DESIGN CALCULATIONS FOR PROPOSED FOUL WATER PUMPING STATION FOR WHITECHAPEL ROAD, CLECKHEATON

ON BEHALF OF

PDAS Ltd

Pump Design and Services Ltd

Date: May '22
Ref: 6711

DOCUMENT CONTROL RECORD

Document Issue:

Rev	Date	Issue Status	Prepared by	Checked by
-	18-05-22	First Issue	A Krakowiak BEng (Hons)	J A Kerton BEng CEng MICE

CONTENTS

MJA CONSULTING

Civil & Structural Engineers

www.mjaconsulting.co.uk

Ipsum Court
24 The Quadrant
Abingdon Science Park
Abingdon
Oxfordshire
OX14 3YS

DESIGN BRIEF

These design calculations cover the design of the wet well, inlet chamber, valve chamber and the cover slabs to the Foul Water pumping station.

The following calculations have been prepared to ensure that the inlet chamber, wet well and valve chambers do not become buoyant in certain conditions. These being in the permanent condition, when the tank may be considered empty. Long term ground water monitoring has not been undertaken therefore water is considered at worst case of being at ground level; for this condition we have assessed the tank against a factor of safety of 1.1. The chambers have also been assessed against the temporary condition during the construction phase to ensure that the chambers do not become buoyant. For the temporary condition we have assessed the chambers against a factor of safety of 1.0.

The design of the tank has been assessed to ensure that the allowable bearing capacity is not exceeded in the permanent condition with the tank 90% full of water. Ground conditions are Mudstones for deeper chambers. The allowable bearing capacity of this site has been taken as 100kPa. These values are based on Phase I and II Geo-environmental Report, Whitechapel Road, Cleckheaton, Ref: 17036/139, dated August 2018.

The cover slabs have been designed to the chambers to ensure that the they do not fail under an accidental wheel load applied.

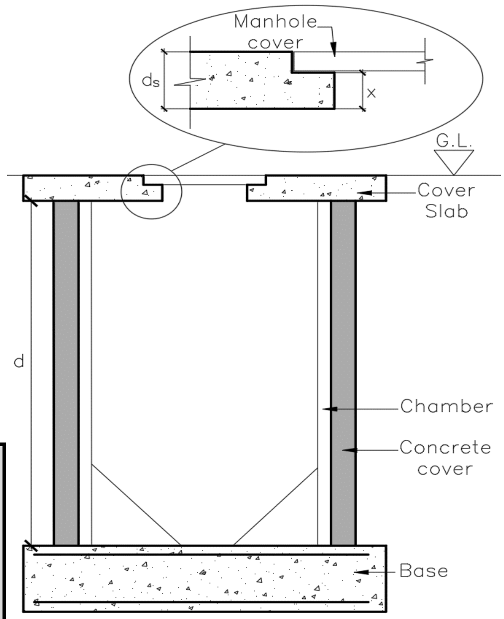
REFERENCES

- Sewers for Adoption – 6th Edition including interim technical addendum No.1
- BS 5911-6: 2004 +A1:2010 Concrete pipes and ancillary concrete products — Part 6: Specification for road gullies and gully cover slabs.
- BS 8110-1:1997 Structural use of concrete. Code of practice for design and construction
- Phase I and II Geo-environmental Report, Whitechapel Road, Cleckheaton, Ref: 17036/139, dated August 2018.

Wet Well Design (Worst case)

Chamber	
Wall thickness:	150 *mm*
Concrete cover:	200 *mm*
Internal diameter:	2700 *mm*
Depth (*d*):	4450 *mm*
Concrete γ	24 kN/m^3
Base	
Depth:	750 *mm*
Length:	3600 *mm*
Width:	3600 *mm*
Cover Slab	
Depth (d_s):	350 *mm*
Length:	3600 *mm*
Width:	3600 *mm*
Void Length:	1500 *mm*
Void Width:	900 *mm*
Void Depth (*x*):	210 *mm*
Ground Conditions	
Water Table:	0.0 *m*
ABP:	100 kN/m^2

Checks		
Floatation:	ACCEPTABLE	*(Perm)*
Bearing:	ACCEPTABLE	
Rebar required:	975 mm^2/m	
Provide:	3 layers A393 mesh top and bottom A_{sprov} =1179 mm^2/m	



Floatation

external diameter= 3.40 *m*

Volume of water displaced = 57.8 m^3

∴ mass of water displaced = 567.4 *kN*

self weight of chamber = 702.2 *kN*

FoS against floatation = $\frac{self\ weight\ x\ 0.9}{mass\ of\ water\ displaced}$ = $\frac{632.0}{567.4}$ = 1.11

1.11 > 1.1 ∴ ACCEPTABLE *against floatation*

Bearing

self weight of chamber empty = 702.2
Assuming 90% full of water = 225.0
Total = 927.1 *kN*

GBP = 71.5 kN/m^2

71.5 < 100 kN/m^2 ∴ ACCEPTABLE *in bearing*

Reinforcement

ULS = 983.1 *kN*

w = 75.9 *kN*

M_{ult} = 34.3 *kNm*

d = 660 *mm*

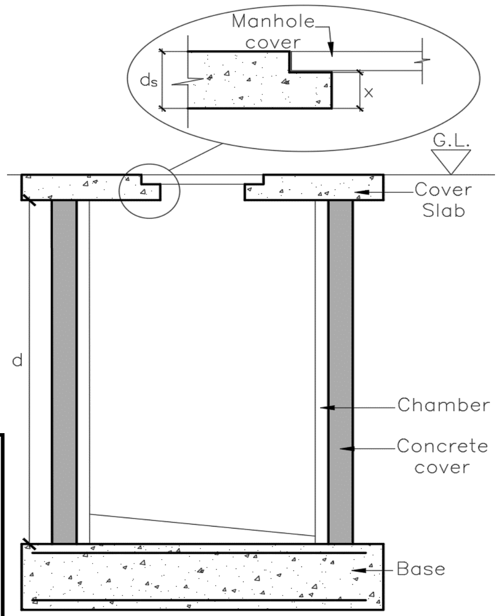
A_s = 126 mm^2/m

A_{smin} = 975 mm^2/m

Inlet Manhole Design

Chamber		
Wall thickness:	105	*mm*
Concrete cover:	150	*mm*
Internal diameter:	1500	*mm*
Depth (*d*):	2655	*mm*
Concrete γ	24	kN/m^3
Base		
Depth:	300	*mm*
Length:	2200	*mm*
Width:	2200	*mm*
Cover Slab		
Depth (d_s):	350	*mm*
Length:	2300	*mm*
Width:	2300	*mm*
Void Length:	675	*mm*
Void Width:	675	*mm*
Void Depth (*x*):	180	*mm*
Ground Conditions		
Water Table:	0.0	*m*
ABP:	100	kN/m^2

Checks		
Floatation:	ACCEPTABLE	*(Perm)*
Bearing:	ACCEPTABLE	
Rebar required:	390 mm^2/m	
Provide:	1 layers A393 mesh top and bottom A_{sprov} =393 mm^2/m	



Floatation

external diameter= 2.01 *m*

Volume of water displaced = 12.8 m^3

∴ mass of water displaced = 125.9 *kN*

self weight of chamber = 166.9 *kN* *temp* = 124.4 *kN*

FoS against floatation = $\frac{\text{self weight}}{\text{mass of water displaced}}$ = $\frac{166.9}{125.9}$ = 1.33

(Perm) 1.33 > 1.1 ∴ ACCEPTABLE *against floatation*

Bearing

self weight of chamber empty = 166.9
Assuming 90% full of water = 41.4
Total = 208.3 *kN*

GBP = 43.0 kN/m^2

43.0 < 100 kN/m^2 ∴ ACCEPTABLE *in bearing*

Reinforcement

ULS = 233.7 *kN*

w = 48.3 *kN*

M_{ult} = 6.7 *kNm*

d = 210 *mm*

A_s = 78 mm^2/m

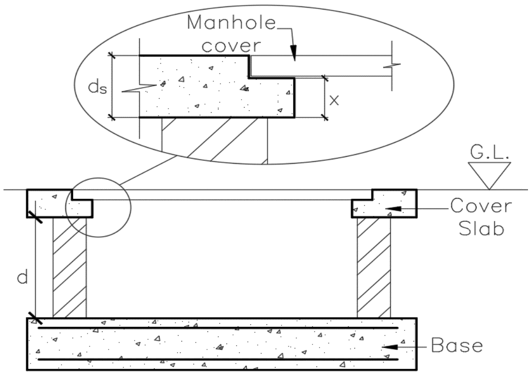
A_{smin} = 390 mm^2/m

Valve Chamber Design

Chamber	
Wall thickness:	215 *mm*
Internal diameters:	1800 *mm*
by	2400 *mm*
Depth (*d*):	1450 *mm*
Brickwork γ	22 kN/m^3
Base	
Depth:	300 *mm*
Length:	3000 *mm*
Width:	2400 *mm*
Cover Slab	
Depth (d_s):	350 *mm*
Length:	3600 *mm*
Width:	3000 *mm*
Void Length:	2400 *mm*
Void Width:	1800 *mm*
Void Depth (*x*):	180 *mm*
Ground Conditions	
Water Table:	0.0 *m*
ABP:	100 kN/m^2
Surcharge:	10.0 kN/m^2
φ':	22 °
γ:	18 kN/m^2

Checks		
Floatation:	ACCEPTABLE	*(Perm)*
Bearing:	ACCEPTABLE	
Rebar required:	390 mm^2/m	
Provide:	1 layer A393 mesh top and bottom A_{sprov} =393 mm^2/m	
Masonry Panel:	ACCEPTABLE	

Mortar class:	I (M12)
Masonry unit:	clay bricks (absorption <7%)



Floatation

Volume of water displaced = 17.3 m^3

∴ *mass of water displaced* = 169.7 *kN*

self weight of chamber = 187.4 *kN* *temp* = 115.3 *kN*

FoS against floatation = $\frac{self\ weight}{mass\ of\ water\ displaced}$ = $\frac{187.4}{169.7}$ = 1.10

(Perm) 1.10 > 1.1 ∴ ACCEPTABLE *against floatation*

Bearing

self weight of chamber empty = 187.4
Assuming 90% full of water = 57.9
Total = 245.3 *kN*

GBP = 34.1 kN/m^2

34.1 < 100 kN/m^2 ∴ ACCEPTABLE *in bearing*

Reinforcement

ULS = 262.4 *kN*

w = 36.4 *kN*

M_{ult} = 13.0 *kNm*

d = 210 *mm*

A_s = 150 mm^2/m

A_{smin} = 390 mm^2/m

Wall design

	K_a	=	0.45
	K_0	=	0.63
	$P_{a(ULS)}$	=	22.9
	$P_{s(ULS)}$	=	10.0
			32.9 kN/m^2
	h/l	=	0.60
	μ	=	0.35
therefore	α	=	0.024

Design bending moment for panel:

a) perpendicular to bed joints = 4.61 *kNm*
b) parallel to bed joints = 1.61 *kNm*

f_{kx}	=	2.0 N/mm^2
γ_m	=	3.0
z	=	7.7 mm^3

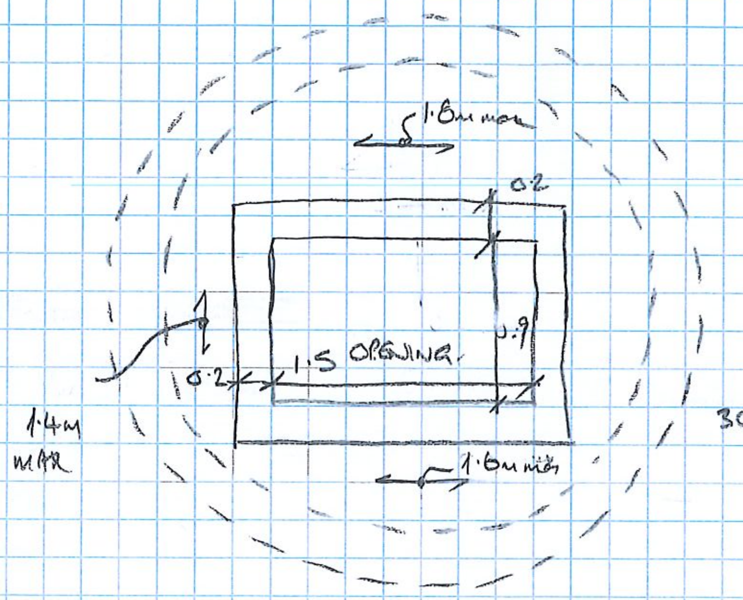
Moment resistance of panel:

M_R = 5.1 *kNm*

5.1 > 4.61 *kNm* ∴ ACCEPTABLE

Project	Job No.	Date	Page No.	Rev
			PS/01	
	Member/Location		Engineer	Checked
	COVER SLAB		JAK	

COVER SLAB



IL: 10 kN/m² basic HA construction loading

PL = 100 kN

COVER SLAB RECESSED FOR ACCESS LID ~ 2.0 kN/m² DL

• Check shear in rib

Assume worst case load carried on 2 opposite sides only

ult = (1.4 × 2.0 + 1.6 × 10) × 1.3/2 = 12.2 kN/m run each side

d = 140 − 30 − 10/2 = 105 mm try H8 bars @ 100 c/c Asprov = 503 mm²/m

$v = \frac{12.2 \cdot 10^3}{1000 \times 105} = 0.12$ N/mm²

$\frac{100 A_s}{bd} = \frac{100 \times 503}{1000 \times 105} = 0.48 < 3.0$ ∴ OK

$\frac{400}{d} = \frac{400}{105} = 3.8$ $\left(\frac{f_{cu}}{25}\right)^{1/3} = \left(\frac{40}{25}\right)^{1/3} = 1.17$

$v_c = 0.79 (0.48)^{1/3} \times (3.8)^{1/4} \times \frac{1.17}{1.25}$

= 0.81 N/mm² >> 0.12 N/mm² ∴ Adequate in shear

Project	Job No.	Date	Page No.	Rev
			PS/02	
	Member/Location: COVER SLAB		Engineer: DRK	Checked

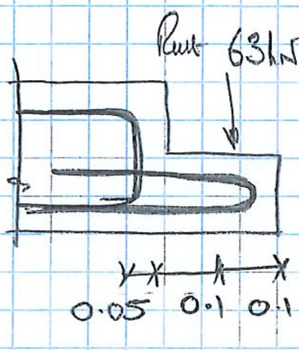
Central PL = 100kN carried on opposite edges

ult load = $(1.6 \times 100/2 + 1.4 \times 2.0 \times 1.3/2) = \underline{82kN}$

short edge 1.3m lg ⇒ $\frac{82}{1.3}$ = $\underline{63 kN/m \text{ equivalent line load}}$

$v = \frac{63.10^3}{10^3 \times 105} = \underline{0.6 N/mm^2 < v_c (0.81) \therefore \text{Adequate}}$

Nib Bending



Mult = 63 × 0.15 = $\underline{9.45kNm}$

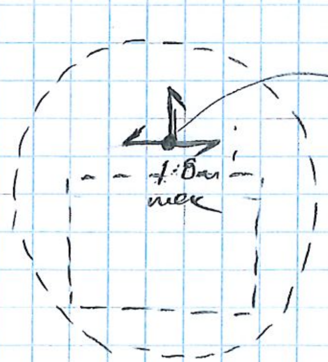
$\frac{M}{bd^2} = \frac{9.45.10^6}{1000 \times 105^2} = 0.857 \Rightarrow \underline{z = 0.95d}$

$As_{req'd} = \frac{9.45.10^6}{0.87 \times 500 \times 0.95 \times 105} = \underline{218 mm^2/m \text{ min}}$

$As_{min} = 0.13 \frac{bh}{100} = 182 mm^2/m < As_{req'd}$

$\underline{As_{prov} = 503 mm^2/m > As_{req'd} \therefore \text{Adequate}}$

Cover Slab Bending



Ignore benefits of side support for general loading

DL = 0.3 × 24 = 7.2 kN/m²

ult = (1.4 × 7.2 + 1.6 × 10) = $\underline{26.1 kN/m^2}$

Mult = $26.1 \times 1.8^2/8 \times 1 = \underline{10.6kNm}$

Project	Job No.	Date	Page No. PS/03	Rev
	Member/Location: COVER SLABS		Engineer: JAK	Checked

Point load condition:

$M_{ult} = 1.4 \times 7.2 \times 1.8^2/8 + 1.6 \times 100 \times 1.8/4 = 4 + 72$

$= \underline{76 kNm}$

$d = 300 - 35 - 20/2 = 255mm$

$\frac{M}{bd^2} = \frac{76.10^6}{1000 \times 255^2} = \underline{1.17} \div 40 = 0.029$

$\therefore \underline{Z = 0.95d}$

$As_{req'd} = \frac{76.10^6}{0.87 \times 500 \times 0.95 \times 255} = \underline{721 mm^2/m}$

$As_{min} = 0.13 \times 1000 \times \frac{255}{100} = \underline{332mm^2/m < As_{req'd}}$

use H12 bars @ 100 c/c

$\underline{As_{prov} = 1131 mm^2/m > As_{req'd} \therefore \text{Adequate}}$

$fs = \frac{2}{3} \times \frac{721}{1131} \times 500 = \underline{212 N/mm^2}$

$mf = 0.55 + \frac{(477 - 212)}{120(1.17 + 0.9)} = \underline{1.62}$

allowable span/d = 20mf = 20 × 1.62 = 32

actual span/d = $\frac{1800}{255}$ = $\underline{7 < 32 \therefore \text{Adequate}}$

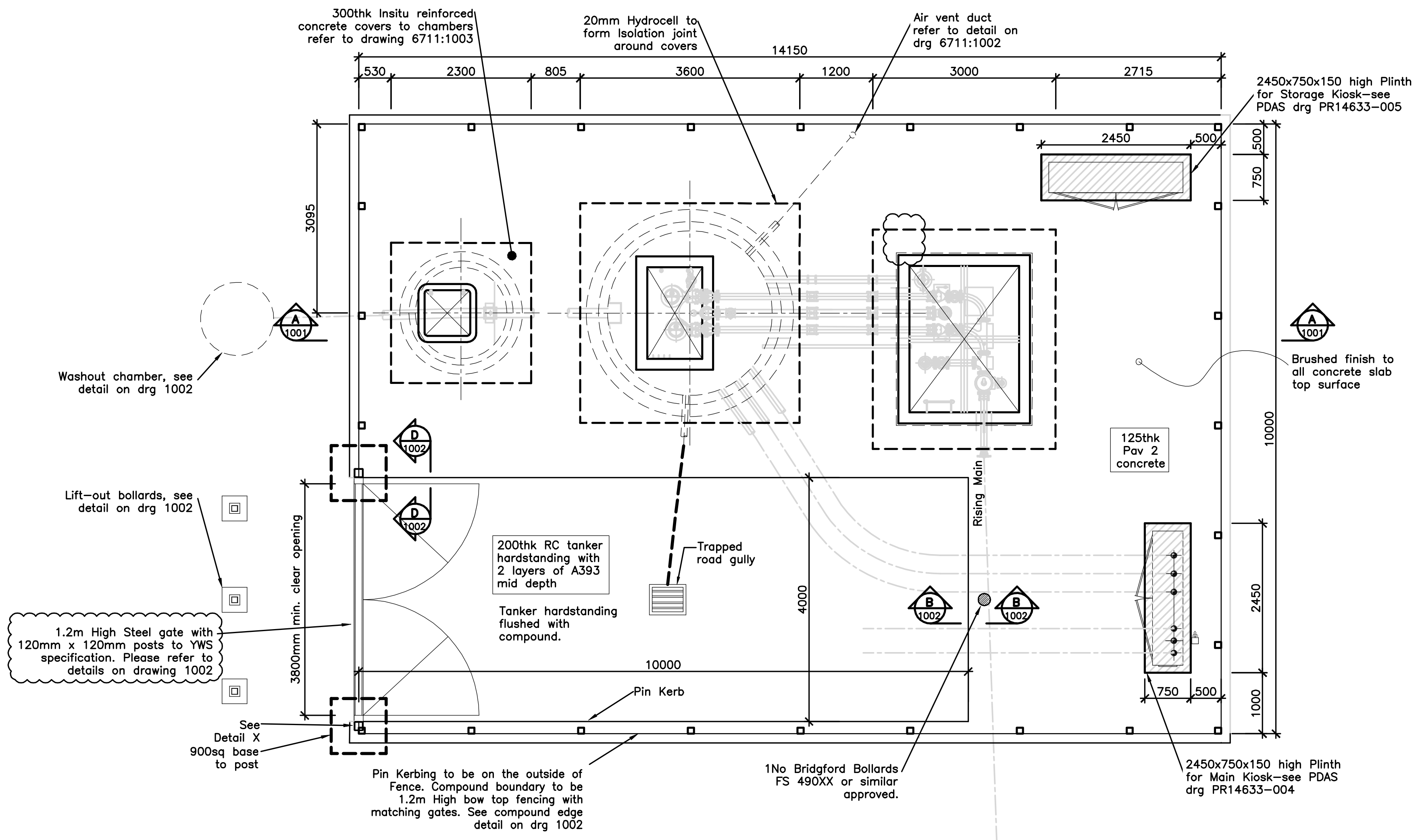
Shear check:

$V_{ult} = (1.4 \times 7.2 \times 1.8/2 + 1.6 \times 100/2) = \underline{89 kN}$

$v = \frac{89.10^3}{1000 \times 255} = \underline{0.34 N/mm^2}$

$v_c = 0.79 (0.44)^{1/3} \times (1.57)^{1/4} \times 1.17/1.25$

$= \underline{0.63 N/mm^2 > 0.34 N/mm^2 \therefore \text{Adequate for shear}}$



Note: all dimensions indicated are to be confirmed on site

Compound setting out layout
(1:50)

1 layer of A393 Mesh mid depth in 125thk PAV with 400mm laps (flying ends)

Details in accordance with PDAS Ltd drg PR14633–006
Check against latest drawings before construction

Reinforced Concrete Notes:

1. This drawing is to be read in conjunction with PDAS Ltd drawings.
2. Dimensions must not be scaled from this drawing.
3. All reinforced concrete is designed to BS 5400 and all construction is to comply with this code.
4. Reinforced concrete to be Grade: RC40/50 for below ground structure, specified in accordance with BS 8500 & BS 206–1.

Above ground/hard surface slabs to be exposure class XF2 & provide grade: PAV2 concrete.

All reinforced concrete below ground level to be exposure classes XD3, XC3/4, design sulphate class AC–2z & DC–2z in accordance with BRE Special Digest No 1:Part 1. Maximum aggregate size: 20mm.

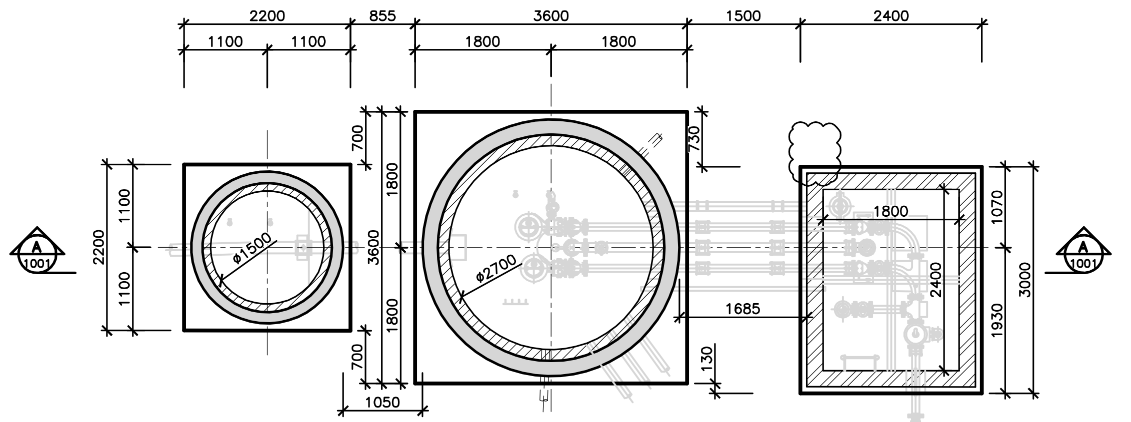
5. Concrete test samples shall be provided in accordance with the requirements of BS EN 12350–1.
6. All excavations for reinforced concrete shall be kept free from water, loose material and rubbish.
7. Reinforcement should comply with BS 4449, 8666, 4482 or 4483. All reinforcement designated 'B' should be high yield high yield in accordance with BS 4482 and BS 4483.
8. Reinforcement shall be free from oils, paint etc (which may adversely affect its bond with the concrete).
9. Cover to reinforcement to be: Nominal 50mm cover when cast against shutters & blinding, 75mm all other faces. Tolerance Δc=5mm for below ground and for above ground/hard surface slabs nominal cover to be 50mm+Δc
10. Top reinforcement in slabs shall be supported on mild steel chairs to ensure all reinforcement has the required cover of concrete.
11. Spacer blocks are to be made of precast concrete or a suitable plastic alternative. They shall be used to ensure that all reinforcement has the required cover of concrete. Pieces of wood, brick etc are not permitted.
12. It shall be the responsibility of the contractor to check bending schedules against the drawings prior to the ordering of the reinforcement and to notify the Engineer of any discrepancies.
13. The structure is designed to be stable upon completion, temporary stability is the responsibilty of the Contrator.
14. Surface finish to contract specification.

Pumping equipment as specified and detailed by PDAS Ltd.

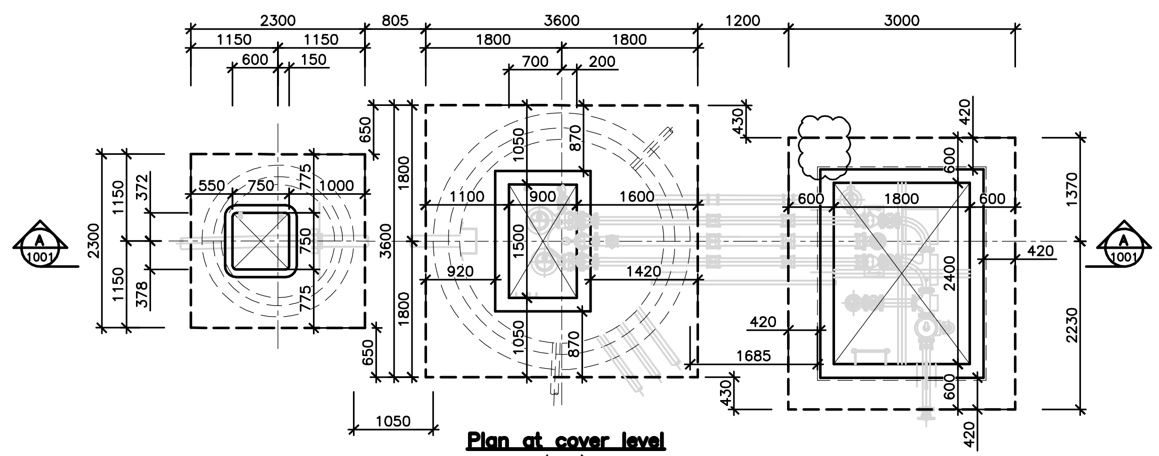
Minimum Laps for Reinforcement

Bar Dia	Lap Lengths
H8	325 mm
H10	400 mm
H12	475 mm
H16	625 mm
H20	1050 mm
H25	1300 mm
H32	1675 mm

All minimum laps to reinforcement are to comply with the requirements of BS 8110.



Plan at base level
(1:50)



Plan at cover level
(1:50)

REV. No.	DATE	DESCRIPTION	DRAWN	CHECKED
P2	11/05/22	Air ducts removed from the valve chamber. Gate post size updated.	AK	JAK
P1	05/05/22	Preliminary Issue.	AK	JAK

Client: PDAS Ltd

MJA CONSULTING
CIVIL & STRUCTURAL ENGINEERS
Ipsum Court, 24 The Quadrant,
Abingdon Science Park, Abingdon
Oxon, OX14 3YS
Tel: 01235 555173
Email: mail@mjaconsulting.co.uk

Project: Whitechapel Road, Cleckheaton

Title: Pump Station GA & RC Details Sheet 1

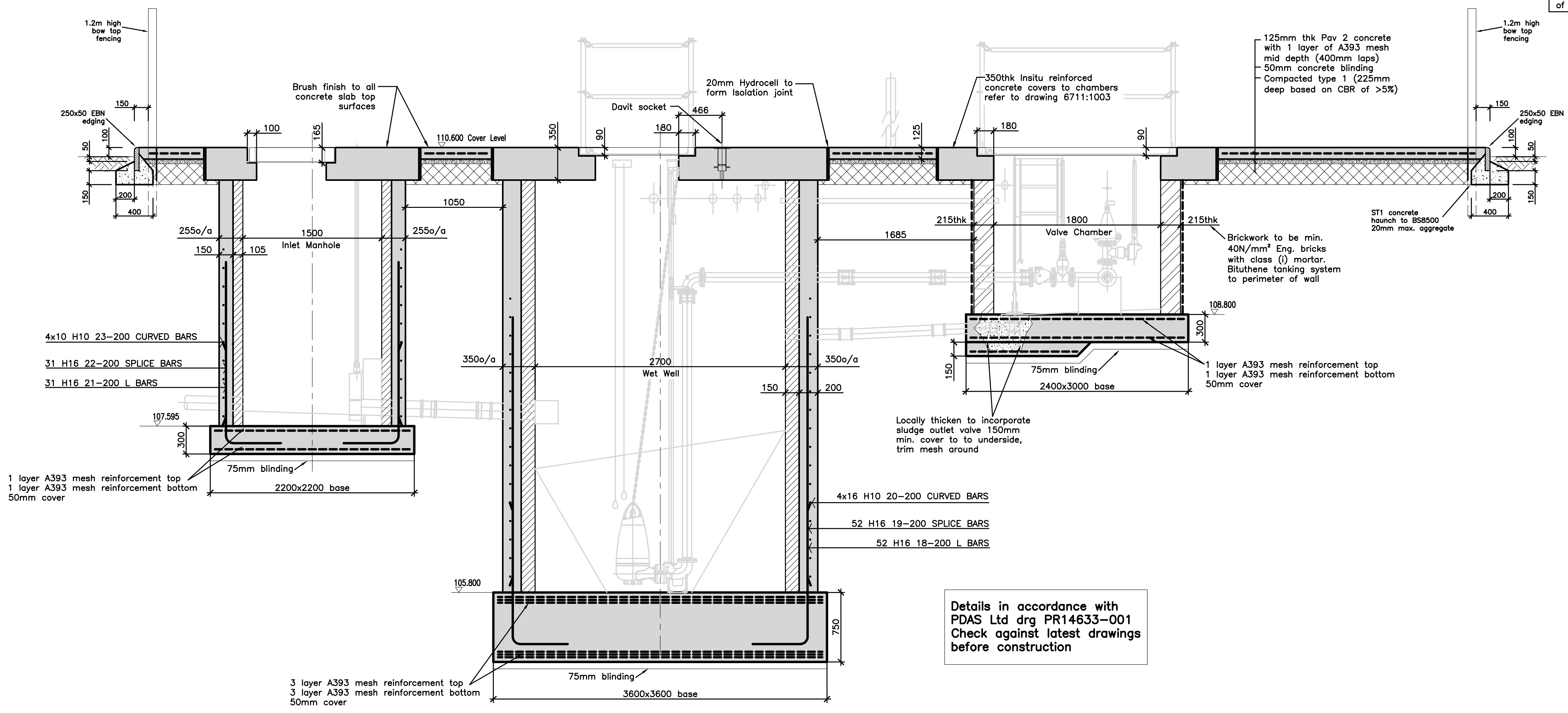
Scale: As shown@A1	Status: PRELIMINARY
Drawn: AK / Project Engineer: JAK / MJA Project No: 6711	Date: 04/05/2022
Drawing Number: 6711–MJA–SW–XX–DR–S–1000	Rev: P2

Pumping equipment as specified and detailed by PDAS Ltd.

Minimum Laps for Reinforcement

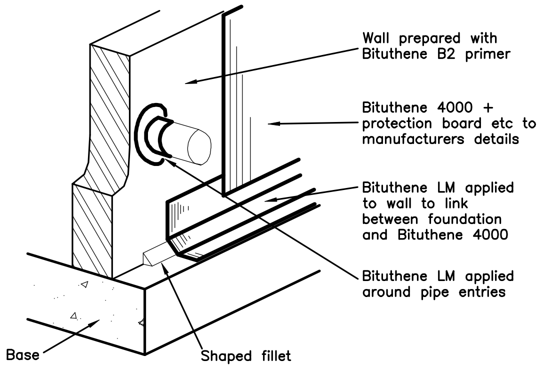
Bar Dia	Lap Lengths
H8	325 mm
H10	400 mm
H12	475 mm
H16	625 mm
H20	1050 mm
H25	1300 mm
H32	1675 mm

All minimum laps to reinforcement are to comply with the requirements of BS 8110.



Details in accordance with PDAS Ltd drg PR14633-001 Check against latest drawings before construction

Section A – A
(1:25)



Isometric view on valve chamber wall

REV. No.	DATE	DESCRIPTION	DRAWN	CHECKED
P1	05/05/22	Preliminary Issue.	AK	JAK

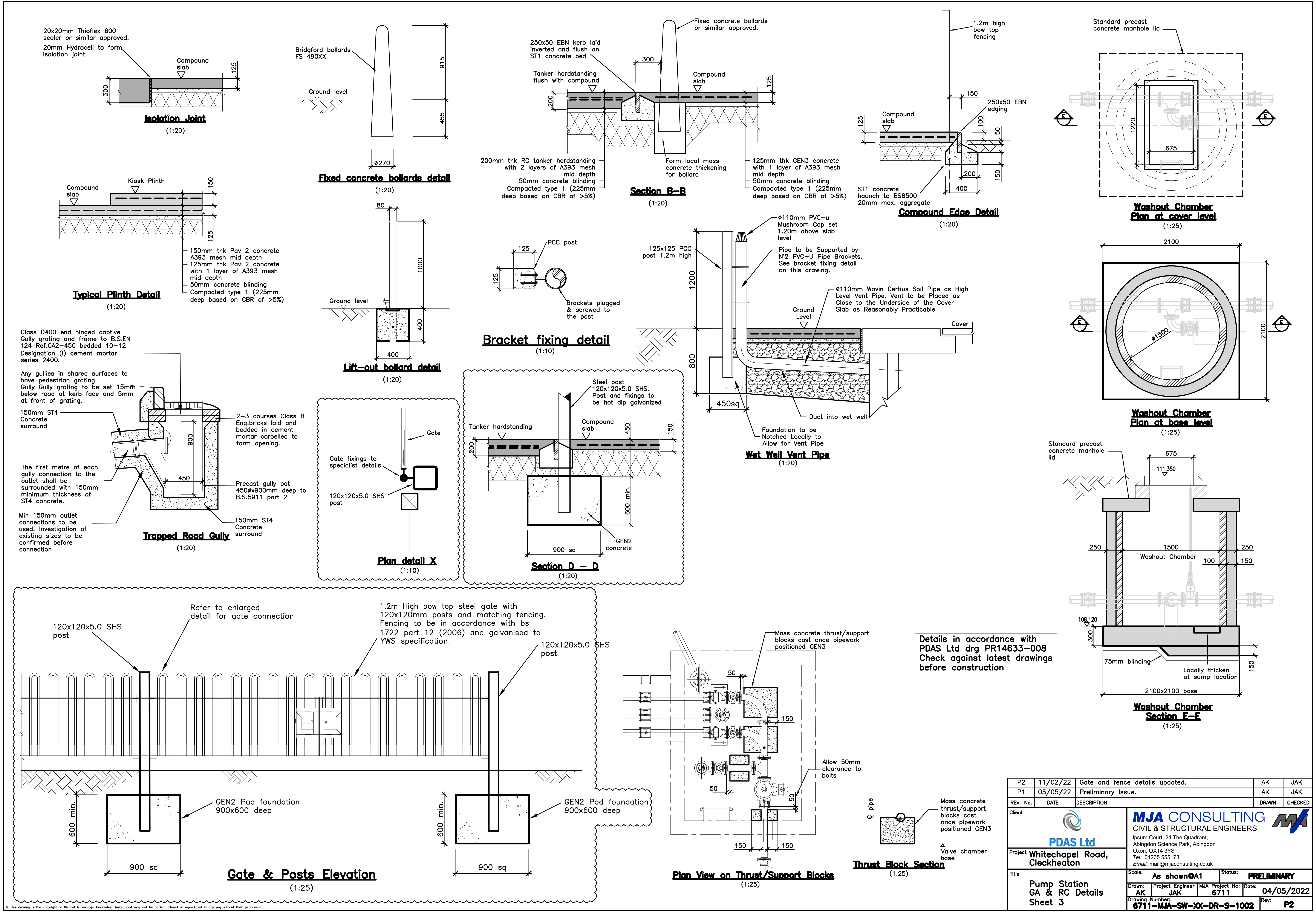
Client: PDAS Ltd

MJA CONSULTING
CIVIL & STRUCTURAL ENGINEERS
Ipsum Court, 24 The Quadrant, Abingdon Science Park, Abingdon Oxon, OX14 3YS
Tel: 01235 555173
Email: mail@mjaconsulting.co.uk

Project: Whitechapel Road, Cleckheaton

Title: Pump Station GA & RC Details Sheet 2

Scale: As shown@A1		Status: PRELIMINARY	
Drawn: AK	Project Engineer: JAK	MJA Project No: 6711	Date: 04/05/2022
Drawing Number: 6711-MJA-SW-XX-DR-S-1001			Rev: P1



Details in accordance with PDAS Ltd drg PR14633-008
Check against latest drawings before construction

REV. No.	DATE	DESCRIPTION	DRAWN	CHECKED
P2	11/02/22	Gate and fence details updated.	AK	JAK
P1	05/05/22	Preliminary Issue.	AK	JAK

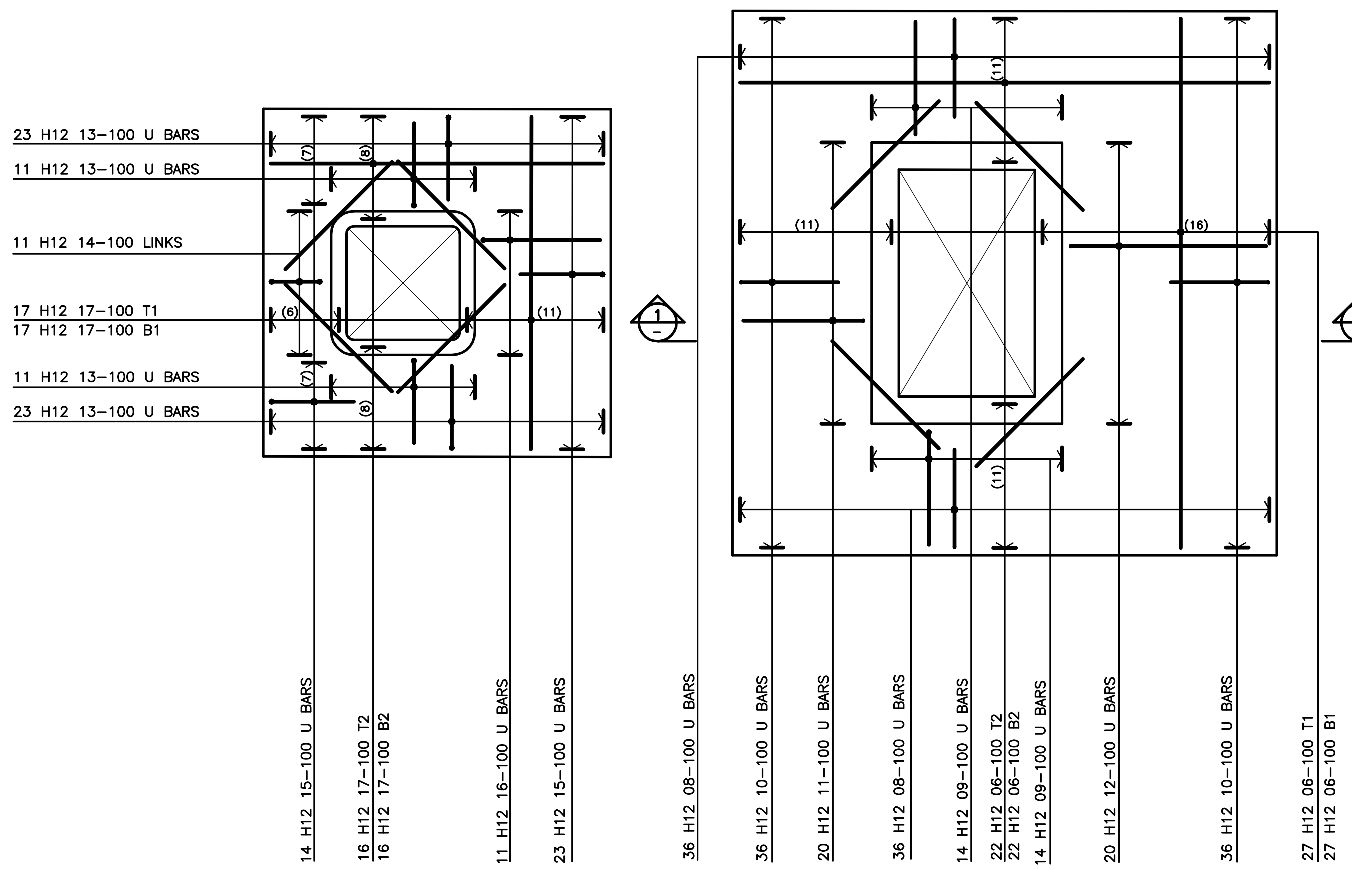
Client: PDAS Ltd

MJA CONSULTING
CIVIL & STRUCTURAL ENGINEERS
Ipsum Court, 24 The Quadrant, Abingdon Science Park, Abingdon
Oxon, OX14 3YS
Tel: 01235 555173
Email: mail@mjaconsulting.co.uk

Project: Whitechapel Road, Cleckheaton

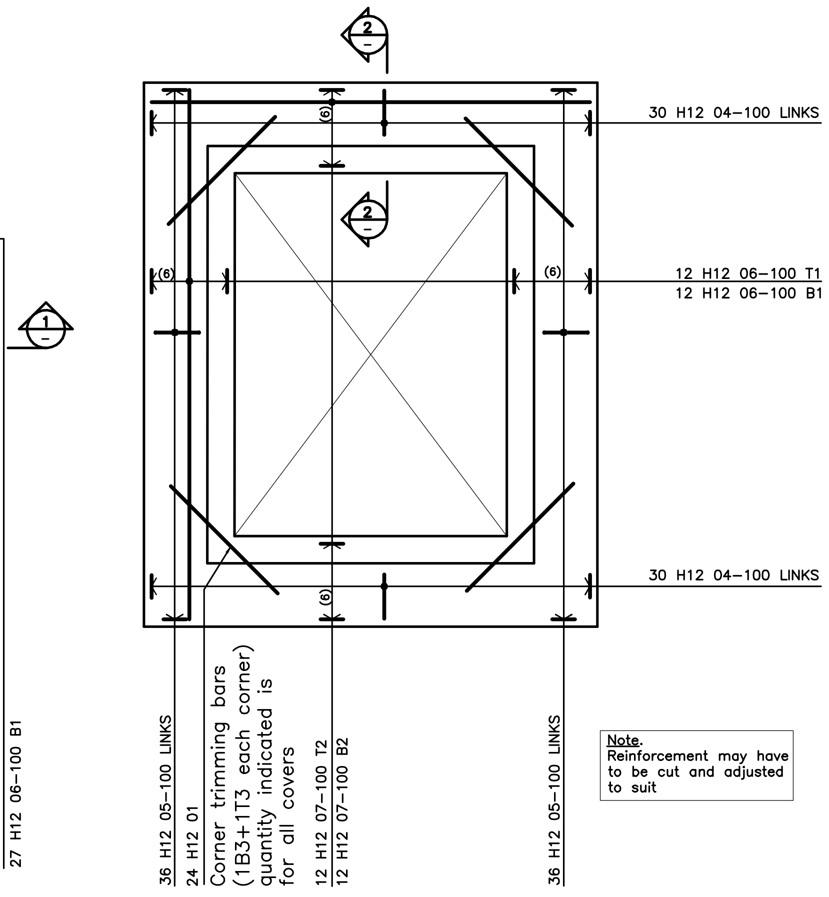
Title: Pump Station GA & RC Details Sheet 3

Scale:	Status:	Drawn:	Project Engineer	MJA Project No:	Date:	Drawing Number:	Rev:
As shown@A1	PRELIMINARY	AK	JAK	6711	04/05/2022	6711-MJA-SW-XX-DR-S-1002	P2



R.C. Plan Wet Well cover

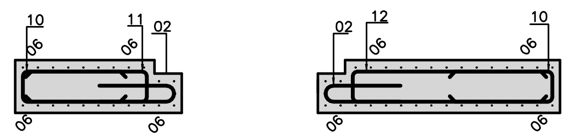
(Scale 1:25)



Note.
Reinforcement may have to be cut and adjusted to suit

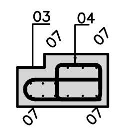
R.C. Plan valve chamber surround

(Scale 1:25)



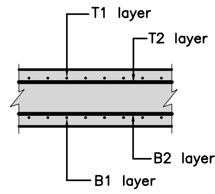
Section 1–1

(Scale 1:25)



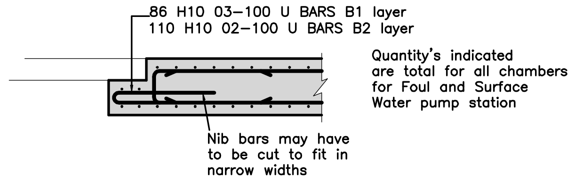
Section 2–2

(Scale 1:25)



Reinforcement layering

(1:20)



Quantity's indicated are total for all chambers for Foul and Surface Water pump station

Typical edge detail at access holes

(1:20)

Reinforced Concrete Notes:

1. This drawing is to be read in conjunction with PDAS Ltd drawings.
2. Dimensions must not be scaled from this drawing.
3. All reinforced concrete is designed to BS 5400 and all construction is to comply with this code.
4. Reinforced concrete to be Grade: RC40/50 for below ground structure, specified in accordance with BS 8500 & BS 206–1.

Above ground/hard surface slabs to be exposure class XF2 & provide grade: PAV2 concrete.

All reinforced concrete below ground level to be exposure classes XD3, XC3/4, design sulphate class AC–2z & DC–2z in accordance with BRE Special Digest No 1:Part 1. Maximum aggregate size: 20mm.

5. Concrete test samples shall be provided in accordance with the requirements of BS EN 12350–1.
6. All excavations for reinforced concrete shall be kept free from water, loose material and rubbish.
7. Reinforcement should comply with BS 4449, 8666, 4482 or 4483. All reinforcement designated 'B' should be high yield high yield in accordance with BS 4482 and BS 4483.
8. Reinforcement shall be free from oils, paint etc (which may adversely affect its bond with the concrete).
9. Cover to reinforcement to be: Nominal 50mm cover when cast against shutters & blinding, 75mm all other faces. Tolerance Δc=5mm for below ground and for above ground/hard surface slabs nominal cover to be 50mm+Δc
10. Top reinforcement in slabs shall be supported on mild steel chairs to ensure all reinforcement has the required cover of concrete.
11. Spacer blocks are to be made of precast concrete or a suitable plastic alternative. They shall be used to ensure that all reinforcement has the required cover of concrete. Pieces of wood, brick etc are not permitted.
12. It shall be the responsibility of the contractor to check bending schedules against the drawings prior to the ordering of the reinforcement and to notify the Engineer of any discrepancies.
13. The structure is designed to be stable upon completion, temporary stability is the responsibility of the Contrator.
14. Surface finish to contract specification.

Refer to bar schedule 6711–MJA–SW–XX–SH–S–B1003

Pumping equipment as specified and detailed by PDAS Ltd.

Minimum Laps for Reinforcement

Bar Dia	Lap Lengths
H8	325 mm
H10	400 mm
H12	475 mm
H16	625 mm
H20	1050 mm
H25	1300 mm
H32	1675 mm

All minimum laps to reinforcement are to comply with the requirements of BS 8110.

Please refer to the following Bar Bending Schedule for beam reinforcement:

BAR BENDING SCHEDULE REFERENCE			
Schedule no: 6711–MJA–SW–XX–SH–S–B1003			Rev: P1
Date: 05/05/22	Prepared by: AK	Checked by: JAK	Rev date:

REV. No.	DATE	DESCRIPTION	DRAWN	CHECKED
P1	05/05/22	First issue.	AK	JAK

Client: PDAS Ltd

MJA CONSULTING
CIVIL & STRUCTURAL ENGINEERS
Ipsum Court, 24 The Quadrant,
Abingdon Science Park, Abingdon
Oxon, OX14 3YS
Tel: 01235 555173
Email: mail@mjaconsulting.co.uk

Project: Whitechapel Road, Cleckheaton

Title: Pump Station RC Details Sheet 4

Scale: As shown @ A1			Status: PRELIMINARY
Drawn: AK	Project Engineer: JAK	MJA Project No: 6711	Date: 05/05/2022
Drawing Number: 6711–MJA–SW–XX–DR–S–1003			Rev: P1