CHAPTER 6

WASTEWATER MANAGEMENT

6.1 Overview

The proposed project is expected to comprise of both the residential and tourism component in which these two (2) activities will require the careful planning of domestic and sewage treatment and disposal. These wastes are potential sources of pollution and can have a negative impact on the environment. This section intends to summarize the estimated wastewater (effluent) production and its subsequent collection and treatment options which include both domestic and water vessels wastewater. Mitigation measures will also be addressed especially considering the ecological sensitivity of the marine and terrestrial environments in which the project site is located and its importance to the protection of the fragile Mesoamerican Barrier Reef System.

6.2 Projected Wastewater Composition

In order to estimate the projected quantity of sewage waste, it is necessary to look at the nature of the sewage effluent. The proposed project is expected to produce domestic wastewater as a result of its residential and marina component. This wastewater typically institutes a combination of flows from the kitchens, bathroom, and laundries along with the marina wastewater encompassing lavatories, toilets, baths, kitchen sinks, dishwashers, washing machines and bilge and marine sewage water. Table 6.1 is a summary of the characteristics of domestic sewage in the Caribbean region and of the proposed project.

Table 6.1 Typical Composition of Untreated Domestic Sewage*

Constituent	**Weak**	**Medium**	**Strong**
	(all mg/l, except for Settleable Solids)		
Alkalinity (as CaC03)	50	100	200
Biochemical Oxygen Demand (BOD)	100	200	300
Chemical Oxygen Demand (COD)	250	500	1000
Total Suspended Solids (TSS)	100	200	350
Settleable Solids (SS)	5	10	20
Total Dissolved Solids (TDS)	200	500	1000
Total Kjeldahl Nitrogen (TKN)	20	40	80
Total Organic Carbon (TOC)	75	150	300
Total Phosphorus	5	10	20

* adapted from Davis-Cromwell: Introduction to Environmental Engineering, pp 353

6.3 Projected Wastewater Production

As mentioned earlier, the proposed Pelican Point Marina and Yacht Club project is expected to generate domestic wastewater as a result of its operation activities. It is expected also that some of this wastewater will be derived from the marina component as a result of water vessels. There is little data on wastewater productions rates and therefore the estimated wastewater production for the proposed project has been derived using the recommended parameters for domestic sewage for developing countries. The parameters (BOD, COD, NH3-N, & suspended solids) use recommended averages for residual gray water and domestic sewage combined. The following summarizes the wastewater volumes generated by the different services.

6.3.1 Domestic Wastewater Production

With this said, it is estimated that the entire development once in operation will require about 40,600 gallon of water a day. This volume, as stated in Chapter 5, represents 100 % occupancy and full employee staffing. For the purpose of the environmental engineering calculations the wastewater production was calculated as 70 % of the water demand as it is normally the standard.

Table 6.2a Projected Domestic Wastewater Production for PPM&YC

Type	Unit Description	Maximum Occupancy Residents	Wastewater Production	
			Unit (gals/day)	Total Volume (gals/day)
A	Condos Type I	96	50	3,360
B	Condos Type II	48	50	1,680
C	Cabanas Type I	180	50	6,300
D	Cabanas Type II	56	50	1,960
E	Marina	384	50	13,440
F	Employee	30	30	630
G	Transient Visitors	100	15	1,050
Total Recycled Wastewater		**894**	**295**	**28,420**

As can be summarized from the table above, the volume of wastewater generated by the proposed project at full operation is 28,420 gallon a day. Type E produced 47 % of the wastewater volume which is followed by Type C with 22 %. These volume percentages can fluctuate according to time of day, occupancy and project activity.

6.3.2 Marine Vessel (boat) Wastewater Production

It is difficult to calculate the international wastewater generated by the marine vessels in terms of visitation frequency. Nevertheless, taken into consideration the marina design and the capacity of the vessel at any one given time, the following table best describes the wastewater volume generated at 100% occupancy. This percentage, in the real world, may never work out but is an important factor in wastewater engineering.

Table 6.2b Wastewater generated by marine vessels

Wastewater Production

Boat Length (feet)	**Slips**	**Total Boats**	**Water Capacity (gals)**	**Water Demand (gals)**	**WW 70% (gals)**
30	27	27	0	0	0
35	41	41	0	0	0
45	8	8	0	0	0
50	31	31	400	12,400	8,680
60	30	30	600	18,000	12,600
100	3	3	1,000	3,000	2,100
Total	**140**	**140**		**33,400**	**23,380**

The projected wastewater volumes are expected to vary and therefore the project plans to explore adequate options for the collection, treatment and disposal of the residential and international wastewater. Provisions will be made to facilitate any wastewater treatment expansion as may be required for the area.

6.3.3 Projected Total Wastewater Volume

Therefore, the total project volume of wastewater generated by the proposed project will be 28,420 gallon/day from the development and 23,380 gallon/day from the marine vessel totaling 51,800 gallon/ day for the entire development (See Table 6.1a and 6.2b).

6.4 Environmental Wastewater Loading

The wastewater loading factor is directly influenced by the daily operation of the proposed project. In considering the different buildings of the project and the nature of the wastewater, the environmental wastewater loading, as illustrated in Table 6.1, will be that of a typical strong domestic load. With this in mind, the related values for TOC and BOD_5 are basically 300 mg/l with 350 mg/l for TSS, 80 mg/l for TKN and 20 mg/l for Total Phosphorus. This is the typical daily load that any treatment method will have to handle to reduce the concentrations to the acceptable national effluent standards.

The pH of all these wastes will be in the range of 6.5 to 8.5, with a majority being slightly on the neutral side of 7.0. Phosphorus may appear in many forms in wastewater. Among the forms found are the orthophosphate, polyphosphates, and organic phosphates. For the purpose of Table 6.3, all these are grouped as total phosphorus. Similarly, the TKN is a measure of the total organic and ammonia nitrogen in the wastewater.

Table 6.3 Project Domestic Wastewater Profile

Constituent	Typical Wastewater (mg/l)	Daily Resort Load (kg/day)
Alkalinity (as CaC03)	200	44.5
BOD	300	66.7
COD	1000	220.4
Total Suspended Solids (TSS)	350	77.8
Total Dissolved Solids (TDS)	1000	220.4
Total Kjeldahl Nitrogen (TKN)	80	17.8
Total Organic Carbon (TOC)	300	66.7
Total Phosphorus	20	4.4

6.5 National Environmental Effluent Standards

In 1992, the Environmental Protection Act established the Department of the Environment. The ACT also grants the Department of Environment broad regulatory and enforcement authority for the prevention and control of environmental pollution, conservation and management of natural resources, and Environmental Impact Assessment (EIA). Under this act, the Environmental Protection Effluent Limitation Regulations came into force in 1996, at which time the Department of the Environment commenced enforcing the Regulations. The Regulations are intended to control and monitor discharges of effluent into any inland waters or the marine environment of Belize. The standards as per the Second Schedule of the Environmental Protection Effluent Limitation Regulations are shown in Table 6.4:

Table 6.4 Effluent Limitation Standards for Commercial Activities

Parameter/Pollutant	Maximum Value	Parameter/Pollutant	Maximum Value
Temperature (T °C)	30 – 33 °C	Sulphide (as S)	500 mg/l
Ph	6 – 9	Oil and Grease	10 mg/l
Dissolved Oxygen (D.O.)	> 4.0 mg/l	Phosphate(PO_4^-)	5 mg/l
BOD_5 at 20°C	50 mg/l	Nitrates (NO_3)	3 mg/l
Chemical Oxygen Demand (COD)	200 mg/l	Ammonia (NH_4)	1 mg/l
Total Suspended Solids (TSS)	50 mg/l	Total Organic Carbon (TOC)	200 mg/l
Total Dissolved Solids (TDS)	2000 mg/l	Total Coliform	0 – 10 MPN/100 ml
Sulphate(as SO_4)	600 mg/l	Fecal Coliform	0 MPN/100 ml

6.6 Evaluation of Wastewater Disposal Alternatives

The proposed project will consider the most applicable technology based on cost, siting and efficiency. Several options were analyzed as a result of these considerations with the preferred option selected based on the most important criteria which include the economic, the technical and environmental feasibility of the options as summarized below:

Recommended criteria influencing the decision:

Water availability. If no inexpensive public source of water is available, it is likely that the volume of liquid waste will be minimal; therefore, individual household systems become the recommended option.

Surface Topography. If topography allows for sewers to be laid at downward slope from homes, then gravity systems can be used, reducing cost.

Subsurface Conditions. Unstable soils, rocky soils etc. make conventional gravity sewers more expensive to build and maintain.

Social Considerations. Acceptance of the system is important, as systems requiring regular maintenance such as compost toilets often break down due to lack of or inadequate maintenance.

Housing or Population Density. "For dispersed building units, central sewage collection facilities are not economical due to the high cost of piping wastewater to the central treatment facility" (CEP, 1998). This is further determined by topography, soil type, land acquisition cost, evaporation rate, cost of construction and hydrology.

These considerations were compared with the pre-existing conditions of topography, and sensitivity of the site. Table 6.5 summarizes the decision on the preferred option identified.

The various options considered made the following assumptions:

Alternative A "Centralized System with Tertiary Level Treatment". This system would comprise of an advanced "package" type treatment system using aeration as its preferred method of secondary and tertiary treatment.

Alternative B "Individual Treatment Systems". This system assumed that each separate infrastructure unit (See Table 6.2) would consider installing individual units with the same secondary and tertiary treatment capacities as that of Alternative A. However, these systems would be individually owned instead of owned collectively.

Alternative C "Household Systems". This option considered using Individual Septic Tank Systems, with appropriate leach fields.

Alternative D "Composting Systems" are considered systems using composting technology that would be used to apply to either individual buildings, or individual units.

Table 6.5: Summary of Analysis of Alternatives for Sewage Treatment System.

Decision Criteria	**Criteria in relation to Project Site**	**Alternative A (Centralized System with Tertiary Treatment)**	**Alternative B (Individual Package Treatment Systems)**	**Alternative C (Household Systems – Septic System with leach fields)**	**Alternative. D (Compost Toilets)**
Wastewater Availability	Low to Medium water needs, centralized systems recommended	Medium water needs, would require extensive piping from buildings and marina.	Low water needs (acceptable)	Medium volume water usage	Very low water needs
Surface Topography	Unsuitable for gravity feeding. However, installation of pipes is relatively easy.	Gravity feeding is not possible since the area is relatively flat. The system would require the use of pumps.	These systems would generally work well with the individual buildings, but due to cost and wastewater volume, it would not be feasible.	Not fully acceptable since the area is in contact with the marine environment. May be suitable for large lots and insensitive areas.	A critical issue; unsuitable since water is used for flushing.
Subsurface Conditions	Soil is relatively permeable with acceptable infiltration rate	Suitable for a centralized system considering the low lying topography and the available utility zone.	Acceptable, but would utilize available land area for each building	Not acceptable, even with well – designed leach fields.	Excellent for use of low lying areas, and compost use for gardening etc.
Population Density	Average population density for a project of this magnitude	Feasible, especially considering the fluctuating occupancy and wastewater volumes produced	The cost of individual systems is passed on to the home owner or project owner (individual buildings etc.)	Household systems are acceptable in sparse areas (with large lot sizes)	Not a major issue, since the installation costs are relatively low, but considering the occupancy rate
Social Considerations	New systems require regular maintenance & training of staff personnel	Not a major issue of concern	Would require training and regular maintenance	Requires guidelines & training on maintenance & inspection of systems	Requires social acceptance and needs a good understanding of how the system works
Overall Economic Considerations	Cost is important for both initial investment and long-term maintenance.	Relatively expensive (due to high cost of system components, maintenance, energy needs etc) But cost may be acceptable for commercial sites.	Locally available systems have been classified as "expensive" by developers and land owners	Requires adequate installation & regular inspection and maintenance to ensure maximum efficiency	Relatively low-cost of installation (a little higher than installing a septic tank), but long-term water demands are low.

6.7 Selection of the Preferred Option

Based on the above criteria, the recommended preferred option is a centralized package treatment system (Alternative A), as opposed to individual package treatment systems for the proposed Pelican Point Marina & Yacht Club. The contributing factor to the decision is that the volumes generated by the project would be best handled by a centralized package treatment system rather than an individual system.

Moreover, the type of activity would render septic tanks and compost toilets useless considering the number of occupants and transient visitors to the site. In addition, an important factor is cost, which is every developer's concern. In any event, the following sections summarize the treatment option chosen and its recommended management. Nevertheless this system should have the capacity to treat effluent beyond that required by the Effluent Limitations Regulations 1995.

6.7.1 Proposed Treatment Option

The proposed project recommends a series of prefabricated treatment plants (10,000 gals capacity). PPM&YC will employ the "Purestream ES Model BESST" or approved equivalent treatment plant. The BESST is an acronym used for a Biologically Engineered Single Sludge Treatment (See Annex IV). The BESST system is based on the principles of single sludge treatment for efficient BOD, TSS and nutrient removal, and sludge blanket clarification for efficient solids separation.

Also, with its efficient use of the mixed liquor, the BESST system produces less sludge build up. This process places all these components into one vessel thereby reducing the parameters to much less than required by the national standards.

6.7.2 Typical BESST Plant Treatment Effluent and Loading Parameters

The BESST Plant recommended for the proposed project can reduce the Biological Oxygen Demand and Total Suspended Solids to less than 10 mg/L. The treatment plant can also reduce TSS and BOD5 total loading by some 97%, and decrease the daily Organic Nitrogen Total Loading by 67%. Additionally this system could reduce Total Free Ammonia Loading by 97.5% and Total Phosphate Loading by some 80%. The projected performance of the BESST Treatment is summarized in Table 6.6 below.

Table 6.6 Projected Performance of BESST Treatment Plant.

Constituents	Typical wastewater post treatment	Daily load reduction post treatment
Total Suspended Solids	10 mg/L	**97%**
Total Organic Nitrogen	5 mg/L	**67%**
Free Ammonia	1 mg/L	**97.5%**
BOD_5 (5 day)	10 mg/L	**97%**
Phosphate	2 mg/L	**80%**

6.7.3 Proposed Domestic Wastewater Management

The proposed option will require the installation of a sewer system consisting of industrial scheduled pipes and shutoff valves in accordance with the collection and treatment system of the BESST Treatment Plant. This would also entail a combination of gravity collection and pumping system with manholes and clean outs which would convey the generated wastewater to a final pumping station. The wastewater would then be pumped from the pumping station to where it is to be handled by the treatment plant which is capable of treating the effluent to a higher level than those mandated by the National Effluent Standards.

6.8 Boat Wastewater

Wastewater from the boats will consist of wastewater from the boat's holding tank and any bilge water produced by the boat during its travel. It is unlawful for any vessel to discharge sewage or bilge water into the sea as per the MARPOL 73/78 Convention signed between Belize and the International Maritime Organization (IMO). For this purpose Pelican Point Marina & Yacht Club will provide the necessary facilities required for the proper disposal and treatment of the boat's bilge and wastewater for the guests and transient population (See Table 6.2).

The services will be situated on both marinas along the main piers as per Figure 6.2 and the vessels will first obtain permission from the marina supervisor to dock and subsequently discharge their bilge water and/or wastewater into the receiving system. This is to prohibit any vessel from dumping their waste into the marina and adjacent coastal waters.

The marina will have various stations for the pumping out of sewage and bilge water. These stations will be situated along the various fingers of the piers in the form of a dockside pump out system along with a bilge pump out system.

6.8.1 Dockside Pumpout System

The proposed 140 boat marina will have a dockside pump out system. A dockside pumpout system means that the boat can be pumped out while it is in the slip. This system consists of a vacuum pump located near the entrance of the marina dockage on land or on the dock. The pump will have approved PVC piping going from a series of hydrants located approximately every fifty feet on the docks thru the dock system to the pump. From the discharge side of the pump there will be PVC piping to a manhole and then either gravity fed or pumped to the BESST Treatment Plant. A marina attendant supervisor will do the dockside pumping by connecting a hose to the dockside hydrant and to the boat allowing it to flow through the system. The system will have flexible hoses at appropriate locations. Expansion joints will also be installed at appropriately engineered locations. All marina personnel will be trained to operate the pumpouts properly.

6.8.2 Bilge Pump Out

A bilge pumpout system will be located at each of the finger slips of the marina. The bilge pumping system, which consists of an oil/water separator, peristaltic vacuum pump, and waste oil (hydrocarbon) accumulator, will collect and filter the boat's bilge water. This will then be acceptable to be pumped into the BESST Treatment Plant (See Fig. 6.1). The free oils will be separated and collected in a primary collection vessel and then disposed by a licensed waste oil disposal company. All material hauled out by the waste oil company will be documented and kept on file.

This service will also be available to local vessels equipped with such amenities. The marina and adjacent coastal waters will have notice signs to inform all vessels of the pumpout system on site and to deter any dumping of sewage or bilge water in the marina.

6.8.3 Proposed Boat Wastewater Management

It is anticipated that all the marine vessel wastewater and bilge water will be piped from the marinas to the BESST Treatment Plan via a sewer system that will consist of industrial scheduled pipes laid under the marina slips along with a series of pumps. The collection and treatment system of the PPM&YC marina will also entail a combination of gravity feed collection and pumping with manholes and cleanouts which would convey the wastewater to the treatment plant.

The installation of the piping network will be carried out by a tradesman of the industry to assure the quality of work. In retrospect, the management of the proposed project will also develop a maintenance plan encompassing structural failures, inspections, short and long term repairs as well as training for new employees in charge of supervising the marina.

6.8.4 Bilge Water Spill Contingency

A bilge, fuel and spill response plan will be developed as part of PPM&YC's Spill Contingency Plan Marina Component. This contingency plan will be contained within the Disaster Management Plan (See Chapter 12) for the aforementioned project which deals with this particular issue. PPM&YC will deploy the recommended containment booms and spill kits in the marina should the need arise. As mentioned previously, the project will install notice signs on the importance of proper bilge treatment. This issue will be further discussed in Chapter 12 as required for this EIA.

6.9 Wastewater Disposal Alternatives

In any commercial activity such as resorts and marinas, wastewater treatment and disposal are an important and critical issue when it comes to environmental protection. For this purpose the wastewater generated by the project's operation will have several disposal alternatives. These include wastewater recycling for the flushing of toilets, wastewater for non-potable uses such as irrigation and fire fighting and the disposal of the wastewater into the brine deep injection well.

All of these alternatives are environmentally friendly and will pose not long term impact to the surrounding environment. The following sections outline the proposed disposal alternatives as requested by the EIA preparers.

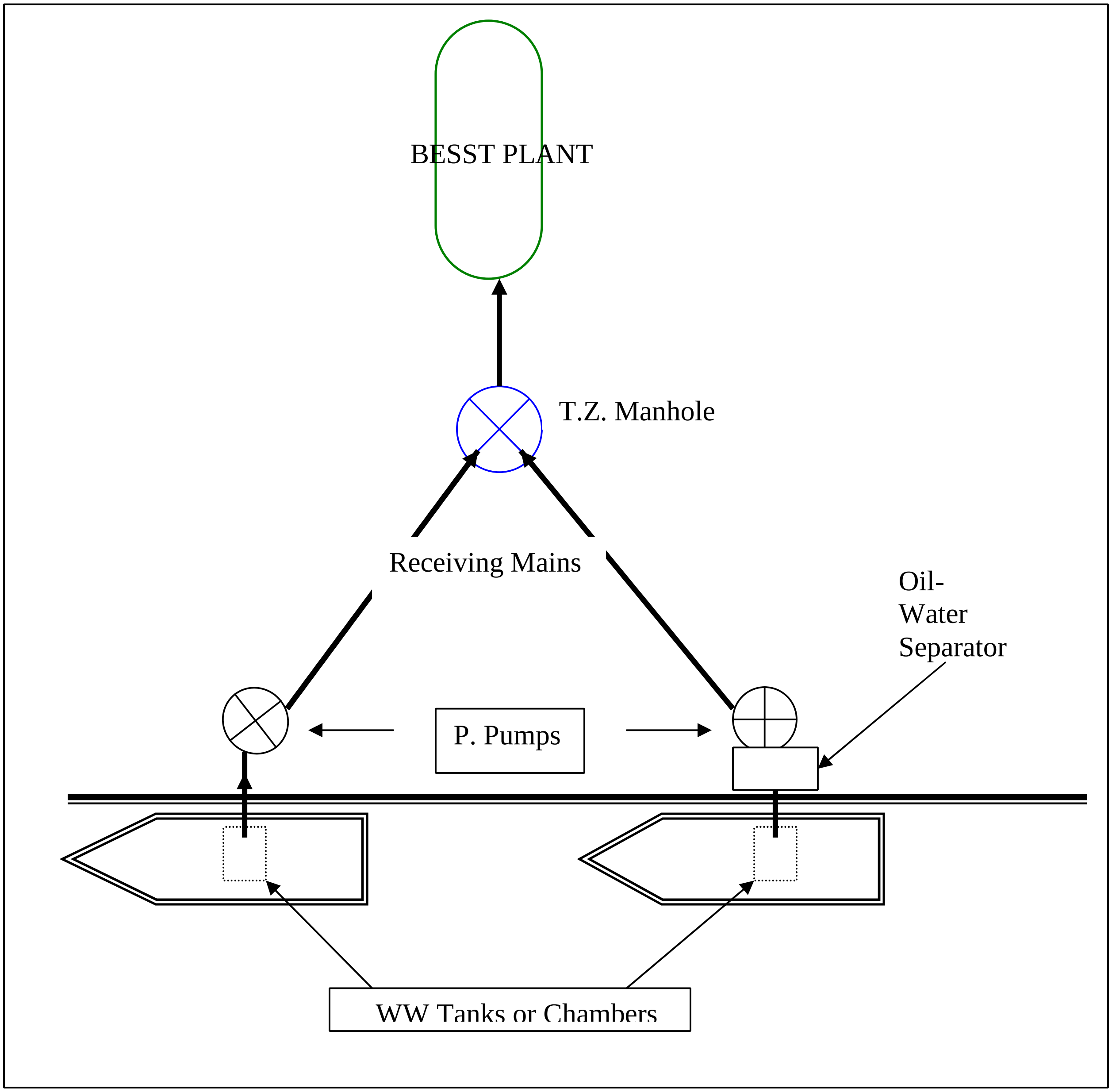

Fig. 6.1 Boat wastewater and bilge water treatment sketch

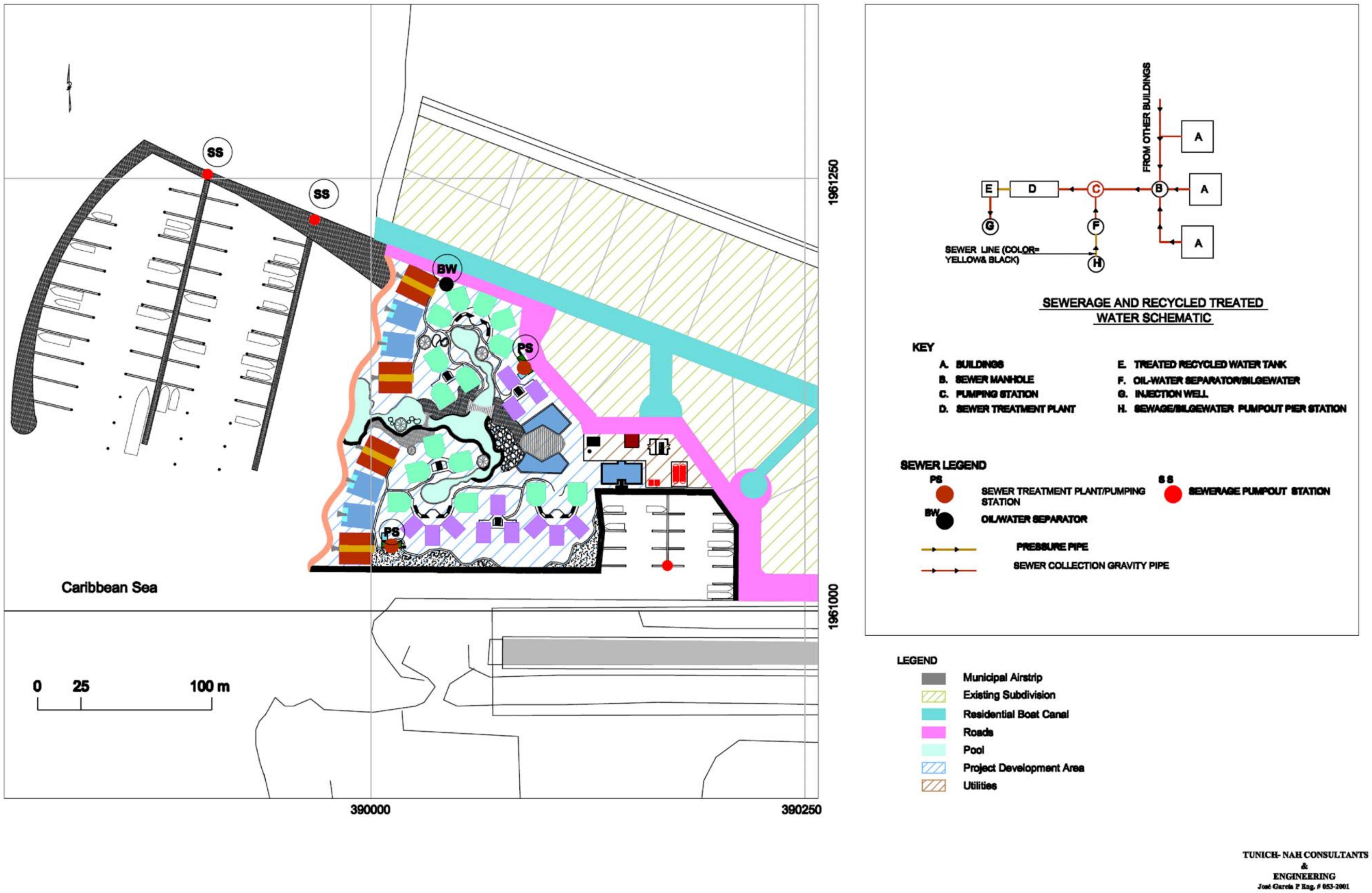

Fig. 6.2 Sewage and Recycled Treated Wastewater Schematic

6.9.1 Wastewater Recycling

The recycling of the treated wastewater is an important factor in reducing the projected water demand for the project. This in turn would conserve water use and reduce energy costs associated with operation of the water desalinization and wastewater treatment plant.

For the purpose of the proposed PPM&YC project, the wastewater generated by the operational process will be treated and recycled. The treated wastewater will be disinfected by a chlorination system as described in the previous chapter. This process is necessary to remove any harmful pathogens that may be found in the treated wastewater. This treated wastewater will be conveyed to a 20,000 gallon holding tank that will be located in the Utility Zone.

It is anticipated that the project will recycle about 45 % of its wastewater for the flushing of toilets as also illustrated in the previous chapter. All the associated recycling water lines will be color coded to distinguish them from the other water lines and mains.

6.9.2 Wastewater Alternative Uses

The remaining volume of wastewater or about 55 % will be used for irrigation purposes which include the irrigation of the lawns, hedgerows and other related non-potable uses such as fire combating and dust suppression.

6.9.3 Final Wastewater Disposal

After all the required wastewater alternative uses have been accomplished by the management of the proposed project, the treatment plants, once in operation, will be producing excess wastewater that can only be discarded. With this in mind and considering the environmental sensitivity of the area and subsequent environmental loading, the excess wastewater will be discharged into the water desalinization plant's deep injection well by diffusion (See Fig. 5.3b).

Provisions will be made for the final disposal of the treated wastewater along with the brine from the water desalinization process. The developers will ensure that the discharge wastewater meets and exceeds the environmental guidelines for the discharge of effluent.