

WASTE MANAGEMENT IMPACT ASSESSMENT

Quantem Port Botany

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STATEMENT OF LIMITATION

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Executive Summary

Terminals Pty Ltd (Quantem) propose to install a second thermal oxidiser adjacent to the existing unit at their site at Port Botany, NSW. The operation of a second thermal oxidiser will enable Quantem to treat liquid waste on site while providing redundancy to the existing VOC emission control. It will have a greater capacity than the existing unit, offering more operational flexibility, and be purpose designed to handle both liquids and vapours. The on-site treatment of the liquid waste stream provides additional security around waste disposal, noting that difficulties have occurred in the past with off-site treatment. The new unit will be the primary and the existing unit will act as a standby. This report focuses on the comparative environmental impacts of on-site compared with off-site treatment of the liquid waste.

The current liquid waste management process involves off-site treatment and disposal by combustion of the waste material in a cement kiln. The waste is shipped off-site to a temporary holding site where it is reportedly homogenised with other wastes to generate a waste of constant calorific value and then combusted.

With the installation of the new thermal oxidiser, the proposed waste management process will provide the following benefits over the current waste disposal methodology:

- it eliminates all road transport emissions;
- it will provide broadly equivalent waste destruction of the insoluble flammables in comparison to offsite fuel burning, such as in kilns, in equipment which meets or exceeds the relevant standards.
- it will provide redundancy in the site's waste management system and greater guarantees around waste disposal, with reduced impacts on operations
- it has potential to reduce greenhouse gas impacts when compared to historical treatment regimes
- It will treat wastes where they are generated.

A review of best available waste treatment techniques has been undertaken and this supports the proposed approach. A near identical plant has been installed and operational at the Coode Island site for over 10 years and has been shown to effectively reduce >99 % of VOC emissions with no discernible reduction in destruction efficiency when combusting a similar liquid waste stream. The proposed combuster has been designed with a greater combustion efficiency.

In terms of the Waste Hierarchy, a portion of waste currently produced by the site does fall within the energy recovery option (off site kiln combustion). A review of potential heat recovery opportunities for the new combuster was undertaken and no practicable solutions were identified. There are potential environmental offsets identified with reduction in the overall level of greenhouse gases produced in comparison with historical treatment methodologies, primarily associated with a change away from any biological treatment. Other benefits from the change include that Quantem will have greater control over their waste stream removing a business threat and that the waste is treated where it is produced, supporting the proximity principle. In addition, Quantem will have an additional level of redundancy for managing the vapour waste stream.

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1 Introduction

This report will review changes that Terminals Pty Ltd (Quantem) are proposing changes for the management of wastes, including flammable vapours and liquids, at their existing site at Port Botany, NSW. The operating NSW EPA Environmental Protection Licence for the site is Licence Number 1048.

Wastes generated on the site can be categorised into the follow broad groups:

- Household and Office Waste.
- Waste packaging, plastics and cardboards
- Heavy fraction wastes (Mid-long chain hydrocarbon oils/fats)
- Light fraction gaseous Volatile Organic Compounds (VOC's)
- Light fraction hydrocarbon volatile organic/water washings (liquid waste)

The changes proposed by Quantem relate to the improved treatment of the Light Fraction Gaseous Volatile Organic Compounds and the 'liquid waste' stream; these wastes are collectively referred to as the 'flammable liquids waste stream'. The proposed changes will only impact this waste stream; consequently, other waste streams do not form part of the scope of this review.

Light fraction hydrocarbon wastes are generated on site from a number of sources including diurnal tank breathing, tank and vessel loading operations, these are generally regarded as Volatile Organic Compounds (VOCs).

There are currently two systems to treat flammable vapours generated on the site:

- one (1) Vapour Combustion System (VCS) operating on the site to thermally oxidise flammable vapours,
- one (1) Vapour Emission Control System (VECS) with carbon bed adsorption.

The site also generates a liquid waste stream of predominantly light fraction hydrocarbons, distillates, base oils and alcohols, mixed with water. The generation of these wastes is sporadic in nature arising from line cleaning operations, periodic vessel draining operations to remove accumulated water and periodic cleaning and vessel or line change operations arising from product storage changes. Potentially contaminated rain water from high risk areas on the site (eg: truck loading gantries) is also collected and forms part of this waste stream; the generation of this waste stream is minimised through localised controls such as roofing and rain shielding where practicable. Site maintenance activities also generate a stream of hydrocarbon/water liquid waste.

Currently, this liquid waste generated on the site is currently collected by Cleanaway using a vacuum loading truck and is transported to be treated and disposed of at an EPA-compliant facility or interstate.

A recent shutdown at the Cleanaway Homebush facility had significant impacts on Quantem's ability to operate. Moving to another waste management company was investigated, however no other party willing or capable of accepting this type and volume of waste has been found. This presents a significant operational risk to the current and future site operations.

To reduce this risk, Quantem are seeking to install a second thermal oxidiser, and undertake thermal treatment of the liquid waste, currently collected by Cleanaway. This new thermal oxidiser will run in parallel with the existing oxidiser and is not intended to replace it. The existing thermal oxidiser will continue to run on the site and is not nearing the end of its operational life.

This report has been prepared to support an application to the NSW EPA for a licence amendment to operate the second thermal oxidiser on the site. A review has been undertaken of liquid waste generation on the site, the current disposal pathway and methodology by Cleanaway as it is best understood, and the options for waste treatment under the NSW Waste Hierarchy.

2.1 Existing Licence

Activity	Scale
Chemical storage waste general	> 100 Tonnes annual volume of waste generated or stored
Petroleum products and fuel production	> 10,000 - 200,000 Tonnes annual production capacity
Petroleum products storage	> 100,000 kL storage capacity
Shipping in bulk	> 100,000-500,000 Tonnes of annual capacity to load and unload
Waste storage – hazardous, restricted solid, liquid, clinical and related waste and asbestos waste	Any listed waste type stored

2.2 Existing Operations

Site A and Site C are the sites which generate liquid waste to be treated on site, and thus are the subject of this review.



Figure 1 Quantem Port Botany Facility

Operations on the sites include the storage and handling of a range of flammable hydrocarbon liquids including benzene, hexene, ethanol and methanol. The waste streams that are generated from operations at the terminal include VOCs, Hazardous Air Pollutant vapours (HAP"s), and flammable liquids. Wastes are also generated from operations including tank filling, ship filling, truck filling, line clearing, tank cleaning, and diurnal breathing of tanks.

The hydrocarbon and operational organic based wastes generated on site can be further classified into four (4) general waste streams and these are classified as follows:

1. VOC-nitrogen inert stream; (gaseous)
2. VOC-air dilute stream (gaseous)
3. Light hydrocarbon/water liquid waste stream
4. Heavy & long chain hydrocarbon wastes

Current management of these waste streams involves treatment of the VOC vapour streams (1 and 2) on the site using the existing carbon bed system and thermal oxidiser, and collection of the liquid waste (3) by Cleanaway. Heavy and long chain hydrocarbon wastes (4) are diverted to oil recycling and re-purposing. The VOC-nitrogen inert stream is directed to a thermal oxidiser (VCS) where volatile organics are thermally oxidised to generate carbon dioxide and water (CO₂ and H₂O), which is then discharged at high velocity via a stack at elevated temperature and height. The VOC-air dilute stream is directed to a Vapour Emission Control System (VECS) with carbon bed adsorption to remove harmful contaminants before being vented to atmosphere. Periodic regeneration of the carbon bed using steam generates a light hydrocarbon water waste stream that forms part of the 'liquid waste'

2.3 Proposed Development

To reduce operational risk and to improve management of the waste streams produced by operations at the Port Botany site, Quantem propose to install a second thermal oxidiser that will have the capacity to treat both the vapour and liquid waste streams. The new unit will be located adjacent the existing thermal oxidiser, and may operate independently or in parallel with it, to treat the waste streams.

The operation of a second thermal oxidiser will enable Quantem to treat liquid waste on site, removing the need for transport to a third-party waste disposal site. This will provide a level of redundancy in their waste management system for both vapour and liquid waste, improving reliability and system performance. It will reduce reliance on the operations of an external party and allow Quantem further control and confidence in the management of their waste.

The new thermal oxidiser will be designed and installed to meet the requirements of the *Protection of the Environment Operation (Clean Air) Regulation 2010*, and performance testing for adequate destruction efficiency shall be undertaken based on the nominated chemical composition of the waste streams. The final equipment specification and performance specification including thermal destruction temperature and residence times is detailed in the appended CEC/Gasco Specification (Appendix A).

3 Waste Review

Quantem operates a number of terminal facilities throughout Australia, with a goal to minimise environmental impacts from waste. The process of waste minimisation and management is an ongoing process with a continual driver for improved performance. Quantem's practices are aligned with the *Waste Avoidance and Resource Recovery Act 2001* in its adoption of the Waste Management Hierarchy as detailed in Figure 2. This section reviews how the liquid waste stream sent for off-site treatment and disposal is generated, it will review the nature of the waste stream and the current management practices at Quantem Port Botany with reference to the waste hierarchy shown below.

The off-site treatment of the waste will be reviewed against the proposed treatment methodology as well as being reviewed and compared with published best available treatment options. There is no fundamental change proposed to management of the gaseous waste streams that will be thermally oxidised on site.

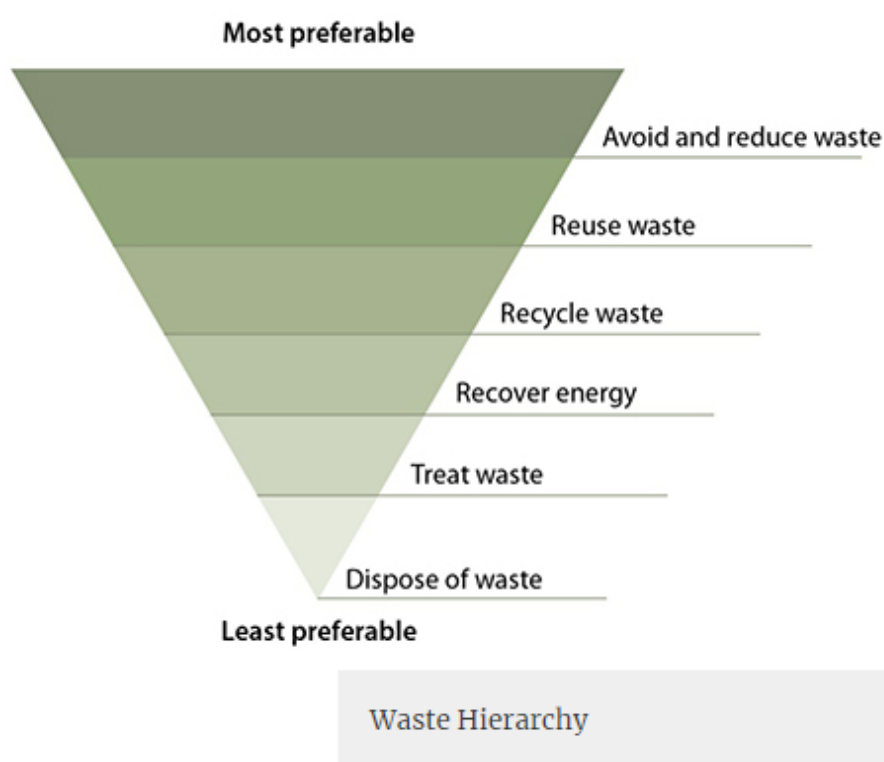


Figure 2: Waste Management Hierarchy

3.1 Liquid Waste Generation

A review has been conducted of the liquid waste generation on sites A and C using annualised data from 2018, 2019 and 2020. Site B, the bitumen facility is excluded from this review as no changes are proposed and the waste streams from this facility are treated separately.

Table 1 details the annualised liquid waste generation compared to the overall site throughputs. The data show that the site currently generates only a very small percentage of waste from its total operations indicating that current waste minimisations strategies employed on the site are effective. As external waste disposal has a cost penalty (typically increasing) associated with it there is usually a financial driver to minimise this overhead. The steady state of waste generation indicates that the site has not been able to economically employ additional minimisation options.

Table 1 Annual Throughput and Waste Generation`

	Period	Annual Throughput (ML)	Waste Generation (approx. – per annum) (ML)	Waste as % of annual throughput
Site A – Chemicals Business	2018	266	0.84	0.32%
	2019	236	0.84	0.36%
	2020	272	0.93	0.34 %
Site C – Fuel Terminals	2018	253	0.18	0.071%
	2019	331	0.18	0.054%
	2020	270	0.27	0.10%
Totals	2018	519	1.02	0.20%
	2019	567	1.02	0.18%
	2020*	547	1.20	0.21%

Recent and planned plant modifications including the installation of tank roofing will further minimise waste generation from that site. Site C is dedicated to ‘ground fuels’ (motor spirits [petrols] and diesel) and has no water based line cleaning or flushing resulting in a lower waste generation rate. Moving forward Site C may store aviation and ground fuels.

Data from 2020 has been impacted by the inability of Cleanaway to dispose of wastes through their local facilities, this has resulted in waste stockpiling on the sites, effectively skewing volumes. Further, pandemic related ‘lockdowns’ resulted in a significant reduction in ground fuels use resulting in reduced site throughput. changes in the location and method.

It should also be noted that waste generation from the collection of potentially contaminated rainwater is variable and will depend on the frequency, volume and intensity of rainfall that can vary significantly on an annual basis. Quantem have undertaken upgrades to their loading gantry bays with an aim to minimising rainwater ingress, as detailed in Appendix B.

3.2 Waste Stream Generation and Composition

The composition of wastes on the site is linked to the waste generating processes on the site. The site stores, ships and transfers a range of chemicals including, automotive fuels, jet fuel, alcohols for local and overseas use, base oils and lubricants, as well corrosives. As a multi-purpose storage facility, the site utilises common transfer lines for products that are loaded to and from ships as well as to and from road tankers. Some of these materials are ‘food grade’ and some require that cross contamination risk is minimised (eg jet fuel).

The waste generating activities on site can be broadly categorised into three (3) categories as detailed below:

3.2.1 Waste from Routine Operations

Waste from routine operations is generated primarily from line cleaning and line changeover operations. The site will typically load or unload two shiploads of chemicals per week. The chemicals are typically different, meaning that at a minimum two cleanout operations will occur per week.

Quantem attempt to schedule deliveries and sequence product changeovers so as to minimise cleanouts. Quantem have developed a detailed cross contamination management plan and have developed a cleaning and cross contamination matrix. Figure 3 below details an excerpt of the cross contamination matrix. The matrix details the compatibilities and required cleaning methods to maintain product integrity that are detailed in Figure 4. It is noted that Quantem uses a single dock line for sensitive cargoes

(Dockline 4) that requires more complex cleaning protocols in order to minimise cross contamination risk and to maintain food grade standards.

PREVIOUS CARGO \ NEXT CARGO	ACETONE	ALIMET	APE CORE 150	APE CORE 600	APE CORE 2500	ARAMCOPRIMA 150	ARAMCOPRIMA 500	BTX (BENZENE)	BUTYL ACRYLATES STABILISED	DNP	EHCL10 BASE OIL	EHCS0 BASE OIL	ETHANOL 100 HIGH GRADE	ETHANOL 95 HGNA	ETHANOL SINO GRADE	ETRO 4	ETRO 6	FUEL GRADE ETHANOL	HEXENE-1	ISO
ACETONE	1	9,8,11	2	2	2	2	2	N/A	2	2	2	2	2	2	2	2	2	2	2	2
ALIMET	9,3	2,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9,5,5	9,5,5	9,5,5	N/A	N/A	9,5,5	9,3	9,3
API/E CORE 150	3,4	N/A	1	1	1	1	1	N/A	6	3	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
API/E CORE 600	3,5	N/A	1	1	1	1	1	N/A	6	3	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
API/E CORE 2500	10,4	N/A	10,3	10,3	10,3	10,3	10,3	N/A	10,3	10,3	10,3	10,3	N/A	N/A	N/A	10,3	10,3	N/A	N/A	N/A
ARAMCOPRIMA 150	6,7	N/A	1	1	1	1	1	N/A	6,4	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
ARAMCOPRIMA 500	6,7	N/A	1	1	1	1	1	N/A	6,4	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
BTX (BENZENE)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BUTYL ACRYLATES STABILISED	4	N/A	6,7	6,7	6,7,1	6,7	6,7	N/A	1	3	6,7	6,7	N/A	N/A	N/A	6,7	6,7	N/A	N/A	N/A
DNP	7	N/A	6	6	6	6	6	N/A	6	1	6	6	N/A	N/A	N/A	6	6	N/A	N/A	N/A
EHCL10 BASE OIL	6,7	N/A	1	1	1	1	1	N/A	6,4	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
EHCS0 BASE OIL	6,7	N/A	1	1	1	1	1	N/A	6,4	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
ETHANOL 100 HIGH GRADE	1	1,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6,4	6,4
ETHANOL 95 HGNA	1	1,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6,4	6,4
ETHANOL SINO GRADE	1	1,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6,4	6,4
ETRO 4	6,7	N/A	1	1	1	1	1	N/A	6,4,1	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
ETRO 6	6,7	N/A	1	1	1	1	1	N/A	6,4,1	6	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A
FUEL GRADE ETHANOL	1	1,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6,4,1	6,4,1
HEXENE - 1	7	8,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7,11	7,11	7,11	N/A	N/A	7,11	1	2
ISOHEXANE	8	8,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7,11	7,11	7,11	N/A	N/A	7,11	1	2
JET AVIATION FUEL F44	6,7	6,8,11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,7,11	6,7,11	6,7,11	N/A	N/A	6,7,11	6,7	6,7
METHANOL	7	6,8,11	12	12	12	12	N/A	N/A	N/A	N/A	12	12	6,7,11	6,7,11	6,7,11	12	12	6,7,11	3	3

Figure 3: Excerpt of Cross Contamination Matrix

No. Description

N/A Not applicable, due to product vs dockline segregation

1 Dry pig only, with received pig NOT dry

2 Dry pig only, until received pig is clean and dry

3 Pig with MEK (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.

4 Pig with Acetone (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.

5 Pig with IPA (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.

6 Pig with MEK (200L) and pig with another MEK (200L) shot. If received pig is not clean, repeat process. Dry pig until received pig is dry.

7 Pig with Acetone (200L) and pig with another Acetone (200L) shot. If received pig is not clean, repeat process. Dry pig until received pig is dry.

8 Pig with IPA (200L) followed by an IPA-soaked pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.

9 Fresh water (1000L) shot

10 Hot water (1000L) shot

11 Dockline conditioning with product

12 UNACCEPTABLE PREVIOUS CARGO (Never)

Product uses Dockline 4 ONLY

Figure 4: Cleaning Protocols

The general approach to cleaning lines is to 'pig' the lines (flush with solvent and push a sponge through the line with air) with solvents that are capable of dissolving most residual product and then either flushing with the lines with a water shot or with product and 'wasting' a small portion of the incoming product (first flush).

The solvents used include Methyl Ethyl Ketone (1-butanone), Acetone and *iso*-propyl alcohol (IPA). These have been specifically selected as they offer high solvency of hydrocarbons and water that will effectively clean the product lines.

For example, if the site is changing from a methanol receipt to an Ethanol (Food grade) export, then the product dock line would be required to pigged at least twice with MEK (200 L) followed by at least two 200 L pigs of Acetone and followed up with a small quantity of Ethanol to be shipped out. This is in essence a minimum quintuple rinsing and cleaning of the line that would typically generate approximately 1,000 L of flammable liquid that would be a mixed waste consisting of acetone/MEK and ethanol as well as any remnant product from the previous shipment. This waste is collected and stored in dedicated waste tanks on site.

The carbon beds from the VECS system are periodically regenerated (to maintain their activity) using steam, this process also contributes waste to the 'liquid waste' stream.

3.2.2 *Waste from Environmental Events*

The site has identified road tanker gantries as higher risk external pavement areas for the generation of potentially contaminated stormwater. The gantries have roofs and are shielded from windborne rain; however, during some rain events stormwater is collected in gantry sumps. This water is typically contaminated with minor quantities of product that has collected on pavement such as small drips and spills associated with sampling and hose couplings in the gantry bays. Due to its potential to cause environmental harm and mixed composition, this material is regarded as waste and is transferred to the waste storage tank. As detailed previously, Quantem have made changes to gantry loading bay roofing to reduce the volume generation of potentially contaminated water.

3.2.3 *Waste from Routine and Planned Maintenance*

The Port Botany site has over 50 storage tanks. In keeping with good asset management and to comply with requirements of the Australian Standard for the Storage and Handling of Flammable and Combustible Liquids (AS1940), tanks must be regularly inspected and for larger tanks (such as those on the Port Botany Site) be emptied and internally inspected at least once every 10 years. This typically means that approximately 5 tanks are emptied, cleaned and inspected every year. The tank cleaning process is bespoke and will depend on the materials that have been previously stored in the tank. Cleaning will typically involve the use of solvents with steam and water washing. This process generates a mixed composition waste, can include flammable base solvents, cleaning solvents and water, degreasers, scale and general heavy sludge from tank bases. This material is treated as flammable mixed waste by the site.

Pipeline and equipment maintenance (eg pump maintenance) will also generate quantities of mixed hydrocarbon/water wastes.

3.3 **Waste Composition**

The waste generating events, processes and activities detailed above indicate that the waste composition may vary. To investigate the waste composition, grab samples from the two main waste tanks on site (Tanks 261 and 219) were taken at various levels in the tanks. The moisture, density and pH were measured, Table 2 shows the results obtained at various levels in the tanks. In most samples, upon resting, 2 phases formed, with the water content measured in both phases. In order to determine the total water content of the wastes, the observed %split of the phases was multiplied by the measured water content.

The results indicate the waste can be separated in most cases into an aqueous and hydrocarbon phase; however, the results of the aqueous phase testing that show values in the ranges of 65 – 84 % water indicate that these phases also contain something other than water. Given the miscibility of the cleaning/flushing solvents with water, this is most likely hydrocarbon cleaning products such as alcohols, acetone and methyl ethyl ketone. The pH of the samples would indicate that there is no strong concentration of acids or alkalis in the water.

In summary, the waste stream varies as a function of the tank depth and the waste is typically ~ 60 - 80% water, with the remainder being hydrocarbon waste.

Table 2: Waste Tank Water Composition

Tank	Description	Water Content (% H ₂ O)	Density	% phase split	% H ₂ O (weighted)	% H ₂ O (Total)
219	Top Phase 1	1.7	0.8504	5	0.085	79.89
	Top Phase 2	84	0.9868	95	79.8	
	Mid Phase 1	0.3	0.8532	5	0.015	74.31
	Mid Phase 2	78.2	0.9887	95	74.29	
	Lower Phase 1	0.1	0.8504	5	0.005	71.45
	Lower Phase 2	75.2	0.9885	95	71.44	
	Bottom Phase 1	0.6	0.8511	2	0.012	71.45
	Bottom Phase 2	72.9	0.9886	98	71.442	
261	Top	0.5	0.8461	100 ¹	0.5	0.5
	Mid	0.5	0.846	100 ¹	0.5	0.5
	Lower Phase 1	0.7	0.9508	10	0.07	59.38
	Lower Phase 2	65.9	0.9861	90	59.31	
	Bottom Phase 1	0.7	0.8524	4	0.028	75.29
	Bottom Phase 2	78.4	0.9874	96	75.264	

In addition to the tank samples, two waste samples drawn from material to be sent off-site to Cleanaway were sent for further characterisation; coupled with a waste sample from 2019 we can gain further insights into the composition of the wastes. Table 3 shows a summary of the main components detected in the wastewater (aqueous) phase samples, as well as the total organic content (TOC) and the chemical oxygen demand (COD) which is a measure of the amount of oxygen required to degrade the materials in the samples.

Table 3: Compositional Analysis of Waste Water Streams

	Sample 1 (g/l)	Sample 2 (g/l)	Sample 3 2019 (g/l)
TOC	23.8	24.8	63.2
COD	223	263	704
Styrene	0.0202	0.116	1.12
Vinyl Actetate	0.381	0.308	1.2
MEK	25.6	23.6	178
Napthalene		0.00942	0.00507
2 Methyl Napthalene	0.00223	0.0148	0.00408
Benzene			0.173
Toluene			0.0456
di-n-octylphthalate			0.0249

The waste composition will vary and is dependent on the product load imports and exports explaining the difference between styrene and MEK concentrations in the samples above.

Water and Methyl Ethyl Ketone (MEK) are known to form an azeotropic mixture (Chemical Rubber Company, 1995). Other cleaning solvents used in pigging operations (Acetone and Ethanol) also form

¹ No aqueous phase reported in this sample

azeotropic mixtures with water. The polar nature of these solvents (MEK and Acetone) as well as the miscibility with hydrocarbons and water makes them excellent candidates for cleaning/pigging operations meaning that the volumes of waste generated by this process are minimised.

The definition or primary property that an azeotropic mixture has is that they are very difficult to separate out into component parts. A common method for separating the liquid components is fractional distillation. Typical and simple separation methods like this typically fail to separate out the component parts of azeotropes. Under typical distillation for an azeotrope, the composition post distillation is barely changed. This is a fairly common phenomenon; consider rubbing alcohol or *iso*-Propanol (typically 70% alcohol in water). Distillation to remove water under standard conditions fails and obtaining alcohol concentrations greater than 70% while possible it is difficult, typically requires multiple steps, and is energy intensive.

Quantem have undertaken investigations into the potential for processing or further separating this waste stream with a goal to minimising the aqueous waste stream. As detailed in the Site A Waste Minimisation Strategy (Appendix B), filtration and adsorption on activated carbon media failed to separate organics from the waste stream, with the potential that the total volume of waste generated could be greater than the starting volume. This is not unexpected given the azeotropic nature of the waste stream that does not lend itself to separation.

Thus, when we consider the liquid waste stream, we have a variable liquid waste stream that contains hydrocarbons and other solvated products that are not easily separated using conventional methods. The amount of hydrocarbon in the liquid can vary significantly and this then has an impact on its 'calorific value' or the useful amount of heat that can be obtained from the liquid. The testing results clearly show that this will vary significantly. Notwithstanding this, the waste stream does have some calorific value and can be combusted.

To highlight the difficulty in separating azeotropic mixtures, a doctoral thesis "Liquid Waste Treatment with Physicochemical Tools for Environmental Protection" (Toth A. J., 2015) reported on the treatments of azeotropic waste streams from a printing company that contained mixtures of Ethanol, water, MEK and Ethyl Acetate; some separation was able to be achieved through either a 4 or 5 column distillation process. This separation is for a homogeneous waste stream. This author is not aware of such a waste treatment facility within the greater Sydney region, or within Australia for that matter of sufficient scale that could treat all the waste volumes produced. The Quantem waste stream is not homogeneous, in the event that the wastes could be separated they would not be able to be recycled or re-used and their only fate would be incineration or flaring. It is not considered practicable to develop customised waste treatments for the variable waste streams that are generated.

The waste stream can be summarised as follows:

- a) The waste stream is not homogenous
- b) The rate of waste generation is not steady, rather it is sporadic
- c) The mixtures are azeotropic and not readily distilled or treatable using conventional technologies
- d) Separation and filtration methodologies have failed to effectively separate the waste
- e) The liquid waste stream contains water and hydrocarbons that have some calorific value.
- f) Recycling the hydrocarbon wastes is not considered practicable as the end of line fate is incineration/thermal oxidation

3.4 Current Management Approach

There is a business cost associated with waste management and disposal, Quantem have progressively worked to minimise both the cost and volumes of waste generated at its facilities over the past decades. A recent internal review of the Site A wastes has been undertaken (Appendix B), which provides more technical detail around some of processes. The current management approach broadly follows acceptable good practice, the hierarchical approach is summarised below.

3.4.1 Avoid and Reduce

The site data in Table 1 shows that through avoidance and reduction practices waste generation has been reduced to a very low level (<0.2%) of the total volume throughput for both sites. This has been achieved through careful and consistent operational and management processes on the site. Predominantly these measures target the quantity of waste generated from cleaning activities, and include the following minimisation procedures:

- Segregation of products to distinct transfer pipelines, ie. separation of food grade and chemical products;
- Where possible, product changeovers are minimised through site scheduling operations.
- Use of a cleaning compatibility matrix, strictly adhering to guidelines for acceptable levels of cross-contamination, to minimise the flushing volume
- Product line and tank scheduling to minimise changeovers
- Operation of pigging systems to clean lines in lieu of flushing
- Utilising tanks with sloped bases and sumps to minimise residuals

The current processes already avoid or reduce waste whilst still maintaining product quality and plant integrity. No further practicable options have been identified.

3.4.2 Re-use

Waste from the site does not meet the requirement for chemical and physical homogeneity of the waste described in the *NSW Eligible Waste Fuels Guidelines*. The chemical composition and fractions within the waste streams, particularly from the chemicals business, can vary significantly depending on operations and activities at the site during a given time period. It can range from pure vapour (VOC's) to predominantly water. Complicating the process is the range of water-soluble waste streams from the storage of alcohols and the solubility of the cleaning agents. No immediate re-use options have been identified.

These streams would require the development of multiple bespoke methodologies employing a range of technologies; eg: oily water separation, vacuum distillation, membrane filtration and condensation. The site does not currently have processing equipment to undertake these processes; any operation would need to be run on an almost batch-by-batch approach.

Given the low volume, relatively low value of the end use products to be extracted from the waste generated, and its varied nature, it is not considered practicable to re-use waste.

3.4.3 Recycle

The heavy oil/tallow/long chain hydrocarbon waste stream has been identified as having a recycling/re-use option and this is separated and disposed of via oil recyclers. No recycling option has been identified for the mixed composition liquid waste stream. Quantem is an 'end of line' storage facility and import terminal. Return of wastes to their origin (eg overseas) is not considered practicable because the wastes cannot readily be recycled into the original processes and the low volume of materials generated. As detailed above the azeotropic nature of the aqueous waste phase cannot be practicably recycled.

3.4.4 Recover Energy

The liquid waste stream contains organics and the proposal involves thermal oxidation that will generate heat. No readily obtainable homogenous waste mix is able to be reliably provided as an input to the oxidiser making heat recovery options more difficult to identify. In addition to this, a review of operational heating demands was unable to identify a corresponding beneficial use that aligned with potential recovery.

Installation of heat recovery functionality would require significant additional capital expenditure with no identifiable benefit; hence, at this time it is not considered as a practicable waste reduction measure. The oxidiser will be designed and constructed in a such a manner that if a beneficial use is identified in the future a heat recovery system can be added.

Heat recovery while the oxidiser was operating in stand-by mode was also considered. Approximately 230 kW of recoverable heat was estimated from the stack when on stand-by. However, the heat is recovered at the thermal oxidiser at Site A, and there is no matching heat demand in the vicinity.

3.4.5 *Treatment and Disposal*

Having exhausted higher order methods in the methods in the waste management hierarchy, the final options are treatment and or disposal. Currently the vapour stream of VOC's from the site is treated by thermal oxidation to produce carbon dioxide and water, while the liquid waste is disposed of by a licenced contractor (in this current case – Cleanaway).

This proposal eliminates the current disposal route (lowest level of waste hierarchy) and implements an on site treatment process that will eliminate the final disposal and treatment steps.

Disposal to air will be increased locally, but the overall impact, from a national perspective, will be reduced. This is further detailed in Sections 3.3 and 3.5.

3.4.6 *Cleanaway's Liquid Waste Disposal Pathway*

Detailed information from Cleanaway as to their processes is not readily available (proprietary information), however the following has been determined from discussions with various personnel within, and closely associated with, the organisation. After collection from Quantem by truck, Cleanaway undertake the following steps at their Homebush facility.

1. Solids removal, by gravity settlement, skimming, or course filtration. This step has minimal energy input. Solids are disposed to landfill, and liquid proceeds to step 2.
2. Hydrocarbon separation, by gravity settlement (Note this does not remove the water-soluble components, such as Ethanol/MEK/Acetone.) This step involves minimal energy input. The remaining liquid waste is sent to step 3, and hydrocarbons are sent to step 4.
3. The water phase is treated biologically, and eventually disposed of into Sydney Water sewer once it meets their acceptance standards. This step involves minimal energy input. Methane which is generated during this step is not captured and is released to atmosphere. Sludge is disposed to landfill.
4. The hydrocarbon phase is sent to a site that mixes, and blends the wastes (Geocycle) cement kiln in either Victoria or Queensland by truck, where it is combusted for useful heat.

Cleanaway have indicated that they also can ship the waste (essentially untreated) directly to a cement kiln in either Victoria or Gladstone (Qld).

In summary, the site minimises waste generation; where waste is generated some recycling outcomes for heavier oils have been identified and are followed. Gaseous vapours (VOC's) are treated on site and a liquid waste stream is disposed of from the facility where a third party treats the liquid waste stream with a mix of biological treatment and thermal oxidation at remote cement kilns that results in fugitive emissions from the biological treatment processes as well as disposal of wastes at very low but acceptable levels to the municipal sewerage system.

Quantem have no control over the treatment mechanism once the wastes are transported off site. The final environmental impacts of the waste disposal by a third party cannot be managed and will vary dependent upon the treatment and disposal mechanisms.

3.5 Proposed Management

It is proposed to remove the off-site disposal process from the current management plan and to implement a process where all wastes are treated on site with essentially complete oxidation to form carbon dioxide and water (CO₂ and H₂O). This will be achieved by installing a new thermal oxidiser (designed and installed to meet the requirements for a *category 6* thermal oxidiser) that will treat both the existing gaseous waste stream and the liquid waste stream. This will provide a significantly better destruction performance compared to Quantem's combustor at Coode Island.

Quantem have been operating a combustor at their West Melbourne site since 2002, undertaking thermal oxidation of VOC vapour streams. From late 2007 onwards, they commenced thermal oxidation of the liquid waste stream from their site in addition to the vapour stream. Operational data from the West Melbourne site pre-2008 and post-2008 demonstrates no deleterious impacts from the introduction of the liquid waste stream. The latest testing results from 3rd February 2020 show a destruction efficiency of 99.99% for VOC's.

The liquid waste stream at the West Melbourne site has comparable chemical composition to the liquid waste stream proposed for thermal oxidation at the Port Botany site.

3.6 Benchmarking

The European Union Joint Research Centre has published an extensive series of briefing manuals and guides associated with waste management that arises from chemical manufacturing and storage. The JRC has also published details of techniques for waste treatment and thermal oxidation (waste incineration).

3.6.1 Best available Techniques.

While the best available technique documents examine a number of industries and manufacturing types, there is no direct guide that specifically addresses or examines storage terminal operations. The guides generally review municipal treatment facilities that accept a wide range of waste streams or specific end of pipe solutions for sites with homogenous waste streams. On site, 'end of pipe' solutions for mixed aqueous/hydrocarbon wastes are not examined. There is general guidance that favours onsite end of pipe management and this proposal meets that requirement.

(Thomas Brinkmann, 2016) *Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector* is probably the most relevant of the JRC guides; however, there is a general presumption in this and related documents that water emissions will end up in a waterbody release. On the basis of the final waste emission and removal of an emission to water bodies, this treatment technique would meet or exceed current best practice outcomes.

(Thomas Brinkmann, 2016)(p 405) detail waste treatment methods and note that thermal oxidation is a suitable technique for the disposal of VOC wastes from:

- the storing and loading/unloading of volatile organic liquids;
- vessel cleaning (rail tank cars, road tankers, and barges);

A review focused on wastewater treatment from pharmaceutical industries is presented by (Toth A. J., 2011). Figure 5 (reproduced from Toth 2011) summarises treatment techniques.

By way of example; following the decision tree presented in this paper, there are **no** halogens in the waste stream (AOX <8ppm), the waste has a VOC-COD greater than 1,000 mg/L (**yes**). The mixture is

azeotropic and thus cannot be simply distilled (*ibid*) and is not recyclable; this leads to 'incineration' or thermal oxidation as a treatment.

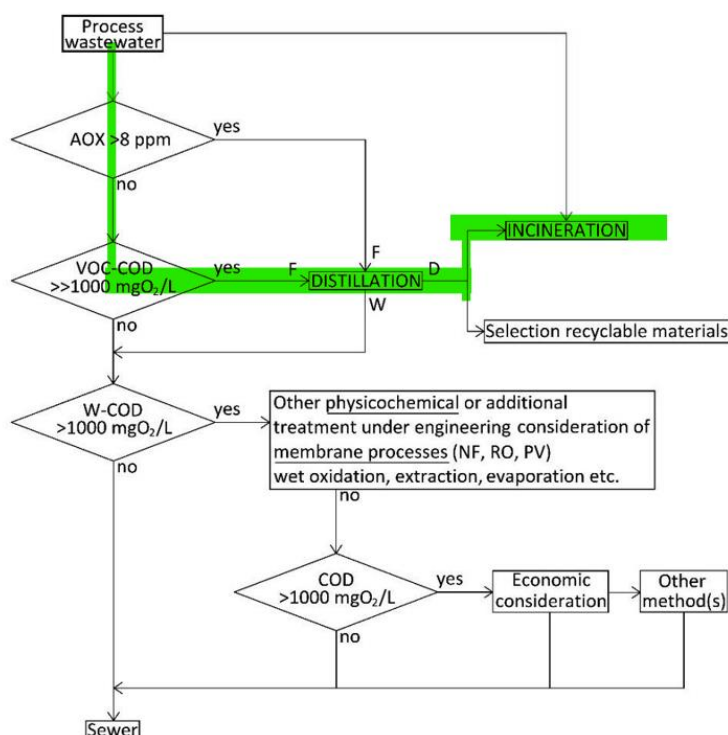


Figure 5: Treatment Methodologies adapted from Toth (2011)

With regard to the thermal oxidation process, CEC reviewed available technologies and have recommended this process in favour of other destruction methodologies, including Regenerative Thermal Oxidation, Catalytic Oxidation and Recuperative Thermal Oxidation. They have specified a system that will thermally oxidise the waste at a temperature in excess of 980 °C for a residence time of greater than 2 seconds; they have factored in the need for the aqueous phase destruction as a part of their design; noting that thermal oxidisers that treat aqueous phase waste streams have been installed in facilities such as Queensland Alumina, APA Group, Leigh Creek Energy and Northern Oil Refinery.

3.7 Comparative Assessment

In order to compare the merits of the proposed process in comparison to the existing management approach, a preliminary review of the environmental impacts for each step has been undertaken. It is noted that Quantem have no control over the disposal pathway once the waste material has been transferred to Cleanaway. In order to undertake a comparative assessment, two waste disposal scenarios for Cleanaway are posited; *Scenario 1* involves the disposal and treatment route that Cleanaway's have previously advised was undertaken involving local treatment, separation, biological treatment and disposal of flammable fractions at a cement kiln. Table 4 details the impacts from Scenario 1 (the historical treatment process). *Scenario 2* assumes that the wastes are transferred and treated directly at a cement kiln interstate. Cleanaway have advised that this disposal route is feasible and has been used in recent times when local facilities are not able to process waste. The environmental impacts from Scenario 2 are shown in Table 5. The major difference with complete kiln treatment is that there is no generation of methane as a by product of biological treatment processes and no final discharge to municipal sewerage systems.

The impacts from the proposed treatment for all waste generated and consumed by thermal oxidation are detailed in Table 6.

Quantem have a legislative requirement to upgrade the pollution control equipment on site to have category 6 performance outcomes because they emit a priority organic pollutant (benzene) as a part of ancillary operations. Regardless of the waste management outcomes this upgrade to a higher performance unit is required and mandated. The higher order of destruction efficiency required will have the unintended consequence that additional gas and standby gas will be required. The comparative negative impacts (increased CO₂ emissions) are excluded from the comparative assessment as the additional gas consumption and associated increase in overall emissions will be required regardless of the location for waste disposal; benzene disposal and treatment is incidental to this argument.

Table 4: Environmental Impacts - Current Process – (Scenario 1)

Process/Step	Aspect	Impacts
Waste Generation	Air	Minor localised fugitive VOC and odour (eg styrene)
	Water	Nil
	Noise	Negligible – noise emissions from pumps/transfers
	Land	Nil
	Resources	Negligible
Waste Storage	Air	Minor fugitive VOC emissions
	Water	Nil
	Noise	Nil
	Land	Nil
	Resources	Negligible (fixed infrastructure)
Waste Transport Off Site	Air	Vehicle Emissions (Diesel combustion engine) – diffuse over the road network/route Fugitive VOC releases on transfers (loading and unloading)
	Water	Minor runoff from roads/transit routes.
	Noise	Vehicle noise – local road corridors
	Land	Nil
	Resources	Fossil fuel, fixed infrastructure
Waste Treatment (Physical)	Air	Minor fugitive VOC emissions
	Water	Nil (no emissions at this stage)
	Noise	Negligible
	Land	Nil (no emissions at this stage)
	Resources	Negligible (fixed infrastructure)
Waste Treatment (Biological)	Air	Minor fugitive VOC emissions Methane (CH ₄) biological treatment by product (greenhouse gas)
	Water	Low level pollutants released urban wastewater systems
	Noise	Negligible
	Land	Sludges/solids from biological processes
	Resources	Negligible (fixed infrastructure), water
Waste Treatment (Physical) Transfer to intermediate plant for waste homogenisation prior to transport to cement kiln for thermal oxidation.	Air	Vehicle Emissions (Diesel combustion engine) – diffuse over the road network/route Fugitive VOC releases on transfers (loading and unloading) and for homogenisation processes Combustion Gases – CO ₂ + H ₂ O
	Water	Minor contaminant runoff from roads/transit routes.
	Noise	Vehicle noise – local road corridors Processing noise – localised to plant
	Land	Ashes/solid burner wastes (eg fly ash)
	Resources	Fossil fuel, fixed infrastructure (existing)

Table 5: 100% Waste Treatment at Interstate Cement Kiln (Scenario 2)

Process/Step	Aspect	Impacts
Waste Generation	Air	Minor localised fugitive VOC and odour (eg styrene)
	Water	Nil
	Noise	Negligible – noise emissions from pumps/transfers
	Land	Nil
	Resources	Negligible
Waste Storage	Air	Minor fugitive VOC emissions
	Water	Nil
	Noise	Nil
	Land	Nil
	Resources	Negligible (fixed infrastructure)
Waste Transport Off Site	Air	Vehicle Emissions (Diesel combustion engine) – diffuse over the road network/route Fugitive VOC releases on transfers (loading and unloading)
	Water	Minor runoff from roads/transit routes.
	Noise	Vehicle noise – local road corridors
	Land	Nil
	Resources	Fossil fuel, fixed infrastructure
Waste Treatment (Physical)	Air	Minor fugitive VOC emissions
	Water	Nil (no emissions at this stage)
	Noise	Negligible
	Land	Nil (no emissions at this stage)
	Resources	Negligible (fixed infrastructure)
Waste Treatment (Physical) Transfer to intermediate plant for waste homogenisation prior to transport to cement kiln for thermal oxidation.	Air	Vehicle Emissions (Diesel combustion engine) – diffuse over the road network/route Fugitive VOC releases on transfers (loading and unloading) and for homogenisation processes Combustion Gases – CO ₂ + H ₂ O
	Water	Minor contaminant runoff from roads/transit routes.
	Noise	Vehicle noise – local road corridors Processing noise – localised to plant
	Land	Ashes/solid burner wastes (eg fly ash)
	Resources	Fossil fuel, fixed infrastructure (existing)

Table 6: Environmental Impacts - Proposed Process – On-Site Thermal Oxidation

Process/Step	Aspect	Impacts
Waste Generation	Air	Minor localised fugitive VOC and odour (eg styrene)
	Water	Nil
	Noise	Negligible – noise emissions from pumps/transfers
	Land	Nil
	Resources	Negligible (fixed infrastructure)
Waste Storage	Air	Minor fugitive VOC emissions
	Water	Nil
	Noise	Nil
	Land	Nil
	Resources	Negligible (fixed infrastructure)
Waste Pre Treatment (Physical) Filtration &	Air	Minor fugitive VOC emissions
	Water	Nil (no emissions at this stage)
	Noise	Negligible
	Land	Minor solids/separation/settlement
	Resources	Negligible (fixed infrastructure)
Waste Treatment (Physical) Onsite thermal oxidation.	Air	Combustion Gases – CO ₂ + H ₂ O
	Water	Nil
	Noise	Processing noise – localised to plant
	Land	solid burner wastes (ash)
	Resources	Fossil fuel (standby gas firing), fixed infrastructure (new)

In comparing the existing process with the proposed system, the following commentary can be made. The proposed process is simpler, involves fewer handling and transfer steps, this will lead to a reduction in VOC emissions as the potential for fugitive VOC emission release is reduced. Fewer resources and less physical infrastructure is required for the proposed process. Resource savings in the form of a reduction in fossil fuel consumed for transport are identified. There will be minor reductions in noise and the elimination of low level contaminants from roadway pollution (tyre wear/brake wear/minor oil & grease leaks). There will be an overall reduction in risk associated with loss of containment events, with the majority of handling and transfer steps eliminated (higher order control).

There are a number of environmental improvements that treating the waste on-site presents. The quantification of these minor improvements (eg noise, infrastructure requirements) would be very difficult, however it is clear that the proposed process is simpler, cleaner and more controllable for Quantem with reduced risk and fewer overall environmental impacts.

Environmental impacts to air through changes in the volumes and intensity of the greenhouse gases emitted from both treatment and disposal options are probably the most quantifiable change. A greenhouse gas emission comparison is presented below.

The discussion is prefaced with the fact that there are many assumptions made in such a comparison and that the information is provided as an example of how changing the treatment approach could reduce environmental impacts. As well as the environmental benefits previously detailed, there are significant reductions in operational risk that on their own standing would justify the proposal even without quantifiable reductions in greenhouse gas emissions.

3.8 Greenhouse Gas Comparison

In order to provide a benchmark for greenhouse gas emissions, the CO₂-equivalent method was used, with guidance from the *National Greenhouse Accounts Factors – October 2020*; any formulae referenced are from this document, in addition to any content factors, adjustment factors, or similar. The use of the CO₂ equivalent method provides a weighting for emissions such as methane (CH₄) (generated by the biological treatment) that has a significantly greater greenhouse gas potential than CO₂ (~28 times).

The following is a comparative assessment between the current management methods and the proposed treatment.

3.8.1 Greenhouse Gas Impacts - Scenario 1

Total annual quantity of liquid waste is ~ 1,000 tonnes, which is estimated to have an average makeup of 30% aqueous phase and 70% oily/hydrocarbon phase. Of the hydrocarbons, 15% is estimated to be water soluble (alcohol/MEK/acetone or similar), and a further 10% would be drawn off as part of the gravity separation process. It is assumed for the current process that the total mass being treated in the biological step is ~475 tonnes per year of contaminated water which is heavily soiled with soluble and emulsified flammables. The remaining ~ 525 tonnes per year is transported to Gladstone for destruction in a cement kiln, generating useful heat in that process.

Table 7 (below) compares the emissions associated with each stage of the existing and proposed operations.

Table 7 - Summary of Emissions by Pathway

Step	Existing Processes	Proposed Process
Truck to Homebush	Transport Emissions	Nil
Gravity Separation	Minor	Nil
Biological Treatment	CH ₄ Release + Landfill	Nil
Truck to Gladstone	Transport Emissions	Nil
Combust for Useful Heat (Gladstone Kiln)	Air Emissions ¹	Air Emissions (from alt-fuel burned) ¹ Scope 3 Emissions (from alt-fuel sourced) ²
Additional Fuel to Facilitate Combustion (Gladstone Kiln)	Air Emissions ³ Scope 3 emissions ³	Nil
Combust on Site (Port Botany)	Nil	Air Emissions
Additional Fuel to Facilitate Combustion (Port Botany)	Nil	Air Emissions ³ Scope 3 emissions ³
Additional Fuel to Maintain Idle Flame (Port Botany)	Nil	Air Emissions ⁴ Scope 3 emissions ⁵
Additional Fuel to Vaporise Water Phase (Port Botany)	Nil	Air Emissions Scope 3 emissions ⁵

Notes:

1. As the Gladstone facility is one which burns a wide range of fuels, including wastes, in its ovens, it is impossible to know what the alternate fuel would be. As such, the emissions are assumed to be equivalent to those from Quantem's waste stream, and thus excluded.
2. Scope 3 Emissions were calculated as if new coal were used, as an example only. It is unlikely to be greater than this likely less.
3. Depending on detailed design, it is likely that both facilities' consumption will be equivalent, and thus excluded.
4. As the site is currently operating a burner for their vapour waste stream, it is likely that idle energy consumption will be at least equivalent to the status quo, and potentially reduced via increased utilisation. No benefit has been claimed.
5. The air emission formulae for this section include Scope 3 emissions.

In addition to the CO₂-equivalent method, air emissions of benzene and sulphur dioxide were considered, in relation to their mention in 1033.1 – *Air Quality Impact Assessment Report Rev 1* by PJR and Associates. Emissions from the combustion of the waste are likely to be broadly equivalent or reduced if the proposed thermal oxidiser is installed.

3.8.2 Transport Emissions – Scenario 1

The following assumptions were made in relation to the transport emissions:

- Vehicle is a B-double, maximum capacity is 48 tonnes
- Full load efficiency averages 80%
- Return trip efficiency averages 50%
- Fuel consumption averages 65 L/100 km
- The following formula was used: (*National Greenhouse Accounts Factors – October 2020* s2.2 – p15)

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

E_{ij} is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO₂-e tonnes).

Q_i is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

EC_i is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4.

If Q_i is measured in gigajoules, then EC_i is 1.

EF_{ijoxec} is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO₂-e per gigajoule) used for transport energy purposes — see Table 4.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

E_{ij} is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO₂-e tonnes).

Q_i is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

EC_i is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4.

If Q_i is measured in gigajoules, then EC_i is 1.

EF_{ijoxec} is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO₂-e per gigajoule) used for transport energy purposes — see Table 4.

- On this basis, to dispose of 525 tonnes of waste at 48 tonnes per load is (525/48) = ~ **11 trips (10.9)**
- Each trip is 1,444 km each way (Sydney to Gladstone by way of example) = **31,768 km**
- At 65 litres per 100 km – this corresponds to **20,650** Litres of fuel consumed. (Q_i = **20.650**)
- From 4 of *National Greenhouse Accounts Factors – October 2020* – for a Euro IV heavy vehicle using diesel oil as a fuel we have EC_i = **38.6 GJ/kL**
- From Table 4 of *National Greenhouse Accounts Factors – October 2020* – for a Euro IV heavy vehicle using diesel oil as a fuel we have: EF_{ijoxec} = **69.9 GJ/kL**

Thus,

$$E_{ij} = Q_i \times EC_i \times EF_{ijoxec} / 1000$$

$$E_{ij} = (20.650 \times 38.6 \times 69.9) / 1000$$

$$E_{ij} = \mathbf{55.7 \, t \, CO_{2e}}$$

3.8.3 Biological Treatment Emissions – Scenario 1

Little is known about the details of the biological treatment at the Homebush facility, Cleanaway have responded that the aqueous phase of the wastes are diluted and treated in the biological ponds and that biogas (methane) is not recovered from the ponds. On this basis the following assumptions have been made in order to inform a comparison of methods.

- Methane capture is 0%, as advised by Cleanaway
- 10% of the process is anaerobic – this corresponds to the default value from Table 29 of 0.1 (10%) for the level of anaerobic treatment for Organic Chemicals.
- The chemical oxygen demand (COD) as measured has varied between 22% up to 70%. On the basis of the average of three measured samples (Table 3) the COD is estimated to be 39%
- Sludge take-off is minimal and assumed to be zero.

The following formula from s4.4 of *National Greenhouse Accounts Factors – October 2020* (p 53) was used (entire variable list not shown):

$$CH_{4gen} = \left\{ \left[\left(\sum_{w,i} COD_{w,i} - COD_{sl} - COD_{eff} \right) \times (MCF_{ww} \times EF_{w,ij}) \right] + \left[(COD_{sl} - COD_{trf} - COD_{tro}) \times (MCF_{sl} \times EF_{sl,ij}) \right] \right\} - Y(Q_{total})$$

where:

CH_{4gen} is the annual methane emissions from the on-site treatment of industrial wastewater in tonnes.

$\sum_{w,i}$ is the total **$COD_{w,i}$** of wastewater entering the plant.

$COD_{w,i}$ is the COD in wastewater entering the plant related to the production by the plant of the commodities listed in Table 26 during the year measured in tonnes of COD. Where facility-specific data are available on COD quantities, these should be used. Where these data are not available the following equation together with the default values in Table 26 can be used:

The quantity of waste treated is estimated to be 475 tonnes per annum, with a COD of 39%, this corresponds to 185.3 t of total COD material ($\sum COD_{wi} = 185.3$)

The default MCF_{ww} for organic waste from Table 29 for Organic Chemicals of 0.1 is used and using the Default EF_{wij} value of wastewater of 7.0 (p54) the following estimate is made:

$$CH_{4gen} = 185.3 \times 0.1 \times 7.0 = 129.7 \text{ tonnes}$$

Using the default conversion factor for methane of 28 from Table 46 (p79) we obtain

$$CO_{2e} = 28 \times 129.7 = 3,631 \text{ t}$$

Noting that the COD of the waste water will vary significantly as witnessed by the results provided in Table 3, the actual quantity of CO_{2e} will vary from batch load to batch and from year to year.

3.8.4 Waste Incineration Emissions – Scenario 1

To estimate emission volumes, the waste incineration tables from the *National Greenhouse Accounts Factors – October 2020* were used.

The following assumptions were made in relation to the waste incineration emissions:

- Carbon content factor averages 0.655 (default value for hydrocarbon waste)
- Fossil-origin factor is 0 for solubles and 1 for all other hydrocarbons.

The following formula was used:

4.6 Waste incineration – carbon dioxide emissions

Emissions from the incineration of waste may be estimated according to the following formula.

$$E_i = Q_i \times CC_i \times FCC_i \times OF_i \times 3.664$$

where:

E_i is the emissions of carbon dioxide released from the incineration of waste type (i) by the plant during the year measured in CO₂-e tonnes.

Q_i is the quantity of waste type (i) incinerated by the plant during the year measured in tonnes of wet weight value in accordance with Division 2.3.6.

CC_i is the carbon content of waste type (i) (default is 0.60 for clinical waste).

FCC_i is the proportion of carbon in waste type (i) that is of fossil origin (default 0.4).

OF_i is the oxidation factor for waste type (i) (default 1).

Thus we have: $Q_i = 525$ tonnes, $CC = 0.665$, using the value for petroleum fuels and values of 100% of the fuel being of carbon waste ($FCC = 1$) and a value of 1 for OF_i .

We obtain: for the Existing case

$$E_i = 525 \times 0.655 \times 1 \times 1 \times 3.664 = 1,260 \text{ t}$$

3.9 Scenario 2 – Complete Cement Kiln Destruction

Under this scenario the total volume of waste is increased to 1,000 tonnes, the waste has a lower overall carbon content, the waste is shipped 1,450 km. The same assumptions for scenario 1 transport emissions apply.

3.9.1 Proposed Treatment (Cement Kiln Emissions)

The following assumptions were made in relation to the waste incineration emissions:

- Carbon content factor averages 0.34 (to account for additional water in the waste)
The aqueous phase of the waste will contain dissolved organic materials. No calorific benefit has been claimed for these materials. The same treatment will be made for all combined waste stream allowing for comparison across sites
- Fossil-origin factor is 0 for solubles and 1 for all other hydrocarbons.

We obtain: for scenario 2

$$E_i = 1000 \times 0.344 \times 1 \times 1 \times 3.664 = 1,260 \text{ t}$$

3.9.2 Transport Emissions

To assess these impacts the following assumptions were made in relation to the transport emissions:

- Vehicle is a B-double, maximum capacity is 48 tonnes
- Full load efficiency averages 80%
- Return trip efficiency averages 50%
- Fuel consumption averages 65 L/100 km
- The following formula was used: (*National Greenhouse Accounts Factors – October 2020* s2.2 – p15)

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

E_{ij} is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO₂-e tonnes).

Q_i is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

EC_i is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4.

If Q_i is measured in gigajoules, then EC_i is 1.

EF_{ijoxec} is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO₂-e per gigajoule) used for transport energy purposes — see Table 4.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

E_{ij} is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO₂-e tonnes).

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If Q_i is measured in gigajoules, then EC_i is 1.

EF_{ijoxec} is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO₂-e per gigajoule) used for transport energy purposes — see Table 4.

- On this basis, to dispose of 1,000 tonnes of waste at 48 tonnes per load is (1000/48) = ~ **21 trips (20.83)**
- Each trip is 1,444 km each way (Sydney to Gladstone by way of example) = **60,648 km**
- At 65 litres per 100km – this corresponds to **39,421 Litres of fuel consumed. ($Q_i = 39.421$)**
- From 4 of *National Greenhouse Accounts Factors – October 2020* – for a Euro IV heavy vehicle using diesel oil as a fuel we have **$EC_i = 38.6$ GJ/kL**
- From Table 4 of *National Greenhouse Accounts Factors – October 2020* – for a Euro IV heavy vehicle using diesel oil as a fuel we have: **$EF_{ijoxec} = 69.9$ GJ/kL**

Thus,

$$E_{ij} = Q_i \times EC_i \times EF_{ijoxec} / 1000$$

$$E_{ij} = (39.421 \times 38.6 \times 69.9) / 1000$$

$$E_{ij} = \mathbf{106.4 \text{ t CO}_{2e}}$$

3.10 Proposed Treatment (Thermal Oxidation – Port Botany)

Of note, by treating the waste the location where it is generated, there will be a reduction in transport related emissions.

For the proposed thermal oxidiser, the fuel content is assumed to identical to the mix in scenario 1:

$$E_i = 1,000 \times 0.343 \times 1 \times 1 \times 3.664 = \mathbf{1,260 \text{ t}}$$

3.10.1 Scope 3 Emissions Change

To compensate for the loss of fuel from the cement kiln, an additional amount of fuel will be required to be consumed in the kiln when the waste is consumed at Port Botany.

The average heat content of the fuel to be burned has been estimated to 43.0 MJ/kg (modelled on the liquid having a typical solvent energy content for aromatic hydrocarbons (34.4²) with a density of 0.8 (34.4/0.8), resulting in 22,575 GJ of usable heat to be accounted for.

The following assumptions were made in relation to the scope 3 emissions:

- The alternative fuel used is sub-bituminous coal, this a coal grade typically used for electricity generation – emission factor 2.5

The following table was used:

Table 40: Scope 3 emission factors – solid fuels including certain coal based products

Solid Fuels combusted	EF for scope 3
	kg CO ₂ -e/GJ
Bituminous coal	3.0
Sub-bituminous coal	2.5
Brown coal	0.4
Coking coal	6.4
Coal briquettes	NE
Coal coke	NE
Solid fossil fuels other than those mentioned above	NE

Using this factor, an additional amount of coal to compensate for the heat from the waste is required. Back calculating this results in an additional 56 t CO_{2e} released from the kiln operations.

3.11 Results Summary

Table 7 below shows a comparison of the CO₂ equivalent emissions (CO_{2e}) for both the existing disposal pathway and the proposed pathway.

Table 8: Summary of CO_{2e} Emissions

Step	Scenario 1 Baseline CO _{2e} – t	Scenario 2 100% kiln CO _{2e} – t	Proposed CO _{2e} - t
Truck to Homebush	3		0
Biological Treatment	3,631		0
Truck to Gladstone	56	100	0
Incinerate for Useful Heat (Gladstone Kiln)	1,260	1,260	56
Incinerate on Site (Port Botany)	0		1,260
TOTAL	4,950	1,360	1,316

All values represent tonnes per year of CO₂-equivalents. As the above table shows, thermal destruction of the liquid waste either on site or at an interstate kiln carries a significantly lower environmental impact than current practices, due mainly to the biological release of methane to atmosphere which is eliminated. The primary influence on the comparative performance of the methods are the COD of waste stream and the distance to transport the waste. As the COD of the waste stream rises the methane release from biological treatment will be greater.

The 'scenario 2' option where waste is shipped (untreated) to a cement kiln is close to parity with the proposed on site treatment option. It is noted that there are many assumptions made in order to make a quantitative comparison and a variation in these assumptions could alter the final assessment.

² From Table 3, National Greenhouse Accounts Factors 2020

Notwithstanding this, the ancillary benefits and risk reduction of handling the waste on site provide compelling benefits for the proposed thermal oxidiser. When considering impending technology changes associated with the general decarbonisation of operations, the alternative disposal route of a thermal oxidation in calcining cement kilns may not be available.

Finally, it is worthwhile considering the potential calorific value of the waste stream as a part of any discussion. Feedback from the oxidiser designers on the waste stream as a fuel is that:

“ At the flammable content/ mixture rates of (~20%+) no additional gas consumption in the oxidiser would be required’ to combust the liquid waste and “thus the waste stream can be assumed to contributing to useful combustion and would also partially off-set an amount of gas that would otherwise be consumed in a standby mode “

The benefits of the calorific value of the fuel have largely been excluded from comparisons as the benefit will be available to whomever uses the fuel; it is worth noting that the typical concentrations of water in the waste stream do not always require addition fuel to water vaporisation. The calorific value of the waste adds further argument to support combustion as a sensible treatment route as opposed to biological treatment.

4 Discussion & Conclusion

Quantem propose to install a second thermal oxidiser adjacent to the existing unit at their site at Port Botany. The new thermal oxidiser will be capable of treating both vapour and liquid waste streams that are generated during operations at Site A – the chemicals business, and Site C – the fuel terminal.

The operation of a second thermal oxidiser will increase treatment capacity, enable Quantem to treat liquid waste on site, and remove the need for transport to a third-party waste disposal site. The increased capacity will provide a level of redundancy in the waste management system to increase reliability and improve system performance. Thermal treatment of the liquid waste stream on site will effectively minimise disposal of any wastes associated with the management of the flammable liquid waste stream to landfill or Sydney water.

The current waste disposal process involves off-site treatment through a number of steps, including destruction of a portion of the waste in a cement kiln. This has some beneficial heat recovery in the calcining process, by displacement of another fuel. There is no additional, secondary heat recovery, such as exhaust steam generation, or similar, in the proposed solution.

Thermal oxidation of the liquid waste on site provides the following benefits over the current disposal methodology:

- a) It eliminates all road transport emissions, including noise and vehicle emissions associated with the management of the flammable liquid waste stream
- b) It will provide broadly equivalent waste destruction of the insoluble flammables in comparison to offsite fuel burning such as kilns, in equipment which meets or exceeds the relevant standards
- c) It will provide redundancy in the site's waste management system and greater guarantees around waste disposal, reduced impacts on operations
- d) It will provide a reduction in transport related greenhouse gas impacts when compared to the current operations.
- e) It manages wastes at the point of generation
- f) It reduces overall environmental risk

A review of the proposed technique for waste disposal against accepted best available techniques was undertaken. While the concept of thermally oxidising an aqueous waste stream may seem counterintuitive, the best available alternate treatments involve transport off-site, dilution and biological treatments that will generate methane, a more potent greenhouse gas than the combustion products that are released as part of thermal oxidation. While there is no definitive guidance on the best treatment techniques for azeotropic aqueous/hydrocarbon waste mixtures, thermal oxidation is acknowledged as a treatment and based on the work of (Toth A. J., 2011) it is suitable for wastes with high COD, as is the situation in this instance.

Quantem have in excess of 10 years of operational data and optimisation experience from a similar thermal oxidiser in use at the Coode Island facility where VOC destruction efficiency has been demonstrated to be greater than 99.99%. A review of alternative methods for waste destruction was undertaken by CEC Engineers that re-affirms thermal oxidation as the preferred destruction method.

Premised on the fact that an upgrade to a category 6 emission control device is required regardless of the waste treatment routes; the comparison to the existing waste disposal methods and scenarios reveals that the proposed thermal oxidiser is no worse than existing disposal methods (and is most likely significantly better than some existing methods) and has many ancillary benefits including a reduction in overall environmental risk and secondary environmental impacts associated with vehicle movements.

5 Bibliography

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APPENDIX A

GASCO THERMAL OXIDISER SPECIFICATION



Appendix B

Quantem Site A Waste Minimisation Plan



Quantem Port Botany Site A and C

Waste Management and Heat Recovery Report

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Executive Summary

This report provides overview and analysis of how Quantem generates liquid flammable waste and initiatives undertaken to minimise waste at Quantem's Site A and Site C Terminal's Friendship Road, Port Botany. The report should be read in conjunction with the Waste Management Impact Assessment (WMIA) report for the disposal of waste from the Quantem Terminal Sites A and C Friendship Road, Port Botany.

The body of the report reviews areas of operations and describes improvements that have been made over the last 5 years to reduce waste. Quantem's improvements have reduced waste considerably by ~25% to reduce impact to the environment and resultant waste disposal costs. The waste generated on site has been reduced from ~1,300kl to ~1000kl per annum and Quantem consider the current generation of waste is minimised as far as practicable and concluded:

- Further separation of product to recycle is not feasible due to various miscible products
- Filtration to recycle is not feasible
- reuse not viable due to the array of products handled and infrastructure requirements are not possible with the footprint required for the multitude of products

The amount of recoverable energy from the Thermal Oxidiser stack gases are:

- Standby mode at 114kW; and
- Liquid waste burning at 282kW.

Heat recovery uses contemplated:

- Waste heat steam boiler – use of stack heat recovery
- Liquid waste pre-heat – reduce energy to burn waste
- Electricity generation – use of stack heat recovery

In conclusion the report demonstrates that Quantem have applied the Waste Management Hierarchy to exhaust the practicable options to minimise the amount of flammable waste that is disposed prior to applying the thermal oxidiser option. Offsite disposal is unreliable and less environmentally friendly as described in the WMIA. Therefore, the best method environmentally and commercially is to incinerate the liquid waste using the proposed new bespoke Thermal Oxidiser with liquid waste burning capability optimised with the state-of-the-art burner technology.

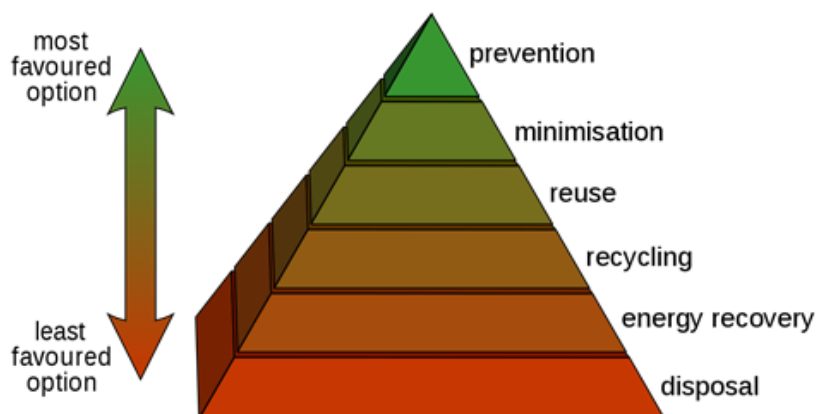
Further, the heat recovery review concludes there is inconsistent energy and lack of viable options to use as the current site has sufficient existing heating for the small number of products that require heat on Site A.

1 Introduction

This report part answers items 1 a) and 2 a) of the EPA letter dated 28/4/2021 in the context of taking reasonable steps to reduce aqueous component of waste and liquid waste management strategy.

A review of waste at Quantem's Port Botany 'Site A' was completed due to the large volume of waste that is produced each year at the site from general storage operations including shipping, truck loading and management of vapours from the storage tanks.

The waste management hierarchy was applied as a basis to review options for waste reduction for best environmental and commercial outcome.



The areas that were chosen to target due to the volumes of waste produced were:

- Vapour Emissions Control System (VECS) which is made up of 2 carbon beds for managing tank and truck loading emissions.
- Dockline cleaning and ship preparation which involves cleaning of universal transfer lines to ensure quality compliance of products loaded and discharged from ships.
- Recycling of oil / petroleum products via segregation of common.
- Rainwater reduction into loading bays (pumped to flammable waste)
- Flammable waste / water separation.

The report provides further information on the liquid waste generation, waste management activities and initiatives taken at Terminal Sites A and C, and supporting waste is minimised through implementation of changes identified.

Considerations of disposal through a new thermal oxidiser is contemplated and the report reviews heat recovery possibilities which are detailed in Appendix A.

The report also contemplates onsite liquid waste burning via the Thermal Oxidiser as the best outcome for the flammable liquid waste disposal and looks at heat recovery opportunities from the Thermal Oxidiser. This is supported by the Waste Management Impact Assessment report by i³ Consulting Pty Ltd.

2 Operations and Waste Management

The following table 1 describes the operational areas on both Sites A and C that generate flammable waste. Potential further initiatives are described in last column.

Waste Stream Origin	Waste Stream classification	Existing Water Mitigation Controls	Potential Further Improvements
Site A loading bay gantry	Flammable	- Bunding - Walls and roof with awnings - Pressure washing of surfaces to reduce water volume whilst managing area - Spill prevention and elimination focus with any spills recorded into SMS and root cause / preventative actions identified and tracked	- Review design to determine additional water mitigation measures - Review frequency of loading gantry pressure washing
Site C loading bay gantry	Flammable	- Bunding - Walls and roof with awning	None expected
Site C tank dewatering	Flammable	- Required for quality control - Documented procedure followed - Minimal volume of water removed	Installation of Geodesic dome roofs will be installed 4Q21 on both external floating roof Tanks 91 and 92. These tanks are the largest on site. This will prevent rainwater from entering the tank and reduce load on waste system. \$1.9m is being spent on this separate project. See Appendix B
VECS (desorbing waste)	Flammable	Optimisation works has been completed to improve the efficiency and reduce waste through the regeneration process	Already optimised
Site A Dockline Cleaning	Combustible - Dilute stream primarily cleaning chemicals, tested to ensure correct waste category	- Procedure in place specifying volume of water required (shots) – discrete amount added - Dockline cleaning matrix has been determined through test work utilising external experts	None expected
Site A Tank Cleaning	Combustible -Dilute chemical content, tested to ensure correct waste category	- Procedure in place specifying time for water addition for each cleaning stage - Tank inspection prior to additional cleaning to ensure need - Engineered water distribution system (Daisic bowl and head washer) to maximise cleaning impact and minimise water addition - Waste is tested to determine whether flammable or combustible	Already optimised

Table 1 – Operational areas and water mitigation controls

3 Waste Reduction Review

Quantem has been working diligently over the past 5 years to reduce waste on its Port Botany Site A to improve the environmental footprint, optimise operations and reduce costs. The review and accompanying changes were able to reduce the waste sent for disposal at Botany Site A from 1,300kl to an annual average of 1000kl (300kl or ~25% total reduction). The following sections 3.1 to 3.5 describe those initiatives.

3.1 VECS Optimisation - Minimisation

Botany Site A uses a Vapour Emissions Control System (VECS) based on 2 carbon beds absorbing flammable vapours to control emissions.

The carbon beds are then regenerated, and the trapped flammable vapours removed using steam to re-condition the beds. This regeneration of the carbon beds produces 300L of flammable waste per bed. The load on the VECS system has increased over time due to increased storage and movement of flammable products and as a result the regeneration frequency increased on average to 4 to 5 times per 24hr period.

An optimisation review of the VECS operations was completed to address this and the flowing areas targeted for improvement:

1. PLC Control System and Sensors – The VECS control system had been in service for 30+ years and only gave limited room for changes in onstream and regeneration cycle time. An upgrade to the PLC control system to a modern Siemens Win CC operating system allowed for the installation of better, more accurate measurement system allowing for finer control and better regeneration capability allowing the carbon beds to increase their absorption capacity.
2. Upgraded Regeneration Heat Exchanger – During the VECS regeneration cycle, the off gas from the heat exchanger (made up of flammable vapour and steam) is passed back through the online bed to ensure there is no emissions to atmosphere that have not been treated. A review of the efficiency of the regeneration heat exchanger found that there was an opportunity to improve the efficiency of the regeneration cycle by changing the design of the heat exchanger, this change allowed for more flammable vapours to be removed during a bed regeneration and therefore reducing the carry-over into the online bed increasing its absorption capacity.
3. Upgrade of Bed Isolation Valves – Higher grade valves were installed between the 2 carbon beds to reduce the possibility of any flammable vapour from passing from one bed to the other either while online or during regeneration. These changes saw a reduction in average bed regeneration to 2 regenerations per 24 hrs and a reduction in annual waste sent for disposal of 140,000L. The waste could be eliminated if all tank and truck loading vapours were diverted to the Site A Thermal Oxidiser rather than to the VECS carbon beds. This would require the Site A Thermal Oxidiser to have capacity.

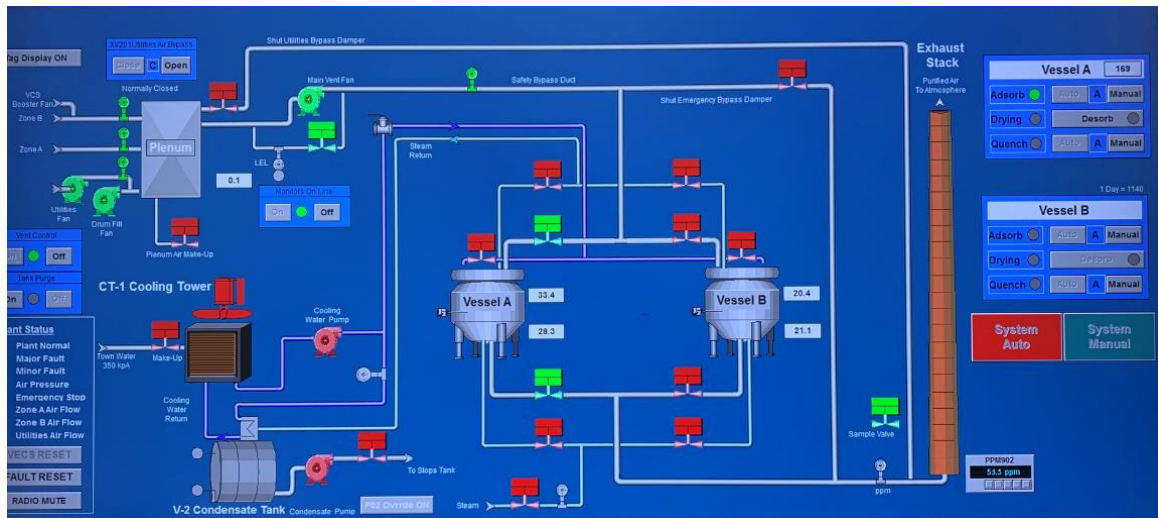


Figure 1 - VECS Schematic

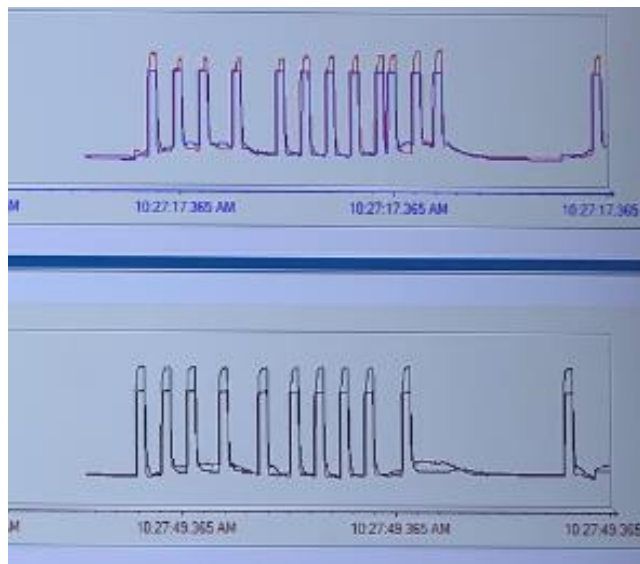


Figure 2 - Example Regeneration Pattern Before Optimisation

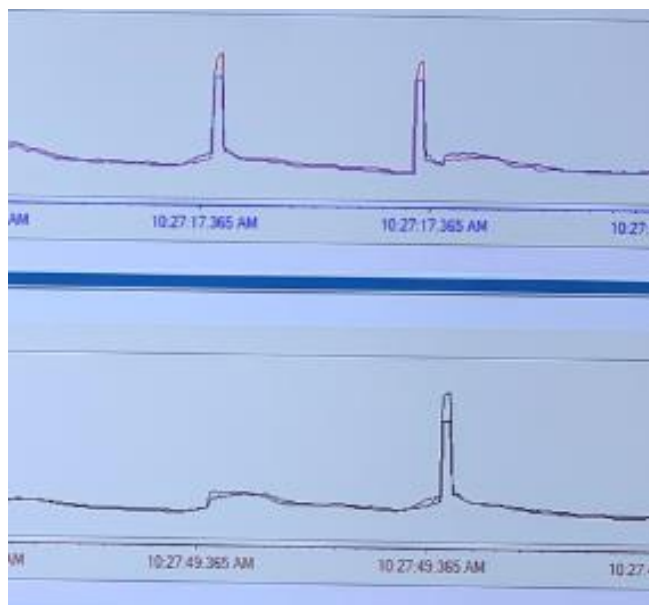


Figure 3 - Example Regeneration Pattern After Optimisation

3.2 Dock Line Cleaning Optimisation - Minimisation

A review was completed of site dockline cleaning and product compatibility to reduce the waste produced when cleaning docklines between products while still maintaining the quality requirements of our customers. Reduction in waste produced was achieved by dedicating one dockline to BTX ship loading as this product is difficult to clean back to a level required to accept other products down the same dockline and would result in a large amount of flammable waste.

Of the 3 remaining docklines, one was dedicated to food grade product, one to base oils and one to general flammable chemicals reducing cleaning requirements due to compatible products.

Finally, a review of the volume of cleaning shots required for each product stored on site and between each of the compatible products was completed by Intertek (product testing and surveying company) and a cleaning matrix produced, this then becomes part of the shipping procedure to ensure the docklines are cleaned to the required level without using excess cleaning shots and producing excess waste.

These changes saw a reduction in annual waste sent for disposal of 50,000L.

PREVIOUS CARGO	NEXT CARGO	ACETONE	ALIMET	API/E CORE 150	API/E CORE 600	API/E CORE 2500	BTX (BENZENE)	BUTYL ACRYLATES, STABILISED	DIMP	EHC110 BASE OIL	EHC90 BASE OIL	ETHANOL 100 HIGH GRADE	ETHANOL 95 HGNA	ETHANOL SINO GRADE	ETRO 4	ETRO 6	FUEL GRADE ETHANOL	HEXENE - 1	ISOHEXANE	JET AVIATION FUEL F44	METHANOL	NYTRO GEMINI X	NYTRO LIBRA	PALATINOL AH
ACETONE		1	9.8.11	2	2	2	N/A	2	2	2	2	2	2	2	2	2	2	2	2	2.11	2	2	2	2
ALIMET		9.3	2.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.5.5	9.5.5	9.5.5	N/A	N/A	9.5.5	9.3	9.3	9.3.5	9.3	N/A	N/A	N/A
API/E CORE 150		3.4	N/A	1	1	1	N/A	6	3	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6	1	1	3
API/E CORE 600		3.5	N/A	1	1	1	N/A	6	3	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	7	1	1	3
API/E CORE 2500		10.4	N/A	10.3	10.3	10.3	N/A	10.3	10.3	10.3	10.3	N/A	N/A	N/A	10.3	10.3	N/A	N/A	N/A	N/A	10.3	10.3	10.3	10.3
BTX (BENZENE)		N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BUTYL ACRYLATES, STABILISED		4	N/A	6.7.1	6.7.1	6.7.1	N/A	1	3.1	6.7.1	6.7.1	N/A	N/A	N/A	6.7.1	6.7.1	N/A	N/A	N/A	N/A	6.1	6.7.1	6.7.1	6.1
DIMP		7.1	N/A	6.1	6.1	6.1	N/A	6.1	1	6.1	6.1	N/A	N/A	N/A	6.1	6.1	N/A	N/A	N/A	N/A	6.4.1	6.4.1	6.4.1	1
EHC110 BASE OIL		6.7.1	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
EHC90 BASE OIL		6.7.2	N/A	1	1	1	N/A	6.4.2	6.2	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.2	1	1	6.2
ETHANOL 100 HIGH GRADE		1	1.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6.4.1	6.4.1	6.4.1.11	1	N/A	N/A	N/A
ETHANOL 95 HGNA		1	1.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6.4.1	6.4.1	6.4.1.11	1	N/A	N/A	N/A
ETHANOL SINO GRADE		1	1.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	N/A	N/A	1	6.4.1	6.4.1	6.4.1.11	1	N/A	N/A	N/A
ETRO 4		6.7.1	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
ETRO 6		6.7.1	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
FUEL GRADE ETHANOL		1	1.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	1	N/A	N/A	1	6.4.1	6.4.1	6.7.11	1	N/A	N/A	N/A
HEXENE - 1		7	8.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.11	7.11	7.11	N/A	N/A	7.11	1	2	6.7.11	6.7	N/A	N/A	N/A
ISOHEXANE		8	8.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.11	7.11	7.11	N/A	N/A	7.11	1	2	6.7.11	6.7	N/A	N/A	N/A
JET AVIATION FUEL F44		6.7	6.8.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.7.11	6.7.11	6.7.11	N/A	N/A	6.7.11	6.7	1.11	6.7	6.7	N/A	N/A	N/A
METHANOL		7	6.8.11	12	12	12	N/A	N/A	12	12	12	6.7.11	6.7.11	6.7.11	12	12	6.7.11	3	3	6.7.11	1	N/A	N/A	N/A
NYTRO GEMINI X		6.4	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
NYTRO LIBRA		6.4	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
PALATINOL AH (DOP)		7.1	N/A	6.1	6.1	6.1	N/A	6.1	1	6.1	6.1	N/A	N/A	N/A	6.1	6.1	N/A	N/A	N/A	N/A	6.4.1	6.4.1	6.4.1	1
REFUELED		10.6.7	10.6.8.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.6.7.11	10.6.7.11	10.6.7.11	N/A	N/A	10.6.7.11	10.6.7	10.6.7	10.6.7.11	10.6.4	N/A	N/A	N/A
POWER OIL TO 1020-60U		6.7.1	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1
PYGAS		N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SODIUM HYDROXIDE		9.9.7	9.8.11	12	12	12	N/A	9.7	9.7	12	12	9.6.11	9.6.11	9.6.11	12	12	9.6.11	9.6	9.6	9.6.7.11	9.6	N/A	N/A	N/A
STYRENE MONOMER		6.7	N/A	6.7	6.7	6.7	N/A	6.7	6.7	6.7	6.7	N/A	N/A	N/A	6.7	6.7	N/A	N/A	N/A	N/A	6.7	6.7	6.7	6.7
SUPER 150N		6.7.1	N/A	1	1	1	N/A	6.4.1	6.1	1	1	N/A	N/A	N/A	1	1	N/A	N/A	N/A	N/A	6.7.1	1	1	6.1

Figure 4 - Dockline Cleaning Matrix

No.	Description
N/A	Not applicable, due to product vs dockline segregation
1	Dry pig only, with received pig NOT dry
2	Dry pig only, until received pig is clean and dry
3	Pig with MEK (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.
4	Pig with Acetone (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.
5	Pig with IPA (200L) followed by dry pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.
6	Pig with MEK (200L) and pig with another MEK (200L) shot. If received pig is not clean, repeat process. Dry pig until received pig is dry.
7	Pig with Acetone (200L) and pig with another Acetone (200L) shot. If received pig is not clean, repeat process. Dry pig until received pig is dry.
8	Pig with IPA (200L) followed by an IPA-soaked pig. If received pig is not clean, repeat process. If received pig is not dry send a second dry pig.
9	Fresh water (1000L) shot
10	Hot water (1000L) shot
11	Dockline conditioning with product
12	UNACCEPTABLE PREVIOUS CARGO (Never)

Figure 5 - Dockline Cleaning Legend

3.3 Recovered Product - Waste Oil Recycling

A review was completed of all products managed on site and in consultation with a waste oil recycling company. The products identified as recyclable were base oil products that could be filtered, cleaned, and recovered for use in other oil-based applications.

A system was established to track any possible products that could be collected for recycling and a slops tank dedicated so that this product would not get contaminated by other waste products.

These products and slops tanks were then managed as part of the shipping operations and when enough volume had been segregated (approx. 20,000L), a waste oil truck is organised to recycle the oil waste. These changes saw a reduction in annual waste sent for disposal of 80,000L.

15F						16B					
EXCHANGER PIT 4											
Date	Ship Name	Product	Quantity	Emptied to	Date Emptied	Date	Ship Name	Product	Quantity	Emptied to	Date Emptied
19/01/2019	Stolt Momiji	EHC110 BASE OIL	700L	WT2	21/01/2019	19/01/2019	Stolt Momiji	EHC110 BASE OIL	700L	WT2	21/01/2019
25/01/2019	Golden Chie	ULTRA S4	600L	Recycle	01/02/2019	19/01/2019	Stolt Momiji	EHC50 BASE OIL	1100L	WT2	21/01/2019
23/02/2019	Stolt Renge	EHC50 BASE OIL	400L	WT3	28/02/2019	23/02/2019	Stolt Renge	DINP	500L	WT3	28/02/2019
22/03/2019	Stolt Hagi	NYTRO LIBRA	550L	Recycle	02/04/2019	03/03/2019	Bow Asia	YUBASE 3	300L	Recycle	02/04/2019
28/03/2019	Stolt Ajisai	EHC50 BASE OIL	600	Recycle	02/04/2019	09/04/2019	Gwen	YUBASE 3	850L	Recycle	30/04/2019
28/03/2019	Stolt Ajisai	EHC110 BASE OIL	400L	Recycle	02/04/2019	24/04/2019	Stolt Yuri	EHC110 BASE OIL	550L	Recycle	30/04/2019
04/04/2019	Golden Leader	aramcoPRIMA 150	550	Recycle	30/04/2019	18/05/2019	Stolt Ajisai	EHC50 BASE OIL	1650L	WT3	
24/04/2019	Stolt Yrui	EHC50 BASE OIL	500L	Recycle	13/05/2019	02/08/2019	Golden Uni	EHC50 BASE OIL	650	Recycle	12/08/2019
18/05/2019	Stolt Ajisai	NYTRO LIBRA	400L	WT3		02/08/2019	Golden Uni	EHC110 BASE OIL	500	Recycle	12/08/2019
21/05/2019	Golden Creation	ULTRA S4	550L	WT3		20/08/2019	Golden Res	aramcoPRIMA 150	600	Recycle	14/10/2019
21/05/2019	Golden Creation	aramcoPRIMA 500	500Lts	WT3		20/09/2019	Stolt Satsuk	NYTRO LIBRA	300L	Recycle	14/10/2019
15/06/2019	Stolt Momiji	DINP	500Lts	WT3		01/10/2019	Stolt Ajisai	EHC50 BASE OIL	500L		19/10/2019
15/06/2019	Stolt Momiji	EHC50 BASE OIL	500Lts	WT3		19/10/2019	Stolt Satsuk	DINP	500Lts		19/10/2019
10/07/2019	Golden Leader	aramcoPRIMA 500	350L	Recycle	12/08/2019	28/10/2019	Golden Res	ULTRA S4	460Lts	Recycle	12/11/2019
10/07/2019	Golden Leader	aramcoPRIMA 150	400L	Recycle	12/08/2019	28/10/2019	Golden Res	aramcoPRIMA 150	600L	Recycle	12/11/2019
8/08/2019	Stolt Ajisai	NYTRO LIBRA	200	Recycle	12/08/2019	15/11/2019	Golden Sky	EHC50 BASE OIL	780	Recycle	30/12/2019
18/08/2019	Stolt Tsubaki	EHC50 BASE OIL	500	Recycle	14/10/2019						
17/09/2019	Golden Aspirant	ULTRA S4	380	Recycle	14/10/2019						
17/09/2019	Golden Aspirant	Prima 150	300	Recycle	14/10/2019						
17/10/2019	Stolt Tsubaki	EHC110 BASE OIL	500	Recycle	12/11/2019						
17/10/2019	Stolt Tsubaki	EHC50 BASE OIL	550	Recycle	12/11/2019						
15/11/2019	Golden Sky	NYTRO LIBRA	300	??	??						
21/12/2019	Stolt Satsuki	Etro 4	500	Recycle	30/12/2019						
21/12/2019	Stolt Satsuki	EHC50 BASE OIL	500	Recycle	30/12/2019						

Figure 6 - Example of Slops Tank Tracking Sheet (Shipping Pack)

3.4 Rainwater to Waste Reduction - Minimisation

A large volume of waste was produced at Botany due to excess rainwater entering the truck loading bays during heavy rain. As the bays are setup to pump any potential spills to flammable waste in the case of an emergency, any rainwater entering the loading bays is automatically pumped to flammable waste.

A review of the loading bays was completed to understand:

- The required bunded area for the largest trailer that enters the site to be within the bund while loading / unloading.
- The impact of rain on each of the bays and the required roof area to reduce this impact.

As a result of the review:

- 2 of the loading bays had the roll over bunds moved in so that the bunded area had more cover from the existing gantry roof.
- 3 of the loading bays had the gantry roof extended so that the bunded area had more cover from the existing gantry roof. See Appendix C for photos

It was also concluded that it was not possible to stop all rain from entering the loading gantries due to the angle and volume of rain during extreme weather events. Any additional extensions of roofing or enclosure creates a risk to operators as it will reduce the flow of air to working areas potentially creating a hazardous environment. These areas need to be appropriately ventilated in accordance with Section 4, AS1940:2017.

These changes saw an estimated reduction in annual waste sent for disposal of at least 50,000L based on an average year's rain fall.

3.5 Flammable Waste / Water Separation – Minimisation (of water waste)

Stephenson Applied Services (SAS) were engaged to review options currently available for separating water from flammable liquids based on the current storage requirements at Botany Site A.

Trial Parameters

The main chemicals chosen for the trial were based on the volume stored on site or if they were used as part of the dockline cleaning / preparation process.

- Ethanol – both stored and used for line cleaning / preparation.
- Methanol – stored in site tanks
- Acetone – both stored and used for line cleaning / preparation.
- MEK - used for line cleaning / preparation.
- IPA - used for line cleaning / preparation.

Trial Process

The trial was setup using filtration through a filtration bag and an activated carbon filter:

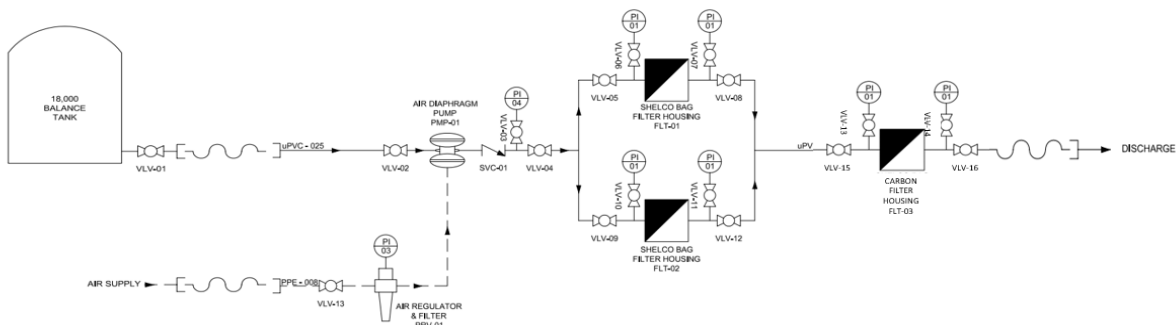


Figure 6 – Filtration Skid

Testing was completed using a sample from Waste Tank one, as well as blended samples of water and solvents. The results of the trial showed:

1. Acetone, ethanol and methanol and water at a 1: 3 ratio as a representative sample of Waste Tank #1 will did not work due to the high miscibility of Acetone in water.
2. The secondary Carbon filter showed a reduction in flammable carry over but still resulted in waste in the flammable range.
3. The principle of absorption by activated carbon in essence will reduce the level of various solvents typically stored in Tank # 1 with water. It is difficult to achieve the flash point results required to not be classed as flammable waste as the solvents exhibits signs that they are readily miscible in water and especially in large volumes in perspective to the ratio of solvent to water phase that exists in the waste tank from time to time.
4. Housekeeping will need to be considered and adhered to if Acetone and Ethanol are the choice of purging solvent. As it will need to be kept as a separate waste stream when considering our trial.
5. Regeneration or disposal of the activated carbon after absorption of the flammable solvents is cost prohibitive (similar to the process required for the current VECS) and is likely to produce more flammable waste in any case.

Type of Samples: Eight water samples from Terminals as listed on pages 1 to 3. Sampled by customer. Analysed 'as received'.

Tests	7. ^s Ethanol 10% in water Raw	8. Ethanol 10% in water via Carbon filter	Methods
Total Organic Carbon mg/L	17,000	1,100	Envirolab: Inorg-079
*Calculated ethanol content from TOC results mg/L	32,583	2,108	Calculated
*Calculated % ethanol content from TOC	3.3	0.21	Calculated
Chemical Oxygen Demand (COD)	62,750	2,040	APHA 5220 B

Note: Units: Measurements in mg/L for water samples except pH.

Samples will be disposed of seven days after issue of this report unless otherwise notified.

< Denotes 'less than'.

Total Organic Carbon analysed by Envirolab, NATA accreditation No. 2901, report No. 70828

[^sSample number 7.Ethanol 10% was dispatched to Envirolab after dilution by LabPoint by 500 times (for safety purpose) and sample 8 was sent as received basis, TOC result reported above for this sample adjusted for dilution by LabPoint and be viewd as result on the undiluted sample.]

*Calculated results not part of the scope of our NATA accreditation

Figure 7 – Wastewater Sample Analysis excerpt

It was concluded from the trials conducted and the test results achieved, that filtration and activated carbon was not an effective method of removing or separating flammable solvents from the wastewater system at Port Botany Site A. This was due to the samples still retaining levels of flammable solvent and the cost and expected waste that will be produced by running this system.

Better separation of the individual cleaning solvent streams (into separate tanks) may have improved the results of this trial allowing for water separation for the compatible products. However, separate tanks and space are not available.

It must also be noted that if products were able to be recovered, sending them back to the supplier is not an option due to most suppliers being overseas and the shipping and handling costs would be prohibitive.

4 Part 2 - Energy recovery from proposed new Thermal Oxidiser

A study was performed to ascertain if any heat recovery was possible from the proposed new Thermal Oxidiser.

The amount of recoverable energy from the Thermal Oxidiser stack gases are:

- Standby mode at 114Kw; and
- Liquid waste burning at 282kW.

Heat recovery uses contemplated:

- Waste heat steam boiler;
- Liquid waste preheat; and
- Electricity generation.

The existing site already has sufficient heat from an existing boiler and the cost of infrastructure for use elsewhere already serviced is uneconomic and unjustified with current demands. Further, the variable nature of the Thermal Oxidiser operation is not viable for electricity generation which requires a steady state to be feasible. The heat recovery review concludes that that due to the inconsistent available energy for recovery and lack of viable options to use the energy no viable option could be justified. Full details are available from the CEC report in Appendix A.

5 Conclusion

Of the 5 options reviewed to achieve reduction in the waste produced at Site A through storage and handling of bulk liquids, all but one achieved some level of waste reduction for the site and the majority resulting in a high level of achievement against the waste management hierarchy.

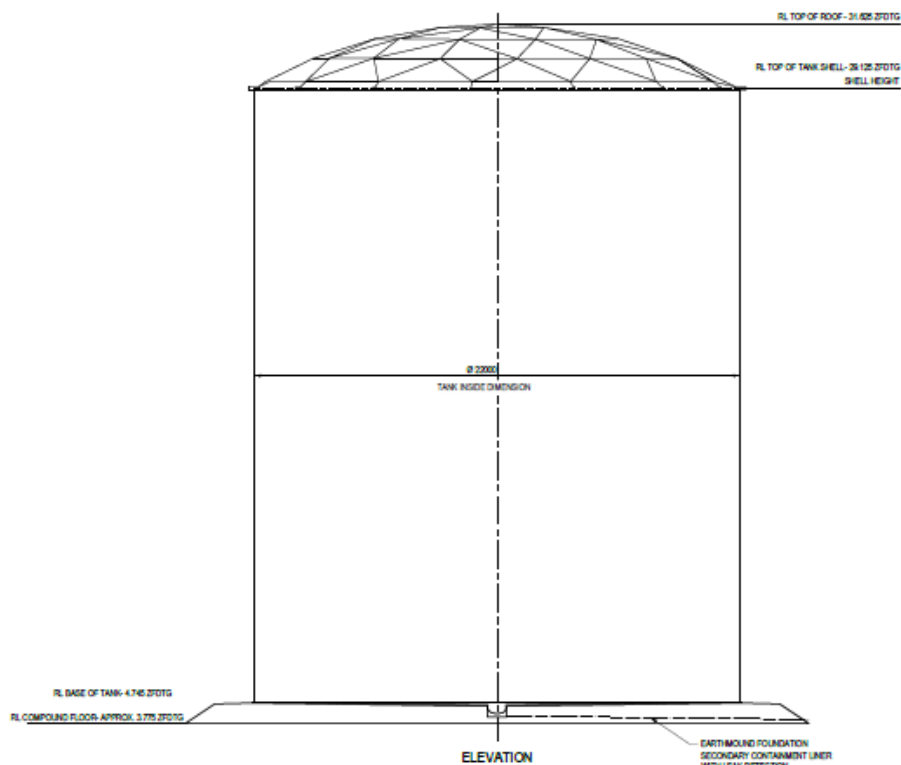
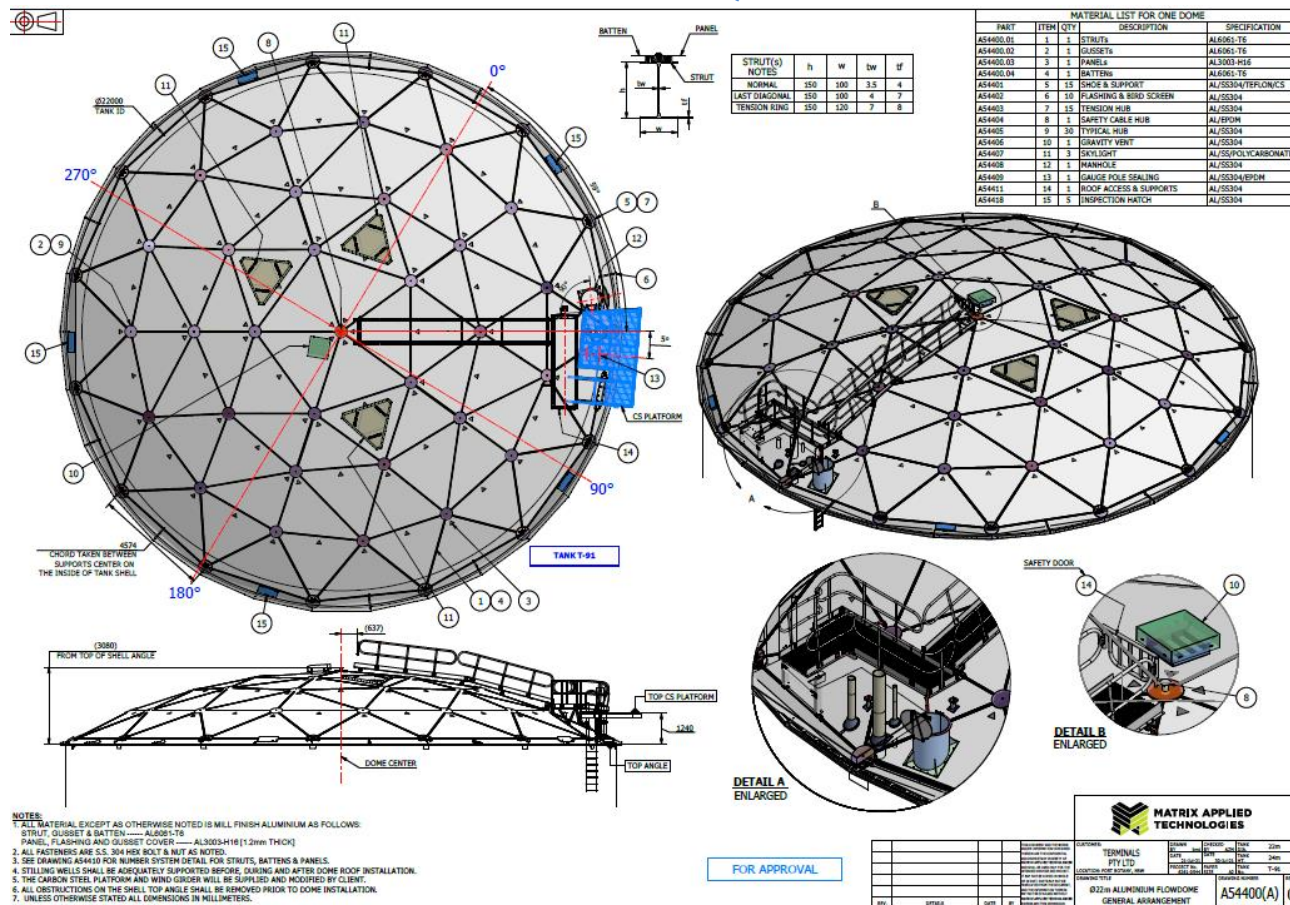
Strategy	Hierarchy Level	Level of Achievement Against Waste Hierarchy	Waste Reduction Achieved	Volume Reduced (L)
VECS Optimisation	Minimisation	High	Yes	140,000
Dockline Cleaning Optimisation	Minimisation	High	Yes	50,000
Waste Oil Recycling	Reuse	Medium	Yes	80,000
Rainwater Waste Reduction	Minimisation	High	Yes	50,000
Flammable Waste / Water Separation	Minimisation	N/A	No	N/A

Although a reduction of ~300kl of waste was achieved, separation of water from the liquid waste collected across the site was not successful due to the miscible nature of some of the stored and dockline cleaning solvents used across the site. A review was completed of alternative cleaning solvents but there was no alternative found that would meet the quality requirements of the products handled.

Therefore, with the above initiatives reviewed, results suggested that offsite disposal was the only method to dispose of the remaining liquid waste that cannot be reduced further/ reused / recycled. That said offsite disposal is unreliable and not possible in NSW anymore and flammable waste is shipped interstate by the waste disposal company for incineration. Quantem considered a more reliable method being onsite disposal of flammable waste by incineration through the current thermal oxidiser if it had the required capability and capacity. However, the current Thermal Oxidiser is not designed for liquid waste burning. Quantem's need for an additional larger vapour Thermal Oxidiser on the Port Botany Site A now presents the opportunity to use the new build Thermal Oxidiser to emulate its liquid waste burning capability in Melbourne. Quantem has run the Thermal Oxidiser successfully for many years which has an approval from the Victorian EPA.

APPENDIX A - 2nd Thermal Oxidiser and Liquid Waste Burning Heat Recovery Report

APPENDIX B – Dome roof additions Site C – Tanks 91 and 92 PC 4Q21



APPENDIX C – Photos of water reduction initiatives



Gantry Bay 2 – rollover kerb to stop rainwater entering. Roof extension also visible at top right



Main hose exchanger pit with roof over and weather protection shown for pumps top right