown sandy SILT with much fine to coarse gravel and occasional cobble size angular to subrounded sandstone and limestone fragments. (Alluvial Deposits)	(1.80)
1.00-2.00	3	B					
2.00-2.45	4	CPT	25	1			2.30
2.00-3.00	5	B					
						Medium dense brown silty medium and coarse SAND and fine to coarse subrounded to angular GRAVEL size sandstone, quartz and limestone fragments with some cobble size subrounded, subangular and tabular limestone fragments. Occasional orange iron staining. (Glacial Sand and Gravel)	
3.00-3.45	6	CPT	13				
3.00-4.00	7	B					
4.00-4.45	8	CPT	11			... becoming slightly silty below 4.00m.	(3.70)
4.00-4.50	9	B					
4.50	10	W					
5.00-5.45	11	CPT	16			... grading to sandy GRAVEL and COBBLE size fragments below 5.00m.	
5.00-6.00	12	B					6.00
						Dense brown and red-brown medium and coarse SAND and fine and medium subrounded to angular GRAVEL size sandstone, grit, quartz and limestone fragments. Occasional cobble size subrounded limestone and quartz conglomerate. (Glacial Sand and Gravel)	
6.50-6.95	13	CPT	40				
6.50-7.00	14	B					(1.75)
7.00-7.31	15	CPT	97*			... becoming very dense towards 7.00m.	
7.00-7.50	16	B					
7.50-7.75	17	CPT	126*				7.75
						Borehole terminated at 7.75m depth.	

Boring Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth
01.08.01	-	2.40	1.50	150	2.40
01.08.01	+20mins	2.40	1.50	150	2.30
01.08.01	-	7.75	7.50	150	3.50

Chiselling

From	To	Hours
6.50	7.50	2.00

General Remarks

* Extrapolated CPT N-value.
Diesel hydrocarbon odour to groundwater strike.
Standing water level 2.00m below ground level 3 hours after completion.

All dimensions in metres Scale 1:50	Method Cable percussion	Drilled By JW	Logged By MW	Checked By

STRUCTURAL SOILS

BOREHOLE LOG

Contract	Client	Borehole No
Garnswllt WWTW, Ammanford	**Montgomery Watson Ltd**	**BH2**

Job No	Start / End	Ground Level (m AOD)	Co-Ordinates	Sheet
01629	Start **01.08.01** End **02.08.01**			**1** of **1**

Depth	No	Type	Blows	Water	Instrumentation	Description of Strata	Depth (Thickness)
						MADE GROUND: Grass over grey-brown clay TOPSOIL with frequent thin roots and gravel and cobble size sandstone, limestone and brick fragments.	0.40
0.50	1	D				MADE GROUND: Soft brown and green-grey mottled slightly sandy organic CLAY/SILT with a little scattered fine and medium subangular sandstone and limestone gravel.	(1.40)
1.00-1.45	2	CPT	5				
1.00-1.50	3	B					1.80
2.00-2.45	4	CPT	5			Soft brown and dark green-grey mottled sandy SILT with occasional thin orange-brown and purple-brown lenses and fine gravel size carbonised plant remains.	
2.00-2.50	5	B		1 (struck)			(1.20)
				1 (standing)		... with occasional decomposed timber fragments towards base of layer.	3.00
3.00-3.45	6	CPT	13			Medium dense brown very silty sandy medium and coarse subrounded to subangular GRAVEL and COBBLE size sandstone and limestone fragments. (Glacial Sand and Gravel)	(1.70)
3.00-3.50	7	B					
4.00-4.45	8	CPT	20			... grading to slightly silty sandy GRAVEL and occasional cobble size fragments towards 4.00m.	
4.00	10	W					
4.00-4.50	9	B					4.70
5.00-5.45	11	CPT	6			Loose brown silty medium and coarse SAND and fine to coarse subrounded and locally flat/tabular GRAVEL size sandstone, grit, quartz and limestone fragments. Occasional subrounded cobble size limestone fragments. (Glacial Sand and Gravel)	(1.10)
5.00-5.50	12	B					5.80
6.00-6.38	13	CPT	67*			Very dense pale brown and yellow-brown silty medium and coarse SAND and subrounded to angular GRAVEL size sandstone, quartz and limestone fragments. Occasional cobble size subrounded limestone fragments. (Glacial Sand and Gravel)	
6.00-6.50	14	B					(1.30)
6.50-6.79	15	CPT	103*			... grading to a very silty medium and coarse SAND with many gravel size fragments and occasional thin red-brown sandy clay laminae towards 6.5m.	
6.50-6.80	16	B					
6.80-7.10	17	CPT	99*				7.10
						Borehole terminated at 7.10m depth.	

Boring Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth
02.08.01	1305	3.00	1.50	150	3.00
02.08.01	1325	3.00	1.50	150	2.50
02.08.01	-	7.10	6.50	150	2.50

Chiselling

From	To	Hours
6.00	6.50	1.00
6.50	6.80	0.50

General Remarks

* Extrapolated CPT N-value.

All dimensions in metres Scale	Method	Drilled By	Logged By	Checked By
1:50	**Cable percussion**	**JW**	**MW**	

STRUCTURAL SOILS

BOREHOLE LOG

Contract	Client	Borehole No
Garnswllt WWTW, Ammanford	Montgomery Watson Ltd	BH3

Job No	Start / End	Ground Level (m AOD)	Co-Ordinates	Sheet
01629	Start 02.08.01 End 02.08.01			1 of 1

Samples and In-situ Tests: Depth	No	Type	Blows	Water	Instrumentation	Description of Strata	Depth (Thickness)	Legend
						Grass/weeds over dark grey-black clay/silt TOPSOIL and leaf mould with frequent thin roots.	0.30	
0.50	1	D				Soft dark brown and locally yellow-brown mottled CLAY/SILT with some medium and coarse gravel and cobble size subrounded limestone fragments. (Alluvial Deposits)		
1.00-1.45 1.00-2.00	2 3	CPT B	5			... with occasional lenses and pockets of loose sand and quartz and limestone gravel below 1.00m.	(1.70) 2.00	
2.00-2.45 2.00-2.50	4 5	CPT B	17	1 ▽ 1 ▼		Firm brown and dark green-grey thinly laminated slightly sandy organic CLAY/SILT with some scattered gravel and cobble size subrounded to subangular sandstone and limestone fragments. (Alluvial Deposits)	(1.00) 3.00	
3.00-3.45 3.00-3.50 3.00	6 7 8	CPT B W	16			Medium dense dark grey slightly silty medium and coarse SAND and fine subrounded to subangular GRAVEL size sandstone, quartz and limestone fragments. Some scattered coarse gravel and cobble size subrounded limestone fragments. (Glacial Sand and Gravel)	(1.00) 4.00	
4.00-4.45 4.00-4.50	9 10	CPT B	17			Medium dense brown slightly silty medium and coarse SAND and fine to coarse GRAVEL and occasional cobble size subrounded to subangular sandstone, grit, quartz, quartz conglomerate and limestone fragments. (Glacial Sand and Gravel)		
5.00-5.45 5.00-5.50	11 12	CPT B	48			... becoming dense, locally red-brown and pale grey towards 5.00m.	(2.00) 6.00	
						Very dense brown slightly sandy (medium and coarse) fine to coarse subrounded to angular sandstone, quartz and limestone GRAVEL. Occasional subangular elongate cobble size limestone fragments. (Glacial Sand and Gravel)		
6.50-6.88 6.50-7.00	13 14	CPT B	69*				(1.32)	
7.00-7.32	15	CPT	68*				7.32	
						Borehole terminated at 7.32m depth.		

Boring Progress and Water Observations

Date	Time	Borehole Depth	Casing Depth	Casing Diameter	Water Depth
02.08.01	0905	2.40	2.00	150	2.40
02.08.01	0925	2.40	2.00	150	2.20
02.08.01	-	7.32	7.00	150	3.00

Chiselling

From	To	Hours
6.50	7.00	1.00

General Remarks

* Extrapolated CPT N-value.
Standing water level 1.65m below ground level after pulling casing.

All dimensions in metres Scale 1:50	Method Cable percussion	Drilled By JW	Logged By MW	Checked By