

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Shaun Judge	Student ID number:	104870
Programme:	HNC Process Operations Engineering		
Module:	Environmental Protection and Sustainable Manufacturing Systems		
Module code:	PCPO4003	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Richard Wray	Internal Verifier:	Lance Rutherford
Assignment Title:	Research Report	Word count (or equivalent):	2000
Submission deadline:	15/05/19	Return date of provisional marks & written feedback:	29/05/19
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)
LO1, LO2.

TASK DESCRIPTION

Investigative report

There are many examples of industrial manufacturing plant, equipment and process that pose a potential risk to the environment and/or where operations may meet or fall short of the requirements for sustainable manufacturing.

For this assignment you are required to analyse a chosen industrial process at your place of work with respect to environmental protection and sustainable manufacturing systems.

Research Guidance

- Fully research the industrial plant, equipment and manufacturing process design and operation
- Evaluate specific aspects associated with meeting environmental protection, legal requirements and best practice
- Evaluate specific aspects associated with ensuring sustainable manufacture can be achieved through efficient equipment, plant and process operation
- Develop conclusions and recommendations on how the process could be improved with respect to environmental protection and manufacturing sustainability

Note: When choosing a work based plant, equipment or process please ensure you have your employers permission to use relevant information in your assignment. Do not include names of personnel or commercially sensitive information.

Research evaluation

You will produce the written report in a clearly structured and professional manner. The report should evaluate the findings of your research and present logical arguments and conclusions. It is expected that you will organize your report following a pattern to that suggested below:

- A brief abstract
- An introductory section outlining the background, the scope and intended readership
- A clear statement of the aim and objectives of the report
- Central sections, explaining any findings, arguments and outcomes
- A suitably structured conclusion that draws together the findings of your research and any recommendations you are making

When writing your report make sure that you:

- Use acceptable academic language and tone
- Check spelling and grammar
- Show that you can evaluate evidence from reference sources and use this material to make a logical and consistent argument
- Make sure that you analyse and evaluate arguments and evidence in a way that meets your stated outcomes and objectives

Report structure

The report document must be constructed in a formal and professional manner using an appropriate word-processed program. The completed report should contain the following sections:

- A cover page or document title page
- A table of contents page
- Sections or paragraph headings related to each aspect of the report
- Headers on each page with the title of your report
- Paragraphs should be spaced using '1.5 line spacing'
- Footers on each page with the author's name on the right hand side and 'Page ... of ...' on the left
- A references page and bibliography as appropriate
- Appendices where appropriate for larger quantities of data
- Diagrams, charts or tables, suitably incorporated and labelled
- The text format should be Times New Roman or Ariel with a font size of 12
- A word count of 2000 words ($\pm 10\%$)

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS

NOTE: The guidance offered below is linked to the five generic assessment criteria overleaf.

1. Engagement with Literature Skills

Your work must be informed and supported by scholarly material that is *relevant* to and *focused* on the task(s) set. You should provide evidence that you have accessed an appropriate *range* of sources, which may be academic, governmental and industrial; these sources may include academic journal articles, textbooks, current news articles, organisational documents, and websites. You should consider the *credibility* of your sources; academic journals are normally highly credible sources while websites require careful consideration/selection and should be used sparingly. Any sources you use should be current and up-to-date, mostly published within the last five years or so, though seminal/important works in the field may be older. You must provide *evidence* of your research/own reading throughout your work, using a suitable referencing system, including in-text citations in the main body of your work and a reference list at the end of your work.

Guidance specific to this assessment: You must provide evidence of individual research with respect to the area of study and provide relevant referencing.

2. Knowledge and Understanding Skills

At level 4, you should be able to demonstrate knowledge of the underlying concepts and principles associated with your area(s) of study. *Knowledge* relates to the facts, information and skills you have acquired through your learning. You demonstrate your *understanding* by interpreting the meaning of the facts and information (knowledge). This means that you need to select and include in your work the concepts, techniques, models, theories, etc. appropriate to the task(s) set. You should be able to explain the theories, concepts, etc. to show your understanding. Your mark/grade will also depend upon the *extent* to which you demonstrate your knowledge and understanding.

Guidance specific to this assessment: Your report should show you gained knowledge of the subject area.

3. Cognitive and Intellectual Skills

You should be able to present, evaluate and interpret qualitative and quantitative data, in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of your subject(s) of study. You should be able to evaluate the appropriateness of different approaches to solving problems related to your area(s) of study and/or work. Your work must contain evidence of logical, analytical thinking. For example, to examine and break information down into parts, make inferences, compile, compare and contrast information. This means not just describing what! But also justifying: Why? How? When? Who? Where? At what cost? You should provide justification for your arguments and judgements using evidence that you have reflected upon the ideas of others within the subject area and that you are able to make sound judgements and arguments using data and concepts. Where relevant, alternative solutions and recommendations may be proposed.

Guidance specific to this assessment: The report should show analysis of the research.

4. Practical Skills

At level 4, you should be able to apply the basic underlying concepts and principles to evaluate and interpret these within the context of your area of study. You should be able to demonstrate how the subject-related concepts and ideas relate to real world situations and/or a particular context. How do they work in practice? You will deploy models, methods, techniques, and/or theories, in that context, to assess current situations, perhaps to formulate plans or solutions to solve problems, or to create artefacts. This is likely to

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Name: Shaun Judge

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Excellent: Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	25	18
2. Knowledge and Understanding Skills		
Excellent: Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.	25	20
3. Cognitive and Intellectual Skills		
Excellent: Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.	30	22
4. Practical Application Skills		
Very good: A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	10	6
5. Transferable Skills for Life and Professional Practice		
Very good: Work is accurate, coherent, fluent, well-structured and organised. Can work effectively independently and/or as part of a team, with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness. Please see additional comments in assignment text.	10	6

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		72%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

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Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

72 %

involve, for instance, the use of real world artefacts, examples and cases, the application of a model within an organisation and/or benchmarking one theory or organisation against others based on stated criteria.

Guidance specific to this assessment: The report indicates a level of research with respect to the application and deployment of the equipment, materials or processes that form the basis of the area of study.

5. Transferable Skills for Life and Professional Practice

Your work must provide evidence of the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility. This includes demonstrating: that you can communicate the results of your study/work accurately and reliably, and with structured and coherent arguments; that you can initiate and complete tasks and procedures, whether individually and/or collaboratively; fluency of expression; clarity and effectiveness in presentation and organisation. Work should be coherent and well-structured in presentation and organisation.

Guidance specific to this assessment: Your work should be well organised and presented in a professional manner.

GENERIC ASSESSMENT CRITERIA

Level 4

In accordance with the Framework for Higher Education Qualifications, at the end of Level 4 students will be expected to have demonstrated knowledge of the basic underlying concepts and principles of a subject, and an ability to evaluate and interpret these within the context of that area of study. They should be able to present, evaluate and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements in accordance with basic theories and concepts of their subject(s) of study. They will have learned how to evaluate different approaches to solving problems, and will be able to communicate the results of their study/work accurately and reliably, and with structured and coherent arguments. They will be able to undertake further training and develop new skills within a structured and managed environment and will have the qualities and transferable skills necessary for employment requiring the exercise of some personal responsibility.

Level 4	Category	FAIL	MARGINAL FAIL	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
		0-29%	30-39%	(3 rd / Pass) 40-49%	(2.2 / Pass) 50-59%	(2.1 / Merit) 60-69%	(1 st / Distinction) 70-84%	(1 st / Distinction) 85-100%
	Engagement with literature (including reading, referencing, academic conventions and academic honesty)	Little or no evidence of reliance on inappropriate sources. Views and findings mostly unsupported and non-authoritative. Referencing conventions used incoherently or largely absent.	Poor engagement with essential reading. No evidence of wider reading. Reliance on inappropriate sources, and/or indiscriminate use of sources. Heavily reliant on information gained through class contact. Inconsistent and weak use of referencing.	Engagement with a limited range of mostly credible sources but with some reliance on information gained through class contact. Some omissions and minor errors. Referencing conventions evident though not always applied accurately or consistently.	Engagement with an appropriate range of literature, including sources retrieved independently. Some over-reliance on texts rather than other sources. Referencing may show minor inaccuracies or inconsistencies.	Engagement with a wide range of literature, including sources retrieved independently. Selection of relevant and credible sources. Generally sound referencing, with no/very few inaccuracies or inconsistencies.	Engagement with an extensive range of relevant and credible literature. Consistently accurate application of referencing.	Exceptional engagement with an extensive range of relevant and credible literature. High-level referencing skills consistently applied.

Level 4		FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category		0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
Knowledge and understanding (Knowledge of the basic underlying concepts and principles of a subject.)		Major gaps in knowledge and understanding of the basic underlying concepts and principles of the subject matter. Inclusion of irrelevant material. Substantial inaccuracies.	Gaps in knowledge of the basic underlying concepts and principles, with flawed or superficial understanding. Some significant inaccuracies and/or irrelevant material.	Limited knowledge and understanding of the basic underlying concepts and principles within the subject area. Some elements may be missing.	Knowledge of the basic underlying concepts and principles is accurate with a good understanding of the field of study but lacks depth and/or breadth.	Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding.	Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.	Exceptional, detailed knowledge and understanding of the basic underlying concepts and principles
Cognitive and intellectual skills (Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.)		Wholly or almost wholly descriptive work. Little or no evaluation of the underlying concepts and principles. Failure to develop arguments, leading to illogical or invalid judgements. Minimal or no use of evidence to back up views.	Largely descriptive work, with superficial evaluation of the underlying concepts and principles. Weak interpretation of data, flawed development of arguments and judgements. Information accepted uncritically, uses generalised statements made with scant evidence and unsubstantiated opinions. Ideas sometimes illogical and contradictory.	Limited attempt at evaluation of the underlying concepts and principles, tending towards description. Can interpret qualitative and quantitative data, with minor errors. An emerging ability to use evidence to support the argument. Mostly valid arguments and logical judgements.	Good evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements.	Sound evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately. Ability to devise arguments using evidence to make mostly appropriate and valid judgements.	Excellent evaluation of the underlying concepts and principles. Can interpret qualitative and quantitative data accurately and with some insight. Excellent ability to devise arguments using evidence and make appropriate and valid judgements.	Exceptional evaluation of the underlying concepts and principles based on evidence. Outstanding interpretation of qualitative and quantitative data. Exceptional ability to devise arguments using evidence and make wholly appropriate and valid judgements.

Level 4	Category	FAIL 0-29%	MARGINAL FAIL 30-39%	SATISFACTORY (3 rd / Pass) 40-49%	GOOD (2.2 / Pass) 50-59%	VERY GOOD (2.1 / Merit) 60-69%	EXCELLENT (1 st / Distinction) 70-84%	EXCEPTIONAL (1 st / Distinction) 85-100%
	Practical skills (Different approaches to solving problems in particular contexts.)	Limited or no use of taught, basic methods, tools and/or techniques. Little or no appreciation of the context of the application. Very weak evidence of different approaches to problem-solving in particular contexts.	Rudimentary application of taught, basic methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application. Weak evidence of different approaches to problem-solving in particular contexts.	An adequate awareness and mostly appropriate application of basic methods, materials, tools and/or techniques. Basic appreciation of the context of the application. Can identify problems in particular contexts and propose basic alternative approaches or solutions though there may be errors.	A good and appropriate application of basic methods, materials, tools and/or techniques. Clear appreciation of the context of the application. Good evidence of different approaches to problem-solving in particular contexts and proposes mostly appropriate solutions.	A very good application of a range of basic methods, materials, tools and/or techniques. Very good consideration of the context of the application. Very good evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	An advanced application of a range of taught, basic methods, materials, tools and/or techniques. The context of the application is well considered, and insightful. Excellent evidence of different approaches to problem-solving in particular contexts and proposes appropriate solutions.	Exceptional levels of application and deployment skills in particular practical contexts. Outstanding identification of problems in particular contexts and formulation of wholly appropriate, thoughtful solutions / different approaches.

Level 4	FAIL	MARGINAL FAIL	SATISFACTORY (3 rd / Pass)	GOOD (2.2 / Pass)	VERY GOOD (2.1 / Merit)	EXCELLENT (1 st / Distinction)	EXCEPTIONAL (1 st / Distinction)
Category	0-29%	30-39%	40-49%	50-59%	60-69%	70-84%	85-100%
Transferable skills for life and professional practice (Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.)	Work is poorly structured, disorganised, inaccurate and/or confusingly expressed. Very weak use of language and/or very inappropriate style. Failure to work effectively individual or as part of a group. Little or no evidence of the skills for employment requiring the exercise of some personal responsibility.	Work is poorly presented in a disjointed manner. It is loosely, and at times incoherently, structured, with information and ideas often poorly expressed. Weak use of language and/or inappropriate style. Flawed approach to individual or group work, meeting only partial obligations to others. Limited evidence of the skills for employment requiring the exercise of some personal responsibility.	Mostly ordered presentation and structure in which relevant ideas / concepts are reasonably expressed. Work may lack coherence and/or accuracy in places. Can work as part of a group, meeting most obligations to others but perhaps with limited involvement in group activities. Demonstrates the basic skills for employment requiring the exercise of some personal responsibility, with some areas of strength and some of minor weakness.	Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed. Can work effectively independently and/or as part of a team, with a clear contribution to group activities. Demonstrates the skills for employment requiring the exercise of some personal responsibility, with some areas of strength and some of minor weakness.	Work is accurate, coherent, fluent, well-structured and organised. Can work effectively independently and/or as part of a team, with very good contribution to group activities. Demonstrates very good skills for employment requiring the exercise of some personal responsibility, with just occasional minor weakness.	Work is coherent, very fluent and is presented professionally. Can work effectively independently and/or as part of a team, with an excellent contribution to group activities. Demonstrates excellent skills for employment requiring the exercise of some personal responsibility with an appetite for further development.	Work is accurate, exceptionally coherent, very fluent and presented well. Can work effectively independently and/or as part of a team, with an exceptional contribution to group activities. Demonstrates exceptional skills for employment requiring the exercise of some personal responsibility with an appetite for further development.

THIS DOCUMENT IS ALSO AVAILABLE IN WELSH

HNC PROCESS OPERATION ENGINEERING

ENVIRONMENTAL PROTECTION AND SUSTAINABLE
MANUFACTURING SYSTEMS

Shaun Judge (104870)
VALERO ENERGY |

Environmental Protection and Sustainable Manufacturing Systems

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Introduction

One industrial process at Pembroke refinery which poses a potential risk to the local environment is the Waste Water Treatment Plant (WWTP). This process is responsible for treating all waste water and reducing all contaminants to within governed acceptable tolerances before it is discharged back into the Milford Haven waterway. The following report will detail the WWTP process and associated equipment, detail aspects related to environmental issues, and develop conclusions and recommendations relating to how the WWTP could be improved in relation to environmental protection.

The WWTP is responsible for treating an approximate 13,600 cubic meters of contaminated water a day. This water must be treated to reduce all contaminants to the levels set out in the European Union Industrial Emissions Directive 2010/75/EU. The table in figure A sets out the levels of emissions of TOC, COD and TSS relating to the same European union directive.

Parameter	BAT-AEL (yearly average)	Conditions
Total organic carbon (TOC) ⁽¹⁾ ⁽²⁾	10-33 mg/l ⁽³⁾ ⁽⁴⁾ ⁽⁵⁾ ⁽⁶⁾	The BAT-AEL applies if the emission exceeds 3,3 t/yr.
Chemical oxygen demand (COD) ⁽¹⁾ ⁽²⁾	30-100 mg/l ⁽³⁾ ⁽⁴⁾ ⁽⁵⁾ ⁽⁶⁾	The BAT-AEL applies if the emission exceeds 10 t/yr.
Total suspended solids (TSS)	5,0-35 mg/l ⁽⁷⁾ ⁽⁸⁾	The BAT-AEL applies if the emission exceeds 3,5 t/yr.

Figure A- Emissions of TOC, COD and TSS to a receiving water body

To achieve these levels of emissions, Pembroke refinery uses a biological activated WWTP, the process and major equipment will be outlined below. The waste water treated is typically made up of process water which can become extremely contaminated as it passes through different plant units. It is also made up of surface water, product tankage such as accumulated water drawn off tanks in the tank farm and water from sanitary systems all around the refinery buildings.

Industrial process and equipment

The initial stage of the process involves two identical API separators, here scrapers on a continuous conveyor skim off any sludge and oil that has accumulated on the top of the sludge entering the WWTP. The influent then enters a Dissolved Air Flotation (DAF) unit, this process aims to remove the fine suspended material and oil from the influent. This process is explained in research from Environmental wastewater solution who state 'The incoming effluent enters the flotation vessel where it comes into contact with recycled, treated effluent (sometimes termed white water). Once this saturated effluent enters the flotation tank, the pressure is released back to atmospheric. This immediately results in the recycled flow becoming supersaturated, generating micro bubbles as the dissolved air comes out of solution' ref (DAF, 2019)

These micro bubbles cling to the solids entering the process, causing them to float to the surface where they are held and subsequently removed by a skimmer. The effluent then makes its way to next part of the process which is the equalisation basins.

The equalisation basins have a capacity of 5,150 m³ and have a retention time of 18 hours, the objective of these equalisation basins is to control the speed of the influent flow and to prevent any shock loads to the downstream processes. The importance of this controlled flow rate is highlighted in research from norwec who state 'The equalization of flow prevents short term, high volumes of incoming flow, called surges, from forcing solids and organic material out of the treatment process. Flow equalization also controls the flow through each stage of the treatment system, allowing adequate time for the physical, biological and chemical processes to take place' (Norweco, 2019). There are eight mixer pumps located on the floor of each basin to aid the mixing of influent water.

The next stage of the process is the aeration lanes, these are large concrete tanks with a holding capacity of 2,553m³, each lane has a residence time of 9 hours. This secondary treatment process adds air into the wastewater to allow aerobic biodegradation of the contaminants in the waste water. An activated sludge process is adopted to ensure the biodegradable effluents come into contact with micro-

organisms present in the oxygen. This is explained further in research from Byrne who states 'Unlike chemical treatment which uses chemicals to react and stabilize contaminants in the wastewater stream, biological treatment uses microorganisms that occur naturally in wastewater to degrade wastewater contaminants' (Byrne, 2019). A jet aeration system is used in each basin to pump air into the tanks, this increases the microbial growth in the wastewater where the microbes feed on the organic material in the waste water effluent. This process creates sludge flocks which settle out, after settling out, the bacteria forming the activated sludge flocks are recirculated into the aeration lanes to help maximise the rate of decomposition. The temperature and level of added nutrients are vital to ensure the adequate growth of the microbiological population, as well as the sludge flocks this process produces a clear effluent.

The next part of the process is the clarifiers. The effluent from the aeration lanes enters the clarifiers through individual underground pipes, these clarifiers are circular in shape and are made of concrete with a capacity of approximately 1450m³. Each clarifier incorporates a waste water inlet, sludge outlet and features a rotating bridge scraper. The outer perimeter of the clarifier features a weir plate, collection channel and scum baffle. The bridge scraper also has submerged rake blades that are used to remove any sludge that has accumulated on the clarifier floor. The skimming blade fixed to the top of the bridge scraper extends the full diameter of the vessel and is used to direct any floating scum to the outer edge of the clarifier where it is retained in a scum collection box. Any collected sludge is directed into sludge slumps which have individual pumps which pump the sludge back into the aeration lanes via the aeration lane inlets. The individual components of the clarifiers can be seen in figure b below:

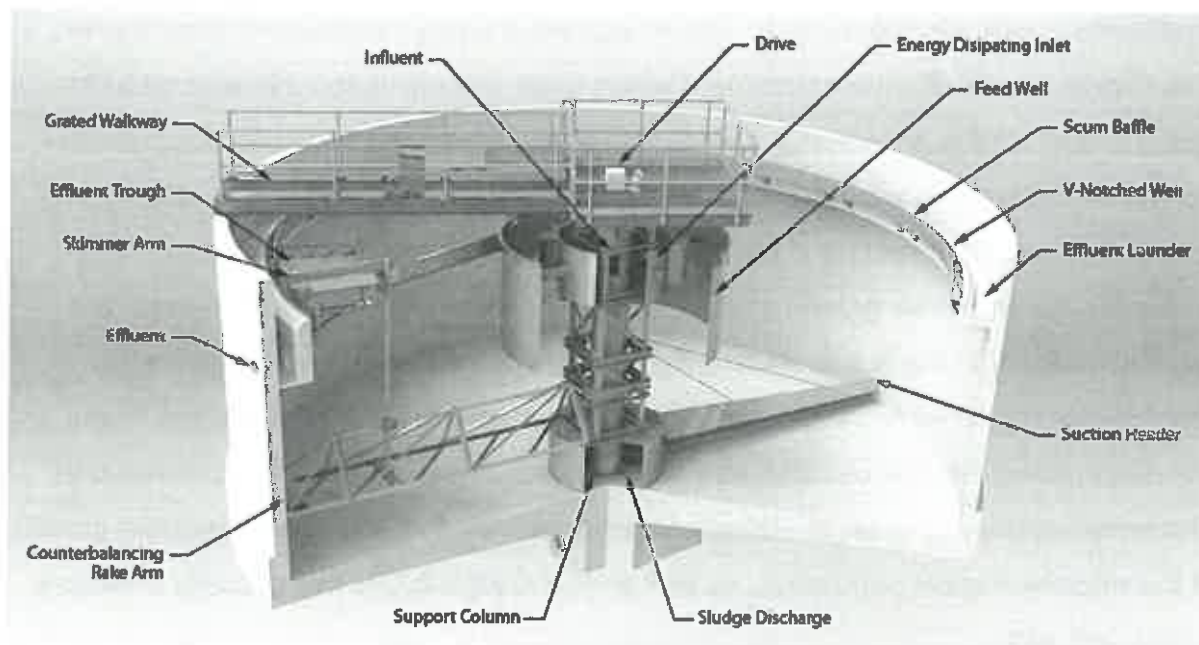


Figure B- Clarifier components

This treated wastewater that leave the secondary clarifiers flows into a clarified water sump before it is pumped into the Milford Haven water way. As the clarified water is routinely tested for level of contaminants, if the water was deemed to be over required parameters for contaminants, pumping into the water way would be stopped immediately with the pumps realigned to pump the water back into a holding surge pond before it can be re-processes through the WWTP. ✓

Meeting Environmental Requirements

The waste water processes at the Pembroke refinery can contain all manner of hazardous chemicals and contaminants, this is why it especially important that it is clean and free from all harmful materials before it re-enters the water way. Any contaminants could have a detrimental effect on the quality of the water in the haven as well as on any wildlife and eco system situated within and around the haven itself. The legal requirements are set out by the European Union Industrial Emissions Directive 2010/75/EU 'establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for common waste water and waste gas treatment/ management systems in the chemical sector' (Europa.eu, 2019) This legislation sets permit limits for all effluent discharge into the haven. ✓

One of the new limits set out in this directive is for total nitrogen (TN) at 25 mg/L, to comply with this new limit, the WWTP will need to be modified. This new limit of nitrogen as well as other limits can be seen in figure B below:

Table 3-1. Discharge Permit Limits				
Parameter	Units	Limit	Averaging Period	Monitoring Frequency
Flow	m ³ /day	25,000	weekly	daily
Temperature	°C	35	daily	continuous
pH		6-9	daily	daily
Oil*	mg/L	2.5	annual	daily
Oil	mg/L	17	daily	daily
Ammonia-Nitrogen	mg/L	20	daily	daily
Total Nitrogen*	mg/L	25	annual	daily
COD*	mg/L	125	annual	daily
COD	mg/L	270	daily	daily
Phenols	mg/L	3	daily	daily
Phenol Index*				monthly
Suspended Solids*	mg/L	25	annual	daily
Suspended Solids	mg/L	85	weekly	daily
Sulphides	mg/L	1	weekly	daily
Fluoride	mg/L	15	weekly	daily
Fluoride	tonnes	5.3	monthly	weekly

Figure C-Discharge permit limits for effluent into the water way

An evaluation performed by Valero identified that compliance with the new TN limit would be accomplished by conversion of the existing biological treatment system to a modified process for denitrification.

Anoxic processes are typically used for the removal of nitrogen from wastewater. The process of biological nitrogen removal is known as denitrification. Denitrification requires that nitrogen be first converted to nitrate, which typically occurs in an aerobic treatment process such as a trickling filter or an aerated suspended growth system. The nitrified water is then exposed to an environment without free oxygen.

Organisms in this anoxic system use the nitrate as an electron acceptor and release nitrogen in the form of nitrogen gas or nitrogen oxides

Currently, the WWTP's activated sludge process converts influent organic nitrogen to nitrate-nitrogen. This existing approach was appropriate for complying with the current nitrogen limits however, with the new TN limit, this would have to be reduced. The new process removes nitrate-nitrogen and converts it to nitrogen gas that is released to atmosphere, and thus provides a net reduction in total nitrogen. The chemical process is detailed further in research by the European union commission who state 'A two-step process that is typically incorporated into biological waste water treatment plants. The first step is the aerobic nitrification where microorganisms oxidise ammonium (NH_4^+) to the intermediate nitrite (NO_2^-), which is then further oxidised to nitrate (NO_3^-). In the subsequent anoxic denitrification step, microorganisms chemically reduce nitrate to nitrogen gas' (Europa.eu, 2019). The flowing diagrams in figures D and E highlight the modification of the WWTP that would be needed to reduce the total nitrogen entering the water way.

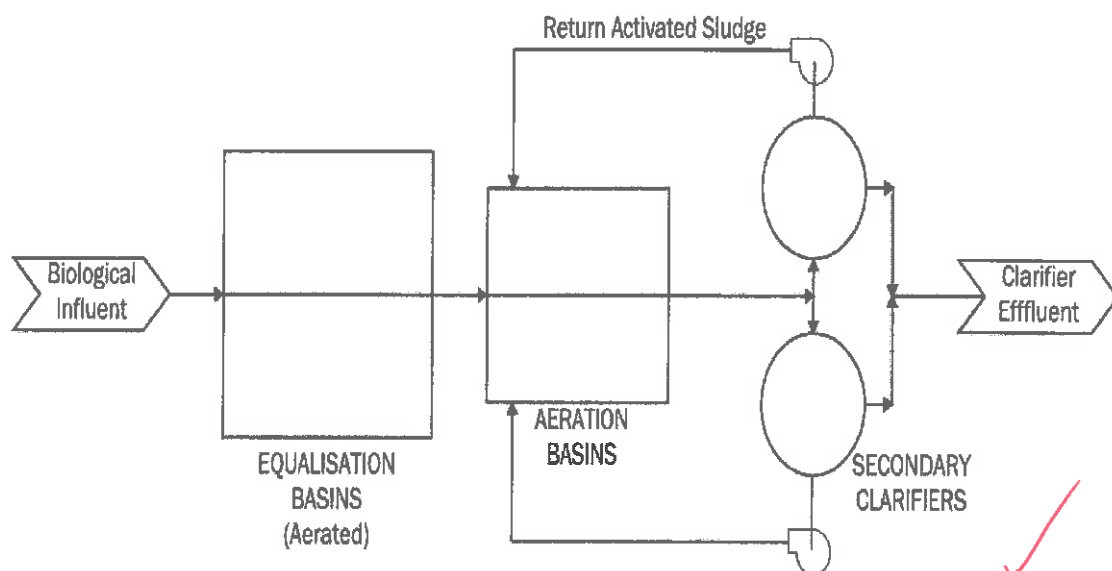


Figure D-Block Flow Diagram of Existing Biological Treatment Section of the WWTP

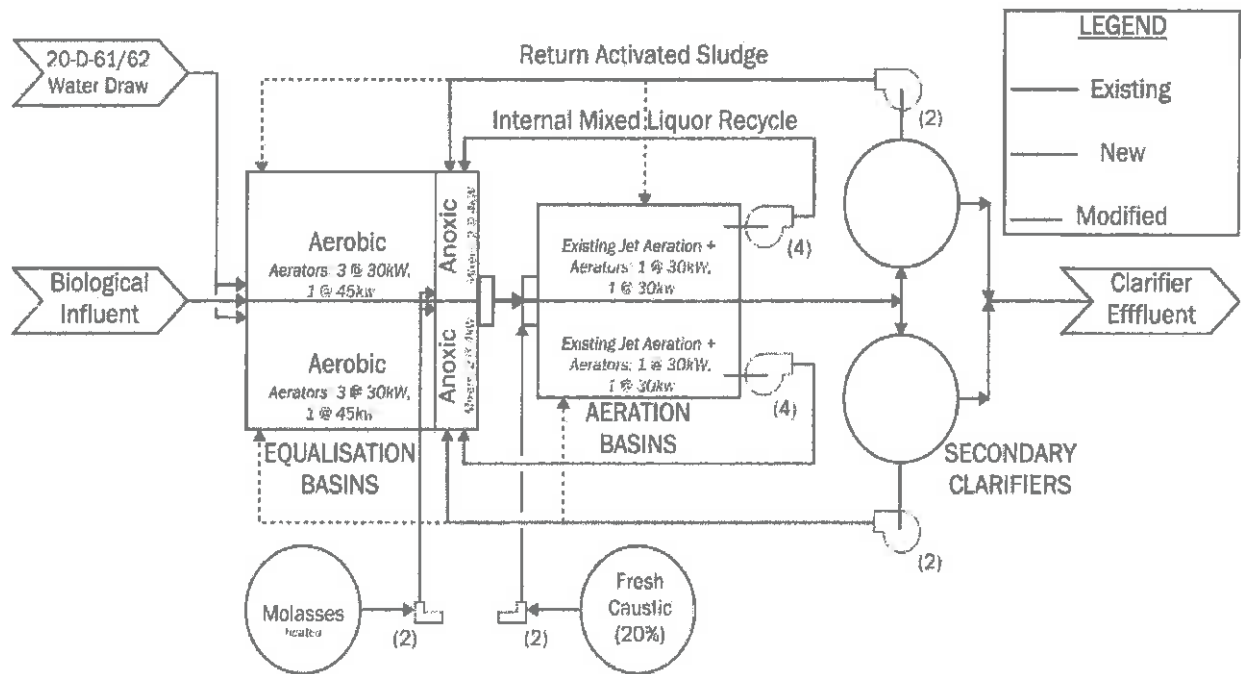


Figure E-Block Flow Diagram of WWTP Denitrification Upgrades

The key components of the WWTP upgrade would include:

- Anoxic zones to be installed in the outlet end of each of the two parallel equalisation basins. The zones would be created by constructing a concrete wall across the entire width of the two basins.
- Floating mixers would be installed in the anoxic zones to keep the biomass in suspension.
- New pumps would be installed to transfer biomass from the aeration basins to the anoxic zones.
- A new fresh caustic storage tank and feed pumps would be installed to provide alkalinity to the aeration basins. Alkalinity addition is required for reliable nitrification.
- New process pipework would be installed between all the new pumps as well as new electrical cabling for all new instrumentation.

*Good identification
of improved processes*

Environmental Protection and Sustainable Manufacturing Systems

These modifications should ensure that a sustainable process is in place that is efficient and has the capability of reaching all effluent limits set out in law (Figure C). The modification highlighted above also ensure that sustainable manufacture can be achieved through efficient equipment, plant and process operation. ✓

Conclusion and Improvements

Even though the WWTP is sustainable and its operation efficiently removes contaminants from waste water on a daily basis, there are possible improvements that could be made. One of these processes revolves around improved digestion processes that can convert volatile matter into biogas, this biogas can then be converted into electricity through combined heat and power engines. This process is called Thermal Hydrolysis and is explained further in research from Veolia who state 'Thermal hydrolysis (TH) offers a very effective way to release and capture the energy in sludge. The technology involved is like a big pressure cooker: the sludge is heated to around 150-190°C at 6-15 bar pressure, which 'cracks' the long chain sludge molecules. This process releases a substantial amount of gas as well as reducing and pasteurising the sludge (Wwtonline, 2019). This increases sustainability as part of the gas generated can be used to fuel the "pressure cooker" and the rest of the gas can be used to generate electricity. The pasteurised sludge can be sold to company's wishing to use it as fertiliser, this increases the manufacturing sustainability as levels of waste are reduced as well as improving company probability.

A good synthesis of waste material.

Nutrient recovery is another process that could be adopted to improve sustainability, it involves removing valuable nutrients in the waste water such as phosphorus, this explained further in research from smart plant who state 'Nutrients will also be recovered as struvite and as sludge which is rich in phosphorus via the treatment of municipal wastewater and sludge reject water. In the first case struvite precipitates with the addition of magnesium and proper pH adjustment. In the second case, enhanced biological phosphorus removal results in the accumulation of high concentrations of phosphorus in sludge' (Smart-plant.eu, 2019). The produced chemicals and sludge have high levels of phosphorous which is great in compost, which when added to farming land leads to increases crop yields. ✓

A reed bed system would be a good method in this case

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