SECTION THREE

GUIDELINES FOR POINT SOURCE DISCHARGE INTO THE MARINE PARK

INTRODUCTION

A number of important sources of nutrient discharge into the Marine Park are known. These include sources originating both within and outside the Marine Park. An approach to regulating those sources outside of the Marine Park need to be developed by industry itself or by Queensland government agencies. The Authority will work with those agencies where it can make a contribution.

As discussed in the previous section, sources of discharge within the Marine Park can be controlled by a variety of mechanisms available to the Authority, including education, specific permit conditions, regulations and reliance upon international conventions such as MARPOL. This section focuses on guidelines for waste discharge permits, as a prime mechanism for control of waste discharge into the Marine Park.

To date, assessment of new permits for waste discharges into the Marine Park has been undertaken in consultation with QDEH. Existing permits for the discharge of sewage into the Marine Park have utilised standards applied by QDEH. These standards address the location of outfall pipes, diffusion rates, non-filtrable residue (NFR) levels, biological oxygen demand (BOD) and disposal of sludge.

Although in some instances increasing BOD levels can be correlated within increasing stress symptoms on coral reef communities (Tomascik et al, 1985), often there is no relationship. For example, studies in Kanoehe Bay showed that sewage discharge had not markedly affected dissolved oxygen or BOD outside the immediate areas of discharge, yet there was significant coral mortality away from the outfall (Banner, 1974). In addition, it has been suggested in one study that BOD measurements do not adequately assess the environmental impact of sewage effluent because of important limitations on the BOD test. These are: it does not indicate the presence of organics which are not degraded under the prescribed conditions; it assumes that no toxic or inhibitory materials will affect microbial activity; and it does not measure the nitrogenous oxygen demand of the organic waste (Water Quality Criteria, 1972; Bell et al, 1987b).

Guidelines need to be adopted by GBRMPA that take into account concerns for nutrient effects on reef biota. These guidelines need to provide clear direction for those applying for waste discharge permits and for those assessing such applications.

Point source discharges into the Marine Park are primarily from:

. resorts or research stations on high islands or cays,
. coastal discharges from small communities, marinas or resorts,
. fixed structures such as floating hotels and pontoons.

The latter, due to usually being located on the lee of reefs having poor circulation characteristics and in locations not adapted to high nutrient loads , should not be permitted to discharge into surrounding waters. In event of any permit applications for discharge from fixed structures, reference should be made to management and monitoring criteria applied to John Brewer Reef Floating Hotel. This type of discharge will not be discussed in greater detail in this paper.

FACTORS TO CONSIDER IN DEVELOPMENT OF GUIDELINES

The objective of these guidelines is to minimise effects of nutrients from point source discharge on reef biota through maintaining or improving quality of receiving waters.

and odours. Septic systems tend to become saturated after a few years with a subsequent decrease in efficiency and possible groundwater contamination.

Septic systems are not recommended at any resorts due to potential odours, possible groundwater contamination and lack of treatment for nutrients.

Secondary treatment

The breakdown of most organic waste to more simple compounds by oxidation, through bacterial or chemical action, such as activated sludge. The activated sludge process involves pumping of settled sewage into aeration tanks, oxidation, then sedimentation. The excess activated sludge is anaerobically degraded in digestion tanks (Higgins and Burns, 1975).

Secondary treatment involving biological breakdown of waste, does not significantly reduce the nutrient concentration of the effluent stream, but reduces suspended sediments (SS) and biochemical oxygen demand, (BOD, a measure of biodegradable organics).

For example, phosphorus reduction in conventional secondary biological treatment processes was found to be limited in the Gold Coast region, where there was an average total phosphorus concentration of approximately 6.8 mg/l in raw sewage compared to 5.6 mg/l in treated effluent (Camp et al, 1976). The latter is considered typical for conventional activated sludge process effluents.

Tertiary Treatment

A further stage of processing may include near elimination of bacteria by chlorination or ultraviolet radiation, filtration, and/or the removal of nutrients to some degree.

Chlorination is the most generally accepted method for effluent disinfection for protection of public health, through reduction of coliform bacteria, an indicator of possible faecal contamination. Chlorination has been found to have little effect on some pathogens such as enteroviruses and parasitic worms. Modifications of chlorine application practices may be needed to protect marine biota if residual chlorine or organic chlorine effects are shown to persist in the receiving waters. One possible method of chlorine residual elimination is by dechlorination processes prior to effluent discharge. This usually involves either use of sulphur dioxide or activated carbon (Camp et al, 1976).

An alternative method of removing almost all human bacteria and viruses is by means of multicell stabilisation ponds with a 20 day day retention time. These are low cost, relatively easy to operate and can produce an effluent suitable for irrigation of even vegetables (Falkenmark, 1987). Possible use of this system on islands is limited due to space requirements.

Two systems are commonly in use as a means of polishing the effluent after secondary treatment. They are capable of achieving an effluent quality of 5 mg/l BOD and 5 mg/l suspended solids. They are however somewhat limited in their effectiveness at removing nutrients. Filtration removes suspended matter from water by passage through a porous substance, usually sand.

Activated carbon removes organic contaminants from water by adsorption and is especially effective at removing dissolved organic compounds including many which are non-biodegradable.

Nutrient Removal: Control of Nitrogen and Phosphorus in Effluent Discharge

An advantage to removing nutrients is that it can reduce turbidity to low levels which can be important for recreational/tourist areas.

Removal of nitrogen can be accomplished by chemical or biological means. The chemical methods used are breakpoint chlorination, ammonia stripping, and ion exchange while biological N removal involves nitrification/denitrification. The latter system is expected to achieve greater overall N removal and is the system most commonly used. (Australian Environment Council, 1987). Nitrogen concentration in effluents from correctly designed and operated plants would generally lie in the following ranges:

organic N 1-3 mg/l
ammonia N 0.5-1.5 mg/l
nitrate N 2-7 mg/l.

Phosphorus may be removed from wastewater by chemical, biological or combined chemical/biological means. Chemical P removal is generally achieved through precipitation of P using the mineral salts (aluminium sulphate, ferrous and ferric chloride and sulphate, and sodium aluminate) and/or lime. Iron-based chemicals are not recommended due to significant carryover into effluent resulting in discoloration and possible effect on biota.

Biological P removal involves a process modification to the activated sludge process such that organisms that are able to take up P far in excess of their normal growth requirements are encouraged to proliferate within the activated sludge. It is relatively new technology.

The chemical process for P removal is more commonly used and produces a more consistent effluent quality, achieving P reduction of up to 95% or P levels of 1-2 mg/l and possibly as low as 0.1-0.2 mg/l.

The disadvantages of chemical P removal are listed as:

- high level of personnel expertise
- recurring chemical costs
- increase in effluent salinity (should not be a great problem for marine waters)
- alkalinity reduction
- increased sludge production, although this can vary greatly. (AEC, 1987)
- care in use of mineral salts to minimise effects on reef biota.

Biological treatment to remove nitrogen from effluent (dentrification) and chemical treatment to remove phosphorus are, at present, the best methods to use at small scale treatment plants typical at resorts. Capital costs are estimated at approximately 20% higher than secondary treatment (D Barnes, pers. comm.). However, nutrient removal requires specialised maintenance, incurring extra costs for trained personnel and operating expenses (chemical additives).

Phosphorus input can also be controlled at source. Approximately one half the phosphorus in sewage results from the use of detergents and shampoos (Bell et al, 1989). If adopted discharge standards required low levels of P, considerable cost savings in the disposal of sewage effluent would be achieved if this source were reduced by substituion with phosphorus-free detergents. If secondary treatment only was required, controlling phosphorus input at source would still be advantageous to receiving waters.

Sludge Treatment

A major by-product of any level of sewage treatment is a sludge fraction. Collected sludge is less than 1% of effluent volume but contains very high concentrations of nutrients (Bell et al, 1987). Some plants have the ability to treat sludge by digestion to reduce organic material.

Wet sludges are often partially dewatered in order to reduce the bulk of the solids producing more easily and economically handled material for final disposal. The various methods used to dewater sludge in approximate order of simplicity and economy are: sludge lagooning, drained drying beds, vacuum filter dewatering, filter pressing centrifugal dewatering, and one of the aforementioned followed by incineration (Camp et al, 1976). Each of these have their own advantages and would need to be evaluated in terms of space available, likelihood of odour problems and air emissions, and logistics of removal.

EFFLUENT DISPOSAL

Land Disposal of Treated Effluent

Land disposal of treated effluent may be an economically attractive means of water conservation while reducing the nutrient load to some degree. Many of the tourist islands experience some difficulty in obtaining adequate quantities of good quality water. Land disposal of effluent may assist in irrigation of landscaped areas in some cases. The potential for land disposal of treated effluent by irrigation is under-utilized at almost all resorts. The following resorts are presently using effluent for irrigation to at least some extent:

Hayman Island
Contiki Whitsunday (Long Island)
Brampton Island
Dunk Island.
Lady Elliott Island

The following resorts have potential for disposing of a significant proportion of treated effluent via irrigation:

Lindeman Island (could use 100%)
South Molle Island
Hamilton Island
Hinchinbrook Island.

Other existing resort islands are constrained in some manner, such as lack of available area or unsuitable terrain (eg Bedarra and Green Islands).

The relative sensitivity of water quality parameters as indicators of eutrophication in the Kaneohe Bay Study were found to be, from most sensitive to least: Chlorophyll a, inorganic phosphorus, particulate nitrogen, adenosine triphosphate, with secchi disc, particulate inorganic and organic carbon, ammonium, inorganic nitrogen, nitrate and nitrite being relatively insensitive (Laws and Redalje, 1979).

Based on studies reviewed, it is likely that nutrient levels (total phosphorus and total nitrogen) elevated to two or three times the normal ambient levels can cause increased primary production and biomass in both phytoplankton and benthic algal populations, affecting coral nutrition, growth and survival (Bell et al, 1987b).

Tolerance levels are usually arrived at on the basis of estimates from extrapolation of lethal levels; estimates from field observations; and estimates from the absence of sublethal or chronic effects in laboratory tests. Bell et al (1987b) estimate tolerance levels for coral reefs based on sublethal limits determined by direct observation or extrapolation of results from reef studies or in their absence, application factors recommended by the USEPA for marine waters, based on reef organism LC 50's where possible. Table 9 provides an estimation of their proposed tolerance levels for coral reefs to a number of water quality parameters. It must be noted that there is a need for verification of these estimates.

Though this provides a starting point for discussion, it is generally acknowledged that a widely applicable tolerance level of corals to water quality parameters is difficult to establish. Ambient water quality levels vary according to reef and position on reef, with individual coral assemblages adapted to their surrounding waters. In addition, different species of corals appear to be more tolerant to variations in water quality than others.

As the levels of nutrients in tropical waters are very low, they are difficult to accurately and consistently measure. In the interest of keeping the Tables in this report clear in terms of the message presented, standard deviations have not been presented. By referring to the original studies one can see that standard deviations for such measurements are frequently as high as .50. Care must also be taken to standardise weather conditions during sampling if possible. Turbulence and mean residence times of waters have a strong influence on the uptake of nutrients and the type of algae that will grow.

Bell et al (1987b) proposed that water quality standards be determined in relation to background levels and a 10% increase over background levels. So in reference to Table 9, measuring 2 times the ambient levels of nutrient may be difficult to achieve, let alone a 10% increase. A huge number of samples would be required to achieve statistical validation.

Required Dilution Factors

The required dilution factors for a number of the components of primary, secondary and tertiary treated domestic sewage to meet criteria recommended by Bell are given in Table 9. The levels of dilution required for phosphorus and nitrogen are particularly high. It is clear that if the dilution criteria for the nutrients are met then the criteria for all other components, both major and minor, should easily be met. However, it is stressed here that even the proposed required initial dilution factor for tertiary treated sewage is an order of magnitude greater than is normally achieved with conventional marine outfall systems.

Sewage Sludge Disposal

Due to the fact that sewage sludge tends to concentrate many harmful constituents (eg. heavy metals, toxic organics, nutrients), discharge of sludge to the marine environment should never be considered as a disposal option. Land disposal of sludge on some island resorts is currently practised. Spreading the digested sludge over dry land is an acceptable method of disposal on the mainland given certain conditions. However, there may be a lack of suitable land on many resort islands. This option needs to be looked at carefully as there is potential for sludge to be a significant source of pollution of the groundwater, surface water and ultimately marine water.

Nutrient removal results in sludge that is denser than secondary sludge but is not much greater in volume (D Barnes, pers. comm). Consequently, disposal of sludge should not be an increased problem as a result of nutrient removal. Removal of sludge to the mainland is preferable.

NUTRIENT REMOVAL REQUIREMENTS ELSEWHERE

The following three examples of government adoption of nutrient removal standards are of interest. The Australian example of Kosciusko National Park illustrates feasibility of adoption of such processes in conditions similar to many GBR resorts but also the difficulties of technically achieving the desired results. The example of Cyprus is logistically similar in many ways to Barrier Reef resort islands, but is all the more impressive in that tertiary treatment costs are being accepted by tourist complexes in an undeveloped country in order to maintain environmental quality. The third example that of Sweden, is provided as an example of where tertiary treatment processes have been widely in use in urban areas for ten years but are not seen to be achieving the objectives.

Kosciusko National Park

Nutrient removal is a standard condition of discharge in Kosciusko National Park, New South Wales. Other than the colder climate making nutrient removal technically more difficult to control, conditions are similar to those applying to many GBR resorts: remoteness, cost of transport, personnel previously untrained in sewage treatment, peak use periods resulting in fluctuating flow volumes (J Davis, pers.comm.).

The draft Kosciusko stream quality report based on surveys conducted during 1980 and 1981, found that most impact on the streams was caused by sewage discharges rather than diffuse pollution from the villages. It also found that the stream water quality below the sewage outfalls was poor, especially with respect to nutrients (total nitrogen, ammonia, and phosphorus), and faecal coliforms, and that such discharges were not consistent with the desired water quality objectives.

At that time most of the sewage treatment works in the area provided secondary treatment with little or no disinfection and no nutrient removal, while some relied on disposal by septic tanks and absorption trenches. Licences required a 20/30 effluent standard.

In 1984 existing sewage treatment facilities were reviewed in line with desired water quality and it was decided that new sewage treatment augmentations should be designed to meet the following effluent criteria and that existing treatment works should be upgraded within a reasonable time to comply with these standards:

20 mg/l BOD
30 mg/l NFR
10.0 mg/l NO_2 plus NO (N_3)
1.0 mg/l total P
0.5 mg/l NH_3(N)
not greater than 200 faecal coliform per 100 ml
6.5 - 8.5 pH

All sewage treatment plant augmentations have incorporated intermittent extended aeration treatment, use of an anoxic inlet zone to assist sludge formation and denitrification, chemical dosing for nitrogen and phosphorus removal, and ponding as well as ultraviolet disinfection of final effluent. Other safety features have been included such as standby pumps and back up diesel power and a full telemetering alarm system.

The status of treatment plants for this area which either have been, or are to be, upgraded is summarised in Table 10. The licence conditions for Perisher Valley Sewage Treatment Plant, for example, require, among other things, the monitoring of pH, BOD, NFR, ammonia, total P, nitrate plus nitrite determined on a representative sample on a monthly basis between July and September and three monthly between October and June. Data indicates that there are still problems at some of the recently augmented works but it is hoped that these will be rectified by the 1989 season (State Pollution Control Commission, 1988).

Cyprus

An overseas example of a tourist area attempting to modify its sewage treatment and waste discharge processes is in Cyprus. Cyprus is a popular tourist destination, with no permanent rivers and limited ground water resources. It has a Mediterranean climate: low average annual precipitation of 477 mm during the period 1951-1980; and high evaporation and evapotranspiration of 1800 mm and 1200 mm respectively. The supply of drinking water is mainly from water wells, so it is very important to protect underground water resources. Maintenance of sea water quality is essential to the viability of the tourist based economy.

Since 1979, approximately two hundred (200) small sewage treatment plants for hotels, restaurants, tourist complexes and communities have been installed mainly in coastal tourist areas of the island. The size of the sewage treatment plants is of the range of 50 to 1250 E.P. The disposal of domestic wastewater or even of the treated water into the sea is forbidden. Tertiary treatment standards are required for tourist complexes within 100 m of the sea. Tertiary processes usually include an equalisation tank, chlorination, addition of alum, and in some cases dechlorination by activated carbon filter (Larcou, 1987).

Sweden

In Sweden, chemical precipitation of phosphorus was rapidly adopted over a ten year period: in 1970 98% of the urban population had secondary or primary treatment of sewage; by 1980 almost 100% were served by tertiary treatment plants. The normal requirement was an effluent standard of less than 0.5 mg/l total phosphorus. The estimated load of total phosphorus from point-source discharges decreased from 50,000 kg annually in 1970 to 8600 kg by 1980. In general, the treatment process has been improving continually, leading to the use of lower doses of precipitation chemicals and to more reliable modes of operation (Lowgren et al 1987).

Though the system of sewage treatment had some important positive local hygienic and aesthetic effects, the study by Lowgren et al (1987) found that there was no sharp decline in the level of phosphorus transports in the Svarta River after upgrading systems and introduction of chemical precipitation.

The standards adopted have been criticised for the following. The objectives of the Swedish water pollution abatement program were not expressed in terms of improved water quality, but as the percentage of urban population served by a certain kind of wastewater treatment technology and effluent standards, despite the fact that recipient conditions varied greatly. Eutrophication was mainly a problem for the densely populated areas in southern Sweden. It was administratively and technically feasible to add another treatment step to many of the already existing systems. It did not specify removal of nitrogen which may be just as important as phosphorus in affecting eutrophication. It did not specify recipient conditions or give priority to removal of nutrients from severely polluted waters. The uniformity of the national effluent standards also hampered the development of wastewater re-use (Lowgren et al, 1987).

As a result of this Swedish study it is recommended that the most effective approach to formulating standards involves the following:

- to decide what water quality to aim for,
- to undertake a comprehensive nutrient budget specifying the size and origin of the most important plant-nutrient discharges,
- to include a mixture of both point source and diffuse-source controls,
- to take account of the user-related water quality objectives,
- to consider zoned rather than uniform treatment.

OPTIONS FOR DISCHARGE STANDARDS

Two options for management of direct waste discharge through establishing standards are:

1. To specify the quality of the **effluent or waste stream** at the point of discharge as is the case for the current licence system.

2. Alternatively, to specify levels of key parameters that must not be exceeded in **receiving waters** within the vicinity of a development.

These are not mutually exclusive. The advantages and disadvantages of each of these options are discussed below. It is inappropriate for GBRMPA to dictate what technology should be used in a treatment plant. The discharge standard should be set but the choice of technology and methods used to meet those standards are for the permittee to make.

Option One

Specification of the quality of effluent in terms of BOD and NFR, at the point of discharge has been applied to date in most Queensland licences and GBRMPA permits.

(a) Advantages: As the level and technology of waste treatment applied makes it relatively easy to predict the eventual effluent quality, this is the most efficient option for management. It is simple to explain to applicants for licences. It is relatively easy and inexpensive to monitor effluent quality as sampling is undertaken at the treatment system, thus also facilitating enforcement.