Ebeye - Water and Wastewater Strategy

Infrastructure Development and Maintenance Plan 2003
for the Republic of the Marshall Islands

Beca

5 Ebeye Wastewater System

5.1 Background

The Ebeye wastewater system was originally constructed in the 1960's when the island was established as the main housing area for Marshallese working on the Kwajalein US military base. The system consisted of cast iron gravity sewers with two collection pumping stations and a main discharge pumpstations. Untreated sewage was pumped into the lagoon through a 660-foot, 10-inch diameter outfall located about 400-feet to the north of the shipping dock. A reticulated salt water system was installed to provide flushing water.

In the 1970's an oxidation ditch wastewater treatment plant was constructed on the northern end of the island to serve Trust Territory buildings, the hospital, school and military style government housing units. A new 12-inch diameter outfall discharging approximately 700-feet offshore in to the lagoon was constructed. The discharge depth in the Kwajalein lagoon is 15 to 20 feet. The old outfall was used as an emergency overflow from the main pump station.

Since the construction of the treatment plant a further pump station serving the northern area was added in the early 1980's. This station pumps directly to the treatment plant.

The wastewater system has progressively failed due to lack of maintenance and equipment replacement over the years. At the time of inspection for this report (April 2003) the wastewater treatment plant was non-operational and raw sewage was bypassed directly to the outfall. The pumping equipment is reduced to one pump of poor reliability in each station. The physical condition and performance of the outfall is unknown.

In 1999 the Kwajalein Atoll Joint Utilities Resource (KAJUR) contracted the American Samoa Power Authority (ASPA) to provide operational assistance for the power, water and wastewater utilities on Ebeye. ASPA has been working to establish a reliable power supply and is now commencing improvement and reliability of the water treatment and distribution system. The ASPA is currently just maintaining the mechanical functionality of the sewage pumping system and outfall discharge. No wastewater treatment is provided.

5.1.1 Population Predictions

The current population of Ebeye is variously reported between 10,000 and 12,000 persons. The SOPAC 1996 report suggests a Marshall Islands population growth of 3.2% by 2000, falling to 2.8% by 2005. The total Marshall Islands population at 2005 is estimated as 76,189, based on a medium growth scenario. It is estimated that about 22% of the total population resides on Ebeye, giving a predicted future population of 16,700. This would seem unrealistically high, given the restricted area for further growth on Ebeye. ASPA has used a design population of 14,500 in their WWTP Feasibility Study, 2002. This figure will be used in this report for design purposes.

5.2 Wastewater Collection

The gravity sewer system was initially installed in 1965 - 67 in the original island development. This still forms the bulk of the reticulation. Sewer pipes were cast iron with asbestos cement force mains from the pump stations. A report by US Army Engineers Corps (USAEC 1978), notes that the sewers are buried "from 2 to 8 feet below the ground elevation". The condition of the sewers is expected to have deteriorated with time and the aggressive salt water environment. Infiltration rates are high. The 1978 report estimated the infiltration rate for the northern catchment as 31gpm, which was 50% of the collected flow. The ASPA report, Jan 2002, notes that it is not possible to empty the wet well of the #2 pump station during high tide, implying there is significant sea water infiltration. High infiltration levels have adverse implications for the performance of pumping equipment and result in hydraulic overloading of treatment facilities.

5.3 Wastewater Treatment Plant

The wastewater plant was constructed in early 1970's and is located on a site towards the northern end of Ebeye. Fig 1.

5.3.1 *Existing Treatment Plant*

Wastewater is received at the treatment plant by force main from the main pump station. Pump station #3 collecting wastes from the Northern Camp discharges directly into the treatment channel. There are no screening or grit removal facilities.

The plant is believed to be a proprietary extended aeration oxidation ditch design by Lakeside Equipment Corp of USA. Discharge from the plant is by an ocean outfall extending some 700 feet into the Kwajalein lagoon.

The oxidation ditch is constructed above ground in reinforced concrete into a "folded" configuration to give a flow length of approximately 750 feet. The channel is 8 feet deep giving a total basin volume of 0.53Mgal (2000m^3). Aeration is supplied by two Magna horizontal brush aerators driven by 25HP motors (Photo 1). Separation of the mixed liquor is by 9 rectangular clarifiers integral with the northern wall of the ditch, each 10 feet x 3 feet, giving a total surface area of 270 ft^2 (25 m^2). Settled sludge falls directly back into the channel, obviating the need for RAS pumping. There is no facility to waste sludge from the channel and it is assumed that the design was intended to operate in an extended aeration mode with long sludge age.

When the plant was inspected by BICL on 24th April 2003 the plant was bypassed and non operational. The oxidation basin had been pumped out and was empty. This provided an opportunity to assess the integrity of the channel walls, which appeared in good condition. There was no evidence of concrete corrosion at the water line and no evidence of serious structural faults. A quantity of grit (sand) is visible in the bottom of the channel, particularly downstream of the raw wastewater input (Photos 2, 3).

The motor and gearbox has been removed from one brush aerator and the motor has been removed from the second. (Photo 4). The stainless steel aerators are in reasonable condition although the end discs show surface rusting where the shaft is bolted (Photo 5). The condition of the bearings is unknown.

5.3.2 Design Flow

It is reported by USAE 1978, that the plant is designed as an extended aeration process for an average flow of 0.3mgd with a design hydraulic retention time of 43 hours. The ASPA 2002 report notes a design population of approximately 4000 persons for the plant. Based on these figures the original per capita wastewater flow was 75gal/c/d (284L/c/d). This could be considered somewhat lower than a typical American rate of 80 – 95gal/c/d (300 – 350L/c/d), no doubt reflecting the belief of a more limited water supply situation.

Measurements reported in the 1 USAE 1978 study estimated the wastewater flow to have an infiltration component of ~50%, suggesting an actual per capital of about 150gal/c/d. ASPA 2002 calculated the current per capita wastewater flow from the salt water flow records and drinking water production. They estimated the daily flow as 146gal/c/d, which is in good agreement with the 1978 study.

It is interesting to note that the USAE 1978 report attributed the extra flow to infiltration, whereas ASPA considered that a portion of this may relate to the lack of metering on the salt water distribution system. *"Many toilets leak and run continuously resulting in much higher flows than normal. Because the residents do not pay for salt water, there is no incentive to fix leaking toilets"*.

5.3.3 Treatment Capacity

The USAE 1978 report notes the design organic loading for the treatment plant is estimated as 10.5lb BOD_5/1,000ft^3 (0.17kg BOD_5/m^3). The ASPA report has considered a BOD_5 and TSS load a 0.18lb/c/d, which equates to a design load of 720lb/d for a population equivalent of 4000 persons. This would give an organic loading of 10.2lb/1000ft^3, which is consistent with the previous assessment. This is reasonable confirmation that the design population capacity of the plant is indeed around 4000 persons.

Combining the flow assessment of 150gal/c/d and BOD load assessment of 0.18lb/c/d. gives an estimated BOD concentration of 0.544lb/gal (~143g/m^3). This is considerably lower that typical domestic wastewater BOD due to the high infiltration into the sewers. This value will be used for assessment of the upgrade treatment plant design. This is consistent with US Army Corps BOD measurements of 127g/m^3 at the North Pump station made in 1978.

5.3.4 *Maximum Upgrade Capacity of the Present Plant*

Given that the design population for the current plant extended aeration is approximately 4000 persons, it is undersized by a factor of 2.5 – 3 for the existing population.

The maximum treatment capacity of the plant as an activated sludge process will be limited by the available basin volume, aeration and clarification capacity, and the required effluent quality. Assuming that secondary effluent standards are desired (30g/m^3 BOD, 20g/m^3 TSS, and nitrification) for discharge, the plant could be loaded at a higher rate to run as a conventional activated sludge process. A reasonable volumetric load into the existing aeration basin would be in the order of 12 – 15 hours retention time. This equates to a flow of 3200 – 4000m^3/d, or a population equivalent of 5700 – 7100 persons. The organic loading rate for this population contribution is 0.22 – 0.28 kgBOD/m^3, which is within the acceptable loading rate range for the activated sludge process.

The use of salt water for flushing means that sewage will have a chloride content close to salt water. Chlorides inhibit the activated sludge nitrification process and it is recommended that the design loading is decreased by 2% per 1000mg/L chlorides in excess of 5000mg/L (MIL-HDBK-1005/16) to maintain nitrification. Ebeye wastewater chloride concentration was measured as 12,100mg/L (USAE 1978), resulting in a suggested design load reduction of 14%. This would mean an acceptable BOD load design range of 0.17 – 1.0 kgBOD/m^3. The plant capacity would be in this range.

Aeration requirements are directly related to the BOD load received at the plant. For a design population of 7100 the BOD load is 568kg/d. Typical oxygen requirements for conventional nitrifying activated sludge are 1.6 – 1.9 kgO_2/kg BOD, giving an oxygen load of 1080kg/d. The two existing 25HP brush aerators are capable of providing approximately 1200kgO_2/d (1.5kgO_2/kwh). This should be derated by 10% to allow for lower oxygen saturation at higher wastewater temperatures. Therefore the existing aerators are barely adequate to meet the oxygen demand and additional aeration capacity would be required.

The in-channel clarifier system of the existing plant severely limits the performance and would be inadequate to meet a higher flow rate. A new clarifier is required. For a flow of 4000m^3/d (7100 p.e.) the clarifier area is approximately 210m^2 (16.5m diameter). The existing treatment plant site does not have sufficient vacant land to accommodate a settler of this dimension.

Activated sludge systems produce excess biomass resulting from the removal of BOD. For the plant operating in the conventional mode the sludge production will be 0.7 – 1.0 kg/kg BOD removed. For the 7100 design population a BOD removal of ~500kg/d is expected, which will result in the production of 350 – 500kg of sludge dry solids per day. Based on a settler sludge concentration of 1% solids, this represents 35 – 50m^3/d of waste sludge to handle. Handling and disposal of this quantity of waste sludge presents major difficulty on the island. With thickening and dewatering this volume could be reduced to around 2 - 5m^3/d. However disposal of this daily quantity of sludge would still present a major difficulty, as there are limited options. Disposal to a landfill would take up valuable space, given that there is also a significant solid waste problem on Ebeye.

The existing treatment plant has no inlet screening or grit removal. These facilities should be included to improve operational performance.

5.3.5 Summary

The design review of existing wastewater plant indicates that it would be possible to double the original design capacity if the process were converted from an extended aeration loading to conventional activated sludge loading. The population capacity would be approximately 7100 persons. This is insufficient to meet the current population and 50% below the predicted future design population of Ebeye.

To upgrade the plant to a maximum capacity of 4000m^3/d will require the installation of an additional 20kW of aeration capacity, installation of a 54 foot diameter clarifier and sludge handling and disposal facilities for up to 500kg/d. Inlet screening and screenings disposal will be required.

Given the limited scope for expansion at the treatment plant site, the sludge disposal constraints and the inadequate population capacity, it is not considered feasible or economic to reinstate or improve the existing plant.

5.4 Alternative Use of Existing Treatment Plant

If the treatment plant is abandoned the aeration tank could be converted to other uses. Since the tank is still structurally sound and waterproof it would have utility as a freshwater reservoir. The tank could be covered to provide an additional 2000m^3 of storage of RO treated drinking water. The salt water pumping station would remain on the site as it is the feed source for the drinking water RO system.

Alternatively the basin could be used as a rainwater storage reservoir and pumped back into the saltwater line feeding the drinking-water RO plant. Filtration would be required to minimise suspended solids and turbidity carry over to the RO feed water. The covering roof could be constructed to maximise rainwater collection from the site.

6 Interim Wastewater Treatment Options

To implement an interim strategy of public health protection for the present wastewater system requires that short term improvements are made to increase the health barriers.

6.1 Pump Station Upgrade

The sewage pump stations are in urgent need of complete refurbishment to prevent pumping failure and discharge of sewage into the streets from overflows. Replacement of pumps, mot+

ors and electrical controls is required to improve reliability (Photo 6). The existing vertical shaft pumps are unsatisfactory from a maintenance and corrosion aspect (Photo 7). The ASPA report notes various valves, check valves and pipe work is non-functional. These items will require repair or replacement.

Submersible pumps may be a satisfactory replacement, however they will need to be corrosion resistant (stainless steel) and be designed to operate with the salt water flushing. This may require specialist pumps. An alternative pump configuration using an above ground pump with a vertical suction has been trialed by ASPA in pump station #3 (Photo 8). This has proved successful and is easy relatively to clear of blockages by disconnection the inlet pipe. It is recommended that replacement pump sets are configured in this fashion. Above-ground self priming solids handling pumps are available from a number of suppliers (Gorman Rupp, Gresco). These pumps also have the facility to clear blockages without removal of the inlet piping, which would facilitate maintenance.

The electrical contactors and level control systems require replacement. New electrical systems would be installed with the new pump sets.

Overflow pipes to the lagoon foreshore were included in the pump station designs in the 1970's. The main pump station used the old shoreline outfall as the overflow. The ASPA report notes that the functionality of the overflows is unknown and overflowing sewage may discharge into the streets. The overflows should be repaired or new pipes installed to ensure overflows are to the shoreline and the public health risk is reduced.

6.2 Wastewater Screening and Disinfection

The current discharge of untreated raw wastewater through the existing lagoon outfall has a high public health risk. The risks are:

1. The unknown integrity of the outfall. It is reported by ASPA 2002 that the outfall may be collapsed due to fill placed over the pipe. Dye testing was unable to confirm flow through the outfall. If the outfall is collapsed and/or leaking raw sewage into the local

groundwater, this could contaminate the salt water abstracted for feed to the drinking water RO plant.

2. The discharge of raw sewage close to the shoreline as a result of the reclamations in the pipeline area. This brings the public directly in contact with contaminated seawater and gross solids that may be discharged.

The interim strategy should be to minimise the health risk by screening gross solids from the sewage and disinfection prior to discharge.

6.2.1 Screening

The sewage currently receives no screening. The pump stations originally had manually cleaned basket screens and the main pump station had two comminutors installed in the screen pit. This equipment is no longer functional. It is recommended that a milliscreen plant is installed at the existing WWTP site to receive the wastes from the main pump station and the #3 pump station.

The screening plant would be based on a rotary or step screen system with a 3mm aperture. Screenings would be collected for disposal in the landfill. A screenings press could be used to reduce the volume of disposal.

6.2.2 Disinfection

The screened sewage will still have a high microbial level and continues to pose a health risk for public contact after discharge from the outfall. Disinfection can provide a significant reduction in bacterial and pathogen numbers and substantially reduce the public health risk.

Chlorination is considered the only viable disinfectant process for use with raw screened sewage in the Ebeye situation. It has the advantage that it can be applied with relatively simple chemical dosing equipment and can be generated on-site or from powder reagents. The use of gas chlorine is not considered appropriate given the potential hazards and shipping difficulties. The possible production of chloro-organics in the wastewater is considered to be a minor environmental issue in relation to public health risk.

Given the availability of salt water at the wastewater treatment plant site it is considered that electrolytic generation of sodium hypochlorite from seawater would be a cost effective process for disinfection of the screened sewage. Electrolytic hypochlorite can be generated on demand to meet the discharge flow, or can be stored for later use. Approximately 6.5kg/hr of hypochlorite is required for a 20mg/L chlorine dose. The electrical power requirement for disinfection of the sewage flow for the design population of 14,500 persons is approximately 35kW. Hypochlorite generators are available as complete process units. The efficiency of hypochlorite generation could be increased if the concentrated waste brine from the RO plant were used as a feed instead of seawater. This would require piping the waste brine from the RO plant some 1800 feet to the wastewater treatment plant site. The plant would be installed in the existing salt water pump station building. The power supply capacity to the site would not require upgrading to meet the power demand of the hypochlorite generator as it was originally designed to include the two 25HP (37kW) brush aerator motors on the oxidation ditch, which will no longer be required.

6.2.3 Priorities

In terms of public health priorities it is necessary to address the pump station upgrades as the most urgent item. Without adequate collection of the sewage there will continue to be overflows into the street where people could be directly in contact with raw sewage.

Once adequate collection and reliable conveyance of sewage to the wastewater treatment plant site is achieved the issue of public health of the outfall discharge can be addressed. Disinfection of the sewage will provide the interim public health protection required in the lagoon while the existing outfall is in operation. It will also assist to reduce the microbial contamination of salt water drawn for the water supply, particularly if the outfall is leaking into the groundwater.

Screening of the wastewater has a lower priority, as it is primarily associated with improvement of the aesthetics of the shoreline and lagoon. However the presence of gross solids and plastic material discharged from the outfall can be a health hazard, so screening will also improve the public health.

6.3 Outfall Improvements

In the interim the existing outfall would be used for the discharge of screened and disinfected sewage. The integrity of the outfall pipe should be established and the discharge location determined. A remote TV camera investigation should be made of the interior of the pipe to detect any broken or collapsed sections. A comprehensive dye study should be made to reliably determine where the discharge exits relative to the existing shoreline.

Should the outfall be found to be substantially damaged the programme to implement the long term replacement outfall could be re-evaluated for earlier construction or repair.

7 Long term Wastewater Treatment Options

The objective of the long term wastewater disposal option is to provide a secure system with low public health and environmental risk that will meet the future development needs of Ebeye and will meet the regulatory environmental conditions.

7.1 Replacement of the Outfall

The existing outfall is considered unsatisfactory for a long term disposal option. The structural integrity of the pipeline is questionable and the discharge location is too close to the shore following reclamation of land. The hydraulic capacity of the pipeline is limited.

The options for outfall replacement will depend on the level wastewater treatment provided and conditions required to meet the RMI environmental regulations. The options considered are:

- An outfall to the ocean side of Ebeye discharging screened sewage
- A long outfall into the Kwajalein lagoon discharging screened and disinfected sewage
- An outfall into the Kwajalein lagoon discharging treated sewage from a new secondary treatment plant.

The RMI Government environmental regulations established for the discharge of treated wastewater to the sea are in part a legacy of the former US Trust Territory administration. The regulations require that wastewater effluent discharged into the lagoon should be of a quality provided by a secondary treatment process.

It has been suggested in ASPA report 2002 that ASPA and KAJAR should request a waiver from the existing water quality standards for the discharge into the sea. The waiver would request the KAJAR be permitted to discharge screened but untreated wastewater through an outfall such that the discharge did not impact on the shoreline or water quality.

The construction of a new outfall would improve water quality near the shore and greatly reduce the present public health risks associated with the discharge of untreated wastewater immediately adjacent to the shore.

7.1.1 *Outfall to the Ocean Side*

The discharge of screened wastewater to the ocean side of the island would provide the greatest public health security, as the outfall could be located into deeper water where current movements would prevent wastewater washing to the shore. Also the shoreline of the ocean side of the island is less frequented due to the more vigorous wave climate. Since the wastewater contains a high proportion of seawater from the toilet flushing system it will not form the strongly buoyant plume when released from the outfall, as would be found with typical freshwater discharges. This will "trap" the wastewater below the surface, and provided the water currents are favourable to transport the discharge away from the coastline will provide a high degree of public separation from the wastes.

The construction of an outfall on the ocean side is significantly more difficult due to the unprotected coast, wave and weather conditions. The construction difficulty could be addressed by the use of a "jack up" barge to provide a work platform for a dig-and-lay outfall. In adverse weather conditions the barge can be demobilised and towed to the lagoon side for shelter. As the length of the outfall is likely to be less than 1000 feet a temporary piled platform above the wave level could alternatively be used to allow construction. This technique has been used successfully on wave affected coasts to lay outfalls of over 3000 feet length (Photos 9 - 12).

The estimated cost of $2,480,000 for a lagoon outfall is provided in the ASPA 2002 report. An ocean outfall of 300 – 500 feet is estimated in the order of $3,500,000, to allow for the more difficult construction conditions.

7.1.2 Long Outfall to Lagoon

A long outfall into the lagoon to discharge screened sewage is an alternative to the ocean outfall. To achieve adequate dilution and separation of the discharge from the shore will require an outfall of 3000 – 4000 feet length. The water currents in the discharge vicinity are believed to be influenced by the blocking effect of the causeway, which has reduced the flushing of the lagoon. A water movement study has been proposed, (Sea Engineering Inc, March 2002), to determine the best outfall length. Further oceanographic assessment may be required to establish if the provision of culverts under the causeway could improve flushing. Given that this discharge will still be into the lagoon where there is high usage of the waters for fishing and public contact, it is considered prudent to provide disinfection of the untreated sewage before discharge.

The construction cost of a 4000 feet outfall into the Kwajalein lagoon has been estimated by the ASPA 2002 report as $2,500,000. This does not include the screening costs.

7.1.3 Short Outfall to Lagoon

If a new secondary wastewater treatment plant were constructed it could be possible to reduce the length of the outfall given that the improved effluent quality would mitigate the lower dilution of the outfall and closer proximity to the shoreline. Disinfection of the treated effluent would further improve public health security. The reduction in outfall length will only marginally reduce the outfall construction costs as mobilisation of staff and equipment is a significant overhead cost relatively independent of the outfall length. ASPA 2002 has estimated the cost of the treatment plant and outfall to be in the vicinity of $25,000,000.

7.2 Rehabilitation of Sewers

The original cast iron gravity sewers have been in service for over 35 years in very aggressive operating conditions. The infiltration leakage has been estimated up to 50% of the total flow. Rehabilitation of the sewers would:

- Reduce the volume of sewage pumped, allowing better pump operations with fewer overflows.
- Provide power savings from lower pump duty.
- Reduced the volume of wastewater requiring treatment and discharge. This may substantially reduce the size and cost of a future wastewater treatment plant.

The repair of the sewers by grouting or relining (e.g. InsituForm) is possible and a study would be needed to ascertain if this were a viable option for Ebeye. Relaying the trunk sewers may be cost effective as these are likely to be the deepest and therefore most subject to groundwater infiltration.

It has been noted in Section 5.3.2 that some of the excess flow may be due to poorly maintained household toilet and plumbing fixtures and the lack of a cost incentive for repairs to be made. A programme to replace household seawater plumbing and to install water meters for cost charging may be an effective strategy to reduce infiltration.

7.3 New Wastewater Treatment Plant

The provision of a new secondary treatment wastewater plant to meet the present population needs and future population growth is considered to be the least priority action. The requirement for a high degree of wastewater treatment would be driven by regulatory criteria for discharges or by significant failure of the outfall disposal system.

A secondary biological treatment would require an area of land that is unavailable on Ebeye without reclamation. The existing wastewater treatment plant site is too small for a plant capacity sufficient for the future population growth. Biological treatment has a significant energy cost and a requirement for disposal of waste sludge generated by the process. This presents a major difficulty for Ebeye as disposal of solid waste is already severely limited by available space and waste sludge would consume valuable landfill volume.

Not withstanding the above difficulties, the cost burden of a secondary treatment plant is substantial and would be difficult to justify in this situation. ASPA 2002 has estimated the cost of a new treatment plant, built on a new reclamation near the causeway, to be in the order of $22,500,000.

8 Priority of Water and Wastewater Improvements

The priority for implementation of the water and wastewater programme is to sequentially improve the public health situation with each upgrade action. The following table provides guidance for the recommended priority of actions. Several actions could be undertaken simultaneously, subject to funding.

Table 8.1

Recommended Priority of Water and Wastewater Improvements

Utility	Item	Action	Recommended Priority
Electrical Power	Secure power supply	▪ Improve reliability	1 (complete)
Water Supply			
	Secure water source	▪ Improve salt water bore microbiological quality	Will occur with implementation of 5, 10, 13
Water Treatment			
	Quantity	▪ Increase to 0.45Mgd (14,500 population)	11
	Quality	▪ Install RO	2 (complete)
Water Reticulation			
	Delivery main	▪ Install new ring main	4
	Laterals/house connections	▪ Install new laterals and house connection with water meters	7
Wastewater reticulation			
	Pump stations	▪ Upgrade pump stations	3
	Sewers	▪ Repair/replace trunk sewers	12
	Flushing water	▪ Install new laterals and house connection with water meters	9
Wastewater treatment			
	Disinfection	▪ Install electrolytic disinfection	5
	Screening	▪ Install milliscreen	8
	Outfall	▪ Survey and repair existing	6
		▪ New long outfall	10
		▪ New treatment plant	13

9 *Indication of Costs*

The indication of costs for the wastewater pumping stations, treatment plant and outfall improvements identified in this report have been taken directly from the ASPA 2002 report. These estimates have not been reviewed as they are considered best current cost estimates. Budget costs associated with water mains laying, house laterals and chlorination are based on nominal rates or supplier budget quotes with an engineering component of 20% and a contingency of 25%, as used in the ASPA 2002 report budgets.

Table 9.1
Cost Schedule Table

Cost Item – Upgrade Activity – Wastewater System	***Budget cost USD$***
1. Refurbish sewage pump stations (4 stations) Costs identified in ASPA 2002 Report – Section 4.4	$1,320,000
2. Seawater chlorinator (5kg/hr) installed at WWTP site	$455,000
3. Screening plant at WWTP site. 3mm screen aperture, includes concrete base, screening press and solids bin, electrics	$90,000
4. Outfall – Ocean side outfall ~500 feet	$3,500,000
5. Outfall – Lagoon outfall – 4000 feet	$2,500,000
6. Secondary treatment plant – including reclamation in North Camp area	$23,000,000
Cost Item – Upgrade Activity – Water System	***Budget cost USD$***
1. Water main replacement – 6-inch HDPE x 13,600 feet, laid in road, 6ft cover, including reinstatement.	$40/ft $550,000
2. House lateral replacement with water meter. 2000 households	$300/house $600,000
3. Electrolytic seawater chlorinator – 0.5kg/hr	$580,000
4. New RO water treatment plant to supplement potable water capacity (250,000 gpd).	$2,500,000
5. New potable water storage reservoir (250,000gal) and pumps	$550,000

10 Implementation Strategy

The implementation programme of water and wastewater improvements should be based on the public health priority ranking as developed in Section 8. The priority items 1 and 2 have been completed. The next most pressing tasks are Priority 3 - Upgrade of Sewage Pump Stations and Priority 4 - Water Main Replacement.

It is recommended that a consultant is engaged to undertake an engineering design of the projects and to provide a detailed cost estimate and procurement schedule for funding approval and implementation. Tabulated below are provisional design task descriptions and budget fee estimates for BICL to undertake these two priority tasks.

Priority 3 – Upgrade Sewer Pump Stations - Design Task Description	*Estimated Fee Budget*
Review the findings of the ASPAReport - 2002	$500
Re-inspect and measure up pump stations	$6,000
Specify new pumps and control equipment	$6,000
Design revised station layout for new pumps	$9,000
Specify new electrical equipment and station upgrade works	$4,000
Investigate and design upgraded pump station overflow pipes	$5,000
Schedule new works and prepare pre-tender cost estimate	$8,000
Prepare procurement program and documentation	$3,000
Miscellaneous & Contingency	$8,000
Disbursements	$6,000
Total Budget Fee for BICL **	**$55,500**

Priority 4 – Design Task Description	*Estimated Fee Budget*
Field investigation	$10,000
Route survey and selection	$8,000
Pipe and valve sizing and specification	$6,000
Design Documentation	$12,000
Schedule new works and prepare pre-tender cost estimate	$8,000
Prepare procurement program	$2,000
Miscellaneous & Contingency	$6,000
Disbursements	$5,000
Total Budget Fee for BICL **	**$57,000**

** Does not include any RMI taxes or levy.

11 References

USAEC 1978 – US Army Engineering Corps, Facilities Plan for the Marshall District Vol 2 – Ebeye Island, October 1978

SOPAC 1996 – Water & Sanitation Sector Strategy and Action Plan. SOPAC Technical Report 236, August 1996.

SOPAC 2001 – Report of Visit to Ebeye, Kwajalein Marshall Islands. SOPAC Preliminary Report 134, October 2001

ASPA 2002 – Ebeye Wastewater Treatment Plant Feasibility Report. ASPA Wastewater Division, January 2002. Prepared by Westech Engineering Oregon.

Beatty M. 2001 – Outbreak of toxigenic *Vibrio cholerae* 01 infections, Ebeye Island, Kwajalein Atoll, Republic of Marshall Islands, Preliminary Trip Report Epi-Aid 22-01.

12 Photographs

Photo 1 Magna Brush aerator

Photo 2: Empty basin showing grit buildup

Photo 3: Empty basin showing grit buildup

Photo 4: Removed gearbox and motor

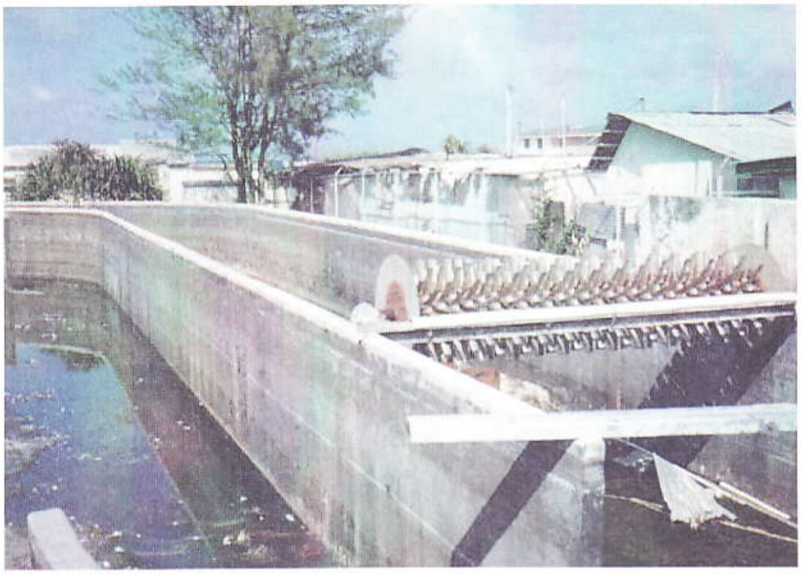

Photo 5: Magna aerator showing corrosion

Photo 6: Sewage pump motor – poor state of repair

Photo 7 Corroded vertical shaft sewage pumps

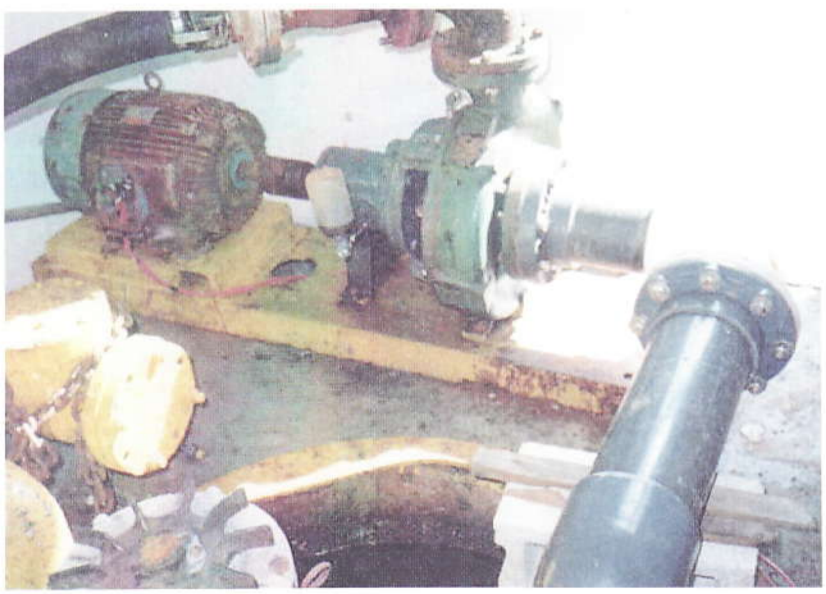

Photo 8 Modified sewage pump using suction with foot valve

Photo 9: Outfall construction using jacking platform

Photo 10: Outfall construction using pile platform

Photo 11: Piled Platform

Photo 12: Piled platform showing wave tolerance

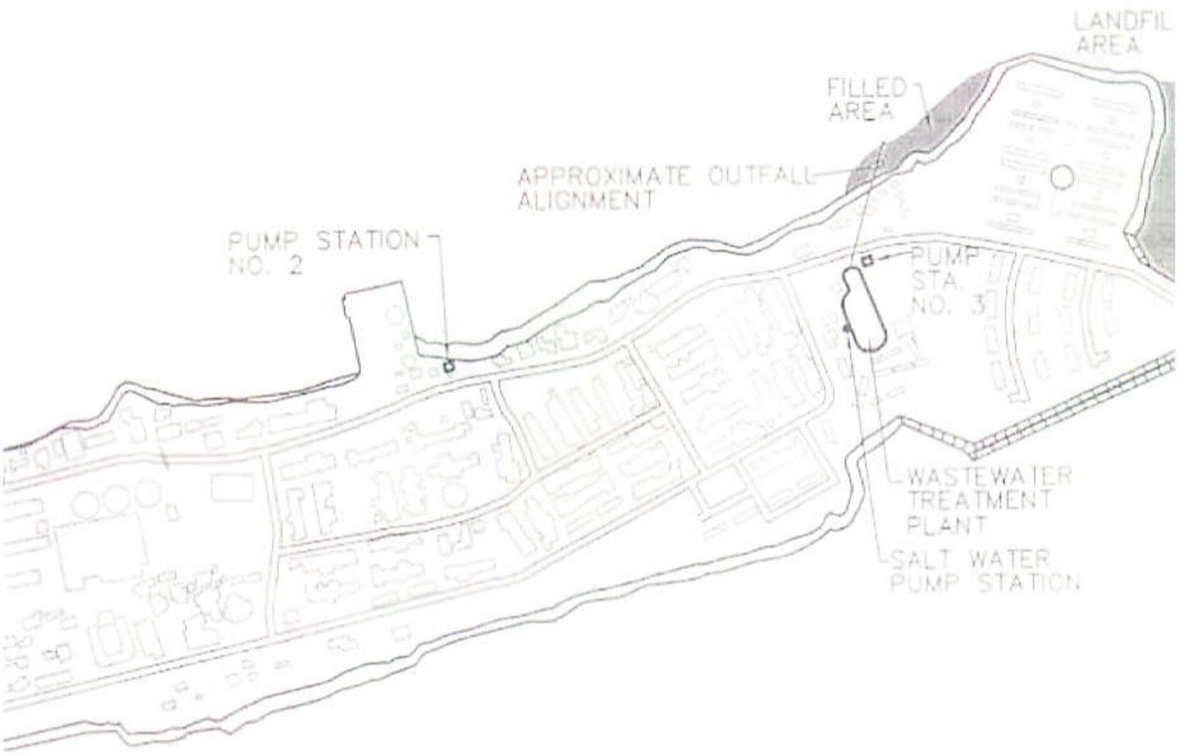

Figure 1 Ebeye Wastewater Treatment Plant