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27th. June 2007

The Environmental Protection Agency
P.O. Box 3000
Johnson Castle Estate
Co. Wexford

Re: Application from Mayo County Council to the EPA for the Review of Waste Licence (No. W0021-01 / W0021-02)

Dear Sir/Madam

The Clew Bay CLAMS Group wishes to submit the following comments and observations for your consideration in relation to Mayo County Council's recent application seeking a review of the Waste Licence (No. 0021-01) in respect of the landfill facility located at Derrinumera and Drumilra Townlands, Newport, Co. Mayo. See also attached letters to An Bord Pleanála in relation to the two associated EISs outlining same concerns and observations from the Group. The CLAMS Group comprises of all shellfish and finfish producers in the Bay area.

The proposed developments and the associated EISs of a Sewerage Scheme for Newport and a Sludge Hub Centre & Leachate Treatment Facility at Derrinumera Landfill are intrinsically linked and while we welcome the provision of a sewage treatment facility for the town of Newport we have grave concerns over the impact that landfill leachate from outside the area will have on the quality of the waters and health of the shellfish stocks in the Bay. This leachate will also include elements from the proposed sludge hub centre at Derrinumera, which will be accepting sludge from wastewater and water treatment plants all over Mayo and beyond.

Firstly it must be brought to your attention that Clew Bay is a Designated Shellfish Area under EU Directive 923 of 1979 Quality of Shellfish Waters Regulations and S.I. No 268 of 2006 and as such it is incumbent on public authorities to ensure that all measures are taken to preserve and enhance the quality of the waters therein. We are advised that the piping of leachate into a designated shellfish production area is in contravention of this directive and therefore should not be permitted under any circumstances.

Clew Bay is also designated under the Water Framework Directive for transitional and coastal waters and is a candidate Special Area of Conservation (SAC). In addition the Bay is also protected under an Oyster Fishery Order that was granted to the Clew Bay Oyster Co-operative in 1979.

The Clew Bay CLAMS Group's main concerns and observations are as follows:

- We feel that the proposed discharge standards to be applied do not sufficiently account for the bioaccumulation of substances in shellfish and the inevitable food safety issue that this poses. The long-term and synergistic effects have not been addressed. In regard to this point we feel that the Food Safety Authority of Ireland (FSAI) should be consulted on the food safety issue that this discharge poses.

- It is of concern to the group that the discharge limit set for faecal coliforms of 2000 per 100ml is inadequate to protect shellfish from contamination. Faecal coliforms are only an indication of sewage contamination and this limit is not sufficiently stringent to protect the class 'A' status of the growing waters (see EU 852 and 853/2004).

- The area proposed for the outfall is a shellfish production area and there are active shellfish beds in close proximity. The area is also utilised for periwinkle collecting, seaweed harvesting and swimming by the local people. We feel that the EIS does not adequately address the safety of persons either swimming, working or eating shellfish collected from the environs of the outfall pipe. As a minimum precaution some form of closed area should be put in place. The closed area would prevent further development of the oyster industry within this area and this has not been adequately assessed.

- The effects of the construction phase on the local shellfish beds and production areas has also not been adequately addressed. The area that is disturbed and therefore unavailable for development of oyster production has not been assessed.

- The monitoring regime proposed was described as woefully inadequate by an expert ecotoxicologist whose opinion was sought by the Group. The report by Prof. Peter Matthiessen (see attached) describes a suitably rigorous sampling plan and this report is available if requested. The report also advises on the provision of continuous monitoring of a number of indicative water quality parameters such as conductivity, which could trigger an alarm if a limit is breached, therefore acting as an early warning system. This would address a major concern of the industry, namely that currently the only proposed monitoring is post process and discharge, and therefore any failure in the treatment would not prevent pollution occurring. A comprehensive risk assessment should be carried out to determine the most suitable sampling plan to give a 99% confidence that breaches of licenced limits would be detected.

- Installation of sufficient storage capacity to enable the withholding of treated leachate on site and testing each batch to ensure it conforms to standards before release should be investigated. A system of testing and releasing batches would prevent a spill or breakdown in the process from polluting the receiving environment.

- We would like to raise the issue of the characterisation of the leachate used in the EIS. The analytical tests used to characterise the components of the leachate were not accurate enough and the limit of detection (LOD) was too high to be certain that all substances were accounted for. Also certain substances were not taken into account such as endocrine disruptors.

- No details on the characterisation of the current effluent from Newport town or of the expected treated effluent from the proposed new wastewater treatment plant were provided. It is impossible to access the impacts of the combined marine discharge if full details of the content of both treated leachate and treated sewage is not available.

- The baseline ecological survey carried out was inadequate. The number of samples collected was insufficient, riverine invertebrates were sampled from an inappropriate river (Newport river was sampled but the proposed discharge is to the Burrishoole system). The EIS and surveys did not take into account the seasonal factors for flora and fauna regarding potential impacts the discharge may have, e.g. on shellfish and fish larval. The proposal to begin monitoring 6 months before construction will not adequately set a baseline for the undisturbed nature of the receiving environment.

- The council proposes to tanker the untreated leachate to the Westport WWTP for a period of 4 years. This group would have grave concerns regarding the efficacy of a plant, designed to treat urban wastewater, to treat landfill leachate. No study has been undertaken to ascertain the impact of the leachate on the plant treatment processes, the increased storm overflows caused and the effects of the leachate on the receiving environment. Any such proposal even if temporary must be subject to an EIS to ascertain the suitability of the plant for this waste and to ensure that no deterioration occurs in the shellfish production area.

- The total lack of an Emergency Plan, Safety Plan or Indemnity Plan is a matter of major concern to the group. A plan must be developed to deal with unforeseen effects on the shellfish industry, due to mismanagement, equipment failure or spill.

- Alternatives to the piping of the treated leachate to the sea at Newport have not been adequately explored. As a sensitive area, in which food is produced, Clew Bay is not a most suitable site for the discharge of leachate and alternatives should be investigated. In addition alternative sites for the marine outfall have not been investigated fully. The preferred site (A) is a sensitive area, it is in close proximity to shellfish beds, is within an area under a development order, and will impact on the food production area and sensitive environment of Lough Furnace. Notwithstanding the foregoing, the availability of alternative technologies for dealing with leachate (if any) to those which rely on discharging treated effluent into receiving waters should also have been investigated.

- The provision to store and then release the effluent only at certain states of the tidal cycle have not been investigated. An improvement in dilution and a decrease in the area of impact may be possible by releasing the effluent only on a falling tide and this should be investigated.

- The proposed provision of a sludge hub centre will double the tonnage of received material. It is proposed that the dried sludge cake be exported for land spreading. If the export of such tonnages in the future proves difficult or is legislated against then there is a possibility of this cake being deposited on the landfill. We would have concerns regarding the impact of this sludge cake on the character of the landfill leachate over time.

- The Group feels that the technologies to be used to treat the leachate were not adequately described. It is impossible to fully appreciate the impacts of the treated leachate on the receiving environment when the details of the treatment process are not known. More details should be requested on the types of systems available and the success of those systems to make safe the final effluent.

In conclusion the CLAMS Group wishes to reiterate our welcome to the treatment of the urban wastewater from Newport. However the disposal of landfill leachate into a designated shellfish production area is not acceptable, is in breach of the Shellfish Waters Directive and is a risk to the livelihood of the shellfish and finfish producers in the bay. In addition it is also a risk to the consumers of food produced from the area. We trust that An Bord Pleanála will take our concerns into consideration and ensure that this development does not lead to deterioration in the water quality of the bay.

Thanking you

Yours sincerely

Mr. James Ryan
Chairman

Assessment of the likely marine environmental impacts of the proposed discharges from the Newport Sewerage Scheme and the Derrinumera Landfill Leachate and Sludge Hub Centre

Report to the Clew Bay CLAMS Group

Professor Peter Matthiessen, Ecotoxicology Consultant
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27 June 2007

1. Contents

2. Summary

2.1 This report reviews the Derrinumera EIS (2007) and the Newport EIS (2007) from the point of view of likely impacts caused by the proposed leachate and sewage discharges on the marine environment and fisheries of Newport Bay.

2.2 The report concludes, on the basis of predicted contaminant concentrations provided in the EIS, and on other information, that the proposed combined discharge of treated landfill leachate and treated sewage effluent is unlikely to have a significant effect on the commercially important fisheries, and conservationally important wildlife, of Newport Bay.

2.3 Furthermore, the quality standards of the proposed discharge are sufficiently low so as to avoid a significant risk of bioaccumulation of toxicants in shellfish.

2.4 However, there is inevitably some uncertainty in this risk assessment, and the serious consequences for Newport Bay should the assessment be incorrect justify the conduct of a robust discharge and environmental monitoring programme. Unfortunately, the programme proposed in the Newport EIS (2007) is considered inadequate, particularly with respect to the measurement of holistic biological variables.

2.5 The report concludes with a series of recommendations, including some proposals for biological monitoring.

3. Background

3.1 This assessment was commissioned by Mary Hannan of the Clew Bay CLAMS Group, Newport, County Mayo, in an email to Peter Matthiessen dated 30 May 2007 which set out the following points for attention concerning discharges from the proposed Newport Sewerage Scheme and Derrinumera Landfill Leachate combined discharges:-

- Review the EISs
- Give an opinion on the leachate and effects of chemicals/metals identified in the profile
- Effects/impact on shellfish including longterm effects
- Alternative technology for leachate treatment – risk assessment needed?
- What monitoring regime would need to be put in place, in terms of food safety etc.?
- Comments on the emergency plan in the EIS
- Effects of storm surges on leachate
- Opinion on the sampling regime required to protect the bay from any discharges in excess of licence limits, based on a full risk analysis.

3.2 In essence, this report makes a critical analysis of whether the combined treated discharges are likely to lead to any deterioration in environmental quality in Newport Bay, and it evaluates the adequacy of proposals for marine environmental monitoring.

3.3 The assessment is based primarily on information in Environmental Impact Statements (EIS) prepared for Mayo County Council (Newport EIS, 2007; Derrinumera EIA, 2007), and supplied to PM by Mary Hannan on compact disks in a letter dated 17 May 2007.

3.4 Formation of landfill leachate. Leachate is the liquid that leaks, or is pumped, from landfill sites that are not completely sealed. It is produced by the chemical degradation, biodegradation, suspension and dissolution of substances in the landfill, and occurs due to the ingress of rainwater and/or groundwater (Farquhar, 1989). Because the volume of this incoming water varies seasonally in most places, the volume of leachate also varies during the year, and there are also longer-term variations in leachate volume as the contents of the landfill age. The moisture content of municipal waste varies rather little (20-30% by weight: Farquhar, 1989), but the waste itself is very variable between sites. Values quoted by Farquhar (1989) for Canada and the US are as follows (% wet weight):- Food 5-20; Garden waste 15-25; Paper 40-50; Plastic 1-5; Wood 2-5; Other organic materials 2-10; Iron 5-10; Other metals (mainly aluminium and zinc) 0-1; Glass 5-10; Other inorganics 2-5. These percentages will change as more waste begins to be re-cycled in the future, but they are fairly typical of European municipal wastes at present. The variability of water ingress (e.g. from excessive rain) and waste composition in turn leads to enormous variability of leachate quality, both between different leachates, and in individual leachates over time. The variation over time is largely driven by waste composition, which means that soluble contaminants tend to appear first in the leachate, followed by the degradation products of readily biodegradable substances. Poorly soluble substances, or degradation products of poorly degradable substances, tend to appear last (after several years in some cases). As far as the major cations and anions are concerned, concentrations in the leachate tend to reach their peak (up to several thousand mg/l) within 5 years, after which concentrations tail off to <10-300 mg/l after 20 years (Farquhar, 1989). Metals tend to lie in the 0.1-10 mg/l range, while maximum concentrations of organic substances are in the range <0.01-20 mg/l. The picture is complicated further by the fact that fresh waste is continually added to most landfills, so the contents will be a mixture of old and new material. Yet another dimension is added by landfills of industrial waste, but this will not be dealt with further as the Derrinumera landfill essentially contains non-hazardous waste, presumably of a largely domestic nature (although this does not appear to be stated unequivocally in the EIS).

3.5 Composition of landfill leachate. The variability of landfill leachate is illustrated in Table 3.1 which summarises some of the main constituents of leachate in England (Defra, 2004). The database from which the information is drawn includes the 27 substances on the Environment Agency's Pollution Inventory of 77 substances which have been found to occur in more than 5% of leachate samples from up to 67 landfill sites. It is apparent from Table 3.1 that many substances are largely removed from raw leachate before it is discharged to English surface waters. Raw leachate also contains many other potentially important substances – for example, work by Chu *et al.* (1994), Kjeldsen and Christophersen (2001), Kjeldsen *et al.* (2002), Jimenez *et al.*

(2002) and Baun & Christensen (2004) have reported concentrations in raw leachate from various countries of acidity (down to pH 4.5), chemical oxygen demand (≤152,000 mg/l), biological oxygen demand (≤57,000 mg/l), total organic carbon (≤29,000 mg/l), dioxin-like substances (≤0.6 mg/l), phthalates (≤300 mg/l), bisphenol A (≤0.24 mg/l), nonylphenol (≤0.007 mg/l), benzene (≤1.6 mg/l), ammonia (≤3860 mg/l), cadmium (≤0.14 mg/l), and mercury (≤0.05 mg/l). Baun and Christensen (2004) also point out that typically <10% of the heavy metals in leachate are present as bioavailable free metal ions, the rest being present as colloids, or complexed with various organic and inorganic materials. Gounaris *et al.* (1993) confirm that many metals in leachate are present in colloidal form. Furthermore, the organic matter responsible for metal complexation and some colloids alters its properties as the landfill waste ages (Calace *et al.*, 2001). This poses problems for monitoring programmes which only measure total metal. Of more recent concern is the fact that leachate contains many other substances at relatively low concentrations which are rarely measured, but which may nevertheless constitute a potential risk to surface waters. An example of this is the presence of oestrogenic activity in some leachates, which in one case has been attributed principally to bisphenol A (Coors *et al.*, 2003). This paper showed that various treatment processes (activated carbon and reverse osmosis) were able to remove most of the oestrogenic activity, but there is clearly potential for leachates to cause endocrine disruption. Domestic waste will also contain a range of discarded pharmaceuticals that probably also enter leachate in trace amounts which may nevertheless have high potency.

Table 3.1. Concentrations of the 27 most frequently detected Environment Agency Pollution Inventory substances in raw English landfill leachate, and following treatment and discharge to surface waters (Defra, 2004).

Substance	Range of mean concentrations in raw leachate	% removal	Range of median concentrations in leachate following treatment and discharge to surface water
Aniline (µg/l)	<0.97 - <2.19	90	<0.05 - <0.2
Methyl tertiary butyl ether (µg/l)	<0.98 - <1.93	0	<0.53 - <1.9
Chloride (mg/l)	1187 - 1710	0	636 - 2061
Cyanide (as CN) (mg/l)	<0.025 - <0.12	0	<0.025 - <0.1
Di (2-ethylhexyl) phthalate (µg/l)	1.06 - 17.0	95	<0.01 - <0.2
Ethylbenzene (µg/l)	9.5 - 38.0	80	<1.0 - <4.0
Fluoride (mg/l)	0.66 - 1.12	0	0.34 – 1.23
Methyl chlorophenoxyacetic acid (µg/l)	0.10 - 4.83	95	<0.0007 - < 0.035
Dichloromethane (µg/l)	0.99 - 1840	-	<0.023 - <43
Nitrogen (total) (mg/l)	314 - 1258	-	182 - 728
Organotin (µg/l)	0.15 - 0.6	0	0.1 – 0.4
Phenols (mg/l)	0.03 - 4.2	99	0.000025 – 0.0036
Phosphorus (mg/l)	3.00 - 5.07	2	1.63 – 5.29

Substance	Range of mean concentrations in raw leachate	% removal	Range of median concentrations in leachate following treatment and discharge to surface water
Polycyclic aromatic hydrocarbons (µg/l)	<5.09 - <6.16	50	<1.55 - <4.47
Nonylphenol (µg/l)	0.98 - 24.5	95	0.01 – 0.25
Biphenyl (µg/l)	0.09 - 2.3	95	0.001 – 0.025
Mecoprop (µg/l)	10.9 - 43.6	99.5	0.027 – 0.11
Naphthalene (µg/l)	0.43 - 21.3	95	0.003 – 0.16
Pentachlorophenol & compounds (µg/l)	0.11 - 0.96	60	<0.01 - <0.12
Toluene (µg/l)	21.7 - 348	80	1.05 – 16.8
Xylenes (µg/l)	29.5 - 118	75	4.37 – 17.52
Arsenic (µg/l)	8.0 - 32	70	1.2 – 4.8
Chromium (µg/l)	46 - 184	30	17.5 - 70
Copper (µg/l)	13 - 52	50	1.8 – 16.5
Lead (µg/l)	50 - 72	0	<27.8 - <90
Nickel (µg/l)	53 - 477	20	16 - 144
Zinc (µg/l)	138 - 11214	70	4.5 - 364

3.6 Biological effects of leachate. Given the complex mixture of contaminants present in leachate, it is not surprising that it can have high toxicity in its untreated form, as well as exerting an often huge oxygen demand which could cause asphyxiation of aquatic species. Defra (2004) reports that, in practice, few effects of leachate discharges on water quality can be detected in the UK, presumably because most receive some treatment. Nevertheless, bioassays are often used to predict the acute toxicity of leachates, and Kjeldsen *et al.* (2002) reviews the use of fish, crustaceans, duckweed, algae, bacteria, and genotoxicity/mutagenicity assays for this purpose in leachates from more than 98 different landfills. In some cases, high acute toxicity was associated with leachate arising from the co-disposal of industrial and domestic waste (Clément *et al.*, 1996), but the latter can also exert high toxicity on its own (Schrab *et al.*, 1993). Kjeldsen *et al.* (2002) conclude that most acute toxicity in leachate is associated with ammonia and alkalinity, although pH, chloride, zinc and copper are also implicated. Interestingly, Cameron and Koch (1980) showed that aging municipal waste for 5 years caused an 80-fold reduction in acute toxicity of the leachate to fish. The possible long-term or chronic effects of leachates on aquatic life have unfortunately not been studied to any great extent, although some have been shown to have mutagenic or genotoxic properties in *in vitro* tests (Kjeldsen *et al.*, 2002). Generally speaking, environmental managers have aimed to remove the acute toxicity (i.e. lethality) of leachates, but the long-term and possibly subtle effects of exposure to the relatively low levels of contaminants in treated leachate have generally been ignored. One example of this is the possibility that treated leachate may have endocrine disrupting properties. Endocrine disrupting substances are extremely potent, and are able to interfere with the normal operation of the endocrine systems in animals at very low concentrations.

Oestrogenic endocrine disrupting chemicals (EDCs) such as phthalates, alkylphenols and bisphenol A have been detected in raw leachate (see above), but few attempts (see Coors *et al.* 2003 for one example) have been made to measure oestrogenic activity *in vitro* in treated leachate, let alone to study oestrogenic effects *in vivo* in fish and other organisms. In the past, micro-contaminants such as endocrine disrupters and pharmaceuticals have not been targeted for removal from leachate before discharge, but it would be helpful if the treatment technology to be employed at Derrinumera took such substances into account, given the sensitivity of the receiving waters.

3.7 <u>Sewage effluent</u>. Like landfill leachate, domestic sewage effluent contains a complex mixture of substances, but it is less variable in quality from year to year. It does, however, vary seasonally because sewers normally carry surface runoff that acts to dilute the treated sewage during the wetter months. It also may contain industrial waste. It is not proposed to describe the components of treated sewage in detail, as Newport Bay already receives an essentially untreated sewage discharge. However, a useful general description of the effects of sewage discharges on an estuary (the Thames) is given by Moriarty (1988), and more detail is given in Klein (1962). This makes it clear that the main polluting components of untreated sewage are usually suspended solids, pathogenic bacteria, high biological oxygen demand (BOD), ammonia and surfactants. These can lead to smothering of gravel beds and benthic communities, microbial contamination of edible shellfish, oxygen depletion and overt toxicity, respectively, and the aim of modern sewage treatment is to reduce these factors to levels which will allow a healthy ecosystem and food-chain to function. In the Thames, sewage pollution from the mid-19th to mid-20th centuries caused the elimination of all fish species from the estuary, mainly due to de-oxygenation, but these have now made a substantial recovery as a result of sewage treatment which aims *inter alia* to maintain dissolved oxygen levels in the estuary at minimum 30% saturation. This is sufficient to permit the survival of estuarine fish populations, and the passage of migratory fish such as salmon.

3.8 <u>Micro-contaminants in sewage effluent</u>. However, in recent years, it has become apparent that traditional sewage treatment is not able to remove all of the many so-called micro-contaminants present in sewage. The best-understood of these are endocrine disrupters, of which perhaps the most significant are oestrogenic hormones and their mimics (Matthiessen, 2006), but there has also been more recent concern about pharmaceuticals (Crane *et al.*, 2006). Complex mixtures of oestrogens have caused widespread feminisation of English (and other) fish populations, both in rivers and estuaries. Modern sewage treatment (particularly with long hydraulic retention time) is able to remove most, but rarely all, of these substances from sewage, and the resulting trace concentrations of hormones (in the low ng/l range) in receiving waters often retain sufficient potency to cause effects such as yolk production and ovotestis induction in male fish. It is thought that some oestrogens may also cause adverse effects in molluscs (Oehlmann *et al.*, 2006), and tributyltin compounds present in both leachate and sewage effluent (Mersiowsky *et al.*, 2001) are well known to cause masculinisation in gastropods and shell-thickening in oysters (Matthiessen and Gibbs, 1998). Concern about oestrogenic effects has led to the initiation of the Endocrine

Disrupter Demonstration Programme by the English and Welsh Environment Agency (Matthiessen, 2006), which is seeking to pilot-test new technology to remove oestrogens from sewage. In particular, the use of granular activated carbon (GAC) is being investigated, but the practicality of this approach remains to be proven in operational sewage plants. Furthermore, it is not certain that the feminisation of fish populations will necessarily lead to their demise or reduction, although a large-scale experiment in a Canadian lake has recently shown that environmentally-realistic concentrations of the synthetic oestrogen ethynylestradiol caused the collapse of the fathead minnow population (Kidd *et al.*, 2007). In summary, although regulatory authorities in Europe and elsewhere are not yet regulating sewage discharges to control micro-contaminants such as endocrine disrupters and pharmaceuticals, it is certainly worth considering whether this should be investigated for discharges to protected areas such as Newport Bay.

4. Characteristics of the proposed Derrinumera leachate effluent

4.1 According to the Derrinumera EIS (2007), the design philosophy has been to treat the leachate such that environmental quality standards (EQSs) specified in the Irish Government's Water Quality (Dangerous Substances) Regulations 2001, and European Communities (Quality of Shellfish Waters) Regulations 2006, are met in the pipeline prior to discharge to the treated Newport sewage effluent. This fairly conservative approach has been taken in view of the fact that the receiving water (Newport Bay) is a candidate Special Area of Conservation (SAC), a Class A Shellfish Production Area, and a Site of Special Scientific Interest. The task of this section will therefore be to consider those EQSs and decide whether they are sufficiently stringent, and whether they cover a sufficient range of substances.

4.2 Five samples of the Derrinumera raw leachate were analysed in 2003 (Derrinumera EIS, 2007), and a summary of the most significant determinands is given in Table 4.1. Comparison of these data with information from elsewhere (e.g. Table 3.1 for EA Pollution Inventory substances in English leachates) suggests that most contaminants were present at similar or rather lower concentrations compared with many other raw leachates. However, it should be noted that limits of detection (LOD) were generally rather high. For example, the LODs for metals were 50 µg/l, but the normal range for metals in other leachates reaches down to 8 µg/l. Thus, although some of the most harmful potential constituents of leachate (e.g. most heavy metals, phenols, most PAHs, PCBs, most organotins, endocrine disrupters, most pesticides, oils etc.) appeared to be absent, the relatively high LODs imply that some may nevertheless have been present at potentially harmful concentrations. This may, of course, not be a problem providing that the leachate receives proper treatment, but it implies the need for caution, and the application of stringent discharge standards. It should also be noted that these analytical data are just a snapshot in time. Given the notorious variability of leachate composition as the waste ages and as new waste is added, the discharge standards must therefore be framed in such a way as to account for the appearance of higher concentrations, or unexpected contaminants, in the future.

4.3 A further single sample of raw Derrinumera leachate taken in 2005 was analysed with somewhat lower LODs for a more limited range of determinands (Derrinumera EIS, 2007), and the data are summarised in Table 4.1. This also suggests that contaminant concentrations are generally low, but illustrates how they can change with time. For example, the mean zinc concentration in 2003 was 0.07 mg/l, but it had apparently increased by 2005 to 0.246 mg/l.

4.4 Limited toxicity data on the raw leachate (sampled in 2003) is provided in the Derrinumera EIS (2007). Acute toxicity data are available for the marine bacterium *Vibrio fischeri* ('Microtox'), the freshwater microalga *Pseudokirchneriella subcapitata*, the freshwater crustacean *Daphnia magna*, and juvenile rainbow trout (*Oncorhynchus mykiss*). The acute toxicity of the raw leachate (expressed as toxic units i.e. 100/EC50) was <2.2, 4.5, 1.4, and 4.2, respectively. This indicates that the acute toxicity was rather low in 2003, but of course gives no indication of how toxicity might change with time, and gives no information on possible chronic toxicity, including oestrogenic effects, for example. Once again, this implies a need for caution, both when setting discharge standards, and when designing the environmental monitoring programme.

4.5 It should be noted that, in addition to leachate, the Derrinumera plant (the sludge hub centre) will also be required to take up to 24,731 tonnes/annum of sewage sludge and 7,844 t/a of waterworks sludge for de-watering. The EIS states that the dried sewage sludge will be transported off-site for land-spreading, but the sludge water will be routed into the leachate treatment plant and subjected to the same clean-up processes as the leachate. No prediction of the contaminant concentrations in this water are provided in the EIS, but experience elsewhere suggests that it will be less contaminated than raw leachate, and it will therefore not be considered further in this report.

4.6 The proposed discharge standards for the treated leachate are shown in Table 4.2, together with the predicted concentrations in the initial mixing zone around the discharge, and relevant marine EQSs from other jurisdictions (for the protection of both humans and wildlife). In due course, the EQSs being developed under the Water Framework Directive will apply (with the aim of preventing any reduction in environmental quality), but these have not yet been finalised. At present, it is intended that the discharge will meet the standards of the Urban Wastewater Treatment Directive for BOD, COD, suspended solids, ammonia (as N), and faecal coliforms. In addition, the discharge will be intended to meet additional standards in order to protect the shellfish industry and wildlife in Newport Bay. This assessment has not examined the details of the preliminary hydrodynamic modelling used to derive the worst-case minimum dilution factor (18.6) to be expected outside the immediate mixing zone around the discharge outfall (20 x 20 m grid), but on the basis of experience elsewhere with estuarine discharges in relatively shallow waters such as those near the proposed outfall (3 m at low water mean spring tides), there is a high probability that 18.6 indeed represents a worst-case (i.e. for most of the tidal cycle, dilution will be much better than 18.6). This is supported by the validatory modelling which suggested that minimum dilution at the outfall site (Option A) would actually be a factor of 913. Given that the water in Newport Bay gets deeper and probably more turbulent as one moves offshore from the location of the proposed discharge, one would expect even greater dilution if the discharge were to be moved offshore to Option B, and this is borne out by the validatory modelling.

Table 4.1 Concentrations of the most important contaminants and other determinands measured in current raw Derrinumera leachate – samples taken in 2003 and 2005 (Derrinumera EIS, 2007).

Determinand	Mean concentration of 5 samples taken in 2003	One sample taken in 2005
pH	7.7	-
Dissolved oxygen (mg/l)	5.26	-
Aluminium (mg/l)	-	0.0782
Arsenic (mg/l)	<0.05	<0.001
Cadmium (mg/l)	<0.05	<0.0001
Chromium (mg/l)	<0.05	0.0119
Copper (mg/l)	<0.05	0.0539
Iron (mg/l)	4.49	-
Lead (mg/l)	<0.05	0.00246
Manganese (mg/l)	0.48	-
Mercury (mg/l)	<0.05	<0.000008
Nickel (mg/l)	<0.05	0.0352
Silver (mg/l)	-	<0.001
Zinc (mg/l)	0.07	0.246
Nitrate (mg/l)	5.54	-
Phosphate (mg/l)	0.52	-
Biochemical oxygen demand (mg/l)	179	-
Chemical oxygen demand (mg/l)	307	-
Cyanide (mg/l)	<0.05	<0.01
Fluoride (mg/l)	0.4	0.19
Total suspended solids (mg/l)	34.4	-
Faecal coliforms (no/100ml)	1397	-
Volatile organics (mg/l)	<0.001	<0.0001-<0.001
Phenols (mg/l)	<0.001	-
Endocrine disrupters (mg/l) (incl. *inter alia* nonylphenol, bisphenol A and dioxins)	<0.001	-
Total phthalates (mg/l)	<0.00001	-
Acenaphthene (mg/l)	0.000016	<0.00001
Fluorene (mg/l)	0.00002	<0.00001
Naphthalene (mg/l)	0.000064	<0.00001
Anthracene (mg/l)	0.000007	<0.00001
Phenanthrene (mg/l)	0.000035	<0.00001
Other PAHs (mg/l)	<0.00001	<0.00001
Other semi-volatile organics (mg/l)	<0.00001	-
Polychlorinated biphenyls (mg/l)	<0.00001	<0.000001
Chlorinated pesticides (mg/l)	<0.00001	<0.000001-<0.0000025
Acid and nitrile herbicides (mg/l)	<0.003	-
Triazine herbicides (mg/l)	<0.001	<0.00001-<0.0000488
Organophosphorus insecticides (mg/l)	<0.00001	-

Determinand	Mean concentration of 5 samples taken in 2003	One sample taken in 2005
Diesel-range organics (mg/l)	0.055	-
Mineral oil (mg/l)	0.024	-
Tributyltin (mg/l)	<0.00005	<0.000002
Triphenyltin (mg/l)	0.00012	-
Dibutyltin (mg/l)	<0.00005	-

Table 4.2. Proposed discharge standards and worst-case receiving water concentrations for Derrinumera leachate compared with environmental quality standards in other jurisdictions. At the bottom of the table are listed the important components of leachate that are not listed in the EIS.

Substance	Proposed discharge standards* for Derrinumera treated leachate (mg/l unless otherwise stated)	Predicted worst-case concentrations in receiving water post initial mixing zone (dilution x18.6) (mg/l unless otherwise stated)	English and Welsh marine EQS (mg/l as an annual average, unless otherwise stated) – Environment Agency	OSPAR ecotoxicological assessment criteria (mg/l dissolved) – Oslo and Paris Commission	United States chronic marine criteria values (mg/l dissolved) – US Environmental Protection Agency
Chromium (total)	0.03 (max) 0.015 (mean)	0.0016	0.005 (dissolved)	0.001 - 0.01	0.05 (chromium VI)
Nickel	0.05 (max) 0.025 (mean)	0.0027	0.015	0.0001 - 0.001	0.008
Copper	0.01 (max) 0.005 (mean)	0.00054	0.005	0.000005 - 0.00005	0.003
Zinc	0.2 (max) 0.04 (mean)	0.011	0.01	0.0005 - 0.005	0.081
Arsenic	0.04 (max) 0.02 (mean)	0.0021	0.025	0.001 - 0.01	0.036
Silver	0.01	0.00054	0.0005	-	-
Cadmium	0.005	0.00027	0.0025	0.00001 - 0.0001	0.009
Mercury	0.0004	0.00002	0.0003	0.000005 - 0.00005	0.00094
Lead	0.02 (max) 0.005 (mean)	0.0011	0.01	0.0005 - 0.005	0.0081

Substance	Proposed discharge standards* for Derrinumera treated leachate (mg/l unless otherwise stated)	Predicted worst-case concentrations in receiving water post initial mixing zone (dilution x18.6) (mg/l unless otherwise stated)	English and Welsh marine EQS (mg/l as an annual average, unless otherwise stated) – Environment Agency	OSPAR ecotoxicological assessment criteria (mg/l dissolved) – Oslo and Paris Commission	United States chronic marine criteria values (mg/l dissolved) – US Environmental Protection Agency
Ammonia (as nitrogen)	5	-	0.021 (un-ionised)	-	0.19-31 depending on temperature and pH
Polychlorinated biphenyls (sum of ICES 7)	0.0003	0.000016	-	-	0.00003
Phenol	0.00005	-	0.03	-	-
Benzene, toluene, ethylbenzene and xylene (BTEX)	Xylene 0.01 Toluene 0.01	Xylene 0.00054 Toluene 0.00054	Xylene 0.03 Toluene 0.04	-	-
Dichloromethane	0.01	0.00054	2.0	-	-
Cyanide	0.01	0.00054	0.001 (tentative)	-	0.001
Fluoride	1.5	0.081	5.0 (tentative)	-	-
Atrazine	0.001	0.000054	0.002	-	-
Simazine	0.001	0.000054	0.002	-	-
Tributyltin	0.000001	0.00000005	0.000002 (maximum acceptable conc.)	0.00000001 – 0.0000001	0.0000074
pH	7-9 units	-	6.0-8.5 units (95%-ile)	-	6.5-8.5 units
Chemical oxygen demand (COD)	125	-	-	-	-
Biological oxygen demand (BOD)	25	-	-	-	-
Suspended solids	35	-	-	-	-

Substance	**Proposed discharge standards* for Derrinumera treated leachate (mg/l unless otherwise stated)**	**Predicted worst-case concentrations in receiving water post initial mixing zone (dilution x18.6) (mg/l unless otherwise stated)**	**English and Welsh marine EQS (mg/l as an annual average, unless otherwise stated) – Environment Agency**	**OSPAR ecotoxicological assessment criteria (mg/l dissolved) – Oslo and Paris Commission**	**United States chronic marine criteria values (mg/l dissolved) – US Environmental Protection Agency**
Faecal coliforms	2000 per 100 ml	-	-	-	-
Colour	Deviation of <10 mg/l from background	Deviation of <10 mg/l from background	-	-	-
Salinity	<40 practical salinity units	2.15 PSU	-	-	-
Dissolved oxygen	≥ 70% (mean) 60% (min)	-	5%-ile value of 5.7 mg/l proposed under WFD	-	-
Some important pollutants in leachate not listed in the EIS discharge standards					
Pentachlorophenol	-	-	0.002	-	0.0079
Aniline	-	-	-	-	-
Phthalates	-	-	0.008 – 0.8	-	-
Benzene	-	-	0.03	-	-
Ethylbenzene	-	-	0.02	-	-
Nonylphenol	-	-	0.001	-	0.0017
Bisphenol A	-	-	-	-	-
Biphenyl	-	-	0.025	-	-

Substance	Proposed discharge standards* for Derrinumera treated leachate (mg/l unless otherwise stated)	Predicted worst-case concentrations in receiving water post initial mixing zone (dilution x18.6) (mg/l unless otherwise stated)	English and Welsh marine EQS (mg/l as an annual average, unless otherwise stated) – Environment Agency	OSPAR ecotoxicological assessment criteria (mg/l dissolved) – Oslo and Paris Commission	United States chronic marine criteria values (mg/l dissolved) – US Environmental Protection Agency
Mecoprop	-	-	0.02 (interim)	-	-
Naphthalene	-	-	0.005	0.005 – 0.05	-
Polycyclic aromatic hydrocarbons	-	-	0.00003-0.000002 depending on congener	0.000001-0.05 depending on congener	-

*based *inter alia* on the standards in Irish legislation – European Communities (Quality of Shellfish Waters) Regulations 2006, and the Urban Waste Water Treatment Regulations, 2001.

4.7 It is worth digressing briefly to explain how aquatic EQSs are derived. The general approach is described in Reiley *et al.* (2003) for the USA and Lepper (2002) for the European Union, but in essence they differ little. Separate EQSs are generally derived for each substance of interest, and are based on a large database of toxicity data. The usual approach for deriving a long-term EQS is to identify the lowest credible no-effect concentration from the chronic toxicity data, and then to apply a so-called assessment factor which takes into account such issues as the probability that more sensitive species than those tested may exist, the possibility of bioconcentration and biomagnification, and the availability of mesocosm and field data. Risks from bioaccumulation to human consumers of food such as fish are also accounted for. It is important to note that exceedance of an EQS does not necessarily imply that a problem exists, but it should trigger investigatory action. On the other hand, the conservative nature of assessment factors implies that if an EQS is complied with, the likelihood that a problem nevertheless exists is small.

4.8 The main weakness of the EQS approach to environmental protection, apart from the need for effective chemical monitoring of the environment, is that it usually only considers each substance on its own, and therefore may underestimate the effects of substances acting together in the complex mixtures which are the norm in most surface waters. It is therefore considered essential that monitoring should not only include chemical analysis of waters, but also holistic biological assessment (see monitoring section below).

4.9 Considering first the degree of stringency of the proposed discharge standards, it will be apparent from Table 4.2 that most of the predicted concentrations in the receiving waters of Newport Bay not only meet the standards in Irish legislation, but also meet those used by the England and Wales Environment Agency (EA), the Oslo and Paris Commission (OSPAR), and the United States Environmental Protection Agency (USEPA). Note that the OSPAR assessment criteria are only guidance for the interpretation of monitoring data, but the EA and USEPA EQSs are generally mandatory values for the protection of the marine environment as a whole. The two exceptions are copper and zinc, which both comply with the EA and USEPA EQSs, but do not quite meet the OSPAR assessment criteria. However, if one bears in mind that the extremely conservative OSPAR criteria are for guidance only, and that a significant proportion of 'dissolved' copper and zinc in estuarine waters will not be bioavailable due to complexation with dissolved organic matter or binding in colloids, the predicted concentrations are considered individually acceptable. Furthermore, the validatory modelling in the EIS suggests that the minimum available dilution at the outfall (x913) is actually 49 times greater than has been allowed for in the predicted exposure calculations in Table 4.2 (x18.6). This additional safety factor indicates that the risks of treated leachate causing environmental damage in Newport Bay are probably small (but see below).

4.10 Given the fact that predicted pollutant concentrations outside the mixing zone at the proposed discharge site (Option A at Rosmore) are likely to be below acceptable EQSs, the extra expense involved in locating the discharge further offshore (Option B at Muckinish) where dilution may be greater does not appear to be justified.

4.11 Of the substances with potential to bioaccumulate, the most important are mercury, the polychlorinated biphenyls (PCBs), and the polycyclic aromatic hydrocarbons (PAHs) (PAHs accumulate in some invertebrates, but not fish). However, all these compounds are predicted to be present at extremely low concentrations (indeed, they were largely absent from the raw leachate in 2003), and would therefore be expected to be metabolised sufficiently fast to avoid significant bioaccumulation or biomagnification. It should also be noted that the EQSs for all bioaccumulative substances are set lower than the toxicity data dictate in order to protect against bioaccumulation in shellfish and other organisms.

4.12 Of the substances/factors for which no standards are shown in Table 4.2, the most important in the context of Newport Bay are probably faecal coliforms which can accumulate in shellfish, and which are also a surrogate for other microbes such as pathogenic viruses. Faecal coliforms generally occur in both leachate and sewage effluent (mean of 1397 per 100ml in raw Derrinumera leachate 2003), and the EU Directive on the Quality Required of Shellfish Waters (2006/113/EC) recommends a guideline value for faecal coliforms in shellfish flesh and intervalvular liquid of ≤300 /100 ml. No value for coliforms in water is suggested in the legislation, but the target value in the EIS of 2000/100 ml in the treated leachate, if diluted by a factor of 18.6, gives a maximum predicted concentration in the receiving environment of 107/100 ml. Furthermore, the validatory modelling in the EIS suggests that faecal coliform concentrations outside the mixing zone will reach a maximum of only 1.8-19.4/100 ml. Faecal coliforms and most pathogenic viruses are rapidly killed under marine conditions, so the target value of 2000/100 ml for treated leachate is therefore probably sufficient to prevent harmful effects or bioaccumulation in shellfish.

4.13 It will be apparent from Table 4.2 that target concentrations for at least 11 important substances in leachate have not been considered in the EIS. These include nonylphenol, bisphenol A and the phthalates, which are all weak oestrogen mimics, and the polycyclic aromatic hydrocarbons (PAHs) which are highly toxic and potentially carcinogenic to some species. These appear to have been largely absent from the raw Derrinumera leachate in 2003, but note that LODs were rather high in 2003, and note also that concentrations are likely to change over time. There will be many more substances present at trace concentrations, many of which do not have an EQS or which exert negligible toxicity. The lack of EQSs may not necessarily be a problem, but it highlights the need for effective biological monitoring of the receiving waters, and possibly of the discharge itself (see below).

4.14 The probable presence of many organic substances in trace amounts will need to be considered by the regulatory authorities when specifying the type of treatment required for the leachate. This particularly applies to those substances such as oestrogen-mimicking endocrine disrupters which are extremely potent (at concentrations below the LODs in the raw leachate analyses conducted in 2003), and which can act additively in mixtures. The treatment technology will also have to be capable of coping with the expected large seasonal and longer-term variations in leachate quality caused by rainfall surges, landfill aging, etc. It is considered unacceptable that the EIS does not specify the optimum treatment method to be used, and there is no doubt that some of the alternative approaches (e.g. reverse osmosis or granular activated carbon) are likely to be much more effective than others (e.g. rotating biological contactors) at removing organic micro-contaminants. It is not suggested that relatively untried and potentially expensive treatment technologies such as ozonolysis or GAC filtration should necessarily be used for this purpose, but the expected presence of endocrine disrupters in the leachate, and its inherent variability, suggests the need for caution given the sensitivity of the receiving water. This report is unable to give detailed recommendations about the best treatment technology available, but experts such as the UK's Water Research Centre in Swindon would be able to advise.

4.15 It would appear from the EIS that it is proposed to tanker untreated leachate to the Westport sewage treatment plant in the event of equipment failure, and possibly also during the period of leachate treatment plant construction (this latter point is unclear). The EIS states that the Castlebar sewage treatment plant has been shown to be capable of handling the Derrinumera leachate, and that by extension, this will also be the case for the Westport plant. However, caution should be exercised with this assumption. Although no data are available about exactly how well Castlebar handled the leachate, it seems likely that the assessment only investigated its capacity to deal with a limited suite of contaminants. Furthermore, the EIS itself points out that the leachate will have to be treated with some fairly sophisticated technology (better than that used in a standard sewage treatment plant) in order to achieve the standards set out in Table 4.2. In consequence, if the Westport sewage treatment plant is to be expected to handle anything more than small amounts of leachate in emergencies, it would seem prudent to request that the discharge standards at Westport should be as stringent as those for the proposed Derrinumera plant. This would presumably involve the installation of improved treatment plant at Westport.

4.16 There is no doubt that an accidental discharge of untreated or poorly-treated leachate could have serious consequences for the fisheries and wildlife of Newport Bay. As well as causing oxygen sags leading to asphyxiation, this might well kill fish and shellfish through overt acute toxicity, and would certainly cause bioaccumulation of contaminants and micro-organisms. There would also be a risk of longer-term chronic effects (e.g. impaired reproduction), although as a spill would be expected to be transient, such effects might be avoided. For these reasons, and because of the strong likelihood of longer-term changes in effluent composition, it is vital that discharge quality in-pipe is monitored (both on a continuous basis for some easily measurable variable like conductivity, and approximately monthly for a larger suite of contaminants, in a more thorough way than proposed in the EIS), and essential that standby equipment and emergency leachate storage facilities are adequate to deal with equipment breakdowns. The daily maximum leachate volume (500 m^3) must be capable of on-site storage for as long as a potential equipment failure or maintenance downtime is likely to last, bearing in mind the presumably limited capacity for tankering the leachate off-site.

4.17 In summary, on the basis of the analytical data collected in 2003/2005, and the predicted chemical concentrations in the receiving environment, the risk of environmental impacts in Newport Bay caused by the proposed discharge of treated leachate (considered here in isolation from the sewage discharge) is considered to be acceptably small. However, given the limitations of EQSs, the relatively high analytical LODs in 2003, the variability of leachate, and the sensitivity and value of the receiving environment, it is essential that an effective environmental monitoring programme is implemented, and that such a programme should include both chemical and biological elements (see below). Furthermore, the secondary and tertiary treatment of the leachate should be designed in such a way as to remove as much of the organic micro-contaminants as possible from what will inevitably be a variable raw effluent, using best available technology, within reasonable cost limitations. Finally, it is considered essential to design the leachate treatment plant in such a way that spills to sea in the event of equipment failure are completely avoided.

5. Characteristics of the proposed Newport sewage effluent

5.1 The Newport sewage treatment plant will be designed to treat sewage originating from a relatively small number (2500) of population equivalents, using standard secondary treatment technology, with the addition of UV treatment to reduce faecal coliforms. The influent largely derives from domestic (1514) commercial (655) and institutional (208) population equivalents, with only 124 industrial population equivalents. As such, it is unlikely to contain large amounts of industrial chemicals, but no analysis of its present constituents, or predictions of its future composition, are provided in the Newport EIS (2007).

5.2 The EIS indicates that the present Newport sewage treatment plant is over-capacity, and the effluent quality is poor, approximating to raw sewage. The provision of secondary treatment will therefore lead to improved effluent quality. It is intended that the effluent will meet the standards laid down in the Urban Waste Water Treatment Directive, plus additional standards for ammonia-nitrogen and faecal coliforms. These standards are shown in Table 5.1.

Table 5.1. Standards to be applied to the treated Newport sewage discharge.

Determinand	Concentration
Biological oxygen demand	25 mg/l
Chemical oxygen demand	125 mg/l
Suspended solids	35 mg/l
Ammonia nitrogen	5 mg/l
Faecal coliforms	2000/100 ml

5.3 Comparison between Tables 4.2 and 5.1 shows that the 5 treated sewage standards are identical with those to be imposed on the treated landfill leachate. Of course, additional standards are also being applied to the leachate. The volume of the combined effluents will be 12.3 litres/sec, and the mean leachate volume will be approximately 3 l/s (~260 m^3/day), implying a treated sewage volume of approx. 9 l/s. If one makes the assumption that the contaminant concentrations in the treated sewage will be at least as low as those in the treated leachate, then the predicted environmental concentrations listed in Table 4.2 for the leachate should be attained by the combined discharge. However, in the absence of predicted contaminant concentrations for the sewage effluent alone, there remains some uncertainty about this. It would therefore be desirable to obtain, a) as complete an analysis as possible of the present Newport sewage effluent, and b) an assurance that the target contaminant concentrations in the treated effluent from the new sewage plant will be at least as stringent as those applied to the treated leachate.

5.4 Concerns about trace contaminants in treated sewage effluent are by no means theoretical. As described above, treated domestic sewage contains a large array of potential pollutants, including the factors of traditional concern shown in Table 5.1 (e.g. Hickey *et al.*, 1989), a wide range of inorganic substances (e.g. Neal *et al.*, 2005), and an even wider range of natural and synthetic organics (e.g. van Stee *et al.*, 1999). The organics include *inter alia* pharmaceuticals (Metcalfe *et al.*, 2003; Yu *et al.*, 2006), personal care products (Yu *et al.*, 2006), natural hormones (Matthiessen, 2006), and industrial chemicals, of which some are genotoxins, mutagens or endocrine disrupters (see section 3.8) that may be chronically toxic at very low concentrations. Modern secondary treatment of domestic sewage can reduce most (but not all) of these substances to negligible levels, but the Newport EIS (2007) makes no attempt to predict the concentrations which might appear in the proposed sewage effluent.

5.5 The environmental risks posed by a storm sewage overflow appear to have been adequately covered by the provision of storm balancing tanks in the plant design. In the unlikely event that these tanks cannot contain the overflow, resulting in a discharge of raw sewage, one would expect some reduction in receiving water quality (e.g. a reduction of dissolved oxygen due to increased BOD), although this is unlikely to be of poorer quality than that caused by the present poorly-treated sewage.

6. Likely environmental impacts of the combined effluents on marine fisheries and ecosystems

6.1 This assessment assumes that the predicted receiving water quality which will result from the treated leachate discharge (Table 4.2) also applies to the combined discharge as a whole. As indicated above, the Newport EIS (2007) does not make this issue entirely clear, although it is a not-unreasonable conclusion given the relatively dilute nature of most contaminants in treated domestic sewage.

6.2 The Newport EIS (2007) describes a reasonably thorough survey of present environmental conditions in Newport Bay. Although no rare species, or those of conservation interest, were recorded by this survey, the area is a candidate SAC, and the Burrishoole system is a world index site for wild Atlantic salmon. Furthermore, the fisheries in the Bay are worth €11m annually (2000 data), consisting mainly of farmed salmon (*Salmo salar*), rainbow trout (*Oncorhynchus mykiss*), native oysters (*Ostrea edulis*), Pacific oysters (*Crassostrea gigas*), mussels (*Mytilus edulis*), scallops (*Pecten maximus*), clams (*Tapes semidecussatus*), and abalones (*Haliotis tuberculata* and *H. discus hannai*). The surveys of wild invertebrates, which covered 14 stations in greater or lesser detail, indicate a system with satisfactory species diversity for the biotopes that are present, although there was some evidence of mild impact in the inner Newport Channel. The survey of fish species was rather sketchy, and it is therefore not surprising that few species were found. A more thorough fish survey would be desirable in order to provide satisfactory baseline data.

6.3 A summary of the contaminant concentrations reported in the Newport EIS (2007) for water, sediment, mussels and macroalgae from Newport Bay is given in Table 6.1.

Table 6.1. Contaminant concentrations in various compartments of Newport Bay.

Contaminant	**Water (µg/l)**	**Fine sediment (mg/kg dry wt.)**	**Mussel (*Mytilus edulis*) or oyster (*Ostrea edulis*) tissue (mg/kg wet wt.)**	**Macroalgae (*Fucus vesiculosus*) (mg/kg wet wt.)**
Arsenic	<20	4 - 13	<1	7 - 24
Cadmium	<4	<4	<4	<4 - 19
Chromium	<10	3 - 18	<1	<1
Copper	<10	1 - 9	<1 - 180	<1
Lead	<30	2 - 7	<1	<1
Mercury	<1	<1	<1	<1
Nickel	<10	3 - 18	<1	<1 - 4
Silver	<10 - 50	3 - 18	-	-
Zinc	-	24 - 160	15-640	11 - 49
Tributyltin	<0.5	<0.1	-	-
Organotins	-	<0.1	<0.1	<0.1
Lindane	-	-	-	-
PCBs (WHO list)	<0.005	<0.05	<0.05	<0.05
Anthracene	<0.1 – 0.1	0.1	<0.1	<0.1
Benzo(a)anthracene	-	0.01	-	<0.1
Benzo(a)pyrene	<0.1	<0.01	<0.1	<0.1
Chrysene	-	<0.01	-	<0.1
Fluoranthene	0.2 – 0.5	0.01 – 0.02	<0.1	<0.1
Naphthalene	<0.1 – 0.4	<0.1	<0.1	<0.1

Contaminant	**Water (µg/l)**	**Fine sediment (mg/kg dry wt.)**	**Mussel (*Mytilus edulis*) or oyster (*Ostrea edulis*) tissue (mg/kg wet wt.)**	**Macroalgae (*Fucus vesiculosus*) (mg/kg wet wt.)**
Phenanthrene	0.3 – 0.6	0.01	<0.1	<0.1
Pyrene	0.2 – 0.5	0.01 – 0.02	<0.1	<0.1
Semi-volatile organics	<10	<0.1	<0.1	<0.1
Phthalates	-	-	0.2 - 15	-
Organic pesticides	<0.01	<0.01	<0.01	<0.01
Total petroleum hydrocarbons	<0.1	<1 - 21	<1 - 8	<1 – 4
Octylphenol / nonylphenol	<10	<0.1	-	<0.1
Faecal coliforms	-	<1/g	1 – 540 cfu/ 10g	0 – 389 cfu/10g

6.4 These chemical and microbiological survey data show that, although the Newport Bay area cannot be considered completely pristine (few if any areas could claim this status), the measured contaminants suggest the system to be only moderately impacted at worst. The water appears to be generally of good quality, but there is some elevation of PAHs – these concentrations are not as high as the most contaminated sites in UK coastal waters (Law *et al*., 1997), but they are not negligible. Anthracene and fluoranthene exceed both the conservative OSPAR Ecotoxicological Assessment Criteria (EAC), and the UK annual average EQSs. On the other hand, the sediments are only slightly contaminated with PAHs, and none exceed the OSPAR EACs. Other contaminants in sediments also appear to be close to the OSPAR EACs. Copper was elevated in some shellfish samples, as was zinc, but concentrations generally were satisfactory. Faecal coliforms were elevated in shellfish and macroalgae taken from the vicinity of sewage outfalls, indicating the poor quality of present sewage treatment, although the area generally conforms to Class A shellfish water status.

6.5 In summary, therefore, the proposed discharge will be entering an area of considerable biological and commercial value, with relatively low contaminant levels, and it will clearly be important to avoid impacts on habitats, wildlife, or fish and shellfish quality/quantity.

6.6 It will be apparent from section 4 that the predicted environmental concentrations for a range of determinands are almost all well below EQSs (or their equivalents) applicable in the OSPAR area, the UK and the USA. This is due to the sensible decision to achieve shellfish and waste water standards in the treated (leachate) effluent before discharge. Furthermore, predicted concentrations of potentially bioaccumulable substances such as mercury and PCBs also meet available EQSs, and are all so low that it is not anticipated that these will build up to harmful levels in either wildlife or fisheries. On the face of it, therefore, there appears to be little overt threat to the Newport Bay system, even though the discharge will be entering relatively shallow waters north of the Rosmore peninsula. Moving the discharge offshore to Muckinish would reduce the small risk still further, as a result of improved dilution and dispersion, but there seems to be no clear reason for incurring this extra expense.

6.7 There are, however, three provisos which must be made to this relatively optimistic prognosis. First, as noted in section 4, EQS values are derived in isolation from each other, and although large assessment factors are used in their derivation, these may not always be big enough to account for mixture effects and other uncertainties. In particular, substances with similar modes of action tend to act together in an additive fashion – an example of which are the oestrogens and their mimics which act additively in fish (Brian *et al.*, 2007). It is therefore possible that some of the substances present at individually harmless concentrations may interact. Secondly, there will probably be many trace organic substances in the treated discharge (or at least in the raw effluents) whose environmental risk has not been assessed because their presence is not known. A few of these are listed at the bottom of Table 4.2, but there are likely to be many more. Some of these (e.g. the oestrogens and their mimics) are known to be present in sewage and leachate discharges, and are causing biological effects in rivers and estuaries around the world (e.g. Kirby *et al.*, 2004). Thirdly, storm water overflows and fluctuations in leachate quality may introduce unknown quantities of contaminants into the system.

6.8 It is thought that the first two of the three problems outlined above may not be of major significance for Newport Bay because in order to achieve the effluent contaminant concentrations listed in Table 4.2, it will be necessary to use very efficient treatment technology on the leachate (e.g. reverse osmosis or activated carbon) which will tend to remove most organic substances down to very low levels, not just those listed in the table. There is less of a need to install such efficient treatment technology at the sewage plant because the sewage is likely to be much less contaminated than leachate, although it will probably contain endocrine disrupters of human origin. It could be argued that these will already be entering Newport Bay in the presently poorly treated sewage, so if they are not currently causing environmental impacts, then they are even less likely to do so when the new plant is installed. The problems caused by accidental spills and storm water overflows may be partly averted by the proposal to warn aquaculture interests when such overflows occur. Well-designed discharge treatment technology must be capable of coping with such events, but the EISs do not go into sufficient detail on this issue. In view of the sensitivity of the receiving environment, the significant uncertainty described above is probably best addressed through a well-designed environmental monitoring programme.

7. Monitoring proposals

7.1 The Newport EIS (2007) makes some proposals for monitoring both the discharge itself, and the receiving environment. These proposals are, however, very sketchy and inadequate as they stand.

7.2 The quality of most leachates is known to vary rather slowly, over timescales of weeks or months (although some relatively minor hourly variation can occur) (e.g. Ragle *et al.*, 1995; Khattabi *et al.*, 2002). The proposal to conduct monthly chemical analyses of the discharge (with a 95%-ile pass criterion) therefore seems satisfactory as far as it goes, although the variability of the Derrinumera leachate should be checked before the monitoring frequency is finalised. However, the standards for the determinands to be monitored are not fully specified beyond the minimal list of BOD_5 (25 mg/l), COD (125 mg/l), ammonia N (5 mg/l), suspended solids (35 mg/l), and faecal coliforms (2000/100 ml). The EIS indicates that a longer list of chemical measurements and standards in the discharge is required, but does not specify these. This must be rectified.

7.3 Furthermore, this report considers that suitable bioassays should be used in addition to analytical chemistry to monitor the holistic properties of the effluent, given that its constituents are complex and cannot be predicted with certainty. Such bioassays could be simple acute *in vivo* toxicity tests (e.g. with microalgae and *Daphnia*), supplemented with rapid *in vitro* tests for key properties predictive of possible longer-term effects such as mutagenicity, genotoxicity, and oestrogenicity. Further guidance on appropriate bioassays can be found in Den Besten and Munawar (2005). Responses measured in such tests would give valuable early warning of possible effects in the environment, and could allow fine-tuning of the environmental monitoring programme in Newport Bay. It would be appropriate to conduct monthly effluent bioassays on the same samples used for chemical analysis.

7.4 The purpose of the treated leachate monitoring described above is to detect any long-term changes in quality due to alterations in the efficiency of leachate treatment. It is not primarily intended to detect catastrophic plant failures, or chemical spills. It should, of course, be standard practice for the plant operators to report such failures to the authorities as soon as they are aware of them. However, as a back-up, it would be desirable to continuously monitor some easily measured variable in leachate which would instantly reveal breakthrough of untreated effluent. Probably the simplest such measure would be conductivity, which can be continuously detected and logged using an electronic probe. One would expect continuous conductivity measurement (or some equivalent surrogate for leachate breakthrough such as chloride or ammonia) to be a standard feature of the effluent treatment plant.

7.5 Of even greater importance than the lack of bioassays of the effluent prior to discharge is the absence of detail in the proposals for monitoring the receiving environment. The Newport EIS (2007) calls for biannual (i.e. 6 monthly) monitoring of waters, sediment, fish and shellfish tissue at 4 stations (Clew Bay north; Burrishoole Channel; Rosmore Peninsula; plus a 'control' site to be chosen) *"having regard to the analytes specified in Appendix 18"*. Unfortunately, Appendix 18 appears to be blank. However, elsewhere the EIS states that *"when assessing the results from the biannual monitoring programme..., the following 'early warning limits' as specified ...in Table 2.5.2 - Proposed Screening Limits for Receiving Environment – will be referenced..."*. The meaning of this statement is unclear (i.e. what is meant by 'will be referenced'?), and consideration of Table 2.5.2 of the EIS reveals that the so-called screening criteria for receiving waters are identical with the contaminant concentrations to be achieved in the treated leachate (not in the environment). They are derived from the Irish European Communities (Quality of Shellfish Waters) Regulations, 2006, and the Water Quality (Dangerous Substances) Regulations, 2001, but in view of the sensitivity of the receiving environment, some of the screening criteria are probably not sufficiently low to protect all biota. It is considered important that the analytical methods employed should be sufficiently sensitive to permit quantitation of the predicted environmental concentrations in the vicinity of the discharge (i.e. for waters, the concentrations shown in the third column of Table 4.2).

7.6 The main point of chemical monitoring is to establish if the proposed discharge causes any decline in environmental quality, irrespective of whether standards are being exceeded. It should be noted that the receiving environment is not pristine, so some variables will probably exceed satisfactory limits before discharge commences, but it must be demonstrable that these variables do not deteriorate further. However, there are currently insufficient baseline data to permit a statistically valid before-and-after comparison. It will therefore be essential to conduct further monitoring for the agreed determinands before the discharge begins. The frequency of such monitoring must be determined partly in the light of measured variability, so that any deterioration in environmental quality can be detected with an agreed probability of error and with minimum effort. However, if the long-term monitoring is to be conducted biannually (probably the minimum acceptable frequency, although 4 times per year would be ideal), it will be necessary to establish a pre-discharge baseline using samples also taken at least biannually over about 3 years.

7.7 The proposals implied in Table 2.5.2 of the Newport EIS (2007) to monitor the faecal coliform counts in water and shellfish and the organoleptic properties of shellfish, are sensible as a precaution to protect human consumers. However, as with the chemical measurements, there are insufficient baseline data to establish whether change takes place after the discharge begins.

7.8 The largest gap in the environmental monitoring proposals is the almost complete lack of biological measurements, with the exception of unspecified 'health' assessments of plaice or flounder. For the reasons outlined above, simple chemical monitoring is insufficient given the probable complexity of the proposed discharge, which opens the possibility of additive interactions and effects due to unmonitored substances. What is needed, therefore, is a biological monitoring programme which uses holistic measures of impact, as well as 'early-warning' biomarkers for specific chemical classes of concern. As with biological measures for monitoring the discharge itself, useful guidance can be obtained from Den Besten and Munawar (2005).

7.9 Given the importance of shellfish in Newport Bay, it will probably be sensible to build a biological monitoring programme primarily around molluscs. The species used most frequently for this purpose in Europe and elsewhere is the blue mussel *Mytilus edulis*, which is widespread in the Bay. A number of measures of chemical effect in mussels are available for routine use, but probably the most appropriate in the present context is scope-for-growth (SFG) (e.g. Widdows *et al.*, 2002). This essentially measures the energy left over for growth after repair of tissues damaged by pollution, and also allows identification of the probable causative substances through analysis of soft tissues (which will be taking place anyway as part of the chemical monitoring programme). SFG is reasonably simple to measure, is directly related to a property of interest to shellfish farmers (i.e. growth potential), and forms part of a suite of biological monitoring tools approved as part of the OSPAR Joint Assessment and Monitoring Programme (JAMP). Another useful and sensitive biological endpoint in mussels is lysosomal stability (e.g. Fernley *et al.*, 2000), in which the ability of blood cells to deal with invading micro-organisms etc. is impaired by many pollutants. This is also recommended by JAMP as a holistic measure of chemical effect. If either measure is observed to deteriorate, it provides a very useful early warning of subsequent damage at the ecosystem level, allowing remedial action before serious damage occurs.

7.10 The proposal to monitor fish disease has some merit, particularly if significant concentrations of planar organic molecules such as PAHs and PCBs are detected in the treated effluent. Various diseases of flatfish, for example, are good indicators of generalised environmental stress, and the appearance of certain liver lesions is a marker for the effects of PAHs and PCBs (e.g. Stentiford *et al.*, 2003). However, given the cost of fish sampling (fish must be captured by trawling, and tissues processed immediately after capture), a focus on mussels would probably be more cost-effective.

7.11 As well as these holistic measures of effect, specific responses to certain key contaminant classes should also be considered for inclusion in a biological monitoring programme, again as early warnings of more serious long-term impacts. Perhaps the most important of these is the induction of a protein called metallothionein (in fish or bivalve molluscs) which is caused by a suite of heavy metals (e.g. Mourgaud *et al.*, 2002). Although this biomarker does not provide much information about effects on the whole organism, it does give a holistic response to bioaccumulated and bioavailable metals (i.e. those not complexed or in colloidal form) which allows a judgement of whether any metal EQS-exceedance has the potential to cause harm. An equivalent and useful measure of exposure to toxic hydrocarbons such as PAHs and PCBs is induction of an enzyme known as cytochrome P450 1A1 (or EROD) in fish such as dab (*Limanda limanda*) (Lyons *et al.*, 2000). Finally, the widespread contamination of sewage discharges with oestrogens and their mimics is causing feminisation of fish in many estuaries, and a sensitive measure of exposure to these substances is induction of the yolk protein vitellogenin (VTG) in males (Kirby *et al.*, 2004). This has been measured successfully in estuarine fish such as flounder (*Platichthys flesus*) which are almost certainly present in the Newport Bay system. It gives early warning of more serious effects such as the appearance of eggs or oviducts in the testis (ovo-testis, or intersex) which probably impairs reproduction.

7.12 Ultimately, it becomes important to know whether the ecosystem as a whole is being damaged by a new discharge, although use of the early-warning measures described above will hopefully trigger remedial action that will avoid such damage. The most effective approach is to measure the biodiversity of the benthic macro-invertebrate community in fine sediments (e.g. Waldock *et al.*, 1999), and it is recommended that this approach is taken in Newport Bay.

7.13 As with chemical contamination, measures of biological effect must be compared with the situation before the discharge commenced in order to establish with reasonable confidence whether a change has occurred. Although limited benthic community data are available for Newport Bay in the EIA, these are insufficient as a baseline, so it will be important to gather sufficient new biological data over at least three years before the discharge begins. Again, frequency of sampling will be driven by the variability of the endpoints being measured, and the confidence with which changes need to be detected.

7.14 The monitoring programme should include regular reviews, to ensure that sampling and analysis are being conducted efficiently and at reasonable cost. If no biological responses to the discharge are detected over a period of several years, it may be possible to reduce sampling intensity safely. However, the probability that discharge quality will vary unpredictably in the long term implies that biological monitoring should never be completely dispensed with.

7.15 It is considered essential for contractors to be asked to draft a professional chemical and biological monitoring programme, along the lines indicated above, which can then be agreed with the various stakeholders. The two key points are the need to establish a reliable baseline before discharges begin, and the need to include holistic measures of biological impact. It is noted that the EIS stipulates that all monitoring data should be forwarded to the Irish Environmental Protection Agency, but it is important to ensure that the deadlines for such reporting are sufficiently rapid to permit potential remedial action. Furthermore, it is recommended that other stakeholders (e.g. aquaculture operations in Newport Bay) should also have ready access to the data once it has been validated by the EPA.

7.16 It is clear that more intensive environmental monitoring than biannually would be required in the event of an accidental spill of untreated effluent, or a storm surge which causes unavoidable release of untreated effluent that overtops the balancing tanks. Procedures for dealing with emergencies such as this are poorly described in either EIS, although it is understood that balancing tanks for holding untreated effluent will be provided. It is therefore important that a detailed plan for monitoring after emergencies is also drawn up in advance and included in the Emergency Plan, so that time is not lost if it has to be implemented.

7.17 Finally, it is worth pointing out that the commercial viability of fisheries such as those in Newport Bay can be seriously damaged if the public perceives (rightly or wrongly) that a waste discharge is putting their health at risk. Although the risks to the public of bioaccumulated contaminants or 'off' flavours in shellfish are expected to be adequately managed by the environmental standards and monitoring programme proposed, it will nevertheless be important to ensure that this is communicated effectively to all stakeholders. A commitment to complete transparency concerning prompt publication of monitoring data is one way to ensure good public relations in this respect.

8. Conclusions

8.1 The individual predicted concentrations of contaminants in the receiving waters of Newport Bay are not considered to pose a significant threat to wildlife or fisheries (or by implication, to human consumers), either in terms of toxicity or potential bioaccumulation.

8.2 Although environmental risks could probably be reduced still further by moving the discharge outfall offshore to Muckinish (Option B) or beyond, the low predicted risks for Option A (Rosmore) would not appear to provide sufficient justification for this.

8.3 However, the proposed discharge is a chemically complex one, and one cannot rule out the possibility of mixture effects, or of effects caused by substances not considered in the EIS. The discharge is also likely to be temporally variable on a timescale of months and years. Given the sensitivity of the receiving environment, these possibilities should be adequately addressed through monitoring.

8.4 It is therefore essential to put in place a robust monitoring programme for both the discharge and the receiving environment. However, the proposed monitoring as set out in the Newport EIS (2007) is not properly thought-through, and requires establishment of both a better pre-discharge baseline, and the inclusion of measures of biological effect.

9. Recommendations

9.1 Certain key substances present in most leachates (e.g. nonylphenol, bisphenol A, phthalates, PAHs) need to be included in the chemical monitoring programme, and predicted concentrations of these substances in the receiving environment calculated.

9.2 A revised EIS should include a fuller discussion of the most appropriate (best available) treatment technology for the leachate. Bearing in mind the probable presence of variable amounts of many organic substances with the potential to cause long-term toxicity at low concentrations, it is recommended that the technology should be capable of removing such substances to low levels. Granular activated carbon filtration is a possible approach, but this assessment is not able to give firm recommendations about this.

9.3 If it is proposed to use the Westport sewage treatment plant to handle Derrinumera leachate for more than brief periods during emergencies (e.g. for the whole period of plant construction at Derrinumera), then similar discharge standards to those proposed for Derrinumera should be applied at Westport. This implies the probable need for improved treatment plant at the latter site.

9.4 Given the potential environmental consequences of a spill of untreated leachate, it is essential that expected leachate volumes are capable of storage on-site in the event of equipment failure or maintenance downtime. However, the plant should be engineered in such a way as to make an accidental spill virtually impossible.

9.5 The available information about the action plan in event of emergencies (i.e. accidental spills and storm overflows) is not sufficiently detailed. Indeed, there appears to be no properly set-out Emergency Plan in either EIS, which is not acceptable for a development of this size.

9.6 It would be helpful for an improved risk assessment if a full chemical analysis of the existing Newport sewage effluent is conducted (or obtained) as soon as possible. Predicted concentrations of contaminants in the proposed new sewage effluent should also be provided, together with predicted concentrations for the combined sewage and leachate effluent. For the purposes of this report, the assumption is made that contaminant concentrations in the combined effluent will be no higher than indicated for the treated leachate alone, and while this is not unreasonable, it requires confirmation.

9.7 The baseline survey of organisms and contaminants in Newport Bay is insufficient to act as the basis of a long-term monitoring programme. Further baseline surveys are essential if the monitoring programme is to have the power to detect significant changes with an acceptably low risk of false negatives. The baseline fish survey is particularly inadequate as it reported the presence of hardly any species.

9.8 The proposed monitoring programme itself is inadequate and should be fleshed out in much more detail. First, monitoring of the effluent prior to discharge should include some biological measures of holistic chemical effect, in order to account for substances unsuspected in the EIS. Secondly, the levels down to which contaminant concentrations in the receiving environment are analysed need to be clarified – it is insufficient to set limits of detection at the concentrations predicted for the undiluted discharge. Thirdly, and crucially, it is considered essential for a suite of biological measures of pollutant effect to be conducted in molluscs (probably wild mussels), and for holistic measures of ecosystem impact (probably benthic macro-invertebrate biodiversity) to be made.

9.9 Contractors should therefore be asked to draft proposals for a much more professional monitoring programme which can then be discussed by stakeholders. This programme should include details of how to monitor in the aftermath of an unplanned spill or storm surge.

9.10 Finally, it is recommended that the results of monitoring should be reported to the Irish EPA as soon as they become available, and should be released to other stakeholders once they have been validated. Such a commitment to full openness will help to reassure the public that the proposed discharge will not pose a risk to human health or the environment.

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11. Glossary

activated carbon	A form of charcoal with large internal surface area suitable for filtering organic compounds from water by adsorption
acute toxicity	Toxicity caused by short-term exposure to a substance
benthic macroinvertebrates	The larger invertebrates living on or in the seabed

bioaccumulation	The accumulation of a substance in an organism from all sources
bioassay	A test for toxicity using a tissue culture or whole organism
bioavailable	The fraction of a contaminant which is present in the environment in a form which can be taken up into organisms
bioconcentration	The accumulation of a water-borne substance in an organism via its gills and/or body surface
biomagnification	The increase in concentration of a substance in organisms as one moves higher up the foodchain
biomarker	A change in an organism which reveals exposure to, or the potential effects of, a contaminant or contaminants
biotope	A habitat feature such as saltmarsh
BOD	Biological oxygen demand – the ability of a substance to cause decreases in dissolved oxygen due to its ability to encourage microbial blooms
CFU	Colony-forming units
chronic or long-term toxicity	Toxicity caused by exposure to a substance for a period which is a significant fraction of the affected organisms life cycle
COD	Chemical oxygen demand – the ability of a chemical to react with dissolved oxygen, hence causes oxygen sags in receiving water
colloids	Suspensions in water of very small particles which are too small to separate or be filtered out.
EA	England and Wales Environment Agency
EAC	Ecotoxicological Assessment Criteria – a type of EQS
EIS	Environment impact statement
endocrine disruption	Chemical interference with the normal operation of the hormone system of animals
EQS	Environmental quality standard
EROD	Ethoxyresorufin-o-deethylase – an enzyme used in the detection of exposure to planar organic pollutants such as PCBs
EU	European Union
faecal coliforms	A group of harmful bacteria found in sewage
genotoxicity	The ability to damage genetic material
intersex	Having features of both sexes
in vitro	Outside the living organism e.g. in a test tube
in vivo	In the living organism
JAMP	Joint Assessment and Monitoring Programme of OSPAR
leachate	The liquid which drains from landfill
LOD	Limit of detection
lysosomal stability	A measure of cellular damage by chemicals
mesocosm	A model ecosystem

mg/l	Milligrams per litre
mutagenicity	The ability to cause mutations
oestrogenic	Having actions similar to or identical with the female hormone oestradiol.
organoleptic	Taste/smell
OSPAR	Oslo and Paris Commission
ovotestis	The presence of eggs in the testis
ozonolysis	The use of ozone to degrade organic substances in sewage, and to sterilize it
PAH	Polycyclic aromatic hydrocarbons – toxic substances derived from combustion and oils
PCB	Polychlorinated biphenyls – highly persistent and bioaccumulative substances that can cause chronic toxicity
pH	A measure of acidity – values below 7 indicate an acid medium
PSU	Practical salinity units
reverse osmosis	A form of filtration based on membrane technology
SFG	Scope-for-growth - a holistic measure of pollutant impact in an organism
µg/l	Micrograms per litre
USEPA	United States Environmental Protection Agency
UV	Ultra-violet radiation
VTG	Vitellogenin – a yolk precursor protein
WFD	EU Water Framework Directive