Technical note

Project:	Queens Quay	**To:**	VITAL Energi
Subject:	Review of Intake Sump Design	**From:**	Paul Timmons
Date:	3 Apr 2019	**cc:**	Steven Cowan

Author: Tom Slater **Checker:** Steffi Aziz **Reviewer:** Paul Timmons

1. Introduction

As part of the Queens Quay development project Atkins have been commissioned to provide input into the design of an intake sump. The sump design requires positioning of the strainer to allow sufficient operation whilst minimising the rate of material deposition and associated maintenance at the pump chamber base.

2. Existing Design

The main components of the river intake system are:
- Intake screens, intake sump and maintenance platform (Riverside).
- Pumps and filters housed within the pump chamber (Landside).

2.1.1. Intake Sump

In Nov. 2017 Ramboll produced a Design Basis and Assumptions document (Rev 3) for Queen Quay District Heating. Appendix 2 of this Design Basis and Assumptions document contains a concept report developed for River Abstraction and Discharge of this project. Key conclusions of this report are as follows:

- The report concluded the lowest recorded water level compromises the necessary submergence required to keep the intake strainers flooded.
- The report proposed sump areas below bed level formed by concrete or sheet piling with 1000mm clearance between intake strainers and the sump floor to allow adequate submergence to be realised at all water levels without impacting operation.
- For an AMIAD FS-14 River Intake Strainer System the minimum clearance for strainers is 900mm to each other and 500mm away from other infrastructure.
- Site photographs show evidence of the accumulation of significant sized debris including timber and trees onto the existing structure. Therefore, collision protection barriers may be required to prevent contact of large debris with the proposed intake pipes.

A design was developed in 2018 to support the intake sump chamber structure entirely from the sheet piled wall, independent of the river bed.

This concept was developed in drawing 15001-420 produced by Arch Henderson in June 2018. This drawing shows the pump sump chamber formed from a steelwork box supported by a frame fixed to the sheet piled wall. In this design the pump sump chamber is mostly submerged below river bed level forming a “pocket” which will house the intake screen strainer and pipework.

Drawing 15001-420 was updated to Revision A and issued on 16.01.19 as a draft for discussion. Atkins were commissioned to comment on the intake sump design based on the concept provided by Arch Henderson in drawing 15001-420 Rev A.

Arch Henderson have subsequently updated this drawing and proposed layout as per 155001-420C (Intake Sump) and this TN has been revised accordingly taking cognisance of these changes.

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2.1.2. Pump Chamber and Filters

Pump chamber design has been completed to "For Review" stage by Arch Henderson. Drawings of this design are listed in Appendix A.

2.1.3. Intake Screens

The intake strainer will be AMIAD FS-14 intake screens.

Technical details of this system have been obtained from direct contact between Vital Energi, AMIAD (the pump supplier) and STF-Vican (the strainer manufacturer).

The required clearance for operation is as follows:

- Minimum 0.5m clearance offsets around the strainer,
- Minimum 0.3m clearance offset below the strainer,
- Filter submergence:
  - The filter should be submerged at all times,
  - AMIAD recommended 1m clearance between the minimum water level and top of strainer filter intake. This accounts for a minimum operating head of the strainer and an allowance for weather conditions such as wind, waves and any other disturbance on the water level.

2.1.4. Maintenance platform

A riverside platform is required for maintenance and removal of screens and associated pipework the concept of which was agreed at a Project meeting on 10.01.18. The updated concept is as reported on Arch Henderson drawing 155001-420 Rev C.

Design of this platform and associated pipework should take cognisance of wave loading where appropriate.

3. Marine Considerations

3.1. Wave Loading

Maximum wave heights were calculated for the Queens Quay location using JONSWAP wave height prediction curves[1] based a maximum fetch of 1500 m and maximum wind speed of 27 m/s derived from UK National Annex to EC 1 - Actions of Structures Part 1-4 - General actions - Wind actions (2010).

The maximum predicted wave height at the structure, H_s = 0.65m.

Wave loading on the structure was calculated as a uniform pressure at a maximum 10kN/m^2 based on the wave height above with Horoi (1917) and Goda (1973) formulas.

[1] K McConnell (1998), Revetment systems against wave attack - A Design Manual, Section 7.2.2 Wave Prediction Methods, JONSWAP wave height prediction curves

3.2. Water Levels

Tide levels for nearby Clydebank (Rothesay Dock) are listed below in Table 1.

Table 1. Clydebank (Rothesay Dock) tide levels - Admiralty tide book (2017)

Datum	Mean L	MHWS	MHWN	MLWN	MLWS
m Chart Datum (CD)	2.71	4.5	3.7	1.6	0.6
m Above Ordnance Datum (AOD)	0.51	2.3	1.5	-0.6	-1.6

Tidal levels for the Queens Quay location were predicted from a tidal simulation[2] at nearby Clydebank (Rothesay Dock). The exceedance probability curve for tide levels is shown below.

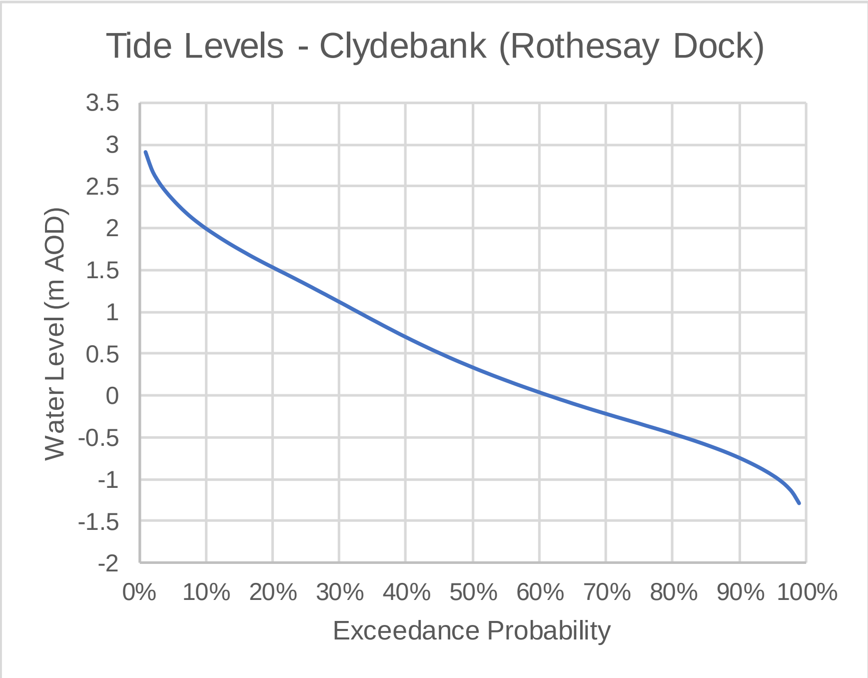

Figure 1 - Tide Level Exceedance Curve - Clydebank (Rothesay Dock)

It should be noted that these simulations do not take account of the fluvial flow in the river which may influence levels at this location. The level of this influence is considered minor and as will most likely to increase rather than reduce the predicted levels. Therefore, this effect has conservatively not been considered.

[2] 16-year period simulated with TIDSIM software using harmonic constants from Admiralty tide tables (2017)

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3.3. Intake strainer position

3.3.1. Design minimum water level

The intake strainer will have insufficient submergence when tidal levels fall below the minimum water level required for intake strainer operation. Tidal simulation results were examined to understand the impact of differing water levels on operation.

The number of annual occurrences in which tide levels fall below certain levels is shown in Table 2.

Table 2. Periods when tides are below different water levels

Water Level	% Tides below water level	Periods per year when tide levels are below water level		
		1-2 hours	2-4 hours	>4 hours
0m AOD	39%	0	89	661
-0.25m AOD	29%	34	477	216
-0.5m AOD	18%	98	496	0
-0.75m AOD	10%	165	232	0
-1m AOD	4%	140	45	0
-1.1m AOD	2.6%	112	11	0
-1.2m AOD	1.6%	77	0	0
-1.3m AOD	0.9%	39	0	0
-1.4m AOD	0.5%	14	0	0
-1.5m AOD	0.2%	3	0	0
-1.6m AOD	**0.0%**	**0**	**0**	**0**
-1.7m AOD	0	0	0	0

In agreement with Vital Energi a design minimum water level of -1.6m AOD was chosen. Whilst this level suggests zero number outages, there remains the risk that local variations may still induce outage events.

3.3.2. Intake strainer level

Based on the design minimum water level (-1.6m AOD) and a minimum submergence of 1m below design water level (Section 2.1.3) the top of the strainer water intake would be set at -2.6m AOD.

Strainer dimensions are as shown on Figure 2

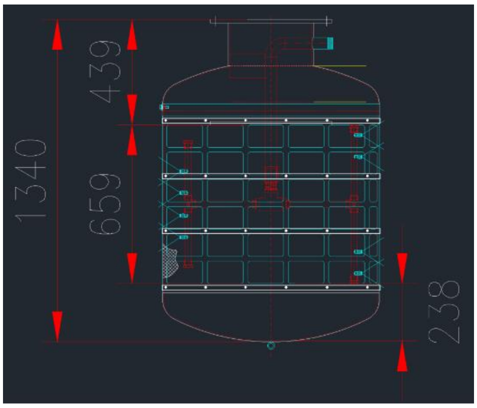

Figure 2 - Strainer details

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This results in the following levels and observations:

- Note that the top of strainer intake sits ~440mm below the strainer flange.
- The base level of the strainer intake is at -3.26m AOD.
- Base of strainer set at -3.5m AOD.
- Conservatively assuming 1m water clearance beneath the strainer equates to a control clearance level of -4.26m AOD.
- Base of stilling chamber set at -6.0m.

Refer to Figure 3 for level diagram.

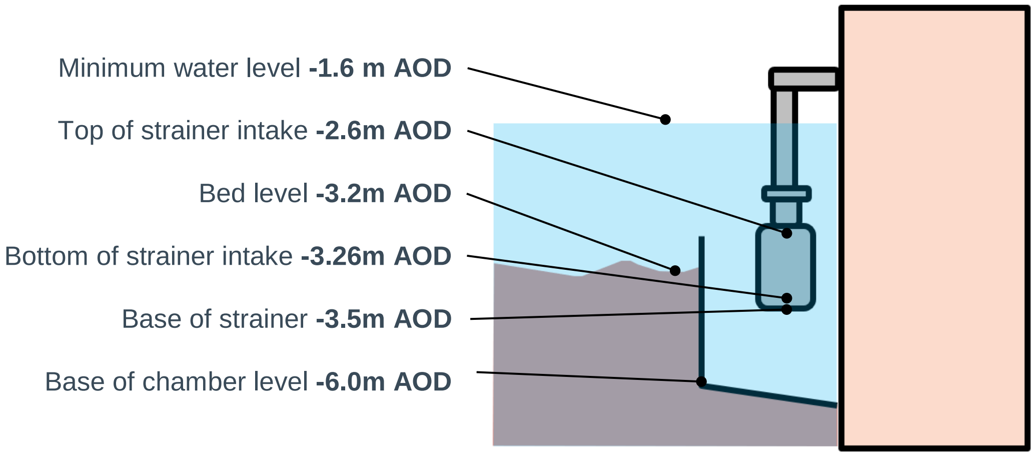

Figure 3 - Intake sump chamber sketch (not to scale)

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3.4. River Bed

3.4.1. Levels

River bed levels at the sump chamber location were estimated from River Clyde bathymetric survey data obtained from Peel Ports. Survey data of the Clyde covered 2014, 2016-2018. This data indicates bed levels at the pump sump location at -3.1 to -3.3m AOD over the period 2016-2018.

The longer-term variation in bed levels at this location is unknown. Bed levels will have increased since Queens Quay historic operations however it is not known whether current bed levels represent an equilibrium between erosion and deposition processes. There is a risk that future accretion of material in the area surrounding sump will increase bed levels. This could significantly increase the rate of deposition in the proposed pump sump chamber and potentially affect the strainer operations.

Based on the limited information available there is a high uncertainty as to what future bed levels at the pump sump location will be.

3.4.2. Material

Limited information is available about bed material local to the pump sump. No samples of bed material were available and, therefore, the type and size of bed material has not been classified. However, based on the position of the Queens Quay relative to the Clyde estuary it is assumed that the bed material is mostly fine silt with some sand.

Accretion of material in the pump sump chamber will occur from fine suspended sediments and coarser bed loads which will move along the river bed.

Suspended sediments

Fine silty sediments will be suspended within moving water. When water within the pump sump chamber is static, some of these suspended sediments will deposit at the bottom of the chamber. The rate of accretion will depend on water movement within the chamber and the concentration and size of suspended sediments in the water. Based on experience an estuarine environment suspended sediment concentration can vary between 200-1000 mg/lt However this may be lower for the Clyde as J Allen (1966)[3] reported suspended solids content within the Clyde channel itself is generally low – less than 50 mg/l. For the purposes of estimating siltation rates high, medium and low concentrations of 500mg/l, 200mg/l and 50mg/l have been assumed.

When the strainer pumps/backwash system are operational suspended material may remain suspended within the pump chamber and some deposited silt may become mobilised. However, this is not guaranteed and due to the shape and depth of the chamber there will still be dead spots where movement of water is minimal. Tidal and fluvial currents may also keep water mobile within the higher part of the chamber however, at slack tides (high or low tides) these currents will be minimal.

Bed loads

Coarser sandy material which is too large to be suspended may be transported along the river bed in a tumbling manner blown by tidal and fluvial currents. These materials will deposit at the base of the sump and be will be too heavy to be mobilised as suspended sediment. Rates of accretion of bed load will depend on sediment sizes, tidal currents and bed levels. Increases in bed levels above the level of the top of the pump sump chamber would significantly increase the volume of material despotised into the chamber from bed loads.

[3] Allen, J. H. (1966), Coastal Engineering 1966, Chapter 76 – On the Hydrography of the River Clyde, p1360-1374

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3.4.3. Material accumulation rate estimate

The rate of silt accumulation was estimated in Table 3 for High, Medium and Low rates of accumulation.

This estimate assumes the accretion of a fixed percentage of total suspended sediments within the pump sump chamber every slack tide. This estimate provides an indication of a range of probably accretion rates.

Table 3. Pump Sump Chamber – Suspended sediment accumulation estimate

	Silt accumulation rate	High	Medium	Low	Unit
1	Sediment concentration	500	200	50	*mg/lt*
2	Weight of suspended silt per 1m³ of water in chamber	0.5	0.5	0.2	*kg*
3	Density of silt	1300	1300	1300	*kg/m³*
4	Volume concentration of suspended silt	0.00038	0.00015	0.00004	*m³*
5	Height of pump sump chamber	3.1	3.1	3.1	*m*
6	Accumulation rate (%)	100%	75%	50%	
7	Depth accumulation of sediment (per slack tide)	0.001192	0.000358	0.000060	*m*
8	Depth accumulation of sediment per year	1.7	0.5	0.1	*m*

An additional to 25% volume has been assumed for the addition of bed loads. Table 4 shows an accumulation rate at 0.03-1.1m per year with a medium (most likely) accumulation rate of 0.2m per year.

Table 4. Total pump sump chamber material deposition

Total material deposits	High	Medium	Low	Unit
Total depth accumulation of sediment per year	2.5	0.8	0.1	m
Total depth accumulation of sediment per 10 years	25.3	7.6	1.3	m
Allowable depth for sediment accumulation	1.74	1.74	1.74	m
Time to fill	0.7	2.3	14	Years

For the current design the base of sump chamber level is proposed at circa -6.0 m AOD. It is deemed prudent to maintain this design level for worst case siltation rates and, any future requirement to change / lower the strainer system.

Based on the intake strainer position in Section 3.3 the minimum clear water level under the strainer would be at -4.26m AOD when conservatively assuming 1m clearance. This would give an allowable height for deposits of 1.74m. Respectively based on high, medium and low accumulation rates in Table 4 this height would take 0.7, 2.3 or 14 years to fill. This wide range of estimates indicates a high level of uncertainty in the rate at which the pump sump will fill up with sediment.

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4. Filter Sediment Accumulation

This water abstracted from the River Clyde will be filtered through a 1500 µm strainer, 130 µm filter (Heat Pump 2) and a 20 µm filter (Heat Pump 1). Each filter will work at a maximum design flow rate of 160l/s, based on the maximum flow rate of the Water Source Heat Pump (WSHP). The filters will only be operating at the flow rate for a small number of hours per year.

Comparing the filter sizes against sediment sizes:

- The 130 µm filter will trap sediments larger than fine sands.
- The 20 µm filter will trap silt and some fine sands.

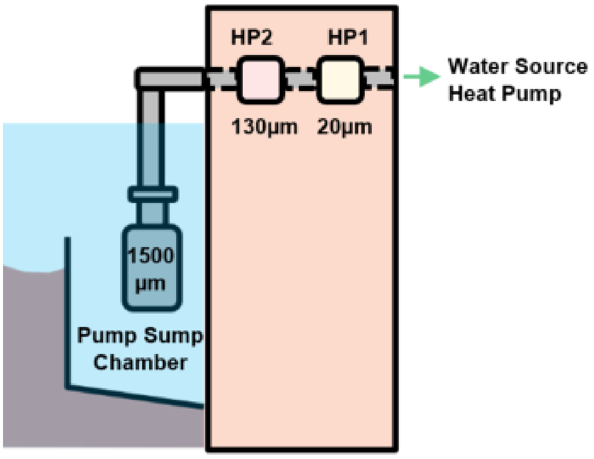

Figure 4 - Schematic of intake filter system (NTS)

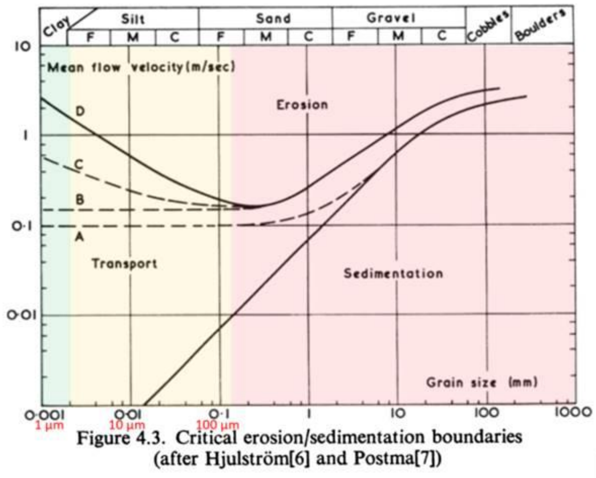

Figure 5 - Sediment size distribution and erosion/sedimentation boundaries (Hydraulic Behaviour of Estuaries, McDowell & O'Connor, 1977)

4.1. Heat Pump 1 (20 µm filter)

Suspended sediment concentrations at the site were recorded on 28/09/18 as 18mg/l at high tide and 28 mg/l at low tide. This sample provides a snapshot of sediment concentrations on a particular day, however suspended sediment concentrations can vary greatly with river flows and tidal cycles.

The highest suspended sediment concentrations occur around spring tides and lowest around neap tides. On the day of recording (28/08/18) tides were around mid-way between spring and neap tides. Therefore, based on tidal cycles alone, suspended sediment concentrations on this date would be expected to be close to median values.

Fluvial flows can affect suspended sediment concentrations with higher suspended sediment concentrations occurring with higher fluvial flows. Rivers flows could not be sourced for the date of sampling in September 2018 however based on the time of year fluvial flow in the Clyde and attributable suspended sediment concentrations are expected to have been low.

Due to the variability of suspended sediment concentrations it is recommended that the suspended sediment content adopted for filter loads calculation is assumed as higher than the recorded values recorded from sampling.

Therefore, the 20 µm filter (Heat Pump 1) will accumulate with silt from suspended sediments. It may be possible to estimate the rate of this accumulation based on pump usage and suspended sediment concentrations. If this estimate is undertaken it is recommended to use a higher concentration of suspended sediments than recorded during the September 2018 water sampling.

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4.2. Heat Pump 2 (130 µm filter)

Sediments trapped by the 130 µm filter will be mostly sands. These sands will be transported to the pump sump chamber as bed load rather than suspended sediments with most of this transport expected to occur around spring tides.

Possible paths for bed load transportation are illustrated in Figure 6. Sands which accumulate within the sump pump chamber and Heat Pump 2 filter will mostly come from bedload transport.

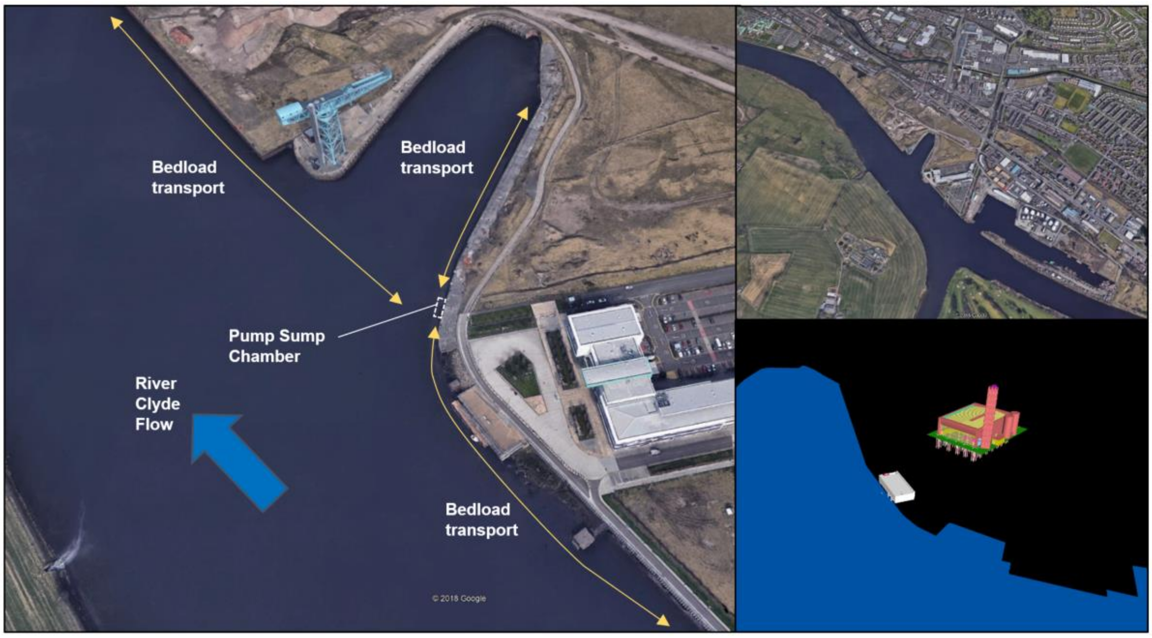

Figure 6 - River Clyde and Site Location (Google Earth 2018 and 3D model 50520-VE-EC-ZZ-MR-ME-5001 P1)

Bed loads are mobilised when river velocities exceed a threshold to allow erosion. Figure 5 shows that sediment larger than fine sand (130 µm) is mobilized when river velocities at bed level exceed 0.1-0.15 m/s. River velocities at this site will depend tidal currents and fluvial flows however, as no records of river velocity at the site are available, it is difficult to estimate the sizes of sediments which will be transported to the pump sump chamber as bed loads.

The rate of sediment accumulation within the Heat Pump 2 filter will depend on the availability of 20-130 µm sized sands for bed load transport. However, no bed material samples are available at this site.

If river velocities records and river bed material samples were available, it would be possible to estimate the accumulation rate of bed load into the pump sump chamber. However, this would require a large amount of data and estimates would still have a large degree of uncertainty. Additionally, it is difficult to estimate the proportion of the sands which enter the pump sump chamber that will be pumped into the 130 µm filter.

From the available information it is not possible to reliably estimate the accumulation rate of sediments within the 130 µm filter (Heat Pump 2). It is therefore recommended this rate is monitored closely following initial operation of the pump system.

5. Pump Sump Design

5.1. Arrangement

The draft arrangement of the pump sump chamber is shown in drawing 15001-420 Rev C shown in Appendix A and below. Comments on this proposal are given in Table 5.

Table 5. Comment on draft proposal for pump sump

	Item	Comment
1	Strainer position	Vertical position of strainer to be adjusted as discussed in Section 3.3.
2	Bed level	From analysis of PEEL Ports bathymetric data, the bed level shown at -3.2m AOD is correct.
3	Top level of pump sump chamber	The top of sump chamber steelwork is shown at an upstand to bed level of 0.3m. • Provision of an upstand/lip above bed level will increase the volume of dead space within the pump sump in which suspended sediments may deposit, thereby increasing sedimentation rates. • Although the upstand/lip may act as a barrier against bed load entry into the sump chamber, based on the location of the pump sump within the estuary, significant bed loads volumes are not anticipated. Therefore, on balance it is recommended to limit the upstand of the pump sump chamber relative to bed levels to a nominal amount in order to minimise the deposition of suspended sediments. The proposed level of -2.9m AOD is acceptable.

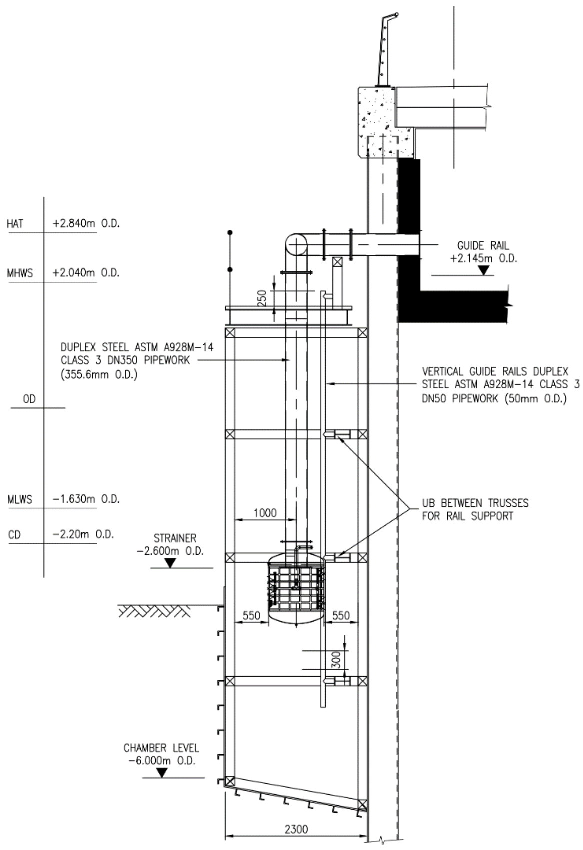

Figure 7 – Modified Strainer Position

5.2. Maintenance requirements

5.2.1. Strainer Maintenance

General operation and maintenance of the strainer units including design of the maintenance platform and lifting equipment is covered by others. This technical note comments on maintenance considering periodic removal of material from the pump sump to ensure the required clearance under the screen is maintained.

The proposed removal procedure is defined as follows:

- Isolation of the strainer and backwash system as per manufacturer's instructions.
- Detachment of backwash pipe work connection.
- Decoupling of bolted flanges on pipe work perpendicular to the wall.
- Placement of lifting strops around the T-section until strops in tension.
- Lifting of strainer and pipe work in purely vertical direction (1.0m vertical movement) sufficient to permit access to supporting 'goal-post' structures.
- Decoupling and removal of supporting 'goal-posts'.
- Lifting of demountable deck panels.
- Lifting of strainer and pipe work in purely vertical direction.
- Cessation of lifting when strainer is above working platform. Strainer and pipework will now de-coupled from the lifting guides.
- Placement of demountable deck panels to permit safe working.
- Permissible maintenance operations of the strainer in this position can then be undertaken – general inspection, cleaning.
- Reverse operation to reinstate.
- In event complete removal is required, the pipework and strainer would be lifted up to ground level for more invasive maintenance.

5.2.2. Stilling Chamber Maintenance

Three potential methods of removal are explored below in Section 4.2.1.

All methods will require a means to detection when silt and other materials deposits build up above the level of clearance required under the strainer for operation. Detection is required before silt and other materials affect operation of the strainer. Bed levels within the pump sump chamber may be detected with installation of sonar level instruments[4] and telemetry to alert operators of the pump station to the issue else, visual inspections by divers planned during strainer maintenance operations.

5.2.3. Removal methods for silt and other deposits

Divers only

Divers could attempt to remove silt/sand deposits at the base of the sump by jetting water or air to break up and move the deposits. This may be successful to mobilise sediment however considering the depth and shape of the pump sump chamber this is unlikely to be sufficient to remove significant quantities of deposits from the base of the chamber. This action may be attempted in combination with manually operated suction dredger which could discharge into a boat or directly into the river. Any displacement of silt from the chamber into the surrounding area may require licencing.

In addition to silt/sand deposits, divers will be able to remove large items such as tree branches. As noted in Section 2.1.1 the site has previously accumulated significant sized debris including timber and trees onto the existing structure. Collision protection barriers may be provided to prevent contact of large debris with the proposed intake pipes however it will not be possible to exclude all problematic debris.

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[4] Sonar level monitoring equipment such as Hawk ORCA Sonar Bed Level System
http://www.hawkmeasure.com/productdetail.asp?id=36

Combo tanker

Fixing pipes to the river wall / back wall of the pump sump chamber may allow suction using combo tankers without the assistance of divers. Tanker suction pipes would connect at ground level to 100mm or 150mm pipes which could be fixed to the wall at multiple locations ending at the base of the chamber. Pipes could be jetted to break up solid material deposits at the base of the pump sump prior to suction operations.

This method of suction would limit suction to areas local to the base of the pipe. As such harder silt/sand deposits away from the pipe are unlikely to be removed by this operation. There is also a significant risk that pipes, or pipe exits block up with material that cannot be removed by jetting the pipe. Additionally, large debris would still require removal from divers.

Divers and combo tanker

Suction from a combo tanker vehicle can remove silt/sand deposits at the base of the pump sump. This would require suction over 10m head which is achievable with a combo tanker. A diver team would be required to manually direct the suction pipe and to break up hardened deposits mechanically or through water/air jetting. Extracted materials and water would be pumped into the combo tanker and disposed off-site. Additionally, divers could remove larger debris.

Extraction of material to 1m depth would require removal of 5.29m^3 of material over the proposed plan area of the pump sump (5.29m^2). With two chambers of ~11m^3 total, this may require multiple tanker trips as the material is mixed with water when extracted. To minimise round trips for disposal of silt a super combo tanker (typ. 13.5m^3 capacity) or larger articulated tanker (27m^3) could be used.

5.2.4. Frequency of maintenance

The frequency of maintenance to remove materials from the base of the pump sump chamber will depend on the rate of accumulation of materials and the available storage volume below the strainer.

High, medium and low estimates of the rate of accumulation have been provided in Section 3.4.2. There is a low level of certainty in material accumulation rates and future changes in bed levels local to pump sump chamber area. Therefore, it is difficult to estimate the frequency of maintenance required with confidence.

5.2.5. Risks

The following risks have been identified:

- Sediment concentrations and accumulation rates could be significantly higher or lower than estimated in Tables 3 and 4,
- Bed levels may not be stable over the long term. There is a risk that if bed levels increase significantly then rates of accumulation rates will rise sharply. This is especially true if bed levels increase to exceed above the top level of the pump sump chamber.

6. Recommendations

The following recommendations are made with regarding to the pump sump design and maintenance:

- It is recommended to remove material and debris which deposits in the pump sump chamber with divers working in conjunction with suction to a combo tanker or equivalent.

- It is recommended to discuss the methodology for silt removal with local divers to further explore the any difficulties with diving operations and understand any improvements which can be made.

- It is recommended that any licence requirements are investigated for maintenance operations to the pump sump chamber.

Appendix A. Reference information

A.1. Arch Henderson Drawings

The following drawings produced by Arch Henderson relate to the pump sump and chamber design.

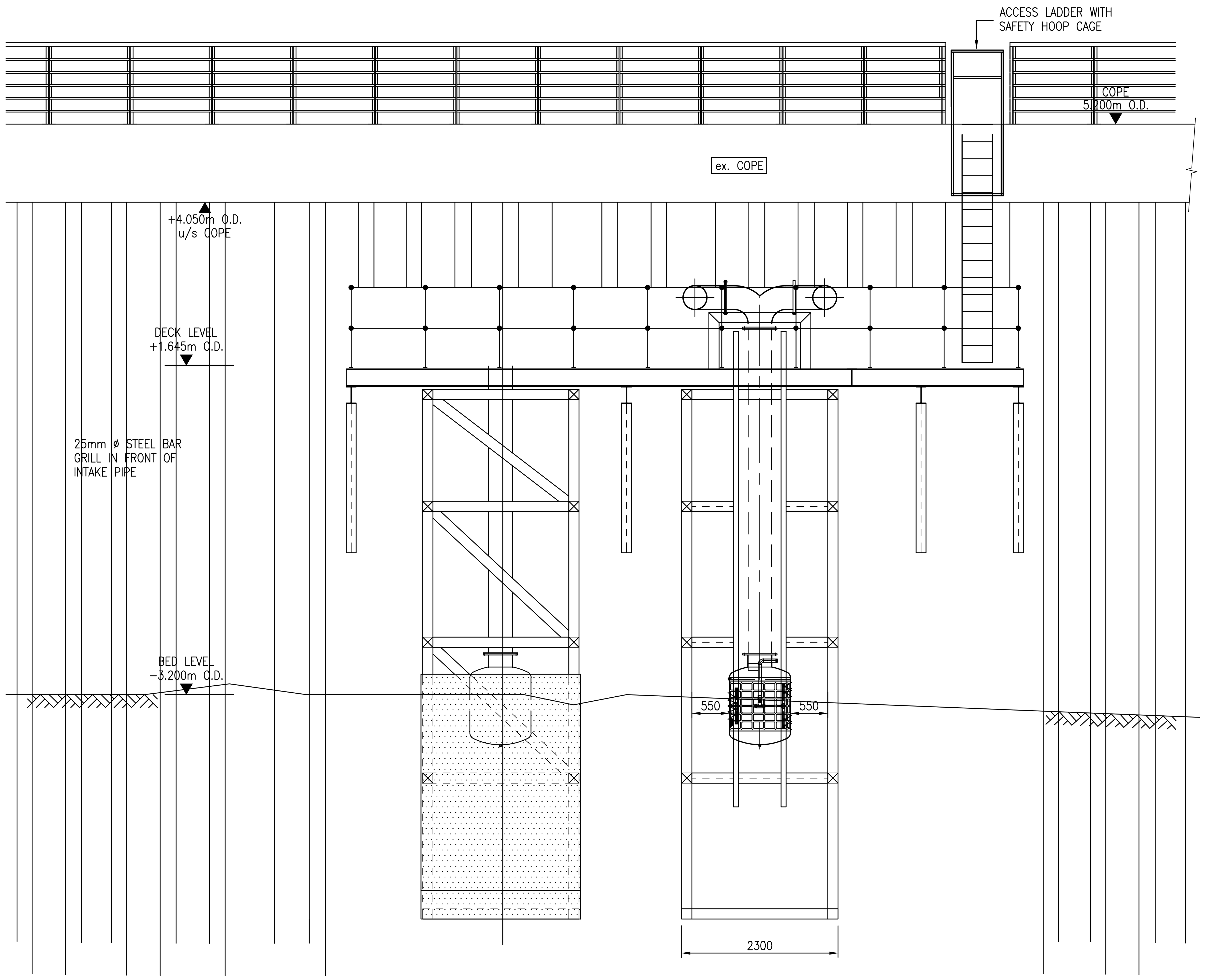
Drawing 15001-420 Rev C is attached digitally within Appendix A.

Table 6. Drawings relating to pump sump and chamber design

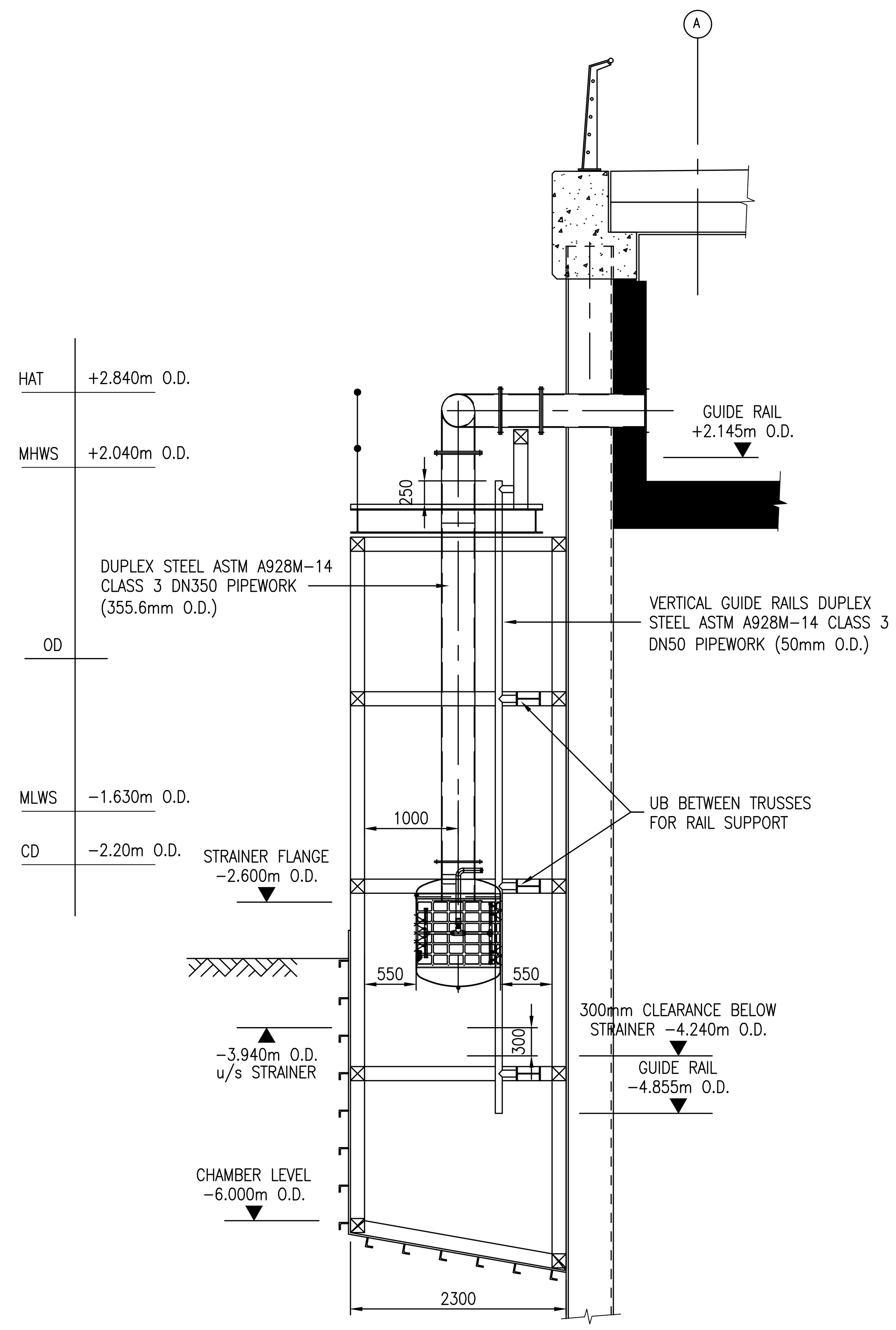
Title	Drawing Number	Date	Relevant information
Pump Chamber Intake Sump Bent 148-165	15501-420 Rev C	18.3.19	Strainer level and clearances revised. Pipe and rail materials confirmed. Sump chamber revised.
Pump Chamber Drawings • General Arrangement • Sections 1-4 • Section 2 • Section 3 • Details • Details 2 • Roof & Vent Details • Access Stair	155001- • 411 Rev J • 412 Rev F • 413 Rev F • 414 Rev E • 415 Rev A • 416 Rev A • 417 Rev A • 422	12.12.18	

A.2. AMIAD Screening System

A quote and general arrangement of the AMIAD Screening System is attached digitally within Appendix A.



STILLING CHAMBER SECTIONAL ELEVATION
(SCALE 1:50)



SECTION
(SCALE 1:50)

NOTES

1 ALL STEEL IS GRADE SJ355.

DRAFT FOR DISCUSSION

REV	DATE	REVISION DESCRIPTION	DRN	VER
C	18.3.19	Strainer level revised. Pipe guide top level revised.	G.B.	
B	19.2.19	Strainer level and clearances revised. Pipe and rail materials confirmed. Sump chamber revised.	G.B.	
A	16.1.19	SUMP CHAMBER REDRAWN	G.B.	

PROJECT :
CLYDESIDE REGENERATION LIMITED
QUEENS QUAY CLYDEBANK

TITLE :
PUMP CHAMBER INTAKE SUMP
BENT 148 - 165

DRAWN :	DATE :	VERIFIED :	APPROVED :
G.B.	28.6.18		

SCALE : (A1)	DRAWING STATUS :
1:25	FOR REVIEW

DO NOT SCALE	DRAWING No :	REV :
	155001-420	C

Amiad Water Systems UK Ltd.
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OUR QUOTATION REFERENCE / YOUR RFQ REFERENCE

Industry

EB65044957-1

YOUR SALES REPRESENTATIVE IN AMIAD

John WILSON - Sales Manager UK & Ireland - +[Redacted]

SUBJECT

Company:	VITAL ENERGI
Contact person:	Allan Muir
Contact telephone:	[Redacted]
Contact Email:	[Redacted]
RFQ Number:	N/A
Project name or reference:	QUEENS QUAY
Installation location:	UK

Revision history

Revision number	Reason for revision	Revision date
1	Updated flow rates & scope	11/09/18
0 (original)	Original Version	16/03/18
	Internal segmentation code: Enter	

LIST OF ATTACHMENTS

- ✓ Brochure – for information only
- ✓ Plan/drawing – for information only
- ✓ Internet link to the proposed technology – for information only:
    - ARKAL : https://www.youtube.com/watch?v=6hkrxQ8qpSI

PRELIMINARY REMARKS ON THE APPLICATION

Following a review of the documentation provided we understand at this time you are only requesting 2 secondary filter batteries of the 4 planned given the planned phasing of the development.

Please note our filter batteries come assembled and would need to be lifted into place. We have not allowed for the secondary filter batteries to come broken down and then to be re-assembled insitu. The filters are capable of being disassembled and parts removed once installed through the access hatch (1.3m x 6m)

Our material selection is based upon brackish water quality. We understand water testing is going to be undertaken to allow the chloride levels of the water to be tested. Upon review of this analysis we will be able to advise if our material selection needs to be updated.

Water quality information in terms of TSS loadings has not been reviewed as part of this proposal.

A. PROCESS DATA & TECHNICAL PROPOSAL

APPLICATION DESCRIPTION AND REQUIREMENTS-PROCESS DATA

Source water	Estuary
Sub-segment	Commercial
Application	Heat Exchanger Protection
Flow (m^3/h) (average / max) per line	450m3/hr / 525.6m3/hr per line
Pressure (bar)	3
Requested filtration grade	1500um, 200um & 20um
Voltage/Frequency	TBC
Water quality - Type of contamination and quantity (TSS-mg/l)	TBC
Water temperature	6-14 degrees C
Installation (indoor/outdoor)	Indoor

TECHNICAL REMARKS / ASSUMED DATA

Note 1: the self-cleaning and flush frequency depends on TSS loads and on the particle size distribution.

TECHNICAL PROPOSAL

1. AMIAD SOLUTION DESCRIPTION

The filtering process:
Color-coded polypropylene or nylon discs are grooved on both sides to a specific micron size. A series of these discs are then stacked and compressed on a specially designed spine (‘’spin’’).

When stacked, the groove on top runs opposite to the groove below, creating a filtration element with a statistically significant series of intersecting grooves which trap the solids. The stack is enclosed in a corrosion and pressure resistant housing (‘’pod’’).

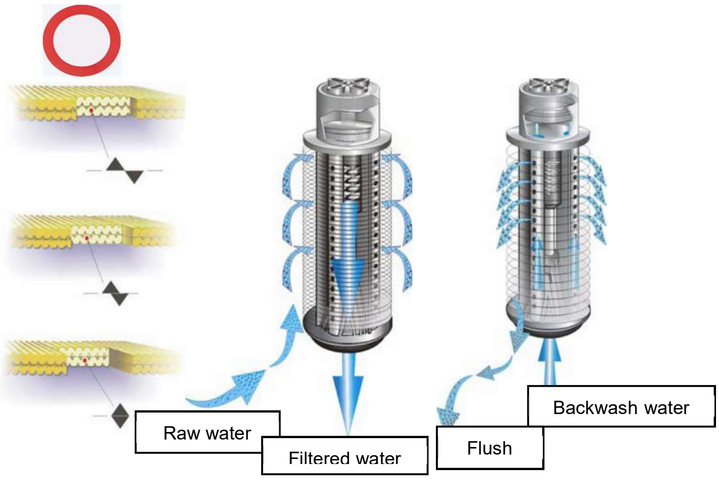
During filtration, the discs are tightly compressed together by a combination of the spring's power and the differential pressure, thus providing high filtration efficiency. Water flows through the inlet manifold and is distributed through the backwash valves into the Spin Klin filters. Filtration occurs while water is percolating from the outer diameter to the inner diameter of the element.

The backwash process:
The controller transmits an electrical command to the first solenoid, according to a predetermined differential pressure or time.

The solenoid then sends a pressure command to the backwash valve, moving it from filtration to backwash mode. During the backwash process, the disc compression is released. The spine piston rises up, releasing the pressure on the discs.

Tangential jets of clean water are pumped at high pressure in the opposite direction through nozzles at the center of the spine and the solids are quickly and efficiently flushed out through the drain manifold.

On completion of the allotted backwashing time (between 20 and 25 seconds), the controller releases the backwash command and filter number one returns to filtration mode. Filter number two then enters in backwash mode, etc. While all filters/pods have backwashed, system returns fully to filtration mode until next cycle.



4" Spin Klin™ Galaxy filter pod

Image for 4''SK Galaxy Internal Source

Image inside each 4" Galaxy Pod

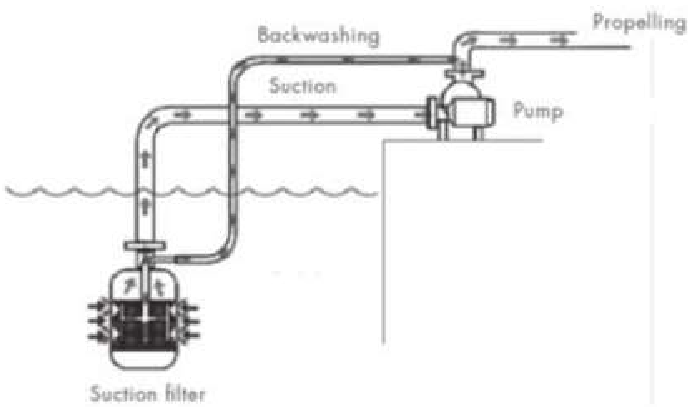


Image Self Cleaning Primary Intake Filter

Typical Configuration for Intake Filters

SELF CLEANING PRIMARY INTAKE FILTERS

1. TECHNICAL CHARACTERISTICS

Model	FS-14
Cleaning method	Pressurised backwash spray nozzles
Nominal / maximum flow rate during filtration	385.2m3/hr / 450m3/hr
Filtration grade	1500 µm
Inlet/outlet Ø	14" - DN350 mm
Flushing Source	Secondary Filtrate
Filter Body Ø	900mm
Design pressure	10 bar
Min. pressure (working / Backwash)	3 bar / 4 bar
Flow for flushing	10m^3/h @ 4bar
Dimensions (LxWxH – m)	900mm diameter x 1340mm long
Weight (empty)	120 Kg

2. CONSTRUCTION MATERIALS

Filter housing	Stainless Steel AISI-316
Flanges	DIN PN10 DIN-2576

SECONDARY DISC FILTERS – 200 MICRON BATTERY

3. TECHNICAL CHARACTERISTICS

Model	4" Galaxy IS - AW
Number of Battery	1
Number of Pods (per Battery / Total)	12
Cleaning method	IS - Internal Source
Nominal / maximum flow rate during filtration	450 m^3/h / 525.6 m^3/h
Maximum flow during self-cleaning cycle (inlet/outlet)	525.6 m^3/h / 580.6 m^3/h
Filtration grade	200 µm
Battery Inlet/outlet Ø	12" - DN300 mm
BatteryExternal Source manifold	N/A
BatteryFlush Ø	6" - DN150 mm
Design pressure	10 bar
Min. pressure (working / Backwash)	3 bar / 3 bar
Flow for flushing	55 m^3/h
Flushing cycle time	5 min : 0 s - (25 seconds per pod)
Rejected water volume per flush cycle	4.6 m^3
Maximum temperature	60 °C
Filtration area (per pod / Total)	4400 cm^2 / 52800 cm^2
Filtration volume (per pod / Total)	5740 cm^3 / 68880 cm^3
Clean filter pressure drop	TBC bar
Maximum flushing pressure drop	0.5 bar

4. CONSTRUCTION MATERIALS

Filter housing & Lid	RPP (Reinforce Polypropylene) & RPA (Reinforce Polyamide)
Discs	PP (Polypropylene)
Disc Spines	PA (Polyamide)
Spring	SS316 Halar Coated
Valves	Bermad 4x4 AW
Gaskets	NBR or EPDM

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SECONDARY DISC FILTERS – 20 MICRON BATTERY

5. TECHNICAL CHARACTERISTICS

Model	4" Galaxy EXTERNAL SOURCE - AW
Number of Battery	2
Number of Pods (per Battery / Total)	14
Cleaning method	ES – EXTERNAL SOURCE
Nominal / maximum flow rate during filtration	450 m³/h / 525.6 m³/h
Maximum flow during self-cleaning cycle (inlet/outlet)	525.6 m³/h / 525.6 m³/h
Filtration grade	20 µm
Battery Inlet/outlet Ø	12" - DN300 mm
BatteryExternal Source manifold	N/A
BatteryFlush Ø	6" - DN150 mm
Design pressure	10 bar
Min. pressure (working / Backwash)	3 bar / 5 bar
Flow for flushing	55 m³/h @ 5 bar
Flushing cycle time	11 min : 40 s - (25 seconds per pod)
Rejected water volume per flush cycle	10.7 m³
Maximum temperature	60 °C
Filtration area (per pod / Total)	4400 cm² / 123200 cm²
Filtration volume (per pod / Total)	5740 cm³ / 160720 cm³
Clean filter pressure drop	TBC bar
Maximum flushing pressure drop	0.5 bar

6. CONSTRUCTION MATERIALS

Filter housing & Lid	RPP (Reinforce Polypropylene) & RPA (Reinforce Polyamide)
Discs	PP (Polypropylene)
Disc Spines	PA (Polyamide)
Spring	SS316 Halar Coated
Valves	Bermad 4x4 AW
Gaskets	NBR or EPDM

7. ELECTRICAL DATA & REQUIRED UTILITIES

Rated operation voltage	TBC
Instrumentation	Solenoid valves
Utilities – Pressurized air	Air supply: 5 to 7 bar, clean and dry

8. CONTROL & UTILITIES

Control board type	PLC Control Board (Siemens S7)
Number of Commands / Solenoids	14 / battery
Control method	Pneumatic
Power voltage	TBC
Control voltage	24 V DC
Inputs	TBC
Outputs	TBC
Visual signals	7” HMI Touch screen, information about: alarm/delta- P/flushing counters
Manual commands	Cleaning cycle