ANNEX 6A: IPCC PERMIT
LEACHATE TREATMENT PLANT REPORT
NANT Y CAWS LANDFILL SITE

Project: Nant y Caws landfill Site

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Nant y caws 40 m3 pilot-scale SAF plant 2011

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1. Introduction

The landfill site at Nant y caws has two phases: an active landfill, managed by CWM Ltd, and a closed landfill, the responsibility of Carmarthenshire County Council (CCC). This report concerns the leachate treatment plant for the closed section only.

The original plant was a serial bioreactor design, comprising an initial aerobic filtration stage, feeding into an aerated lagoon, with an option to ‘polish’ effluent in a small reed bed. It was operating under a simple Discharge Consent.

Following some non-compliances with the existing Consent, plant redesign commenced in 2009, implemented at that time by the then-operator Rockbourne Ltd. However, modifications attempted by Rockbourne were not successful, and shortly thereafter they ceased trading. At about the same time the Environment Agency (EA) requested that the Consent be upgraded to a full Environmental Permit.

WEBS Ltd won the contract to take over and improve the plant in 2010, and have been carrying out pilot-scale trials of a submerged aerobic filter (SAF) design. Based on 3+ months of trials of a $40m^3$ pilot reactor, a full-scale plant has now been designed, and CCC has just approved the capital spend. Construction will take about 3 months, so we are applying for the Permit now.

The following report provides the information on the new plant that is required for the Permit.

Site Address

The site location and address is:

Nant Y Caws landfill Site
Nant Y Caws
Carmarthen
SA32 8BG

Site location, site layout and process diagrams are enclosed in the Appendix.

2 Leachate Reception and Storage

2.1 Leachate Reception

The treatment plant receives leachate from two sources:

<u>French Drain</u> – a French drain has recently been constructed beside the closed landfill and along the banks of the stream running alongside Phase 1 of the landfill site. This is to capture the surface water run off from Phase 1. A sump with a submersible pump pumps the surface water to the sump that collects the subsurface leachate from Phase 1.

Tip Drain – a sump collects the leachate from sub surface drains of Phase 1 and pumps it to the main reception pit of the storage lagoon.

The composition of the leachate has been monitored on a monthly basis by taking samples for analysis to Severn Trent Laboratories. The quality is reliable and varies little. The choice of a biotreatment system and the design for upgrading the treatment plant are based on the results of this monitoring programme.

2.2 Pump Operation

The pumps are located within pump sumps and are controlled by float switches. As the level in the sump rises, the float switch triggers the pumps.

The pumps are being operated and maintained by the WEBS Ltd under an annual contract.

2.3 Leachate Characterisation

The leachate has been characterised by monthly samples that have been taken from the:

- French Drain
- Tip
- Lagoon

The samples have been analysed on site as part of the routine maintenance of the treatment plant.

The lagoon and final effluent from the recently installed SAF plant is being sampled monthly and the samples sent off for analysis by Severn Trent Services Laboratory, an UKAS accredited laboratory.

The composition and flow rate of leachate into the plant cannot be controlled and so the treatment plant has been designed with a large degree of redundancy, to treat the maximum flow and loads that are likely to occur, as judged from the sampling regime and historical records.

2.4 Storage

The leachate is presently stored within a holding lagoon of 4,823 m^3 prior to treatment in the 40 m^3 pilot SAF plant.

The lagoon is lined and has dimensions of 53m x 35m x 2.6 m and is lined to prevent contamination of surface water. There is no significant odour.

As part of the upgrade, the following will be decommissioned:

- 6 x Floating nitrifying filters
- Solar powered mixer
- Floating reed bed

All three are deemed not fit for purpose and will be scrapped as soon as the plant has been upgraded and fully commissioned.

Treatment at full scale will be carried out prior to lagoon storage. This allows us to take advantage of the naturally elevated temperature of the fresh leachate to enhance treatment rates and prevent freezing on winter.

The lagoon is however being retained: it is a useful storage and flow-balancing feature in normal operations, and will also serve as emergency storage of untreated leachate (with capacity for several days) should treatment fail for any reason.

The design of the existing treatment plant is outlined in the attached drawing ref: L23–101–02PID (Annex 8).

2.4.1 Odour control

Once the plant has been upgraded, the leachate will be pre-treated in an enclosed SAF plant and hence all biodegradable organics will be removed and the effluent will be fully nitrified before reaching the lagoon. This means that the treated leachate stored within the lagoon will have no odours.

2.4.2 Level control

The lagoon has a residence time of 38 to 64 days and so the level and composition of the lagoon do not change appreciably from day to day.

The leachate level in the lagoon will be visually checked on a day to day basis and the level recorded as part of the operational procedure. There is no automated level control because the lagoon will contain only treated leachate, posing no hazard.

Monitoring and control of level and flow will be manual, by means of a daily visit.

In the event that there is excessive rainfall (generating flows in excess of treatment capacity), or a failure of the treatment plant, then the leachate accumulating in the lagoon would be untreated, but this would then be tankered off site, as is currently being undertaken.

When the upgraded plant is installed, the leachate will be first treated in the plant and then discharged into this lagoon.

The existing 40 m^3 SAF plant will be retained for final polishing prior to discharge.

The plant operates autonomously. WEBS will provide a daily visit to check that all is well and monitor influent and effluent flow and quality.

New Plant Design Principles

The leachate will be treated with the following treatment processes:

2.5 Pre Aeration

The leachate will first be pre-aerated in a 40.6 m^3 underground tank using a blower (85 m^3/hr, Gardner Denver 2BH7610) coupled to fine bubble diffusers. This is to fully oxidise the soluble ferrous iron to insoluble ferric ions. This will ensure that the iron can be settled out, as a solid, prior to treatment and so remove the iron from the leachate prior to biological treatment and discharge.

2.6 Primary Settlement

The solids that are formed, after pre aeration, will be settled out in a settlement tank. The solids will be removed from the settlement tank, weekly, for disposal onto the land fill site.

2.7 Biological Treatment

The settled leachate will be biologically treated to oxidise the BOD (Biochemical Oxygen Demand) and $N\text{-}NH_4$ (Ammonium) within the leachate.

A total of 4 x 40 m^3 SAF (Submerged Aerated Filters) tanks will be provided. The tanks are aerated by a grid of fine bubble diffusers mounted on the base of the tank coupled to an air blower, each rated at 85 m^3/hr (Gardner Denver 2BH7610). The aeration system satisfies the oxygen demand for biological treatment. The tanks are packed with plastic media to provide a high surface area for biological sludge to attach and grow.

The SAF treatment system is a well proven process (accepted as one form of BAT) and is ideal for the process of nitrification. It provides a large surface area for the nitrifiers to attach and grow. Nitrifiers have a slow growth rate and so an attached growth system is particularly suitable for the nitrification process as it retains the bacteria within the system.

3 The Full Scale Plant

A 40 m^3 SAF (Submerged Aerated Filter) pilot-scale plant has been installed and operated from October 2010 to the present. The plant treats the leachate from the holding lagoon prior to discharge to the stream.

This has successfully demonstrated that the leachate can be fully treated to meet the present discharge consent limits, and a full scale plant has now been designed and approved.

3.1 SAF Plant - Treatment Principles

A SAF (Submerged Aerated Filter) is an aerated tank packed with plastic media. The plastic media has a high surface to area volume (~150 m^2/m^3) that enables bacterial growth (sludge) to grow and bind to the surface. This enables a high sludge mass to be held within the treatment plant and so is well suited for applications where nitrification is required as nitrifying bacteria are slow growers.

The media also has a high voidage that enables the air to easily rise up through the media to supply the oxygen demand and also to scour off excess dead sludge. The air for the treatment plant is supplied by an air blower (high volume, low pressure) that blows air through a grid of fine bubble diffusers. The diffusers consist of rubber membranes that have fine slots cut within them. Under pressure, the slots open and close emitting a fine mist of bubbles. The diffusers are mounted on the base of the plant and hence both oxygenate the water and air-scour the media.

3.2 Existing SAF Plant

The 40 m^3 SAF plant does not have sufficient aeration capacity to treat the full volume of leachate that is being received by the plant so excess is currently being tankered off site.

For the full volume of leachate to be treated, the treatment plant requires an upgrade. The design parameters for the upgrade is outlined in section 6

4 Design Parameters

The new treatment plant is designed to treat the following flow and loads:

Table 1, Design combined flows (Tip + French Drain) and concentrations

Max Daily Flow m^3/day	300	
Average Daily Flow m^3/day	100-120	
	Max mg/l	Average mg/l
COD mg/l	150	75
BOD mg/l	90	45
N-NH_4 mg/l	55	30
TSS mg/l	50	20
Total Fe mg/l	4	2

The flow and loads are based on the combined leachates from the “French drain” and “Tip”

5 Planned Improvements - Design Outline

The design of the plant upgrade is as follows.

5.1 French Drain and Tip Pumps

The existing submersible pump of the “french drain” would be retained and used to pump the leachate to the pump sump housing the pumps for the “tip” leachate pumps.

The “tip” leachate pumps would be used to pump the leachate to the combined pre aeration tank/settlement tank.

5.2 Underground Aeration and Settlement Tank

The leachate contains relatively high levels of dissolved ferrous salts (reduced form of iron). The dissolved iron will require removal prior to biological treatment otherwise it will coat the plastic media with insoluble iron. There is also an iron limit for the consent to discharge and hence iron in the leachate requires removal.

The main leachate pumps would be used to pump to a pre aeration tank which would be used to fully aerate/oxygenate the leachate, this will oxidise the iron from soluble ferrous to insoluble ferric. The insoluble ferric salts would then be settled in a primary settlement tank, prior to treatment of the supernatant in the SAF plants.

Aerated Zone Tank:	10 m^3
Aeration:	Coarse bubble aeration by a grid of pipes on the base of the tank
Airflow:	30 m^3/hr

The first tank would be below ground with covered turrets to prevent odour emissions. The pre aeration tank is underground to prevent double pumping of the leachate and also to lower the cost of installation. The tank used is a standard septic tank that is designed to be underground.

The last section of the tank would be a baffled settlement zone to enable the solids to settle out prior to biological treatment.

Upflow Velocity:	0.75 m/hr
Surface Area:	40 m^2

The underground tank would be of a cylindrical (Spel type) design as used for a septic tank with a settlement zone.

5.3 Pump Sump and SAF Feed Pumps

The settled effluent would discharge by gravity to a new pump sump and set of submersible pumps (duty/assist) rated at 15 to 20 m^3/hr.

There would be an overflow from the pump sump to the lagoon in the event that the leachate flow exceeds the capacity of the pumps.

5.4 Phosphoric Acid Dosing

The leachate is short of bioavailable phosphorus and a phosphoric acid dosing set is required to supplement the leachate with small doses of phosphate.

Holding Tank: 150 l

Peristaltic Pump: 1 to 5 ml/min

The phosphoric acid would be dosed into the inlet sump pump, to achieve an approximate 10:1 nitrogen:phosphorus ratio, i.e. optimum for denitrification. Consumption will only be a few grammes per day.

5.5 SAF Plants

Four 40 m^3, above ground SAF plants would be provided of the same type that has been used for the pilot plant (see photo). The SAF plants would be operated in series and each SAF plant would be divided into two, baffled, sections.

Each SAF plant would be supplied with an access ladder and walkway to allow access to the individual compartments.

The SAF plants would be mounted on metal cradles and located on a concrete plinth much as for the present plant.

The drawing does not show it but the plant will include an all-inclusive bund of at least 210 mm in height, providing a capacity in excess of 40 m^3 (10.5m x 18.0m x 0.210m) in case of sudden failure. The plinth will incorporate a grated drain leading to the lagoon.

5.6 Lagoon

The lagoon would be retained for flow balancing prior to discharge to the stream.

The floating filters would be retained with the spray bars as well as the floating reed beds. These do not impinge on planned operations and could be useful in future.

5.7 Existing SAF Plant (40 m^3)

The existing pilot SAF plant will be retained and used as a final polishing stage for the leachate, prior to discharge to the stream.

5.7.1 SAF Feed Pump

A surface mounted, positive displacement pump (mono type) would be installed to provide a consistent and easily, manually, adjustable flow to the SAF plant. The inlet pipe would be submerged in the lagoon with a coarse filter to protect it from blocking with algae.

5.7.2 Recirculation

A submersible pump, with flexible pipework, will be installed to enable the treated leachate to be recirculated back to the pre aeration tank if required. This will enable any out-of-specification leachate to be recirculated and treated again prior to discharge to the lagoon.

The pump and pipework will be held in store in the event of threatened consent failure and only used as required. See 6.10.

5.7.3 Flow Meter

A flow meter will be installed on the outlet pipe of the feed pump to measure the feed to the SAF plant and hence flow to stream.

5.8 Drum Filter

A drum filter (10 um) will be installed to filter the outlet from the SAF plant to ensure the final effluent meets the TSS (Total Suspended Solids) limit.

The drum filter would be rated at 15 m^3/hr. The back wash from the filter would be discharged to the lagoon for solids settlement.

5.9 Final Effluent Discharge Pipe

The final effluent discharge pipe would be routed underground and connected to the existing outlet chamber and V-notch weir.

5.10 Recirculation

A valve will be installed on the feed pipe from the lagoon to the final SAF plant so that the treated leachate can be diverted back to the inlet to the primary SAF plants if required. This will enable any out of spec leachate to be re circulated back to the primary SAF plants for further treatment.

5.11 On Line Monitoring

The existing Hach Lange pH, DO and temperature probes in the lagoon would be retained.

The existing ammonium probe, monitoring the ammonium of the final effluent, would be retained. The existing flow meter would also be retained.

The V notch weir and ammonium probe will comply with the relevant MCERTS standard.

6 Plant Design

6.1 Organic Loading Rates and Residence Time

The SAF plants are designed with the following organic loading rates and hydraulic residence times.

Table 2, Design combined flows (Tip + French Drain) and concentrations and loadings.

Max Daily Flow m^3/day	300			
Average Daily Flow m^3/day	100			
	Max mg/l	Max kg/day	Average mg/l	Average kg/day
COD	150	45	75	7.5
BOD	90	27	45	4.5
$N\text{-}NH_4$	55	16.5	30	3.0
TSS	50		20	
Total Fe	4			

Table 3, Design loadings onto SAF plants

Aeration m^3	160	
	Max	Average
Kg COD/m^3/day	0.28	0.04
Kg BOD/m^3/day	0.17	0.028
Kg $N\text{-}NH_4$/m^3/day	0.10	0.03
HRT hrs	12.8	38

The composition of the leachate is variable depending upon the time of year and rainfall levels. A relatively large aerated volume is therefore being provided to allow for this variability and so there is a wide range in the organic loading rates.

The maximum loading rates would be seen as being conservative and hence there is spare aeration capacity to cope with the variability of the leachate, both in terms of flow and composition.

6.2 Temperature Dependency

The treatment plant is biological, and designed based on the leachate having a temperature of at least 9°C (records suggest that it arrives from the landfill at 10-15°C depending on season). For sustained temperatures lower than 9°C the aeration volume would become very large, (up to double the design of 160 m^3) and hence would require a major increase in capital expenditure. If the temperature of the incoming leachate drops significantly below 9^{o}C for a long period, e.g. in mid-winter, then a Consent failure may therefore be possible.

It is understood that a small percentage of failures is considered acceptable in such circumstances, and is indeed preferred by the EA to, for example, setting different Consent limits for summer and winter (ref: EA Horizontal Guidance Annex E). We expect such circumstances to be rare, and indeed factoring in the storage/mixing capacity of the lagoon may never happen. This will however need to be monitored closely in the first full winter of operation and reviewed if necessary.

7 Civil Engineering Works

The main civils work would be:

- Demolition of the existing, block built, nitrifying filter.
- Disposal of the plastic media held within the filter
- Connection of the feed pipe from the main pumps to the underground aeration/settlement tanks
- Excavation for the underground aeration/settlement tank
- Refilling around aeration/settlement tank with gravel
- Excavation and positioning of the SAF feed pump sump
- Preparation and provision of a concrete plinth for the 3 x 40 m^3 above ground SAF plants
- Provision of underground pipe from the final SAF plant to the outlet sump
- Mounting of outlet pipe in the outlet sump

8 Consent Limits

The upgraded plant is designed to meet the existing Consent limits:

Daily Flow: 100 m^3/day

BOD: 20 mg/l

TSS: 30 mg/l

N-NH_4: 4.0 mg/l

Total Fe: 0.75 mg/l

These are the existing Consent limits. They have been re-examined using the H1 risk assessment tool and confirmed as acceptable (see separate report).

9 Messing Facilities

A cabin is required to provide messing facilities for site operation. This would provide a changing area with a small office and an on site laboratory.

The outlet from the toilet and hand basin would discharge to a septic tank which would be emptied, when required, by vacuum tanker.

10 Plant Performance

10.1 Present Performance

The results from the 40 m^3 pilot SAF plant are outlined in the table below.

Flow Rate: 2.11 m^3/hr, 50.64 m^3/day

Table 4, Sample analysis, Nant- y - caws, October 2010 – February 2011

	COD Total mg/l	pH	N-NH_4 mg/l	P-PO_4 mg/l	Fe mg/l	Temp ^oC
Tip	107	7.42	42.2	0.325		11.9
French Drain	34.1	7.22	30.5	0.065		10.4
Lagoon	50.3	7.72	40.7	0.074		7.7
Final (Ex SAF)	38.7	7.54	1.45	1.36	0.222	8.2

11 Power Drawn

The upgraded plant will have the following, estimated, power drawn:

Table 5, Estimated power drawn for the treatment plant

	No	Rating	kWh/day
French DrainPump	1	0.7	16.8
Tip Pump	1	1.5	36
SAF Feed Pump	1	1.5	36
Blowers	4	2.5	240
Final Effluent Pump	1	0.7	16.8
Total			**345.0**

The estimated average power drawn is 345 kWh per day giving an annual power drawn of 126 MWh. The peak power drawn for the plant is estimated to be 600 kWh/day.

12 Plant Monitoring

The plant will be attended daily and the check sheets on the operation of the plant completed (sample attached). The laboratory used for external confirmatory analysis will be UKAS and MCERTS accredited.

The plant performance will be monitored as outlined in the table below.

Table 6, Plant performance monitoring

Parameter	Frequency	Method
Flow	On line meter	"Magflo" Type
Ammonium (N-NH_4)	On line meter	Hach Lange
pH	On line meter	Hach Lange
Temperature ^oC	On line meter	Hach Lange
COD, BOD, TSS, Tot Fe	Manual monthly	Severn Trent Labs

13 Raw Material Input

The only raw material input will be the dosing of phosphoric acid to supplement the ortho phosphate level of the leachate. The leachate is short of ortho phosphate and requires small doses of supplemental ortho phosphate dosing to ensure full biological degradation. This phosphate is a nutrient and will largely be consumed by bacteria. This is not regarded as chemical treatment. The dosage rate will be 250 to 500 ml/day of 80 % phosphoric acid.

14 Waste Disposal

14.1 Primary Sludge

The waste that will be generated from the plant will be the primary sludge that is settled in the primary settlement tank. The volume is estimated as follows:

Flow: 100 m^3/day

Max TSS: 150 mg/l

Max DS/day: 150 kg/day

Volume @ 2%: 7.5 m^3/day

There will be an estimated volume of 7.5 m^3/day of primary sludge that will require disposal to the landfill site.

14.2 Secondary Sludge

The excess sludge from the SAF plants will be settled out in the lagoon and will undergo “mineralisation”, over time, due to the extended residence time of the sludge. The back wash from the drum filter will also be passed to the lagoon for settlement and mineralisation.

In effect, there will be no biological sludge generated that will require off site disposal and treatment.

15 Risk Assessment

15.1 Health and Safety

A health and safety risk assessment is attached outlining the main risks and measures to counteract them.

15.2 Environmental

The major environmental risk is if the discharge exceeds the consent limits. It has been found that the first parameter that is exceeded is the ammonia limit.

There is an on line ammonium probe and this is being cross checked with daily analysis of the final with an ammonia test kit. In the event that the ammonia limit is exceeded the discharge will be stopped and the leachate will be tankered off site.

The existing 40 m^3 pilot plant has the capacity to treat 50 to 60 m^3/day with temperatures at 7 to 8^oC. The remaining volume of leachate is being tankered off site until the temperatures rises and higher volumes of leachate can be treated.

The disposal route for tankered leachate is via a local waste management company that has its own waste water treatment plant that has the capacity to treat the leachate volume prior to discharge to an estuary.

16 Contingency Planning

There are duty/standby pumps in the main pump chamber for the leachate that alternate in their duty for each pump cycle. In the event that there is a power cut, or pump failure, there is an over flow pipe from the pump sump to the lagoon and the leachate would overflow into the lagoon.

In the event of a pump failure in the main treatment plant, the effluent would overflow from the initial aeration /settlement tank, into the lagoon, via an overflow pipe.

Any out of specification final effluent would also be diverted from the final discharge pipe and stored within the lagoon.

There will be a pump to return the stored effluent in the lagoon for treatment in the main treatment plant during periods of low flow.

In the event that the lagoon fills to a dangerously high level then tankers would be used to lower the level and keep it at a safe level.

17 Best Available Technology review

A variety of processes can be used to treat landfill leachate, either alone or as part of a multi stage process. The nature of leachate in that it not only can its quality vary from site to site but the quality will also vary over the life of any particular site as wastes progressively decompose. Provision of treatment facilities should take this into account.

In choosing a replacement plant which fulfils BAT for the treatment of landfill leachate, the adoption of one or more treatment processes might be required. The processes which were considered can be grouped under broad headings:

1. Physical treatment processes

2. Chemical treatment processes

3. Aerobic biological treatment processes

4. Anaerobic treatment processes

5. Aerobic/ anaerobic biological treatment processes

17.1 Physical Treatment

The leachate treatment is effectively driven by the Consents, in particular for Ammoniacal-N. Destruction of this is preferred to relocation from one medium to another, so the leachate is not being physically treated at this site because:

- Air Stripping could remove Ammoniacal –N to the air but would not destroy it, so would impact on local air quality and would create an odour problem
- Reverse Osmosis can be used to treat raw leachate but only at high expense, so is usually used as a polishing processes.
- Solids removal would not reduce Ammoniacal-N significantly.
- Activated carbon adsorption could in principle be used but has very high consumable costs.
- Ion exchange is not appropriate for ammonia.
- Membrane filtration is prohibitively expensive

17.2 Chemical Treatment

Chemical treatments at least have the potential to destroy rather than simply relocate the ammonia. Ammonia can be oxidised in particular, however, the leachate is not being chemically treated at this site because:

- Ozonation, where ozone is used to oxidise complex organic constituents that do not easily biodegrade, could certainly do the job, but has very high running costs and a high carbon footprint due to high electricity consumption.
- Hydrogen peroxide could be used, but the costs would be high and the chemicals are hazardous.

17.3 Biological Treatment.

Biotreatment is still the treatment of choice in the UK, and the leachate is being treated biologically at this site. Biotreatment is by far the most successful method for dealing with ammonia, the most difficult Consent parameter. However, of the several options available, most could be ruled out for this site:

- Ammonia cannot be treated anaerobically, ruling out all anaerobic systems.
- Treatments requiring a large surface area – such as reed beds and ponds – could not be used due to lack of available land.
- Suspended growth systems – such as the previous aerated lagoon system – are susceptible to freezing in winter (which had caused breaches of Consent), and are also susceptible to wash-out of biomass due to the low growth rates in low BOD leachates such at that at Nantycaws (as evidenced by the previous operator having to keep adding sludge).

Thus some form of enclosed aerobic attached growth system was expected to be the most successful design, and this has now been proven at pilot scale. Enclosure in vessels ensures that the treatment is less likely to freeze in winter (the influent leachate arrives at 10-15^{o}C), and allowing biomass to grow as a fixed film over a high surface area fixed material prevents biomass washout. Modular design also allows individual units to be taken off-line for maintenance or repair, and more to be added if required. This method of treatment of the leachate (Attached Growth Systems – Submerged Aerated Filters) is widely accepted for low-BOD, high ammonia leachates, and is referenced in the guidance:

> **Guidance for the Treatment of Landfill Sector Guidance Note IPPC S 5.03 (**Page 24 – Attached Growth Systems)

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