

Blaenau Gwent County Borough
Council (BGCBC)

**Silent Valley Landfill Leachate
Lagoon**

**IC2 - Review of Requirements and
Feasibility Study**

16/9494

Issue | 16 November 2016

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instructions and requirements of our client.

It is not intended for and should not be relied
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1 Introduction

Ove Arup & Partners Ltd (Arup) has been appointed by Blaenau Gwent County Borough Council (BGCBC) to provide engineering services for the management of the Silent Valley leachate lagoon located at the toe of Silent Valley landfill, Cwm, Ebbw Vale.

A number of ongoing issues have been identified with the current lagoon and leachate management infrastructure, including:

- malfunction or loss of fuel to the diesel pumps that pump leachate from the sump to the lagoon, resulting in the overflow of leachate from the sump;
- maintenance and blockage issues in the subsurface pipe that transports the leachate from the lagoon to the Welsh Water sewer in Cwm.

As part of the improvement conditions associated with the revised environmental permit issued in March 2016, it is required that an Options Report for a long term leachate treatment and disposal system is submitted to address the issues detailed above.

As part of the commission, Arup has therefore carried out a feasibility study for the site (refer to Figures 1 and 2 for location and current layout) in order to identify the site constraints and available options to address the above issues and to detail actions required to facilitate design.

A desk study for the site has been undertaken as part of this study and is presented in Sections 2 to 4 of this report. The desk study reviews the available information for the site area, its geology, topography existing leachate infrastructure and potential engineering constraints at the site.

Section 5 presents a review of the available records in relation to leachate flows and summarises the agreement currently in place with Welsh Water in relation to the discharge of leachate into the sewage network

Proposed options for the development are presented in Section 6. Conclusions and recommendations are discussed in Section 7.

2 The site

2.1 Site location and description

The study area lies at the toe of Silent Valley landfill and is located at approximate National Grid Reference 318650, 206730, as shown on **Figure 1**.

A site visit was undertaken by two Arup engineers on the 15th July 2015 to observe the existing infrastructure at the site and surrounding area and identify any site constraints to the proposed development. These are discussed in **Section 4.5**. Photographs taken during the site visit are included in **Appendix A**.

The site currently comprises a concrete holding leachate lagoon and a sump and associated drainage infrastructures as shown on **Figure 2** and further discussed in **Section 3**.

The sump accepts leachate from two leachate inputs (LP1 and LP2) and four other inputs (LP3, LP5, LP6 and LP7). The combined leachate from the sump is pumped into the lagoon via LP3A.

In addition to LP3A, the lagoon accepts two further inputs: LP4, which collects the landfill toe drainage, and an input from the landfill's leachate pumping system, called PSO (pumping system outfall). It is noted that LP4 is continually submerged – due to the weir overflow to the storage tank of the lagoon being at a higher level than LP4's invert.

Details of the outfall inputs to the lagoon and sumps are given in **Section 3**.

The site is bounded by the landfill to the north and steep valley sides to the east and west. The Cwm Merddog Nature Reserve, which is a designated SSSI site, is located to the immediate south of the site.

The landfill area is also bounded by steep valley slopes to the west, north and east. The Nant Merddog stream runs down the valley to the south of the landfill and site. Where the landfill is present, the Nant Merddog has been diverted into a pipeline that passes to the east of the landfill and re-joins its original course approximately 30m to the south of the existing leachate lagoon (also refer to **Section 3**).

Following the recent works for the capping of Phase 1 of the landfill, the associated drainage infrastructure has been improved, and a 900mm diameter pipe now runs beneath the site area, collecting the surface water run-off from the capped area and discharging into the Nant Merddog. The position of this pipe in respect to the site area is shown on **Figure 2**.

No waste has been accepted at the Silent Valley landfill since August 2011 and capping of the whole of the landfill is now complete – including the remedial works required for Phase 1.

2.2 Proposed options

BGCBC are responsible for the management of the Silent Valley leachate sump and lagoon and are the permit holders for the installation, and furthermore an improvement condition has been applied to the revised permit, issued in March 2016, that requires a sustainable solution based on the proposals within this report.

In order to address the issues with the existing leachate infrastructure (refer to **Section 1**), several options have been considered. These include:-

- Providing an electrical pumping station at the site in order to reduce the risk of failure of the diesel pumps and costs associated with their maintenance;
- constructing a new gravity-fed lagoon system further downstream of the existing lagoon, into the SSSI;
- increasing the capacity of the existing lagoon by increasing the size of the existing lagoon;
- options to improve or replace the existing leachate pipe between the lagoon and the discharge to sewer.

These options have been reviewed as part of this study, as further discussed in **Section 6**. The advantages and disadvantages of a do-nothing scenario are also considered.

2.3 Summary of history

The history of the site has been previously researched as part of earlier studies undertaken for the Silent Valley landfill site. These are referenced at the end of this report and can be viewed in the Arup Cardiff office on request.

A summary of the history of the site and surrounding areas, supplemented by information obtained from more recent OS maps and available documents (see **References** section), is presented in **Table 1** below.

Table 1 - Summary history of the site and surrounding areas

Date	On site	Off site
1880	The site consisted of fields and agricultural land. Tracts of land adjacent to the Nant Merddog were wooded, indicative of steeper ground.	Fields and agricultural land are present across Cwm Merddog.
1920	No significant changes to the site.	On the eastern side of the valley, approximately 300m to the south of the location of the present-day leachate lagoon, a spoil tip (likely associated with coal mining works) is annotated in the OS plans. The tip is marked as 'disused' by 1979.
1930's to 1960's	No significant changes.	Ebbw Vale Iron and Steel Works was re-constructed in the mid 1930's, following which tipping of spoil, mainly blast furnace slag, industrial oils and waste products commenced in Cwm Merddog. Two spoil tips with a distinct conical shape (Maclane cones) were present in the western area of the valley (visible on aerial photographs dated 1946, 1951 and 1955). Their approximate maximum extent is recorded in the 1961 OS plan which indicated their height reached 90m and a culvert had been provided to convey the Nant Merddog beneath these tips. During the 1960's, blast furnace slag was viewed as resource and several companies were involved in the excavation of the spoil tip, subsequent processing and utilisation of the materials.
1970's	No significant changes.	The Maclane cones had been re-profiled or substantially removed and the area they had occupied comprised a series of spoil platforms terminating in steep cut faces. The spoil material left in the valley was viewed as being contaminated by the industrial waste oils percolating into the slag and therefore rendering it useless as a product. Firebricks, used as liners for the furnaces, and asbestos were also tipped in the area.
1981	No significant changes.	The site was sold to BGCBC and was licenced to accept domestic refuse. BGCBC commissioned a topographic

Date	On site	Off site
		survey of the site around this period.
Mid 1980's	Historical maps and records indicate that the leachate lagoon at the toe of the landfill was constructed around this time (possibly 1987).	A new pipeline (Armco pipeline) was installed in 1983 to the east of the original line of the Nant Merddog to convey it. Since then, the valley bottom has been progressively infilled with domestic refuse.
Early 1990's	No significant changes.	In 1993, BGCBC installed a plastic drain along the valley between the slag tips on the western side of the valley and the landfill site on the east to collect drainage from groundwater issues from the toe of the slag banks and convey it beneath the landfill. The pipeline has since been covered over by the landfill operations.
1994	No significant changes.	The operator responsibility for the waste disposal at the landfill was transferred from BGCBC (landfill developed as Phase 1) to Silent Valley Waste Services Ltd. (Phase 1A landfill). There is significant overlap in terms of areas of filling under these two phases.
1996	No significant changes.	Capping of Cell 1 in the south-eastern corner of Phase 1A.
2000-2001	No significant changes.	Capping into the southern face of Phase 1 landfill.
2004	In 2004, modification works were undertaken to the leachate outfall system layout in the leachate sump to allow monitoring of leachate.	Further capping works on the eastern flank of phase 1A were undertaken in 2005.
2009	No significant changes.	Capping works western and eastern flanks Phase 1A and temporary and sacrificial cap to Cell 5 north.
2005-2010	No significant changes.	Installation of the groundwater cut-off and pumping system at the southern toe of the landfill in various phases between these years.
2014 - present	No significant changes.	Improvement works to the capping of Phase 1 of the Silent Valley landfill are currently being undertaken. In addition to the new capping, improvements are also being made to both the surface water drainage and the leachate drain at the toe of the landfill.

3 Details of current installations and drainage

3.1 Leachate lagoon and sump

The sump construction is mostly below ground level and of concrete, with external dimensions of 3.9m by 7.1m and an approximate depth of 2.0m. The layout of the existing sump is shown on **Figure 3A**.

The sump accepts leachate flow from two inputs (LP1 and LP2) and groundwater from four land drain inputs (LP3, LP5, LP6 and LP7).

The two leachate inputs are from LP1 (750mm diameter) and LP2 (900mm diameter), which are known as the BSC pipe and the ARMCO pipe, respectively. Both of these were originally culverted diversions for the Nant Merddog, but due to the gradual expansion of the landfill, the Nant Merddog has been relocated on a number of occasions. The pipes now carry leachate collecting at the bottom of the landfill.

LP3, LP5, LP6 and LP7 pipes are believed to extend for about 1m from the sump, collecting shallow water from the surrounding area, relieving groundwater pressure on the sump.

The combined flow from the several pipes draining into the sump (LP1, LP2, LP3, LP5, LP6 and LP7) is collected through LP3A and is pumped via a mobile diesel pump, permanently located at the site, into the settlement tank of the leachate lagoon, approximately 5m to the south of the sump. The diesel pump is managed by BGCBC and regularly maintained by Sykes Pumps on behalf of BGCBC. Silent Valley Waste Services Ltd arranges the pumps refuelling on behalf of BGCBC, and undertake daily maintenance, including provision of fuel and lubricants as required.

LP3A is monitored monthly in accordance with the Environmental Permit for the landfill, but no individual flows from the inputs to the sump are currently monitored. Chemical testing at each individual input point and flow monitoring at each pipe inlet entering the lagoon should be undertaken as discussed in **Section 7**.

An emergency pipe located on the southern wall of the sump has been blocked up. The pipe was previously used to carry flows from the sump to the Nant Merddog whenever the overpumping arrangement failed.

In addition to LP3A, two other flows enter the settlement tank: LP4, a 300mm diameter concrete pipe which collects the landfill toe drainage and enter the settlement tank through a silt trap, and the Pumping System Outfall (PSO) input from the landfill's leachate pumping system.

The lagoon consists of two separate tanks located next to one another and separated by a gated weir. The tank at the northern end of the structure is the settlement tank, where some of the solids transported by the leachate settle out. The settlement tank is approximately 7m long by 17.6m wide by 2m deep. The second tank is approximately 16.1m long by 17.6m wide and also 2m deep and is a storage/attenuation tank. The estimated capacity of the settlement tank is approximately 500m³. The layout of the lagoon is shown in **Figure 3B**.

The leachate enters the settlement tank and overflows a weir to the storage tank, prior to discharging into an underground connection pipe and eventually into the Welsh Water

foul sewer approximately 750m to the south of the lagoon. The outlet to the connection pipe is 150mm in diameter and is able to convey some 50 l/s with inlet control.

The flow entering the Welsh Water sewer is monitored to determine the volume of discharge into the sewer via an electrical gauge, as further discussed in **Section 5.2**.

Photographs of the site are included in **Appendix A**.

3.2 Drainage

Drainage installations at the site are summarised in **Figure 4**.

BSC pipe (G-H)

This pipe is recorded to have an internal diameter of 750mm and was laid in the floor of the valley in the 1970's to convey the Nant Merddog beneath part of the steelworks waste tips. The pipe is now buried under up to 30m of waste and the lower end of the pipe (approx. 150m long) discharges leachate and groundwater to the sump.

A herringbone system of underdrains was constructed in the early 1980's on the lower slopes on the eastern and western sides of the valley and connected to the BSC pipe approximately every 10m to collect groundwater issues.

In October 2012, a CCTV survey of the BSC pipe was carried out, confirming that the pipe is in a reasonably good condition for its age and depth beneath the waste, with no major defects visible. Fines (covering approximately 10% of the pipe's diameter) are evenly distributed along the invert. No manholes were encountered along the length of the pipe and its upstream end is capped with a steel grill and backfilled with rubble and slag. The survey has showed that the pipe has a total of 13no 225mm diameter saddle connections along its length which collect leachate and ground water from the base of the landfill and convey it to the sump area. The majority of these saddle connections enter the pipe at midpoint. All of the connections were flowing and the majority of them showed signs of silting up, which may potentially restrict or prevent leachate flows in the future.

To date, it has not been possible to monitor the flow from the BSC pipe due to access restrictions, however it is considered that with adequate control measures this may be possible and currently these are being reviewed.

ARMCO pipe (D-E-B-F-H)

This pipe was constructed in 1982-1983 to convey the Nant Merddog from about point D near the head of the valley to points E-B-F and H east of the original stream course. The BGCBC drawings indicate that the downstream 226m length of the pipeline already existed by 1982 as a 146m length of 800mm diameter pipe upstream of an 80m length of 900mm diameter concrete pipe leading to the outlet. A concrete chamber is present where the pipe changes diameter. At this point, the pipe also changes direction of approximately 30°.

At point E, the upstream section of the pipe collects groundwater flows via French drains and surface water flows downstream of point D.

At point B, the pipe is connected to the Nant Merddog diversion pipeline (see below) via a 400mm diameter twin-walled plastic pipe. Hence, the clean flows from section D-E-B are discharged at C through the Nant Merddog diversion pipeline and then enter the Nant Merddog downstream of the landfill. The section B-F-H of the ARMCO pipeline collects groundwater and possibly leachate.

Similarly to the BSC pipe, the flow from this pipe is not currently monitored due to access restrictions and health and safety constraints.

New outfall pipe from capping to Nant Merddog

Following the recent works for the capping of Phase 1 of the landfill, the associated drainage infrastructure has been improved. The capping works involved the placement of an LLDPE geomembrane, together with Pozidrain drainage blankets and a 600mm thick layer of soil cover which now form an impermeable barrier above the buried waste in this area.

All surface water flows currently generated from the capped area are intercepted by a series of concrete canvas lined channels and stone filled mattresses, placed within the 600mm cover material and conveyed to the south-east corner of the landfill where they discharge into the Nant Merddog stream via a recently installed 900mm dia pipe. The position of this pipe in respect to the site area is shown on **Figure 2**.

Plastic pipeline (N-H)

This pipe was installed in 1993 as a 400mm diameter twin-walled plastic pipe along the valley between the slag tips on the western side and the landfill site on the eastern side to collect drainage from groundwater issues from the toe of the slag banks and convey it beneath the landfill. The pipeline has since been covered by the landfill operations, and is understood to be no longer in use.

Pipe from lagoon to sewer

As discussed in **Section 3.1**, the leachate entering the lagoon is discharged into a 150mm diameter underground connection pipe which is connected to the Welsh Water foul sewer approximately 750m to the south of the lagoon, at the location shown on **Figure 4**. The exact layout of the connection pipe in the immediate south of the lagoon is unclear. Records show the presence of an underground tank in this area, as further discussed in **Section 4.5**, which may be connected to the pipe. Investigations, including review of BGCBC as built records, should be carried out to confirm the extent and layout of the existing infrastructures in the vicinity of the site.

Based on the flow data recorded at the Welsh Water manhole, the pipe is conveying up to 50 l/s peak flow as suggested by the hydraulic head/depth of leachate above the 150mm diameter outlet pipe (see **Section 5.2**). The leachate flows down the pipe therefore appears to be unrestricted.

4 Site settings

4.1 Topography and morphology

The morphology of the valley where the landfill and existing leachate lagoon and sump are located is of glacial origin (**Ref. [1]**).

In the area of the existing leachate lagoon and sump, the ground ranges approximately between 305mOD and 310mOD, sloping gently to the south. Ground elevations from recent topography surveys are shown on **Figure 2**.

4.2 Site geology

The geology in the area of the existing leachate treatment system and proposed developments has been reviewed using the following information:

- Memoir of the Geological Survey, South Wales Coalfield - Part 2 - Abergavenny, **Ref.[1]**;
- British Geological Survey (BGS) 1:50,000 Sheet 232, Abergavenny, **Ref. [2]**;
- British Geological Survey (BGS) 1:10,000 scale geological map SO 10 NE, **Ref. [3]**;
- Arup Hydrogeological Risk Assessment, **Ref.[4]**;
- results of ground investigations carried out between 1997 and 2010 in the area south of the landfill;
- Observations made during the site walkover carried out in April 2014.

Based on the information reviewed, the following geological sequence is anticipated beneath the site:

- Glacial deposits (boulder clay and head deposits, approximately 2.5m thick);
- Weathered bedrock (approximately 8m to 10m thick)
- Unweathered bedrock.

The geology in the study area is discussed in more detail in the sub-sections below.

4.2.1 Published geology

The bedrock comprises a sequence of alternating mudstone, siltstone, sandstone and occasional coal seams of the Rhondda Beds of the Pennant Sandstone Formation (Carboniferous Upper Coal Measures, Westphalian C and D series). The sandstone in the Pennant Sandstone Formation is generally cross-bedded and conglomeratic at the base and represents alluvial deposition in highly sinuous channels. The overlying mudstone and siltstone represent floodplain deposits.

The local dip recorded in the published geological maps is at 3° to 4° in a south-south easterly direction (165°). Similar values have also been encountered by boreholes and mineworkings. Minor faults trending NW-SE have been proved in mineworkings.

The solid geology at the site is overlain by boulder clay and head deposits, typically comprising stiff sandy silty clay with a varying content of gravel, cobbles and boulders.

4.3 Previous ground investigations

Boreholes GW6 and GW7 have been undertaken within the site area in October 1997. Their location is shown on **Figure 2**.

GW6 is situated some 10m to the east of the diesel pump and indicates the boulder clay deposits to be present to a depth of 2.45m below ground level. GW7 is located approximately 10m to the south east of the leachate lagoon and shows the boulder clay to a depth of 2.7m below ground level. It is noted that “driller’s descriptions” are reported in the logs for the boulder clay layer and therefore the actual strata boundaries may differ slightly from those stated in the logs.

Laboratory testing has shown the boulder clay to be typically a well graded deposit with some 60% silt and clay, with moisture content ranging between 16% and 31%. Atterberg Limit determinations indicate an inorganic clay of generally intermediate plasticity.

The borehole logs show that bedrock is present beneath the boulder clay, consisting of alternating layers of mudstone, siltstone and sandstone weathered to a depth of about 8m to 10m with iron staining reported on joints in the siltstones and sandstones.

Highly weathered mudstone is present directly underneath the boulder clay in GW6. Here, the mudstone is recovered as a very stiff to hard orange brown becoming pink sandy clay with angular fine to medium gravel of very weak mudstone lithorelicts. Highly weathered mudstone is also present in GW7 beneath a 3.5m thick layer of sandstone which underlies the boulder clay. The mudstone becomes less weathered with depth and is described as a greenish grey/grey with closely and medium spaced bedding fractures.

The weathered sandstone beneath the boulder clay in GW7 is recovered as gravels and cobbles for 0.1m and then as strong and very strong grey medium grained sandstone with medium to widely spaced bedding fractures and occasional conglomeritic bands.

Siltstones were encountered in GW6 beneath the highly weathered mudstone and beneath a 2.7m thick sandstone layer, which in turn underlies the upper layer of siltstone. Siltstones are typically described as grey/dark grey with close and medium spaced bedding fractures, moderately strong to strong.

Occasionally thin coal seams are present in the siltstones and mudstones.

The ground investigation data confirm that fractures are common in all bedrock strata and frequently show black, brown and orange staining, suggesting that groundwater may be flowing through the discontinuities.

Evidence of the presence of structural discontinuities in the area was also provided by the findings of a geophysical investigation and the results of dye tracers tests carried out in 2010 in the vicinity of GW9, located some 60 m to the north-east of the sump. These investigations were carried out on behalf of Silent Valley Waste Services Ltd and also comprised drilling of probe holes at a number of locations to the north of the site area. Further evidence of a high degree of fracturing in the bedrock was that, when drilling, water was forced from the ground by the air flush at previously-drilled probe holes nearby.

4.4 Hydrogeology

As discussed above, the solid geology is overlain by a combination of boulder clay and head deposits, which act as a relatively impermeable layer covering the valley floor (an estimate of the field permeability of the boulder clay is 1×10^{-9} m/sec, based on data from previous ground investigations).

The mudstones and siltstones generally have a much lower permeability than the sandstone layers and are expected to act as aquicludes or aquitards inhibiting or reducing the downward circulation of groundwater, which, in combination with the valley topography, will be predominantly along the dip of the beds within the sandstone strata over the mudstone/siltstone strata. Groundwater is therefore directed to the weathered bedrock horizon and moves down-gradient in this horizon being prevented from movement to greater depth by mudstone/siltstone strata and the dip of these strata.

Frequent well-developed spring lines have been noticed at sandstone/mudstone boundaries in the valley, which strengthen the validity of such theory.

Consequently, groundwater flow in the area will be largely restricted to the near surface strata within the weathered siltstone/sandstone/mudstone horizon and will flow downhill along the weathered rockhead topography and along the dip of the beds. This is confirmed by observations in boreholes GW6 and GW7 which indicate a shallow water table between 1.5m and 2.7m bgl in the weathered bedrock horizon and base of the boulder clay.

Observations of iron staining in joints indicate that the main zone of groundwater flow is the top 10m of the rockhead.

This interpretation indicates that the heterogeneity of the geology has an important effect on groundwater flows. Groundwater flow at any given location is determined by the particular nature of the strata at that locations and its relationship to other strata that together make up the hydrogeological system described.

The flows emerging from the pipelines at the toe of the landfill are considered to reflect the two components of groundwater flow described above: seasonally changing base flows due to groundwater flowing through the natural strata before entering the base of the landfill and short-duration peaky flows due to rainfall on the landfill area rapidly percolating to the downhill toe.

The available groundwater level monitoring results indicate that the monitored strata are partially saturated.

Aquifer status and vulnerability

The site lies on a minor aquifer overlain by soil of high leaching potential, as defined by the Environment Agency. Such soils have little ability to attenuate diffuse source pollutants and may allow rapid movement of non-adsorbed pollutants and liquid discharges to the shallow groundwater.

Specifically the soils at the site are sub-class H3; 'Coarse textured or moderately shallow soils which readily transmit non-adsorbed pollutants and liquid discharges but which have some ability to attenuate adsorbed pollutants because of their clay or organic matter contents'.

4.4.1 Review of previous ground investigation records

Groundwater levels

The leachate sump and lagoon are located in the bottom of the valley of the Nant Merddog.

As previously discussed in **Section 4.4**, the natural groundwater table is near to ground surface and feeds the Nant Merddog via springs.

The boreholes within the site (GW6 and GW7) confirm the groundwater level to be about 1.5m to 2.7m below ground level, at the base of the boulder clay or in the highly

weathered bedrock. This is consistent with a groundwater table controlled by drainage to the Nant Merddog stream. The groundwater is therefore in hydraulic continuity with the surface water, with the groundwater feeding the surface watercourse, as also indicated by recent studies in the vicinity of the Nant Merddog, which have revealed the presence of groundwater breakouts feeding the stream.

Excavations carried out within the site below these depths are therefore anticipated to encounter groundwater.

Groundwater quality

Groundwater quality at and around the Silent Valley landfill is monitored by Silent Valley Waste Services Ltd. This includes monitoring of two wells on the site of the existing leachate lagoon and sump, GW6 and GW7.

The results of the groundwater quality monitoring are discussed in the quarterly and annual monitoring reports, which are submitted to Natural Resources Wales. The report discusses contaminants concentrations up-hydraulic-gradient and down-hydraulic-gradient of the landfill site, which are compared to assess the degree of groundwater contamination upstream and downstream of the landfill.

A groundwater cut-off and pumping system is present at the southern toe of the landfill to prevent the migration of any leachate-impacted groundwater downstream of landfill. The system is upstream of GW6 and GW7, which therefore act as 'compliance wells' for monitoring the magnitude of any contaminant release from the landfill and the effectiveness of the pumping system.

As discussed in the recent monitoring reports, the groundwater quality monitored in wells GW6 and GW7 generally reflects background concentrations monitored upstream of the landfill (e.g. mercury, manganese and zinc). Leachate species such as ammoniacal nitrogen and chloride were not detected at elevated levels. Occasional exceedances of lead, chromium, nickel, iron and mercury were measured in July and August 2014, when issues with a number of pumps in the cut-off system occurred.

Monitoring of pumping wells

Available monitoring results from the pumping wells, involving the laboratory analysis of 46 groundwater samples from three monitoring rounds carried out between August 2010 and January 2011, have been reviewed as part of this study to confirm the chemistry of the water pumped from each well and assess whether any of the pumping wells could be disconnected from the drainage system feeding into the leachate lagoon to reduce the input flows.

The pumping wells are located immediately downstream and adjacent to the toe of the Silent Valley landfill and feed to the leachate lagoon via a drainage system, as discussed in **Section 3.2**.

The results of the laboratory analyses indicate that chloride was recorded on all monitoring occasions at concentrations between 17.7 and 473mg/l in each well. Ammoniacal nitrogen was also detected above the laboratory analytical level in the majority of the monitoring occasions and pumping wells, although some of the results were not replicated in subsequent rounds of monitoring.

In summary, the above results indicate that leachate species are generally present within the water pumped from all wells, therefore suggesting that it is not possible to isolate single pumping wells from the drainage system discharging to the lagoon.

4.5 Site constraints

4.5.1 Topography and existing structures

The site area to the east of the sump and lagoon is relatively flat; however a new 900mm diameter pipe has been recently installed underground at this location to collect water run-off from the Phase 1 landfill area and discharge it to the Nant Merddog, which flows to the south east of the site. The layout of the recent pipe installation is shown on **Figure 2**.

The area to the south of the lagoon, within the SSSI site, slopes southwards at a gradient of approximately 4° and is highly vegetated. Existing infrastructure is present at this location, comprising an underground tank and associated drainage, which are understood to be disused. The as-built drawings for this infrastructure should be reviewed to confirm its extent and determine whether it poses a constraint to any proposed development.

4.5.2 Obstructions

The review of the geology at the site highlighted the presence of approximately 2.5m of boulder clay overlying weathered bedrock. Shallow bedrock is exposed in the bed of the Nant Merddog some 20m to the south of the lagoon. Obstructions including boulders within the superficial deposits or hard bands within the weathered bedrock may be encountered during any excavation required. A review of the local ground conditions and anticipated presence of obstructions should be undertaken, as recommended in **Section 7**.

4.5.3 Groundwater

Shallow groundwater is anticipated to be encountered in excavations below 1.5m. High rates of groundwater may therefore occur in shallow excavations. A review of the local groundwater conditions should be undertaken, as recommended in **Section 7**.

5 Monitoring records

5.1 Lagoon flow rates

Titan Environmental Surveys Ltd conducted two surveys for the measurement of the leachate flow rates into the settlement lagoon in December 2008 and April 2009. Both surveys were undertaken during dry weather conditions and the results obtained have been reviewed as part of this study.

Two methods of testing were carried out at three locations (“input 2”, “input 7” and “input 1”, believed to correspond to LP4, LP3A and the input from the landfill’s leachate pumping system respectively), in order to determine the actual leachate flows into the settlement lagoon. The methods comprised:-

- Catch test, which involves recording the time taken to fill a container of a known volume. Flow rates can then be determined by dividing the volume of leachate (litres) by time taken (seconds);
- Drop / Fill test, which involves dropping the level of leachate within the lagoon and then recording the time to fill a known volume again by dividing the volume (litres) by time taken (seconds).

It should be noted that the flows from inputs 1 and 7 are pumped flows (from the landfill’s leachate pumping system and the leachate sump respectively).

Table 2 below shows the rate of flow measured during the two tests undertaken by Titan Environmental Surveys Ltd.

Table 2 - Measured flow rates

Flow Rates into Lagoon	Test 1 (l/s)	Test 2 (l/s)
Flow from input 1	0.184	0.127
Flow from input 2	1.593	0.942
Flow from input 7	6.306	4.003
Total Flow	8.083	5.072

Assuming that the flow rates were constant throughout the day (24 hour period), the data above indicates the following volumes of leachate passing to the Welsh Water sewer during a dry period:-

- Test 1 (18/12/2008): 8.1 l/s (equivalent to 698 m³/day)
- Test 2 (17/04/2009): 5.1 l/s (equivalent to 438 m³/day)

Based on these data, the majority of the leachate base flow is considered to be discharging from the pumped combined flow from the pump sump (flow from input 7), with a total base flow measured at 5 – 8 l/s.

These measurements are not deemed representative of the base flows discharging as they apply to 2 days of measurement during dry spells, and it is expected that flows in general will also have reduced further with the progression and completion of the capping of the landfill.

5.2 Monitoring at Welsh Water manhole

As discussed in **Section 3**, the outlet pipe from the leachate lagoon discharges to the Welsh Water public sewer at the head of the sewer run at manhole MH SO18056901, located some 750m to the south of the site (see **Figure 5**).

The available flow monitoring records, which have been reviewed as part of this study, include automatic measurements taken at this location every two minutes for the past 5 years. **Table 3** below provides a summary of the recorded measurements from November 2013 to April 2015. Graphs for the records available between November 2013 and April 2015 are also included within **Appendix B**.

Table 3 - Summary of recorded base flow measurements (Nov 2013 to Apr 2015)

Period	Base Flow l/s	Peak Flow l/s
November 2013	10 - 15	39
December 2013	10 - 15	50
March 2014	10 - 15	41
April 2014	5 - 10	26
May 2014	5 - 10	14
June 2014	5 - 10	26
August 2014	5 - 10	37
December 2014	10 - 15	40
January 2015	10 - 15	42
February 2015	5 - 10	18
March 2015	5 - 10	17
April 2015	5 - 10	13

The available monitoring indicates that the base flow (defined by the typical average flows from weekly records) varies seasonally, between 5 to 10 l/s in the drier summer months (equivalent to 430 m³/day to 860 m³/day) and 10 to 15 l/s in the wetter winter months (equivalent to 860 m³/day to 1300 m³/day). The flows peak up to 50 l/s during rainfall events.

Rainfall is recorded daily at Silent Valley using a rainfall monitoring station located at the site. The rainfall records since 2013 have been compared to the leachate flows monitored prior to its entry into the Welsh Water sewer. The data show a close correlation with the volumes of leachate produced, with the higher rainfall figures typically corresponding to greater volumes of leachate. The correlation is almost immediate, therefore suggesting that rainfall falling on the catchment area passes through the landfill site very quickly before discharging to the Welsh Water public sewer.

The 150mm diameter outlet pipe from the leachate lagoon is able to convey some 50 l/s with a head above invert of 1.8m, confirming the peak flow measurements taken at the manhole. The lagoon provides some 422 m³ of storage volume above the outlet pipe. This volume is able to contain the peak flows in the pond in excess of the capacity of the outfall pipe. We understand that the flows are generally contained in the lagoon and that the overflows only occur from the sump at times of pump failure.

Comparison of the flow monitoring at the lagoon during dry spells (as discussed in **Section 5.1**) with the flow monitoring at Welsh Water manhole indicates similar base flows. These data have therefore been used for the assessment of the proposed options discussed in **Section 6**.

5.3 Welsh Water agreement

Welsh Water have been contacted by Arup and asked to provide any information they may have on the quality and quantity of leachate consented to discharge to the public sewers. Correspondence with Welsh Water is enclosed in **Appendix C**.

The agreement between Welsh Water and BGCBC, dated 1st August 1988 and enclosed in **Appendix C**, confirms the following permitted discharges:

Table 4 -Summary of Welsh Water agreement

Maximum daily volume:	111 m ³ (equivalent to 1.3 l/s)
Maximum rate of discharge	5 m ³ per hour
Effluent described as landfill leachate and contaminated surface water.	

From the review of the available flow monitoring data, the existing base flow rates exceed the permitted discharge rate by a factor of 5 to 10. Under the existing agreement conditions the base flow therefore cannot be attenuated or disposed of to the sewer alone.

It is understood that Welsh Water are aware that the volumes and rates of flow to the public sewer are exceeded as they charge BGCBC for the volume discharged to the sewer.

Consequently discussions have been undertaken with Welsh Water to revise the current agreement and the following discharge rate has been agreed: Maximum Daily Volume of 2000m³/day (83m³/hr). Although, at the time of writing of this report, a formal agreement/consent has not been achieved (due to Welsh Water needing to negotiate changes through their legal department). This is a significant improvement over the current situation.

6 Options appraisal

In order to address the issues with the existing leachate infrastructure (refer to **Section 1**), several options have been considered for improving the quantity and quality of leachate discharging from the site. The proposed options consider aims to address NRW's request that a feasibility study be undertaken to investigate the following:

- Malfunction or loss of fuel to the diesel pumps in the pumping sump resulting in overflow of leachate from the sump;
- Maintenance and blockage in the pipe connecting the leachate lagoon to the public sewer.

It is assumed that Welsh Water will implement the proposed 2000m³/day discharge and therefore accept the existing volumes of leachate to the public sewer. It is also assumed that the effluent quality is sufficiently toxic that it needs to be considered as trade effluent and that Welsh Water continue to impose trade effluent charges.

6.1 Option 1: do nothing

This option assumes that the present condition continues. The capping of the Phase 1 landfill is likely to diminish the peak flows discharging to the pumping chamber. However, the base flows which are predominantly formed from ground water entering the tip from the valley slopes is unlikely to diminish.

Advantages:

- Has minimal capital cost.

Disadvantages:

- High ongoing cost, likely to increase in the future due to increased Welsh Water unit rates for treating effluent;
- System reliant on diesel pumps and higher risk of failure and discharge of effluent to the Nant Merddog;

However, with respect to the improvement condition requirements of the revised environmental permit for the leachate management system this is not considered an acceptable option.

6.2 Option 2: permanent pumping station

The pumps could be replaced with a standard submersible pump station having standby pumps, alarms and electrical supply with a standby generator (refer to **Figure 6**) to pump the effluent to the existing lagoon.

Arup undertook a study in 2013 to assess the options for providing a permanent electrical supply to a pumping station. The report concluded that total cost of providing the pumping station, including electrical and telecommunication supply, control panels and housing and the installation of a new submersible chamber would be of the order of £120,000. This would be offset by the cost of providing diesel to the existing portable pumps which is estimated at £35,000 per year.

Advantages:

- Provides additional security, reduced risk of failure and less maintenance.

Disadvantages:

- High ongoing cost, likely to increase in the future due to increased Welsh Water unit rates for treating effluent.

6.3 Option 3: gravity-fed lagoon

A new settlement/attenuation lagoon could be provided within the SSSI area, subject to NRW approval, so that pumping is no longer required (refer to **Figure 7**). A number of factors would need to be confirmed to determine the most appropriate form, but it is likely that the lagoon would consist of a reinforced concrete tank located some 20m downstream of the existing pump sump within the SSSI area.

It is assumed that the new discharge rates proposed by Welsh Water would apply and therefore the lagoon would need to be designed with this consideration. Depending on its condition, the current pipe network from the existing lagoon, through the SSSI to the Welsh Water sewer would be utilised.

Assuming no hard rock is encountered, as anticipated based on available ground investigation records (see **Section 4.2**), the cost of the lagoon, including excavation, would be in the range of £450,000 - £550,000.

Advantages:

- The new facility can be sized to receive flows from the disused landfill;
- Eliminating pumping will eliminate the risk of failure and reduce maintenance costs.

Disadvantages:

- Will require consent to construct within the SSSI area;
- The existing facility will no longer be required, although the existing lagoon may be used in emergency or when maintenance to the proposed lagoon is required, as presented in **Figure 8** (Option 3A);
- High ongoing cost, likely to increase in the future due to increased Welsh Water unit rates for treating effluent.

6.4 Alternative options

6.4.1 Option A: leachate treatment

In order to mitigate the costs of discharging to the Welsh Water sewer, consideration could be given to the provision of a new leachate treatment plant. This could be provided to treat the base flow only, with the excess peak flow being attenuated in a newly constructed lagoon. The treated effluent could then be discharged to the Nant Merddog, although a hybrid solution of partial treatment and then continued discharge to the sewer may be viable.

This option is worthy of further investigation, but in order to properly assess it, detailed chemical testing data is required in relation to leachate quality and volumes (as noted in **Section 7**).

Guidance on the treatment of landfill leachate published by IPPC gives indicative costs in relation to assessing the viability of treatment options. In the absence of any leachate

quality data, an average daily treatment volume of 800m³ and a relatively poor quality leachate have been assumed. Operational costs in particular can vary significantly depending on the concentration of ammonia in the leachate and the values of BOD and COD. However, applying the guidance costs pro-rata, the capital cost of the treatment plant could be of the order of £2m - £3m, with operational costs running at approximately £1500/day.

It must be stressed that these figures are indicative and for comparison only, and should be further explored on receipt of leachate test data.

Advantages:

- Discharge to Welsh Water sewer no longer required, thereby reduced ongoing cost;
- All treatment is self-contained within the site area.

Disadvantages:

- High capital cost;
- Uncertainty regarding the rate of discharge and quality of leachate makes the design of the treatment facility difficult;
- Specialist maintenance team required;
- Will require consent to construct within the SSSI and discharge to the Nant Merddog;
- Seepage of leachate to the stream which may by-pass the treatment facility and pollute the stream is still possible.

6.4.2 Option B: discharge to River Ebbw

This is essentially a variation on Option A, and can only be assessed when the precise chemical nature of leachate has been determined.

It may be that a weak concentration of leachate could be discharged without full treatment.

Advantages:

- Discharge to Welsh Water sewer no longer required, thereby reduced ongoing cost;
- Reduced maintenance costs.

Disadvantages

- Consent required to discharge to River Ebbw;
- Suitable route needs to be found for the outfall pipe.

6.5 Contingency plan

Assessment of all of the above assumes that the primary leachate feeder (the BSC pipe) remains intact and continues to deliver leachate to the sump.

Initial CCTV investigation (refer to **Section 3.2**) suggests that the branch pipes feeding the BSC pipe may become blocked, leading to a rise in water levels within the capped landfill. A study reviewing leachate levels within the landfill body is currently being undertaken.

A review of viable options to control leachate levels within the landfill is currently being undertaken, and potential options include installation of a new drainage system or

pumping from wells bored into the landfill. The effluent from these would then need to be treated and/or disposed of via the same system chosen from the options identified above.

7 Conclusions and recommendations

The findings of this study have been used to assess the feasibility of the proposed options for addressing the current issues at the existing leachate lagoon site.

Based on the information obtained from the available sources collated in this desk study, the following initial conclusions and recommendations are made.

- Monitoring and sampling of the leachate lagoon inputs LP4 and LP3A should continue to confirm the current understanding of the leachate quality.
- Chemical testing at each remaining inlet point into the sump and lagoon is recommended for at least 12 months, to confirm the chemistry of the ingressing flows, and to determine whether some of these could be diverted into the Nant Merddog without entering the sump or lagoon, should acceptable contaminant concentrations be confirmed during monitoring.

An adequate suite of testing should include as a minimum metals, organics and inorganics compounds (including ammoniacal nitrogen and chloride) and physical parameters such as pH, BOD, COD and suspended solids, in line with the existing Silent Valley Landfill Environmental Permit. The testing suite should be agreed with NRW should the options of discharging leachate into the River Ebbw or the Nant Merddog (treated leachate) be pursued.

- Current discussions with Welsh Water should be finalised to confirm the new agreement/consent conditions and the proposed volume of discharge (2000m³/day), which will then be a key design parameter for the selected option.
- Drop tests are recommended at the attenuation lagoon during dry and wet periods at a frequency of at least four tests per month for a period of 12 months to determine the flow rates leaving the site. In addition, flow rates at each pipe inlet entering the lagoon should be recorded, together with continuing rainfall monitoring, to assist the design of the proposed options 1B, 1C, 2 and 3.
- The presence of the existing structures and utilities at the site will need to be considered in the design of the option selected. The as-built drawing for the existing underground tank and associated infrastructure located within the SSSI site should be reviewed in order to confirm their extent and potential impact on the proposed development (refer to **Section 4.5**).
- Limited geotechnical testing is currently available. Subject to the type and location of the option considered, a ground investigation may be required to assist the geotechnical characterisation of the site and confirm whether the existing ground conditions represent suitable foundation formations for design. Recommendations for a ground investigation at the proposed location of the new lagoon (Option 3) is presented in **Appendix D**.
- Any excavations undertaken for some of the proposed development options within the site are likely to encounter groundwater flows within the weathered bedrock horizon (refer to **Section 4**). Perched groundwater bodies may also be present within the more permeable bands of the overlying glacial deposits. Adequate temporary works and dewatering measures are likely to be required to control groundwater ingress into excavations within the site and avoid disturbance and softening of the excavation sides and the formation levels.
- Consideration will need to be given to the protection of buried concrete should new underground concrete infrastructure be required for the development. Sulphate and pH values are available for groundwater samples obtained from GW6 and GW7, but

values in soil samples should also be determined to assess a suitable class for concrete protection in accordance with BRE Special Digest 1 (2005).

- A review of the potential for providing in situ treatment of the leachate in order to remove the need for discharging into the Welsh Water sewer and associated costs should be undertaken.

References

- [1] Memoir of the Geological Survey, South Wales Coalfield - Part 2 – Abergavenny;
- [2] British Geological Survey (BGS) 1:50,000 Sheet 232, Abergavenny
- [3] British Geological Survey (BGS) 1:10,000 scale geological map SO10NE;
- [4] Ove Arup & Partners Ltd, Silent Valley Landfill, Hydrogeological Risk Assessment, doc. reference 04/6363, November 2004;
- [5] Ove Arup & Partners Ltd, Silent Valley Landfill, Slope stability desk study, doc. Ref. 95/2721, February 1995;
- [6] Ove Arup & Partners Ltd, Silent Valley Landfill site, Phase 1A stability review, July 1996;
- [7] Ove Arup & Partners Ltd, Silent Valley Landfill, Leachate Treatment and Disposal Facility, Site Report for PPC Application, November 2004;
- [8] Arup, Silent Valley Landfill, Interim GW9 and Nant Merddog Monitoring Report, 115825-00, Interim issue, 29 September 2014;
- [9] Ove Arup & Partners Ltd, 2014 Annual Monitoring Report, Document Ref. 2015/9326, February 2015;
- [10] Ove Arup & Partners Ltd, 2015 First Quarter Monitoring Report, Document Ref. 2015/9367, May 2015;
- [11] Environment Agency's website, accessed on 23rd March 2015, <http://maps.environment-agency.gov.uk/>

Figures

Figure 1 Site location plan

Figure 2 Site layout plan

Figure 3 leachate sump and lagoon layouts

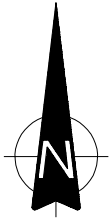
Figure 4 Landfill drainage layout

Figure 5 Location of Welsh Water sewer connection

Figure 6 Option 2 – Proposed pumping station layout

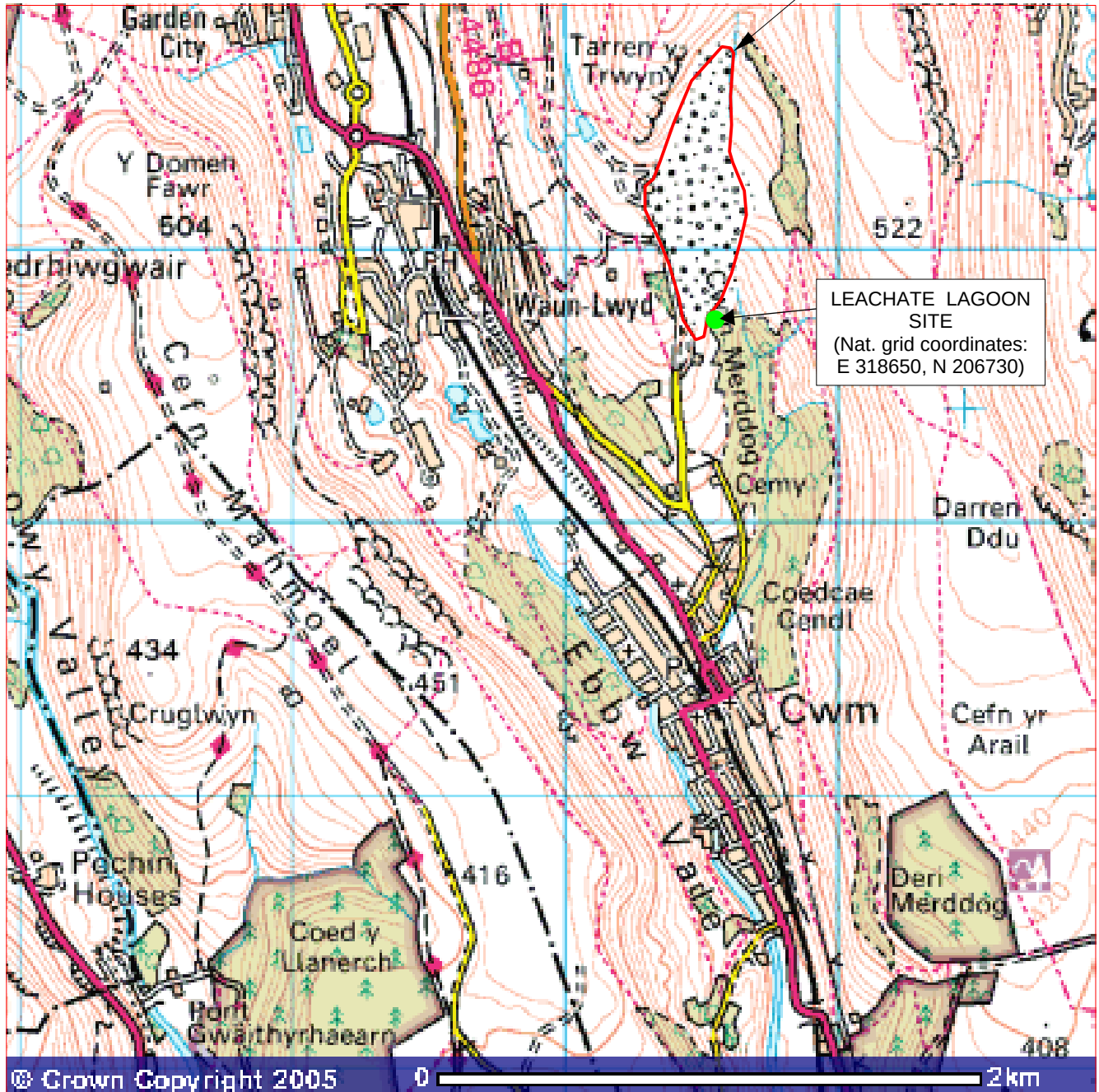
Figure 7 Option 3 – Gravity sewer layout

Figure 8 Option 3A – Gravity sewer with increased storage layout



SILENT VALLEY
LANDFILL

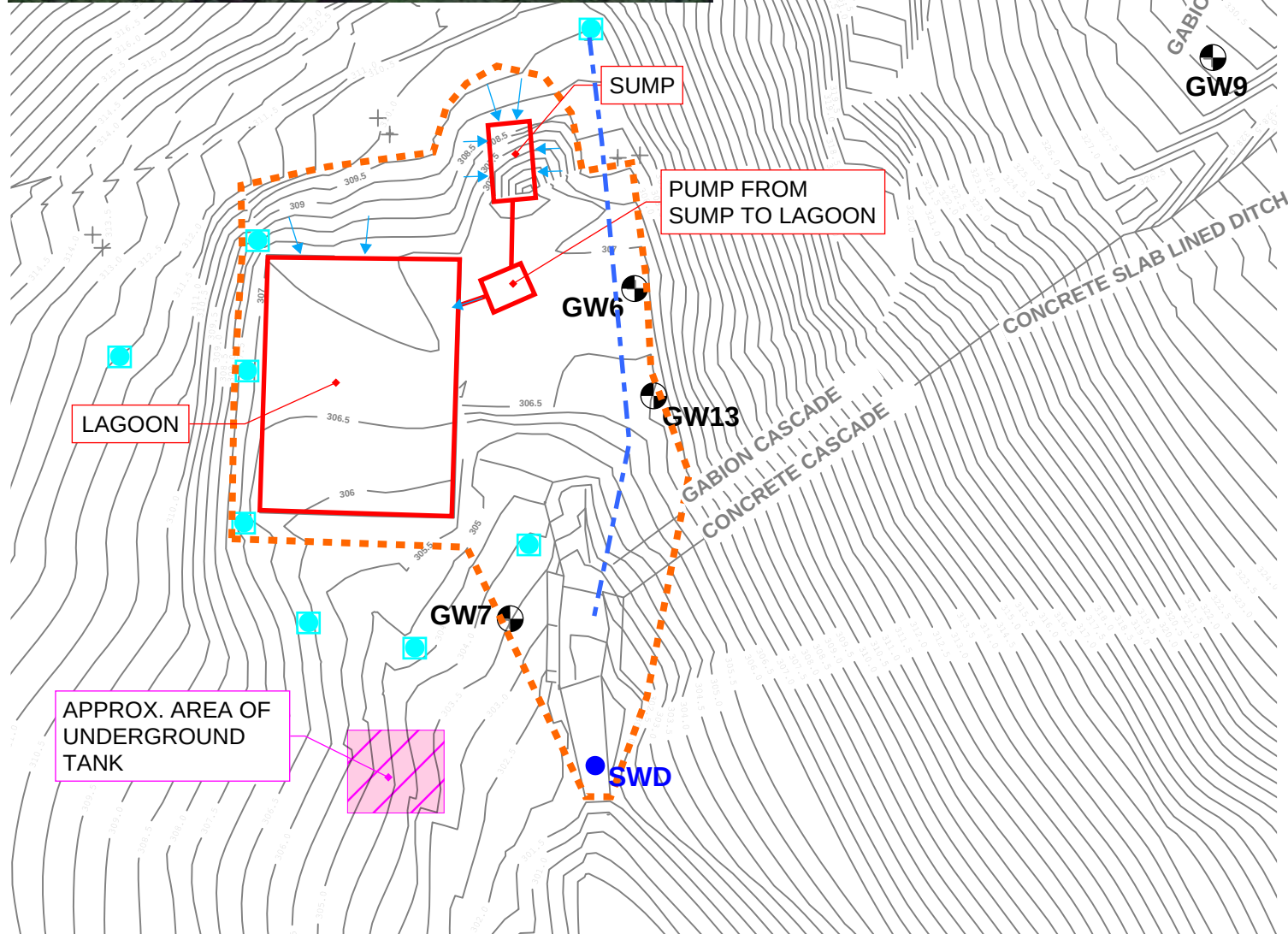
LEACHATE LAGOON
SITE
(Nat. grid coordinates:
E 318650, N 206730)



Silent Valley
SITE LOCATION PLAN

115825-00

FIGURE 1



LEGEND:

-  Existing borehole
-  Existing manhole
-  Surface water monitoring point
-  Site area boundary
-  New 900mm dia pipe
-  Inputs to sump/lagoon

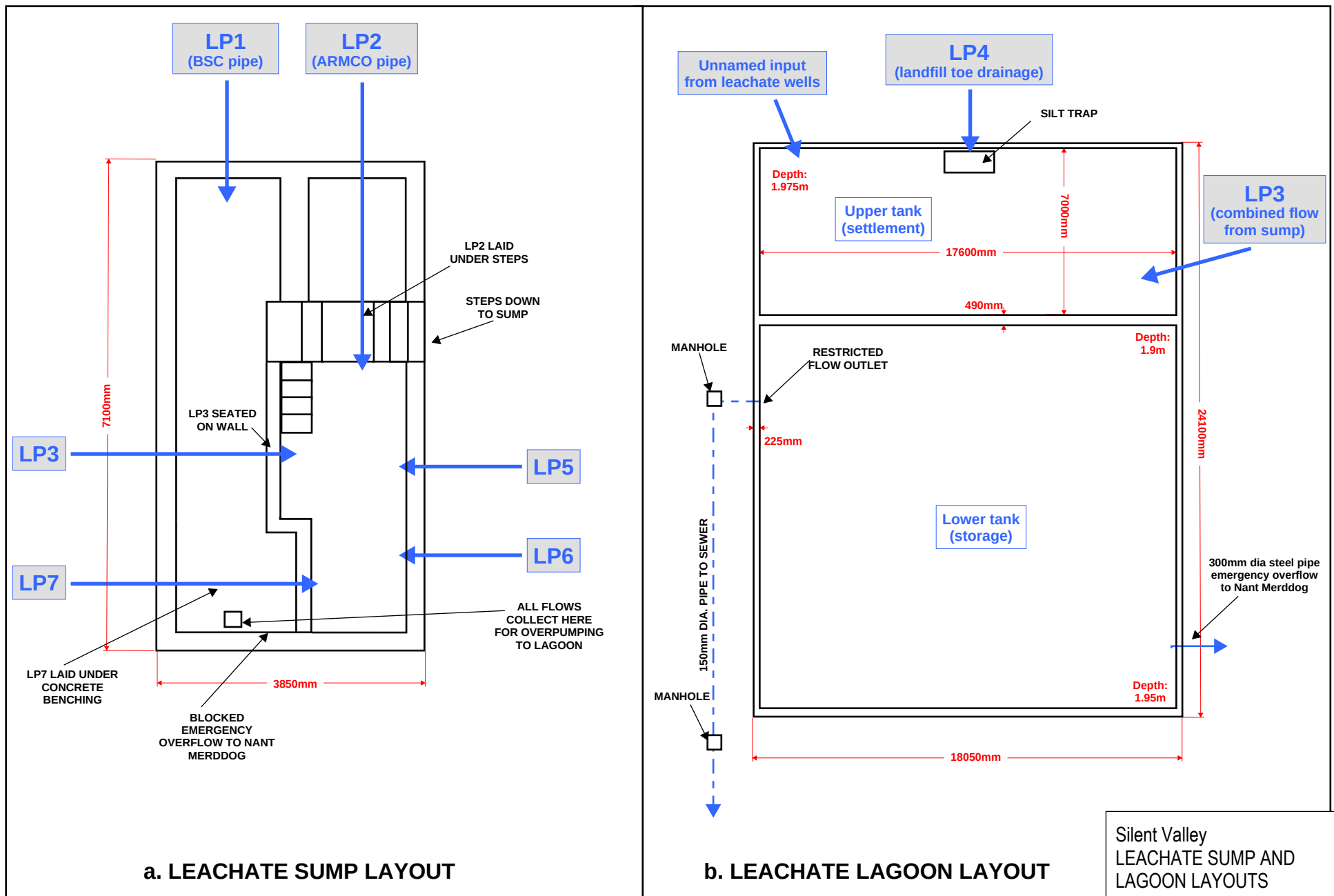
NOTES:

Manhole positions are indicative (from recent topographical survey information).
Extents and location of underground tank and associated infrastructure to be confirmed.

Silent Valley
SITE LAYOUT PLAN

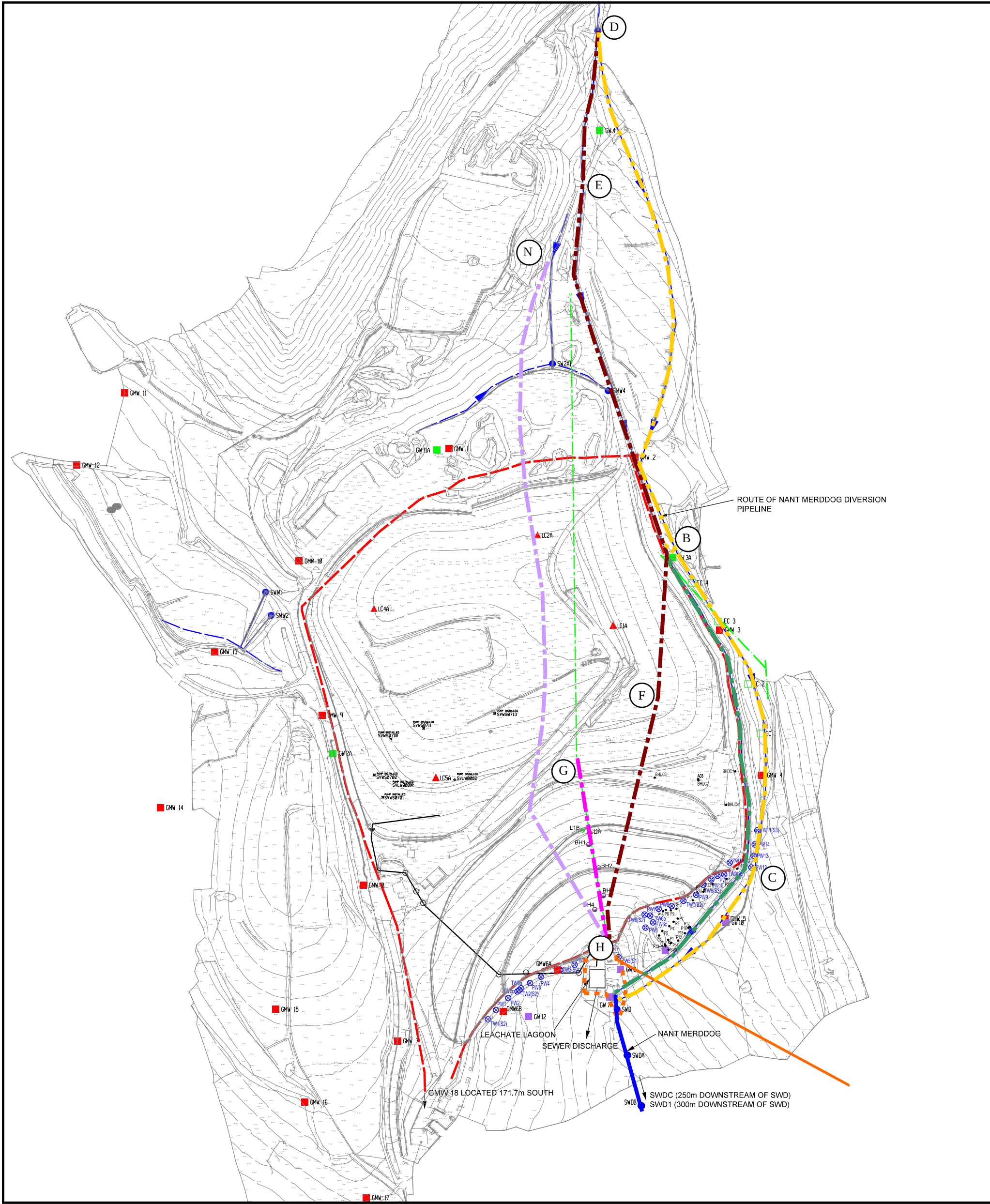
115825-00

FIGURE 2



Silent Valley
LEACHATE SUMP AND
LAGOON LAYOUTS

115825-00



LEGEND

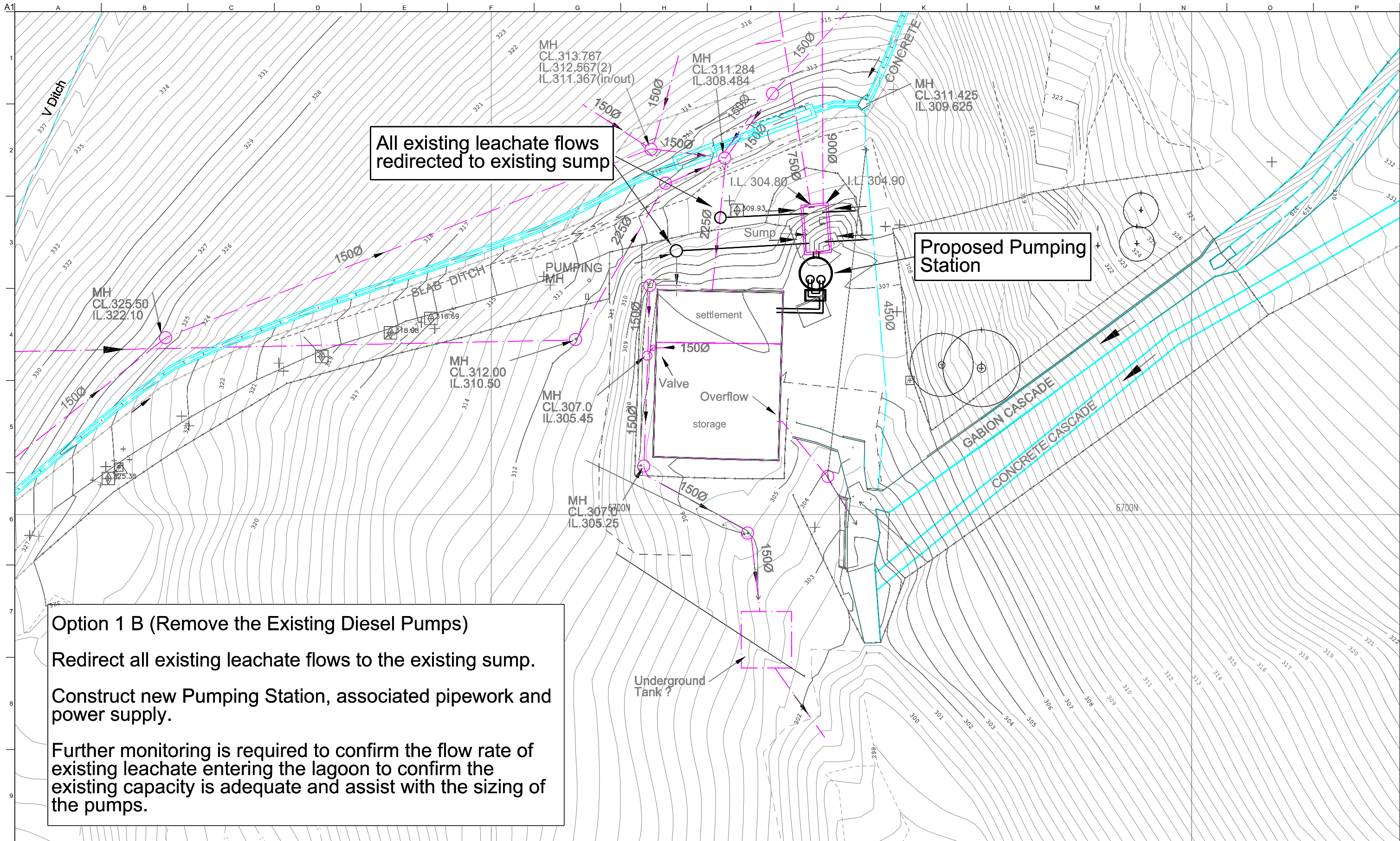
- | | | |
|---|------------------------------------|--|
| ■ EC 1 | EASTERN CUT-OFF MONITORING WELLS | --- BSC PIPE |
| ■ GMW5 | GAS MONITORING POINTS | --- ARMCO PIPE |
| ■ GW10 | COMPLAINE POINT GROUND WATER WELLS | --- PLASTIC PIPELINE |
| ■ GW4 | GROUND WATER MONITORING WELLS | --- EASTERN PERIMETER DITCH (SURFACE WATER) |
| ● SW1 | SURFACE WATER SAMPLING POINTS | --- NANT MERDDOG DIVERSION PIPE |
| ▲ LC1 | LEACHATE MONITORING WELLS | |
| --- | SURFACE WATER DITCHES | |
| --- | EXTENT OF LANDFILLED WASTE | |
| ⊗ TWs & PWs | PUMPING WELL CUT OFF SYSTEM | |

Silent Valley
 LANDFILL DRAINAGE LAYOUT
 115825-00



Silent Valley
LOCATION OF WELSH WATER
SEWER CONNECTION

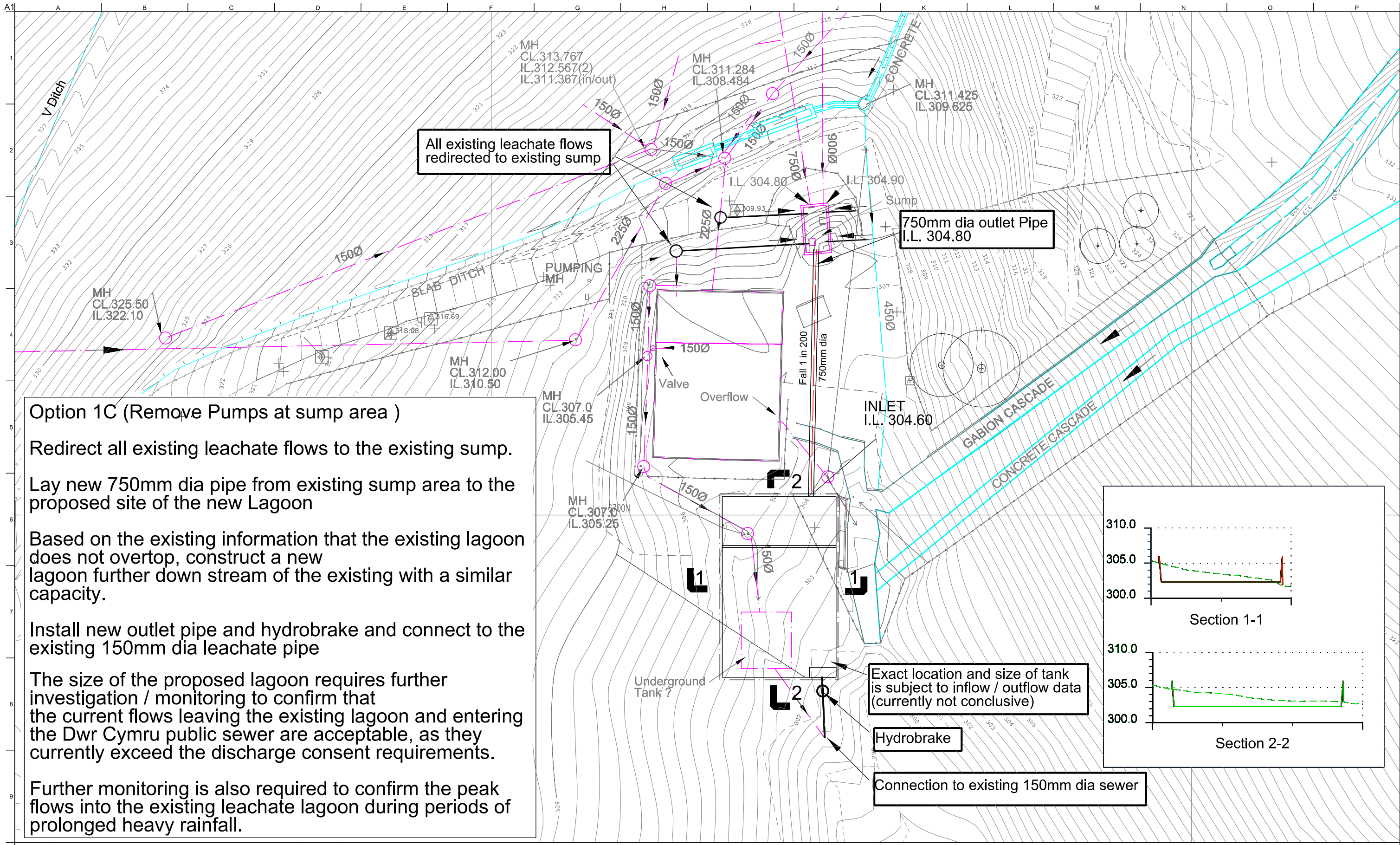
115825-00



Silent Valley
 OPTION 2 - PROPOSED
 PUMPING STATION LAYOUT

115825-00

FIGURE 6



Option 1C (Remove Pumps at sump area)

Redirect all existing leachate flows to the existing sump.

Lay new 750mm dia pipe from existing sump area to the proposed site of the new Lagoon

Based on the existing information that the existing lagoon does not overtop, construct a new lagoon further down stream of the existing with a similar capacity.

Install new outlet pipe and hydrobrake and connect to the existing 150mm dia leachate pipe

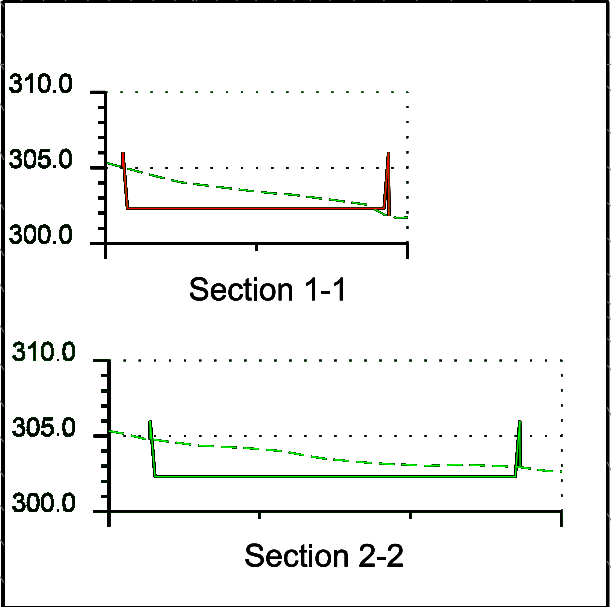
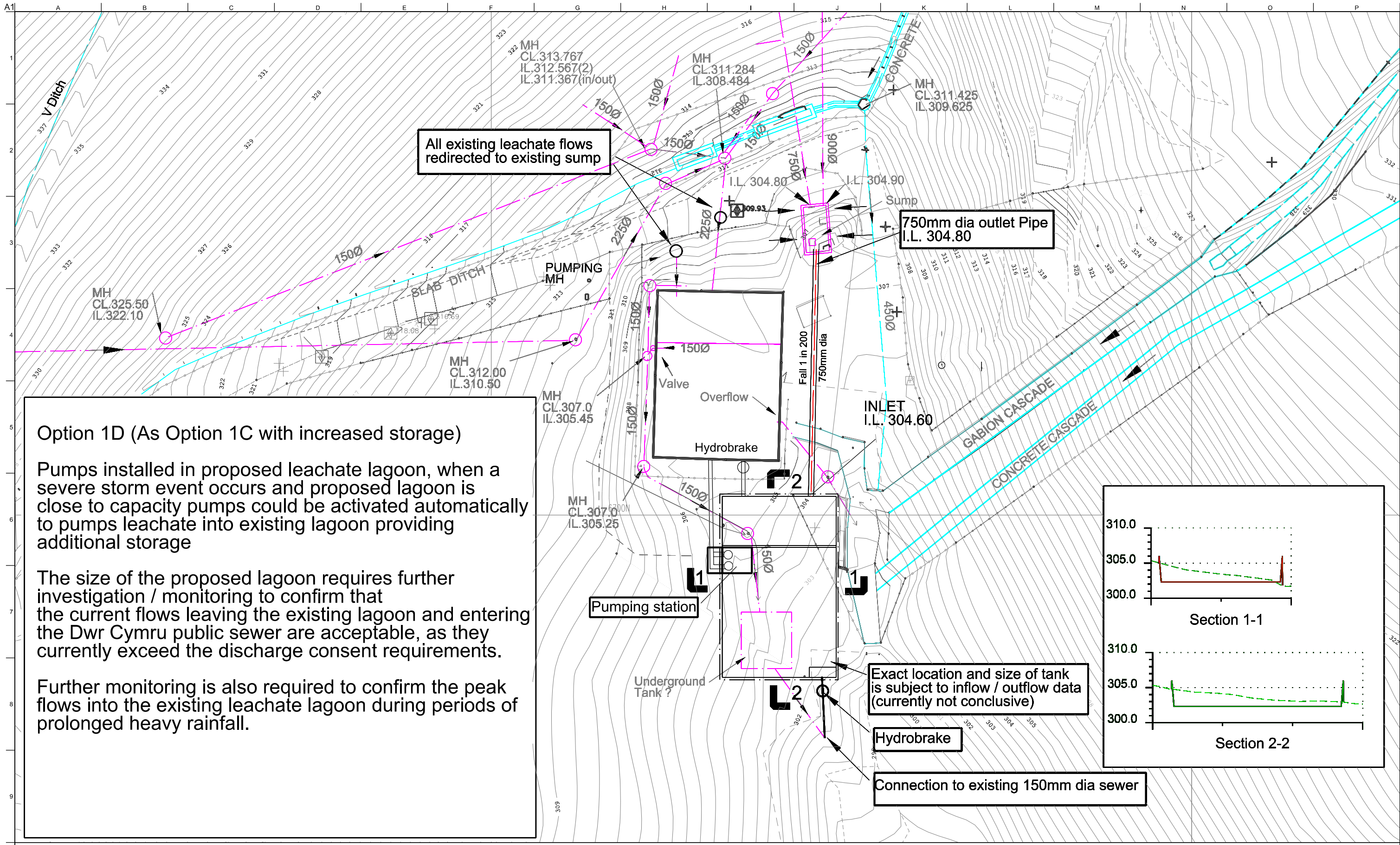
The size of the proposed lagoon requires further investigation / monitoring to confirm that the current flows leaving the existing lagoon and entering the Dwr Cymru public sewer are acceptable, as they currently exceed the discharge consent requirements.

Further monitoring is also required to confirm the peak flows into the existing leachate lagoon during periods of prolonged heavy rainfall.

Silent Valley
 OPTION 3 - GRAVITY SEWER
 LAYOUT

115825-00

FIGURE 7



Silent Valley
OPTION 3a - GRAVITY SEWER
WITH INCREASED STORAGE
LAYOUT

115825-00

Appendix A

Site photographs

Photograph 1 – Leachate sump



Photograph 2 – Leachate sump inputs



Photograph 3 – Diesel pump from sump to lagoon



Photograph 4 – Leachate lagoon tanks



Photograph 5 – Inputs to leachate lagoon



Photograph 6 – Leachate lagoon



Photograph 7 – Leachate lagoon (view from east)



Appendix B

Flow monitoring records - graphs
(2014-2015)

Client : Silent Valley

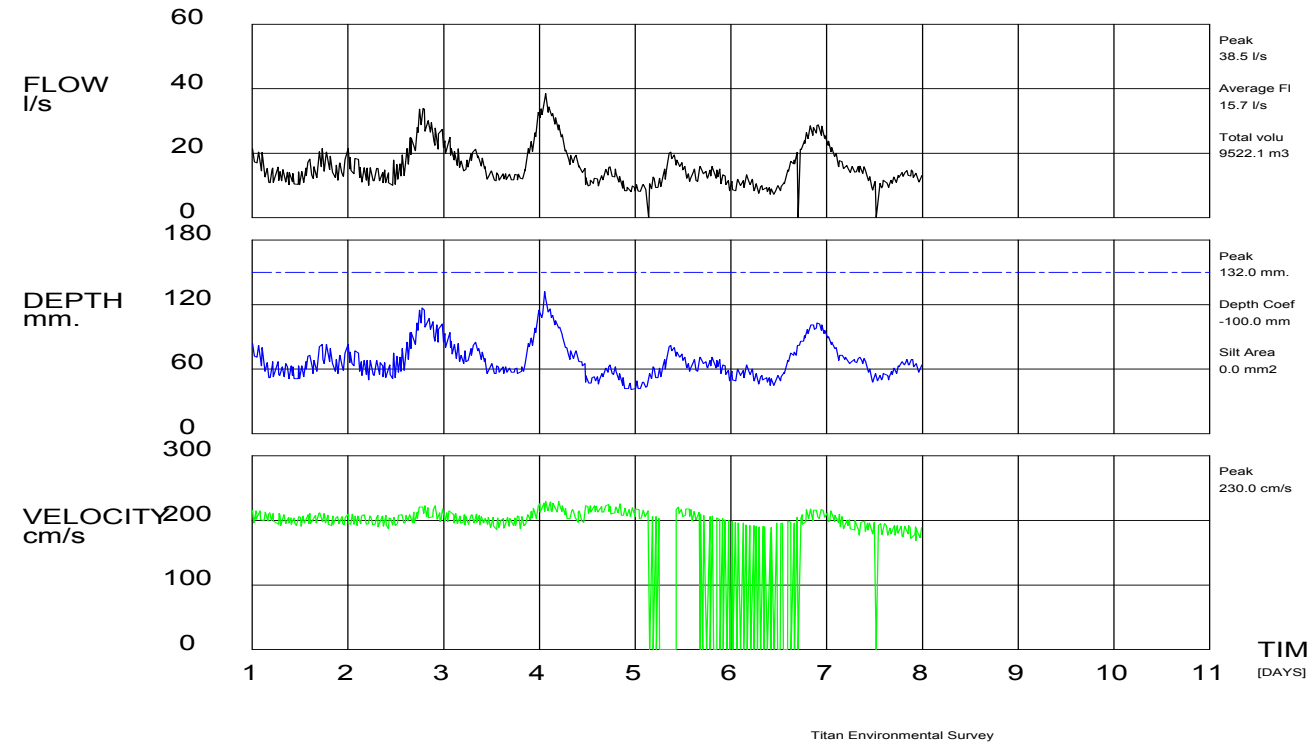
Project: Silent Valley Landfill

Event : 1-NOV-13 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

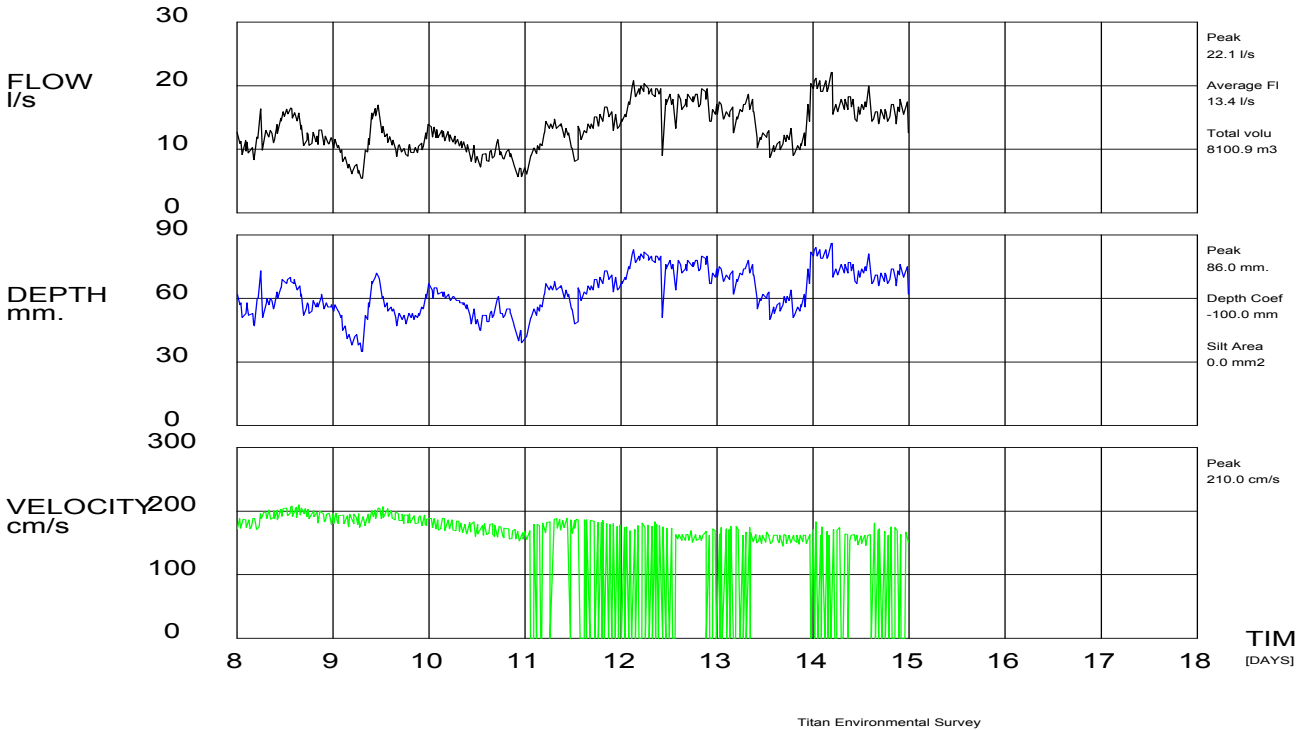
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Site : 1

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Size : 150



Client : Silent Valley

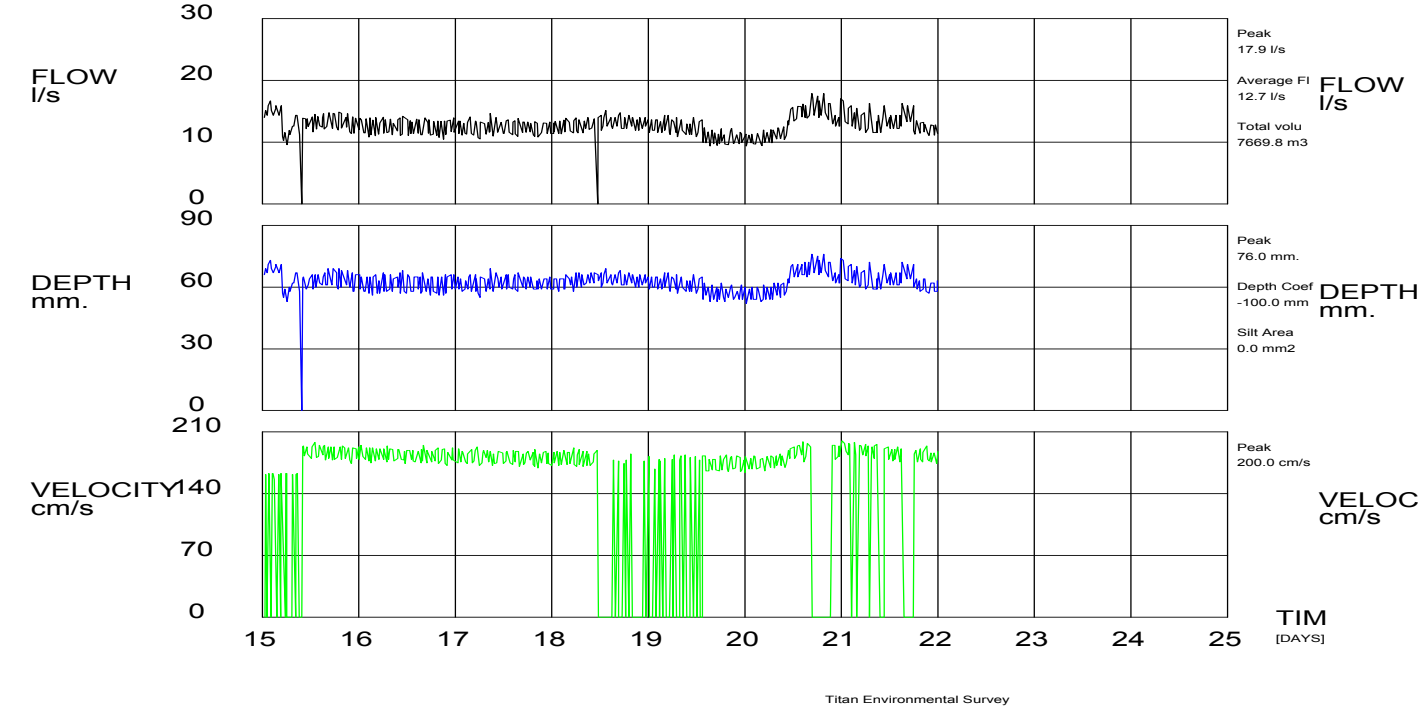
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Size : 150



Client : Silent Valley

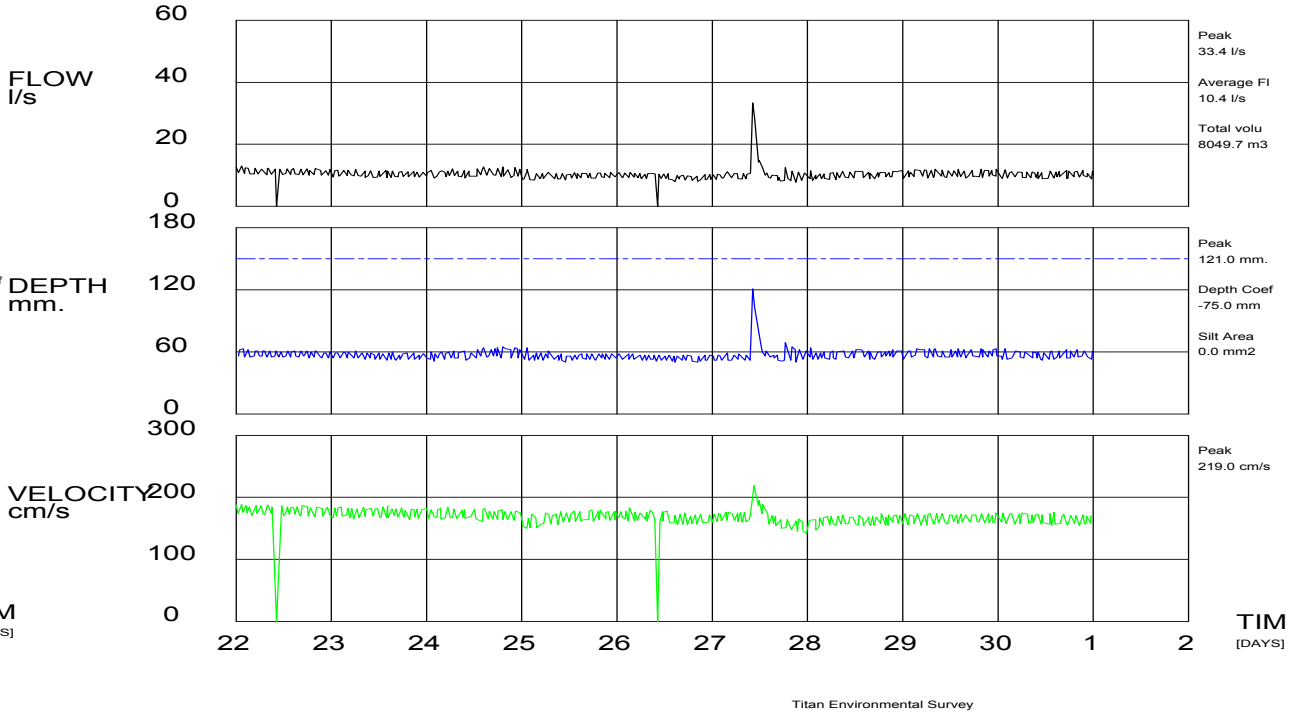
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Size : 150



Client : Silent Valley

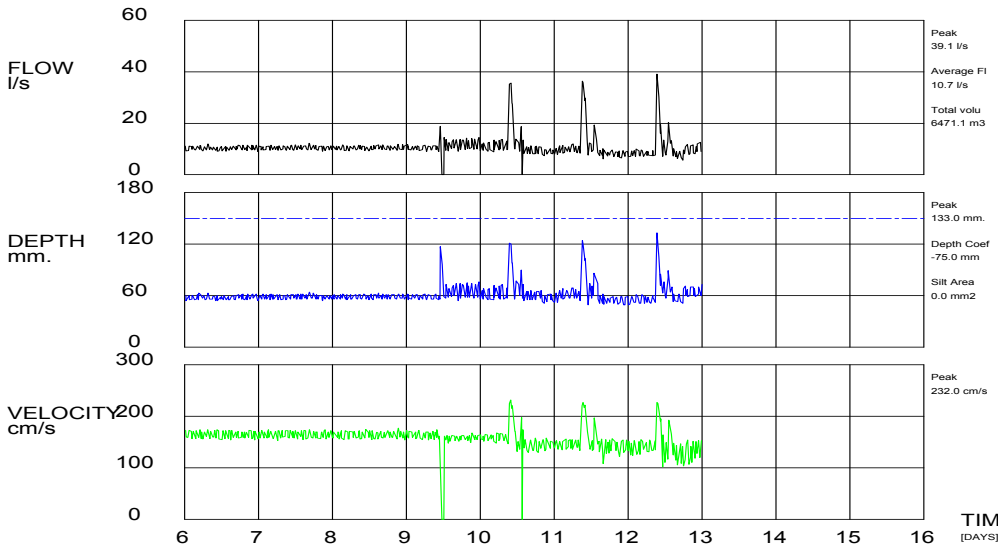
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Event : 6-DEC-13 0:00

Site : 1

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Size : 150



Titan Environmental Survey

Client : Silent Valley

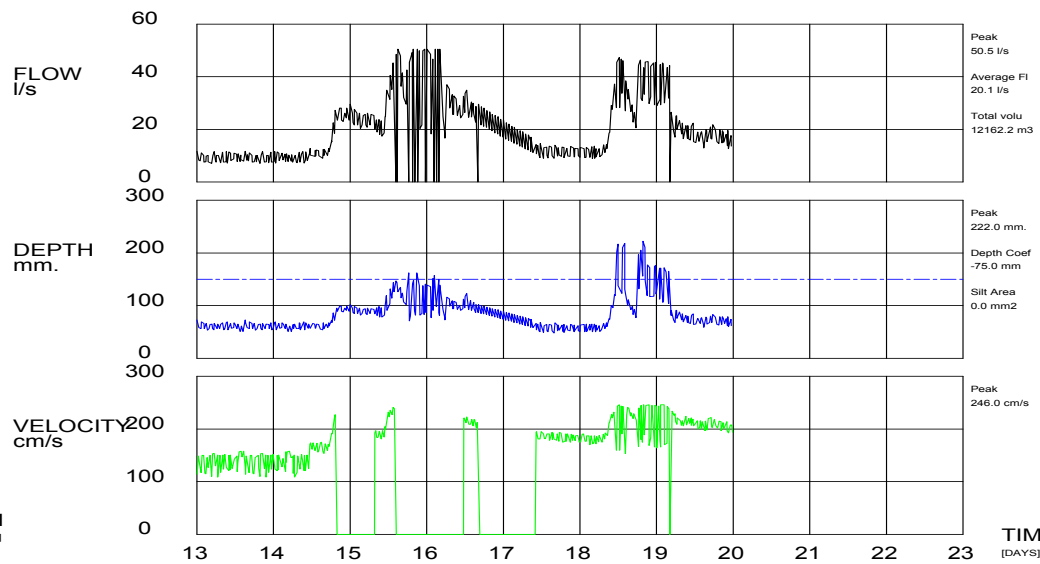
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Event : 13-DEC-13 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

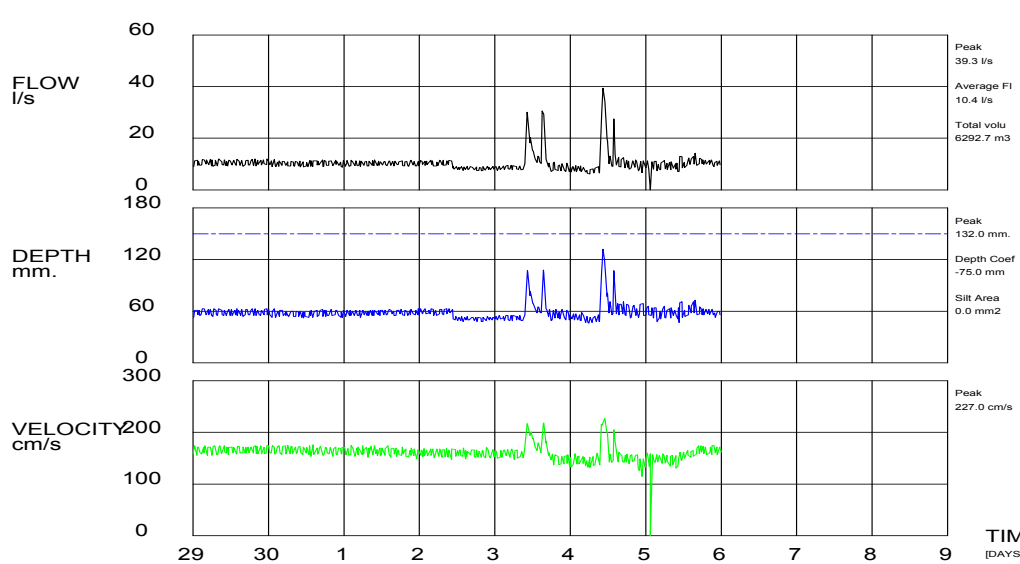
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Site : 1

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Size : 150



Titan Environmental Survey

Client : Silent Valley

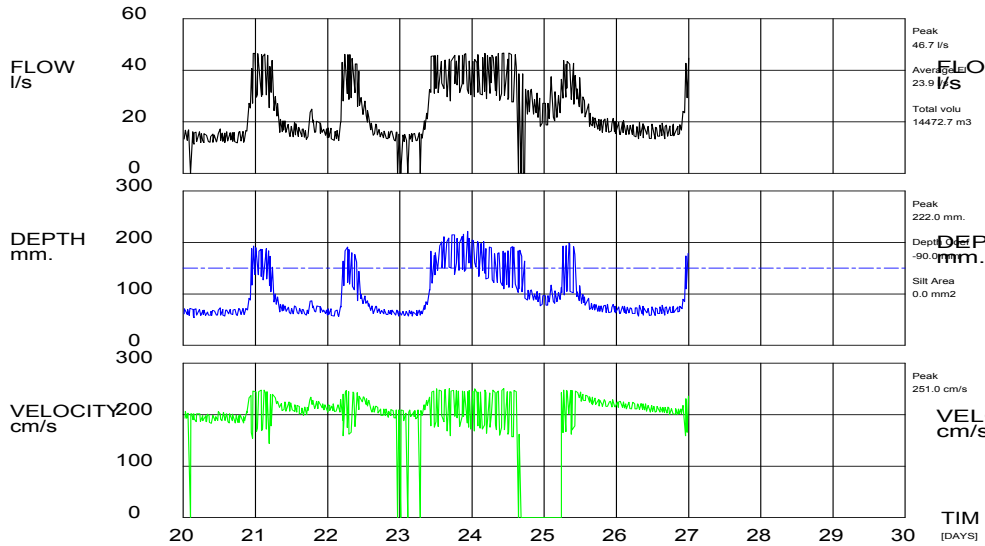
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Event : 20-DEC-13 0:00

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Size : 150



Titan Environmental Survey

Client : Silent Valley

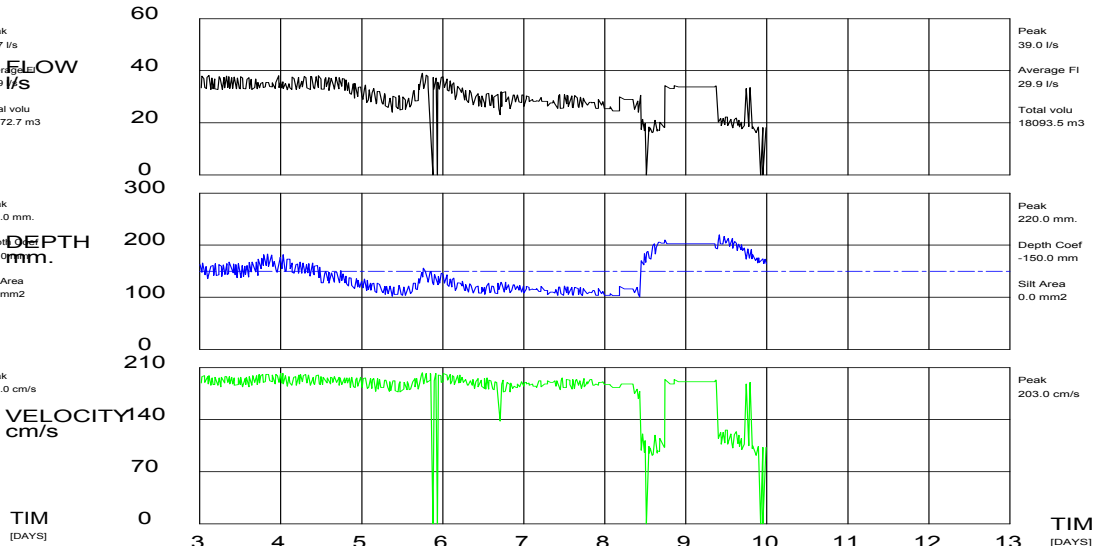
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Event : 3-JAN-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

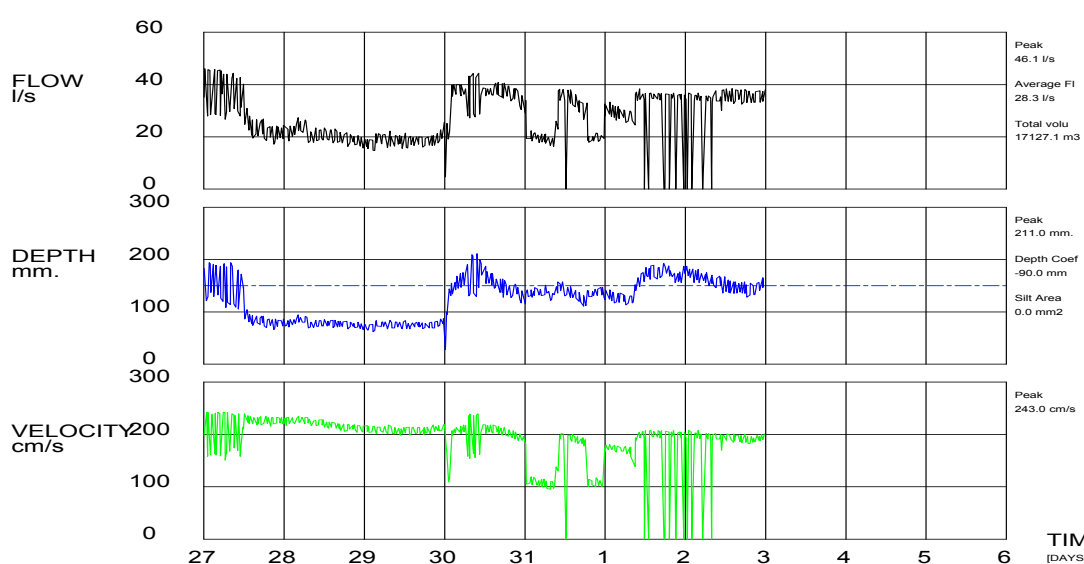
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Titan Environmental Survey

Client : Silent Valley

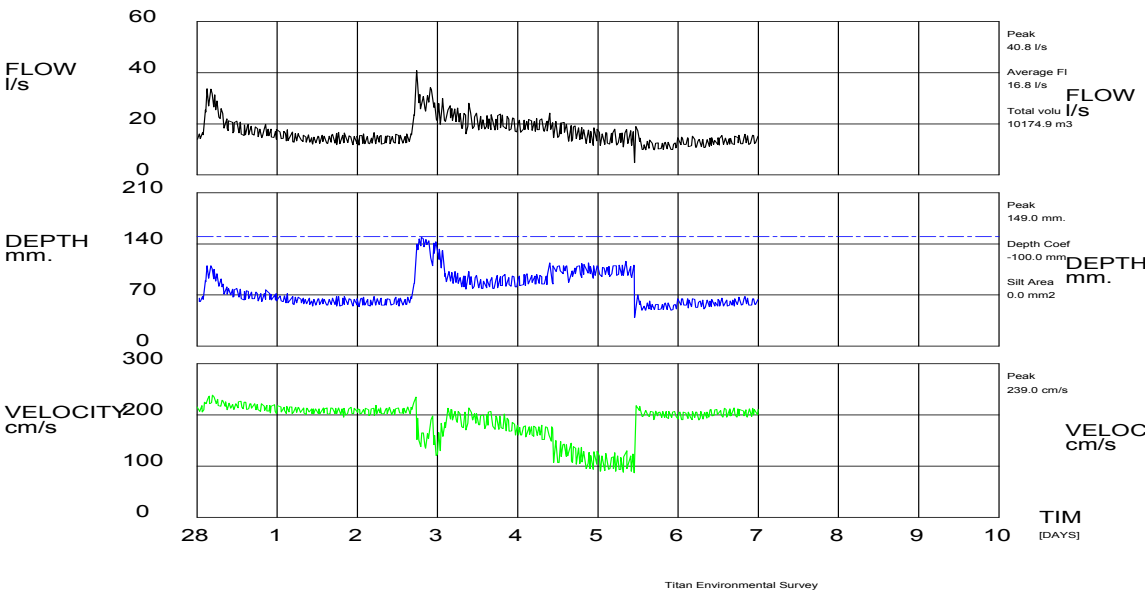
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Event : 28-FEB-14 0:00

Site : 1

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Client : Silent Valley

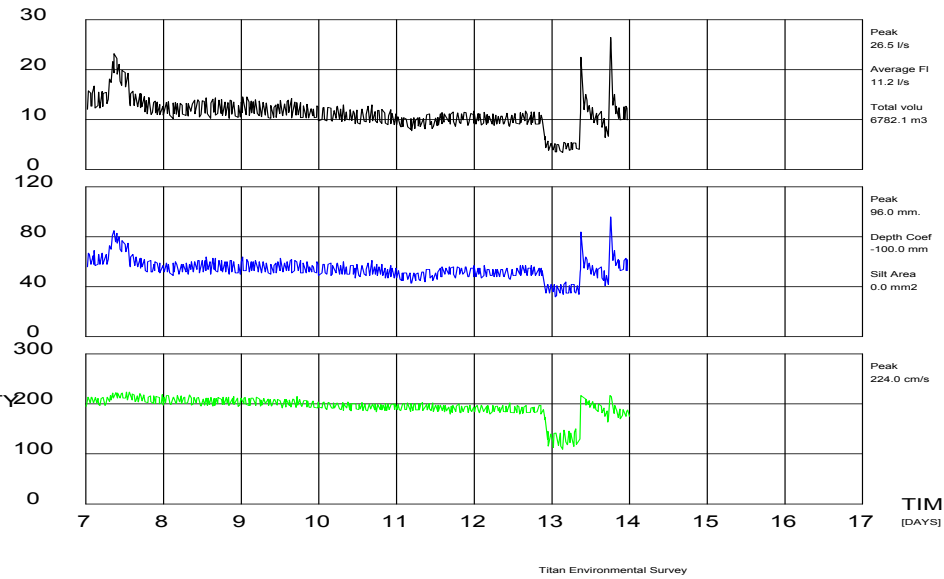
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Site : 1

MH-No:

Size : 150



Client : Silent Valley

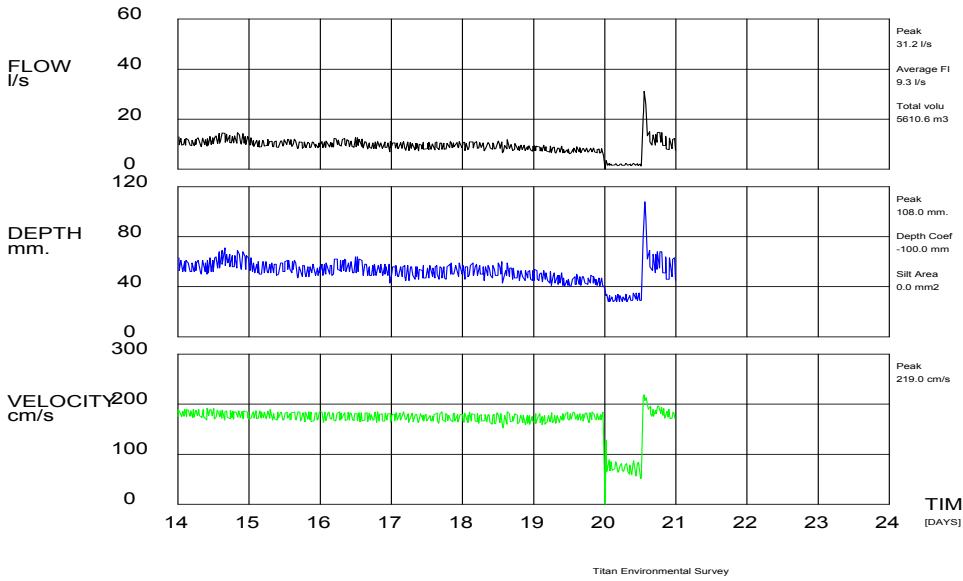
Project: Silent Valley Landfill

Event : 14-MAR-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

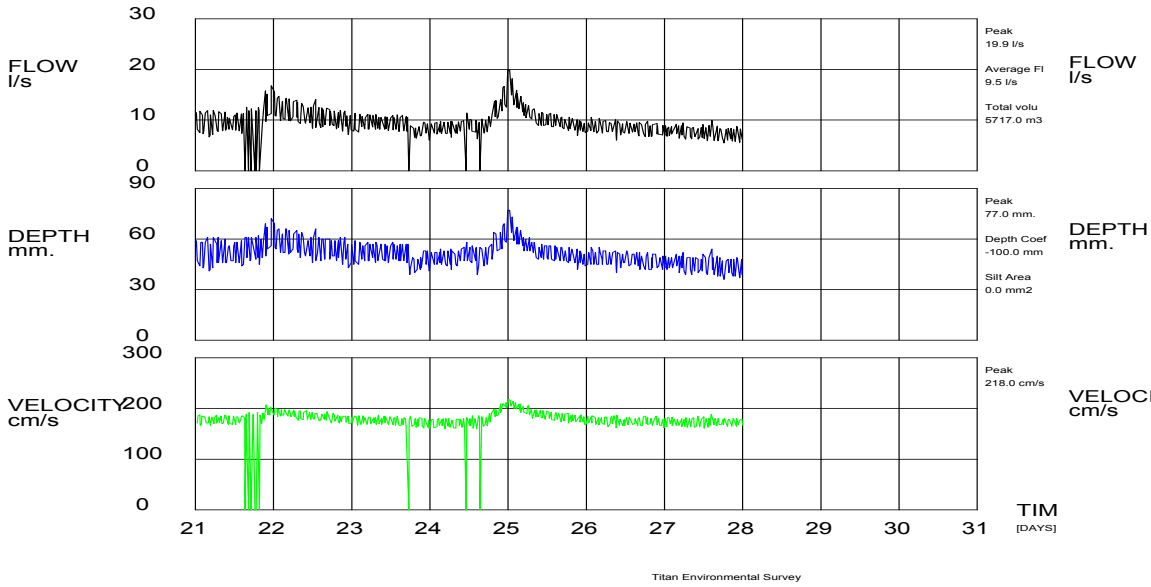
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Event : 21-MAR-14 0:00

Site : 1

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Size : 150



Client : Silent Valley

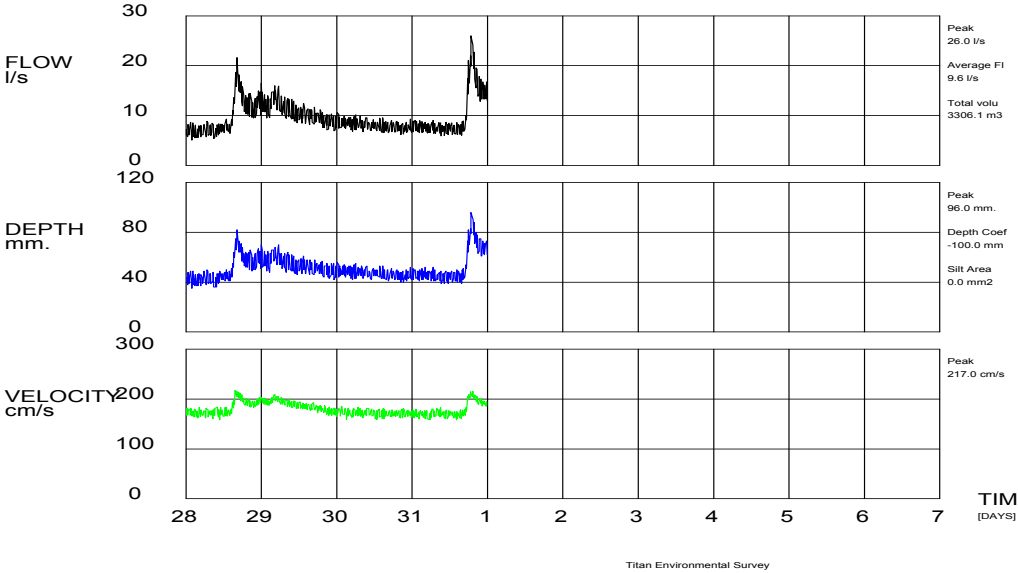
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Site : 1

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Client : Silent Valley

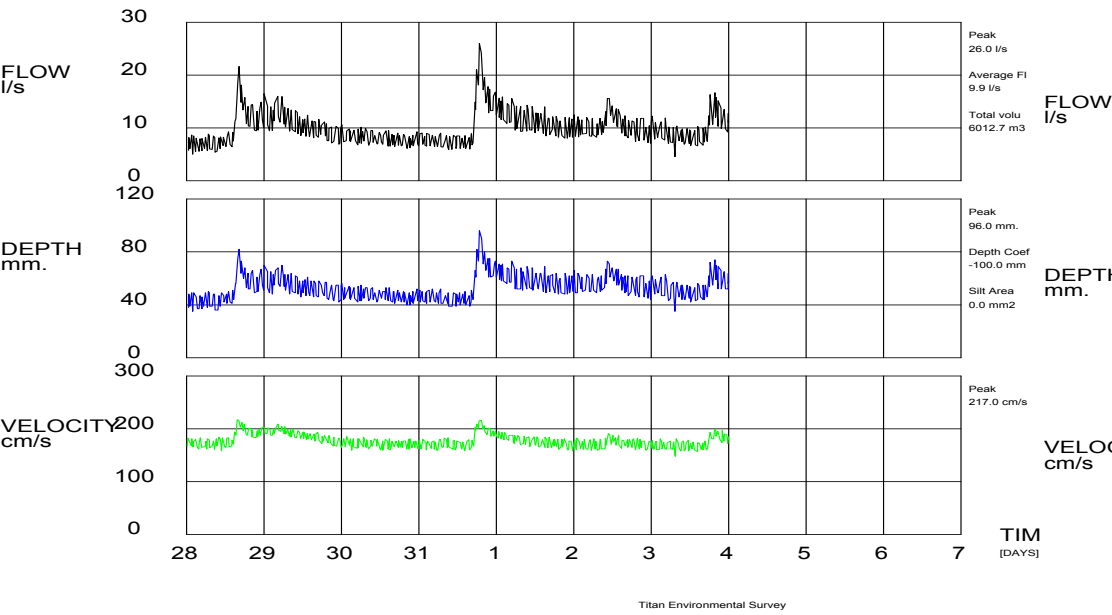
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Site : 1

MH-No:

Size : 150



Client : Silent Valley

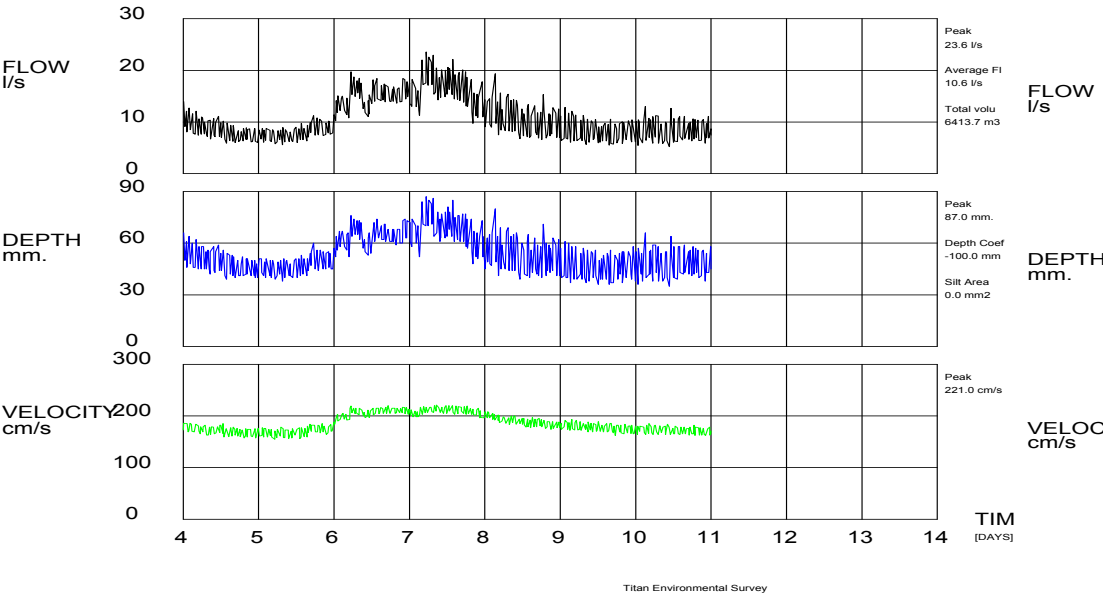
Project: Silent Valley Landfill

Event : 4-APR-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

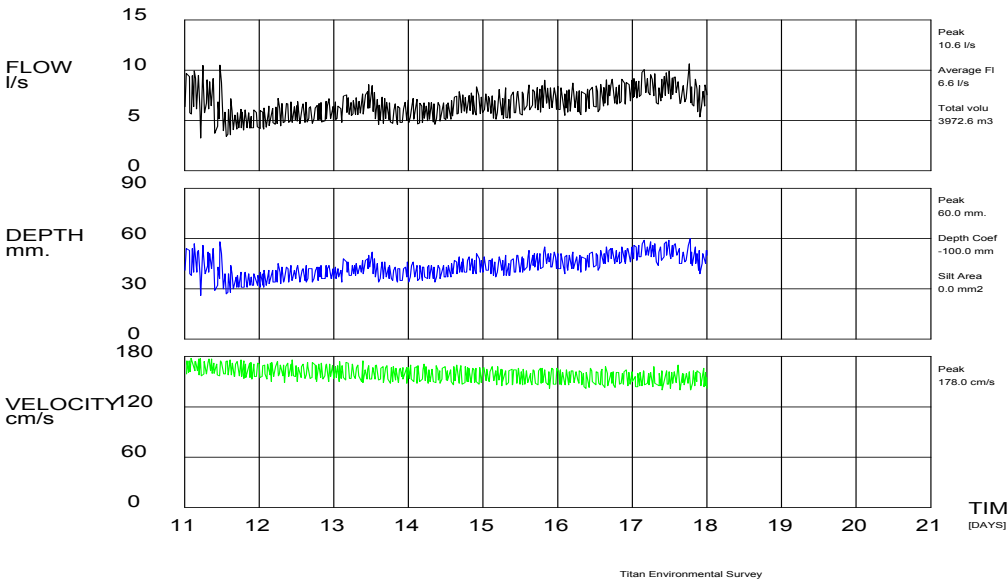
Project: Silent Valley Landfill

Event : 11-APR-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

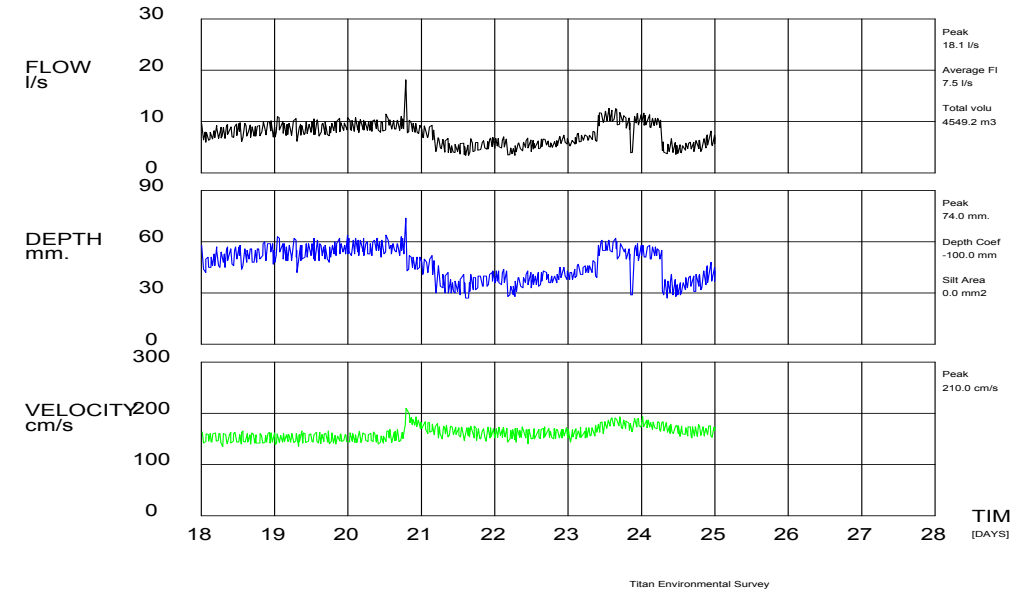
Project: Silent Valley Landfill

Event : 18-APR-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

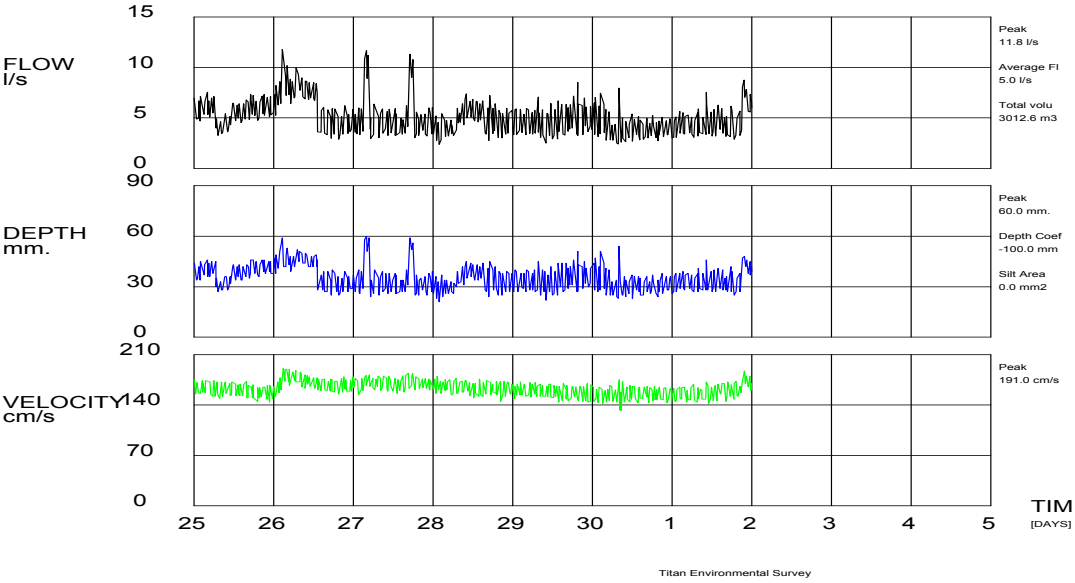
Project: Silent Valley Landfill

Event : 25-APR-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

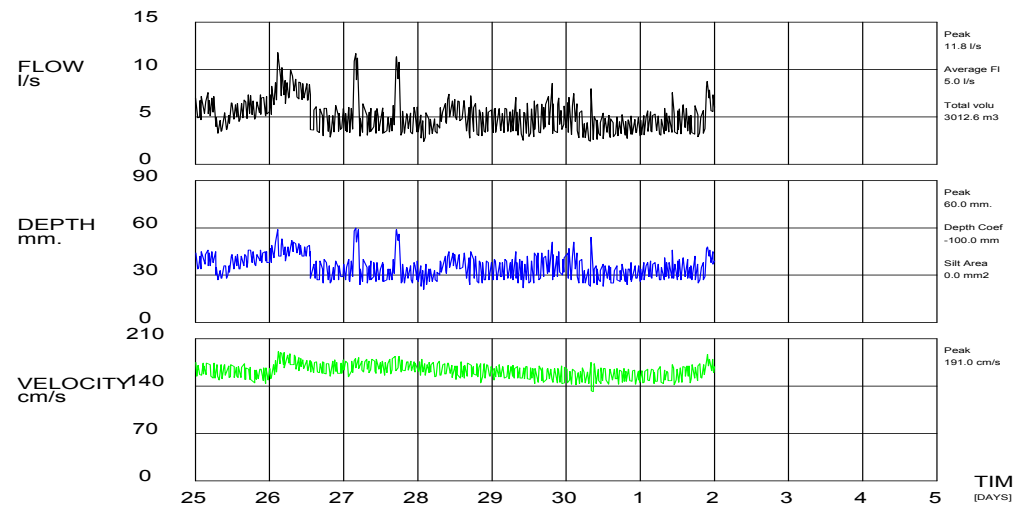
Project: Silent Valley Landfill

Event : 25-APR-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

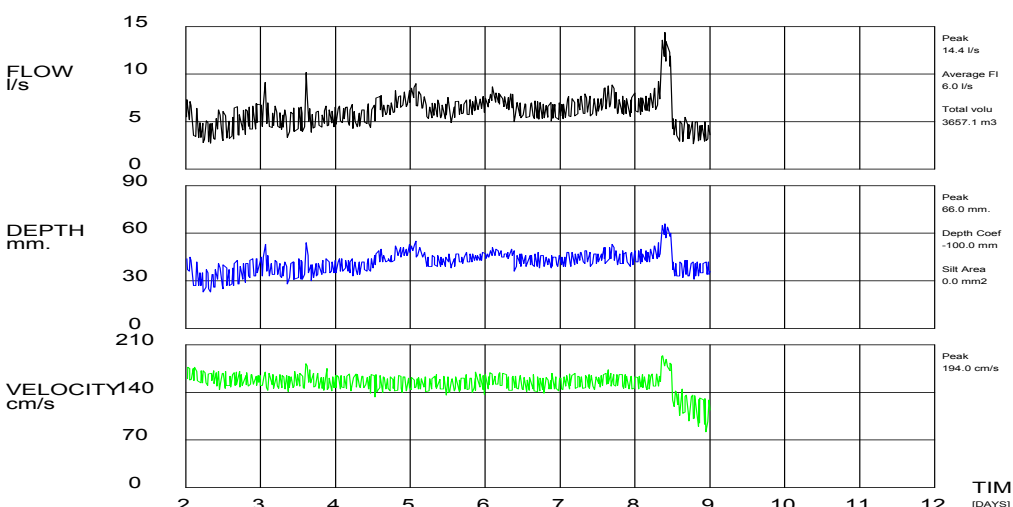
Project: Silent Valley Landfill

Event : 2-MAY-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

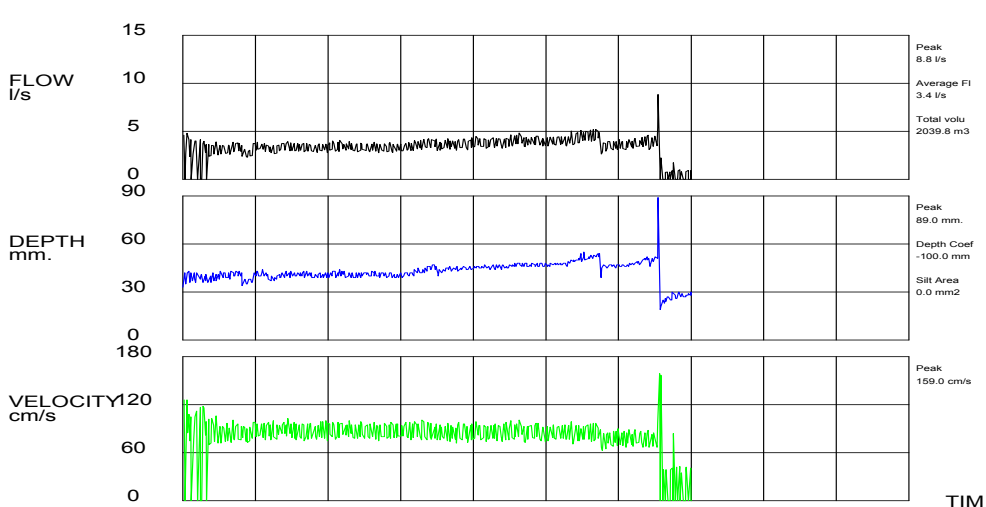
Project: Silent Valley Landfill

Event : 9-MAY-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

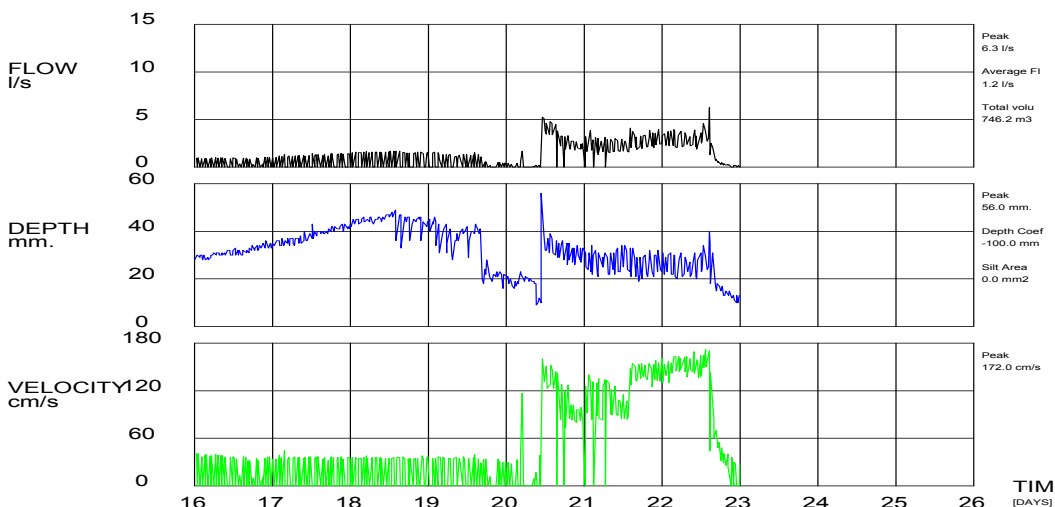
Project: Silent Valley Landfill

Event : 16-MAY-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

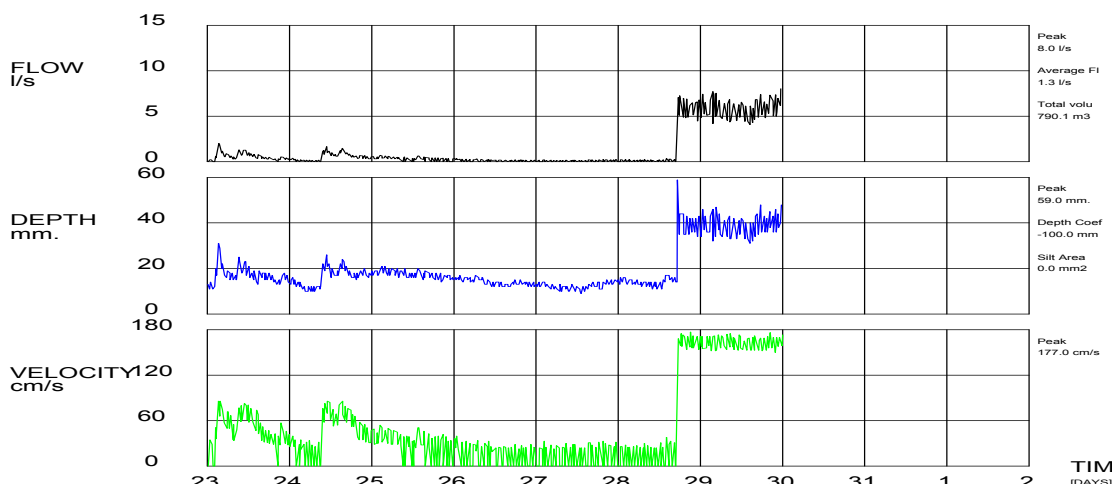
Project: Silent Valley Landfill

Event : 23-MAY-14 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

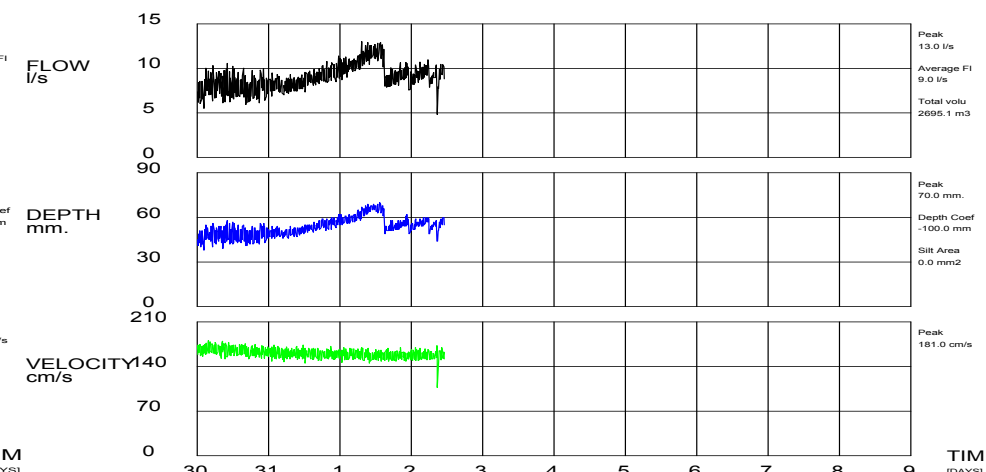
Project: Silent Valley Landfill

Event : 30-MAY-14 0:00

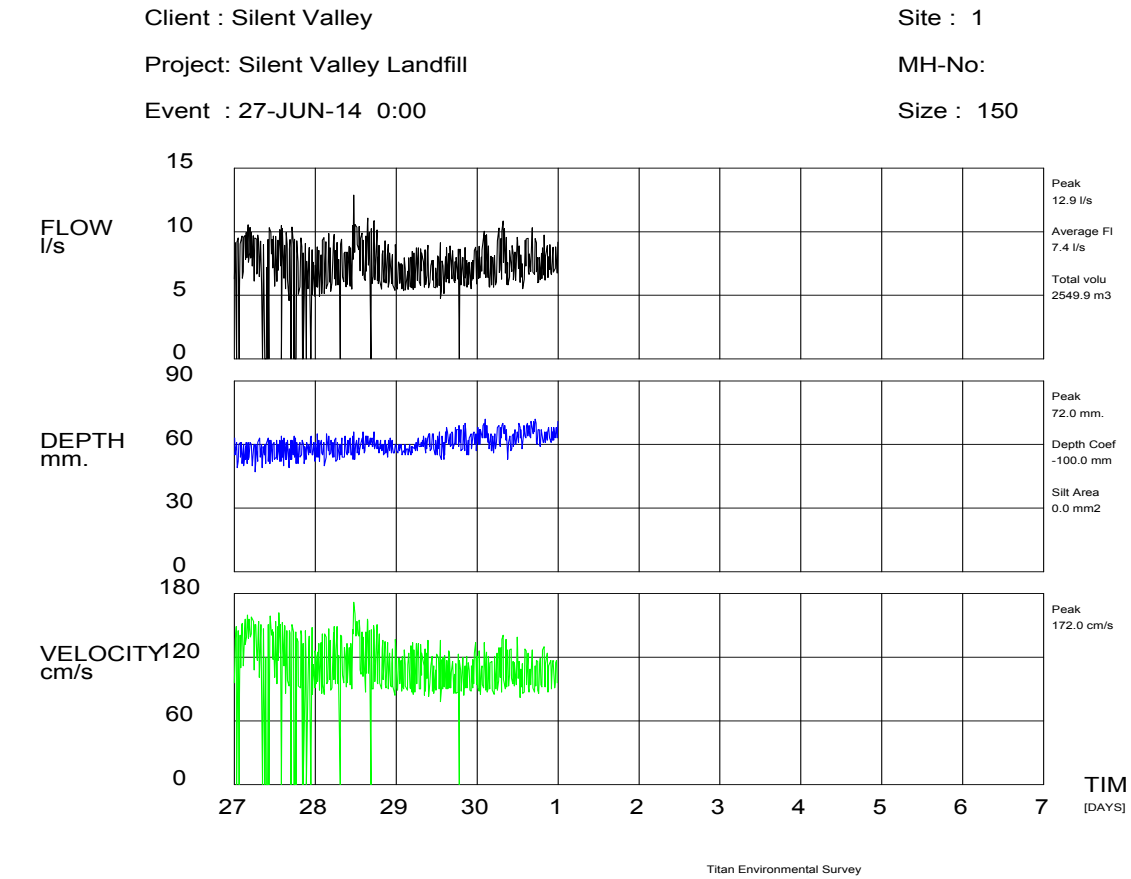
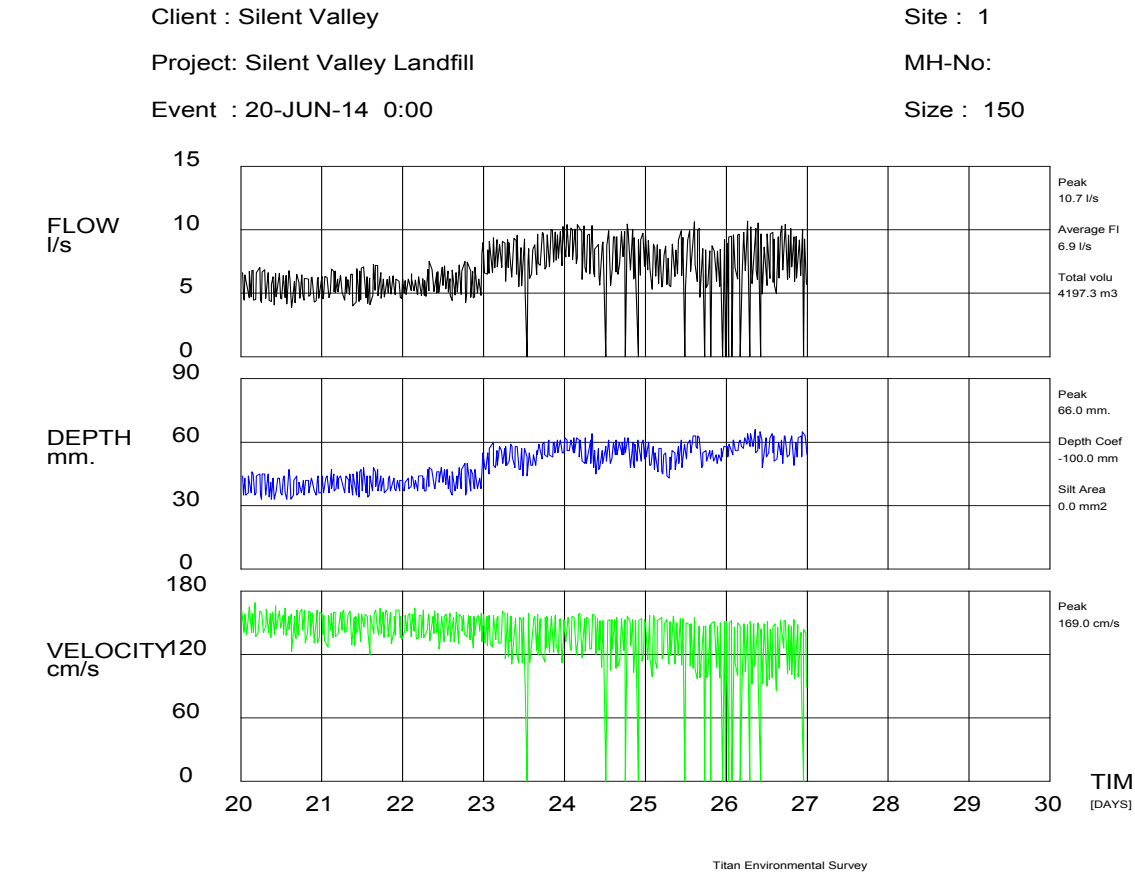
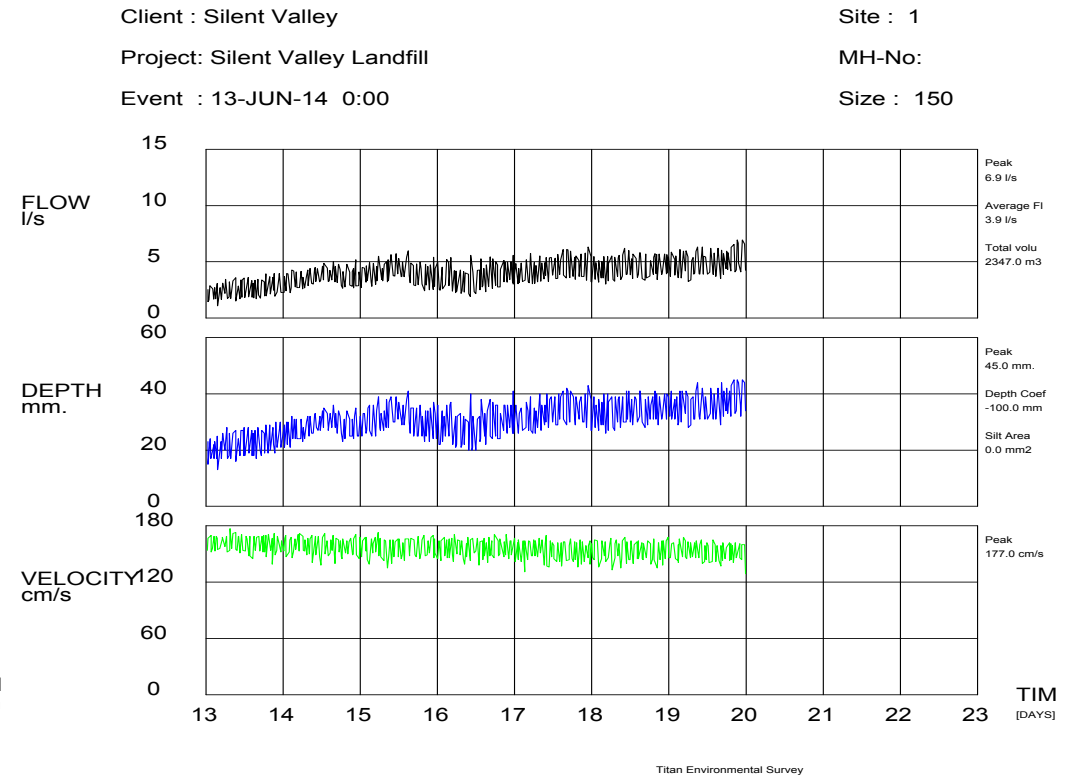
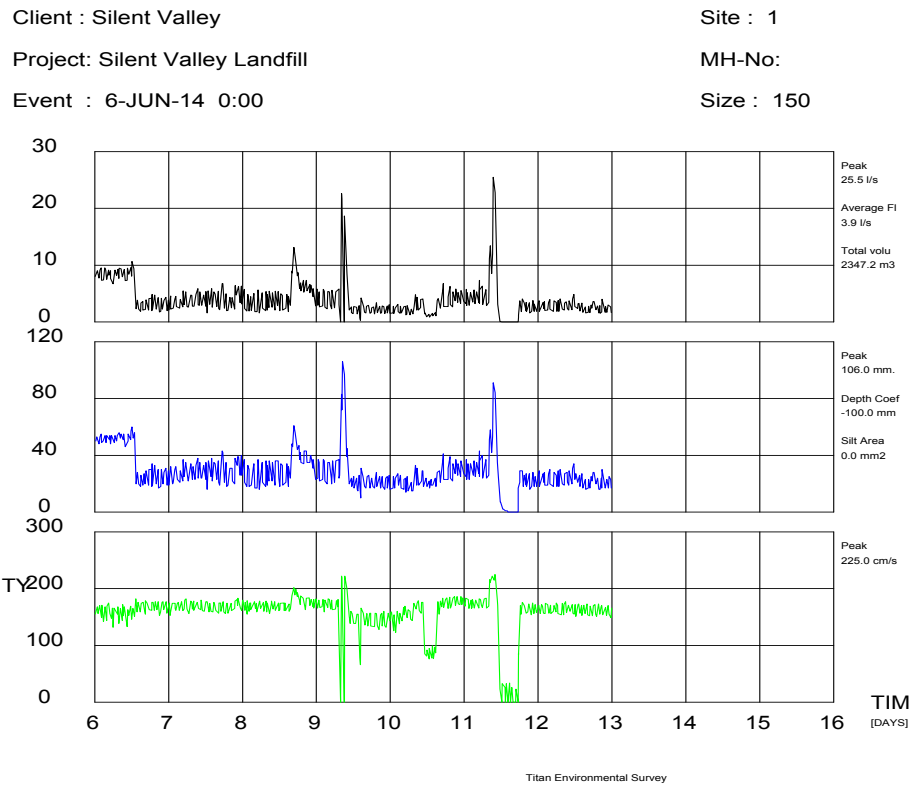
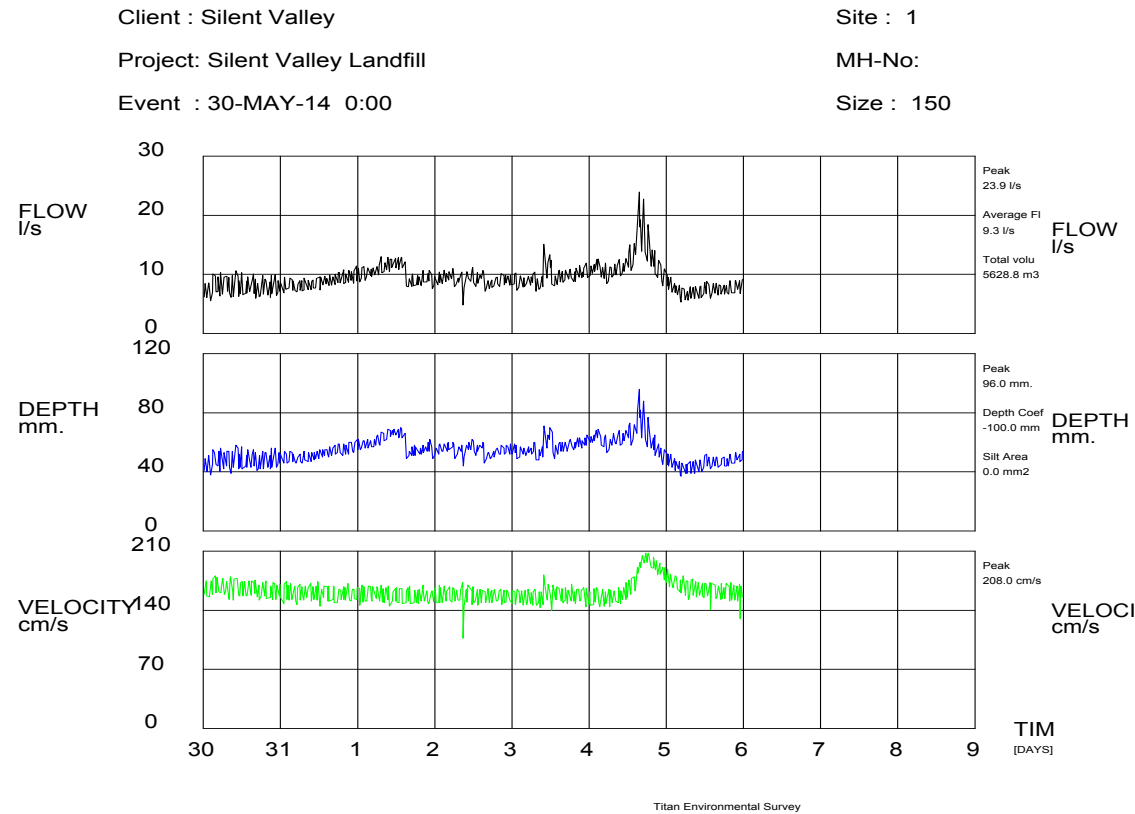
Site : 1

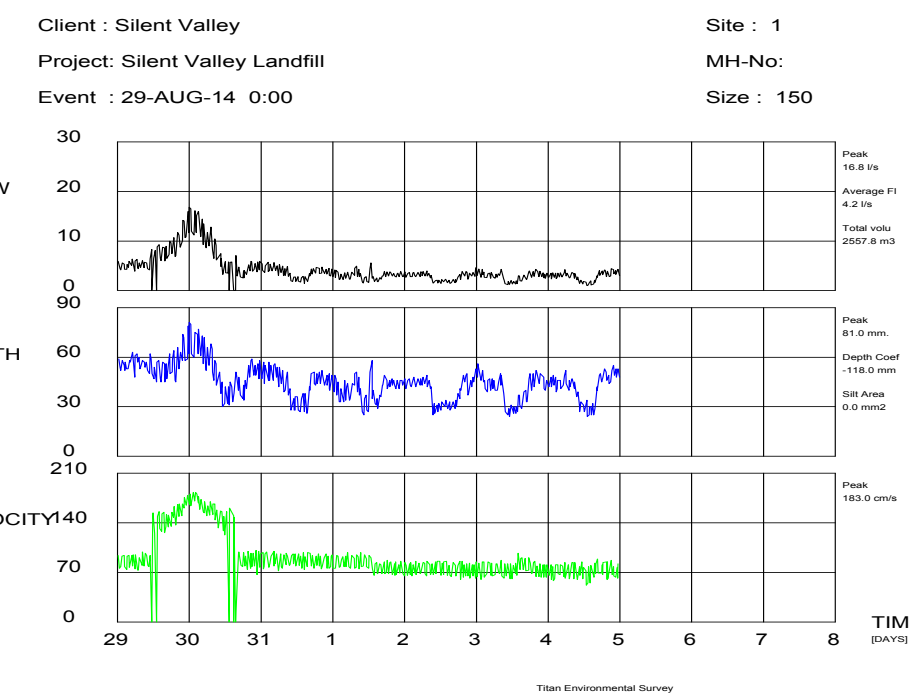
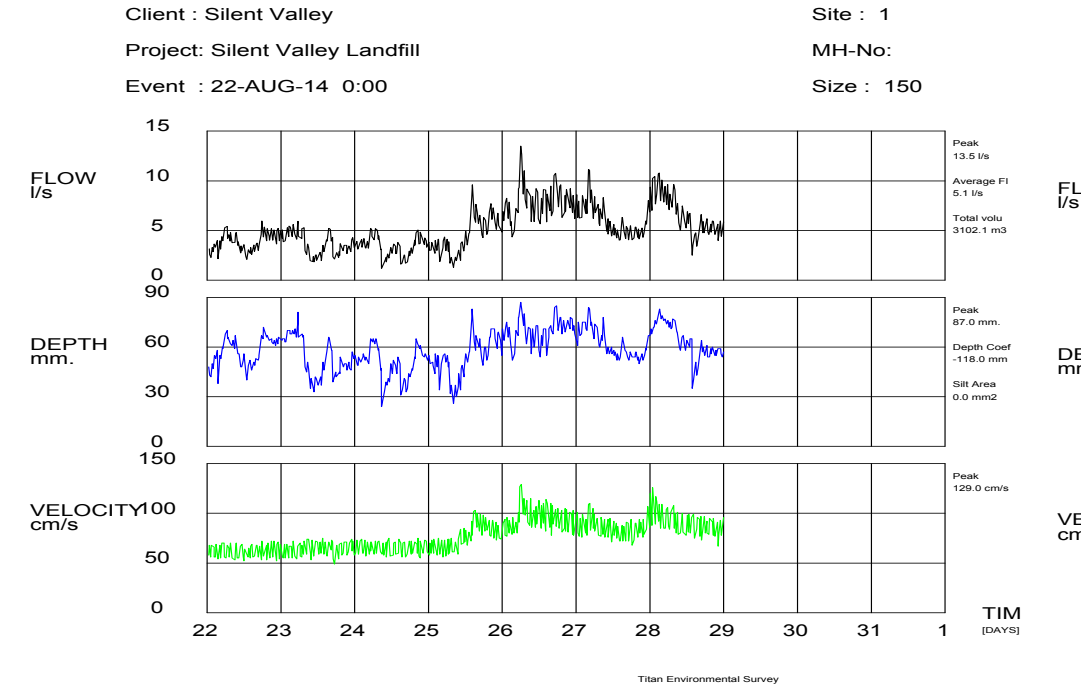
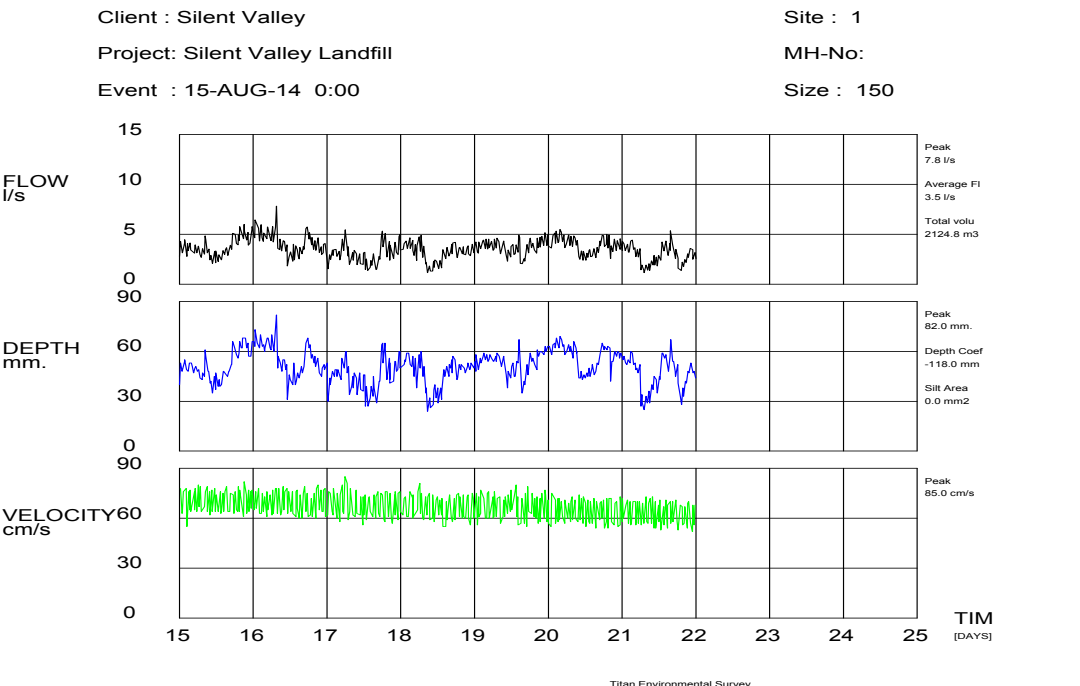
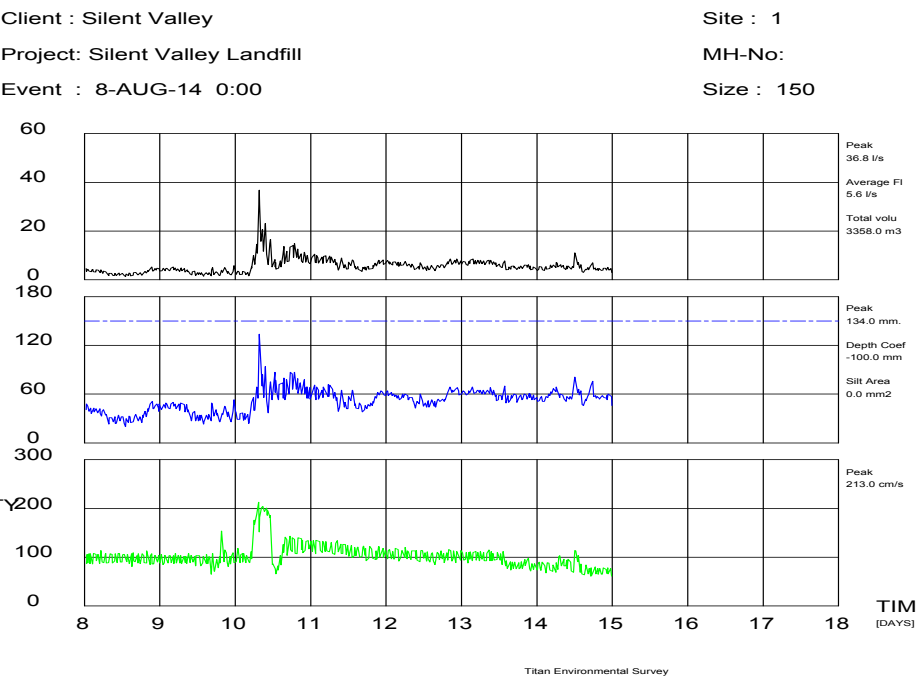
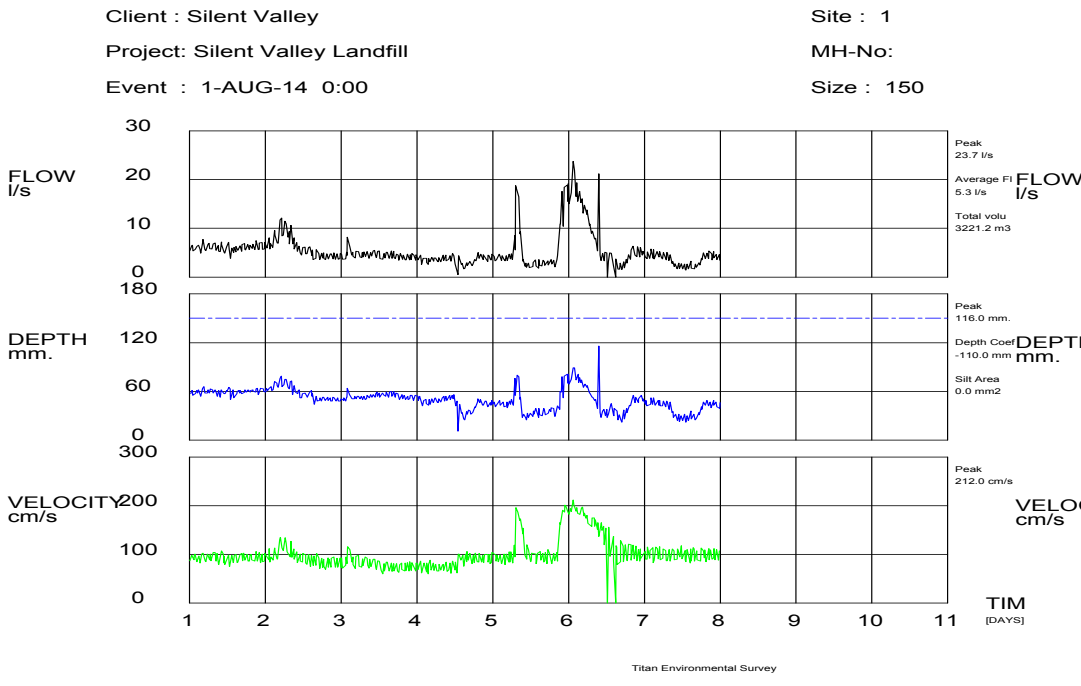
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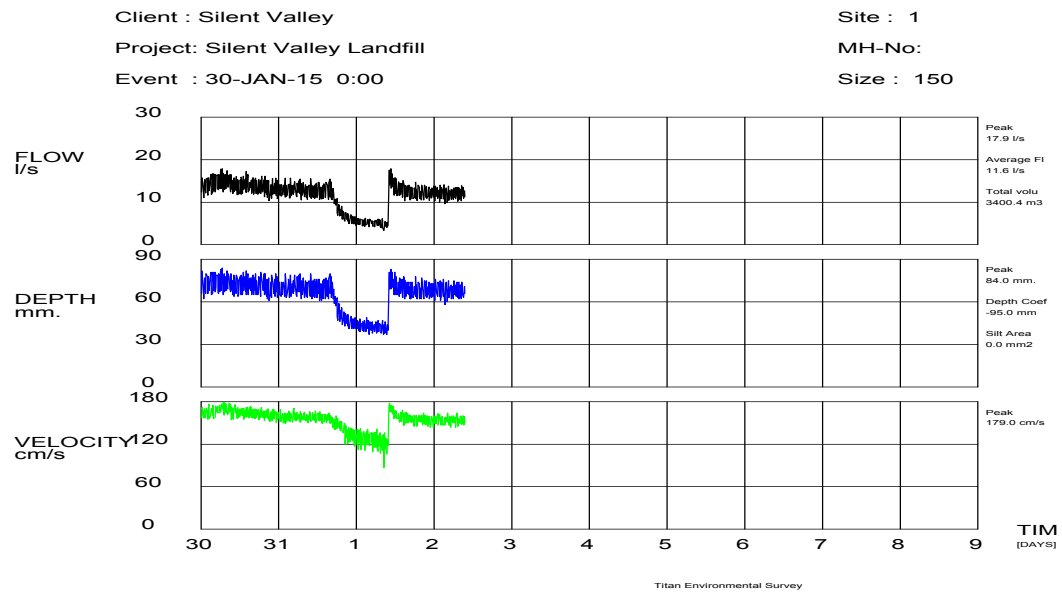
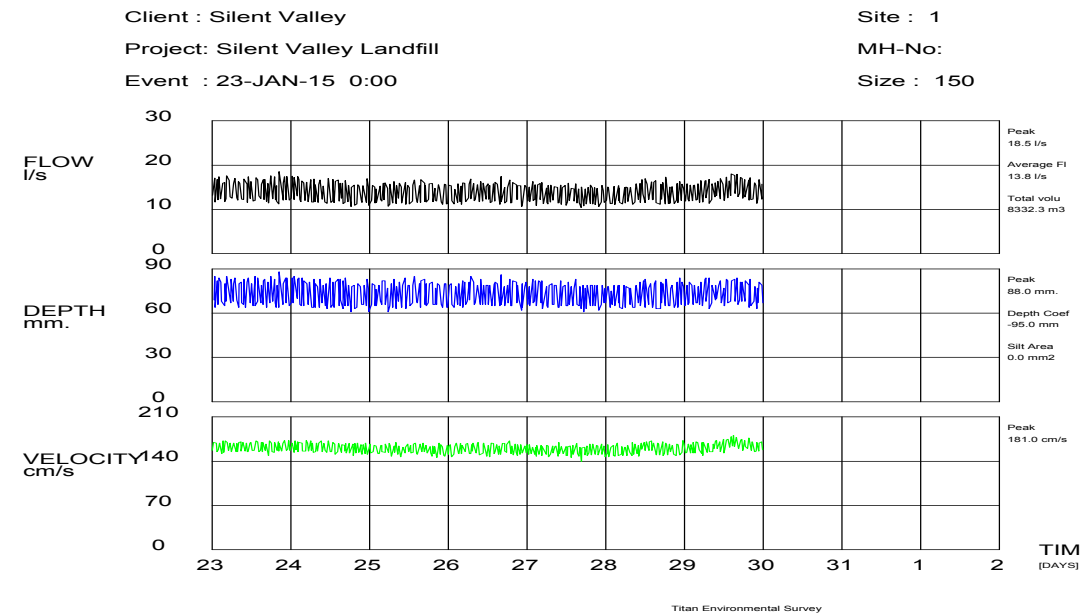
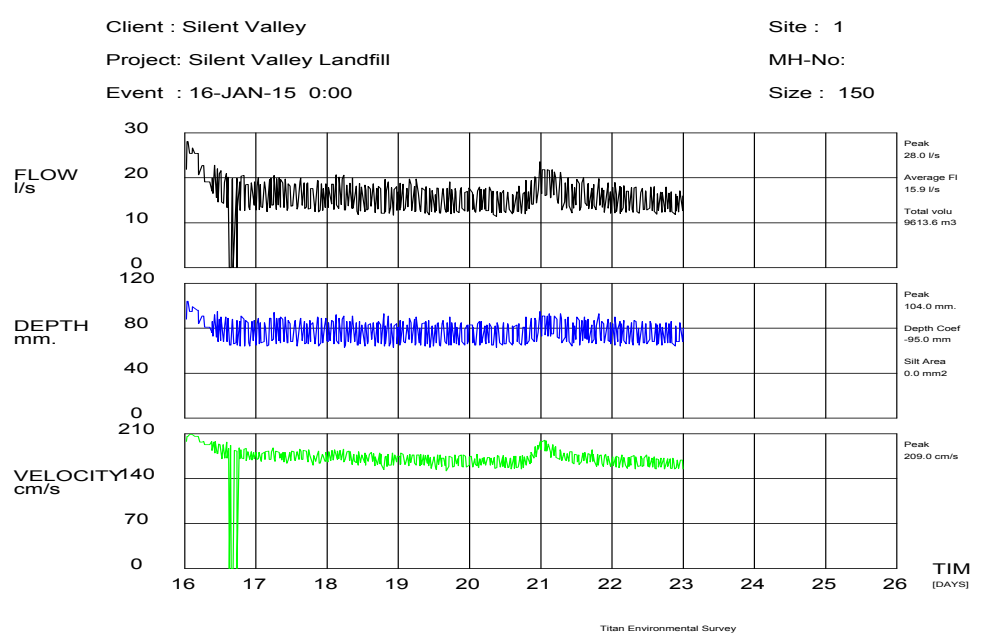
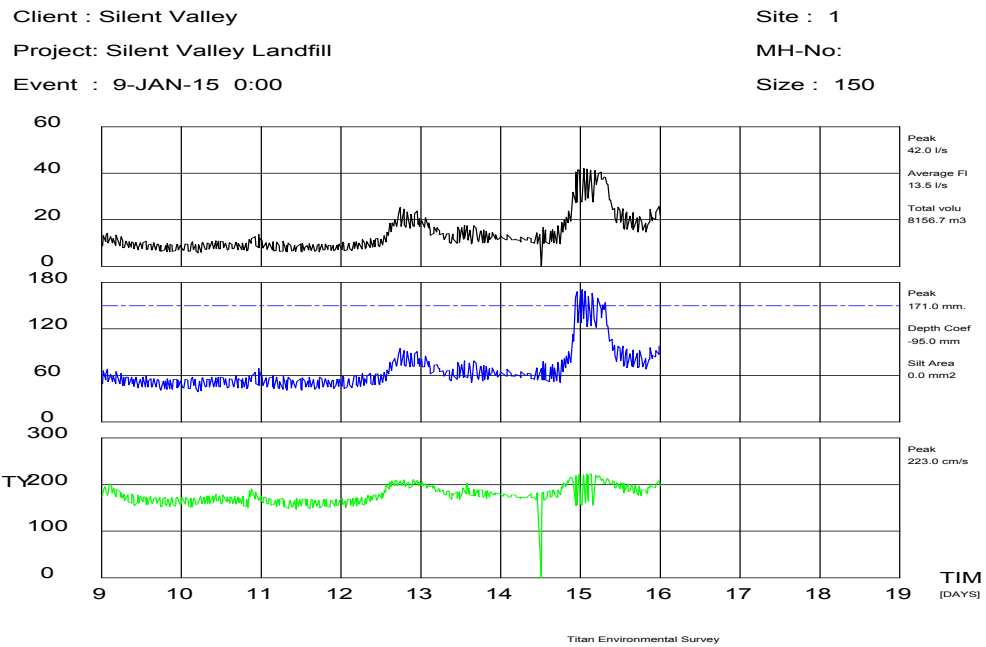
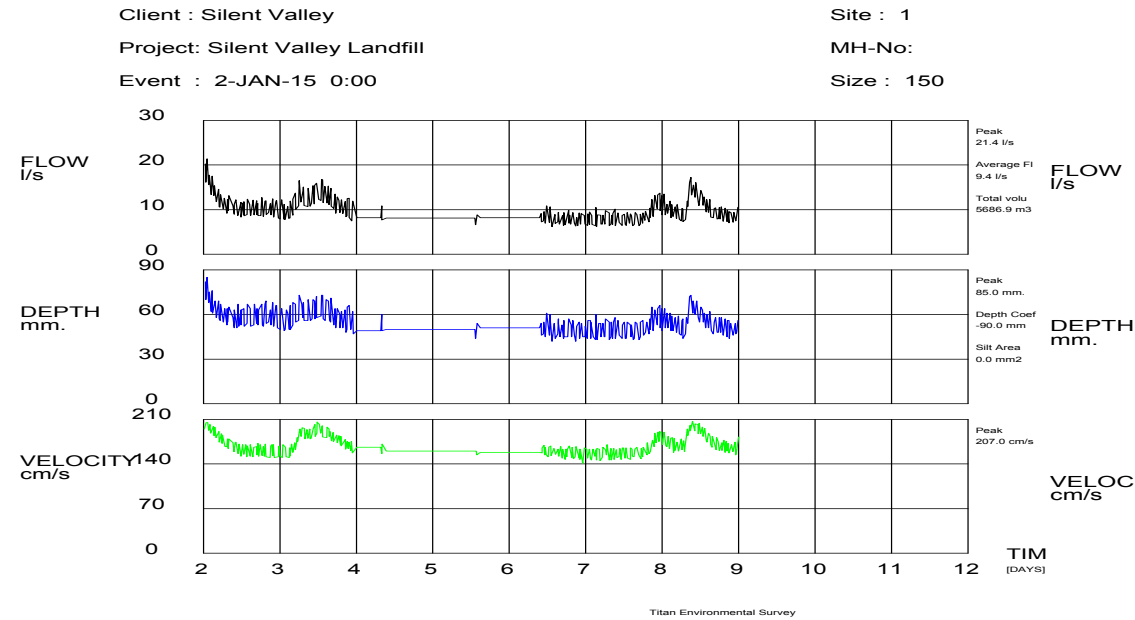
Size : 150

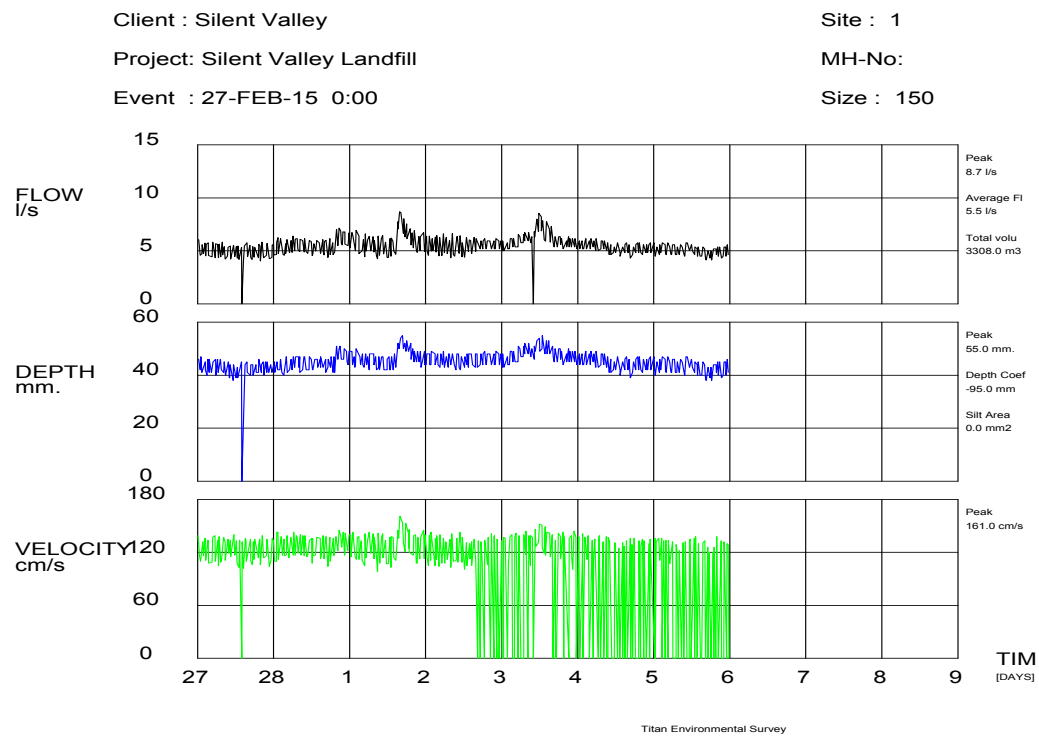
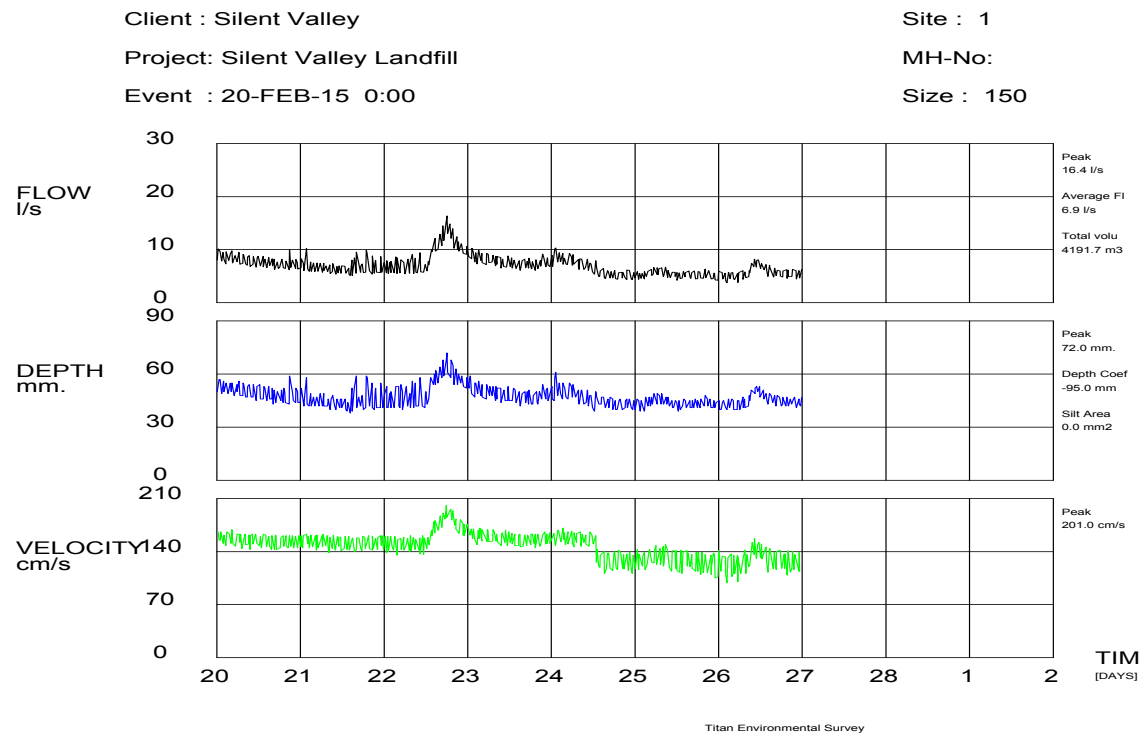
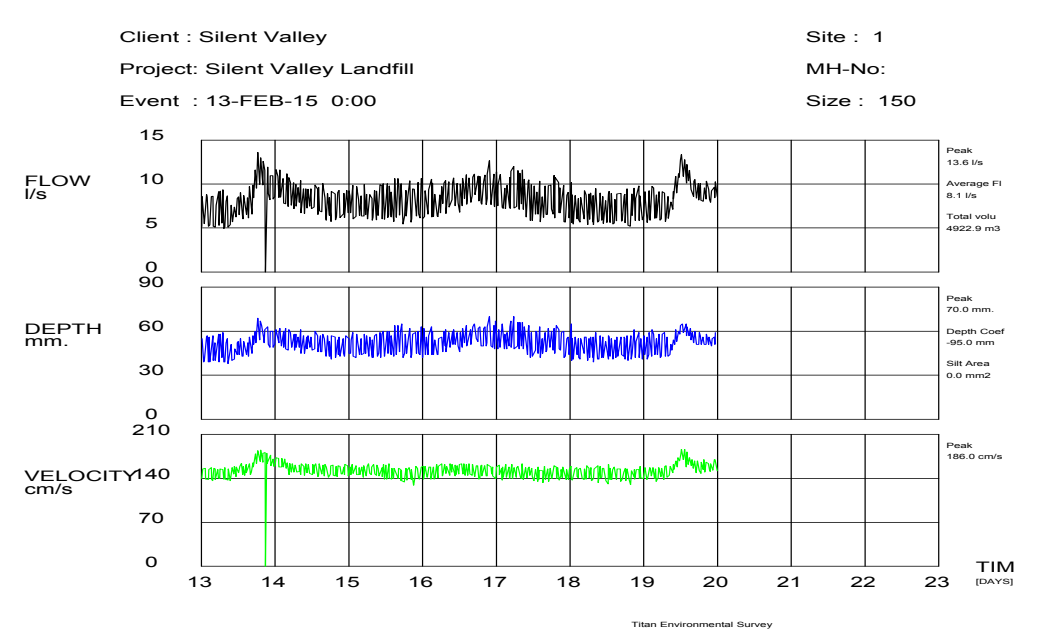
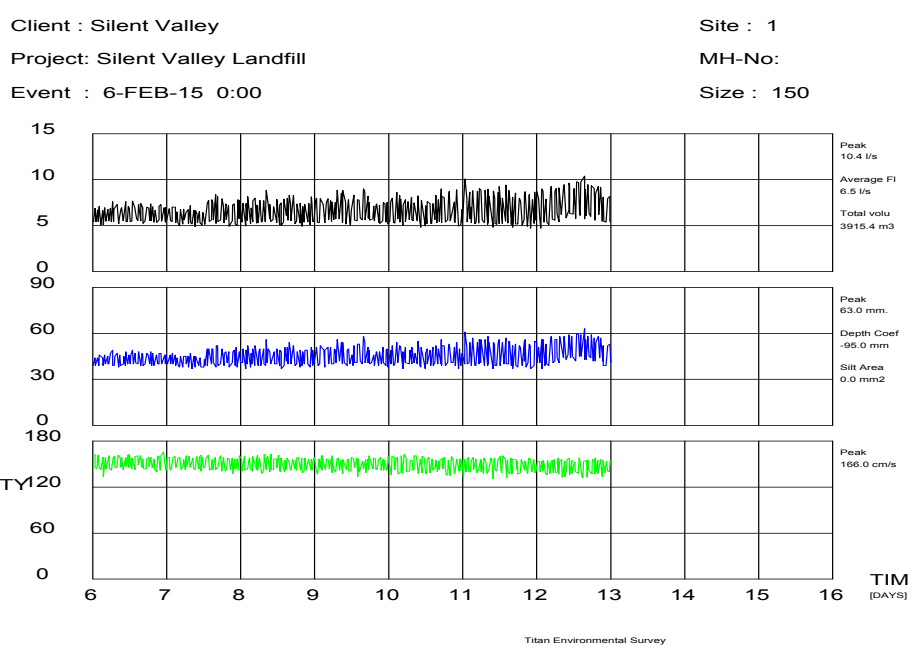
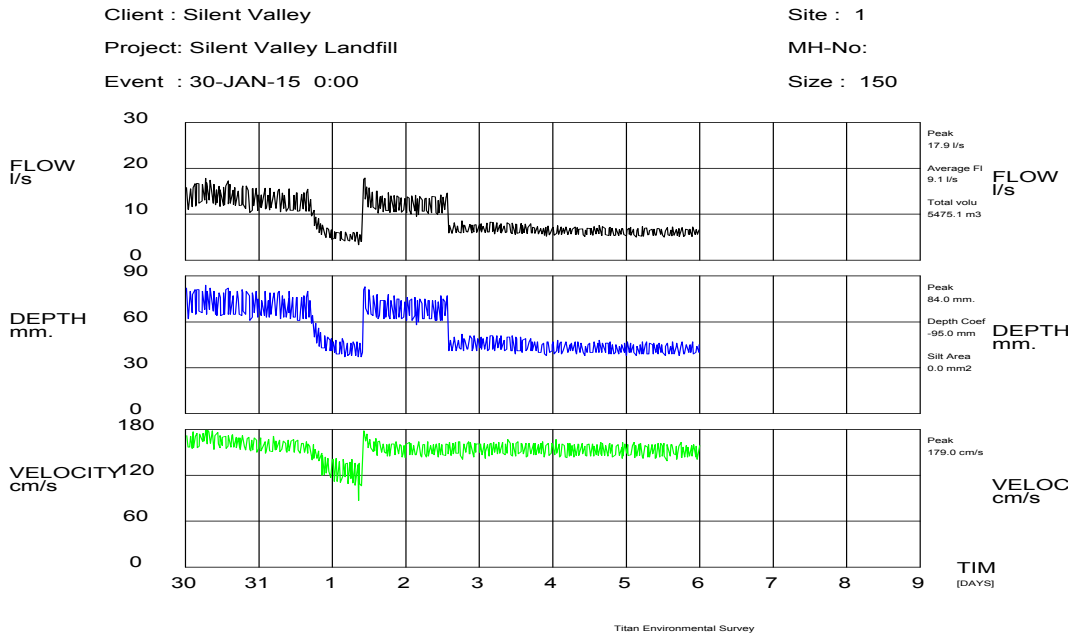


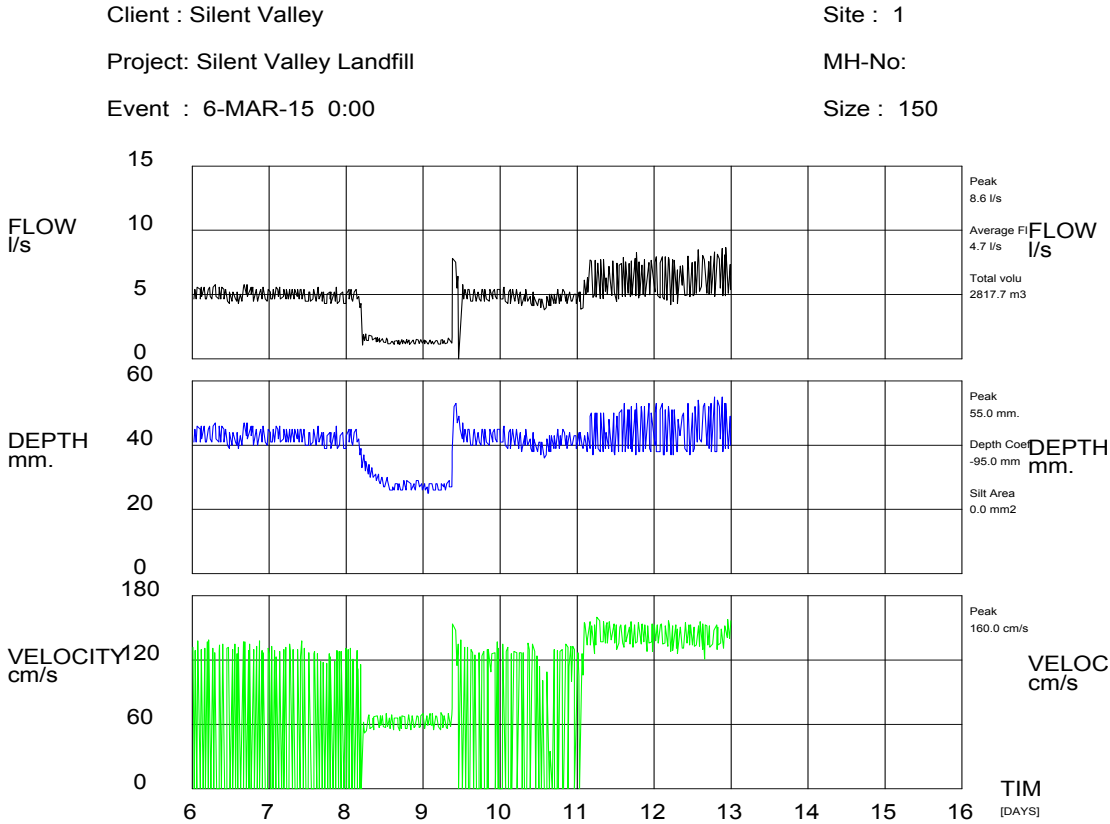
Titan Environmental Survey



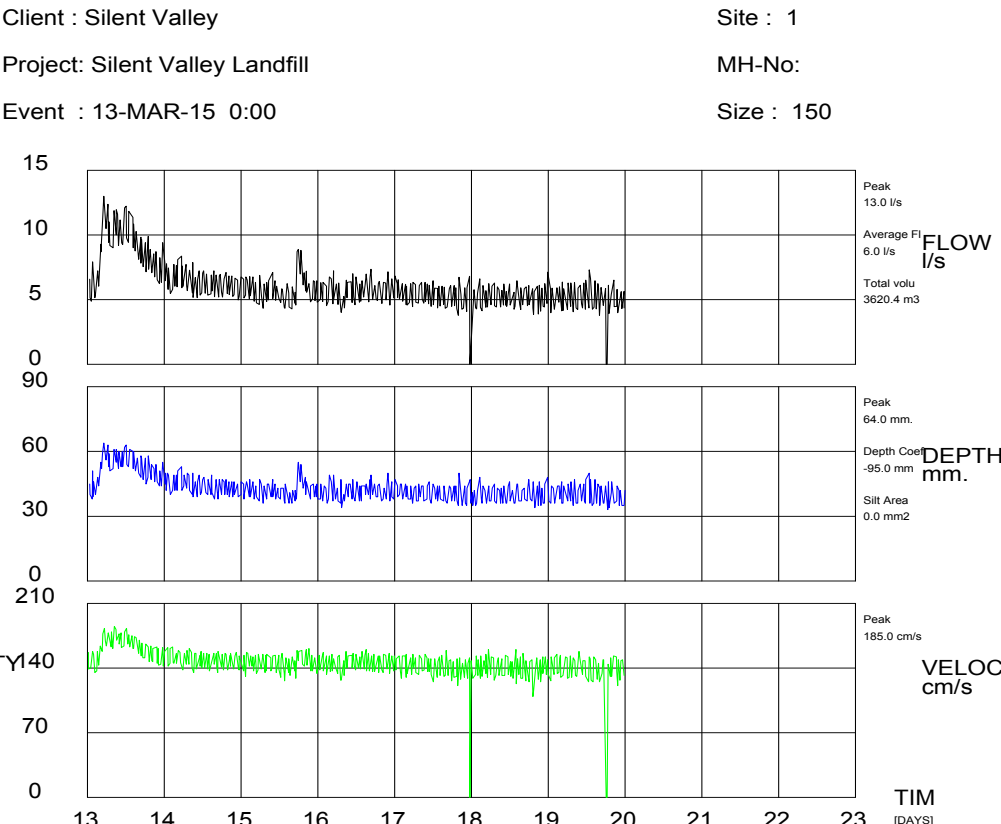




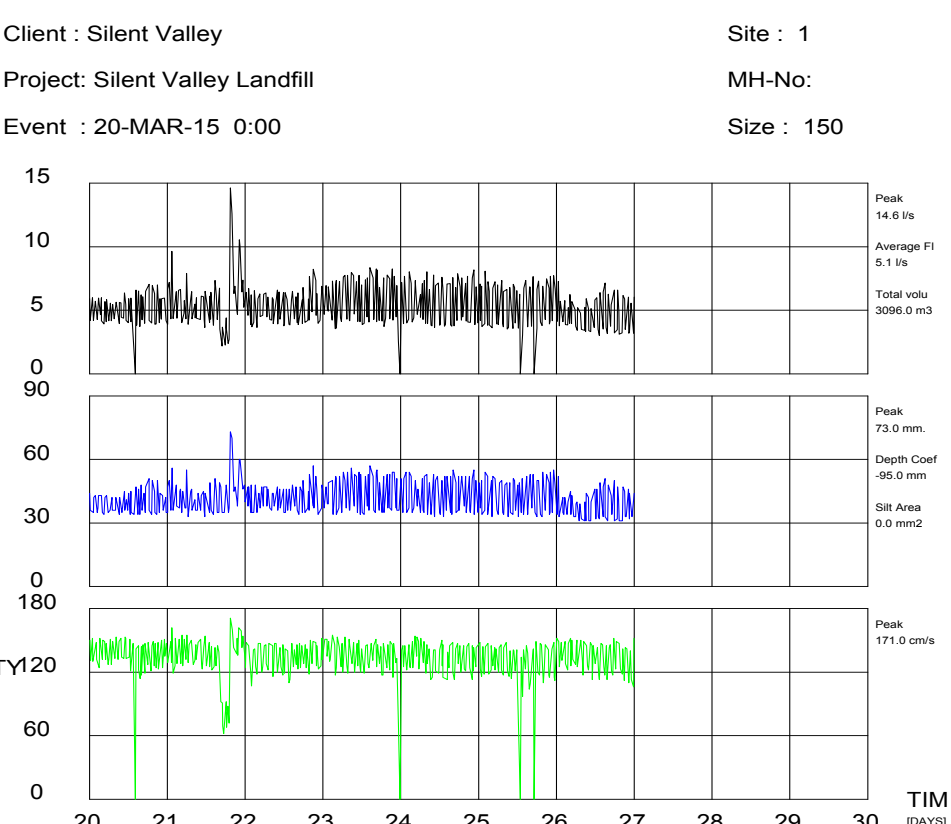




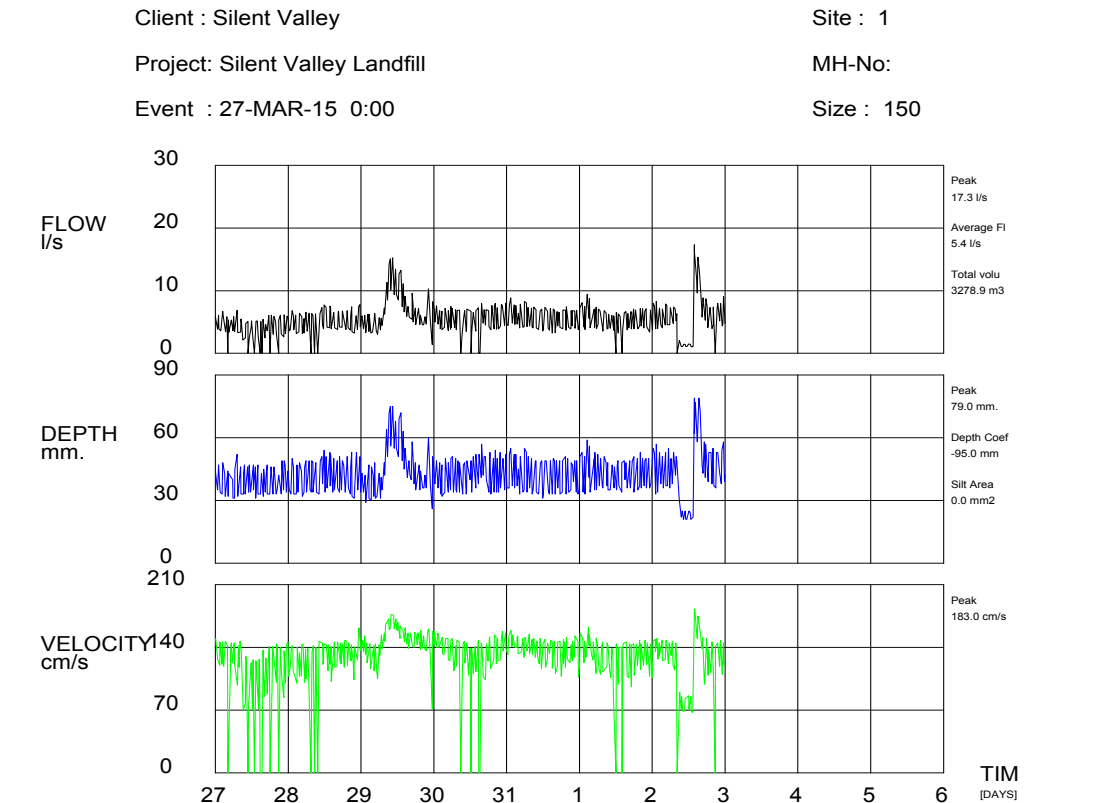
Titan Environmental Survey



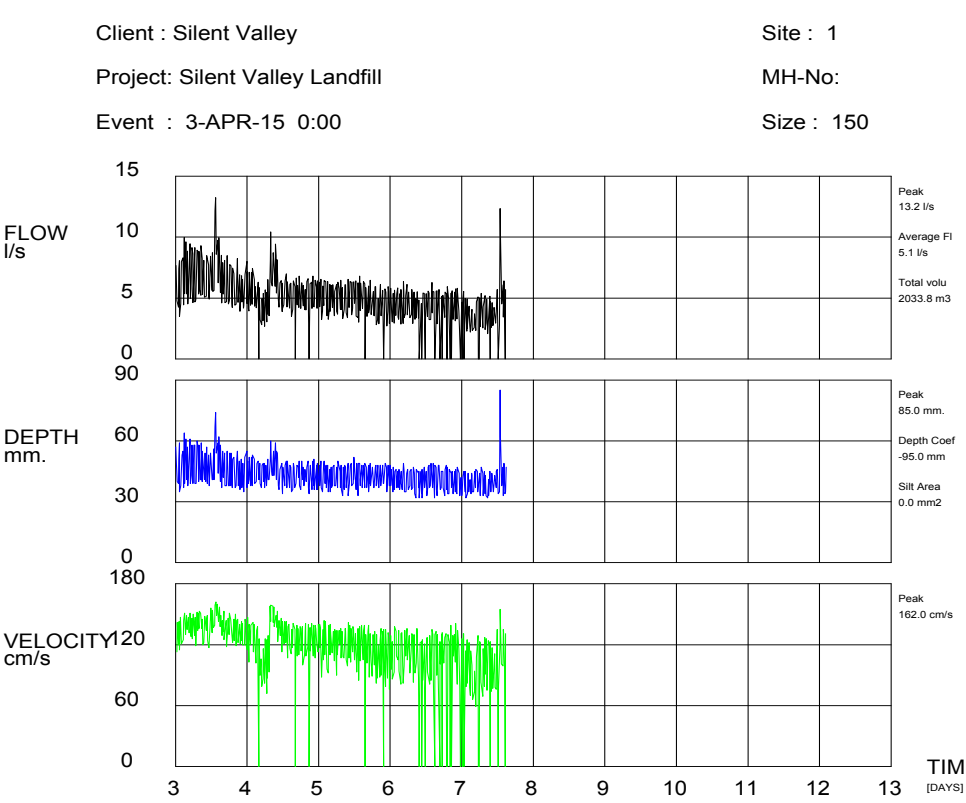
Titan Environmental Survey



Titan Environmental Survey



Titan Environmental Survey



Titan Environmental Survey

Client : Silent Valley

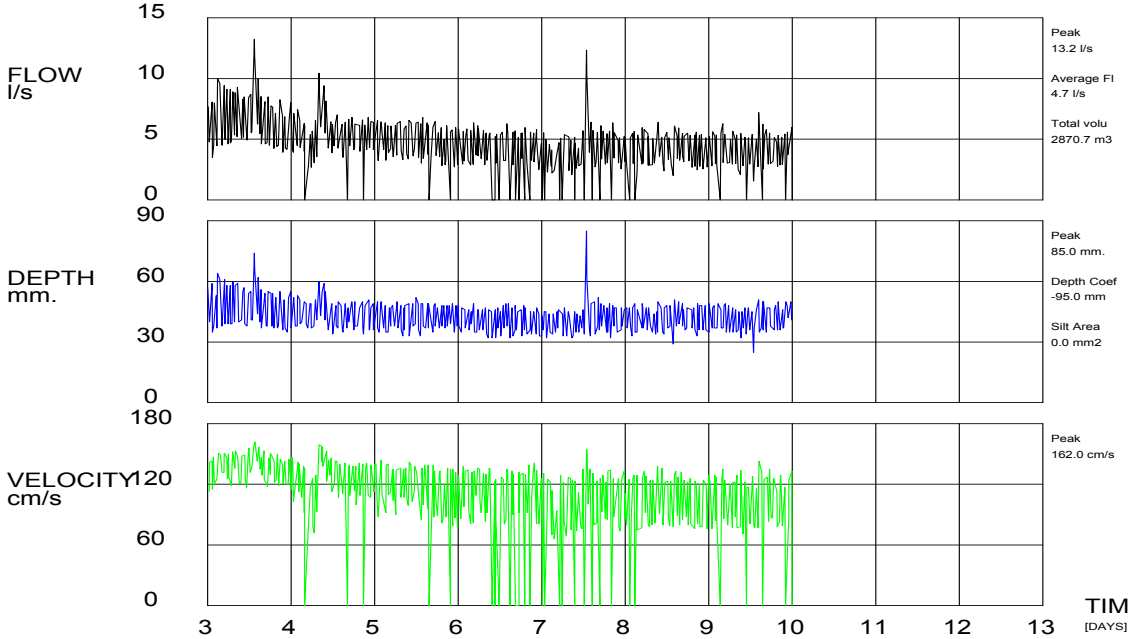
Project: Silent Valley Landfill

Event : 3-APR-15 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

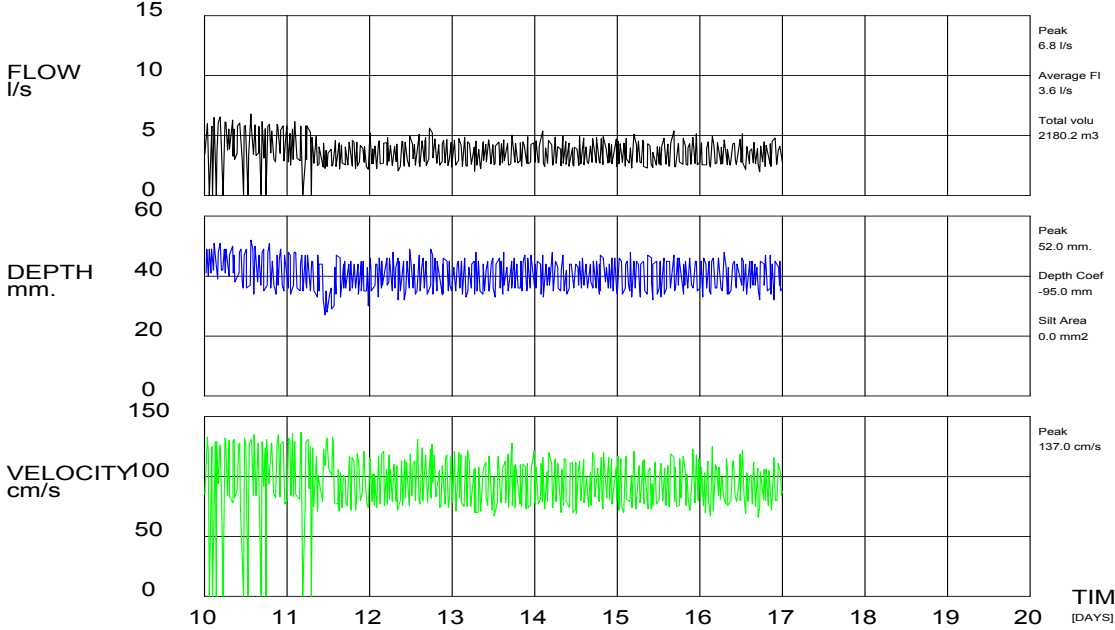
Project: Silent Valley Landfill

Event : 10-APR-15 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

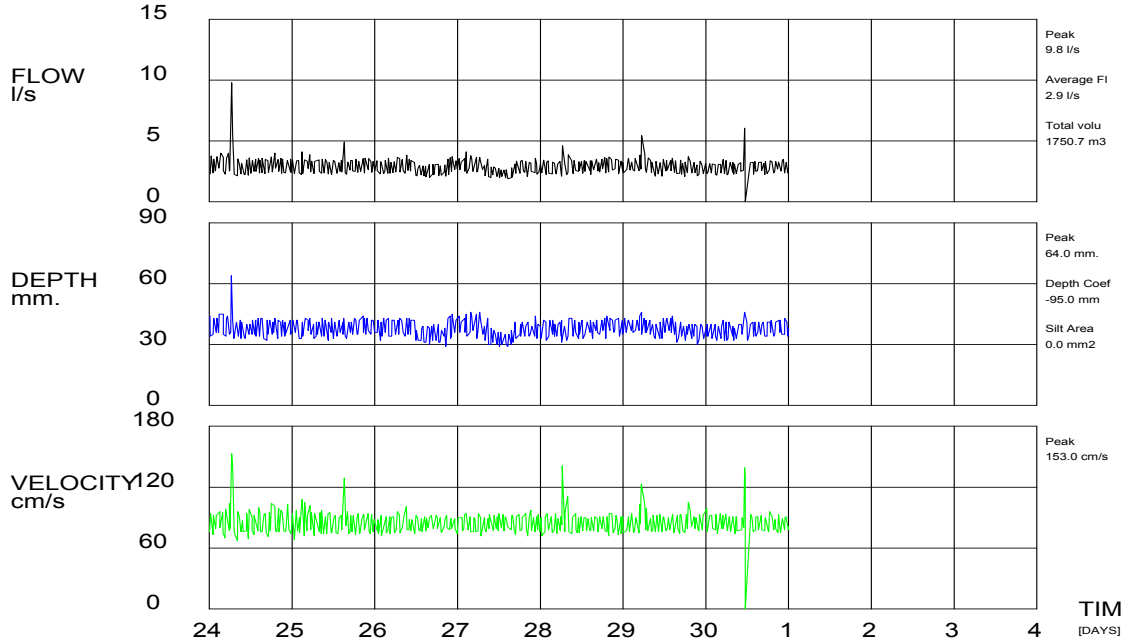
Project: Silent Valley Landfill

Event : 24-APR-15 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

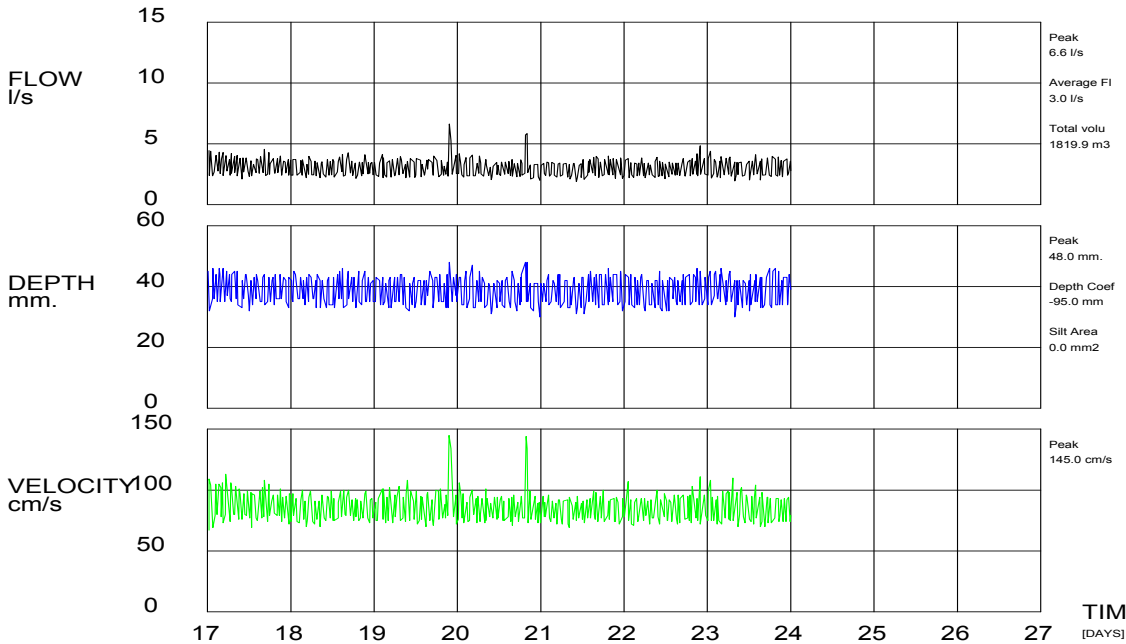
Project: Silent Valley Landfill

Event : 17-APR-15 0:00

Site : 1

MH-No:

Size : 150



Titan Environmental Survey

Client : Silent Valley

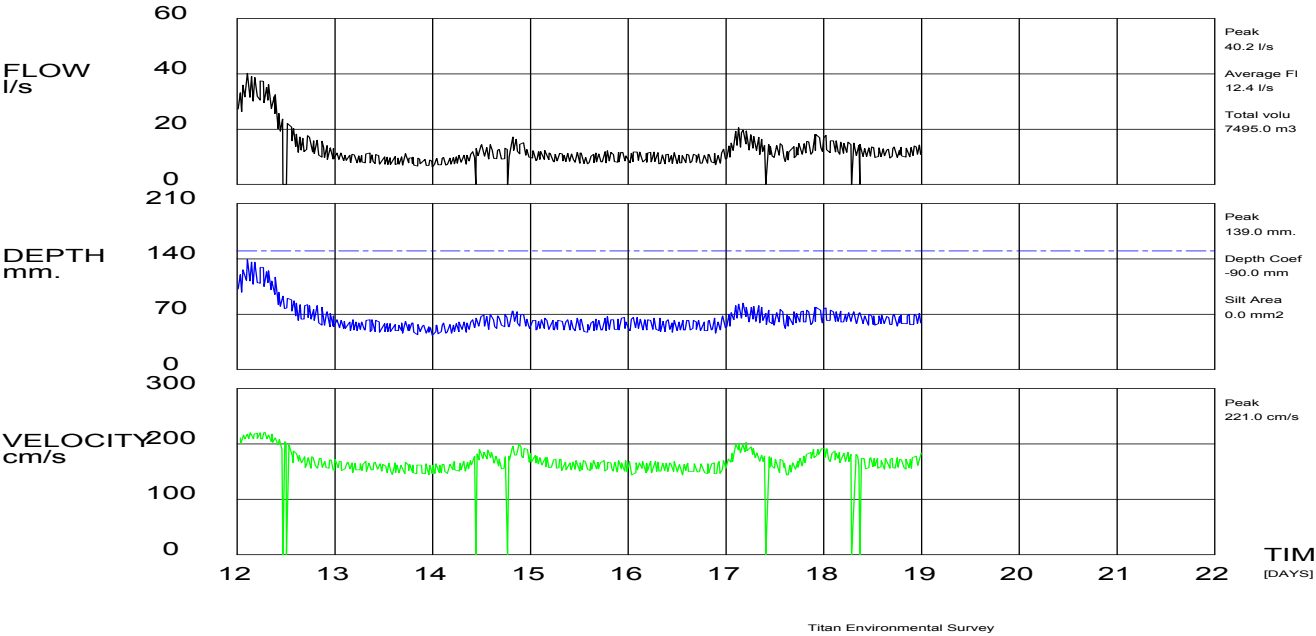
Project: Silent Valley Landfill

Event : 12-DEC-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

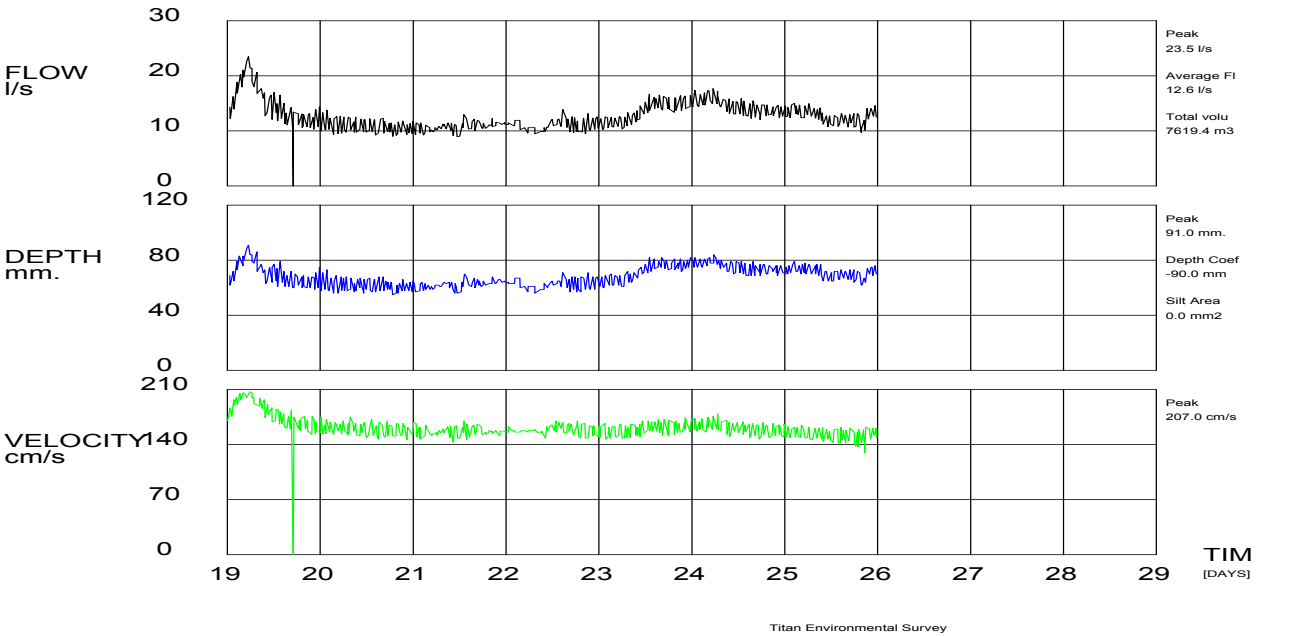
Project: Silent Valley Landfill

Event : 19-DEC-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

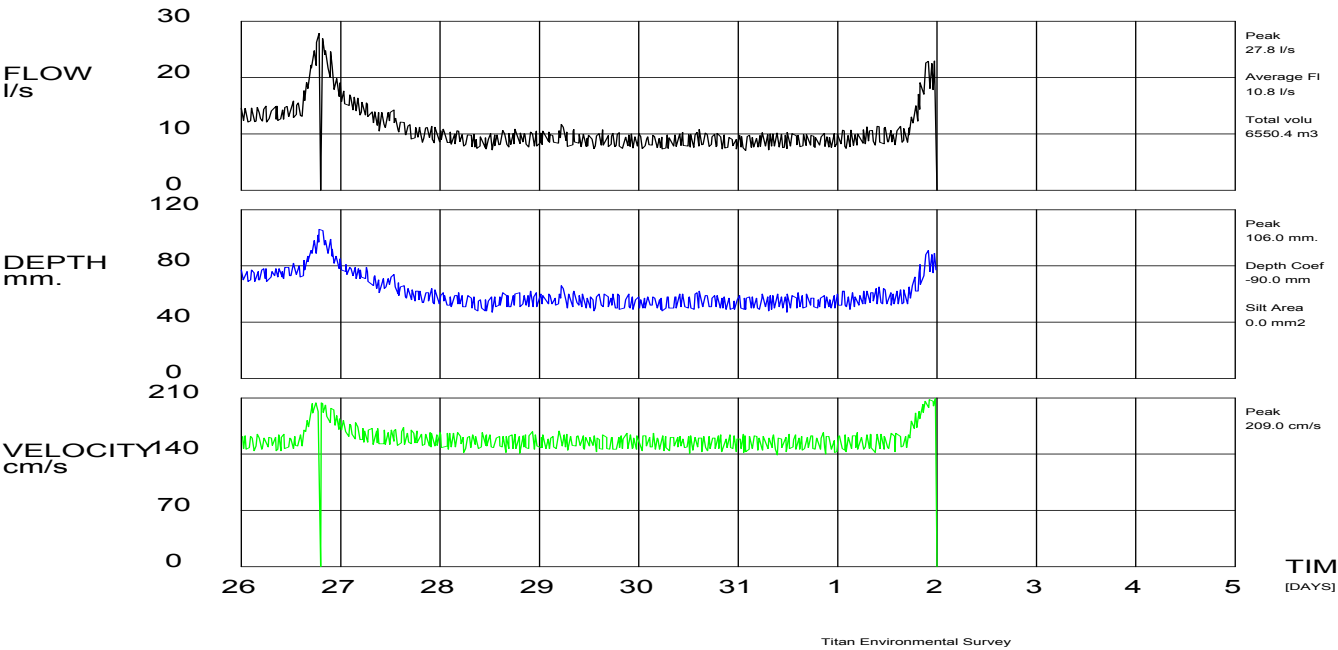
Project: Silent Valley Landfill

Event : 26-DEC-14 0:00

Site : 1

MH-No:

Size : 150



Client : Silent Valley

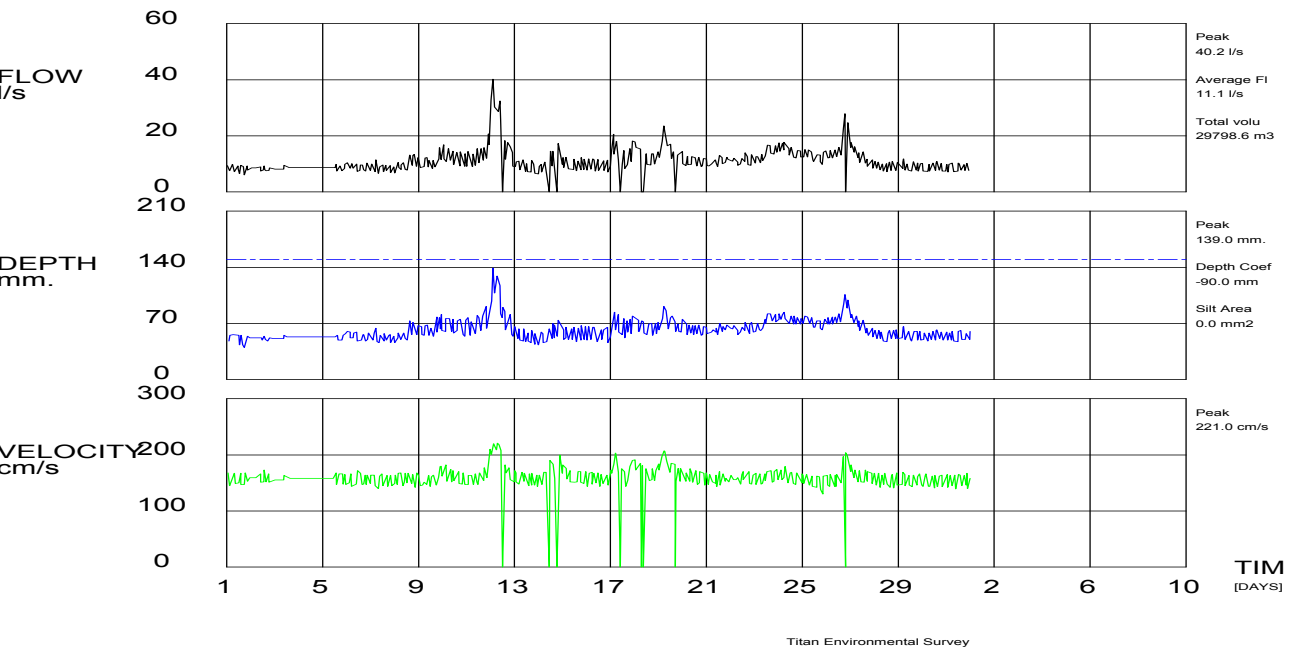
Project: Silent Valley Landfill

Event : 1-DEC-14 0:00

Site : 1

MH-No:

Size : 150



Appendix C

Correspondence with Welsh Water

Flavia Cappelletti

From: Kambiz Ayoubkhani
Sent: 28 July 2015 12:17
To: Flavia Cappelletti; Harriet Fletcher
Cc: Charlie Martin; Keith Williams
Subject: FW: Silent valley Refuse Site leachate discharge
Attachments: Scan Silent Valley Landfill Agreement 1.pdf; TE610A Silent Valley Tip.doc

I have just received DCWW agreement for discharge of leachate.
The conditions are not as bad as we were informed earlier. Daily flow 111m3, peak flow 5m3/hr.

Regards

Kambiz Ayoubkhani
Associate

Arup
4 Pierhead Street Capital Waterside Cardiff CF15 9QQ
d: +44 29 2026 6616 m: +44 78 2527 6301
www.arup.com

From: Pepper Heather [mailto:Heather.Pepper@dwrcymru.com]
Sent: 28 July 2015 11:39
To: Kambiz Ayoubkhani
Subject: RE: Silent valley Refuse Site leachate discharge

Hello Kambiz
I have now retrieved the file from Cilfynydd, please find attached a scanned copy of the agreement plus an amended summary, apologies the one I sent originally contained so many errors!
If you could update me if possible you have any useful information on the project, I'd be very grateful.
Many thanks
Regards
Heather

From: Kambiz Ayoubkhani [mailto:kambiz.ayoubkhani@arup.com]
Sent: 22 July 2015 13:30
To: Pepper Heather
Subject: RE: Silent valley Refuse Site leachate discharge

***** External Mail *****

Thanks Heather

Very useful information.
We are looking at providing additional treatment and storage at the tip in order to improve the discharge conditions, although not an easy task.

Regards

Kambiz Ayoubkhani
Associate

Arup

4 Pierhead Street Capital Waterside Cardiff CF10 4QP United Kingdom
t +44 (0)29 2047 3727 d +44 (0)29 2026 6616
f +44 (0)29 2047 2277 m +44 (0)7825 276301
www.arup.com

From: Pepper Heather [<mailto:Heather.Pepper@dwrcymru.com>]

Sent: 22 July 2015 13:18

To: Kambiz Ayoubkhani

Subject: RE: Silent valley Refuse Site leachate discharge

Hello Kambiz

I hope you're well.

That's great news the site is being capped, as you say the leachate volumes will reduce, but the main problem here is the amount of contaminated surface water we're also receiving from the site, whether some of that will also reduce will remain to be seen!

There is an agreement in place here rather than a consent, which is very old and outdated, and nowhere near covers them for the volumes we are currently receiving from them.

I have attached an incomplete summary, when I am in Cilfynydd, I will dig out a copy of the agreement and scan it and send it to you.

I have also attached some correspondence I had recently with Network Development recently when I was looking at replacing the agreement with a consent. As you can see we were looking at peak flows of around 28 l/sec . This hasn't been progressed at the moment as they obviously couldn't meet any volume consent currently that we would impose.

I hope that helps initially.

Regards

Heather

Heather Pepper
Trade Effluent Officer
Dwr Cymru - Welsh Water
Cardiff WWTW
Tide Fields Road
Rover Way
Tremorfa
Cardiff
CF24 2RX
Tel 029 20 478822
Fax 029 20 442757
Mobile 07976 271426

From: Kambiz Ayoubkhani [<mailto:kambiz.ayoubkhani@arup.com>]

Sent: 17 July 2015 16:16

To: Pepper Heather

Subject: Silent valley Refuse Site leachate discharge

***** External Mail *****

Hi Heather

I wonder if you can help.

The Silent valley refuse tip which is disused is being capped. The leachate discharge from the tip is therefore expected to reduce.

I attach plans showing the approx. route of the leachate discharge pipe and the DCWW manhole I understand the flows discharge in to.

I would be grateful if you can send me a copy of the trade effluent discharge consent specifying the rate of discharge and permitted volumes into the public sewer.

Regards

Kambiz Ayoubkhani

Associate

Arup

4 Pierhead Street Capital Waterside Cardiff CF10 4QP United Kingdom

t +44 (0)29 2047 3727 d +44 (0)29 2026 6616

f +44 (0)29 2047 2277 m +44 (0)7825 276301

www.arup.com

Dŵr Cymru Welsh Water is investing heavily and working hard to ensure top quality services to all its communities. The company is investing £1.7 billion in its water and sewerage network between 2015 – 2020.

It is a 'not-for-profit company' which has been owned by Glas Cymru since 2001. Welsh Water does not have shareholders and any financial surpluses are reinvested in the business for the benefit of customers. Visit our website at www.dwrcymru.com to find out more about us.

This email and any files attached are intended for the recipient(s) only. It may contain proprietary material, confidential information and/or be subject to commercial privilege. It should not be copied, disclosed to or used by any other party. If you are not a named recipient please delete this e-mail and any attachments and promptly inform the sender.

Company Name - DŴR CYMRU CYFYNGEDIG. Registered Office: Pentwyn Road, Nelson, Treharris, Mid Glamorgan CF46 6LY Company No. 02366777

Mae Dŵr Cymru Welsh Water yn buddsoddi'n hael ac yn gweithio'n galed i sicrhau gwasanaethau o'r ansawdd uchaf i'w holl gymunedau. Mae'r cwmni'n buddsoddi £1.7 biliwn yn ei rwydwaith dwr a charthffosiaeth rhwng 2015 a 2020.

Mae'n 'gwmni nid-er-elw', sydd wedi bod ym mherchnogaeth Glas Cymru ers 2001. Nid oes gan Dŵr Cymru gyfranddalwyr, ac mae unrhyw wargedion ariannol yn cael eu hail-fuddsoddi yn y busnes er budd cwsmeriaid. Manylion pellach ar ein gwefan www.dwrcymru.com

Mae'r neges hon ac unrhyw ffeiliau atodedig at sylw'r bobl y cyfeiriwyd nhw atynt yn unig. Gallant gynnwys deunydd perchnogol, gwybodaeth gyfrinachol a/neu fod yn destun breintiau masnachol. Ni ddylid eu copïo, datgelu i neu ddefnyddio gan unrhyw barti arall. Os derbyniwyd trwy gamgymeriad, dilêwch y neges ac unrhyw atodiadau a hysbyswch yr anfonwr yn syth.

Enw'r cwmni - DŴR CYMRU CYFYNGEDIG. Swyddfa gofrestredig: Heol Pentwyn, Nelson, Treharris, Morgannwg Ganol CF46 6LY Rhif y cwmni 02366777

Electronic mail messages entering and leaving Arup business systems are scanned for acceptability of content and viruses

~~25/5/8~~ *25/5/8* *13/8*
AGREEMENT is made on the

*first*day of *August*

One Thousand Nine Hundred and Eighty Eight B E T W E E N THE WELSH WATER
AUTHORITY whose principal office is situate at Cambrian Way Brecon in
the County of Powys (hereinafter called 'the Authority') of the one part
and THE COUNCIL OF THE BOROUGH OF BLAENAU GWENT (hereinafter called
'the Council') of the other part

W H E R E A S

1. The Authority are the owners of a public sewer known as the
Six Inch Sewer at Cendle Terrace Cwm shown by a red line on the
plan annexed hereto.
2. The Council are the owners of the Silent Valley landfill site
shown marked 'A' on the said plan and have constructed the
pipeline shown by a blue line on the said plan.
3. The Council with the agreement of the Authority are desirous
of collecting the leachate and contaminated surface water
from the said site and conveying it into a collecting tank
'B' on the plan and thence via the pipeline coloured blue on
the plan into the said public sewer on the terms and conditions
hereinafter contained.

NOW IT IS HEREBY AGREED as follows:-

- (1) In consideration of the charges hereinafter referred to, the Authority hereby permit the Council to discharge landfill site leachate and contaminated surface water (hereinafter called 'the effluent') into the said public sewer at Cendle Terrace Cwm at N.G.R. SO 1866 0597 marked X on the plan subject to the following conditions:-
- a) The effluent to be discharged shall consist solely of tip leachate and contaminated surface water and shall not contain any chemical process waste or other notifiable hazardous waste.
 - b) The maximum volume of effluent to be discharged on any one day of 24 hours shall not exceed 111 cubic metres.
 - c) The highest rate at which the effluent may be discharged shall not exceed 5 cubic metres per hour.
 - d) There shall be eliminated from the effluent before it is discharged to the sewer the matters listed below:-
 - a) Effluents with a temperature in excess of 43^o Centigrade (110^o Fahrenheit).
 - b) Calcium carbide.
 - c) Petroleum spirit.

- e) There shall be excluded from the effluent any substance which in its pure state or in combination with other materials in the sewage would produce flammable or toxic vapours.
- f) The effluent shall not include any of the substances or properties listed in the Appendix in concentration greater than those stated.
- g) The effluent shall not contain any other matter likely to injure the sewer either alone or in combination with the contents of the sewer or interfere with the free flow of the contents or affect prejudicially the treatment and disposal of the contents.
- h) There shall be provided and maintained by the Council in connection with the pipeline through which the effluent is discharged to the public sewer : -
 - i) An inspection chamber or manhole such as will enable any authorised officer of the Authority readily to take at any time samples of the effluent being discharged.
 - ii) A notch gauge and recorder or some other apparatus suitable and adequate to the Authority for measuring and recording the volume and rate of effluent so discharged.

- i) If the notch gauge and recorder or other apparatus ceases to record or is suspected of not measuring or recording correctly the quantity of effluent discharged on each day into the public sewer during the period from the date on which the records of the volume of effluent discharged into the public sewer were last accepted by the Authority as being correct up to the date when the gauge and recorder or other apparatus again registers correctly shall unless otherwise agreed by the Authority be deemed to be the same quantity as the average monthly quantity preceding the date on which the said records were last accepted as aforesaid or during the month immediately after the gauge and recorder or other apparatus has been corrected whichever is the higher.
- j) Records shall be kept of the volume, rate, nature and composition of the effluent discharged into the sewer available at all times for inspection by any authorised officer of the Authority and copies of such records shall be sent to the Authority on demand.
- k) The Authority shall be notified forthwith in writing of any changes in conditions which are likely to alter the nature or composition of the effluent.

(2)(a)(1) Payment for the reception, treatment and disposal of the effluent shall be made by the Council to the Authority by way of charges determined in accordance with sub-clause (b) (1) hereof. The charges shall be at rates per cubic metre of the effluent.

(ii) Payment for the reception, treatment and disposal of the effluent shall be on demand and made at such intervals and in respect of such period or periods as the Authority may determine.

(b)(1) The charge per cubic metre of the effluent will be calculated in accordance with the following formula : -

$$C = R$$

Where

C = Total charge per cubic metre of trade effluent.

R = The amount determined by the Authority as the average cost to the Authority for the year of charge of receiving one cubic metre of sewage (other than surface water) into its sewers and conveying the same to its treatment works or outfalls.

(ii) The R component and unit cost may be reviewed annually by the Authority.

(iii) Providing that the total annual charge to the occupiers of the premises based on the formula contained in (b) (i) above does not exceed £100 then the occupiers shall be charged such Annual Minimum Charge as the Authority, by resolution, may determine.

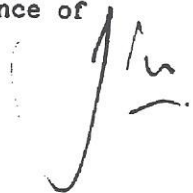
- (3) Except as set out in paragraphs (b) (i), (ii) and (iii) above, the conditions hereinbefore contained may be reviewed and amended annually by mutual agreement of both parties.
- (4) If any of the said conditions are not fully observed and performed by the Council the Authority may revoke the licence hereby granted and at the Council's expense disconnect the flow from the said pipeline into the said public sewer upon having given 14 days advance notice to the Council of its intention.
- (5) This Agreement is not a trade effluent consent under the Control of Pollution Act 1974., the Public Health (Drainage of Trade Premises) Act 1937 or the Public Health Act 1961 and nothing herein contained shall in any way absolve the Council from their statutory and common law liabilities in respect of the pollution of any watercourse.
- (6) The Council are responsible for the repair and maintenance of the pipeline shown coloured blue on the said plan.

- (7) Subject to the provisions of clause 3 hereof this Agreement shall take effect on the *first* day of *August* One Thousand Nine Hundred and Eighty Eight and continue until such time as the discharge of tip leachate ceases or is terminated by mutual agreement of the both parties.

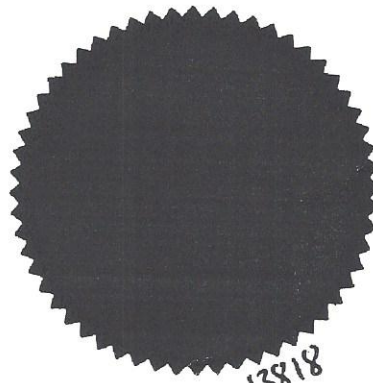
The Appendix hereinbefore mentioned

1. pH VALUE : The leachate discharged to the sewer shall have a pH value of not less than 6 nor greater than 10.
2. SUSPENDED SOLIDS
(dried at 105°C) : Total suspended solids of the leachate discharged to the sewer shall not exceed 2000 milligrams per litre.

THE COMMON SEAL of the
WELSH WATER AUTHORITY
was hereunto affirmed
in the presence of

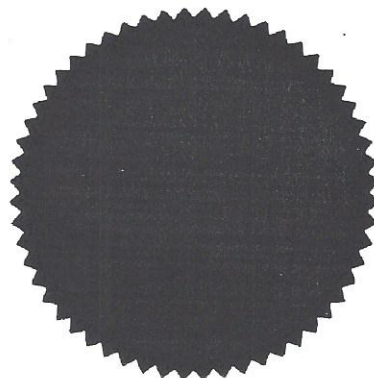
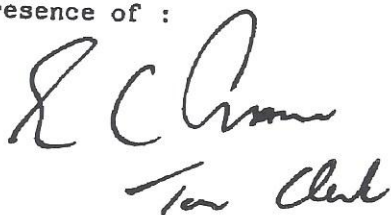


An authorised signatory



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BLAENAU GWENT BOROUGH COUNCIL
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presence of :



Dated

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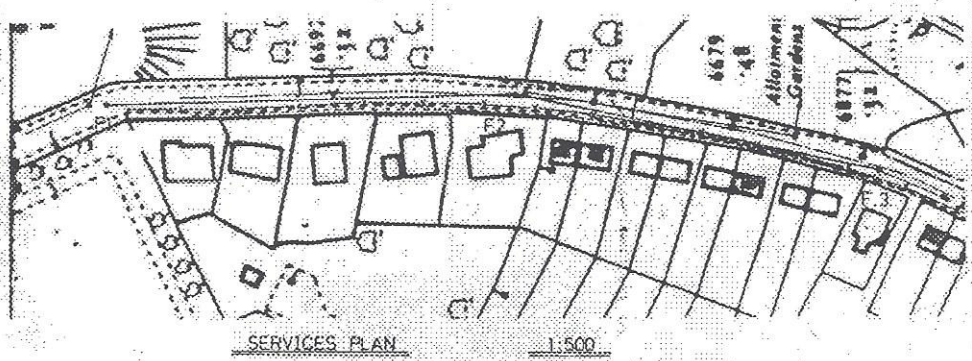
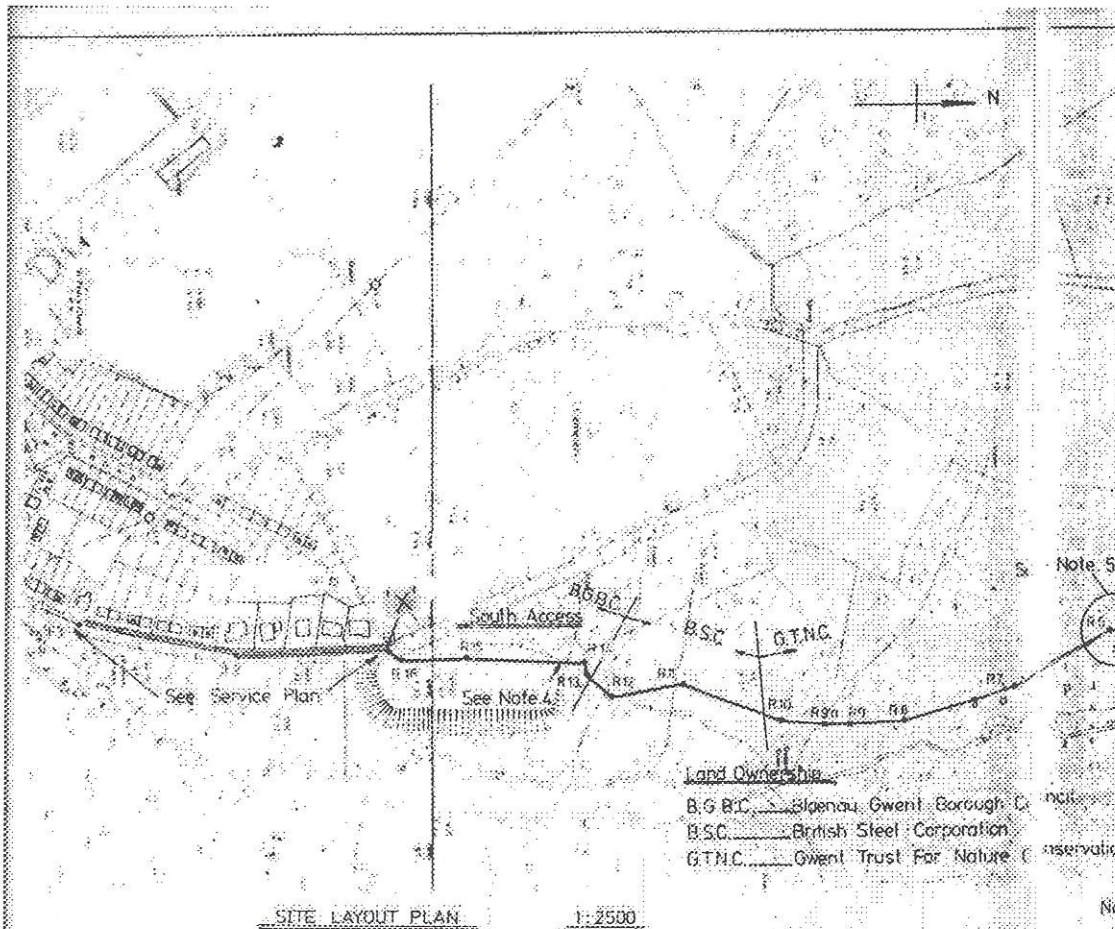
WELSH WATER AUTHORITY

AND

BLAENAU GWENT BOROUGH COUNCIL

A G R E E M E N T

concerning connection of
leachate from Silent Valley
Landfill Site Cwm in the
County of Gwent to a public
foul sewer.



LEGEND

- 75mm water main
- 93mm gas main
- L.V. S.W.E.B. cable
- BT. cable
- Storm sewers
- Foul sewer

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Company

Silent Valley Landfill Site
c/o Blaenau Gwent CBC
Civic Centre
Ebbw Vale
NP3 6XB

Consent No. TE 610

Receiving Works W.V.T.S.

Council Area Caerphilly County

Sample Point No. 44030

Nature of Discharge

Landfill Leachate/Contaminated Surface Water

Date Agreement Issued

August 1st 1988

Current Conditions**Maximum Permissible Value**

pH

Between 6 and 10

Flow Max

111 m³/day

Flow Rate

5 m³/hour

Total Suspended Solids

2000 mg/l

~~25/5/8~~ *25/5/8* *13/8*
AGREEMENT is made on the

*first*day of *August*

One Thousand Nine Hundred and Eighty Eight B E T W E E N THE WELSH WATER
AUTHORITY whose principal office is situate at Cambrian Way Brecon in
the County of Powys (hereinafter called 'the Authority') of the one part
and THE COUNCIL OF THE BOROUGH OF BLAENAU GWENT (hereinafter called
'the Council') of the other part

W H E R E A S

1. The Authority are the owners of a public sewer known as the
Six Inch Sewer at Cendle Terrace Cwm shown by a red line on the
plan annexed hereto.
2. The Council are the owners of the Silent Valley landfill site
shown marked 'A' on the said plan and have constructed the
pipeline shown by a blue line on the said plan.
3. The Council with the agreement of the Authority are desirous
of collecting the leachate and contaminated surface water
from the said site and conveying it into a collecting tank
'B' on the plan and thence via the pipeline coloured blue on
the plan into the said public sewer on the terms and conditions
hereinafter contained.

NOW IT IS HEREBY AGREED as follows:-

- (1) In consideration of the charges hereinafter referred to, the Authority hereby permit the Council to discharge landfill site leachate and contaminated surface water (hereinafter called 'the effluent') into the said public sewer at Cendle Terrace Cwm at N.G.R. SO 1866 0597 marked X on the plan subject to the following conditions:-
- a) The effluent to be discharged shall consist solely of tip leachate and contaminated surface water and shall not contain any chemical process waste or other notifiable hazardous waste.
 - b) The maximum volume of effluent to be discharged on any one day of 24 hours shall not exceed 111 cubic metres.
 - c) The highest rate at which the effluent may be discharged shall not exceed 5 cubic metres per hour.
 - d) There shall be eliminated from the effluent before it is discharged to the sewer the matters listed below:-
 - a) Effluents with a temperature in excess of 43^o Centigrade (110^o Fahrenheit).
 - b) Calcium carbide.
 - c) Petroleum spirit.

- e) There shall be excluded from the effluent any substance which in its pure state or in combination with other materials in the sewage would produce flammable or toxic vapours.
- f) The effluent shall not include any of the substances or properties listed in the Appendix in concentration greater than those stated.
- g) The effluent shall not contain any other matter likely to injure the sewer either alone or in combination with the contents of the sewer or interfere with the free flow of the contents or affect prejudicially the treatment and disposal of the contents.
- h) There shall be provided and maintained by the Council in connection with the pipeline through which the effluent is discharged to the public sewer : -
 - i) An inspection chamber or manhole such as will enable any authorised officer of the Authority readily to take at any time samples of the effluent being discharged.
 - ii) A notch gauge and recorder or some other apparatus suitable and adequate to the Authority for measuring and recording the volume and rate of effluent so discharged.

- i) If the notch gauge and recorder or other apparatus ceases to record or is suspected of not measuring or recording correctly the quantity of effluent discharged on each day into the public sewer during the period from the date on which the records of the volume of effluent discharged into the public sewer were last accepted by the Authority as being correct up to the date when the gauge and recorder or other apparatus again registers correctly shall unless otherwise agreed by the Authority be deemed to be the same quantity as the average monthly quantity preceding the date on which the said records were last accepted as aforesaid or during the month immediately after the gauge and recorder or other apparatus has been corrected whichever is the higher.
- j) Records shall be kept of the volume, rate, nature and composition of the effluent discharged into the sewer available at all times for inspection by any authorised officer of the Authority and copies of such records shall be sent to the Authority on demand.
- k) The Authority shall be notified forthwith in writing of any changes in conditions which are likely to alter the nature or composition of the effluent.

(2)(a)(1) Payment for the reception, treatment and disposal of the effluent shall be made by the Council to the Authority by way of charges determined in accordance with sub-clause (b) (1) hereof. The charges shall be at rates per cubic metre of the effluent.

(ii) Payment for the reception, treatment and disposal of the effluent shall be on demand and made at such intervals and in respect of such period or periods as the Authority may determine.

(b)(1) The charge per cubic metre of the effluent will be calculated in accordance with the following formula : -

$$C = R$$

Where

C = Total charge per cubic metre of trade effluent.

R = The amount determined by the Authority as the average cost to the Authority for the year of charge of receiving one cubic metre of sewage (other than surface water) into its sewers and conveying the same to its treatment works or outfalls.

(ii) The R component and unit cost may be reviewed annually by the Authority.

(iii) Providing that the total annual charge to the occupiers of the premises based on the formula contained in (b) (i) above does not exceed £100 then the occupiers shall be charged such Annual Minimum Charge as the Authority, by resolution, may determine.

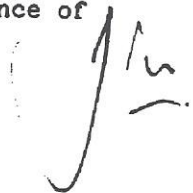
- (3) Except as set out in paragraphs (b) (i), (ii) and (iii) above, the conditions hereinbefore contained may be reviewed and amended annually by mutual agreement of both parties.
- (4) If any of the said conditions are not fully observed and performed by the Council the Authority may revoke the licence hereby granted and at the Council's expense disconnect the flow from the said pipeline into the said public sewer upon having given 14 days advance notice to the Council of its intention.
- (5) This Agreement is not a trade effluent consent under the Control of Pollution Act 1974., the Public Health (Drainage of Trade Premises) Act 1937 or the Public Health Act 1961 and nothing herein contained shall in any way absolve the Council from their statutory and common law liabilities in respect of the pollution of any watercourse.
- (6) The Council are responsible for the repair and maintenance of the pipeline shown coloured blue on the said plan.

- (7) Subject to the provisions of clause 3 hereof this Agreement shall take effect on the *first* day of *August* One Thousand Nine Hundred and Eighty Eight and continue until such time as the discharge of tip leachate ceases or is terminated by mutual agreement of the both parties.

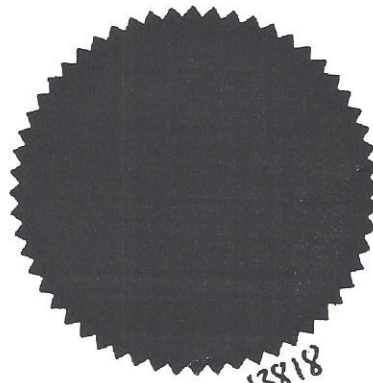
The Appendix hereinbefore mentioned

1. pH VALUE : The leachate discharged to the sewer shall have a pH value of not less than 6 nor greater than 10.
2. SUSPENDED SOLIDS
(dried at 105°C) : Total suspended solids of the leachate discharged to the sewer shall not exceed 2000 milligrams per litre.

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WELSH WATER AUTHORITY
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in the presence of

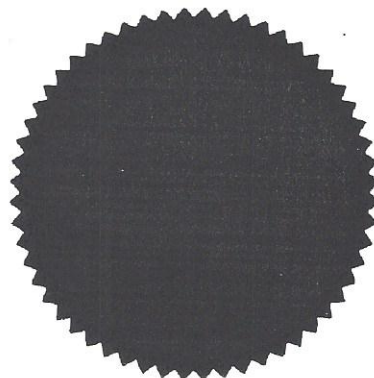
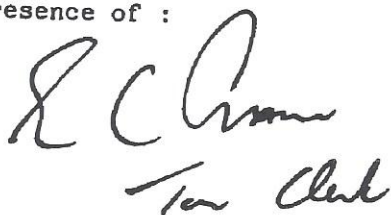


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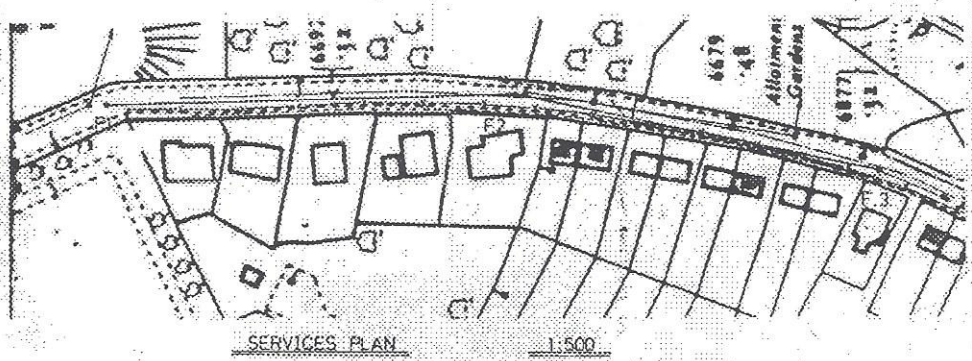
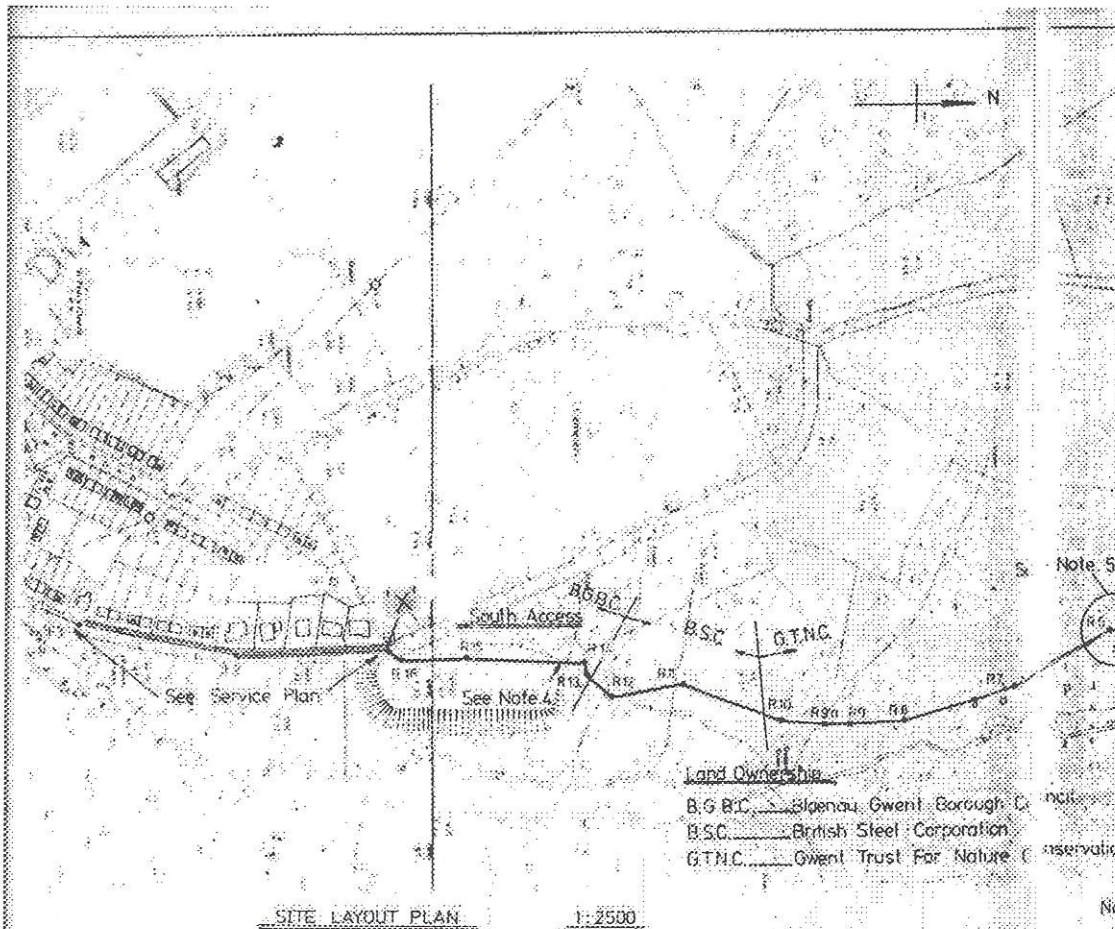
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[illegible]

Appendix D

Ground investigation specification

Subject Silent Valley landfill, Feasibility study – leachate lagoon

Date August 2015

Job No/Ref 2015/9402

Scope of ground investigation

The following scope of works is proposed in relation to Option 3 discussed within the main text of this feasibility study.

In summary, the proposal involves the construction of a new gravity fed lagoon to the south of the existing leachate lagoon tanks, within a SSSI site, in the area shown on **Figure 7**.

Records have indicated that an underground tank and associated pipeworks may be present in this area and therefore pose a constraint to the proposed structure.

The following scope of ground investigation is proposed:-

- Carry out 1no trial pit in the area of the proposed new lagoon, as indicated in the figure below.
The objectives of the trial pit are:
 1. to confirm the local ground and groundwater conditions;
 2. to assess the excavatability of the materials using standard equipment;
 3. to confirm the presence of underground structures and their extent.
- Based on the preliminary layout of the proposed option as presented in Figure 7, the trial pit should be extended to at least 3.5m depth in order to confirm the nature of the founding materials. In view of the anticipated geology, it may not be possible to achieve this depth; however, the trial pit should be extended as far as practically possible into the ground in order to assess the easiness of excavation.
- In order of the meet the objective set out in the third bullet point of the list above, it may be necessary to extend the trial pit.
- During excavation of the pit, any groundwater ingress should be monitored for at least 20 minutes and an estimate of the rate of inflow recorded as far as this is reasonably practical.
- Sampling of soil, rock and groundwater should be undertaken for geotechnical and chemical analyses.
- Geotechnical testing should include the following:
 1. Atterberg limits and moisture content determination;
 2. Particle size distribution analyses;
 3. Soil pH and sulphate analyses for assessing aggressivity to concrete;
 4. Geo-environmental samples should evidence of made ground be encountered.