Port Antonio Water, Sewerage and Drainage Project

Government of Jamaica/European Investment Bank

ENVIRONMENTAL IMPACT ASSESSMENT for STAGE 2

XU0396
April 2006

KBR

in Association with
WRC, Swindon, UK
RPS Water Services, Exeter, UK
Lawson & Associates Ltd, Kingston, Jamaica
N.O. Whyte & Associates Ltd, Montego Bay, Jamaica

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Document Title: **Port Antonio Water, Sewerage and Drainage Project: Stage 2 Environmental Impact Assessment**

Doc. Ref : **XU0396/100/G/0009**

Rev	Issue	Reason for issue	Prepared	Check	Approve	Authorise	Date
R01	01	Draft Submission to NWC	JCD	DL	JKM	JKM	8th April 2006

PREFACE

The Works proposed for the Port Antonio Water, Sewage and Drainage Project (PAWSDP) are divided into Stage 1 and Stage 2.

The Stage 1 Works are primarily concerned with the provision of improved water distribution, sewage collection and storm water drainage within Port Antonio town.

The present Environmental Impact Assessment (EIA) analyses the potential environmental impacts and discusses their mitigation in respect of the Stage 2 Works, which primarily encompass:

- The development of additional water resources;
- The delivery of collected sewage flows for treatment and disposal.

For a full understanding of the overall impacts of the PAWSDP reference should therefore also be made to the EIA for the Stage 1 Works.

The EIA studies for Stages 1 and 2 were undertaken simultaneously.

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EXECUTIVE SUMMARY

1. The area covered by the *Port Antonio Water, Sewage and Drainage Project* (PAWSDP) stretches along the North coast of Jamaica from the mouth of the Rio Grande River in the east to Fairy Hill in the west and inland as far as Fellowship, Nonsuch, Cambridge and Sherwood Forest.

2. The recent harbour redevelopment was the first step in the rejuvenation of this once prosperous area. The second, the upgrading of the road to Ocho Rios, has recently commenced. The next step is to improve public health infrastructure. There is currently insufficient water to provide a 24-hour pressurised supply and much of what is distributed is lost to leakage. There is no centralised sewerage system and no facilities for sewage treatment and safe disposal. Coastal waters, including the twin harbours, are therefore seriously polluted. Parts of the town are below sea level and prone to flooding due to the inadequacy of the drainage system.

3. The overall objective of the PAWSDP is therefore to improve the availability of water, provide for the safe and sustainable disposal of sewage, and reduce the risk of flooding to reduce soil and water pollution, improve public health and support economic revival.

4. The project was originally conceived from the 1966 Master Plan and the programme reviewed within a Feasibility Study in 2002. In March 2003 Kellogg Brown and Root were contracted by the National Water Commission (NWC), the Project Proponent, to complete detailed design, including Environmental Impact assessment, and undertake construction management.

5. The design horizon is 2025, when the predicted population of the project area will be 48,000, the demand for water 21,000 m^3/d, and sewage outflow 2000 m^3/d. The construction proposed under PAWSDP Stage 2 includes:

   - Upgrading water resources development at the Grant's Level Wellfield;
   - A new water transmission main from East Palm Avenue to Turtle Crawle;
   - Pumping stations at Caneside River and Anchovy to send raw sewage to Turtle Crawle;
   - A waste stabilisation treatment plant comprising two facultative ponds, three maturation ponds and a rock filter, and a treated effluent pumping station at Turtle Crawle; and,
   - A long sea outfall east of Daniel's Harbour to discharge treated effluent 500 m offshore.

6. The increased abstraction of water at Grant's Level will reduce flows in the adjacent Rio Grande River by up to 9% of the 1 in 10 year low flow at Fellowship and by 11% of the historically lowest

flow recorded on 5th May 1968. Generally this reduction will be imperceptible and have no impact of the appearance or use of the river, including rafting activities.

7. The water transmission main and sewage main to Turtle Crawle will be constructed within the existing road corridor, either beneath the road pavement or within the verge reserved for public services. The Caneside River and Anchovy pumping stations will also be within the wayleave corridor.

8. The principal environmental impacts will be the noise, dust and traffic delays that pipe laying along busy roads always entails. To minimise these, conditions will be imposed on the Contractor. Working hours will be limited in built up areas to reduce noise, dust and traffic delays on rest days and public holidays. Strict limits will be placed on the noise generated by construction equipment and on exhaust emissions from vehicles and stand-by generators. Prior to commencing work, the Contractor will prepare a Traffic Management Plan which will detail how traffic delays, any temporary restriction on access and any use of diversionary routes will be managed. The public will receive prior notification of temporary disruptions to access agreed with Portland Parish Council and the Jamaican Constabulary. In all issues, the Contractor shall abide by all standards and regulations currently in force throughout Jamaica, including those of the National Environment and Planning Agency (NEPA), who will be free to undertake their own inspections.

9. The treatment plant will occupy part of the lower Turtle Crawle River valley, south of Turtle Crawle Harbour. Although technically a wetland, it is of relatively recent origin, having been formed when the road crossing restricted drainage. The area has been substantially degraded by the felling of trees, land clearance for agriculture and human habitation. Ecological surveys undertaken in 1973 and recently as part of the present EIA study both concluded that the area was of little ecological significance. An area of mangrove immediately south of the road, the residents of which include a small number of American Crocodiles, will be left undisturbed.

10. The area on which it is proposed to locate the treatment plant is owned by three different non-resident landowners. The site is currently occupied by 15 households, none of whom have legal entitlement to tenure. A preliminary socio economic survey has indicated 21 adults and 26 children will need to be resettled to allow the land to be acquired in accordance with Jamaican law. NWC will prepare a Resettlement Plan.

11. The biological process adopted for the treatment plant will discharge effluent in accordance with NEPA's general requirements for disposal of at sea. It will, however, not meet the more vigorous requirements for discharge within 150 m of coral before it is diluted and dispersed at sea.

12. The decision to locate the long sea outfall off Daniel's Harbour was taken following a detailed assessment of various alternatives during the Master Plan study. The recent marine survey has indicated that although some coral is present it is in generally poor condition. The occupancy of coral for each 10 interval of the route varies from 0-30% (per interval) with an average of 13%. 25% of route is devoid of coral.

13. The outermost 300 m of the proposed route almost coincides with a channel of sand substrate and minor adjustments in alignment will be made to maximise the use of this channel and significantly mitigate impact on the reef. From 100-200 m from the shore, the reef is experiencing mortality, macro-algal overgrowth, bleaching, boring sponges and sedimentation, and there is a significantly low abundance of all types of fish, herbivores, and other species.

14. There is short zone of 'sensitive habitat', 50 to 90 m from the shore, where the substrate is clean, hard, devoid of significant macro-algal overgrowth and actively supporting juvenile coral recruitment. With the route alignment already amended to protect deeper water communities, there is no practical alternative to crossing this zone. However, the footprint is relatively small and juvenile coral specimens will be removed and transplanted in the vicinity or replaced after the pipeline has been buried. It is therefore possible to route the outfall with minimal significant impact upon the reef ecosystem.

15. Preliminary modelling of the dilution and dispersion of the effluent against measured current, tidal, bathymetric, salinity and sea water quality data, indicates the 'initial and entrainment' dilution factor as the effluent emerges from the diffusers into 28 m of water will be over 100, while the 'far field' dilution at key areas of interest, Burnett's Point, Soldier's Bay and Folly Point, will average over 2,000, within the range 1,000-10,000 depending upon current, tides and other variables. The effluent will therefore meet the NEPA requirements for discharge within 150 m of coral within a short distance of the diffusers.

16. The Stage 1 and Stage 2 PAWSDP works will provide Port Antonio with improved water supply, a safe and sustainable means of disposing of human waste. The immediate beneficiaries will be the residents of the main urban area. Visitors and tourists will also benefit, and the availability of these facilities will spur economic growth.

17. In accordance with NEPA requirements, the PAWSDP Stage 2 proposals and the finding of the Environmental Impact Assessment will be the subject of a Public Meeting at a place and date to be advertised locally.

ENVIRONMENTAL IMPACT ASSESSMENT PROJECT TEAM

The Environmental Impact Assessment (EIA) for the Port Antonio Water, Sewerage and Drainage Project (PAWSDP) has been prepared on behalf of the National Water Commission (NWC) by Kellogg, Brown and Root (KBR) as part of the overall design and execution of the project.

The KBR core team contributing to the EIA Study are as follows:

Dr. John. Davey	Principal EIA Preparer
Dr. David Lee	Local Environmental Expert
Mr. John Mazikiauskas	PAWSDP Project Manager
Mr. Karl McIntosh	PAWSDP Lead Design Engineer

Mr. M. White undertook the Aquifer Production Study for the Grant's Level wellfield;
Mr. Chris Burgess undertook the marine investigations for the long sea outfall;
Mr. Gordon Hutchinson of Geotech Exploration undertook the geotechnical survey; and,
Dr. Dwight Robinson of UWI undertook the Pesticides Study.

KBR would also like to thank the following for their cooperation:

At the National Water Commission:

Mr. Randy Maxwell	NWC Project Manager
Ms. Bridget Lawrence	Environmentalist

1. INTRODUCTION

Project Background

1.1. Port Antonio, the capital and main settlement of the Parish of Portland and is located on the north-eastern coast of Jamaica. With recent growth, water supply, sewerage and drainage services have become inadequate to sustain quality of life and maintain public health. Much of the water distribution system dates back to the 1920s, the town remains unsewered, and the drainage network is inadequate to prevent flooding.

1.2. Notwithstanding these problems, Portland was the first parish to adopt the principles of the Green Globe 21 Programme to promote sustainable environmental and social practices. While the area struggles to attract its share of tourists the potential for development has long been acknowledged and new public health infrastructure will substantially contribute to its realisation.

1.3. In 1995 the Urban Development Corporation obtained a loan from the Inter-American Development Bank to develop a Master Plan for water, sewage, drainage and solid waste services[1]. The study was presented in August 1996 but funding for the recommended works was not immediately available.

1.4. The first phase proposals of the Master Plan were revisited by the National Water Commission (NWC) in 2002 and a revised programme for water supply, sewerage and drainage prepared[2]. This work effectively constituted the Feasibility Study for the present project.

1.5. In March 2003 NWC awarded Kellogg, Brown and Root (KBR) the contract for detailed design and construction management of this project. The work is funded by the European Investment Bank under Contract No. EIB 21.613-2005/01 and the present Environmental Impact Assessment (EIA) is a requirement of this contract.

Scope and Structure of the Present Report

1.6. Initial Screening of the project by the National Environmental Protection Agency (NEPA)[3] identified the need for a full Environmental Assessment (EA), including public presentation, as it may potentially have significant impact upon the human and natural environment, including the marine environment, and affect a wide spectrum of stakeholders. In accordance with national requirements, Terms of Reference were submitted to NEPA on 6th December 2005 and approved on 6th February 2006.

[1] *Port Antonio Sanitation Study Master Plan Report*. Louis Berger International, August 1996.
[2] *Review of Master Plan for Port Antonio Urban Development Project for Water, Sewerage and Drainage.* Louis Berger international, April 2002.
[3] Formerly the National Resources Conservation Authority (NRCA).

1.7. As required under KBR's Contract with NWC, the Assessment follows a structure typical of a World Bank EA[4] while also fulfilling the requirements of NEPA[5].

1.8. Section 2 below discuses the need for and objectives of the project, outlines the 'Without Project' situation, and describes the construction to be undertaken, while Section 3 presents an overview of the policy and legal framework under which it will be executed.

1.9. Sections 4 and 5 present the Environmental Baseline Conditions, reviewing biophysical and socio-economic issues respectively.

1.10. Sections 6 to 8 present the assessment of Environmental Impacts. Section 6 gives an overview of the potential temporary impacts that may be suffered during the period of construction. Section 7 defines the potential permanent impacts, while Section 8 details the possible extent and magnitude of post-construction and operational impacts.

1.11. Section 9 discuses the alternative development option that have been considered during the evolution of the project, including the 'Do Minimum' option.

1.12. Sections 10, 11 and 12 comprise the Environmental Management Plan (EMP). Section 10 presents proposals for the mitigation of impacts previously identified in Sections 6 to 8. Section 11 defines the need for environmental monitoring during and after construction, while Section 12 proposes institutional strengthening and capacity building to ensure the EMP is effectively implemented.

1.13. Finally, Section 13 provides information on the consultations with key stakeholders and the general public that have been an integral part of the Assessment.

[4] *World Bank Operational Policies OP.4.01*, *Annexes B and C.* World Bank, January 1999.
[5] *Guidelines for Conducting Environmental Impact Assessment*. NRCA, July 1997.

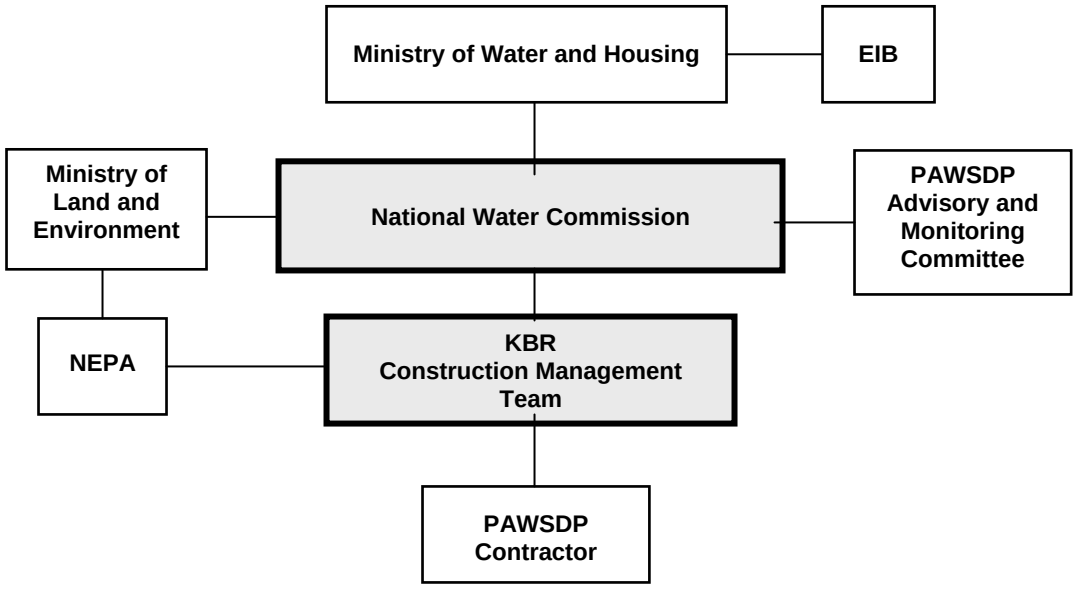
12. INSTITUTIONAL STRENGTHENING

12.1. This Section of the EIA comprises the third and final part of the Environmental Management Plan and discusses the institutional strengthening and capacity building required to effectively implement the PAWSDP EMP.

12.2. The project is not sufficiently large enough to encompass capacity building for GoJ agencies such as NWC and NEPA. NWC staff assigned to the project will attend the briefing sessions to disseminate the requirements and procedures for EMP implementation to those of the Contractor and Construction Manager.

EMP Implementation Structure

12.3. Tendering for the PAWSDP Stage 1 and Stage 2 contracts will be competitive and Tenderers will be post-qualified. NWC is the Project Proponent, Kellogg Brown and Root (KBR) the Construction Manager and the Engineer[1], and the organisational structure for EMP implementation shown in **Figure 12.1**.



(a) Figure 12.1. EMP Implementation Structure

[1] The two roles are almost synonymous but the title 'The Engineer' infers particular responsibility in engineering contract law.

12.4. The Contractor will establish project offices and other facilities at Bryan's Bay. These will include provision for the NWC representative on site and the KBR construction management team.

12.5. KBR will monitor the Contractor's compliance with his responsibilities under the EMP and issue instructions as and when additional remediation may be required. NWC's Environmental Advisor will provide semi-formal auditing with the preparation of bi-annual (every 6 months) EMP Compliance Reports, copies of which will be submitted to NEPA and presented verbally at meetings of the PAWSDP AMC. Copies of these reports will also be lodged with the PPC, NEPA and NWC in Port Antonio for public reference.

12.6. While KBR will work closely with NEPA it will not circumvent their wider responsibilities in respect of environmental protection. NEPA officers will be given free access to all PAWSDP construction and other sites as and when they require, subject to any access and safety restrictions that may need to be imposed at specific sites.

12.7. Since the execution of the majority of works will be highly visible to the public, no special provision for generally informing the public of progress will be necessary. Notices of traffic diversions and temporary limitations on access will be issued separately. A visit to specific sites such as the treatment plant for members of the AMC will be organised if requested. Requests for visits by other groups will be accommodated subject to the constraints of construction activity, staff availability and public safety.

Training for PAWSDP EMP Implementation

12.8. All NWC and KBR staff associated with the project will need to be made sensitive to the particular requirements of the PAWSDP EMP and briefing sessions will be held as staff are assigned to the project. A similar briefing will be given to the AMC prior to construction with the dual aim of eliciting their comments on the implementation procedures and allowing NWC to promote the vigorous consideration of environmental issues that will be imposed.

12.9. Briefing sessions will also be held for the Contractor's site managers and foremen as new or replacement appointments are made.

Training for Operational Performance and Monitoring

12.10. As sections of the PAWSDP Stage 2 works are completed and handed over, NWC will assume responsibility for operational performance and monitoring. Pumping station and treatment plant operational staff will be qualified in accordance with NEPA's Sewage Effluent Regulations but will

still need to be briefed in the specific requirements of the PAWSDP EMP. They will also be trained on the use of any environmental monitoring equipment supplied under the contract.

Summary of Institutional Strengthening Requirements

12.11. A summary of training requirements to achieve the institutional strengthening and capacity building necessary for PAWSDP EMP implementation are listed in **Table 12.1**.

(i) Table 12.1. Summary of Training Requirements

Training	Recipients	Duration
EMP Implementation Requirements and Monitoring	KBR and NWC staff assigned to the project	1 Day
EMP Execution and Compliance	Contractor's managers and foremen	1 Day
PAWSDP Environmental Management	AWC and other invited attendees	Half Day
Operational Monitoring	NWC operations managers and plant operators	5+ Days 'on-the-job'

12.12. Briefing sessions will be given by the KBR Project Manager and Environmental Consultant. Training in the operation of all mechanical and electrical equipment, including environmental monitoring equipment supplied under the contract, will be given by the Contractor or his suppliers.

12.13. The cost of all training is included in either the cost of KBR's construction management contract or the cost of construction.

11. ENVIRONMENTAL MONITORING

11.1. This Section of the EIA presents the proposed Environmental Monitoring Plan for the PAWSDP Stage 2. After defining the Standards against which environmental performance will be assessed the details of the monitoring to be undertaken and how it will be reported is defined.

Environmental Standards

11.2 NEPA and other Jamaican Standards have been adopted as the primary reference in developing the requirements for monitoring. Where Standards have been drafted but have yet to receive legal backing it is assumed this will be forthcoming during the period of PAWSDP execution and should be implemented as would have otherwise been intended.

11.3. While there is a standard for ambient noise as discussed in Section 4, 70 dB(A) beyond 50 m, the likely high impact of construction suggests that more stringent limits be placed on particular items of equipment when working within Port Antonio town as shown in **Table 11.1**.

11.4. The principal standard against which project will be monitored, including the National Sewage Effluent Standard for operational performance, have previously been presented in Section 2.

Table 11.1. Proposed PAWSDP Noise Limits for Construction Equipment

Activity	Source	Day	Night
Earthworks	Bulldozer/excavator	75 dB(A)	55 dB(A)
Piling	Piling machine	85 dB(A)	None
Structural	Concrete mixer/concrete pump	70 dB(A)	55 dB(A)
Surfacing	Roller	70 dB(A)	55 dB(A)

Scope of Environmental Monitoring

11.5. Having discussed in Section 10 the mitigation measures to be adopted to minimise potentially negative impacts, their success can only be determined by a programme to:

- Monitor any changes in the biophysical and social characteristics of the environment;
- Determine if these changes result from project or non-project causes;
- Identify and determine the impact of non-compliance with the EMP by the Contractor with particular regard to emissions and discharges that contravene adopted standards;
- Assess the effectiveness of impact mitigation; and
- Highlight any concerns unforeseen in the EMP and recommend additional mitigation.

Baseline Condition Monitoring

11.6. Section 4 identified a number of shortcomings in biophysical baseline information in respect of:

- The depth and composition of the alluvial aquifer and present abstraction at Grant's Level;
- Geotechnical characteristics of the Turtle Crawle sewage treatment site;
- The potential for Turtle Crawle River to flood the treatment plant after heavy rainfall; and,
- The ecology of the Turtle Crawle wetland and the presence of the American Crocodile (*Crocodylus acutus).*

11.7. The lack of information at Grant's Level will be addressed during the Stage 2 works with the drilling of three monitoring wells prior to the construction of new production wells. Further geotechnical investigations to improve the information available for treatment pond embankment detailed design are currently being undertaken. A conservative view of Turtle Crawle River flooding has been taken and it need not be investigated further. The need for a study of the American crocodiles at Turtle Crawle has been highlighted in Section 10.

Land Acquisition Monitoring

11.8. All aspects of land acquisition and resettlement are being handled by NWC in accordance with the laws of Jamaica. Monitoring of the acquisition process, the assessment of compensation, disbursements, or the evaluation of special needs will **not** be undertaken by the Construction Manager.

Construction Monitoring

11.9. Monitoring of abstraction rates and ground water levels at Grant's Level wellfield will continue throughout the period of well construction and a Wellfield Monitoring Report will be produced to support NWC's application for increased abstraction.

11.10. Whilst the routes of the water and sewerage pipelines, pumping stations and other permanent works are well known, other sites to be used during construction remain to be fully identified. These include the Contractor's Camp and project offices at Bryant's Bay and third party sites such as quarries. The provisions of the EMP and the requirement for environmental monitoring extend to these sites, where and monitoring will address the issues listed in **Table 11.2**.

Table 11.2. Issues to be Addressed during Construction Monitoring

At PAWSDP Construction Sites	At Other Sites used by the Contractor
Temporary obstruction of access; Traffic management; Noise and dust; Maintenance of existing utility services; On-site materials storage; Security of excavations; Disposal of excess spoil; Workers Health and Safety; and, Public Health and Safety.	Arrangements for access; Traffic management; Noise and dust; Wastewater disposal; Solid waste disposal; Materials storage; Workers Health and Safety; and, Public Health and Safety;

11.11. Monitoring by the Construction Manager will be mainly at construction sites and the Contractor's Camp. Monitoring of Other Sites will be undertaken by the Contractor with occasional visits from the Construction Manager. For a project the size of PAWSDP, these issues will be addressed qualitatively rather than quantitatively, except for noise from construction equipment and stack emissions from generators, for which the Contractor shall provide appropriate monitoring equipment. On completion of construction this equipment will become the property of NWC and lodged in the sewage treatment plant to be used for operational monitoring.

11.12. For ambient noise measurements to be meaningful, initial readings will be taken at various locations within area of the PAWSDP works prior to the commencement of construction and will effectively constitute baseline monitoring for which information is not otherwise available.

11.13. In conjunction with the Contractor, the Construction Manager will monitor the monthly consumption of materials including aggregates, hazardous materials, fuel, water and electricity, the disposal of surplus earth materials and other solid and liquid wastes.

11.14. The monitoring of Health and Safety shall include but not be limited to H&S signage, the availability and use of protective headgear, footwear and other clothing, the occurrence of accidents and the potential for accidents in relation to general site condition.

Complaint-Based Monitoring

11.15. During the period of construction, monitoring to investigate complaints received from the public will be initiated by the Construction Manager. Complaints arising during operations will be investigated by NWC.

Operational Monitoring

11.16 Operational monitoring to check the continued sustainability of project performance will be the responsibility of NWC and include the following:

- The quantity and quality of ground water abstracted from the Grant's Level wellfield;
- The quantity and quality of treated effluent leaving the sewage treatment plant;
- The quantity of excess flow discharged via the two treatment plant overflows;
- The dilution and dispersion of treated effluent from the long sea outfall;
- The visual inspection of sewers at manholes;
- The visual inspection of landscape planting at the sewage treatment plant, and,
- Health and safety at the Turtle Crawle treatment plant.

11.17. Routine water meter readings and sewage flow measurements will be undertaken to monitor leakage and to compare water demand and sewage generation with design expectations.

11.18. The daily operational logs of the treatment plant will be available on demand for inspection by NEPA. Monthly reports will be submitted to NEPA and Annual reports to NEPA and the MoH Environmental Health Unit as required by the Sewage Effluent Regulations. Fuller details of these requirements are discussed below.

11.19. The landscape planting at the sewage treatment plant will be inspected twice each year to monitor die back and identify any requirement for replacement planting.

Access Requirements

11.20. For the proposed programme of site inspections and monitoring to be effective it will be necessary for authorised personnel from NWC, the Construction Manager, NEPA and other key agencies to have guaranteed access to all component sites of the project at all times throughout construction and operation. Accordingly, contract documents and operating agreements should incorporate a Clause with intent equivalent to the following:

Any Officer or Agent authorised in writing by the NWC, NEPA their agents or other organisation for which from time to time it may be necessary, may at any time enter any premises whether prescribed or otherwise and may:

- *Examine and inspect equipment, control apparatus, monitoring instruments or plant;*
- *Take samples of any material that is emitted, discharged or deposited, or is likely to be, from such premises;*
- *Examine any books, records or documents relating to the performance or use of such equipment, apparatus, instruments or plant, or relating to the emission, discharge or deposit from such premises; and*
- *Photograph such premises as is considered necessary or make copies of any book, records or documents seen in the course of examination.*

11.21. The Construction Manager will be responsible for liaising between all involved parties and advising on all environmental issues, particularly those relating to compliance and impact mitigation.

Site Inspections

11.22. Site Inspections provide for the day-to-day monitoring of construction activities and are the primary mechanism by which the Contractor's performance will be assessed to have met his contractual responsibilities.

11.23. These inspections are the responsibility of the Contract Manager and will be carried out on a regular basis but not necessarily to a structured pattern. Any standard checklist or pro-forma used for recording observations should include a separate section under which to record environmental issues including incidents of non-compliance. The construction Manager's site staff will pay particular attention to critical operations, which will include the initial clearance of

the Turtle Crawle treatment site and the replanting of coral from the outfall route. These activities will therefore be adequately covered by Site Inspection reports and no special monitoring other than the provision of appropriate staff will be required.

11.24. Copies of all site inspection reports shall be available for reference at each Monthly Project Progress Meeting and 'Environmental Issues' will be a routine item on the meeting agenda, when an 'Environmental Summary Sheet' compiled by the KBR Project Manager from previous site inspection reports will be tabled.

11.25. NEPA will undoubtedly wish to undertake site visits to satisfy themselves the EMP is being effectively implemented. These visits will be undertaken as and when they consider appropriate. NWC, the Construction Manager, the Contractor and sub-contractors will all facilitate free access to sites and data, subject to the same standards of access control and safety requirements applicable to their own staff. Coordination with NEPA will be handled by KBR and copies of NEPA visit reports will also be tabled for discussion at monthly Progress Meetings.

Environmental Reporting During Construction

11.26. For environmental monitoring to be both effective and meaningful it will be comprehensively reported to all concerned parties and, perhaps with limited exceptions, made available for public consultation. The primary levels of reporting will be as follows:

- Individual KBR Site Inspection Reports, tabled at Monthly Contract Progress Meetings;
- Individual site visit reports by NEPA;
- Bi-annual (6 monthly) EMP Compliance Reports.

11.27. These reports will incorporate the results of monitoring undertaken to confirm compliance with the required Standards. Baseline conditions from the new monitoring wells at the Grant's Level wellfield will be reported as soon as they are is completed.

11.28. The bi-annual EMP Compliance Report will include:

- A review of the last six Environmental Summary Sheets;
- A summary and discussion of environmental monitoring data;
- Discussion of any abnormal events that may have influenced the empirical findings;
- His/her own assessment from a one-day inspection of all project sites;
- Discussion of any items outstanding from the previous Compliance Report;
- Discussions with NWC Environmentalist and NEPA; and,
- Recommendation of actions to be taken and/or improvements to the EMP.

11.29. The period of construction is currently expected to be 22 months, necessitating four EMP Compliance Reports. Should this period be extended, reporting will continue at six month intervals. If the final report is due within 3 months of the expected completion date it should be delayed to include discussion of final site clearance and the Contractor's demobilisation.

Environmental Auditing During Construction

11.30. There is no specific provision for formal Environmental Audits during construction. NWC will *de facto* audit the progress reports of the Construction Manager and prepare bi-annual (6-monthly) EMP Compliance Reports. With copies of the latter, NEPA will effectively audit NWC. The Compliance Reports will also be made available for public consultation.

11.31. Although the Funding Agency is unlikely to undertake formal auditing, missions during the period of construction may include members with particular responsible for environmental issues.

Operational Monitoring of Sewage Treatment Plant Performance

11.32. The *National Sewage Effluent Regulations 2001* unambiguously lays down the requirements for monitoring the performance of sewage treatment plants. Responsibility for the administration and enforcement of the Regulations rests with NEPA but responsibility for operational monitoring and compliance rests with NWC.

11.33. The performance and monitoring requirements are dependent upon the level of effluent discharge. For a plant the size of that proposed for Turtle Crawle plant the requirements are listed in **Table 11.3** and the methods by which the parameters should be analysed in **Table 11.4**. Raw sewage inflow and treated effluent outflow must be monitored daily, as must residual chlorine if chlorination if added in the future. Also to be monitored shall be any other parameters NEPA may periodically request. All samples for effluent quality monitoring shall be taken at the discharge from the treatment plant at approximately the same time of day.

Table 11.3. NEPA Requirements for Sewage Treatment Plant Monitoring

Parameter	Effluent Limit	Maximum Allowable	Minimum Annual Sampling Frequency
BOD_5 (mg/l)	20	45	Weekly
TSS (mg/l)	20	40	Weekly
Total Nitrogen (mg/l)	10	35	Weekly
Total Phosphates (mg/l)	4	8	Weekly
COD (mg/l)	100	150	Weekly
pH	6-9		Daily
Faecal Coliform (MPN/100ml)	1000	1500	Weekly

11.34. All analyses are to be undertaken in a NEPA approved laboratory. If NWC or any operating contractor performs their own monitoring elsewhere, confirmation testing by an independent source shall be carried out twice per calendar year. This testing shall be conducted at a minimum of three months apart. Notwithstanding the requirements for monthly and annual reporting detailed below, the results of monitoring analyses shall be submitted to NEPA as defined in the Permit and Licence.

Table 11.4. Methods of Analysis Approved by NEPA for Compliance Monitoring

Parameter	SMEWW Method[1]	ISO Method[2]
BOD_5	5210 B, 5-day BOD test	ISO 5815:1989, Dilution and Seeding
TSS	2450 D, TSS dried at 103-105 °C	
Total Nitrogen	4500-N	ISO 10048:1991
Phosphates	4500-P E, Colorimetric	ISO 6878-1:1986, Colorimetric
COD	5220 D, Closed reflux, Colorimetric	
pH	4500-H^+ B, Electrometric	
Faecal Coliform	9221 C, Multiple tube fermentation	ISO 9308-2:1990
Residual Chlorine	4500-Cl, DPD Colorimetric	ISO 7393-2:1985, DPD Colorimetric

11.35. Also required by the Effluent Regulations is the keeping of a Daily Operating Log together with and monthly and annual reporting. The daily logs are not routinely submitted to NEPA but are retained at the plant for inspection on demand. Monthly reports relating weekly data are be submitted to NEPA no later than the 15th day of the month following the reporting month. Annual reports relating a summary of monthly data are submitted to NEPA and the MoH EHU not later than one month after the end of the reporting year.

11.36. Daily Operating Logs shall include:

- General Information - name of plant, location, name of operator(s), and date;
- Weather Conditions - precipitation, temperature and wind;
- Operating Parameters - influent and effluent flow rates measured at about the same hour each day, pH and, if appropriate, chlorine residual; and,
- Any unusual events of environmental significant, such as flooding of the plant.

11.37. Monthly Reports shall include:

- Collated data for the week/month;
- Listing of repairs;
- Problems at the plant and proposed corrective actions with a corresponding time schedule;
- Improvements to the plant;
- Analysis of any anomalies;
- Any staff changes and whether or not a shift system had been implemented; and,
- Volume of sludge extracted from the treatment facility.

[1] *Standard Methods for the Examination of Water and Waste Water*, Clesceri, L; Greenberg, Arnold and Trussel, R. (Editors), APHA-AWWA-WPCF,17th Edition, 1989

[2] Water Quality Vol. 2 - Chemical Methods. ISO1994, 1st Edition.
Water Quality Vol. 3 - Physical, Biological and Microbiological Methods ISO 1994, 1st Edition.

11.38. Annual Reports shall include:

- Collated data from daily logs and monthly reports
- Listing of repairs.
- Problems at the plant and proposed corrective actions with a corresponding time schedule.
- Improvements to the plant.
- Process modifications at the facility.
- Analysis of any anomalies.
- Calculated average daily flow for the year based on periodic readings throughout the year.
- Sludge volumes removed for the year.

11.39. The format for Daily Logs is not specified. The required layouts for monthly and annual reports are given in Appendix D. A copy of all reports shall be retained by the NWC for a minimum of 10 years.

Operational Monitoring of Effluent Dilution and Dispersion at Sea

11.40. Monitoring is also needed to check the effective dilution and dispersion of the effluent and to check it does not quickly return to the shore before this is achieved. NEPA's existing routine monitoring bathing water sampling stations at Anchovy Beach and Trident Hotel Beach, respectively a short distance west and east o the LSO landfall position are well placed to provide this. For initial monitoring at the start of treatment operations a further 8 sampling sites are suggested, some of which might be abandoned once the general performance of the treatment plant and effluent dispersion has become established. These sites are listed below relative to the outfall location and all sites are shown on Figure 11.1.

- Pegg Point, 1.2 km SW;
- Burnell's Point, 1.9.km ESE;
- Turtle Crawle Harbour, 2.5.km S;
- Folly Point, 2 km W;
- Ship Head, 6 km WNW;
- Over the outfall position (LSO+0); and,
- Two sites on the line between the outfall and Ship Head, 500 m (LSO+500) and 1000 m (LSO+1500) from the outfall.

11.41. Sampling would be undertaken monthly as soon as the treatment plant is commissioned and samples analysed for BOD_5, total nitrogen, total phosphorous and faecal coliforms.

Environmental Monitoring Costs

11.42. The cost of environmental monitoring to be undertaken by the Construction Manager has already been included in KBR's contract with NWC. Monitoring to be undertaken by the Contractor will be included in the Tender Documents to allow Tenderers to make full provision in their offers. Operational monitoring costs will be borne by NWC.

Figure 11.1. Proposed Monitoring Stations for Treated Effluent Dilution and Dispersal

Summary of Environmental Monitoring Requirements

11.43. A full list of environmental monitoring requirements is given in Table 11.5.

Table 11.5. Environmental Quality Monitoring Requirements

Project Phase	Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility
Pre-Construction	Ecological Study	Activities of American Crocodiles	Turtle Crawle	Tagging and observation	1 year	As necessary	To define permanence and condition of present population	Ecologist with an interest in crocodiles	NWC
Construction	Site Inspections	Site Clearance	Turtle Crawle treatment plant and the LSO headworks	Visual and Descriptive, against a check list	For the duration of site clearance	Daily	To ensure compliance with the requirements of the EMP including Health and Safety	Experienced site supervision staff with knowledge of EMP and H&S requirements	NWC and Construction Manager
		Erosion, Turbidity and Sediment Load	Turtle Crawle treatment plant	Visual and Descriptive	Until the earthworks are protected from erosion	Daily			
		Disruption to traffic, access and utility services; Materials storage; Disposal of spoil; Health and Safety.	All PAWSDP construction sites	Visual and Descriptive, against a check list	Throughout the period of construction	Daily when sites active			
		Traffic management; Wastewater disposal; Solid waste disposal; Materials storage; Health and Safety.	Contractor's camp	Visual and Descriptive, against a check list	Throughout the period of construction	Monthly			
		Traffic management; Wastewater disposal; Solid waste disposal; Materials storage; Health and Safety.	Other sites	Visual and Descriptive, against a check list	Throughout the period of construction	Quarterly	To ensure compliance with the requirements of the EMP including Health and Safety	Site supervision staff briefed on EMP requirements	Contractor and Construction Manager
	Air and Dust	PM_{10}, Ambient Noise	All PAWSDP construction sites and Contractor's camp	Portable air quality monitoring equipment	Over 24 hours, at times to be determined by the Engineer	As deemed necessary by the Engineer	To quantify project impacts	Person trained in the use of the equipment	Contractor and Construction Manager
				Portable noise monitoring equipment	Over 1 hour, at times to be determined by the Engineer				
	Aquifer Yield	Well water levels and production yields	Grant's Level wellfield	Dipper and flow meter readings	Throughout the period of well construction	Daily	To confirm the availability of resources and the sustainability of increased production	Drilling contractor or plant operator	Contractor and Construction Manager
	Raw Water Quality	pH, Temperature, Conductivity	Grant's Level wellfield (individual wells)	On site measurement with hand-held meter	Throughout the period of well construction	Daily	To confirm continued acceptability of ground water quality with increased yield	Drilling contractor or plant operator	
		The full list of NWC's standard raw water quality parameters	Grant's Level wellfield (high level tank)	AWWA, WHO or other approved standards of sampling and laboratory analysis	Throughout the period of well construction	Weekly	To confirm continued acceptability of ground water quality with increased yield	Experienced water sampler and resourced water chemist	NWC and Construction Manager
	Complaint Investigation	Any of the parameters listed above, depending upon the nature of the complaint	At or in the vicinity of all sites for which a specific complaint has been received	As appropriate for the parameter being monitored	As necessary	As necessary	To fully investigate all complaints and to provide a basis for mitigation and/or compensation	As necessary	NWC and Construction Manager
	EMP Compliance	Contractor's compliance with Standards and EMP requirements. Low numbers of injuries to workers. Minimal public disturbance.	All sites of construction and project related activity	Site inspection and interrogation of site records	Throughout the period of construction	Every 6 months	To ensure Contractors comply with Standards and EMP requirements	NWC Environmental Advisor	NWC and Construction Manager

Project Phase	Category	Indicators	Location	Method	Duration	Frequency	Purpose	Expertise Required	Responsibility
Post-Construction and Operation	Raw Water Quality	The full list of NWC's standard raw water quality parameters	Grant's Level wellfield (high level tank)	AWWA, WHO or other approved standards of sampling and laboratory analysis	Ongoing	Monthly	To confirm continued acceptability of ground water quality with increased yield	Experienced water sampler and resourced water chemist	NWC
	Treatment Plant Operation	NSER requirement for Daily Logs	Turtle Crawle treatment plant	Collation of information	Ongoing	Daily	To record daily plant performance	Experienced plant operator	
	Treated Effluent Quality	NSER requirement for daily and weekly sampling	Turtle Crawle treatment plant	NSER approved methods of analyses	Ongoing	Weekly	To satisfy NSER monthly reporting requirements	Experienced wastewater sampler and resourced wastewater chemist	
						Monthly	To satisfy NSER annual reporting requirements		
	Treated Effluent Dilution and Dispersion	BOD_5, N, P and faecal coliforms	Sites shown on Figure 11.1	NSER approved methods of analyses	Ongoing	Monthly	To monitor impact on the marine environment		
	Other Effluent Discharged	BOD_5, N, and P	Treatment plant overflows 1 and 2	NSER approved methods of analyses	Ongoing	Monthly during overflows	To monitor quality of storm discharges		
	Long Sea Outfall	NSER standard analyses	Offshore and onshore of Daniel's Harbour	NSER approved methods of analyses	Ongoing	Monthly	To endure expectations of effluent dilution and dispersion are being met	Experienced water sampler and resourced water chemist	
	Sewer Condition	Sewer degradation	Throughout the gravity sewer network	Visual inspection	Ongoing	Annually	To regularly inspect the sewer network	NWC Inspection Engineer	
	Leakage	No unexplained loss of flows	Throughout the water distribution network	Meter readings	Ongoing	Every 2 years	To reduce losses from the water distribution pipelines		
	Health and Safety	The number of reportable incidents and injuries	Turtle Crawle treatment plant	Inspection in accordance with NWC H&S Policy	Ongoing	Annually	To protect the health and safety of workers and the public	NWC Health and Safety officer	
	Landscape	The sustainability of landscape planting	Turtle Crawle	Visual inspection	Half day	Every 6 months	To ensure the planted areas are maintained and that any die-back is replaced	Experienced Groundsman	

10. IMPACT MITIGATION

10.1. The impact mitigation discussed in this Section comprises the first element in the Environmental Management Plan. The other elements, Environmental Monitoring and Institutional Strengthening/Capacity Building are presented in Sections 11 and 12 respectively.

10.2. In addition, a series of Sample Contract Clauses for Environmental Impact Mitigation are given in **Appendix C**. Inclusion of these in the Tender Documents will enable Tenderers to be explicitly aware of their responsibilities to the environment in general and the EMP in particular, enabling them to make appropriate financial provision at the time of tendering.

10.3. The proposed mitigation to address the impacts previously defined in Sections 6 to 8 fall into one of the following six categories:

- Pre-Construction Impact Mitigation;
- Construction Impact Mitigation: On-Site;
- Construction Impact Mitigation: Off-Site;
- Permanent Impact Mitigation; and,
- Operational Impact Mitigation.

Pre-Construction Impact Mitigation

10.4. Detailed Design of the PAWSDP Stage 2 has afforded the opportunity to minimise many potential adverse environmental impacts through the appropriate siting and design of structures, particularly the increase in water resources development and other improvements at Grant's Level wellfield, the sewage pipelines and pumping stations, the treatment plant at Turtle Crawle, and the long sea outfall near Daniel's Harbour.

Construction Impact Mitigation: On-Site

10.5. The majority of construction-related impacts are temporary and can be mitigated through good construction practice and effective site supervision. The World Bank has published[1] principles on waste management that are applicable to many construction activities and these will be utilised by NWC, their Construction Manager and PAWSDP Contractor.

Damage to Landscape

10.6. The Contractor shall exercise all due care to preserve the natural landscape and shall conduct his[2] operations so as to prevent any unnecessary destruction, scarring or defacing of the natural surroundings in the vicinity of the works.

[1] *Pollution Prevention and Abatement Handbook*. The World Bank, 1989.
[2] The use of the term 'his' or 'he' instead of 'hers' or 'she' is not gender specific nor does it signify an individual rather than a group.

10.7. Except where clearing is required for permanent works and approved working space, all trees, native shrubbery and vegetation shall be preserved and protected from damage. No trees shall be cut down outside working areas without the specific approval of the Engineer.

10.8. Where unnecessary destruction, scarring or defacing of landscape, natural vegetation or productive lands has occurred, the Contractor shall be responsible for repair, replanting or otherwise correcting at his own expense.

10.9. On completion of the Works, all surplus equipment and materials shall be removed, and all work areas smoothed and graded in a manner commensurate with the surrounding landscape. Any landscape planting shall only utilise species already common in the area.

Reduction in Biodiversity

10.10. To minimize damage to wildlife, a combination of measures will be required. Specifically the Contractor will be required to:

- Minimise habitat loss from construction activities;
- Minimise destruction of nest and den sites;
- Minimise the capture and trade in fauna;
- Prevent hunting, trapping and egg collecting by construction workers;
- Prohibit the collection of firewood from working areas; and
- Minimise damage to watercourses from earthworks and improper waste disposal.

10.11. These will be achieved by:

- Using only defined and approved liquid and solid waste disposal sites;
- Educating construction crews on the impact of disturbance and damage to habitats;
- Providing construction crews with facilities that does not require them to light fires;
- Ensuring Terms of Employment include severe penalties for the unnecessary disturbance of environmentally significant sites and hunting; and
- Enforcing such penalties on all workers, including sub-contractors.

10.12. Other aspects of impact mitigation, such as the appropriate storage and disposal of solid and liquid wastes will also mitigate many indirect impacts upon vegetation and wildlife. The Engineer will also ensure the Contractor is held liable for any non-compliance with the Wildlife Protection Act and Endangered Species Act by any staff, including sub-contractors, and ensure protection of the environment and key species in line with Jamaica's international commitments.

10.13. Prior to any construction activity the Contractor will be required to securely fence off the area of mangrove to the north of the treatment plant. This will prevent access from the work site by construction workers, reduce disturbance of the habitat and ensure site clearance does not

exceed the approved limits. The site has, of course, always been accessible from the A4 and will remain so.

Disruption to Communication Routes

10.14. The Contractor shall incorporate in his proposed arrangements for traffic diversions in the form of a Traffic Management Plan, with details of all necessary signage and any temporary works for approval by the Engineer. The programme shall also contain details of the timing of the proposed closure, dates of closing and re-opening the route, and of any necessary remedial works.

Damage to Public Utilities

10.15. Record drawings of utility services in Jamaica are not always accurate and the Contractor Shall accurately locate, by trial pitting if necessary, before work commences in any given area. Nevertheless, accidents will occur where small diameter water pipelines and low voltage power cables are unrecorded or where an excavator operator carelessly swings an extended boom into overhead cables. All such incidents shall be reported to the Engineer and the Contractor shall be responsible for the expeditious repair of accidental damage.

10.16. Prior to undertaking any works, the Contractor will obtain from the utilities agencies definition and details of all utilities sites within 50 m of the works. These agencies shall include, but not necessarily be limited to, the following:

- Jamaican Public Service Company;
- Cable and Wireless Jamaica;
- National Works Agency;
- Portland Parish Council; and,
- National Water Commission

10.17. Damage to any utility at a defined site shall be made good to the satisfaction of the responsible agency at the Contractor's cost. Damage to utilities not defined prior to construction, despite the Contractor having undertaken all reasonable liaisons with the responsible agencies, shall not be the responsibility of the Contractor. It shall be the responsibility of NWC to ensure the utilities agencies respond in good time to the Contractor's requests for information.

10.18. Contractors shall liaise with each of the agencies responsible for the maintenance of utilities that are to be crossed, temporarily diverted or otherwise affected by the works as to the timing and nature of any disruption of service. Where required by Jamaican law, the responsible agency shall be requested by NWC to carry out the necessary works at the time required and at NWC's cost. The Tender Documents shall contain sufficient information on utilities crossings to permit the Contractor to include the cost of the works for which he is responsible in his bid.

Disruptions to Public Access

10.19. Disruptions to public access shall be identified in the Contractor's Traffic Management Plan, under which suitable notice of intending delays and closures are given to all concerned parties and approved prior to commencing work. Notwithstanding this, all road closures shall be separately notified and agreed with the Portland Parish Council or the National Works Agency as appropriate, and with the Jamaican Constabulary and publicised through notices posted throughout the effected area at least 48 hours in advance of the proposed closure. Partial closures and traffic delays managed with temporary traffic lights or flagmen need not be separately notified except to the Constabulary.

10.20. Where access to or from an individual property is closed for a period of 2 hours or more, the owner shall be informed at least 24 hours in advance. Vehicular access to and from hospitals, police stations and fire stations shall be maintained through the use of steel road plates over open trenches. Pedestrian access to schools, public libraries, courts, doctor's surgeries, pharmacists, and other premises frequently by the public will be maintained with the use of walking boards. Any special provision for wheelchair or other disabled access shall also be maintained.

10.21. The laying of pipelines, backfilling and temporary reinstatement shall follow trench excavation as quickly as possible and trenches will not be left open for extended periods. Under normal circumstances, the period between trench opening and temporary reinstatement should not exceed 48 hours. It is recognised that extraordinary circumstances will occasionally arise and this period may be extended to 4 days with the approval of the Engineer. Where a longer period is necessary, the trench should be backfilled and re-excavated when required. Excavations for inspection chambers in roads shall not remain open for longer than 10 days.

10.22. All surfaced roads shall be subject to road cleaning and unsurfaced roads to dust suppression, the methodology and frequency of which shall be included in the Traffic Management Plan.

Derogation of Touristic Attraction

10.23. Public infrastructure construction is noisy, dusty and unsightly, and will to some extent derogate from the architectural and other attractions Port Antonio and adjacent settlements offer tourists. All work sites should therefore be kept as tidy as is practicable, without obvious piles of unwanted material or abandoned equipment. The perimeter of pumping station sites shall be boarded.

10.24. The Contractor shall consult with the Port Antonio Chapter of the Jamaican Hotel and Tourism Association (JHTA) and the Jamaican Tourist Board (JTB) to obtain their views on construction programming. However, with a construction period of 22 months, work will extend over at least 2 tourist seasons and which the Contractor will be encouraged to accommodate JHTA and JTB concerns he will not be bound by them without the approval of NWC.

Soil and Water Pollution

10.25. The Contractor shall be required to perform all his activities in a manner that will prevent pollution of the soil by accidental spillage of solid matter, contaminants, debris, and other objectionable pollutants. If a significant spillage does occur, the Contractor shall remove all contaminated soil to a disposal site specified by the Engineer in consultation with NEPA. Appropriate replacement material shall be laid. All the costs of pollution remediation shall be borne by the Contractor.

10.26. The Contractor shall comply with all applicable regulations concerning the control and abatement of water pollution. In addition, His activities shall be performed in a manner that will prevent the entry or accidental spillage of solid matter, contaminants, debris, and other objectionable pollutants and wastes into watercourses and aquifers.

10.27. The Contractor shall provide appropriate on-site storage facilities for chemicals in accordance with manufacturers' recommendations, and for fuel, within bunded areas that have the capacity to retain 110% of the tank volume. Quantities of chemicals retained at an individual construction site shall not exceed those required for short term use and in no circumstances more than is required for work at that site. In the event of a serious spill or contamination the Contractor shall immediately notify the Engineer. Remedial works required shall be undertaken as a matter of urgency by the Contractor or an appropriate specialist at the Contractor's expense. Failure to notify of such incidents will be considered a Breach of Contract.

Drainage, Erosion, Turbidity and Sediment Load

10.28. Site clearance shall only be undertaken when immediately required to permit adherence to the approved Programme of Work. The maximum permitted elapsed time between site clearance and the initiation of construction shall be 5 days. The Contractor shall adopt a site clearance procedure that separates topsoil and stores it under appropriate conditions for reuse as instructed by the Engineer.

10.29. The Contractor shall take all reasonable measures, including the use of settling ponds, to protect cleared sites and open excavations from erosion due to rainfall and the discharge of suspended sediment to watercourses and drainage ditches.

10.30. Dewatering work for foundations shall be conducted in a manner that will prevent highly turbid water directly entering watercourses or the sea, through the use of settling tanks or other appropriate facilities.

10.31. Where short-term construction work in a watercourse, such as at a pipe crossing is unavoidable, turbidity levels may be allowed to increase beyond those normally acceptable on agreement with the Engineer and NEPA. In such cases, the Contractor shall submit to the

Engineer a programme of work detailing any proposed mitigation and the time frame of the required work, for prior approval.

10.32. All temporary discharge points shall be located, designed and constructed in a manner that will minimise erosion in the receiving channels.

10.33. The on-site storage of excessive quantities of unwanted spoil and aggregate materials should be avoided. Where storage is necessary, the Contractor shall ensure heaps and stockpiles are located at sites that they do not permit direct runoff into watercourses and are on land sloping at less than 1.5%. All heaps shall be of a size and stability that will ensure the risk of mass movement during periods of high intensity rainfall is minimized.

Noise and Dust

10.34. Noise from construction activities will primarily be derived from the operation of plant and equipment. The Contractor shall ensure all his equipment is fitted with appropriate noise muffling devices that will reduce sound emissions to below those stipulated in **Table 10.1** and take ambient noise measurements as and when required by the Engineer.

Table 10.1. Typical Noise Standards for Construction Equipment

Activity	Source	Day	Night
Earthworks	Bulldozer/excavator	75 dB(A)	55 dB(A)
Piling	Piling machine	85 dB(A)	None
Structural	Concrete mixer/concrete pump	70 dB(A)	55 dB(A)
Surfacing	Roller	70 dB(A)	55 dB(A)

10.35. The noisiest of construction activities, piling, is at present not expected to be necessary for PAWSDP Stage 2. All other equipment shall be fitted with appropriate muffling devices in accordance with manufacturers' recommendations.

10.36. Vehicles that are excessively noisy due to poor engine adjustment, damage to noise amelioration equipment or other inefficient operating conditions shall not be operated until corrective measures have been taken.

10.37. The Contractor shall ensure all plant and equipment is loaded and unloaded away from noise sensitive areas. Noise and dust sensitive premises will be identified in the Contractor's Traffic Management Plan. Around pumping station sites and the site of treatment plant hoardings of sufficient length and height shall be erected to provide some noise attenuation, some visual relief to adjacent land users, and some dust suppression. Any plant operated intermittently shall be switched off or throttled down during idle periods.

10.38. If piling operations are required they will be restricted to 0900-1800 hours and not be undertaken on Sundays or public holidays. Advance notice of at least 5 days shall be given to residents or users of properties within 50 m of a piling site, through public notices displayed

within affected neighbourhoods. In keeping with standard international regulations the use of diesel driven hammers will not be permitted.

10.39. All other operations shall be restricted to the hours of 0800-1900. Authorisation to extend the hours of working may be given by the Engineer but only where:

- Additional working is necessary to maintain the safety of the site, of site workers, or the public; and
- It can be demonstrated that a short period of additional working will provide significant long-term benefits to affected communities.

10.40. The Contractor shall comply with all applicable regulations concerning the prevention of air pollution in Jamaica, especially those relating to stack emissions. In the conduct of construction activities and the operation of equipment, Contractors shall utilise all practical methods to control, prevent and otherwise minimize atmospheric emissions. Specifically:

- The methods of handling cement, marl and other fine materials shall include means of minimising atmospheric discharges;
- Equipment and vehicles showing excessive emissions of exhaust gases due to poor engine adjustment or other inefficient operating conditions shall not be operated until corrective measures have been taken;
- Burning of material from the clearance of trees, bushes and other combustible matter shall not be permitted.

10.41. The Contractor shall provide all necessary equipment and means wherever and as often as necessary to prevent dust generated by his activities from causing a public nuisance. Specific dust suppression measures will include:

- Damping down of sites and access roads;
- Use of appropriate hoardings;
- Covering all vehicles transporting materials likely to give off excessive dust; and,
- Not permitting lorries to be overloaded.

Demolition

10.42. Existing households will be given as much informal notice to vacate the site as is possible within the time frame of the project. Formal notice will not be less than one month.

10.43 To facilitate materials re-use all existing owners will be given the opportunity to dismantle and remove their own structures. The Resettlement Plan prepared by NWC will make provision for the transport of reusable materials to resettlement sites.

10.44. Materials left on the site, including timber, at the end of the formal notice period will be made available to anyone until such time as the site is fenced in preparation for construction. Only small volumes of excess demolition debris are likely to require disposal elsewhere.

Use of Explosives

10.45. Explosives are not expected to be used. If they are, measures for their procurement, transport, storage, and use will comply with the procedures and regulations of the Mines and Geology Division of MLE, who are the authority in Jamaica for the issue of Blasting Permits.

Disposal of Surplus Materials

10.46. The disposal of all surplus construction materials and debris shall be carried out in accordance with the regulations of the National Solid Waste Management Authority (NSWMA). The normal manner of disposal shall include all necessary precautions for minimising water and air pollution, drainage impedance, the risk of fire, and damage to ecosystems. Only NSWMA-approved landfills shall be used for the disposal of excess non-soil waste.

10.47. Surplus soil and rock materials shall be disposed of promptly in order to minimise the time of storage at the construction site and the risk of erosion and sediment discharge. Where it is known these materials will be required later in the Programme of Work they shall be stored in an appropriate manner. Soil materials shall not be disposed of to landfill unless for reuse as daily or final cover.

Marine Environment

10.48. All works relating to the construction of the long sea outfall shall be undertaken in accordance with NEPA's *Guidelines for the Construction of Pipelines and Conduits on the Floor of the Sea.*

10.49. Prior to the commencement of construction on the long sea outfall the Contractor shall lay out the alignment and his working area, with appropriate safety margins, and produce a detailed map showing the areas of live coral that might be destroyed. NWC and NEPA in discussion with PEPA will identify barren or otherwise poorly populated areas within the vicinity where the Contractor will replant the coral at risk.

10.50. All material dredged during construction of the long sea outfall shall be disposed of in deep water far away from any coral reefs or as otherwise directed by NEPA.

10.51. No bilge waste shall be disposed of at sea but taken to the reception facilities at Port Antonio Marina.

Danger to Navigation and Safety at Sea

10.52. All work at sea shall be undertaken in accordance with the regulations of Maritime Authority of Jamaica and the Port Authority of Jamaica. Communications, position reporting and emergency channel watch shall be maintained in accordance with international maritime procedures.

Public Safety

10.53. The pumping station and treatment plant sites shall be secure from unauthorised access and suitable warning signs erected. At the treatment plant site, 24/7 gate control will record the identity all persons entering or leaving the site.

10.54. Along pipeline routes, warning signs, warning tapes and notices will deter access to trenches. The excavation of trenches ahead of pipe laying and backfilling shall be limited as detailed above.

10.55. At sites accessible to vehicles the Contractor shall maintain flagmen to provide for safe ingress and egress. All sites shall be adequately watched and lit during the hours of darkness.

Worker's Safety

10.56. The Contractor shall present a Health and Safety Policy for approval by the Engineer prior to commencement of work. This will contain normal internationally accepted procedures in relation to the risks imposed by the nature of the work to be undertaken, and equal or exceed the provisions contained in NWC's Health and Safety procedures.

10.57. The Contractor shall ensure all authorised persons present on all sites, be they his own staff, representatives of the Project Proponent or Construction Manager, or other visitors, are aware of any site-specific safety requirements and are supplied with hard hats and other protective clothing or safety equipment as appropriate for the work being undertaken. All PAWSDP Stage 2 sites shall be designated 'Hard Hat' sites.

Construction Impact Mitigation: Off-Site

Construction Camp

10.58. The present proposal is for the PAWSDP construction camp, including site offices, to be located at Bryan's Bay, a largely industrial area on the western approach to Port Antonio.

10.59. For the safe and sustainable disposal of wastewater the Contractor shall supply a self-contained collection and disposal system, for which he shall obtain the approval of the Engineer and NEPA prior to installation. Where practical, the Contractor shall recover, treat and re-use wastewater. Tenderers will be expected to submit details of their proposed plant and arrangements for the ultimate disposal of treated effluent and sludge with their tender.

10.60. Tenderers shall include a list of the potentially polluting substances they intend to keep on site to enable NWC to consult with the NEPA on the precautionary measures required for their storage and handling. It is expected these will include, at a minimum, specific operational requirements such as:

- Definition of any materials to be isolated from each other;
- Use of proper protective clothing and equipment by employees;
- Definition of proper handling techniques;
- Other safety requirements, ventilation, fire fighting equipment; and,
- Any measures needed to contain and isolate spills and leakages to specific areas through the use of hard standings, internal drainage and the construction of holding tanks[3].

10.61. The Contractor shall set aside a building or covered secure enclosure for the storage of lubricating and hydraulic oils, greases, solvents and other hazardous materials required for his operations. For the storage of petroleum for vehicles and fuel oil for generators and other machinery he shall utilise tanks composed of a material approved for the purpose securely fenced with access to authorised personnel only. The area beneath each tank shall be enclosed by a bund adequate to retain 110% of the volume of the tank. An area not less than 20 m beyond each compound shall be designated 'No Smoking or Naked Lights'. The Contractor's site records shall include details of chemical and fuel deliveries and their subsequent dispersal to site, to include date, quantities and responsible persons.

10.62. In the event of a serious spill or contamination, the Contractor shall immediately notify the Engineer. Remedial works required shall be undertaken as a matter of urgency by the Contractor or an appropriate specialist at the Contractor's expense. Failure to notify of such incidents will be considered a Breach of Contract.

10.63. For the disposal of waste other than surplus soil and rock, it is normal practice for a construction camp to be included in the existing municipal solid waste collection and disposal process. From their review of the materials to be stored on site, NWC should notify Contractors of any solid waste expected to be generated that may require special handling and treatment, and hence separation from other waste for collection and disposal.

10.64. If it is not feasible or desirable to incorporate the camp into established waste collection systems the Contractor will himself transport solid waste to an authorised NSWMA landfill or other disposal site approved by the Engineer.

10.65. A joint initiative[4] between GoJ and lead acid battery industries has recently been established to collect used batteries for export to recycling facilities. Collection centres have been set up in each parish and in Portland it is the Petcom Service Centre in Bryan's Bay. Used batteries are both toxic and corrosive and the Contractor will be required to deliver those he expends to this centre.

10.66. Mitigation of the impacts from construction traffic at the camp should primarily take three forms; access control, road cleaning and the definition of approved routes. Access control will require the restriction of turning movements to approved access points to and from existing highways,

[3] In all matters related to Health and Safety it is preferred the Contractor submit a Community Affairs, Health, Environment and Security (CASHES) Plan for approval by NWC.
[4] The 2005 National Used Lead Acid Battery Project

the erection of appropriate signage and, at night, adequate lighting. Road cleaning will be required to ensure major roads are kept in a safe condition, with oil, mud and other materials removed regularly. Wide or abnormal loads shall be transported between 2300 and 0500 hours with routes to be agreed with Portland Parish Council, the Jamaican Constabulary and other relevant authorities.

Other Sites

10.67. The use of pre-existing already licensed quarries will reduce the potential for additional environmental damage. However, the prevailing practices of existing industries may be far from optimum. Any existing quarry utilised for the project shall therefore be subject to inspection by NEPA prior to its approval for use. In effect, it may be possible, to use the project to influence existing industries to improve their operational practices through incentive programmes, pre-qualification criteria, and environmental examination.

10.68. Of particular concern in the approval of quarries and other sites will be the following:

- Operations are restricted to daylight hours;
- Noise and dust shall not impact on environmentally or socially sensitive areas; and,
- Wastewater does not enter watercourses without control of sediment load, discharge velocity and wastewater quality.

Permanent Impact Mitigation

Land Acquisition, Property Take and Resettlement

10.69. The land take requirement for the proposed treatment plant at Turtle Crawle is some 14.1 ha currently privately owned by three different parties not resident in the area. In addition there is as small area of land to be acquired for the long sea outfall headworks chamber also from private ownership.

10.70. The land at Turtle Crawle is currently occupied by 15 separate households who have no legal status to either their homes or the land they utilise, primarily for subsistence farming. Non-residential structures include pig pens and water tanks. The land for the headworks chamber is unoccupied and contains no structures.

10.71. All land acquisition, resettlement and compensatory payments will be undertaken the the Project Proponent in accordance with the full provisions of the laws of Jamaica. In accordance with the provisions of World Bank Operational Procedure OP 4.12 discussed in Section 7 above, transitional support must be considered and the whole exercise characterised by procedural transparency, notwithstanding that funding agency requirements may be somewhat different from Jamaican procedures that do not clearly cater for those having material interest in the land without formal entitlement.

10.72. The recent socio-economic survey has provided only an initial assessment of asset take and involuntary resettlement. Fuller investigations will be undertaken by NWC in accordance with normal procedures. Completed questionnaires from the recent survey, while not presented herein to preserve confidentiality, will form the basis for a more detailed assessment and the development of a structured Resettlement Plan to World Bank standards.

Landscape

10.73. To ameliorate the limited impact on the landscape, reduce visual impact and improve security those parts of work sites not required for access and other operational uses will be planted with species appropriate for the prevailing soil and climatic conditions.

10.74. The external banks of the treatment ponds will be planted with Bermuda Grass. Elsewhere on the site, planting will be of moderate height. The ponds will, so far as is practical, be kept clear of tree shade because exposure to sunlight is an integral part of the treatment process.

Drainage, Erosion Turbidity and Sediment Load

10.75. Land clearance at Turtle Crawle will not significantly change the drainage. Rain falling on the treatment plant site will be channelled into a peripheral open drain to Turtle Crawle River, maintaining the same destination for drainage waters as at present. The replacement of natural open bog with a significant area of hard standing will reduce drainage water retention time but the new drainage channel has been adequately designed to cater for this.

Ecology and Biodiversity

10.76. Two options are open to the American Crocodiles resident or using the mangrove area; they will either decide on peaceful coexistence with their new human neighbours or migrate elsewhere. Assuming they sustain the noise and human presence during construction, peaceful coexistence is likely. However such a small permanent community living so close the main North Coast highway cannot be sustainable and if the removal of refuse and small domestic animals of the present illegal occupiers of the site deprives the crocodiles of a significant source of food they may choose to migrate.

10.77. Whist not a particularly attractive solution, it is reasonable to consider if resettlement of the community to a more sustainable, more heavily crocodile-populated environment such as Black River in St. Elizabeth or Martha Brae in Trelawny may be in their best interest. This option cannot be taken lightly and there is currently insufficient information on which to decide. A number of fundamental questions about the community were posed in Section 4 above.

10.78. It is therefore recommended that as soon as possible, and definitely prior to the start of construction, NWC funds a study of these crocodiles, starting with tagging to record and trace their movement. Should it not be the same individuals always present, or they routinely migrate to another area, perhaps they can be left to decide their own future. Should the same individual

be permanently resident at Turtle Crawle and the study shows limitations on their ability to range widely, the loss of a source of food, or construction activity to be seriously impacting their survival, relocation may be the best option.

The Marine Environment

10.79. Although the expected quality of the treated effluent will not meet the NEPA requirements for discharge within 150 m of coral, the recent marine investigations and computer modelling of effluent dilution and dispersion shows they will be met within a few metres of the point of discharge and no significant pollution will result.

10.80. Watercourses and drainage ditches frequently discharge levels of nutrients far in excess of that allowed in treated effluent discharges and background sea water analyses often show nutrient content only marginally greater than that of the effluent. It is therefore unreasonable to consider the PAWSDP discharge some 500 m offshore will not improve the current situation. Present thinking in the future protection of coral reefs favours a 'bottom-up' rather than a 'top-down' solution to high nutrients; by increasing stocks of fish and other herbivores that consume algae rather than by a blanket ban on nutrient discharges. This however is beyond the scope of the present project and indeed beyond the abilities of the project proponent. It can only be implemented through GoJ policy and sustained enforcement to reverse recent declines in fish stocks.

Induced Development

10.81. Induced development of a type that is desirable and sustainable within the aspirations of the Port Antonio community is a major aim of the PAWSD and will therefore be viewed positively. For this to be achieved future development must be undertaken within the framework of proactive government policy and strict planning and environmental enforcement.

10.82. It is also vitally important the new infrastructure, particularly the sewerage system, be made fully operational as soon as possible, if necessary with incentives to ensure all existing property owners are quickly connected to fully realise the benefits of the project. Such incentive might include tax relief on the costs of connections or interest-free loans.

Operational Impact Mitigation

10.83. The most effective means of mitigating the majority of impacts arising from the operation of water, sewage and drainage infrastructure is effective management and operation, including preventive maintenance and the rapid response to emergencies.

Water and Sewage Overflows

10.84. The expeditious repair of pipe breakages and the maintenance of pumping stations with regular use of stand-by pumps and generators will largely mitigate actual and potential sewage overflows.

10.85. Excessive heavy rain at the treatment plant is a potential source of overflow and given the high intensity tropical storms that characterise Jamaica's climate it is impractical to design the ponds and treated effluent pumping station for such large flows.

10.86. Rain falling within the confines of the site but outside the open ponds will enter a conventional drainage system and be routed towards Turtle Crawle River. This water will have no contact with sewage effluent and for all practical purposes will be no different in quality from rain draining from other area of hard standing.

10.87. Rain falling directly onto the c.3.6 ha[5] of open ponds will mix with sewage at different stages of treatment, from raw sewage in the first facultative pond to almost completely treated effluent in the last maturation pond. To prevent overtopping the plant has been designed with two storm overflows to allow excess water to be taken out:

- **Overflow 1**, after the last maturation pond and before the rock filter, from where the excess will be directed to the wetland for limited natural treatment and nutrient removal prior to being naturally released to the river and ultimately the sea; and,
- **Overflow 2**, at the treated effluent pumping station, and also into the wetland.

10.88. Rain falling into the early ponds and mixing with sewage that has undergone minimal treatment will be retained and pass through the process stream. No diluted raw or 'nearly-raw' sewage will be discharged via either overflow. The discharge from Overflow 1 will have been through all the treatment stages except final filtration while that from Overflow 2 will have undergone complete treatment.

10.89. The 'worst case' BOD loading of the storm water overflow discharge is calculated to be 30 mg/l from Overflow 1 and 15 mg/l from Overflow 2. By comparison the BOD loading of the incoming raw sewage is 250 mg/l and the NEPA requirement for discharge to the sea 20 mg/l. The required reduction in BOD loading from raw sewage to treated effluent will therefore be 100% complete for Outflow 2 and 96% complete for Outfall 1. However, this 'worse case' scenario assumed complete mixing of rain water with the partially treated effluent already within the ponds. In practice, rainfall will be less dense and tend to float on the surface, diluting only the upper few centimetres of effluent rather than completely mixing with it. Since the overflows will be constructed as weirs, only the upper portion of the water column will be discharged.

[5] The total 'mid-depth' area, over which the ponds are at their design depth. The total area of water will be greater because the side slopes are not taken into account during process design.

Discharge of rainfall overflow via the wetland will provide additional natyral treatment for these to be cost effective.

10.90. The quantities of overflow discharged will vary with the intensity and duration of rainfall events. **Table 10.2** gives the predicted volumes discharged during storms of 6 hours duration with return periods of 1 in 2, 25 and 100 years. Again these represent the 'worst case' scenario. The model assumes vertically sided ponds whereas in practice they will have 1 in 3 internal slopes, increasing storage over that on which the discharges have been calculated.

Table 10.2. Storm Water Discharge from the Treatment Plant Overflows

Storm Intensity	Storm Duration	Discharge Overflow 1	Discharge Overflow 2	Total Overflow	Rainfall	Rainfall into Ponds	Dilution Factor
1 in 2 years	15	0	0	0	38.10	1,500	29
	60	0	619	619	69.34	2,730	16
	360	0	1,777	1,777	108.46	4,270	10
1 in 25 years	15	0	397	397	60.45	2,380	19
	60	0	2,122	2,122	127.00	5,000	9
	360	510	5,207	5,717	225.30	8,870	5
1 in 100 years	15	0	642	642	70.61	2,780	16
	360	1,823	5,690	7,513	282.19	11,110	4

Storm duration in minutes, overflow and rainfall into ponds in m^3, and rainfall in mm.

10.91. The total volume of the five ponds is nearly 45,000 m^3 and during even the worst event, a 1 in 100 year/360 minute storm, only 17% will be discharged via the overflows. The volume of rainfall during the same event will be over 11,000 m^3, and even assuming this is only discharged in equal proportions to effluent, i.e., complete mixing, the expected dilution factor is still 4.

10.92. Finally, it must be remembered that the same rainfall event falling onto the ponds will also be falling onto both the wetland and the wider catchment area. Flows in Turtle Crawle River will therefore be high and also contributing to the in the wetland, increasing dilution even further.

Noise and Vibration

10.93. Perceptible noise and vibration from pumping stations will be indicative of equipment malfunction and any problems will most effectively be mitigated through adherence to a programme of preventive maintenance and the expeditious response to emergencies.

10.94. All stand-by generators will be fitted with noise and vibration reduction features in accordance with manufacturers' recommendations and these should also be efficiently maintained.

Air Quality

10.95. The use of stand-by generators to ensure both water and sewage pumping station operation is not interrupted during power outages will produce some exhaust emissions but these are not expected to significantly derogate ambient air quality.

10.96. Bethesda Gospel Hall and Bethesda Basic School are respectively some 20 m and 50 m south from Pumping Station No.1 but this distance together with the overwhelming predominant westwards prevailing wind direction with very little southerly component suggests exhaust gases will be dispersed away from these buildings, which in any case suffer exhaust emissions and noise from vehicles on the adjacent North Coast highway.

10.97. At the January 2006 EIA Scoping Session, it was suggested that LPG fuelled generators would be preferable to ones using fuel oil. The benefits to be gained from this will be limited for equipment to be used intermittently but Tenderers will be asked to offer both and NWC will determine the most cost effective.

Odour

10.98. As with air pollution and noise, the most effective means of combating the propensity of raw sewage to create odour is to maintain pipelines, pumping stations and the treatment plant in good order and ensure efficient operation.

Soil and Water Pollution

10.99. The mitigation of events most likely to result in soil and water pollution has been discussed above. In readiness for incidents NWC should develop an Emergency Response Procedure so the quantity and type of spilled material, and the measures and materials needed to clean it up can be identified without delay. At the same time NEPA, WRA and other potentially affected utility providers, adjacent land users and others would be advised of the potential hazard, the likely duration of adverse effects, and any special measures required.

10.100. The most likely spillage is of fuel oil stored at Grant's Level wellfield and the sewage pumping stations for the stand-by generators. A purpose-built tank of appropriate design and material shall be provided and the area beneath shall be enclosed by a bund adequate to retain 110% of the tank capacity. At Grant's Level this tank shall be separately fenced.

Marine Pollution

10.101. Purely operational impacts are also likely to be minimal and the long sea outfall pipeline will be essentially maintenance-free with the exception of occasional need to clean the diffusers. Discharges will continue to conform with NEPA standards for as long as the treatment plant is effectively operated and maintained.

10.102 A significant potential hazard will be the discharge of hazardous or toxic wastes that will 'kill' the biological treatment process to the sewage collection network. As a matter of routine, NWC should check the type of sewage coming from commercial and industrial premises against the Jamaican National Trade Effluent Standards before they are connected to public sewers. Since the Port Antonio area is not highly industrialised this should not be onerous or costly.

10.103. There are a number of small community and rural activities that potentially have a deleterious effect on biological treatment streams and it is often appropriate they pre-treat their sewage prior to discharge to a public sewer. These activities often, depending on the nature of their discharge, include those listed in **Table 10.3**.

Table 10.3. Activities Potentially Requiring Sewage Pre-Treatment

Activity	Source of Problems	Pre-Treatment
Filling stations	Road grit, spilt petroleum and fuel oil	Route flows through a grit trap and hydrocarbon interceptor
Vehicle repair workshops	Waste oil, lubricants and degreasers	
Vehicle washing facilities	Road grit, oily residue and detergents	
Abattoirs	Blood, faeces, and carcass wash water	Route flows through a screen and grease trap. Collect and pre-treat in accordance with industry standards
Tanneries	Skin process water and wash water	Collect flows and pre-treat in accordance with industry standards
Butchery shops	Blood, bone fragments and meat wash water	Route flows through a screen and grease trap.
Metal workshops	Machine cooling and wash water containing metallic grit, degreasers and cleaning chemicals	Route flows through a grit trap. Collect and pre-treat in accordance with industry standards
Food processing centres	Waste fruit and vegetable particles, process water, machinery and floor wash water	Route flows through a screen. Collect and pre-treat in accordance with industry standards
Fruit and vegetable markets	Waste fruit and vegetable particles, and floor wash water	
Health Centres	Bloody and biologically contaminated swabs, laundry and scrubbing down water	Collect and pre-treat in accordance with accepted medical waste management procedures

10.104. Where the need for pre-treatment is considered necessary, installation should be a pre-condition of a subsequent sewer connection. In the majority of cases, a simple screen, grit trap or hydrocarbon interceptor is all that will be necessary. For others, there are industry-standards for sewage pre-treatment. Clearly such a requirement has to be preceded by consultations with commercial and industrial organisations, business leaders, trade unions and others, as well as by a targeted awareness campaign among individual businesses as already required for NWC contracts.

Natural Habitats

10.105. Operational impacts on natural habitats are likely to be minor providing the whole scheme, including but not only the treatment plant is operated and maintained effectively.

10.106. As the plant becomes established flora and fauna will quickly recolonise the areas along the Turtle Crawle River and areas cleared for construction but not built upon. Operational staff

should be instructed not to unnecessarily disturb these areas. The ponds themselves will, with time, acquire a distinct ecology and become attractive to many faunal species.

Traffic

10.107. The only significant operation traffic will be tankers delivering septage from septic tanks and absorption pits for treatment. The expected frequency is currently estimated at 10 tankers/day, 20 turning movements to and from the A4. Since the treatment plant access road junction is a short distance east of a bend in the A4 the minimum that should be provided is a road mirror to help drivers identify oncoming traffic. Speed ramps either side of the junction could be provided and operator controlled traffic lights should also be considered.

Solid Waste

10.108. The relatively small volumes of solid waste can easily be dealt with by NWC's current waste disposal practices. Wherever possible, waste oil should be recycled and under the National Used Lead Acid Battery Project all such batteries used on the PAWSDP will be delivered to the Portland collection centre at the Petcom Service Centre in Bryan's Bay. Replaced metallic parts and equipment should be sold for scrap rather than disposed of to landfill. Other waste should be considered for recycling prior to disposal.

10.109. The majority of solid material within raw sewage will settle out in the facultative ponds and much will be biologically digested during retention. With time however, residual sludge will accumulate and will need to be removed, perhaps as infrequently as once every 7-10 years. This will be achieved using a floating suction pump so the pond will not need to be taken out of service.

10.110. The removed sludge will be spread on a drying bed, to be designed and built at some future date but before it is first required. Its design and construction is outside the PAWSDP scope of works. Fluid infiltrating through the bed will be collected and recirculated back into the treatment stream.

10.111. The ultimate disposal of the dried sludge has also yet to be considered. Ideally it will be composted and used as a soil improver for landscaping or agriculture in accordance with NEPA guidelines.

Hazardous Materials

10.112. The storage, handling and use of chlorine gas at Grant's Level will follow well documented and practiced procedures in which skilled operators will be trained. Non-skilled workers and others who will not normally be involved in its use should be aware of the dangers and emergency response procedures should a skilled operator become incapacitated. Appropriate HAZMAT training will be given and all necessary safety and monitoring equipment supplied.

Public and Worker's Health and Safety

10.113. Public safety in respect of operational impacts is best secured through the prevention of unauthorised access.

10.114. In the immediate vicinity of the sea outfall, signage on and offshore will be erected at Daniel's Harbour as required by the National Sewage Effluent Regulations and shown in Figure 10.1.

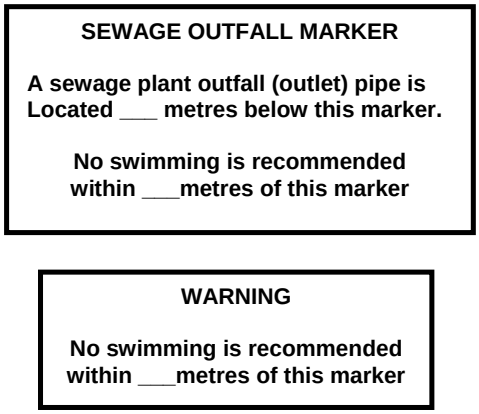


Figure 10.1. Signage to be Erected Offshore and Onshore at Daniels Harbour

10.115. Operational staff will be trained in and comply with all the provisions of the NWC's Health and Safety requirements.

Maintenance

10.116. As with many other issues, the mitigation of impacts arising from the general maintenance of the water and sewerage networks will be programmed preventive maintenance and the rapid and effective response to emergencies.

10.117. It is surprisingly easy for minor problems to escalate due to the lack of appropriate documentation. The National Sewage Effluent Regulations therefore requires the following to be kept permanently at the treatment plant:

- A description of the plant;
- A set of 'As Built' drawings;
- A description of the operating procedures, including details of the process operations;
- A list of equipment, including specifications of the equipment;
- Maintenance requirements and procedures for the equipment and plant components;
- Any other information pertinent to the good operation of the plant;
- A schedule of maintenance activities to be carried out by operations staff; and,

- An approved effluent monitoring schedule.

10.118. The Contractor shall be responsible for the production of 'As Built' drawings and for an Operations and Maintenance Manual that will cover most of the other required items. These will also be produced for each of the three sewage pumping stations.

10.119. Providing any chemical fertilizers, pesticides or herbicides are used in accordance with manufacturers' recommendations, taking full consideration of application rates and weather conditions, the threat to both ecological systems and the health of users is likely to be minimal.

Energy Use

10.120. The primary mitigation measure to reduce future energy consumption was taken during the 1996 Master Plan study with the selection of a waste stabilisation pond treatment process over a mechanical plant. Other energy saving measures, such as the use of energy-saving light bulbs will be introduced wherever cost effective.

Environmental Enhancement Measures

10.121. No particular measures for environmental enhancement are proposed under the project other than the overall objective of providing clean water and safe sewage disposal which will have a major positive impact on public health and the general improvement of the environment.

Summary of PAWSDP Stage 2 Impact Mitigation

10.122. The mitigation measures proposed for the PAWSDP Stage 2, together with the likely costs, is summarised in **Table 10.4**. Sample contract clauses for inclusion in the Tender Documents for construction are given in **Appendix C** to the present report.

Table 10.4. Summary of PAWSDP Stage 2 Impact Mitigation Requirements

Impact/Issue	Mitigation Measure	Responsibility	Comment
Pre-Construction Impact Mitigation			
Water Resources	Adequacy of supplies.	NWC and KBR	Implemented during Detailed Design.
Sewage Flows	Appropriate pipeline sizing, gradients and materials.		
Pumping Stations	Adequate capacity for required duty.		
Treatment Process	Appropriate to conditions and effluent quality requirements.		
Treatment Pond Overflow	No untreated sewage will be discharged during heavy rain		
Effluent Disposal	LSO configured to provide adequate dilution and dispersion at sea.		
Socio-Economics	Project Affected persons identified for NWC Resettlement Plan		
Construction Impact Mitigation: On-Site			
Landscape	Due care of landscape; Movement of equipment and crews to be restricted; No trees to be felled outside working areas; Unnecessary damage to be remedied at Contractors' expense.	Contractor	'Good Practice' only
Biodiversity	Movement of equipment and crews to be restricted; All materials to be stored in approved manner; Only approved waste disposal sites to be used; Crews to be educated on habitat disturbance; Firewood for crews or alternative facilities to be provided; Comply with Wildlife Protection Act; Crews to be penalised for unnecessary disturbance.	Contractor	'Good Practice' only
Communication Routes	Disruptions to be identified in Traffic Management Plan; Inform the public of forthcoming delays; Use appropriate signage.	Contractor	'Good Practice' only
Public Utilities	Document all utilities within 50 m of work sites; Coordinate works with utility companies; Damage to defined utilities to be repaired at Contractors' expense.	Contractor and utility companies	'Good Practice' only
Public Access	Disruptions to be identified in Traffic Management Plan; Inform impacted owners ahead of disruption; Maintain vehicular access to emergency services; Maintain pedestrian access to public buildings; Use appropriate signage; Keep roads clean.	Contractor, PPC and NWA	'Good Practice' only
Tourism	Remove unwanted materials and equipment from work sites; Provide hoarding for pumping station and treatment plant sites.	Contractor	'Good Practice' only

Soil and Water Pollution	Duty of Care to avoid spillage of all polluting materials; Comply with regulations regarding pollution abatement; Contaminated soil to be removed and replaced; Chemical storage to accord to manufacturer's recommendations; Fuel to be stored within bunded areas; All spillage to be reported; Remedial action to be undertaken as a matter of urgency; Incidents to be remediated at Contractors' expense.	Contractor	'Good Practice' only
Drainage, Erosion, Turbidity and Sediment Load	Site clearance ahead of construction to be restricted; Disruptions to drainage channels to have prior approval; Any short-term increases in turbidity to be approved; Dewatering works to avoid excessive turbidity; Store stripped topsoil in manner suitable for reuse; All stock piles and soil heaps to remain stable. Excess spoil and materials not to be stored.	Contractor	'Good Practice' only
Noise and Dust	All equipment to be fitted with appropriate muffles; Equipment/vehicles in poor condition not to be used; Noisy equipment to be located away from sensitive sites; Plant not left to run on idle; Restricted working hours, particularly for piling; Extension of normal working hours to be approved; All relevant Jamaican standards to be complied with; Cement handling to limit atmospheric discharge; Burning of debris from ground clearance not permitted; Damping down of sites and access roads; Hoardings to be used where appropriate; Vehicle loads likely to emit dust to be covered.	Contractor	'Good Practice' only
Demolition	Adequate notice to be given to occupants; Occupants given opportunity to remove materials for reuse; Within time limits, surplus materials made available to others.	Contractor and treatment site occupants	Contract requirement
Use of Explosives	All aspects of use to be in accordance with MGD requirements.	Contractor and MGD	'Good Practice' only
Surplus Materials	All solid waste regulations to be complied with; Unwanted materials disposed of promptly; Spoil for later use to be appropriately stored.	Contractor, NWC and PPC	'Good Practice' only
Marine Environment	Live coral along LSO route to be mapped and relocated; All dredging to be disposed of in deep water away from coral; No bilge waste to be disposed of at sea.	Contractor and NEPA	'Good Practice' only
Navigation	All marine work to accord with navigation and safety standards.	Contractor	'Good Practice' only

Public and Worker's Safety	All sites to be secure from unauthorised access; Adequate warning signage to be provided; Flagmen to provide safe ingress and egress to work sites; Contractor to implement strict Health and Safety procedures; All visitors to be made aware of site safety requirements; Protective clothing and safety equipment to be provided.	Contractor	'Good Practice' only
Construction Impact Mitigation: Off-Site			
Construction Camp	Appropriate facilities for sewerage be installed; Treated wastewater to be re-used where possible; Polluting substances to be identified, stored and handled in accordance with manufacturers' recommendations; Fuel storage to be fully bunded; All spillage to be reported; Remedial action to be undertaken as a matter of urgency; Incidents to be remediated at Contractors' expense; Proposals for solid waste disposed to be approved; Lead acid batteries to be taken for recycling; Access control, including signage, to be implemented; Adjacent public roads to be kept clean; Wide or abnormal loads to be delivered at night.	Contractor, NWC, PPC and NEPA	'Good Practice' only
Other Sites	Priority to be given to the use of existing licensed quarries; Quarry operation restricted to daylight hours; Dust and noise to be suppressed as appropriate; Operations to be restricted to times of low wind velocities; Wastewater only discharged to watercourses after sediment load, velocity and quality control; Aggregate traffic to be subject to access control.	Contractor, NWC and site operators	'Good Practice' only
Permanent Impact Mitigation			
Land Acquisition and Property Take	Acquisition to accord to the laws of Jamaica; A structured Resettlement Plan to be developed; Adequate compensation to be provided for owners and occupiers and for all types of losses; Social impact to be minimised; All procedures to be transparent.	NWC and NLA	To be handled by NWC outside the responsibility of either KBR or the Contractor
Landscape	Landscaping planting to utilise appropriate species; Treatment ponds banks to be planted with Bermuda Grass.	Contractor and NEPA	Contract requirement
Drainage, Erosion, Turbidity and Sediment Load	Adequate drainage to be provided at the treatment plant.	Contractor and KBR	Contract requirement
Ecology and Biodiversity	NWC to fund a study of the American Crocodiles at Turtle Crawle to provide better knowledge on which to base future protection.	NWC and PEPA	
Marine Environment	Promote increases in fish and herbivorous species stocks; Enforce fishing bans.	Min. of agriculture	Beyond PAWSDP scope

Induced Development	All future development to be undertaken within a framework of strict planning and environmental enforcement.	UDC and PPC	Beyond PAWSDP scope
Operational Impact Mitigation			
Water and Sewage Overflows	Broken pipes and other repairs to be undertaken without delay; Pumping station to be adequately maintained; No untreated sewage will be discharged during heavy rain.	NWC	
Noise and Vibration	Pumps and other mechanical equipment to be effectively maintained; Manufacture's noise and vibration equipment on generators to be kept in good condition.	NWC	
Air Quality	Prevailing winds will deflect emissions from adjacent property; LPG in place of fuel oil to be used where cost effective.	NWC	
Odour	Effective maintenance of all elements of the sewerage system.	NWC	
Soil and Water Pollution	An Emergency Response Procedure to be developed.	NWC	
Marine Pollution	Checks on industrial discharges prior to connection to public sewers; Promotion of swage pre-treatment where appropriate.	NWC	
Natural Habitats	Effective maintenance of all elements of the sewerage system.	NWC	
Traffic	Improved access control for septage tanker ingress and egress to the treatment plant.	NWC	
Solid Waste	Application of strict waste disposal policy; Lead acid batteries to be taken for recycling; Other waste to be sold for recycling where possible; Appropriate final disposal of be decided after public consultation.	NWC	
Hazardous Materials	Chlorine use to accord with industry standards.	NWC	
Public and Worker's Health and Safety	Sites to be secure against unauthorised access; Operational staff to be trained in NWC health and safety procedures; Onshore and offshore signage to be provided at Daniel's Harbour.	NWC	
Maintenance	'As built' drawings and O&M manuals to be kept on site; Use of chemicals to accord with manufacturers' recommendations.	NWC	
Energy use	Energy-saving measures to be introduced as appropriate.	NWC	

9. ANALYSIS OF ALTERNATIVES

9.1. The history of the Port Antonio Water, Sewage and Drainage Project and the formulation of the proposals subject to the present environmental assessment have been summarised in Section 1. Investigations into a viable scheme were effectively curtailed with the tendering of detailed design and construction management contract in February 2003.

9.2. Recent investigations have therefore only been aimed at achieving further water resources development at Grant's Level, the design of the sewage treatment plant at Turtle Crawle and confirming the route of the long sea outfall near Daniel's Harbour, rather than revisiting issues concluded by previous studies[1].

9.3. Water and sewage pipelines, sewage pumping stations and storm water drainage are primarily located and designed to deliver specific levels of service to particular areas and there are no viable alternatives if these are not to be compromised. Participants at the EIA Scoping Session held on January 26th 2006 clearly recognised the benefits of the proposed levels of service and these need no be discussed further.

9.4. There may however be viable alternatives in respect of the development of water resources and sewage treatment and disposal. 'Do Nothing' and 'Do Minimum' options are also available. The 'Do Nothing' or 'Without Project' option has previously been discussed in Section 2. The alternative options analysed in the present section are therefore:

- 'Do Minimum';
- Alternative water resources development;
- Alternative sewage treatment systems;
- Alternative long sea outfall locations;
- Alternative treated effluent disposal; and,
- The use of alternative fuels

'Do Minimum' Alternatives

'Do Minimum' - Water

9.5. At the present time the residents of Port Antonio do not enjoy a 24/7 demand -led pressurised water supply. Outflow from the West Retreat service reservoir is curtailed each night to allow storage to build up so as to be available to supply the following day's demand rather than being lost to leakage, which is over 50%.

[1] Primarily the 1996 Master Plan and the 2002 Master Plan Review.

9.6. The proposed PAWSDP Stage 2 works in respect of water supply are limited to the construction of a transmission main to Turtle Crawle and the increase in water resources development needed to supply this and the limited water distribution system within Port Antonio being upgraded under Stage 1. The transmission main will prepare the areas to the east for future water distribution as development expands. It is therefore difficult to imagine how less work could be undertaken at the present time. The design horizon of 2025 is reasonable and any proposal this should be earlier on the basis that pipelines could be smaller and cheaper would be impractical and require demand management such that available per capita quotas were below those required for the maintenance of good public health.

9.7. The Stage 2 works therefore already constitute the only viable 'Do Minimum 'option and will still leave NWC to extend distribution networks eastwards in line with development.

'Do Minimum' - Sewage

9.8. Port Antonio currently has no centralised sewage collection network and no facilities for the safe and sustainable disposal of septic wastes. The existing absorption pits, some preceded by septic tanks, and pit latrines in use throughout the town produce odour and discharge untreated effluent to drainage channels, watercourses, and the sea, rendering the twin harbours and adjacent bays highly polluted.

9.9. The sewers to be constructed under the Stage 1 works will either remain unconnected to consumer's properties or the collected sewage will discharge into Caneside River and West Harbour unless a safe and sustainable means of treating and disposing of it is provided. Such facilities are expensive but their design and construction for the 2025 requirements of the 'extended' system are both feasible and cost effective.

9.10. The provision of treatment and disposal facilities is therefore the 'Do Minimum' option. If the correct treatment process and means of disposal in the most appropriate location has been proposed is a separate issue and discussed below.

Public Perceptions of 'Do Minimum'

9.11. The majority of residents will understand that short term sacrifices such as noise and dust have to be suffered for long term gain, improved water and sanitation. Projects must therefore be extensive and far-sighted enough to solve serious problem permanently rather than temporary fixes for which the ultimate cost of solution will be far greater.

Alternative Water Resource Developments

Alternatives to Abstraction from Grants Level

9.12. The 1996 Master Plan investigated various sources of public water supply but apart from the Grant's Level wellfield at Berridale, all were found to be small, most local springs, and suffering declining yields and/or deteriorating water quality. They were poorly capable of satisfying exiting requirements and it was recommended they mostly be abandoned.

9.13. Being located on the bank of the Rio Grande and abstracting ground water from the alluvial aquifer, the available water resources are only limited by river stage and the ability of the aquifer to transmit river water to the wells. The Aquifer Production Study completed during the present contract[2] showed there to be a direct connection between the river and the aquifer and that water resources needed to meet the 2025 demand, 21,270 m^3d, was available even from a 1 in 10 year base flow without compromising other licensed abstractors or the designated environmental demand of the river. The Rio Grande below Berridale is one of Jamaica's prime rafting rivers and any reduction in the number of 'rafting days due to water levels lowered as a result of increased abstraction would impact the families that operate this attraction.

9.14. Any alternative to increasing resources from Grant's Level will have to supply some 10-12,000 m^3/day, the shortfall between the present abstraction and the 2025 requirement. Other watercourses within the vicinity of Port Antonio are short and could not provide the sustainable yields at times of very low flow to sustain the required abstraction. Other potential abstraction sites adjacent to the Rio Grande will afford the same potential impact on rafting as increased abstraction from Grant's Level.

9.15. The cost of developing an alternative site would be excessive. NWC already own an extensive area at Berridale, adequate for resource development and operations for the foreseeable future. A new site would have to be acquired, investigated and designed, and a new transmission main laid to West Retreat reservoir in addition to new wells being drilled.

9.16. It must therefore be concluded that the resources necessary to sustain water supply demand in Port Antonio to 2025 are best secured by increasing abstraction from the Grant's Level wellfield.

[2] *Port Antonio Water, Sewage and Drainage Project: Grant's Level Aquifer Production Study*. KBR, Doc. No. XU0396/100/w/0002, February 2006.

Alternatives to the Construction of New Wells

9.17. Under the Stage 2 works it is proposed to achieve the required increase in abstraction by drilling up to 4 new production wells. A potentially cheaper option might be to rehabilitate the existing wells.

9.18. This is an option if the present wells are structurally sound, not corroded, and the original yields have only been reduced due to screen clogging. To achieve rehabilitation, each well would be taken out of service, inspected by CCTV and surge or air-lift pumped to create the turbulent flow necessary to clear fine particles from the well screen and surrounding aquifer. Production pumps are generally inappropriate for this exercise. The water discharged may be highly turbid, unsuitable for supply, and have to be discharged to the river.

9.19. There is however little indication, with the exception of Well No.4, that yields have significantly declined due to screen clogging. The present total average discharge of around 9,000 m^3/d is little different from the original design yield of the wellfield, 10,910 m^3/d during the wet season and 9,092 m^3/d in the dry season, or from the operational capacity of 9,428 m^3/d determined from tests undertaken in 1995 for the Master Plan study.

9.20. Three of the four operating wells are nearly 40 years old and the fourth nearly 20 years old. Standards of well design and construction have greatly improved since they were constructed and it is acknowledged that these wells are poorly designed with slotted casing in place of well screen and 'formation stabilizer' in place of a graded gravel pack. Given the age of the wells it is to be expected there will be corrosion of at least the non-stainless steel slotted screens and casing and perhaps also, to a lesser degree, of the stainless steel screens. During the 1995 tests, discharge from Wells 1 and 4 had to be reduced. Well No.4 is still pumping considerable quantities of air and should in any case be replaced.

9.21. It may be suggested that rehabilitation would allow the continued exploitation of an already highly developed zone of aquifer that may have formed around each well over the years of production pumping. If this is the case, the need for redevelopment and its ability to provide a substantial increase in yield must be further questioned.

9.22. It must therefore be concluded that while well redevelopment might provide a modest increase in yield, it is unlikely to satisfy the 2025 requirement, and that new wells designed to modern standards are the most appropriate means of meeting future water demand.

Alternative Sewage Treatment Systems

9.23. The 1996 Master Plan considered a range of sewage treatment systems at different sites before deciding on waste stabilisation ponds at Turtle Crawle. The primary considerations in the decision process were:

- National sewage disposal regulations;
- NWC sewerage policy;
- Experience of treatment technologies in Jamaica;
- Land take and availability;
- Energy consumption;
- Reliability and ease of maintenance; and,
- Environmental considerations.

Alternative Treatment Plant Locations

9.24. Because the Port Antonio area is characterised by steep slopes, narrow valleys and a narrow coastal strip, potential treatment plant sites were limited. Sites outside the project area were not considered as this would have required the construction and operations of even longer pipelines and greater capacity pumping stations than are currently proposed.

9.25. The 7 sites considered by the Master Plan and the reasons for the choice of Turtle Crawle are summarised in **Table 9.1**.

9.26. Further consideration was given to 3 sites; Soldier's Bay, West River and Turtle Crawle. Soldier's Bay and West River were eventually eliminated because they were not large enough to accommodate the size of facility that was subsequently determined to be necessary to meet the required level of treatment. However, acquisition of the West River site was recommended in order to provide for future sewage treatment beyond 2025. The site at Turtle Crawle was therefore selected by the Master Plan study, was confirmed by the 2002 Review, and was taken forward by NWC to the present detailed design.

Alternative Treatment Technologies

9.27. The original terms of Reference for the Master Plan Study anticipated only primary sewage treatment and marine disposal but this was quickly eliminated because of the severe impact on the marine environment that would have resulted. The secondary treatment technologies considered during the Master Plan Study are listed in **Table 9.2**.

Table 9.1. Alternative Sites Considered for the Sewage Treatment Plant

Site	Conclusion
Port Antonio Industrial Area	Potentially suitable for an activate sludge plant but this site was too small for waste stabilisation ponds. A plant here would require sewage from the tourist areas to the east to be pumped across town. During the investigations most of the area was reserved for other development
Port Antonio Folly	The area south of the main road was adequate for activated sludge but there were existing development plans for the site.
Soldier's Bay	This site was in a small valley directly opposite Soldier's Bay. It was not large enough for waste stabilisation ponds but with landscape modification could take an activated sludge plant followed by maturation ponds.
San San	This site was already approved for development as a golf course
West River	This site was cultivated with coconut trees. There was no contiguous wetland and only partially cleared mangrove north of the main road. The area was suitable for a combined treatment system.
Turtle Crawle	The site includes an extensive area of open bog and mangrove wetland south of the road and along the foreshore to the north. The area was large and suitable for waste stabilisation ponds
Fairy Hill	Several sites were considered in this area but being so far from the origin, Port Antonio, construction and operating costs would be substantially higher and was the likelihood of septicity of the sewage flows within the c.16 km pipeline.

Table 9.2. Alternative Technologies considered for Sewage Treatment

Type	Treatment Process
Suspended Growth Systems	Anaerobic Digestion
Activated Sludge Systems	Extended Aeration
	Contact Stabilisation
	Primary Sludge Thickening
	Oxidation Ditch
	Sequential Batch Reactor
Fixed Film Systems	Rotating Biological Contactor
Natural Biological Systems	Waste Stabilisation Ponds

9.28. Each of these systems has particular advantages and disadvantages but all operate successfully in many locations around the world. Most, would provide adequate primary and secondary treatment for Port Antonio and the primary choice is essentially between (i) a predominantly mechanical plant, expensive to construct and very expensive to operate on a small area of land, and (ii) a low technology plant, relatively inexpensive to build, cheap to operate but requiring a very large area of land.

9.29. The history of effective sewage treatment in Jamaica is not characterised by success and many plants, including those serving Kingston, have experiences difficulties that have resulted in raw sewage, albeit with much of the solid content removed, being discharged to the sea. A fundamental problem in many places is that centralised sewage treatment does not attract the financial or human resources necessary for adequate operation and maintenance. It is therefore surprising that the Master Plan list of possible process options should have contained so many mechanical plants, such as extended aeration, that require skilled operators and incur high energy costs.

9.30. The recently constructed sewage treatment plants serving Negril, Montego Bay and Ocho Rios, as well as the Soapvery Plant for Kingston currently under construction all utilise waste stabilisation ponds and the selection of the same process for Port Antonio will allow NWC to benefit from their operational experience elsewhere. Other advantages of waste stabilisation ponds include:

- The process stream is entirely natural and does not require the addition of chemicals,
- The only external energy source required is sunlight;
- Low operation and maintenance costs;
- Few skills required for effective O&M; and
- Sludge removed from ponds is already stabilised.

9.31. The disadvantages of waste stabilisation ponds include:

- The required land take is large compared to alternative processes;
- They do not perform well under 'shock' loading, such as a short term increase in raw sewage inflow or the sudden influx of toxic industrial discharge;
- They also do not perform well if routinely overloaded beyond their design capacity; and,
- They may attract vectors.

Alternative Long Sea Outfall Locations

9.32. The decision to construct the proposed long sea outfall from a landfall location near Daniel's Harbour was also taken a decade ago following the Master Plan study and the issue of site selection has not been revisited since. Recent marine investigations have only been undertaken to confirm the most cost effective and environmentally acceptable pipeline route from the landfall.

9.33. In order to determine the most suitable location for treated effluent discharge, the Master Plan study included an extensive oceanographic survey along the coast in the vicinity of Port Antonio. The following potential locations for the outfall were identified. Both the East Harbour and West Harbour at Port Antonio were excluded as being unsuitable for effluent discharge.

Bryan's Bay	Daniel's Harbour East
Navy Island North	Turtle Crawle Harbour
Soldier's Bay	Burnett's Point
Daniel's Harbour West	

9.34. Each of these potential locations was investigated more fully and ranked according to physical, ecological, oceanographic, engineering and economic criteria. The results are shown in **Table 9.3**. Daniel's Harbour West emerged as by far the most suitable site and was taken forward to detailed engineering design.

Outfall Construction

9.35. Also considered by the Master Plan were various construction issues. In the absence of a detailed survey of the selected outfall route, this primarily concentrated on whether the treated effluent should be delivered by pipeline or by tunnel, and if the former, the preferred material. The options considered were threefold:

- A steel pipeline within a concrete jacket;
- An HDPE pipeline with concrete weights; and,
- Directional drilling.

9.36. Steel pipe was considered too heavy, inflexible, more difficult to construct and subsequently subject to corrosion, while HDPE was lighter and easier to handle, more flexible, non-corrosive, relatively quick to lay, non-corrosive, and would not be attacked by marine organisms. Construction of the outfall as a tunnel by directional drilling was dismissed because it is difficult to control, very slow and extremely expensive. After again considering the issue during detailed design, HDPE pipe weighted down by concrete collars is the chosen outfall material.

9.37. A further consideration is the length of the outfall. The Master Plan concluded that an outfall from Daniel's harbour would encounter deep water devoid of corals after some 420 m. The recent investigations have shown this not to be the case and the proposed discharge will be 500 m from the shore in 28 m of water and less than the 150 m from coral required by the *National Sewage Effluent Regulations* without more stringent nitrogen and phosphorous standards.

9.38. At the request of NEPA, detailed design has considered extending the outfall to the edge of the continental shelf, and beyond the fore-reef. However, the pipeline would need to be some 800 m in length, to where the water depth approaches 100 m. Placing the outfall here precludes conventional construction utilising dredgers, jack-up platforms and pipe-laying barges. The only realistic way to construct such an outfall is as a tunnel, which will be technically difficult, prohibitively expensive and difficult to maintain.

Table 9.3. Suitability Matrix for the Selection of the Outfall Location

Parameter	Bryant's Bay	Navy Island N.	Soldier's Bay	Daniel's Harbour W.	Daniel's Harbour E.	Turtle Crawle Harbour	Burnett's Point
Physical Criteria							0
Access	+4	-5	+4	+4	+2	+5	-1
Distance	-5	-3	-2	-2	-1	+5	-5
Bathymetry	-3	+5	-3	+4	+2	+1	
Ecological Criteria							-1
Shoreline Construction	0	-2	-1	-1	-1	-4	-3
Submarine	-3	-4	-2	+2	-3	-3	-3
Reef Impacts	-4	-5	-2	+5	-2	-5	-3
Fisheries Impacts	-3	-2	-3	+5	+5	-5	-3
Beach Water Quality	-5	-4	-3	-2	+5	-3	-3
Oceanographic Criteria							
Current Patterns	-5	+5	-5	+4	+4	-5	-5
Dispersion Potential	0	+5	+3	+4	+4	-5	+4
Engineering Criteria							
Ease of Construction	+4	-3	+3	+4	+2	+4	-1
Protection Required	+4	-4	-4	-4	-4	-2	-4
Long-term	+4	-3	-2	-2	-2	-2	-3
Economic Criteria							-2
Capital	-5	-5	-3	-2	-2	0	
Maintenance	-2	-4	-3	-3	-3	0	-3
Score	**-19**	**-29**	**-23**	**16**	**6**	**-19**	**-33**

From Louis Berger International, 1996.

Alternative Treated Effluent Disposal

9.39. Because the Terms of Reference for the 1996 Master Plan called for investigations to identify the most appropriate location for marine discharge, alternative disposal of the treated effluent was not fully considered. It has also not been required during detailed design. Notwithstanding this, in the context of the present EIA it is prudent to briefly consider two possible alternatives:

- Wastewater reclamation; and
- Discharge to a surface watercourse.

Wastewater Reclamation

9.40. Wastewater reclamation is the re-use of treated effluent, usually for agriculture or the irrigation of public planting such as roadside verges and parks. There are however limitations on both. Agricultural use should not include application to salad and other crops that may be eaten raw, or spray irrigation. In public parks, it should not be used on areas of grass where children might play.

9.41. The quantities of treated effluent to be produced, ultimately 2000 m^3/d in 2025, are probably greater than could economically be utilised for public planting. Considerable additional cost would be involved in pumping it back to Port Antonio.

9.42. Agriculture in Jamaica is dominated by rain-fed crops and less than 2.5% of the country is irrigated. Given the lack of intense irrigated agriculture in the vicinity of Port Antonio there are likely to be few farmers willing or able to use the effluent economically. Should this not be the case, the proposed treated effluent would need to meet a different set of NEPA standards as shown in **Table 9.4**.

Table 9.4. NEPA Standards for Treated Sewage Effluent Irrigation

Parameter	Standard
Oil & Grease	10 mg/l
Total Suspended Solids	15 mg/l
Residual Chlorine	0.5 mg/l
BOD_5	15 mg/l
COD	<100 mg/l
Faecal Coliform	12 MPN/100ml

9.43. For most parameters the proposed level of treatment is satisfactory but chlorination would need to be added at the end of the process stream to further reduce pathogens and provide chlorine residual to protect farm workers and others who may inadvertently have contact with the effluent.

Discharge to a Surface Watercourse

9.44. When considering a license to discharge treated sewage effluent to a watercourse NEPA takes the following into consideration:

- Whether the discharge of sewage effluent occurs within 2000 m of any potable water intake;
- Whether the discharge will render the river or stream an unsuitable source for potable water, domestic uses, irrigation, recreation or any other activity that occurred prior to the discharge of the effluent;
- Whether the discharge is less than or equal to the 100 m radius on river or stream from locations used for recreational purposes including but not limited to swimming and boating;
- Where there are other sewage effluent discharges licensed or unlicensed which already impact the river or stream;
- Whether or not the discharge is likely to cause an odour; and,
- Any other relevant consideration.

9.45. It is likely to be impractical to pump treated effluent to another catchment area and the only potentially viable alternative to marine disposal would be to discharge it into Turtle Crawle River adjacent to the treatment plant. There are no flow gauging records but estimates made during detailed design suggest base flow around 30 l/s or nearly 2,600 m^3/d. With the ultimate design discharge 2,000 m^3/d, significant dilution would immediately be achieved during even the driest periods.

9.46. However, some 200 m downstream from treated effluent outlet at the plant the river enters Turtle Crawle Harbour, one of the largest embayments along the north-east coast of Jamaica after Port Antonio's twin harbours. The Harbour is renowned as an important fish spawning site and dolphins, lilot whales and even manatees are reported to have visited the bay, albeit perhaps many years ago. A 1998 coastal resources study[3] reported that the coral reefs were '… *among the healthiest in Jamaica'*. However, the 2002 Master Plan Review reported they had '… *experienced medium levels of eutrophication as exhibited by visible levels of macroalgae growth …',* but that the '… *discharge of secondary STP* (sewage treatment plant) *effluent … would significantly increase the nutrient loading and accelerate further eutrophication'.* Marine investigations undertaken in 2002[4] suggested circulation within Turtle Crawle Harbour was insufficient for discharged effluent to be adequately diluted and dispersed.

9.47. Nevertheless, there are some inconsistencies in the available data and the Harbour's present status is uncertain. West River, Banana River and Turtle Crawle River all discharge into it, and recent water sampling (March 2006) show all have nitrate contents between 1.2 and 2.1, significantly greater than that allowed in treated effluent discharged onto coral. More significantly,

[3] *Coastal Resources and Tertiary Treatment in Port Antonio, Jamaica. Phase 1*. Louis Berger, April 1998.
[4] *Proposed Dredging Works at West Harbour, Port Antonio: Environmental Impact Assessment*. Environmental Solutions for the Port Authority of Jamaica, July 2002.

West River passes beneath the uncontrolled landfill at John's Town Dump, while Turtle Crawle River contains domestic sewage outflows and water from the washing of stables and pig pens higher up the valley.

9.48. The discharge of treated effluent into Turtle Crawle River and hence to Turtle Crawle harbour would bean attractive option. The facilities would be simple to construct and there would be significant cost saving if the construction of the effluent pumping station, transmission pipeline to Daniel's Harbour, and the long sea outfall were not required. Nevertheless, and despite somewhat ambiguous data, the potential for serious derogation of the marine environment is real and the chosen alternative of an outfall off Daniel's Harbour at least discharges the effluent where prevailing currents will provide adequate dispersion.

The Use of Alternative Fuels

9.49. At the January 2006 EIA Scoping Session it was suggested that LPG fuelled generators would be preferable to ones burning fuel oil. The benefits to be gained from this will be limited for equipment to be used intermittently but Stage 2 Tenderers will be required to offer both and NWC will determine the most cost effective.

Summary of Alternatives

9.50. A summary of the PAWSDP Stage 2 alternatives discussed above is presented in **Table 9.5**.

Table 9.5. Summary of PAWSD Stage 2 Alternatives

Alternative	Potential Environmental Impact	Ease of Mitigation	Capital and Recurrent Costs	Suitability to Local Conditions	Institutional Requirements	Training Needs	Monitoring Requirements
Proposed Project	Moderate	Satisfactory	US$ 350 M	Good	Moderate. Primarily environmental and operational management	Moderate	Extensive
Without Project (See Section 2)	Serious	Difficult	Zero	Will become worse and further derogate public health	Negligible	Nil	None
Do Minimum	Serious, potentially more so than 'Without Project'	Unknown	Unknown	Low	Moderate	Moderate	Extensive
Alternative Water Resources Development	Serious	Difficult	High	Low	Extensive	Moderate	Moderate
Alternative Sewage Treatment Plant Location	Serious	Difficult	Unknown	Low	Moderate	Moderate	Moderate
Alternative Sewage Treatment Process Technology	Serious	Difficult	High	Low	High	High	High
Alternative Long Sea Outfall Location	Serious	Difficult	Unknown	Low	Moderate	Moderate	Moderate
Alternative Treated Effluent Disposal	Serious	Difficult	Unknown	Low	Moderate	High	High
Alternative Fuels	Less than alternatives	N/A	Potentially High	Good	None	Minor	As alternatives

8. POTENTIAL OPERATIONAL IMPACTS

8.1. In this section the potential environmental impacts that may result from the long term operation and maintenance of the PAWSDP Stage 2 works are identified. Again, discussion of their mitigation is given in Section 10.

Water and Sewage Overflows

8.2. Once the water transmission main is laid, tested and commissioned there should be no impact except for rare accidental breaks and leaks, for which NWC routine line inspection reports will initiate repair.

8.3. Sewage pipelines laid at a suitable depth with appropriate bedding material and adequate depth of cover should also be largely trouble free. Again occasional breakages may occur, but more frequent there may be blockages due to the disposal of inappropriate materials such as food waste, plastics and other household refuse where individuals are unaware of the limitations on sewer capacity.

8.4. Sewage pumping stations should also be largely trouble free. The 'wet well' in each is designed on the basis of 10 pump starts each hour and should the main pump fail, stand-by pumps with 100% operating capacity will automatically take over. To ensure the pumps remain in operation during power outages each station is equipped with a stand-by generator.

8.5. The uncontrolled overflow of raw or partially treated sewage from the sewage treatment plant at times of heavy rainfall is a potential risk, most likely when such rainfall coincides with peak inflow. The treatment ponds therefore require a means of overflowing excess water if overtopping and/or embankment instability is to be avoided.

Noise and Vibration

8.6. Noise and vibration from the sewage pumping stations during normal operation will be minimal and other than perhaps a 'distant hum' will not normally be apparent to passing pedestrians. Increased noise and/or vibration will be indicative of pump malfunction.

8.7. The almost imperceptible routine levels of vibration and noise may be elevated when stand-by generators are being used. At the present time this will be every time there is a power outage. If future power supplies are improved to the extent there are no outages, the generator will only be used for 1-2 hours/month to maintain it in working order.

Air Quality

8.8. The use of the stand-by generator will also produce exhaust gases. While these will not cause serious air pollution under normal operating conditions, the proximity of Pumping Station No.1 to Bethesda Gospel Hall and Bethesda Basic School, respectively some 20 m and 50 m distance, may be seen as a cause for concern for those with respiratory problems if stack emissions drift towards open windows.

Odour

8.9. It is common misconception that sewage treatment plants emit unacceptable levels of odour. An effective and efficient treatment stream will emit little or no odour. High odour is indicative of plant or process malfunction. Nevertheless, some odour can occur for short periods when certain operations, such as desludging, are taking place or when an unexpected discharge of industrial sewage is received and the bacteriological balance within the treatment ponds is upset.

8.10. Similarly, odour emitting from sewer pipelines is indicative of septicity taken place within the line rather than under controlled conditions at the treatment plant. Given the Port Antonio pipelines have been designed with appropriate pipe diameters and gradients to maintain self-cleansing velocities, there should be little potential for odour.

Soil and Water Pollution

8.11. With all Stage 2 sewage pipelines and pumping stations located adjacent to the coast any overflow will quickly contaminate the surrounding soils, nearby water courses and ultimately near-shore environments. However, with adequately sized pipes and stand-by generators at pumping stations any overflow event is likely to be short-lived and not cause serious pollution.

8.12. Any spillage of oil, grease or other hydrocarbon derivatives may quickly spread to contaminate soil, surface watercourses and ground water. Such spillage is most likely at the sewage pumping stations and Grant's Level wellfield where fuel oil for stand-by generators may be stored on site. The proposed treatment plant utilises a natural treatment process rather than a mechanical process and there are no pumps to maintain, although there will be a stand-by generator to maintain safety lighting.

Marine Pollution

8.13. While studies have shown treated effluent discharged through the proposed long sea outfall will quickly be diluted and dispersed, there are three scenarios under which serious marine pollution may accrue:

- If the treatment plant fails, for no specific reason, to produce treated effluent to the required standard;

- If rare and unusual climatic and/or tidal conditions substantially reduce the dilution and dispersion of effluent and/or return it to the adjacent shoreline;
- If unauthorised discharges of hazardous or toxic wastes that will 'kill' the biological process enter the treatment stream; and,
- If the outfall pipe breaks, say in an earthquake, and is not repaired.

8.14. The long sea outfall pipeline will essentially be maintenance-free although rarely, at intervals several years apart, divers may need to clear debris from around the diffusers.

Natural Habitats

8.15. All of the issues discussed above can at varying levels of severity have a serious impact upon natural habitats. The more obvious examples would be uncontrolled and prolonged treatment pond overflow into the Turtle Crawle mangroves and fish nursery spawning in the Harbour beyond, and incompletely treated sewage being discharged via the long sea outfall. Both could result in an increase in present levels of eutrophication.

Traffic

8.16. The attendance of NWC treatment plant operators and maintenance crews will generate a certain amount of traffic but this is likely to be significantly less than that resulting from the present residents. More significant will be the regular movement of septage tankers delivering waste from the emptying of septic tanks and adsorption pits. The expected volume is 10 tankers each day, each passing up and down the access track to the plant and turning off and back onto the A4.

Solid Waste

8.17. The volume of solid waste produced from operation and maintenance of the Stage 2 works will include the following but the total volume will not be large.

- Excess spoil, broken concrete and road surfacing, broken pipes and fittings, from the repair of pipelines and inspection chambers;
- Discarded valve seating, seals, gland packing, replaced pump impellers and other items from the repair and maintenance of valves and pumps;
- Waste oil, oil filters, lead-acid batteries and other parts from stand-by generators and vehicles.

8.18. The continued effective treatment of sewage flows will require the removal and disposal of accumulated sludge, mainly from the facultative ponds when it occupies half the depth of the pond. However, WSP's are low-sludge systems and a considerable proportion is biologically digested as it settles out. Desludging is therefore only likely to be required infrequently, perhaps only once every 7-10 years.

Hazardous Materials

8.19. Water from Grant's Level wellfield is already chlorinated before being pumped into supply and this practice will continue. With the increased discharge to serve the 2025 demand, and increase of some 90% on the present yield, greater quantities of chlorine will be consumed and there will be an proportional increase in the volume of gas stored on site at any given time. Chlorine gas is toxic, corrosive and carcinogenic to human, animals and plants and its storage and use must be undertaken in accordance with strict but well understood procedures if accidents are to be prevented.

Public and Worker's Health and Safety

8.20. Sewage treatment plants and pumping stations at which good operating procedures are not respected can be both unhealthy and unsafe. Notwithstanding this, the waste stabilisation treatment stream is non-mechanical and accidents are generally limited to operators occasionally slipping into the ponds.

8.21. Pumping stations contain hydraulic and electrical apparatus and common accidents include burst oil lines, electric shocks and workers tripping carelessly over pipes and cables. Station design has been such that nowhere are there 'confined access' area that require special equipment to ensure suitable air conditions.

8.22. Wherever there is a danger to operators and other workers there is an inherent danger to the public should they be afforded unimpeded access. Any lack of security at pumping stations and the treatment plant will not only risk theft and vandalism, but also be a considerable danger, particularly to children.

Maintenance Issues

8.23. Solving any problems with water and sewage mains is likely to involve temporary road excavation to affect repair, resulting in traffic delay or diversion. Significant but short-term noise and dust will be generated and surplus spoil may remain to be disposed of. Service to consumers and customers is likely to be temporarily disrupted.

8.24. At the treatment plant site at Turtle Crawle the access road will have to be regularly maintained, potentially causing minor traffic delay. Landscape planting will need to be maintained, with die back routinely removed and replacement planting undertaken. It is not expected that pesticides and other chemical products will be used. Weedkillers may be used at pumping stations and around the outfall headworks chamber.

Energy Use

8.25. There will be an ongoing demand for the consumption of electrical power for the operation of the pumps at Grant's Level and, to a much lesser extent, at the sewage pumping stations

Employment

8.26. The requirement for operational staff will be limited. Under the National Sewage Effluent Regulations all treatment plant operators shall have undergone approved training and attained certified competence in accordance with a NEPA/MoH scheme that recognises Operator I, II and III. Treatment plants with a capacity over 1,000 m^3/d require an Operator II or III and an Engineer , both with a minimum of 2 years experience, to be in full time attendance. The Regulations do not consider different treatment processes and it is difficult to justify the need for a full time engineer and a second operator for a non-mechanical plant such as waste stabilisation ponds. Also required will be 3-5 unskilled labourers for septage reception and grounds keeping.

Summary of Potential PAWSDP Stage 2 Operational Impacts

8.27. A summary of the potential risks from operational environmental impacts accruing from the project is provided in Table 8.1 and their proposed mitigation is discussed in Section 10.

Table 8.1. Summary of Potential Operational Impacts of the PAWSDP Stage 2 Works

Issue	Potential Operational Impact	Risk
Water and Sewage Overflows	Raw sewage leakage and due to pipe breakage	Minor, but short term if repair expedited
	Overflow from blocked pumping stations	Moderate
	Overflow from treatment ponds during heavy rain	Major
Noise and Vibration	Nuisance caused by routine operational 'hum'	Minor
	Enhanced noise levels from stand-by generators	Moderate but for short periods only
	Noise created during the excavation of pipes for repair	Moderate but for short periods only
Air Quality	Impaired respiration and other health affects due to exhaust emissions from stand-by generators	Minor but none expected
Odour	Odour from trunk sewers and pumping stations	Minor but none expected
	Odour indicative of treatment process malfunction	Moderate but none expected
	Odour from septage reception facilities	Moderate but only occasional
Soil and Water Pollution	Overflow from broken pipelines and blocked manholes	Minor
	Spillage of hydrocarbon derivatives	Minor
Marine Pollution	The treatment process generally underperforms and effluent fails to meet the required standard	Minor
	Rare or unusual climatic or tidal conditions prevent adequate dilution and dispersion	Minor
	Hazardous or toxic discharges 'kill' the bacteriological treatment process	Major
Natural Habitats	Overflow from broken pipelines and blocked manholes	Minor
	Overflow of raw sewage from the treatment ponds	None
	Overflow of partially treated effluent during heavy rain	Moderate
Traffic	Vehicular movements of operational staff	Minor
	Septage tankers	Moderate
	Disruptions during network repairs	Moderate but for short periods only
Solid Waste	Broken road surfacing and soil from pipeline repairs	Minor
	Discarded mechanical equipment consumables	Minor
	Waste oil filters, batteries, etc	Minor
	Sewage sludge	Moderate
Public and Workers Health and Safety	Non-injurious accidents	Moderate
	Injurious accidents	Moderate
	Breathing difficulties in confined spaces	None
	Accidents involving hazardous materials	Moderate
	Accidents due to unimpeded public access	Major
Energy Use	Increase in the overall energy consumption	Unknown but probably insignificant.

7. POTENTIAL PERMANENT IMPACTS

Land Acquisition

7.1. Land acquisition and asset take for the PAWSDP Stage 2 works is summarised in **Table 7.1**.

Table 7.1. Land Acquisition and Asset Take

Site	Existing Ownership	Land Acquisition	Asset Take
Grant's Level Wellfield	GoJ (NWC)	None	None
Water Transmission Mains	GoJ (NWA)	None	None
Sewage Trunk Mains	GoJ (NWA)	None	None
Pumping Station No.1 (Caneside River)	GoJ (NWA)	None	None
Pumping Station No.2 (Anchovy)	PPC	None	None
Pumping Station No.3 (Turtle Crawle)	Private	Within STP area	None
Sewage Treatment Plant (Turtle Crawle)	Private	Extensive	Extensive
LSO Landfall and Headworks Chamber	Private	Limited	Limited

7.2. The most extensive land acquisition is for the sewage treatment plant and pumping station 3a/3b at Turtle Crawle. Most of this area comprised the bottom lands within the Turtle Crawle River floodplain that have been progressively drained for unplanned development and degraded by subsistence farming. The lowermost part of the floodplain between the main road and the treatment plant, some 4.5 ha, comprises relatively unaltered mangrove swamp and will be left undisturbed.

7.3. The total land take at Turtle Crawle will be some 14.1 ha between the unsurfaced access track to Nonsuch and Turtle Crawle River. According to the records of the National Land Agency, registered ownership of this land is primarily divided between two parties, as shown in **Figure 7.1**, from whom the take will be 11.0 ha (Area A) and 2.6 ha (Area B) respectively. Neither of these parties is resident in the immediate vicinity, one living elsewhere in Portland and the other in Kingston, and acquisition may be viewed positively. The land is currently occupied by fifteen separate households who, despite having no right of tenure, have built small single storey wooded houses and use the surrounding areas for growing crops.

7.4. A further area of land, some 0.5 ha (Area C) also shown on Figure 7.1, between the treatment plant and Turtle Crawle River is already effectively severed from the rest of a third party's holding by the river. Although not required for construction, the project will impose further severance with the loss of any existing access through the treatment plant site. It is normal practice that such severed areas, albeit with little present value but even less future value, be included in the acquisition.

7.5. The land to be acquired for the long sea outfall headworks chamber is owned by one party. Although appearing to have once been configured as part of a garden, it is now effectively divided from the houses on either side and has all the signs of having been abandoned.

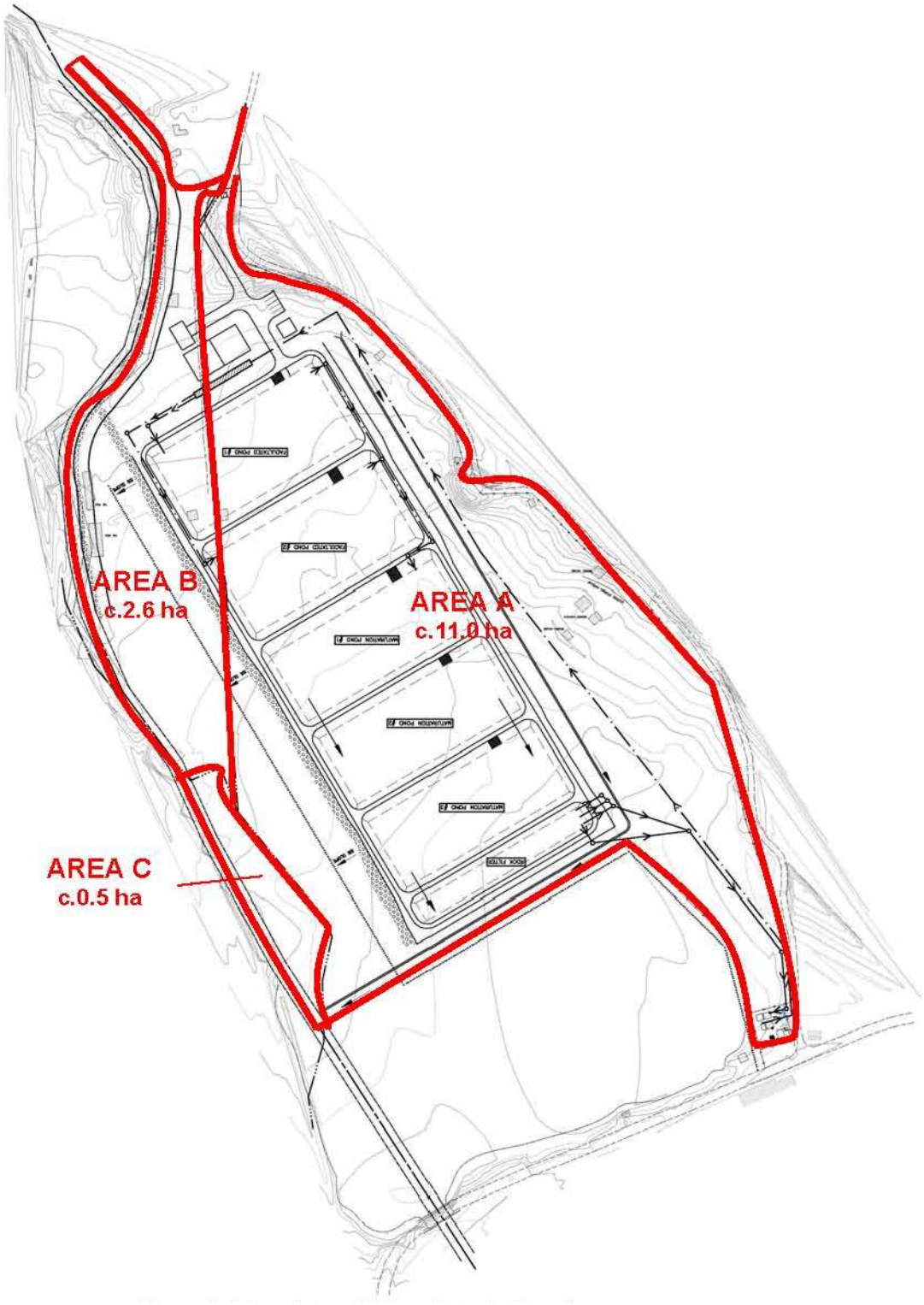


Figure 7.1. Land Acquisition Requirements at Turtle Crawle

Derogation of Subsistence Agriculture

7.6. Agricultural activity on the treatment plant site is primarily rain-fed arable crops and/or animal husbandry. The latter is only practiced by four of the fifteen households, as shown **Table 7.2**. The total population of farm animals as reported during the social survey is 10 pigs, 11 goats and 8 chickens, but field visits suggest the number of pigs has been under-reported and the true number is significantly greater.

Table 7.2. Animal Husbandry on the Treatment Plant Site.

Household	Pigs	Goats	Chicken
A	4		
B		6	
D		5	
N	6		8

7.7. Food crops are grown by 11 of the 15 households. The range of crops is wide, from vegetables such as cauliflower and pepper to tree crops such as apple and coconut, and are grown primarily for their own consumption by each household are shown in **Table 7.3**. The area tended by individual households is 0.1-1.2 ha, with an average of 0.4 ha. The total cropped area is some 3-4 ha.

Table 7.3. Arable and Tree Crops on the Treatment Plant Site

Household	A	B	D	E	F	G	J	K	L	M	N
Ackee	●										
Apple				●	●						
Banana			●	●			●		●	●	●
Calcaloo										●	
Cauliflower		●									
Cocoa		●								●	
Coconut	●			●	●		●				
Dasheen	●			●	●	●			●	●	●
Gungo						●					
Mango	●										
Mustard		●									
Okra		●									
Papaya									●		
Pepper		●				●					
Pineapple									●		
Plantain	●	●	●	●	●	●	●	●	●	●	●
Pumpkin		●									
Sugar Cane	●			●	●	●	●		●		
Tomato		●									
Undefined Fruit			●								
Undefined Veg			●								

Property Take and Population Displacement

7.8. Details of the size, construction and facilities afforded by the residential structures to be acquired are located on **Figure 7.2** and summarised in **Table 7.4.** Many suffer a lack of facilities often considered vital for good public health. Non-residential structures recorded include water tanks at Households B (two tanks), E and H, and two partially collapsed piggeries on the side of Turtle Crawle River.

7.9. The composition of the households to be displaced has been identified in Table 5.11. A total of 21 adults and 26 children will suffer involuntary resettlement, but since they are all squatters with no tenure of the land they occupy, this may be viewed positively if compensatory arrangements include some measure of secure land tenure. Given the high proportion of children to adults and that almost all attend school everyday, continued access to education will be the most significant issue to be addressed in respect of women and young people.

Entitlement to Compensation or Other Benefit

7.10. Under World Bank Operational Policy OP 4.12 on Involuntary Resettlement a 'Displaced Person' is eligible for benefits if they fall into one of the following three categories:

- Those who have formal legal rights to the land, including Customary and Traditional Rights recognised under the laws of the country;
- Those who do not have formal legal rights to land but have a claim on land or assets provided such claims are recognised under the laws of the country or become recognised through a process identified in a Resettlement Plan; and,
- Those who have no recognisable legal right or claim to the land they are occupying.

7.11. Persons covered under the first two categories are provided with compensation for the land they lose and other assistance, which may include support after displacement for a transitional period adequate for them to restore their livelihood and living standard, and development assistance such as land preparation, credit facilities, vocational retraining or employment opportunities. Persons in the third category, into which most of those affected by property and asset take at Turtle Crawle fall (PAP Group 1 identified in Section 5 above) are entitled to resettlement assistance in lieu of compensation for the land they occupy, and other assistance to meet the OP 4.12 objectives.

7.12. All persons falling into any of the three categories are provided for loss of assets other than land. Such assets include but are not be limited to, houses, fences, water tanks, crops and animals, as preliminarily identified in the tables above.

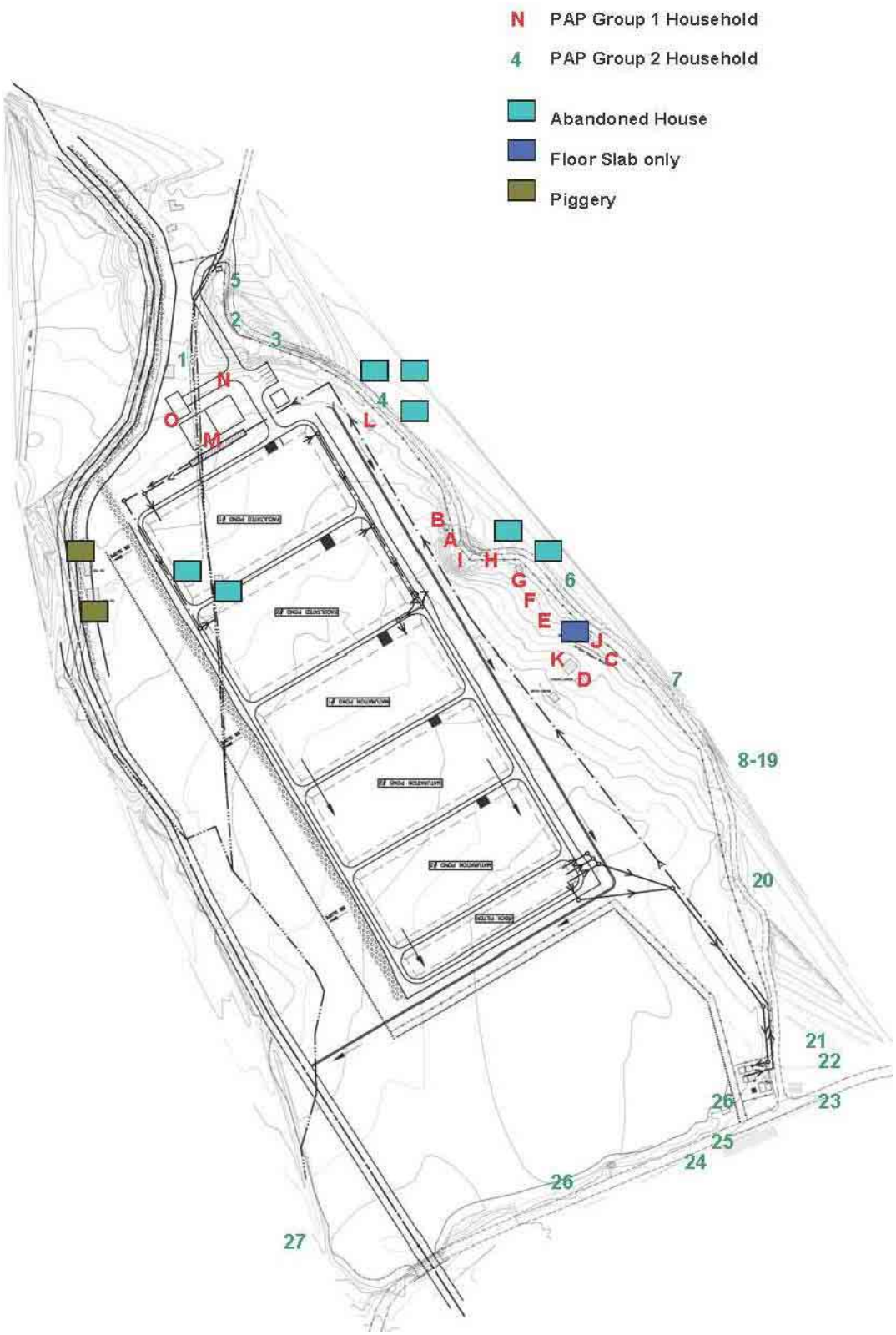


Figure 7.2. Location of PAP Group 1 and Group 2 Households

Table 7.4. Details of the Residential Structures to be Acquired

Household	Floor Area	Rooms	Construction			Facilities					
			Base	Walls	Roof	Kitchen	Washing Area	WC/ Latrine	Gas Stove	TV	Mobile Phone
A	45	2	Concrete	Wood	Steel sheets	Yes	No	Yes	Yes	No	No
B	19	2	Concrete	Wood	Steel sheets	Yes	Yes	Yes	Yes	Yes	Yes
C	34	3	Concrete	Wood	Steel sheets	Yes	Yes	Yes	No	No	Yes
D	30	1	None	Wood	Steel sheets	No	Yes	No	Yes	No	No
E	45	n/a	Brick	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
F	100	1	Concrete	Wood	Steel sheets	No	No	Yes	Yes	No	No
G	40	1	Concrete	Wood	Steel sheets	No	No	Yes	Yes	No	No
H	100	3	Brick	Wood	Steel sheets	Yes	Yes	Yes	Yes	Yes	No
I	44	2	Brick	Wood	Steel sheets	No	No	Yes	No	No	Yes
J	45	2	Concrete	Wood	Steel sheets	Yes	Yes	Yes	Yes	No	Yes
K	14	1	Stilts	Wood	Steel sheets	Yes	Yes	No	No	No	Yes
L	45	2	Concrete	Wood	Steel sheets	Yes	No	No	Yes	Yes	Yes
M	50	3	Concrete	Wood	Steel sheets	Yes	Yes	Yes	Yes	Yes	Yes
N	20	1	None	Wood	Steel sheets	Yes	No	No	No	Yes	Yes
O	20	1	Concrete	Wood	Steel sheets	Yes	No	No	No	Yes	No

The Household E residence is under construction and currently only comprises a foundation slab.
Highlighted boxes indicate facilities not conducive to good public health

Depreciation of Natural Landscape

7.13. The only significant potential long term impact on the landscape will also be at the Turtle Crawle treatment site where an area of some 11.5 ha will be cleared. Few properties directly overlook the site and visual impairment will be limited.

Reduction in Floodplain Storage

7.14. Wade (1973) postulated that the Turtle Crawle wetland only developed after construction of the main road, which only allowed the water in the river and over the adjacent floodplain to pass into Turtle Crawle Harbour via the c.12 m wide bridge. Flood water could no longer reach the sea across the full width of the floodplain and the deposited sediment encouraged the growth of swamp vegetation, which with time and continued siltation and stagnation, promoted the establishment of mangroves. The wetland does not therefore have a historic origin.

7.15 With time, the ability of the land to support flood spreading will naturally diminish, with or without the treatment plant. With the infilling of the area and the creation of bunded ponds, this process is accelerated. Hydraulic modelling of the area for a 1 in 100 year storm indicates adequate floodplain storage remains available to prevent flood water overtopping either the treatment ponds or the A4 road. The overall impact will be that the mangrove area will be inundated somewhat more frequently and to a slightly greater depth than at present, and that water entering Turtle Crawle Harbour through the bridge will do so during periods of flood at slightly greater velocities.

Drainage, Erosion, Turbidity and Sediment Load

7.16. The replacement of largely vegetated land with significant areas of hard surfaces around the ponds and over the area of the treatment plant service area has the potential to increase the turbidity and sediment load in Turtle Crawle River and ultimately Turtle Crawle Harbour.

Derogation of Touristic Attraction

7.17. The increased extraction of water from the Grant's Level wellfield will reduce flows in the adjacent Rio Grande River. The additional abstraction to meet the 2025 requirement is some 9% of the 1 in 10 year low flow at Fellowship, 11% of the lowest recorded flow on 5th May 1968. Generally, this reduction will be imperceptible and will have no impact of the appearance and use of the river, including rafting activities.

7.18. The loss of rafting days is greater due to high flow than it is to low flow, and no low flow losses have been suffered for some years as the rafting companies employ 'pickers' to remove accumulated stones and keep the channel open. Low flow problems manifest themselves more where the river is wide rather than where it is narrow, as the same volume of water is spread more thinly across the channel. A reduction in flow will

therefore have less absolute impact on water depth in the wider channel than in the narrow channel, although the significance of the lesser impact may be greater.

7.19. Discussions with rafting organisations suggest they are less concerned about the proposed increase in abstraction from Grant's Level than they are about the excavation of sand and gravel for aggregate lower down the catchment which is lessening the overall gradient and making journeys slower.

Reduction in Ecology and Biodiversity

7.20. Most of area to be acquired originally comprised the flooded bottom lands within Turtle Crawle River floodplain but has been progressively drained as settlement increased. The lowermost part of the floodplain comprising mangrove, some 4.5 ha between the treatment plant and the A4 is to be left unaltered. Mangrove in the Turtle Crawle area in general will be enhanced by an increase in wet areas and compensatory planting in exchange for removing a small area of mangrove at Port Antonio Marina as part of the PAWSDP Stage 1 works.

7.21. The Open Bog Zone and part of the Forest Zone at Turtle Crawle, as identified in Section 4 above, will be the main location for the waste stabilisation ponds. The ecology and biodiversity of these areas will be reduced, but as concluded from both the 1973 and 2006 surveys, the area is of little ecological significance since its original character has been severely altered by clearance for agriculture and human settlement. Most species of fauna will resettle in adjacent areas and there are no significant species of flora.

7.22. The permanent impact on the small number of American Crocodiles, reportedly 3, living in the mangrove area is uncertain. The major impact will be the noise and intense human presence during construction. If the crocodiles chose not to migrate during this period, they are likely to settle into peaceful coexistence with their new neighbours.

7.23. The area in the immediate vicinity of the treatment plant will be opened up to illegal hunting, trapping and egg collecting. Disturbance may also be caused by 'crocodile spotting'.

Derogation of the Marine Environment

7.24. The quality of the treated effluent produced at Turtle Crawle will meet NEPA's requirements for disposal at sea beyond 150 m from the nearest coral. The point of discharge at the end of the outfall will be much closer to coral and the effluent will not immediately meet NEPA's enhanced requirements for such discharges. The critical parameters are nitrogen and phosphorous, which need to be reduced from 4.5 to 0.081 mg/l and from 3 to 0.055 mg/l respectively in order to comply.

7.25. A 55 times total dilution of the treated effluent is therefore required to meet the NEPA standards. However, a simple total dilution is not applicable because (i) at the beginning of effluent discharge the receiving sea will already have a background nitrogen and phosphorous content, and (ii) during normal operations the immediate receiving water may have already attained the requisite levels of nitrogen and phosphorous and has no further capacity to afford the required level of dilution except in so much as 'clean' water is brought

into the area by tides and currents. Substantially greater dilution s therefore required if NEPA requirements are to be met consistently.

7.26. Preliminary modelling, subject to ongoing verification, of the dilution and dispersion of the effluent against measured current, tidal, bathymetric, salinity and sea water quality data, taken throughout the water column indicates the 'initial and entrainment' dilution factor as the effluent emerges from the diffusers to be over 100. This increases with distance from the outfall and the 'far field' dilution for areas of key interest averaged over 2,000, within the range 1,000-10,000 depending upon current, tides and other variables. The key areas of interest were Burnett's Point, Soldier's Bay and Folly Point, respectively 2 km ESE, 0.8 km SW and 2 km W from the end of the outfall. The outfall is expected to perform better under slower prevailing winds as the plume is more greatly diluted, whereas faster winds increase plume travel time and reduce dilution. Hurricanes however create significant turbulence which will assist dilution and dispersal.

7.27. The outfall pipe is designed so it will not interfere with the passage of marine vessels.

Public Health

7.28. The provision of safe and sustainable water and sanitation for a community such as Port Antonio will have a major positive impact on public health. For the full scope of benefits to be achieved, existing septic tanks and absorption pits should be taken out of service and made safe, and households and businesses connected to the improved water distribution and sewage collection networks with the minimum of delay.

Induced Development

7.29. With the installation of improved water, sewage and drainage, Port Antonio will increase in popularity. Modern infrastructure induces development, stimulates investment and employment and helps improve marginal investment opportunities.

7.30. The extent to which development becomes a positive or negative impact will be determined by the effectiveness of the planning framework. With an ineffective framework the overall impact could be substantially negative. However, given one of the objectives of the PAWSDP is to create an atmosphere for environmentally acceptable residential and commercial expansion, it may be viewed more positively. Without an effective planning framework, vacant land in the vicinity of water and sewage pipelines may become prime targets for squatters who will make their own unauthorized connections to the new sevices.

Summary of Potential PAWSDP Stage 2 Permanent Impacts

7.31. A summary of the potential permanent environmental impacts from Stage 2 of the project is provided in Table 7.5. The proposed mitigation of the potential impacts identified above is discussed in Section 10 of the present report.

Table 7.5. Summary of Potential PAWSDP Stage 2 Permanent Impacts

Issue	Potential Permanent Impact	Risk
Land Acquisition and Property Take	Loss of land ownership	Minor. May be viewed positively
	Loss of agricultural land	Minor, only 3-4 ha but major for those impacted
	Loss of residential buildings	Moderate, but Severe for those 15 households impacted
	Loss of non-residential structures	Minor
	Loss of other assets	Minor
	Severance of landholding	Minor
Agricultural Production Losses	Loss of produce, income and livelihood	Moderate
	Loss of sole means of sustenance	Severe for those 11 households impacted
Population and Business Displacement	Population Displacement	Major for those impacted, but since they are all squatters, resettlement may be viewed positively
	Business Relocation	Minor
Depreciation of Natural Landscape	Landscape Depreciation	Moderate
	Visual impact	Minor
Erosion, Turbidity and Sediment Load	Erosion of cleared land	Minor
	Increased turbidity and sediment loading in Turtle Crawle	Minor
Reduction in Alluvial Floodplain	Reduced flood spreading	Minor. Shown not to be significant for a 1 in 100 year storm
	Reduced siltation	Minor.
	Increased velocities through Turtle Crawle bridge	Uncertain
Reduction in Ecology and Bio-Diversity	Loss of flora	Minor. No significant species present
	Loss of fauna	Minor. Most affected species will easily relocate
	Reduction in ecological interest	Minor. Little ecological interest at present
	Dislocation of endangered species	Uncertain. The small American Crocodile population may relocate
	Area opened up to hunting, trapping and egg collecting	Major unless restrictions enforced
Impact on the Marine Environment	Discharge of effluent with nutrient levels in excess of NEPA requirements	Major, but expected to be mitigated by dilution and dispersion
Public Health	Provision of safe and sustainable water and sanitation	Major and Positive
Induced Development	Unplanned development in the vicinity of water and sewerage services	Minor if planning system is effective

6. POTENTIAL TEMPORARY IMPACTS

6.1. This section identifies and discuses the potential impacts to be suffered during the period of construction, both at construction sites and at other locations such as those of materials suppliers.

Damage to Landscape

6.2. Little overall landscape damage is expected to result from the PAWSDP Stage 2 works. The three pumping stations will afford minor visual impairment but in time the concrete will weather and the residual impact will be minimal. The greatest threat is at the sewage treatment plant site where an area some 11.4 ha will be cleared of existing vegetation. However, the valley is visible from few properties on the surrounding wooded hills and the existing mangroves which front the A4 North Coast highway will be retained.

Reduction in Bio-Diversity

6.3. The physical earthworks and associated noise, dust and increased human activity associated with any construction project frequently causes a temporary reduction in bio-diversity but even on large sites flora and fauna are able to re-establish themselves on completion of work, albeit only over several breeding/growing seasons. Flora populations, unless specifically threatened, are generally more resistant to permanent derogation than fauna. Seeds caught up in stripped topsoil may remain dormant in spoil heaps until re-spread for final landscaping. Vehicle movements beyond agreed working areas, and even unplanned burning, will only knock most species back a few seasons or less. The main threats to flora and fauna during the period of construction are summarised in **Table 6.1**.

Table 6.1. Temporary Threats to Flora and Fauna During Construction

Potential Impact	Severity	Comments
Reduction in mammals and birds due to general disturbance	Low	Primarily due to increased noise, dust and human activity
Road Kills	Low-Moderate	Many species are most vulnerable at night
Reduction in mammals and birds due to poor waste disposal practices	Moderate	Pollution of habitats, poisoning of mammals and the death of birds feeding on contaminated prey
Capture and trade in species, including egg collection	Moderate	Loss of dens and nests makes species vulnerable to capture. Construction improves access to remote areas
Removal of shrubs and trees for firewood by construction crews	High	Particularly significant where tree and shrub cover is very sparse
Hunting of mammals and birds by construction crews	Moderate-High	Particularly significant for species already threatened by hunting local residents
Fishing by illegal means	Low	
Collection and trade in coral	High	

6.4. The majority of impact on biodiversity will accrue through the clearance of the Turtle Crawle treatment site. However, as discussed in Section 4 above, this area is already seriously degraded and has been of significant ecological interest for more than three decades. The majority of birds and animals are likely to re-establish themselves within the vicinity and no floral species is restricted to the site.

6.5. Of greater significance is the potential impact that construction noise and increased human activity may have on the American Crocodiles within the Mangrove Zone adjacent to the work site. They may also be a prime target for illegal hunting by construction crews. Any substantial increase in sediment discharge from Turtle Crawle River during site clearance and pond embankment construction may impact on the fish nursery spawning waters of Turtle Crawle Harbour.

6.6. Construction of the long sea outfall will result in some disturbance to the marine environment, particularly the coral that the pipeline, buried in a trench for a distance of c. 300 m from the shore and laid on the sea bed for a further 200 m, will cross. Trench excavation will disturb sediment, increase turbidity and produce sand and rock spoil to be disposed of.

Disruption to Communication Routes

6.7. The excavation of trenches and pipe installation along the A4 from Caneside River to Turtle Crawle and back to Daniel's Harbour will result in considerable and unavoidable delays to traffic flows. At the present time, and until the Contractor has agreed a detailed Programme of Work the exact timing and duration of delays and the overall impact upon the community is difficult to assess. The impact upon vehicular movement will generally be confined to increased journey time and the costs associated with delays, which in the majority of cases will only be of minor inconvenience. Effective traffic management will be key in determining the severity of impacts.

6.8. Delays will be most noticeable during morning and evening peak 'rush-hours' even though these are relatively modest in Port Antonio. Resulting delays will be most serious when they impact ambulances, fire engines, blood bank vans and other emergency vehicles. There are expected to be no significant impacts to non-vehicular traffic.

Disruption to Public Utilities

6.9. During the installation of new subsurface infrastructure it is very easy to damage existing service cables and pipelines or temporarily interrupt supplies to consumers. The levels of potential impacts arising from disruption damage to public utilities are summarised in **Table 6.2**.

6.10. Investigations during detailed design suggest there are few such services within the vicinity of PAWSDP Stage 2 works. Telecom lines, including cable television, have been installed underground but most power and telephone cables are above ground. Also underground are the water supply pipelines and existing sewage network at Anchovy that are assets of the project proponent. A small number of telegraph poles on the new pipe alignments and will need to be moved but disruption of services should otherwise be minimal.

Table 6.2. Potential Impacts of Disruption to Public Utilities

Utility	Nature of Impact	Severity
High Voltage Electricity Cables	Interruption of Supply	Severe production loss and public inconvenience
	Personal Injury	Likely death of operator
	Cost of Repair/Delay to Works	Very severe
Medium Voltage Electricity Cables	Interruption of Supply	Severe production loss and public inconvenience
	Personal Injury	Probable death of or serious injury to operator
	Cost of Repair/Delay to Works	Severe
Low Voltage Electricity Cables	Interruption of Supply	Localised but severe public inconvenience
	Personal Injury	Possible serious injury to operator
	Cost of Repair/Delay to Works	Minor production loss. Short public inconvenience
Trunk Distribution Pipelines	Interruption of Supply	Significant production loss and public inconvenience
	Personal Injury	Possible injury to operator
	Cost of Repair/Delay to Works	Severe
Local Water Networks	Interruption of Supply	Localised but significant public inconvenience
	Personal Injury	Unlikely
	Cost of Repair/Delay to Works	Minor
Primary Local Sewers	Interruption of Supply	Significant public inconvenience. Significant Risk of pollution
	Personal Injury	Possible risk to operator. Public Health risk
	Cost of Repair/Delay to Works	Significant
Street sewers and House connections	Interruption of Supply	Limited Public inconvenience
	Personal Injury	Unlikely
	Cost of Repair/Delay to Works	Minor
Telephone Cables	Interruption of Supply	Severe disruption to national and international telecommunications
	Personal Injury	Possible injury to operator
	Cost of Repair/Delay to Works	Limited
Telecom Cables	Interruption of Supply	Extreme disruption to national and international telecommunications
	Personal Injury	Unlikely
	Cost of Repair/Delay to Works	Very Severe

Disruption of Public Access

6.11. In addition to the general disruption of communications, pipe laying along the A4 will result in the temporary loss of access as work progresses past individual property entrances. This will be most serious when crossing side roads that serve several properties and in front of premises such as the Trident Hotel.

Derogation of Touristic Attraction

6.12. Construction sites are inherently unsightly but unlike in Stage 1 the PAWSDP Stage 2 works will not be within the town or at specific tourist locations. At the present time, construction is programmed to commence

within the 2006-2007 tourist season, but given work will continue for 22 months, over 2 or 3 tourist seasons, some impact, albeit probably minor in respect of the Stage 2 works, must be expected. At the very minimum tourists will share the impacts of traffic delays, noise and dust with the resident population but the most noticeable impact is likely to be temporarily obstructed access to hotels and beaches.

Soil and Water Pollution

6.13. The risk of soil pollution at PAWSDP Stage 2 construction sites is relatively minor, and generally limited to accidental spillages of hydraulic oil, fuel oil and petroleum at individual work sites and along pipeline routes. Oil spillages and the discharge of bilge wastes may also arise from dredgers working on the long sea outfall.

6.14. Of potentially greater concern is the potential for spillages of chemicals and hydrocarbon products to pollute watercourses and drainage ditches from where they will quickly reach the sea. At Grant's Level there is the potential for liquid spillages to infiltrate into the shallow alluvial aquifer, pollute the groundwater and existing wells. With no treatment except chlorination, contaminated water may quickly be pumped into supply.

Drainage, Erosion, Turbidity and Sediment Load

6.15. Some temporary dislocation of existing drainage systems is likely during pipeline construction and adverse environmental impacts may include ponding, a threat to public health and safety, and damage to adjacent property.

6.16. In the vicinity of existing watercourses and drainage ditches short-term increased rates of erosion and sedimentation may result from:

- Installation of temporary discharge points, particularly in areas of friable soils;
- Clearance of vegetation cover, particularly where undertaken during the wet season;
- Where cut and/or fill materials are prone to erosion, such as on newly laid embankments and where pipeline trenches cross drainage channels; and,
- Loose and unconsolidated aggregate, fill and spoil heaps stored pending re-use.

Noise and Dust

6.17. Certain levels of noise and dust pollution are unavoidable in the vicinity of construction sites and some elevation of background levels is normally acceptable for limited periods. Excessive noise, particularly when experienced continuously, outside normal working hours and on rest days, can be a nuisance to both workers and the public. In extreme cases it may become a health hazard. Typical noise emissions for plant and equipment likely to be deployed in the PAWSDP Stage 2 construction are listed in **Table 6.3** together with typical international standards and the NEPA noise limit.

6.18. Night operations will therefore exceed these standards and day operations will be uniformly excessive up to a distance of 20 m. Only the noisiest operations such as piling and the use of pneumatic hammers are likely to produce excessive noise at 50 m in excess of the NEPA standards. With the exception of the noisiest machinery, ambient daytime noise from traffic in much of Port Antonio is likely to drown out most other construction noise.

Table 6.3. Noise Emission Levels for Construction Plant

Type of Plant	Distance between Plant and Observer			Typical International Standard		NEPA Standard
	5 m	20 m	50 m	Day	Night	
Loader	90	78	70	75	55	70
Grader	90	78	70	75	55	70
Vibration Roller	86	74	66	75	55	70
Bulldozer	86	74	66	75	55	70
Generator	98	86	78	75	55	70
Impact Drill	87	75	67	75	55	70
Impact Piling	112	100	92	85	No Piling	70
Concrete Mixer	91	79	71	70	55	70
Concrete Pump	85	70	62	70	55	70
Pneumatic Hammer	84	86	78	75	55	70

Figures in dB(A)

6.19. Although the frequent rain showers experienced in Port Antonio will suppress dust from excavation and on roads it may be a general nuisance for short periods within a broad corridor adjacent to the road, which may include gardens and areas used for drying household laundry.

Demolition

6.20. The existing houses and other structures on the sewage treatment plant site at Turtle Crawle will be demolished but being mostly constructed of wood their clearance should not produce excessive noise or dust. The existing structures are considered unlikely to contain asbestos or other hazardous materials.

Use of Explosives

6.21. Very limited use of explosives may be needed along the route of the long sea outfall but this will only be permitted where the Contractor has shown other methods of excavation to be impractical. Explosives will often result in over-cut beyond the area required, the death of fish, marine invertebrates and coral.

Disposal of Surplus Materials

6.22. Wherever the material excavated from pipeline trenches and pumping station foundations is suitable, it will be reused, as general backfill, for example, around inspection chambers, and at the sewage treatment works where there will be a need for general fill material since levels have to be built up and unsuitable material excavated. It is not expected that any surplus soil material will be sent to municipal landfill.

Danger to Navigation and Safety at Sea

6.23. Dredging operations for the construction of the long sea outfall will require a barge to be positioned along the route of the pipeline for much of the period of its construction and hence present a potential hazard to other shipping, yachting and water sports.

Employment

6.24. Primarily a positive impact, the project will create significant temporary employment for construction workers, equipment maintenance and support staff. While a small number of senior project managers may come from overseas and other specialists from elsewhere is Jamaica, the majority of project staff are expected to be recruited locally from within the Port Antonio workforce. The number of temporary jobs created during both Stage 1 and Stage 2 of the PAWSDP is likely to be 100-150.

Public Safety

6.25. Given the limited scale of construction for the PAWSDP Stage 2 the risk to public safety, in both physical extent and the types of risk posed, will be restricted. The most serious threats will be in the vicinity of pipeline trench and inspection chamber excavations along public roads where they will be easily accessed. Other areas of public danger will include:

- Where heavy plant and equipment moves in and out of the Contractor's camp;
- Pumping station and treatment plant excavations, particularly before they are stabilised;
- Construction materials and fuel storage areas.

6.26. There will also be an increased risk of traffic accidents where delays and diversions are imposed or altered without adequate warning.

Workers' Safety

6.27. All construction sites are inherently unsafe and for those employed on the project the risks are varied and omnipresent. They are however well understood and documented, and providing normal, accepted Health and Safety procedures are followed are easily minimised.

Construction Camps

6.28. All major construction projects require a large area for site offices, the storage of construction materials and depending on the contractor's preference, facilities for the concrete and tarmac manufacture, concrete pre-casting and workers accommodation.6.30. For the PAWSDP, an area adjacent to the A4 at Bryan's Bay, immediately west of Port Antonio town, has been identified but not fully delimited by the Portland Parish Council as the preferred location for the site offices and contractors facilities. The facilities to be provided will need to include 5-6-prefabricated offices and parking areas for the administration and technical staff of the Contractor, specialist sub-contractors, the Supervising Engineer and NWC. These will also include areas for materials testing and storage, and equipment cleaning and maintenance. The contractors will be asked to maximise the employment of people from the project affected area and the need for residential accommodation is likely to be minimal. A small satellite camp, to provide security, equipment and materials storage and limited worker's accommodation may be established at the Turtle Crawle treatment site.

6.29. The storage of materials will primarily comprise pipes and fittings. Pipe bedding material, aggregate, marl for treatment plant pond embankments and other quarried materials are readily available within Portland and are expected to be procured on-demand with only limited volumes held in the Contractor's storage areas. There should therefore be no requirement for rock crushing and grading within the Contractor's camp. Similarly, any pre-cast concrete items, such as inspection chambers, are expected to be manufactured at a site already licensed for such activities. It is understood there are no asphalt plants in the Parish of Portland but since the need to tarmac in road reinstatement is limited it is expected this will also be brought in as and when required rather than produced by the Contractor locally.

Access and Construction Traffic

6.30. Ease of access to and from the site will be a fundamental requirement and proximity to the A4 is a pre-requisite. All points of contact between construction and existing traffic will potentially give rise to accident black spots due to the number of turning movements by construction traffic, its relatively low speed, increased damage to the road surface and the deposition of mud, chippings, oil and other foreign matter.

Consumption of Water

6.31. A significant adverse impact of construction camps is the consumption of water and even a small project can require 100 m^3/day of water. It is expected that most fill material will be compacted dry and the pressure testing of pipelines will be carried out with compressed air. For the testing of water retaining structures such as pumping stations, water will be used but limited to a single filling of the structure.

Pollution

6.32. Construction camps are major sources of a variety of polluting materials, including:

- Sewage from offices, accommodation blocks and canteens;
- Wastewater containing high suspended solids;
- Oil residues and industrial fluids from the washing of plant and vehicles;
- Spilt fuel oil around fuel storage tanks;
- Waste oil, grease and de-greasing solvents from vehicle and plant servicing; and
- Solid waste, including paper, discarded packaging and crates, redundant plant, used tyres, and broken or failed concrete products

6.33. The major threat of pollution will be to surface and ground waters from the effluent produced by cleaning vehicles and plant with industrial detergents and solvents. There will also be some risk from the accidental spillage of, and/or leakage from industrial materials stored on site, primarily fuel, other hydrocarbon products and construction chemicals such as concrete accelerators and hardeners.

6.34. Notwithstanding such a range of risks, all are relatively easily mitigated through effective management. The most substantial source of pollution from construction camps is therefore likely to be dust, noise and sediment load in surface watercourses.

Other Sites

6.35. Other Off-Site areas include those from where aggregate and other construction materials are supplied by third parties and waste disposal sites. Materials from locations outside the direct control of the Contractor should only be sought from companies already registered and licensed to undertake the requisite activities, and who are able to satisfy the requirements imposed on such sites in the Environmental Management Plan. Only waste that cannot be directly re-used, sold or passed on for recycling should be discarded, and then only via a licensed waste management facility.

6.36. A potentially significant threat in respect of quarries will be the risk of accidents due to:

- Increased heavy traffic on certain sections of the A4 and some local roads;
- The increase in HGV turning movements and the implications for the free flow of existing traffic; and
- Foreign matter such as mud and loose chippings being deposited on roads.

Resource Consumption

6.37. Significant quantities granular material will be used in the project for pipe bedding, general trench backfill, road reinstatement, treatment site re-levelling, treatment pond construction, river entrainment and as the primary constituent of concrete. It is expected this material will be supplied from quarries from within 25-30 km of project sites and that no Borrow Areas will be required.

6.38. As highlighted above, the consumption of water for construction is unlikely to be significant. The testing of the new wells at Grant's Level will consume ground water resources but since these originate from the adjacent Rio Grande River to where any excess test discharge not taken into supply will be returned, there will be no overall consumption or impact on river flow.

6.39. Obtaining granular materials and water, and disposing of any excess spoil and other waste materials will necessitate haulage, and hence the consumption of fuel.

Summary of Potential PAWSDP Stage 2 Temporary Impacts

6.40. A summary of the potential risks from temporary environmental impacts during PAWSDP Stage 2 construction is given in **Table 6.4**. The proposed mitigation of the potential impacts identified above is discussed in Section 11 of the present report.

Table 6.4. Summary of Potential PAWSDP Stage 2 Temporary Impacts

Issue	Potential Temporary Impact	Risk
Landscape	Destruction of natural vegetation	Minor
	Visual impairment	Minor
Ecology and Bio-Diversity	Destruction of habitats	Moderate
	General disturbance of resident species	Moderate
	Disturbance of American Crocodiles	Major
	Hunting, trapping and egg collecting	Moderate
Existing Communities	Disruption to communications routes	Major
	Disruption of public access	moderate
Public Utilities	Interruption of supply, danger and cost	Variable. See Table 6.2.
Tourism	Imposition of unattractive activities	Moderate
Soil and Water Pollution	Pollution due to temporary activities	Moderate
	Pollution at the construction camp	Major
	Discharges at sea	Moderate
Drainage, Erosion and Sediment Load	Disruption of existing drainage networks	Minor
	Erosion from site clearance during the wet season	Moderate
	Erosion from embankments during construction	Minor
	Erosion from spoil heaps, stock piles and other loose materials	Minor
	Increased sediment loading in watercourses	Moderate
Noise and Air	Noise pollution from construction machinery	Major
	Air pollution from construction machinery	Major
	Mud on public roads	Major
Demolition	Public and Worker's safety	Minor
Use of Explosives	Public and Worker's safety	Minor
Surplus Spoil	Excess fill from pipeline trenches and site clearance and treatment pond excavation	Minor
Navigation	Danger to shipping from marine works vessels	Minor
Employment	Temporary local job opportunities for construction workers	Moderate and Positive
Public Safety	General construction activity	Major
	Traffic at construction camps	Major
	Pumping station excavations	Moderate
	Heavy equipment movement and operation in public areas	Major
	Changes in existing traffic circulation	Moderate
Worker's Safety	Accidents common on construction sites	Moderate
Other Sites	Increased HGV turning movements at sites	Moderate
	Increased HGV movements on certain sections of the A4	Minor
	Mud and chippings on roads	Minor
Resource Consumption	Water use at construction camps	Moderate
	Use of aggregate resources	Minor
	Water use for construction	Minor
	Haulage	Moderate

5. ENVIRONMENTAL BASELINE CONDITIONS: SOCIO-ECONOMIC ISSUES

5.1. This section outlines the socio-economic conditions under which the project will be implemented, including the role of women and the importance of young people, using data from publications of the Statistical Institute of Jamaica (STATIN) relating to the 2001 Census and more recent information from the STATIN web site. Also discussed are issues relating to the main project affected communities.

Population

5.2. The last national census was last held on 10th September 2001 when the population of Jamaica was 2,607,632, of which 1,283,547 (49.2%) were male and 1,324,085 (50.8%) female. The previous census in 1991 recorded a population of 2,380,667, a growth rate of 8.7% over the intervening decade. By 2005 the total populations was estimated to have reached 2,731,832[1].

5.3. The corresponding 2001 totals for the Parish of Portland were as follows:

- 2001 Total: 80,174, 3.1% of the national total, of which
- Males: 39,951 (49.8%)
- Females: 40,223 (50.2%)
- 1991 Total: 76,317
- 1991-2001 Growth Rate: 4.8%

5.4. 23.4% of Portland's 2001 population were urban and 76.6% rural. The corresponding figures in 1991 were 20.8% and 79.2%, indicating modest migration from the countryside to the towns, of which the largest is Port Antonio with a 2001 population of 14,541, up from 13,795 in 1991.

Population Structure

5.5. The age structure of the Port Antonio population is shown in **Table 5.1**. 32% is under 15 years of age, 59.9% 16-64 and 8.1% older than 65. The national situation is similar and Jamaica has one of the most rapidly ageing populations in the developing world. Between 1970 and 2001 the proportion of 0-14 year olds fell from 44.8% to 33% while those 15-64 rose from 49.8% to 57.7% and 65+ from 5.4% to 9.3%. The reasons include increased life expectancy, declining fertility and continued high levels of external migration, 23,200 in 2002. Internal migration also affects a significant loss to Portland as shown in **Table 5.2**.

[1] *World Fact Book*. US Central Intelligence Agency, November 2005.

Table 5.1. The Age Structure of the Port Antonio Population

	0-4	5-14	15-24	25-64	65+	Total
Total	1,461	3,199	2,542	6,183	1,184	14,569
%	**10.0**	**22.0**	**17.4**	**42.5**	**8.1**	**100**
Male	725	1,660	1,223	2,859	515	6,982
%	49.6	51.9	48.1	46.2	43.5	Mean 48.0
Female	736	1,539	1,319	3,324	669	7,587
%	50.4	48.1	51.9	53.8	56.5	Mean 52.0
	Pre-School	**School**	**Tertiary Studies or Working**	**Working**	**Retired**	

Table 5.2. Internal Migration in the Parish of Portland

Period	Total Migration	Males	Females
1970 - 1982	6,112	2,365 (38.7%)	3,747 (61.3%)
1982 - 1991	3,535	1,090 (30.8%)	2,445 (69.2%)

Household Structure

5.6. The 2001 census showed the average household size to be 3.4 persons in urban communities and 3.7 persons in rural communities. This is a significant reduction in the overall household size of 3.9 persons recorded in 1991. For Port Antonio the average household size was even smaller at 3.0.

5.7. Households in the poorest consumption quintile (41.1%) averaged 5.2 persons while those in the wealthiest quintile averaged only 2.3. The average number of children in households varied from 2.4 in the poorest down to 0.4 in the wealthiest. The head of 44.7% of all households was female.

5.8. Large households with more than 8 members were just 4.1% in 2001, substantially lower than the 15.6% recorded in 1975. Single member households comprised 27.5% of urban areas outside the Kingston Metropolitan Area (KMA) and 21.6% in rural areas.

Housing

5.9. The majority of the population live in detached houses although shared houses and apartments are more common in the KMA, as shown in **Table 5.3**. The majority of houses, 63.3%, are constructed from blockwork or steel although a significant proportion, 23.8%, are made from wood. Those in the

poorest consumption quintile occupy 39.5% of all wooded houses whereas the wealthiest occupy only 15.2%.

Table 5.3. Types of Housing

	KMA	Other Towns	Rural Areas
Detached	52.0	78.9	88.7
Semi-Detached	6.7	2.1	0.7
Part of House	34.1	17.3	8.0
Apartment/Town House	6.0	1.2	0.7

Excluding institutional housing

5.10. The standard indication of housing stock is The Housing Quality Index (HQI), calculated from parameters such as type of premises, construction materials, the availability of electric light and indoor water taps, and the exclusive use of flush toilets and kitchens. The HQI for Jamaica in 2001 was 69.8, unchanged from 2000 and significantly better than the 61.3 recorded in 1991. There is little difference between the HQI for KMA (73.1) and other towns (72.1), but the Index is significantly lower for rural areas (65.7).

5.11. Just over half (57.3%) of all households own the property they live in, while 18.3% live rent-free and 22.9% pay rent. 1.3% of households are regarded as squatters. The total number of dwellings in Port Antonio in 2001 was 4,331.

Public Utilities

5.12. Public utilities include services such as water supply, sewerage and electric power. 70.9% of households have access to public piped water supply, 13.1% to a public standpipe, while 3.1% use river and/or spring sources, 11.6% depend on rainwater harvesting, and 1.3% have private wells. Overall accessibility to 'safe' water is 84%. The proportion of houses with indoor water taps is 71.6% in the KMA, 60.2% in other towns and only 22.8% in rural areas. The sources of water for households in Port Antonio are shown in **Table 5.4**.

Table 5.4. Sources of Household Water in Port Antonio

Public Source				Private Source		Spring/ River	Other	Not Reported
Piped into Dwelling	Piped into yard	Standpipe	Catchment	Piped into Dwelling	Catchment			
59.35%	18.88%	9.58%	0.65%	0.65%	2.14%	3.67%	3.90 %	1.19%

5.13. Nationally, 61.8% of households have access to a flush toilet while 36.5% rely on pit latrines. However, only 18.3% of those with a flush toilet are connected to a centralised sewage collection and disposal system. The availability of toilet facilities in Port Antonio is shown in **Table 5.5**.

5.14. Jamaica generated 3,302 GWh of electricity in 2001, 3,525 GWh in 2002, but its availability remains elusive for many households. 94.2% of KMA homes had electric light, 88.1% in other towns and 79.5% in rural areas. 11.3% of all households continue to rely on kerosene and 1.3% had no source of lighting. Outages due to power plant and distribution network failures are common.

Table 5.5. Household Toilet Facilities in Port Antonio

SHARED			NOT SHARED			No Facility	Availability and Type not reported
Water Closet	Pit	Not reported	Water Closet	Pit	Not reported		
9.97%	12.94%	0.18%	51.68%	20.82%	0.22%	2.00%	2.18%

Community Services

5.15. Port Antonio is the commercial and administrative centre for other settlements within about 50 km and affords an appropriate range of community services which include:

- Primary, secondary and post-secondary schools;
- The East Campus of the College of Agriculture, Science and Education;
- A 150-bed public hospital, heath clinic and dental clinic;
- National health service regional administration offices and public health laboratories;
- Regional offices of the Ministry of Education, NWC, NEPA and the National Works Agency;
- PPC offices, an infirmary, market and market administration, and a poor relief office;
- Divisional police headquarters, court with resident magistrates and a Bailiff's office;
- A fire station and post office;
- Government department offices including Inland Revenue, Customs and Excise, Motor Vehicle Examination and Social Security; and,
- Places of worship for several different confessions.

5.16. Access to Port Antonio and communications with other communities are at best difficult. The roads to Ocho Rios and Kingston are narrow, winding and generally in poor condition with frequent pot holes, although a new section of the North Coast Highway is under construction. Bus and route taxi services are available but inevitably slow. Both fixed line telephone and cellular network services are widely available.

5.17. The rail connection to Kingston and other towns was badly damaged by a hurricane in 1980 and never repaired. Although international air passengers have always had to transit via Kingston or Montego Bay, the Ken Jones Airstrip near St. Margaret's Bay used to receive internal and occasional chartered flights but has now closed due to the lack of capacity. Although cruise ships increasingly call at Port Antonio there are no regular ferry services to or from the town.

Education

5.18. Taking 15-16 year olds as the most indicative group, 95% of those within the wealthiest quintile but only 67.6% in the poorest were enrolled in education in 2001. For those potentially involved in full-

time education, 3-24 years of age, 73.7 % are enrolled, 92% in public schools and colleges and 8% in private institutions. The rates of enrolment by age for the upper and lower quintiles of the population are given in **Table 5.6**.

Table 5.6. Rates of Enrolment in Education in Jamaica

Age Group	Poorest Quintile		Wealthiest Quintile	
	1992	2001	1992	2001
3-5	63	87.6	81	100
6-11	97	99.5	99	100
12-14	93	96.4	98	100
15-16	65	67.6	92	94.6
17-19	11	21.7	40	71.9
20-24	1	2.2	5	15.0

5.19. Across all household members of not enrolled in education in 2001, 3.5% held a degree, 15.4% had passed CXC and/or A level exams, and 74.3% had no formal qualification. 86% of those in the poorest consumption quintile fell into the latter group but 52.3% of those in the wealthiest quintile also had no qualification. The present literacy rate in Jamaica is 79.9% and has remained at this level for the past 5 years.

Employment

5.20. In April 2001 the Jamaican labour force was 1.106 million with 63% of the population 14 and over participating. Males are better represented than females, with 73% of 14+ males against 53.6% of 14+ females. By 2002 male participation had fallen to 72.6% while that of females had risen to 55.4%. 89.7% of the males and 79.5% of the females were employed when overall employment at 84.5% was somewhat less than elsewhere in the Caribbean (Barbados 87.7%, Suriname 89.4%, Bahamas 92.2%).

5.21. The spread of the labour force between the different occupational groups is shown in **Table 5.7** for April 2001. Females strongly dominate within the '*clerks, service workers …'* group and just dominate the '*professionals, …'* and '*elementary occupations*' groups. In those occupational groups where men outnumber women, they do so very strongly. Males tend to leave education earlier and the 2001 graduate classes from the University of West Indies and the University of Technology were respectively 71.1% and 59.5% female. In the parish of Portland the 2001 labour force was 25,200 of which 61.5% were male and 38.5% female.

Table 5.7. Division of the Labour Force across Occupational Groups

Occupational Group	Proportion of Labour Force			Proportion of Group
	Total	Male	Female	Female
Professionals, senior officers and technicians	16.1%	12.3%	21.6%	55.7%
Clerks, service workers, shop and market sales workers	25.6%	14.4%	41.7%	68.6%
Skilled agricultural and fisheries workers	18.9%	26.0%	7.9%	17.7%
Crafts and related trades workers	16.3%	24.0%	5.3%	13.7%

Plant and machine operators and assemblers	6.3%	9.4%	1.9%	20.4%
Elementary occupations	17.1%	13.9%	21.6%	52.8%

5.22. The unemployment rate in Jamaica in 2001 was 15%, down from 15.5% in 2000. The male rate was 10.3% while the female rate was 21%. By 2004 this had dropped to 11.7% nationally, 7.9% among males and 16.4% among females. Unemployment among young people is most serious, as illustrated by the April 2001 figures shown in **Table 5.8**. Of those outside the labour force, 74.6% had no qualification, a fate shared almost equally between the sexes (male 74.1%, female 74.9%).

Table 5.8. Unemployment among Young People

Age Group	Total	Male	Female
14 -19	47.4%	36.6%	64.5%
20 - 24	28.1%	21.4%	36.8%
25 - 34	13.9%	8.0%	20.6%

Economic Activity

5.23. Jamaica enjoys a relatively stable economy with 2001 GDP at 2001 prices J$ 334.7 billion. Production was 39.4% of GDP while services, including tourism, were 84.2%. Total exports were 17% of GDP and total imports 41%. After several years of single digit inflation, 7% in 2001, this has recently increased and is estimated to have been 12.4% in 2004. Public debt was 146.1% of GDP in 2004.

5.24. Traditional exports such as bauxite, alumina, sugar and bananas were worth US$ 897 million in 2001 when Bauxite exports rose 120% from a historic low in 2000. Sugar and banana exports fell 14.7% and 8% respectively. Non-traditional exports, such as clothing, has fallen significantly in recent years, from US$ 149.1 million (2000) to US$ 88.5 million (2001) US$ 15.9 million (2002).

5.25. Tourism contributed 85% of the Services proportion of GNP. In 2001 Jamaica hosted 2.12 million tourists, most, 1.12 million, 'long-term' while some 840,000 were short-term cruise passengers. By 2004 total visitors had reached 2.5 million and cruise ship passengers had exceeded 1 million. Hotel occupancy rates have averaged more than 56% for several years and tourism foreign exchange earning in 2001 were US$1.24 million, slightly down from 2000 (US$ 1.33 million) due to global security fears and Jamaica's reputation for high crime. Hotel occupancy on Port Antonio is the lowest of all the large coastal towns, 17.3% in 2000, down from a high of 25.4% in 1998.

5.26. Agriculture accounted for 6.6% of GDP in 2001 but fell to 5.5% in 2004. The main activities are the growing of sugar cane, bananas, coffee, citrus, yams and vegetables, the rearing of poultry and goats, and aquaculture. Arable land only accounts for 16% of all land and permanent crops occupy another 10%. Irrigated land only accounts for 250 km^2, 2.3% of the total island's 10,991 km^2 area. In recent years the Agricultural Production Index for both domestic and export arable crops have fallen while that for poultry, livestock and fishing has increased. Fisheries took over 5,000 tonnes of

marine fish and over 2,000 tonnes of shellfish, (excluding aquiculture) and employing some 23,500 persons (including aquiculture) in 2000.

5.27. Agriculture in the Parish of Portland is best developed along the valley of the Rio Grande River and its tributaries, and this area receives substantial input from the EU-funded Banana Support Programme as well as CDB-funded support for the sugar industry.

Consumption and Poverty Reduction

5.28. Mean annual per capita consumption of commodities in 2001 was J$ 82,248, ranging from J$ 116,176 in the KMA, 141% of the mean, to J$ 85,687 in other towns and J$ 59,138 in rural areas, 72% of the mean. The apportionment of consumption across the commodity groups is shown in **Table 5.9**.

Table 5.9. Per Capita Consumption across the Main Commodity Groups

Commodity Group	KMA	Other Towns	Rural Areas
Food and Beverages	37.8	45	50
Fuel & Household Expenses	3.4	4.7	6
Housing and Household Expenses	22.2	21.4	11.3
Personal Care	2.4	2.5	2.8
Health Care	2.9	3.4	3.8
Clothing and Footwear	6.5	6.7	7.2
Transportation	14.6	7.5	10.4
Education	6.1	5.1	4.9
Recreation	1.7	0.7	0.7
Miscellaneous Consumption	1.5	1.5	1.6

5.29. The poorest 10% of the population enjoy only 2.7% of consumption while the wealthiest 10% enjoy 30.3%. Even though GoJ efforts at poverty reduction are proving successful, an estimated 19.7% of the population, 10.9% of households, remained below the Poverty Line in 2002, with the prevailing incidence of poverty 7.6% of the population in the KMA, 13.3% in other towns and 24.1% in rural areas.

5.30. Despite a 17% rise in consumption between 2000 and 2001 the additional poverty reduction was only 1%, reflecting (i) the depth of prevailing poverty, and (ii) the increase in consumption being primarily taken by the higher consumption groups. The percentage of the population living on less than US$ 2/day is estimated[2] at 13.3% and those on less than US$ 1/day, 2%.

5.31. GoJ has a number of social welfare programmes, the most ambitious and far-reaching being the Social Safety Net (SSN) Reform Programme. The centrepiece of this is PATH, under which three

[2] Jamaica's Human Development Report. United Nations, 2002

earlier programmes, Poor Relief, Food Stamp and Public Assistance, have been merged. The scheme targets some 236.000 poor recipients; children 0-17 years (71% of target), those 60+, the disabled, pregnant and lactating women, and a limited number of 'special case' other adults.

Health and Welfare

5.32. The health of the Jamaican population is fairly stable. Rural areas show a higher prevalence of illness and injury than the KMA or other towns but there is no correlation between illness and consumption group. In 2001 63.5% of the population sought healthcare services of which 38.7% exclusively used public facilities and 54.8% the private sector. Mean life expectancy is 73.3 years, shorter for males (71.5 years) than females (75.1 years).

5.33. Overall fertility has fallen significantly from 5.5 children/women in 1970 to 3.0 in 1993 and 1.95 in 2001. The crude birth rate was 21/1000 population and infant mortality 24.5/1000 live births. A surprising large proportion of babies are born out of wedlock; 83% nationally in 2001 and 84% in Portland. The average age at which mothers first give birth is 20.4 years and maternal mortality is 1.1/1000 population.

5.34. For common diseases such as polio, diphtheria, BCG and measles, immunisation of those 6-59 months is 93-96% with no difference between parishes, sexes or consumption groups. The WHO 'z-scores' for infant nutrition indicate only 6.4% of those 0-59 months are of low weight for their age, 5.9% are low height for their age (stunted), while just 2.8% are low weight for their height (wasted). Again these figures do not vary with parish, sex or consumption group.

5.35. In 2001 there were 15,511 recorded deaths, of which 431, 2.8% were in the Parish of Portland. The seven most common causes of death in 2000 are shown in **Table 5.10**.

Table 5.10. Most Common Causes of Death in Jamaica

Cause	Of All Deaths	Of Male Deaths	Of Female Deaths
Cerebrovascular Diseases	12.62%	10.56%	14.95%
Diabetes Mellitus	10.11%	6.82%	13.84%
Ischaemic Heart Diseases	5.94%	5.11%	6.89%
Other Heart Diseases	5.77%	4.79%	6.88%
Hypertensive Diseases	5.67%	5.29%	6.09%
Malignant Neoplasm of the Prostrate	3.32%	6.25%	n/a
HIV/AIDS	3.00%	3.48%	2.45%
Pneumonia	2.50%	2.49%	2.52%

The Role of Women

5.36. The right of women to work and participate in the development process without hindrance or discrimination is enshrined in Jamaican Law and there are no sectors of employment from which

females are barred by law. They comprise 51% of the population and head nearly 45% of all households. Nationally, 54% of 14+ women participate in the labour force (38.5% in Portland).

5.37. Although women enjoy better educational attainment this does not manifest itself in practice. In 2001, 21% of females were unemployed compared to 10% of men. Within the 14-19 age group 64.5% of females were unemployed but even among those who may have taken education to higher levels, 25-34 year olds, female unemployment was still 20.6% as opposed to 8% for males. The average income of females in 2001 was US$ 2,696, 60% of that of males (US$ 4,492). Nevertheless, it is estimated that women, including those only working in the home, are primarily responsible for awareness and education, and frequently control 70% or more of total family resources.

5.38. It has long been recognised that the availability of clean water for drinking, food preparation and sanitary facilities for the disposal of human waste is a major element in the protection of public health. Equally recognised secondary benefits include improved family relationships and better educational attainment. Unsanitary living conditions put a strain on marital relationships and a child who arrives at school clean and having eaten hygienically prepared food will be in a better frame of mind to learn. Women are more commonly the prime mover in maintaining the home, providing food and child rearing, whether or not they are also employed. It is therefore inevitably that women and children are the major beneficiaries of projects to improve public infrastructure such as the PAWSDP.

The Importance of Young People

5.39. The Youth of Jamaica, those under 29 years of age[3], comprise 64% of the island's population (62% in the Parish of Portland) and with an average of 145 live births each day but only 47 deaths this proportion will continue to grow for the foreseeable future.

5.40. Today most young Jamaicans have unprecedented access to basic healthcare, education, and other services and have a positive view of their future[4]. Education and training is the most important factor in determining future qualifications, attitudes, and capabilities, and the well being of Jamaican society. Positive values and productive skills quickly translate into increase productivity and competitiveness.

5.41. Securing satisfactory employment at reasonable rates of remuneration is the prime concern of young people in the increasingly competitive job market. They have a strong desire to participate in decision-making and to end what many perceive to be their marginal role in society. The challenge is to formulate policies and practices that offer the freedom young people need to develop to their full potential as productive citizens.

[3] As defined by the United Nations Development Programme
[4] *National Youth Policy*. National Centre for Youth Development, 2003.

5.42. The improved living conditions resulting from the PAWSDP, both in individual homes and in the community, will make it easier for young people to keep themselves healthy, encourage them to take greater advantage of education opportunities, and develop better relationships inside and beyond their immediate family. With modern infrastructure the presently depressed economic conditions in Port Antonio will improve. Consequential employment opportunities will be created and young people may be less tempted to migrate to other parts of the island.

Project Affected Persons

5.43. The majority of the population of Port Antonio will not be adversely affected by the PAWSDP except for some unavoidable minor nuisance during the period of construction. More seriously affected groups, Project Affected Persons (PAPs), will be those living on or adjacent to the proposed sewage treatment works and pumping station at Turtle Crawle, amongst whom three separate populations have been identified:

- **Group 1:** Those resident on or otherwise having use of land that will be acquired for construction, who will loose their home and/or land from which their derive income;
- **Group 2:** Those located outside the immediate area of construction but who may be impacted during construction and subsequently suffer visual impairment, loss of landscape, noise and/or odour; and,
- **Group 3:** Those more distant from the site of construction who may only be adversely impacted during the period of construction.

PAP Group 1

5.44. In order to define the expected impacts a basic socio-economic survey was undertaken among PAP Group 1 to locate and identify households and collect preliminary information on permanent asset loss. The Questionnaire used is presented in **Appendix B** and a summary of those affected given in **Table 5.11**.

Table 5.11. Composition of PAP Group 1 at the Proposed Treatment Plant Site

Household	Adults		Children			Years Occupancy
	24-64	65+	0-4	5-14	15-24	
A	1					5
B	2			1		4
C	1		1	4	3	1
D	1					1.5
E	1					Under Construction
F	1		3	5	2	3
G	2			1	1	2
H	1	1				1
I	1			1		1
J	2					3
K	1					3
L	2					10
M	2		1	1	1	5 years
N	2					2 years

O	1					6 years
Totals	21	1	5	13	7	

5.45. The land to be acquired for the treatment plant is currently owned by three persons not resident in the area. Those most seriously affected are therefore the 15 households, comprising 22 adults and 26 children, who will be involuntarily resettled. Most houses are of single storey wood construction below a galvanised steel sheet roof, generally comprising 2-3 rooms and with an average floor area of 43 m^2. The standards of accommodation provided are low; 7 households have no place for washing, 4 have no kitchen for the hygienic preparation of food, and 5 have no WC or latrine. Water is fairly readily available, albeit not piped into the house, with 9 households supplied by NWC, 5 from local springs and 1 using rainwater harvesting.

5.46. All but one household admit to be squatting with no legal entitlement to occupancy. Six households moved to the area after personal crises, such as unemployment, marital breakdown, previous house destroyed or abandoned due to poverty. A further 6 settled because of the availability of land. Household J claims to have purchased their house but from someone other than the registered owner of the land. Household O claims to have been given the land they occupy by the registered owner.

5.47. Two households report they do not use the land surrounding their house. All others claim exclusive use of an area between 1,000-5,500 m^2 for the growing of a variety of vegetable, fruit and tree crops, primarily for their own use.

5.48. The occupations and reported income of all adults not registered as students within the 15 households are listed on **Table 5.12**. The majority of affected households report an income somewhat above the National Minimum Wage of approximately J$ 140,000/year[5]. Only two of the 15 households have access to a vehicle. Since almost all children attend school full time, taxi fares for their transport is a significant element of household expenditure.

5.49. Considering the disadvantageous housing conditions within the PAP Group 1 community, recurrent illnesses do not appear to be unduly onerous. None reported having suffered from some of the more serous water-borne illnesses resulting from poor sanitation. Those illnesses reported during the survey are listed in **Table 5.13**. Clearly, Household C should be worthy of some special consideration.

PAP Group 2

5.50. This group includes households located along the main road between the treatment plant site and Turtle Crawle Harbour and those on the hillside to the right of the access track to the plant site. Details of the potentially affected households are shown in **Table 5.14**.

[5] The National Minimum Wage was most recently set by Parliament in January 2006 at JS 2,800 for a 40 hour week, equivalent to J$ 140,000/year over 50 weeks of the year.

5.51. There is one sensitive site. The School of Hope for the deaf, with 8 resident and 8 non-resident staff and 40 pupils, is located on the opposite side of the river from the treatment plant and is some 800 m from any construction activity and subsequent plant operation.

Table 5.12. Occupations and Reported Incomes for PAP Group 1 Households

Household	Sex	Occupation	Annual Income	Income Support
A	M	Farmer	J$ 150,000	No
B	M	Farmer	JS 100,000	No
	F	Sales and Bartender	J$ 300,000	
C	F	Hairdresser	J$ 150,000	Car Sharing Programme
	F	Unemployed		
D	M	Farmer	J$ 80,000	No
E	F	(No Response)		No
F	F	Unemployed		PATH Programme
	F	Gas Station Attendant	J$ 180,000	
	F	Bartender	J$ 130,000	
G	F	Unemployed		No
	M	Construction Worker	J$ 150,000	
H	F	Household Helper	JS 150,000	No
	F	Retired		
I	F	Higgler	JS 360,000	No
J	M	Construction Worker	J$ 500,000	No
	F	Secretary	J$ 360,000	
K	M	Construction Worker	J$ 450,000	No
L	M	Farmer	J$ 200,000	No
	F	Seamstress	J$ 250,000	
M	M	Farmer/Fisherman	J$ 360,000	No
	F	Supermarket Supervisor	JS 150,000	
N	M	Mechanic	J$ 150,000	No
	F	Farmer/Higgler	J$ 130,000	
O	M	Mechanic	J$ 150,000	No

In each household the first person listed in the Head of Household
A 'Higgler' is a general trader who buys and sells available commodities for profit.

Table 5.13. Recurrent Illnesses Reported by PAP Group 1 Households.

Household	Sex/Age of Affected Persons	Nature of Illness
A	Male, 53	Back Pain
C	Female,19	Timeka
	Male, 17	Eczema
	Male, 13	Sickle Cell Anaemia
	Male, 4	Asthma
F	Female, 8	Asthma
G	Male, 14	Asthma
H	Female, 85	Asthma
N	Male,60	Migraine

5.52. Elsewhere 20 houses, 1 house/farm, 1 house/shop, 6 shops, a bar/club and a commercially used container have been identified. The total population of these is reported to be 39 adults and 29 children, with 12 non-resident employees partaking in the commercial activities. Of the 26 residential premises, not including the school, children are present in 13. Only 5 of these properties are 100-200 m from the proposed treatment plant, a further 5 are 200-500 m distant while the other 17 are 500 m or more from the site.

Table 5.14. Summary of PAP Group 2 the Proposed Treatment Plant Site

Household	Property	Adults	Children	Employees	Commercial Activity	Distance from STP
1	House	1				100 m
2	House	2	4			200 m
3	House	2				200 m
4	House	1				100 m
5	House	1				200 m
6	House	2	6			400 m
7	House	1	3			300 m
8	House	1				300 m
9	House/Farm	2			Farming	300 m
10	House	2				300 m
11	House	3	1			500 m
12	House	2	1			500 m
13	House	2	1			500 m
14	House	2	1			500 m
15	House	5	3			500 m
16	House	1	1			500 m
17	House	1				500 m
18	House	1	4			600 m
19	House	2	1			600 m
20	Container	1		1	Block Making	500 m
21	House	1	3			600 m
22	Shop	1			Grocery	700 m
23	Shop			7	Hardware	700 m
24	Bar/Club			2	Bar/Club	800 m
25	House/Shop	1	1	1	Vegetables	700 m
26	House	1		1	Wicker Furniture	700 m
27	School	8	40	8	School	800 m

PAP Group 3

5.53. This group of PAPs are those located at least 100 m further up the valley from the southern limit of the proposed treatment plant. They may be inconvenienced by impaired access while the existing unsurfaced track is upgraded but are otherwise expected to suffer little visual impact, noise and dust during construction and no operational impacts. Within the scope of the present survey individuals have not been identified, but some 12 households comprising about 48 persons are expected to be involved.

4. ENVIRONMENTAL BASELINE CONDITIONS: BIOPHYSICAL ISSUES

Climate

4.1. Jamaica enjoys a tropical climate with temperatures fairly constant all year due to the moderating influence of the warm Caribbean Sea. On the coast average maximum and minimum temperatures are 30.3˚C and 22.0˚C respectively, with an average of 26.2˚C[1]. Inland temperatures vary with elevation. The warmest months are June to August and the coolest December to April.

4.2. The long term mean average rainfall between 1881 and 1990 was 1895 mm, the maximum being 2690 mm in 1933 and the minimum 1895 mm in 1920. The highest rainfall is experienced in the mountains, often more than 5080 mm/year, and the lowest, less than 890 mm, along the south-east and southern coast. There are two distinct wet seasons, May to June and September to November, and the driest months are December to March. Short duration rainstorms are common throughout the year and in Portland rain can fall for several days with little respite.

4.3. For much of the year winds are dominated by the Northeast Trades. By day along the north coast, sheltered from ocean swells by Cuba 150 km to the north, sea breeze combines with the trades to give an ENE wind with an average speed of 15 knots. Between December and March local winds are a combination of trades, sea breezes and a northern or north-westerly component associated with cold fronts and high pressure.

4.4. By night, the trades combine with land breezes and north coast night winds often have a southerly component with a mean speed of 5 knots. By day in June and July, mean offshore winds often reach 23 knots along the north coast. Overall, winds are lighter inland and towards the west, stronger towards the east. Wind roses for the North Coast of Jamaica are shown on **Figure 4.1**.

4.5. Variations in the hours of sun vary little during the year but are greater between coastal and inland areas. The maximum length of day, over 13 hours, occurs in June with the minimum, 11 hours, in December. Mean hours of sunshine are 6 hours in the mountains and up to 8 hours along the coast. Afternoon showers are the major cause of daily variations in relative humidity. Values on the coast at 7am may average 84% for temperatures in the mid 20˚C and 71% at 1pm

4.6. Mean monthly climatic data for Port Antonio between 1951 and 1980 are given in **Table 4.1** with mean rainfall and temperature variations illustrated in **Figure 4.2.**

4.7. Jamaica is located within the Caribbean hurricane belt and there is a long history of strong tropical storms and hurricanes causing damage on the island. Winds of 60 miles/hour or more were recorded 35 times in the 135 years to 2005 for the island as a whole and 26 times in Port Antonio with average frequencies of

[1] Source: National Meteorological Service of Jamaica

once every 3.86 years for the island and once every 5.19 years for Port Antonio. Jamaica as a whole is directly hit[2] once every 27 years and Port Antonio every 10.4 years. The tracks of historic hurricanes across Jamaica are shown in **Figure 4.3**.

Table 4.1. Mean Monthly Climatic Data for Port Antonio 1951-1980

	J	F	M	A	M	J	J	A	S	O	N	D
Max Temp (˚C)	28.1	27.6	28.6	29.3	29.5	30.7	30.7	30.7	03.5	29.8	29.2	28.5
Min Temp (˚C)	19.2	18.9	19.4	20.1	21.1	21.6	21.8	21.8	21.8	21.7	20.8	20.6
Rainfall (mm)	224	144	113	170	299	339	257	250	277	352	359	298
Rel. Hum 7am (%)	86	88	87	86	87	87	88	87	86	86	87	87
Rel. Hum 1pm (%)	78	77	77	77	76	78	75	75	77	80	81	81
Sunshine (hr)	6.1	6.3	6.8	7.4	7.2	7.0	7.6	7.6	7.2	6.9	6.5	6.1

4.8. Notable past tropical storms and hurricanes effecting Port Antonio include:

- 1874: 90 mph winds;
- 1880: 80 mph winds, over 20 people killed;
- 1912: 150 mph winds, massive storm surge, over 100 killed island wide;
- 1917: Very high storm surge along the northern coast;
- 1944: Heavy damage with thousands left homeless island wide;
- 1951: 85 mph winds with much higher gusts causing heavy damage;
- 1980: Moderate damage;
- 1988: Moderate damage;
- 2004: 155 mph winds, moderate damage; and,
- 2005: 110 mph winds, severe damage locally from wind and heavy rain.

4.9. The official Hurricane Season lasts from 1st June to 30th November but tropical weather systems can occur from April to December. There is common public perception that the frequency of severe storms is increasing as a result of global warming. While statistics appear to support this view the long term significance of recent storms and the cause for any increase remains to be proven.

Geology and Structure

4.10. Jamaica is situated on the northern margin of the Caribbean Plate near where it abuts the North American Plate, The plate margin is the tectonically active east-west trending Cayman Trough that separates Jamaica from Cuba.

4.11. Structurally the island comprises an east-west trending anticline upon which has been superimposed two dominant sets of block faulting. A series of east-west strike-slip faults and two sets of rift faults divide the island into three major blocks; the Hanover Block in the west, the Clarendon block in the centre and the Blue Mountain Block to the east.

[2] A 'direct hit' is defined as the centre passing within 40 miles.

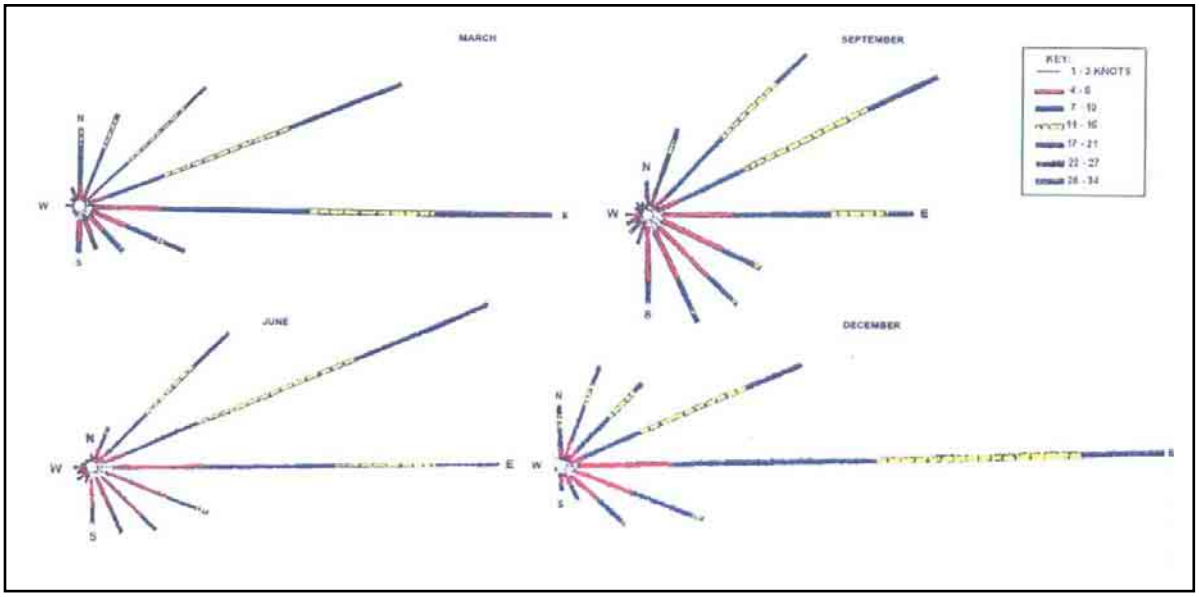


Figure 4.1. Wind Roses for the North Coast of Jamaica

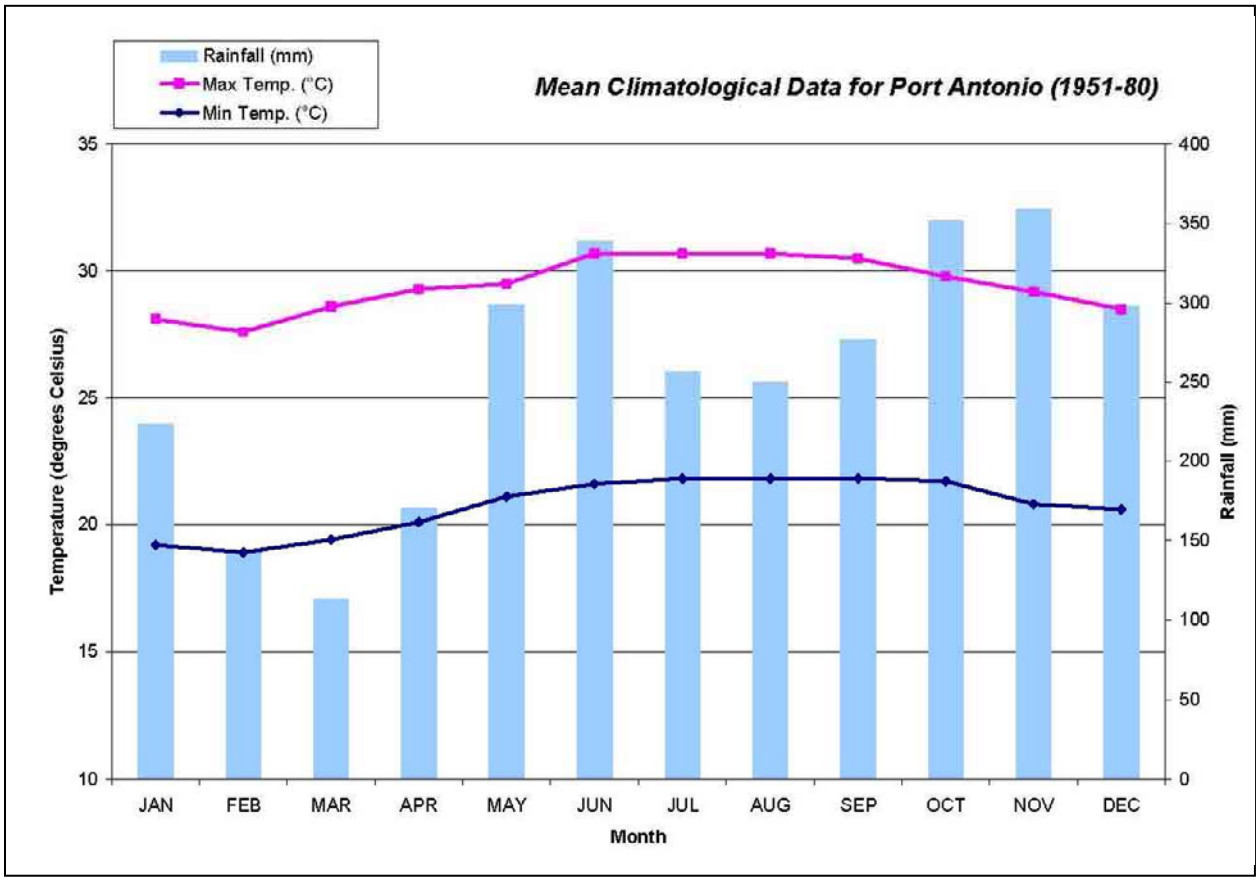


Figure 4.2. Mean Rainfall and Temperature Data for Port Antonio 1951-1980

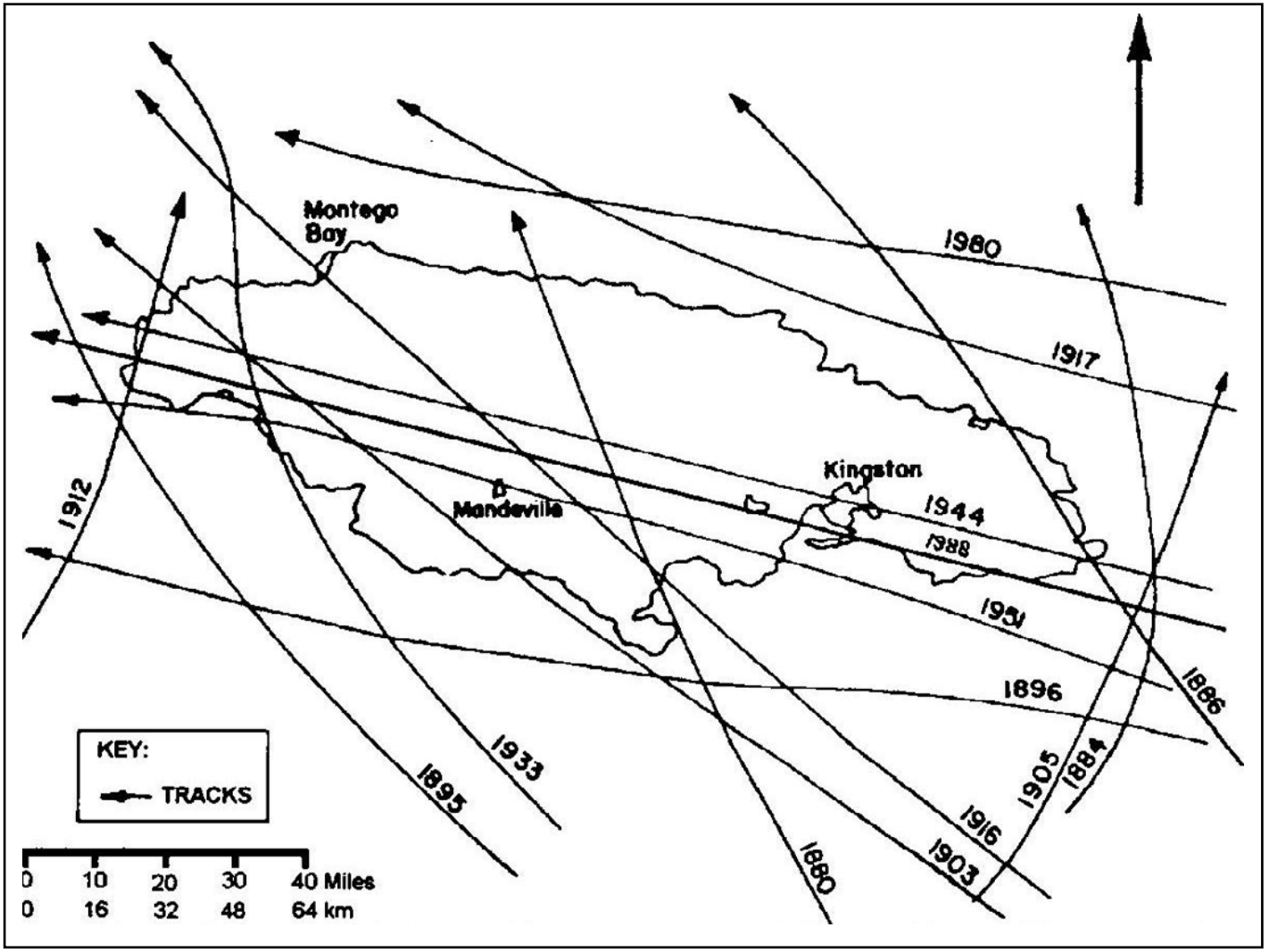


Figure 4.3. Historic Hurricane Tracks 1880-1988

4.12. Stratigraphically the island comprises three major components:

- Tertiary limestones;
- Post-Cretaceous trough sediments, volcanics and intrusives; and,
- Cretaceous basement complex.

4.13. In the area where the limestone cover is breached, older rocks, sedimentary, igneous and metamorphic, are exposed as a series of inliers. The largest is the Blue Mountain Inlier, with Port Antonio located at its northern end, for which and the stratigraphical succession is given in **Table 4.2.** A simplified geological map of the area is presented in **Figure 4.4.**

Table 4.2. The Stratigraphy of the Port Antonio Area.

Age		Group	Formation
Sedimentary Strata			
Q	Quaternary and Recent	Alluvial deposits along major watercourses. Elevated Reef adjacent to the coast.	
Mm	Lower Miocene to Middle Eocene	White Limestone Group	Montpelier Formation
Egb			Gibraltar-Bonny Gate Formation
Ef	Middle Eocene	Yellow Limestone Group	Font Hill Formation
Er	Lower Eocene	Wagwater Group	Richmond Formation
Cb	Upper Cretaceous		Bellvue Formation
Igneous and Metamorphic Rocks			
	Upper Cretaceous	Granodiorites	

4.14. Quaternary and Recent sedimentary rocks are common throughout the coastal plain. Along the PAWSDP Stage 2 pipeline routes and beneath the sites of structures clays and other superficial material dominate the areas to be excavated. At Pumping Stations 2 and 3, 3 m of clay overlies coarser clastic detritus. At the treatment plant site, 9 m of alluvial deposits are underlain by 3 m of peat above more alluvial material.

4.15. Jamaica is well known as one of the world's major producers of bauxite used in the production of aluminium but it also contains extensive deposits of other minerals, including gold, with extractable reserves estimated at 75,000 tonnes[3]. Non-metalliferous minerals are also important and include:

- Limestone, for the chemical industry;
- Crushed stone aggregate for construction;
- Marble for decorative stone;
- Clay for bricks, pottery and ceramics; and,
- Gypsum/Anhydrite for chemicals and construction.

[3] Jamaica Promotions Corporation,www.investjamaica.com

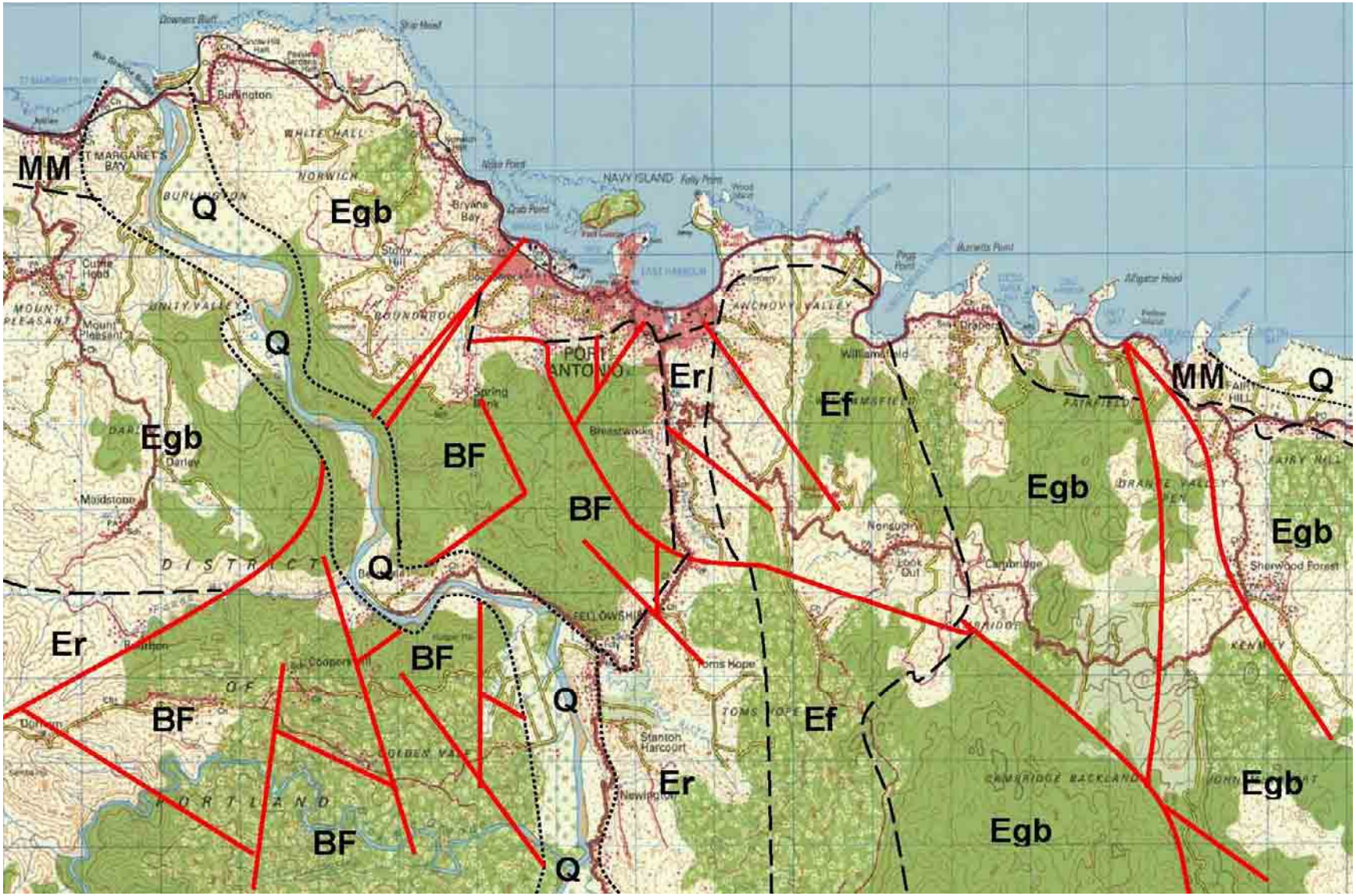


Figure 4.4. Simplified Geology of the Port Antonio Area

4.16. Quarrying is practiced in every parish and in accordance with the Quarries Control Act of 1983 the Mines and Geology Division of MLE has established the quarry zones shown on **Figure 4.5**, to reduce the wide dispersion of quarries while satisfying the demand for aggregate. The Parish of Portland is relatively 'quarry-free' with just one zone west of Buff Bay, some 25 km west of Port Antonio.

Topography

4.17. Port Antonio is located north of the Blue Mountains and John Crow Mountains. The Blue Mountains rise steeply within 5 km of the coast and reach a maximum height of 2256 m, the highest in Jamaica, at Blue Mountain peak some 18 km SW of Port Antonio. The John Crow Mountains rise more gently from the east and reach a height of 1,140 m. The two ranges are separated by steep valley of the Rio Grande River. Although most of the project area falls within the John Crow mountain range the influence of the Blue Mountains is substantial since their steepness and height largely influences rainfall, while the river and alluvial sediments of the Rio Grande determine the nature and extent of agricultural activities.

4.19. The coastal plain below the two mountain ranges is dissected by perennial and seasonal streams. West of Port Antonio the richly vegetated slopes extend to the shoreline, which is dominated by steep cliffs 5-20 m in height. At Port Antonio the coastal plain widens to its maximum and partially encloses two deep embayments, East Harbour and West Harbour. A short distance from the Tichfield Peninsular that separates the twin harbours is the 26 ha richly vegetated Navy Island. East of Port Antonio the coastal plain again narrows and there are several smaller embayments around which are varying degrees of flat or gently sloping land. Inland are richly vegetated gentle to steep hills which rise to 200 m and an extensive network of secondary and tertiary roads serve small-medium sized farming communities.

4.20. The built-up area of Port Antonio follows the narrow coastal plain and the PAWSDP area does not exceed 20 m above mean sea level. All the major structures, the three sewage pumping stations, the sewage treatment works at Turtle Crawle, the water transmission main and the trunk sewer are all at less than 10 m amsl. The Grant's Level Wellfield on the north bank of the Rio Grande some 3.5 km SSW of Port Antonio is 25-27 m amsl.

Existing Land Use

4.21. The majority of the PAWSDP Stage 2 works, the transmission water main and trunk sewer to Turtle Crawle, and the treated effluent pipeline back to Daniel's Harbour will be laid within the existing road corridor, either beneath the existing pavement or within the border set aside for the location of infrastructure services and future road widening. The long sea outfall pipeline route crosses generally inaccessible rocky foreshore before reaching the sea bed.

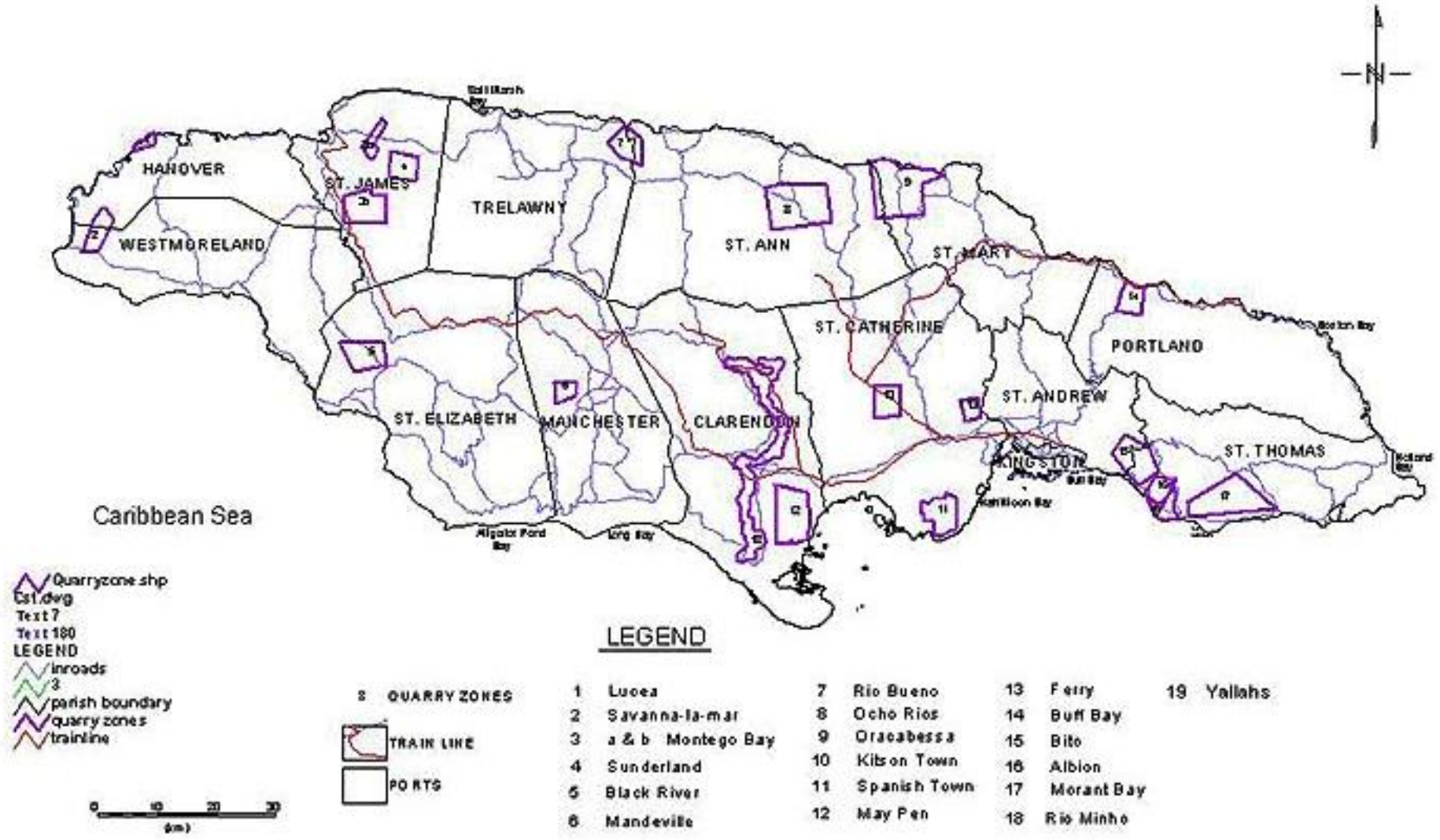


Figure 4.5 Quarry Zones in Jamaica

4.22. The existing uses of land to be taken for other Stage 2 structures are as follows:

- **New wells at the Grant's Level Wellfield** are within the compound already occupied and owned by NWC;
- **Sewage Pumping Station No.1** at the Allan Avenue (A4) crossing of Caneside River is within the exiting road corridor, The site is poorly grassed and is currently occupied by two plywood huts from which sweets and other minor items are sold to pupils from the nearby school;
- **Sewage Pumping Station No.2** at Anchovy is also within the road corridor and adjacent to NWC's Anchovy Sewage Treatment Plant. The site is roughly grassed but also contains opportunistic vegetation;
- **Sewage Pumping Station No.3** (3a and 3b) at Turtle Crawle is at the lower end of the treatment plant site. Just outside an area of mangrove the site is devoid of any significant vegetation having been degraded by clearance, grazing by pigs and fly tipping;
- **The Treatment Plant Site** at Turtle Crawle is largely a wetland through the alteration of natural drainage by road construction. It is well vegetated and presently occupied by 15 households who will need to be relocated. The nature of the site is discussed in detail later in the present Section.
- **The LSO Headworks Chamber** at Daniel's Harbour is located between the A4 and an area of rocky foreshore. The remains of small walls and planting beds indicate it was once part of a garden but it has clearly suffered a lack of maintenance for several years. It is degraded by overgrowth and fly tipping, effectively fenced off from adjacent properties, and abandoned. A land drainage ditch crosses to the west of the site.
-

General Land Acquisition Procedure

4.28. The general procedure for the acquisition of land by the Government is as follows:

- Establish and set out the exact boundaries of the PAWSDP sites;
- Perform a legal survey of each parcel to be acquired;
- Prepare a parcel plan showing the limits of the property required;
- Prepare a Property Valuation Report in co-ordination with the Land Valuation Department;
- Present offers to the property owners; and,
- Execute land transfer agreements and assume vacant possession of the properties.

4.29. GoJ uses various means of compensation including cash purchase, land exchange and Land Bonds. In the event a property owner does not agree to the offer and a negotiated settlement is unlikely, GoJ will initiate expropriation proceedings in accordance with the Land Acquisition Act 1947.

4.30. Under this Act, the Minister responsible for Crown Lands, having satisfied himself the land is required for the public good, will cause a notice to that effect to be published in the Gazette and serve a copy on the owner. The Commissioner of Lands will post the notice locally. Once the land has been surveyed and shown to be fit-for-purpose, the Minister will issue a declaration and instruct the Commissioner to acquire the land. The Commissioner will then have the land valued and enter into negotiations for its purchase by private treaty.

4.31. If there is no agreement within a reasonable time the Commissioner will invite all interested persons to present to him in writing the nature of their interests in the land and their claim to compensation. The Commissioner will enquire into the value of land and the interests of persons claiming compensation and will make an award and apportion compensation. The Commissioner will then take possession of the land, pay the awarded compensation and publish a notice to this effect in the Gazette.

4.32. If the interested persons do not consent to the award; or if there is any dispute as to the right to receive compensation or its appointment, the Commissioner will deposit the amount with the Supreme Court of Jamaica.

4.33. The Government is not required by law to resettle persons who have been disrupted/uprooted/displaced due to land acquisition. The law nobly requires that they be compensated but only those who can show Title or some other means of legal ownership are entitled to compensation. Illegal occupants/squatters are not so entitled.

Surface Water Catchments

4.23. The project area is characterised by the lower reaches of the Rio Grande catchment to the south west and four poorly defined coastal catchments elsewhere, which together with the major watercourses are shown in **Figure 4.6**.

- **The Rio Grande Catchment** (I) is one of the largest in Jamaica. The river is 34.3 km in length and drains an area of some 286 km^2. It provides large perennial flows and is a popular site for rafting and other tourist activities. Recharge into the adjacent alluvial aquifer at Berridale provides Port Antonio with its primary source of water at the Grant's Level wellfield. In its upper reaches the river is bounded by steep heavily wooded slopes, some of which have been cleared for agriculture. On the gentler slopes and alluvial flood plain of its lower reaches banana, cacoa, coconut, pimento and other crops are grown. The WRA maintains a community-based Flood Warning System for the Rio Grande but within the project area the catchment is not heavily populated;
- **The White Hall - Norwich - Boundbrook Catchment** (II) occupies the steep slopes rising east of Port Antonio's West Harbour. It includes much of the town and is the most heavily populated catchment within the project area. The slopes have been heavily denuded for development and agriculture, and this has resulted in widespread flooding of parts of the town after heavy rain. The catchment drains to several unconnected short streams, the largest the Annotto River, sustained by spring issues in the hills;
- **The Port Antonio East - Anchovy Catchment** (III) is more gently sloping with generally longer watercourses. The built-up area drains to the Caneside River and its tributary West Town River, and by the East Side River. To the east, the West River valley takes the watercourse below the uncontrolled landfill at John's Town where it picks up pollution from refuse tipped over the hillside.

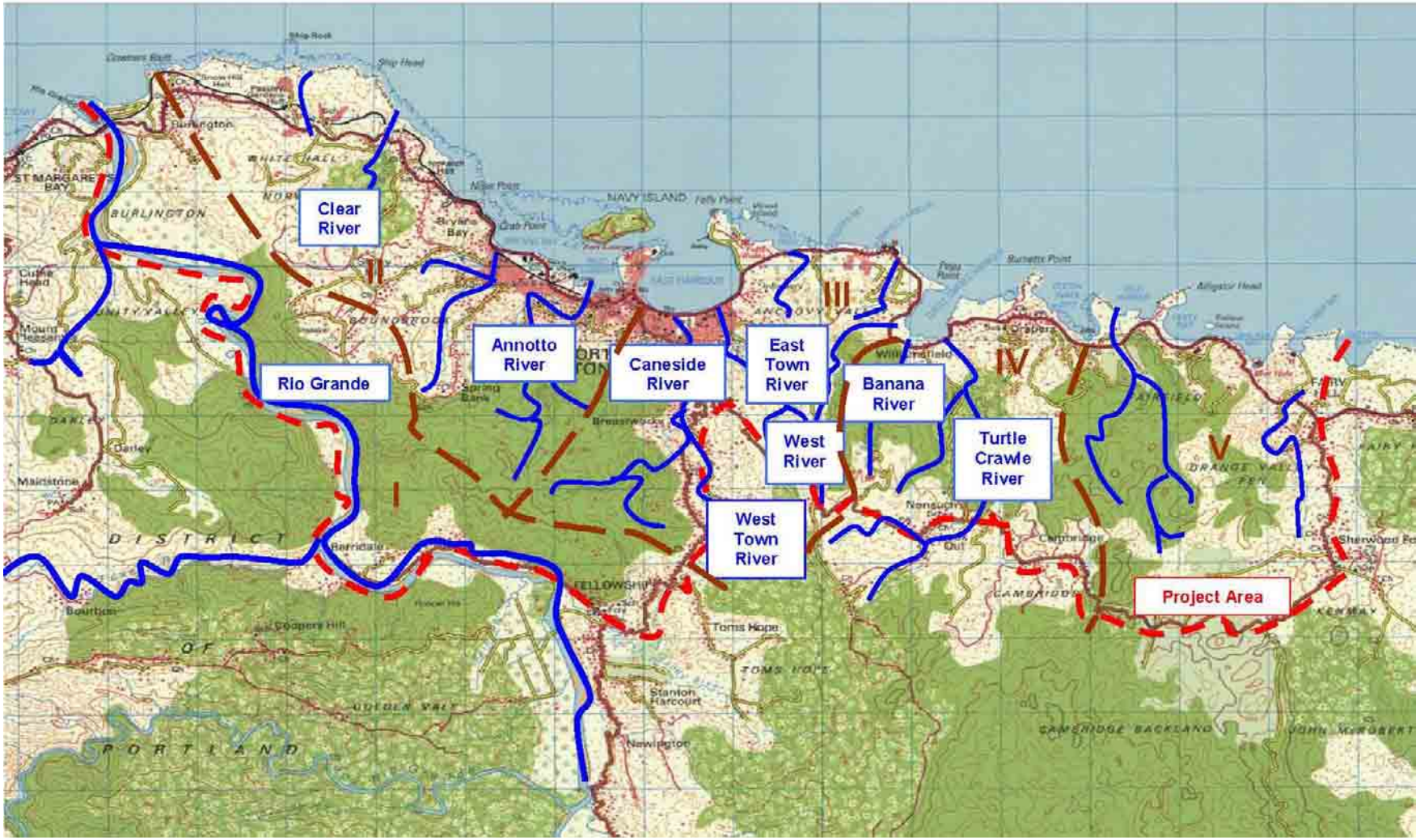


Figure 4.6. Surface Water Catchment Areas and Major Watercourses

- **The Williamsfield - Drapers Catchment** (IV) drains to the Banana River to the west and the larger Turtle Crawle River to the east, both discharging into Turtle Crawle Harbour. The main settlements in the catchment are Nonesuch, Cambridge and Drapers, and there has been much land clearance for development and lumber.
- **The Orange Valley - Fairy Hill Catchment** (V) is at the extreme east of the project area and drains to a number of minor spring-sourced watercourses that are frequently lost underground as they approach the coast only to re-emerge as springs near the shoreline. There is significant housing development and existing resort properties include San San Bay, Blue Hole, Dragon Bay and Fairy Hill. Slopes are gentle with banana cash crop cultivation common.

4.24. In all catchments the removal of natural vegetation for agriculture and development, with consequential erosion, siltation and pollution, has increased the occurrence of flooding and caused degradation of near-shore and marine environments.

Ground Water and Springs

4.25. The occurrence of groundwater in the Port Antonio area is not well understood because resources exploited for public supply have been taken from the alluvial aquifers of the Rio Grande or from springs and whilst these have sustained supply there has been little impetus to investigate alternative sources. However, many of these traditional sources have increasingly experienced problems in maintaining yield and/or water quality and **Table 4.3** gives the recommendations of the 1996 Master Plan for future exploitation.

Table 4.3. Traditional Sources of Water Supply for the Port Antonio Area

Source	Yield (1966)	Recommendation for Future Use
Grant's Level Wellfield	10,681-11,138 m^3/d	Expand to become the primary water source
Norwich Spring (Clear River)	227-455 m^3/d	Abandon due to poor quality
Turtle Crawl Spring	682-1,136 m^3/d	Abandon due to yield fluctuations and high turbidity
Fairy Hill Well	455-682 m^3/d	Abandon due to falling yield and increasing salinity
Stony Hill Spring	11-14 m^3/d	Abandon as unreliable chlorination only
Nonsuch Spring	45-90 m^3/d	Abandon as chlorination of river water only
Cambridge Spring	150 m^3/d	Abandon. Dries up on occasions
Seaman's Valley Spring	< 227 m^3/d	Abandon due to poor quality

4.26. For some years the main source of water has been Grant's Level wellfield located approximately 3.5 km SSW of Port Antonio, which currently contains five wells drilled into alluvium deposits on the right bank of the Rio Grande, laid out as shown in **Figure 4.7**. Wells1 and 2 were constructed in 1968, No. 3 in 1969 and No. 4 in 1987. Well 5 was drilled in 1982 but never commissioned because an obstruction prevented the installation of a pump. The depth of the wells vary from 16.76 m (Nos.1 and 2) to 22.86 m (No.3), with No.4 18.29 m deep. None fully penetrate the aquifer, although the recorded presence of 'boulders and clay', sometimes 'well cemented' in the lowermost 3-5 m suggests the base may have been close when drilling was curtailed.

4.27. In the absence of data on reliable yield because the wells are not fitted with flow meters, NWC estimates maximum wellfield abstraction to be 11,350 m^3/d and mean abstraction about 9,000 m^3/d. Assuming the leak detection and repair work to be undertaken within PAWSDP Stage 1 can reduce leakage from its present 70% + to 50%, still very by international standards, sustainable abstraction needs to be increased to 21,720 m^3/d to meet the predicted requirement for the 2025 design horizon.

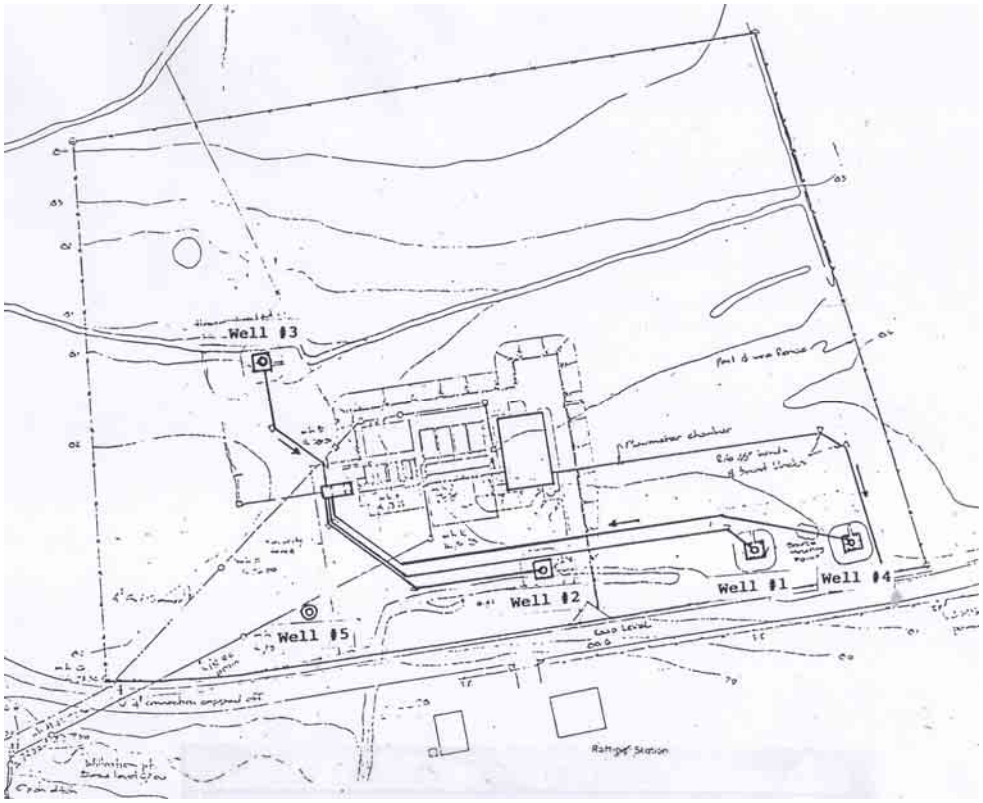


Figure 4.7. The Existing Layout of the Grant's Level Wellfield.

4.28. To achieve this, further wellfield development is being undertaken in two phases:

- **Phase 1:** Investigations to confirm the availability of resources, the reliable yield of the Rio Grande, the efficiency of the hydraulic link between river and aquifer, and the current status of the wellfield; and,
- **Phase 2:** The drilling of 3 monitoring wells to provide information on aquifer depth and composition for new well design and to facilitate future wellfield management, and the subsequent construction of up to 4 new production wells to provide installed capacity to deliver the 2025 requirement.

4.29. The hydraulic continuity between the river and the aquifer has been demonstrated by the simultaneous monitoring of water levels in Well No.5 and river stage at WRA's Fellowship gauging station, 1.6 km upstream, over the period 14th September to 21st October 2005. Hydrographs for this period and for four days of maximum fluctuation, shown in **Figure 4.8,** clearly demonstrate the interconnection between ground and surface water.

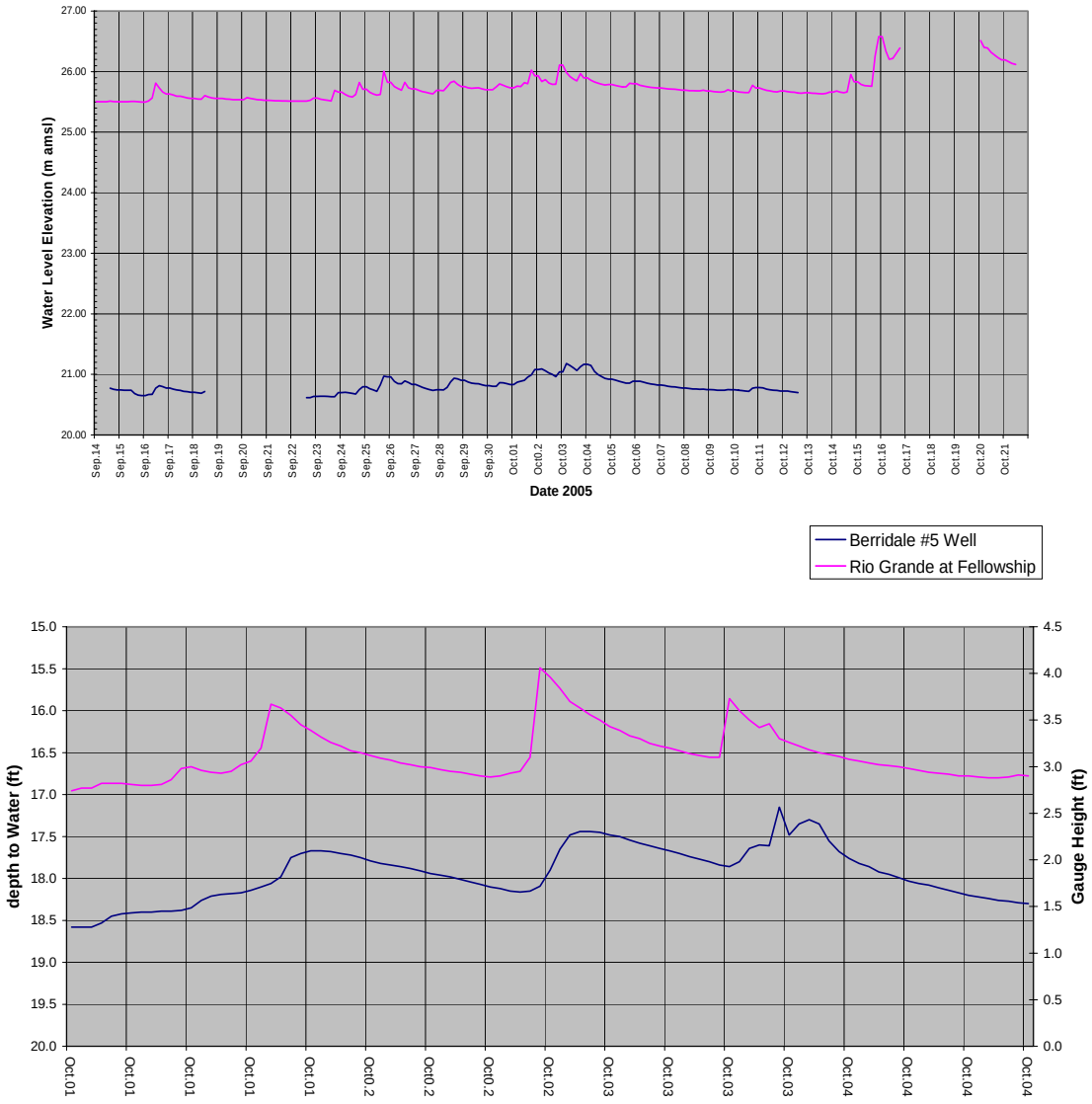


Figure 4.8. Hydrographs for the Rio Grande at Fellowship and Grant's Level Well No. 5.
(A) 14th September to 21st October 2005 and (B) 1st to 4th October 2005

4.30. From the time lag of approximately four hours, the distance between Grant's Level and Fellowship, and the 5 m difference in elevation, a velocity of 0.11 m/s is indicated; less than river flow at this time of year but more than normal groundwater flow. This implies significant flow through the aquifer upstream of the wellfield. The wells function as efficient surface water diversion structures and should sustain future production providing ground water is not abstracted at a rate greater than that at which the river can provide recharge.

4.31. The normal practice in Jamaica is for the sufficiency of domestic surface water supplies to be taken as the annual minimum 30-day discharge from a 1 in 10 year flood event. For the present study, given the high flows in the Rio Grande compared with the Port Antonio requirement, it was decided to use a more exacting

assessment, the annual minimum daily flow for a 1 in 10 year flood event. Statistical analysis of records from WRA's Rio Grande gauging stations at Fellowship and Alligator Bridge concluded the latter were better suited to further analysis, being independent, random, not exhibiting significant trend, and sub-samples split by time appearing to be from the same population.

4.32. Given the 1 in 10 year annual minimum discharge of 0.65 m^3/s at Alligator Church, the reliable yield of the Rio Grande at Fellowship was determined to be 1.361 m^3/s, or 117,590 m^3/d. The required abstraction from Grant's Level will be 21,720 m^3/d, some 18% of this. Surface flow below the wellfield will therefore be reduced by 0.251 m^3/s. The lowest recorded daily discharge at Fellowship was 1.189 m^3/s on 5th May 1968. In a repeat of this, surface flow would be reduced to 0.938m^3/s (81,043 m^3/d). There are however no licensed abstractions from the Rio Grande downstream of the wellfield and no abstractors to be impacted.

4.33. However, low flow conditions in the Rio Grande reduce water levels below what is needed to permit rafting. The start of the rafting run is adjacent to the wellfield. There may therefore be some reduction in the number of ‘rafting days’, particularly in 'dry' years, as a result of increased wellfield abstraction.

4.34. The assessment of minimum flows to sustain environmental conditions in rivers is somewhat subjective. The WRA have recently proposed[4] an environmental requirement of 40% of the annual minimum daily discharge with a 10 year return period. For the Rio Grande at Fellowship this would be 0.54m^3/s, less than the projected residual flow of 0.938m^3/s after wellfield abstraction. Environmental requirements would therefore be met.

4.35. Existing well construction is at best uncertain but the design of the wells is poor by modern standards. Wells 1, 2 and 4 each contain a short length of 'continuously slotted' stainless steel screen and some mild steel slotted screen with bridge or flame cut slots. Well No.3 is lined with galvanized iron casing and slotted screen.

4.36. The nature and accuracy of the data used for the calculation of well efficiencies is also uncertain but the results are both surprisingly low and variable, 10-34% when the wells were new and 3-57% when they were retested in 1995. The yield from all 4 wells had reduced from when they were new, the discharge from Well No.1 by 76% and from Well No.4 by 48%. Given that the proximity of the river ensures constant recharge this reduction may primarily be due to corrosion and clogging of screens. Under steady-state conditions the well interference determined from distance/drawdown data was reported[5] to be only 0.29-0.54 m.

4.37. Specific drawdown and specific yield results are given in **Table 4.4**. Despite the limitations of the step-drawdown and constant rate pumping data they are surprisingly consistent. The expected drawdown for a yield of 5,000 m^3/d is indicated 8 m, or 1.6 m per 1000m^3/d. However, while the data inherently accounts for well interference at the time of the tests, additional allowances will need to be made for greater interference with increased abstraction and during periods of low flow in the Rio Grande.

[4] *Water Resources Master Plan for Jamaica*. WRA, Second Draft 2005.
[5] In: *Water Resources Evaluation of Potential Sources of Supply to Port Antonio,* 1996

Table 4.4. Estimates of Specific Drawdown and Specific Yield

Well No	Specific Drawdown (per 1000 m^3/d)	Specific Yield (per m drawdown)	Drawdown for 5,000 m^3/d
From Step-Drawdown Discharge Data			
1	1.20 m		6.00 m
2	2.25 m		11.25 m
3	0.90 m		4.50 m
4	1.30 m		6.50 m
5	2.20 m		11.00 m
Mean	**1.57 m**		**7.85 m**
From Constant Rate Discharge Data			
3		588 m^3/d	8.50 m
4		673 m^3/d	7.65 m
Mean		**630 m^3/d**	**8.07 m**

4.38. To provide for the 2025 requirement of 21,720 m^3/d it is proposed to drill up to 4 new production wells as shown in **Figure 4.9**. While this is being implemented all the existing wells will continue to operate to provide continuity of supply. On completion of the first new well, existing Well 4 will be abandoned. On completion of all new wells, Wells 1, 2 and 3 will be retained to (i) contribute to overall wellfield production, and (ii) provide stand-by capacity during periods when wells have to be switched off for pump repair and/or replacement, for so long as they continue to operate without problem.

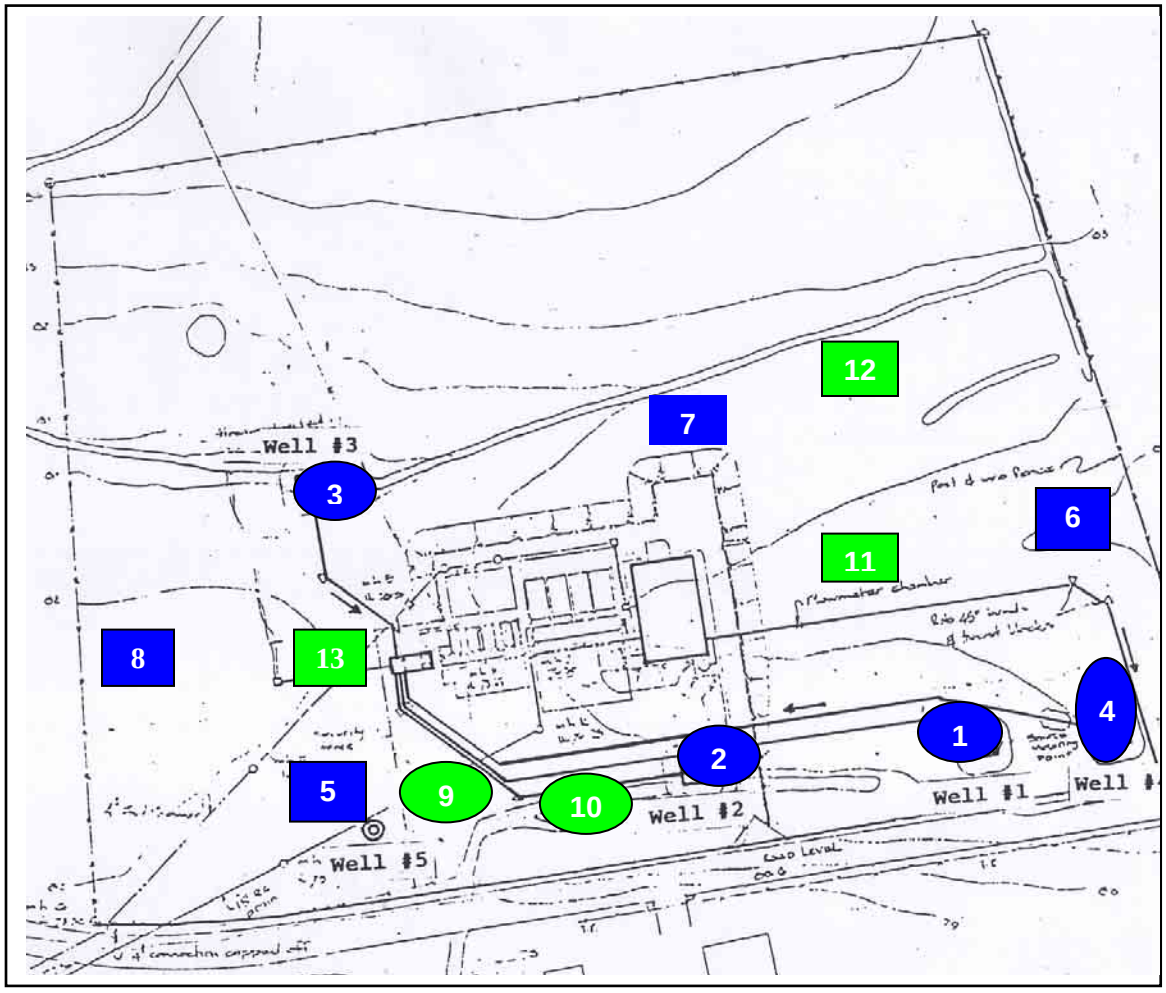
4.39. Water level and well discharge monitoring will commence at the onset of Phase 2 with measurement of the existing wells and extended to take in the new monitoring and production wells as they become available. Each new production well will be commissioned as it is completed to enable monitoring to encompass both individual well and overall wellfield performance and confirm the sustainability of the increased abstraction.

Ground Water Quality

4.40. Available ground water quality data for the Grant's Level wellfield, other than the daily routine monitoring of chlorine residual and other basic parameters, are few and far between, and given in **Table 4.5.**

4.41. Pesticides have been a concern of the NWC since the 1996 Master Plan reported a single pesticide residual in a single raw ground water sample from Grant's Level and recommended regular monitoring of the Rio Grande to enable any trend in the frequency and concentration of detectable residuals to be identified and the need for additional water treatment to be kept under review. No such monitoring was undertaken over the past decade and while the Pesticide Control Authority has significantly improved control and application the issue was revisited during PAWSDP detailed design. A limited sampling programme was therefore initiated to review if pesticide residuals were present[6]. In the event they were, more intensive work would be undertaken.

[6] *Port Antonio Water, Sewage and Drainage Project: Pesticides Study*. KBR, Doc. No. XU0396/100/G/0008, March 2006.



Existing production well to be retained (1, 2, 3)

Existing production well to be taken out of service and retained for monitoring (4)

New production wells (5, 6, 7, 8)

Existing monitoring wells (9, 10)

New monitoring wells (11, 12, 13)

Figure 4.9. Proposed Drilling Locations

Table 4.5. Available Ground Water Quality Data for Grant's Level Wellfield

Parameter	Units	1	2	3	4	5	6	7	8	JNDWG
		25.09.1989	19.11.1991	23.06.1992	17.08.1993	06.12.1994	11.1995	18.08.1998	22.02.2006	
pH		7.46	7.71	7.61	7.81	7.6	7.44	7.4	8.2	7.0-8.5
Conductivity	microhos/cm@25º	312	359	365	363	380.5		349.9	303.0	
Turbidity	NTU	0.10	0.30	0.15	0.17	0.60	0.18	0.08	0.61	1.0
Colour	Hazen Units	0	0	0	0	0	3	0		15
Calcium	mg/l	48	57	60	51		46.7		51.3	200
Magnesium	mg/l	5.9	4.9	3.6	5.5		6.0		7.0	
Sodium	mg/l	12.2	20.0	20.0	12.0					
Potassium	mg/l	0.85	0.72	0.80	0.70					
Iron	mg/l	0	0	0	0		0.010			0.30
Sulphate	mg/l	13.1	14.0	24.5	14.2		8.8			250
Chloride	mg/l	8.5	15.0	11.0	12.5		8.8		6.0	250
Nitrate	mg/l	0.87	3.41	3.90	3.90		5.7		3.7	45
Nitrite	mg/l	0.004	0	0.003	0	0.001		0.001		
Total Hardness	mg/l	144	163	164	150	178		162	157	
Total Alkalinity	mg/l	142	143	160	140	164		161	141	
Total Dissolved Solids	mg/l	200	229		212			214		500
Total Solids	mg/l	200			212				192.0	
Total Bacteria	MPN/100ml						$2.0x10^4$			
Total Coliform	MPN/100ml						0		<2	
Faecal Coliform	MPN/100ml						0		<2	
Chemical Oxygen Demand	mg/l	0.9	0.8	0.5	1.7					
Fluoride	mg/l	0.18	0.05		0.23					1.50
Aluminium	mg/l	0	0	0.005						0.200
Barium	mg/l						0.049			
Cadmium	mg/l						<0.005			
Copper	mg/l						0.0062			
Chromium	mg/l						<0.010			
Lead	mg/l						0.010			
Manganese	mg/l		0		0		<0.0050		0	0.05
Phenol	mg/l						0.10			
Anionic Detergents	mg/l						0.10			
Mercury	mg/l						<0.0005			
Organochlorine Residue	µg/l						0.065			
Organophosphorous Residue	µg/l						<0.008			

Sources: Analyses 1, 2, 3 and 4: NWC production monitoring reported in, *Port Antonio Sanitation Study, Master Plan Report*. UDC/Louis Berger, August 1996.
Analyses 5, and 7: NWC production monitoring, provided in response to KBR request for analytical records, January 2006.
Analysis 6: Louis Berger for the Master Plan Report cited above, November 1995.
Analysis 8: baseline analysis for the PWSDP Stage 2 EIA.
JNDWG: *Jamaican National Drinking Water Standards*

4.42. Two sets of water and river sediment samples were collected and tested, the first on July 5th 2005, representative of the 'wet' season, the second on 15th September, representing the 'dry' season. Testing targeted four groups of pesticides having prevalent use in the Rio Grande Valley; organo-chlorines, organo-phosphates, carbamates and synthetic botanicals. All analyses were undertaken by the University of West Indies.

4.43. No residues from the targeted groups were detected in any of the water samples but a compound with a 70% probable match to the organo-phosphorous compound Etrimfos was found in one of the 'wet' season sediment samples. With no pesticide residuals having been found in the Rio Grande water samples, they may be considered to have met even the most stringent international standards for potable water.

4.44. None of the samples, albeit a limited number, taken between 1994 and 2005 of the Grant's Level ground water or the adjacent Rio Grande river water have detected any residual pesticide concentrations above 0.1 μg/l. In accordance with different international drinking water quality guidelines there is therefore no present need for treatment to remove pesticide residuals to ensure potability.

4.45. There is however, always the potential for hazardous chemical spills and similar accidents, and it behoves the NWC to ensure adequate emergency response plans are maintained to combat such an event and for the agricultural community and emergency services to be aware of the need for rapid communication of incident data to the NWC so supplies from Grant's Level and other sources throughout the island can be protected from contamination.

Biodiversity

4.46. The extent of Jamaica's rich bio-diversity is illustrated in **Table 4.6**.

Table 4.6. Summary of Bio-Diversity in Jamaica

	Higher Plants	Mammals	Breeding Birds	Reptiles	Amphibians	Fish
No. Known Species (1992-2002)	3,308	24	75	49	24	200
No. Threatened Species (2002)	206	5	12	8	4	1

4.47. 27% of the higher plants are unique to the Island, more than 200 species of flowering plants have been classified and there are 579 species of fern. Trees such as cedar, mahoe, mahogany, logwood, rosewood, ebony, palmetto palm, coconut palm, and pimento (allspice) are common, and mango, breadfruit, banana, and plantain were introduced commercially. Forests covered 35% of the island in 1999 but logging and land clearance for development and agriculture had reduced this to 30% by 2000 and it continues to fall. Important coastal species include red, white and black mangrove.

4.48. The bird population is highly diversified with parrots, hummingbirds, cuckoos, and green todys especially abundant. There are 116 species of butterfly, 17 of which are endemic and 450 species of snail. There are 61 species of reptiles and amphibians but no large indigenous quadrupeds or venomous reptiles. Among the butterflies the Great Swallowtail, the largest in the western hemisphere is found in the Blue Mountains and John Crow Mountains.

4.49. By comparison to other Caribbean islands there are fewer fish species due to over-fishing, particularly along the North Coast where the submarine shelf is narrow and fishing is concentrated. Large breeding shoals of parrot fish (*Scarus croicensis*) are a tenth of what they were in the 1970s and sturgeon are no longer numerous in the lagoons.

4.50. For its size Jamaica has a wide range of bio-geography. Twelve separate zones are recognised[7] as shown on **Figure 4.10**. The Parish of Portland lies astride the Blue Mountain (BMO) and John Crow Mountain (JCM) zones, which meet on the North Coast at Port Antonio. Most of the PAWSDP Stage 2 works lie just on the John Crow Mountains side where the wet limestone forest of the BMO gives way to the JCM montane forest. Within the PAWSDP, the only area of potential ecological significance is the treatment plant site at Turtle Crawle.

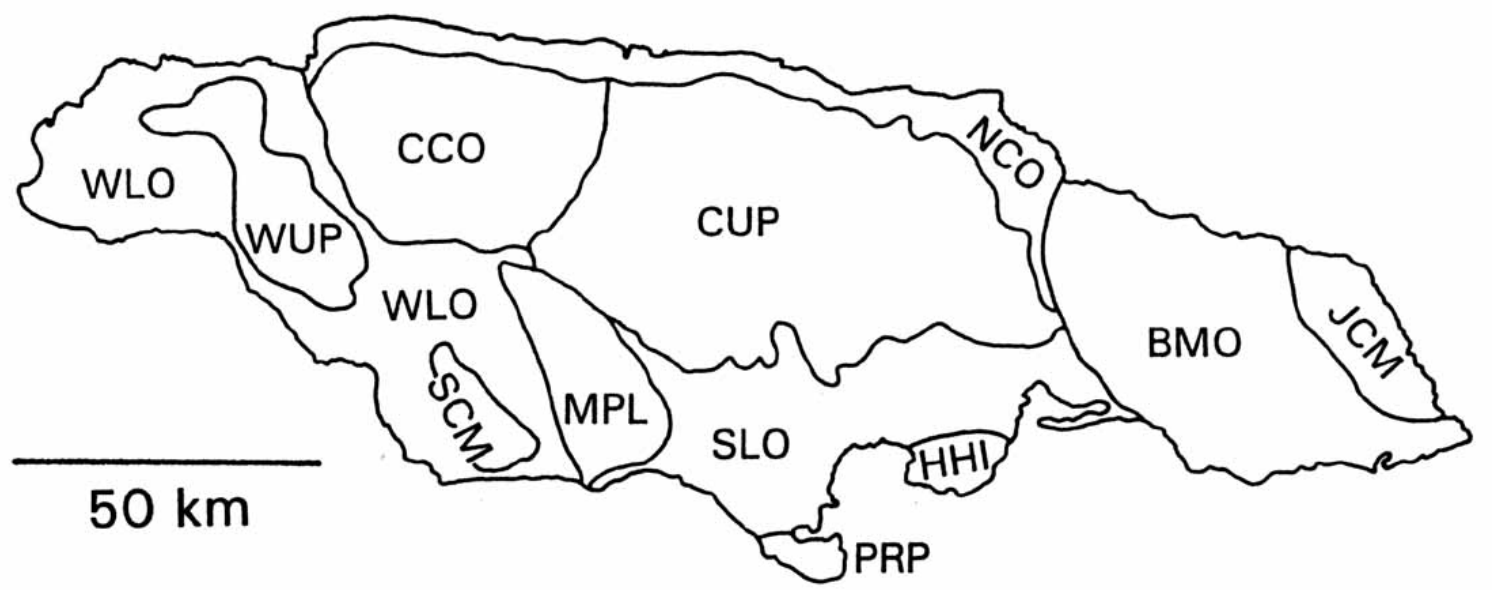
Ecology of the Turtle Crawle Treatment Site

4.51. The present EIA included an ecological survey of the Turtle Crawle Treatment Site undertaken over the period 23rd-25th February 2006. The area comprises four ecological zones as shown in **Figure 4.11**. The area is one of transition from mangrove at the coast, through open bog to forest at and beyond the top of the site, with all three zones changing laterally towards the river. Lists of flora and fauna observed in each of the four zones are given in **Tables 4.7 and 4.8** respectively.

4.52. The methodologies adopted for the survey of flora varied between the zones as follows:

- **Forest Zone:** Comprising disturbed forest interspersed with perennial shrubs, herbs and trees with species randomly distributed, systematic sampling was employed. Species were identified at 2 m intervals along three 60 m transects, at 40 m intervals.
- **Riverbank Zone:** Systematic sampling along 80 m long transects along the river bank.
- **Open Bog Zone and Mangrove Zone:** Being partially inaccessible and with vegetation type clumped with predominantly homogenous patches, 'whole-area' sampling was considered unnecessary and random/stratified sampling using five 10 m x 10 m quadrants within each zone was employed.

[7] *Distribution Patterns of Amphibians in the West Indies*. Hedges, S. B. In, Duellman, W. E. (Ed.) Patterns of Distribution of Amphibians: A Global Perspective. The Johns Hopkins University Press, Baltimore, 1999.



BMO Blue Mountains, CCO Cockpit Country, CUP Central Uplands,
HHI Hellshire Hills, JCM John Crow Mountains, MPL Manchester Plateau,
NCO North Coast, PRP Portland Ridge Peninsula, SCM Santa Cruz Mountains,
SLO Southern Lowlands, WLO Western Lowlands, WUP Western Uplands.

Figure 4.10. The Biogeographical Zones of Jamaica

Table 4.7. Flora Observed at the Turtle Crawle Treatment Plant Site

Zone	Type	Common Name	Scientific Name	Ranking
FOREST ZONE	Trees	Star Apple	*Chrysophyllum cainito*	Occasional
		Almond	*Terminilla catappa*	Abundant
		Trumpet Tree	*Cecropia peltata*	Abundant
		Coconut	*Cocus nucifera*	Frequent
		Ackee	*Blighia sapida*	Abundant
		Flame-of-the-Forest	*Spathodea campanulata*,	Abundant
		Mango	*Magnifera indica*	Occasional
	Epiphytes	Liana		Abundant
		Morning Glory	*Ipomoea sps.*	Abundant
	Herbs and Shrubs	Spanish Needle	*Bidens cyanpiifolia*	Frequent
		Bachelor Button	*Gomphrena celosioides*	Frequent
		Shame-me-Lady	*Mimosa pudica*	Frequent
		Dasheen	*Colocasia esculenta*	Dominant
		Devil Barsley	*Ocimum micranatum*	Occasional
		Marigold	*Wedelia Sp.*	Frequent
		Bacra		Dominant
		Bur Weed	*Triumfetta semitriloba*	Frequent
		Fingrigo	*Pisonia aculeate*	Occasional
		Cold Bush	*Hedyosmum arborescens*	Dominant
		Donkey pee- pee		Dominant
		Ganja	*Cannabis sativa*	Rare
		Guava	*Psidium guajava*	Occasional
			Ludwigia peruviana	Frequent
		Banana	*Musa sp*	Dominant
		Plantain	*Musa sp*	Dominant
	Ferns	Moss Fern	*Selaginella pallescens*	Occasional
			Polipodium vulgare	Abundant
	Grasses	Star Grass	*Dichronema ciliata*	Frequent
OPEN BOG ZONE	Trees	Flame-of-the-Forest	*Spathodea campanulata*	Occasional
		Bastard Cedar	*Guazuma ulmifolia*	Occasional
		Caribbean Royal Palm	*Roystonea oleracea*	Occasional
		Coconut	*Cocus nucifera*	Occasional
	Epithytes	Liana		Abundant
		Bromeliad		Occasional
	Herbs and Shrubs	Ginger Lilly	*Hedychium flavum*	Dominant
		Heliconia	*Heliconia sps*	Dominant
		Dasheen	*Colocasia esculenta*	Occasional
		Swamp Cabbage	*Roystonea princeps*	Rare
	Grasses	Giant Reed	*Arundo donax*	Occasional
		Napier Grass	*Pennisetum purpurem*	Occasional
		Bulrush	*Typha domingensis*	Occasional
RIVER BANK ZONE	Trees	Flame-of-the-Forest	*Spathodea campanulata*	Abundant
		Bastard Cedar	*Guazuma ulmifolia*	Occasional
		Almond	*Terminilla catappa*	Abundant
		Coconut	*Cocus nucifera*	Abundant
	Shrubs	Ginger Lilly	*Hedychium flavum*	Frequent
		Heliconia	*Heliconia sps*	Frequent
		Swamp Cabbage	*Roystonea princeps*	Frequent
		Thatch Palm	*Sabal jamaicensis*	Occasional
	Grasses	Giant Reed	*Arundo donax*	Occasional
		Napier Grass	*Pennisetum purpurem*	Occasional

		Bulrush	*Typha domingensis*	Occasional
MANGROVE ZONE	Trees	White Mangrove	*Laguncularia racemosa*	Dominant
		Black Mangrove	*Avicennia germinan*	Occasional
		Red Mangrove	*Rhizophora mangle*	Abundant
		Almond	*Terminalia catappa*	Rare
		Coconut	*Cocus nucifera*	Rare
		Giant Reed	*Arundo donax*	Occasional
		Napier Grass	*Pennisetum purpurem*	Occasional
		Bamboo	*Bambusa sps.*	Rare

Table 4.8. Fauna Observed at the Turtle Crawle Treatment Plant Site

Type	Zone	Common Name	Scientific Name	Ranking
Macrofauna	Forest	Pig	*Sus domesticus*	Occasional
		Ants	*Solenopsis sps*	Frequent
	Open Bog, Riverbank and Mangrove		*Cardiosoma sp*	
			Gecarcinus sp	

Type	Zone	Common Name	Scientific Name	Ranking	Status
Avifauna	Forest and Open Bog	Heron	*Butorides sps*	Common	Resident
		Parakeet	*Forpus passerinus*	Common	Resident
	River Bank and Mangrove	Blackbird	*Neopsar nigerrimus*	Common	Endemic
		Heron	*Butorides sps*	Common	Resident
		Parakeet	*Forpus passerinus*	Common	Resident

Type	Zone	Common Name	Scientific Name	Conservation Status
Reptiles	mangrove	American Crocodile	*Crocodylus acutus*	Protected

4.53. Vegetation outside the immediate areas of influence of each zone was also examined and any species of ecological and commercial value recorded. The species from all four vegetation zones were subjected to a semi-quantitative abundance DAFOR rating (**D**ominant, **A**bundant, **F**requent, **O**ccasional, **R**are).

4.54. The macrofauna and microfauna in all four zones were sampled using the methods adopted for the flora. Avifauna was assessed by direct observation using point counts. Physical descriptions and vocal peculiarities were noted for later verification, and observations were repeated early morning and late evening to eliminate bias from activity patterns.

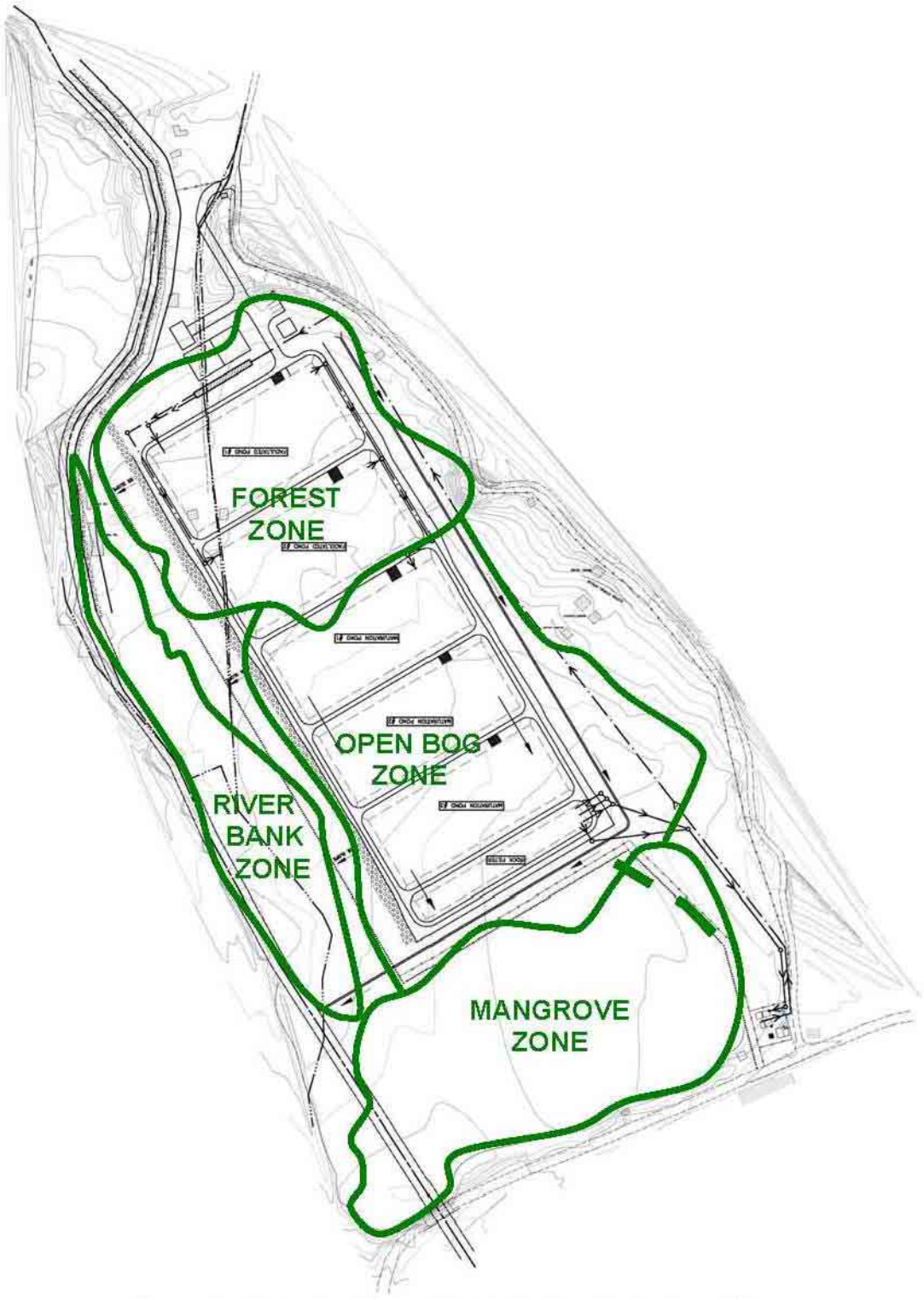


Figure 4.11. Ecological Zones at the Turtle Crawle Sewage Treatment Plant Site

Forest Zone

4.55. This zone comprises the higher southern portion of the treatment site where the soil is more compact and less waterlogged than in the lower areas, and the randomly distributed vegetation comprises mixed perennial herbs and shrubs interspersed with trees. Dominant species include Bacra *(Ardisia tinifolia)*, Cold Bush *(Hedyosmum arborescens)* and Donkey Pee-Pee, Spanish Needle (*Bidens cyanpiifolia*), Marigold (*Wedilia sp*.), Bachelors Button (*Gomphrena celosioides*) and Shame-Me-Lady (*Mimosa pudica).* On one transect a clearing containing Ganja (*Cannabis sativa*) was observed. Mature trees include Flame-of-the-Forest (*Spathodea campanulata)* and the Trumpet Tree (*Cecropia peltata)*. Interspersed frequently is Star Grass (*Dichronema ciliate), and c*ommon epiphytes included Lianas and Morning Glory (*Ipomoea sp.)*. Only two species of fern were observed, the Moss Fern (*Selaginella pallescens*) and *Polipodium vulgare*. However, commercial species such as Dasheen (*Colocasia esculenta),* Banana and Plantain (*Musa sp.),* Almond (*Terminalia catappa),* Guava (*Psidium guajava*) and a few dead/dying Coconut trees (*Cocus nucifera)* are most abundant. A few Ackee (*Blighia sapida*), Mango (*Magnifera indica)* and Star Apple (*Chrysophyllum cainito*) were also observed.

4.56. Few animals and birds were observed in the Forest Zone, primarily domesticated pigs (*Sus domesticus*), the Parakeet (*Forpus passerinus*) and Heron (*Butorides spp*.) with a few insects such as ants (*Solenopsis spp*.).

Open Bog Zone

4.57. The open bog zone is dominated by Ginger Lillies (*Hedychium spp.)* interspersed with *Heliconia spp*. and some Dasheen (*Colocasia esculenta)*. Mature trees include the Flame-of-the-Forest (*Spathodea campanulata)*, Caribbean Royal Palm (*Roystonea oleracea*), Bastard Cedar (*Guazuma ulmifolia*) and a few dying/dead coconut trees (*Cocus nucifera*). The epiphytes Bromeliads and Lianas are also present. To the west are stands of Swamp Cabbage (*Roystonea princeps*), Napier grass (*Pennisetum pupureum)*, Bulrushes *(Typha domingensis*) and Giant Reeds (*Arundo donax),* with a few Dasheen (*Colocasia esculenta)* and Wild Hops (*Mahoghania strobilifera*) along the fringes.

4.58. Macrofauna appears almost non-existent except for land crabs *Cardiosoma spp.* and *Gecarcinus spp*. within the interface with the mangrove zone. Parakeets (*Forpus passerinus*) were the only birds observed.

Riverbank Zone

4.59. This zone has flora similar to the forest zone with observed species including Flame-of-the-Forest (*Spathodea campanulata)*, Bastard Cedar (Guazuma *ulmifolia*), Almond (*Terminilla catappa),* Shame-Me-Lady (*Mimosa pudica),* Thatch Palm *(Sabal jamaicensis)* and a few dying/dead Coconut trees (*Cocus nucifera*). Most of the trees bare the epiphyte Bromeliads. An under storey of Ginger Lillies (*Hedychium spp.)* and Swamp Cabbage (*Roystonea princeps)* is present in some areas as is Napier Grass (*Pennisetum pupureum),* Bulrush (*Typha domingensis*), and Giant Reed (*Arundo donax)*.

4.60. The riverbank avifauna is also similar to that of the forest zone and includes the Parakeet (*Forpus passerinus*), Heron (*Butorides spp*.) and Blackbird (*Neopsar nigerrimus*). Two species of land crab, *Cardiosoma sp* and *Gecarcinus sp*. were also observed.

Mangrove Zone

6.61. The vegetation in the mangrove zone shows an aggregated/clumped pattern similar to the open bog. The dominant species are White Mangrove (*Laguncularia racemosa)* in the southern drier area and Red Mangrove (*Rhizophora mangle*) in the wetter area towards shoreline. Both are interspersed with Black Mangrove (*Avencennia germinan*) and a few coconut trees (*Cocus nucifera*) are also present.

4.62. Fringing the zone to the east and west are patches of riverine flora including Wild Banana (*Musa sp*.), Almond (*Terminalia catappa)*, Napier Grass (*Pennisetum pupureum),* Giant Reeds (*Arundo donax)* and Bamboo (*Bambusa vulgaris*). To the east there is mature Flame-of-the-Forest (*Spathodea campanulata)* bearing Lianas.

4.63. The diversity of fauna in this zone is also low. The land crabs, *Cardiosoma sp.* and *Gecarcinus sp.* were observed. Birds included Blackbird (*Neopsar nigerrimus*) and Heron (*Butorides spp*.). A young American Crocodile (*Crocodylus acutus*) around 2 m in length was also observed. With nightfall, Mosquitoes (*Anopheles spp*.) become abundant.

Synopsis

4.64. The interfaces between forest, open bog and mangrove vegetation are distinct and reflect the communities' ability to tolerate water logging and salinity. The interface between these three zones and the river bank is less discernable.

4.65. The forest zone with a drier, less saline and more compact soil has the highest species diversity. The area is Secondary/Disturbed Deciduous Forest undergoing succession due to clearance and grazing, and is therefore unstable[8]. Apart from a few medicinal herbs and shrubs there are no species of high ecological or commercial value and no endemic or rare species were identified. The macro/micro fauna species diversity is very low and with the low diversity avifauna reflects the high level of human disturbance.

4.66. The open bog zone has low species diversity typical of the clayey and waterlogged nature of the soil. Whereas the 1973 survey identified a few Ginger Lilies interspersed with herbs, shrubs and grass, the recent survey shows this alien invasive species[9] now dominates and further decreases ecological value. The

[8] *http://www.cifor.cgiar.org/docs/_ref/aboutcifor/factsheet/secondary_forest.htm* Center for International Forest Research, 2003

[8] *List of Alien Invasive Species in Jamaica*. Jamaica Clearing House Mechanism,2005.

[8] *Draft Wetland Policy*, Natural Resources Conservation Authority, Jamaica, 1996.

only other species to have survived are the mature trees. No endemics or rare species were observed. Even the few Coconuts are not healthy, seemingly infected with Lethal Yellowing disease.

4.67. The vegetation along the riverbank has high species diversity due to the influence of fresh water. The planting of Napier Grass and other species may have been a past attempt to train the river. Although faunal diversity is also high, the only endemic species observed were the Blackbird and Thatch Palm. No rare species were observed.

4.68. The mangrove zone at Turtle Crawle is a Fringe Mangrove Swamp[10] with the presence of different mangrove species reflecting changes in soil water and salinity. The White Mangrove can tolerate swampy areas but prefers drier conditions, whereas Red and Black Mangrove can to survive more saline conditions. The presence of Coconut, Almond, Bamboo and Giant Reed is not typical of Mangrove swamps but reflects the influence of freshwater and degrees of water logging. The Button Mangrove (*Conacarpus erectus*), a prevalent species in most mangrove areas in Jamaica, was not observed, suggesting the zone here is still in the process of development and cannot be considered stable. The faunal richness of the mangrove zone is also low, the only species of particular significance being the endemic American Crocodile, an endangered and protected species.

4.69. Notwithstanding this, the mangrove is important:

- For arresting Turtle Crawle River flood flows the mangroves reduce the erosion of coral in Turtle Crawle Harbour;
- for retarding water movement and trapping suspended materials the mangroves allowing the surface to build up and eventually dry out; and,
- For removing sediment before it enters the sea the mangroves reduce the potential for highly turbid flows to smother coral and fish spawning areas.

4.70. The American Crocodile (*Crocodylus acutus*) community is reported to comprise three individuals, one male and two females, or two males and one female, which may or may not be permanently resident. With the construction of the treatment plant they will either come to peaceful coexistence with their new human neighbours or decide to migrate elsewhere. Assuming they sustain the increase in noise and human presence during construction, coexistence is likely. However, apart from individual sightings such as during the recent survey, information about them is largely anecdotal. Particular questions need to be addressed to enable the best policy for their protection to be adopted:

- Do they reside in the area permanently or spend periods elsewhere?
- Is it the same individuals that are always present?
- Over what area of the Turtle Crawle wetlands do they range?
- Will the disappearance of household refuse and small domestic animals of present site occupiers deprive them of a significant source of food?
- Is such a small community, permanent or intermittent, so close the North Coast highway sustainable?

- Given that as an endangered species GoJ is committed to their protection, how can this best be achieved?

4.71. Overall, the diversity of floral species across the treatment plant site at Turtle Crawle is, at best; moderate, while the diversity of faunal species is very low. The conclusion of a previous study[11] in 1973 was that the area had no particular outstanding ecological features. Further degradation of the landscape in general and species diversity in particular has occurred during the intervening 33 years and the present study also finds little of ecological interest. The 1973 survey predicted the area would in time develop into firmer dryer land and this is how it has been evolving.

Marine Conditions

4.72. The North Coast of Jamaica is characterised by a shallow shelf with water often less than 10 m for distances of up to 150 m. Thereafter the sea bed slopes off and at a distance of 250-500 m from the shore drops steeply from a depth of 20-40 m to over 100 m within a distance often no more than 30 m. Tidal range is about 0.5 m. Dominant currents along the Port Antonio coastline are strongly orientated westwards[12] as shown in **Figure 4.12**. Embayments complicate the situation inshore but the uniform flow further out induces circulation in all but the smallest. Bathymetric data over the same area collected during the recent PAWSDP marine study are shown in **Figures 4.13**

4.73. After the tropical forests, ecological interest in Jamaica primarily focuses on its coral reefs. They were the first in the Caribbean to be studied and as many as 65 species of stony coral have been recognised They afford an important natural resource, providing the bulk of Jamaica's fisheries and marine bio-diversity, sources of beach sand on which tourism is based, and protection of the shoreline from high seas.

4.74. The majority of coral research in Jamaica has been carried out in Discovery Bay, some 100 km west of Port Antonio where the University of West Indies has its Marine Research Laboratory. The zonation of the coral there, shown in **Figure 4.14**[13], is similar to that elsewhere along the North Coast and for present purposes provides a reasonable model for the Port Antonio area.

4.75. Beyond the barren zone, the area of continuous shallow wave action, the most common coral is *Acropora cervicornis* which on the shallow terrace, 5-20 m depth, is dissected by sub-parallel sand drainage channels that terminates at a depth of 15-30 m. Beyond, on the edge of the drop-off into deep water, *Montastraea annularis* forms pinnacles with *Agaricia* sp. to depths of up to 70 m.

[11] *An Environmental Study of Turtle Crawl.* Wade, B. Environmental Consultants Services Limited, 1973

[12] From the 1996 Master Plan

[13] *Discovery Bay, Jamaica*. Gayle, P.M.H., and Woodley, J.D. Environment and Development in Coastal Regions and Small Islands. UNESCO.

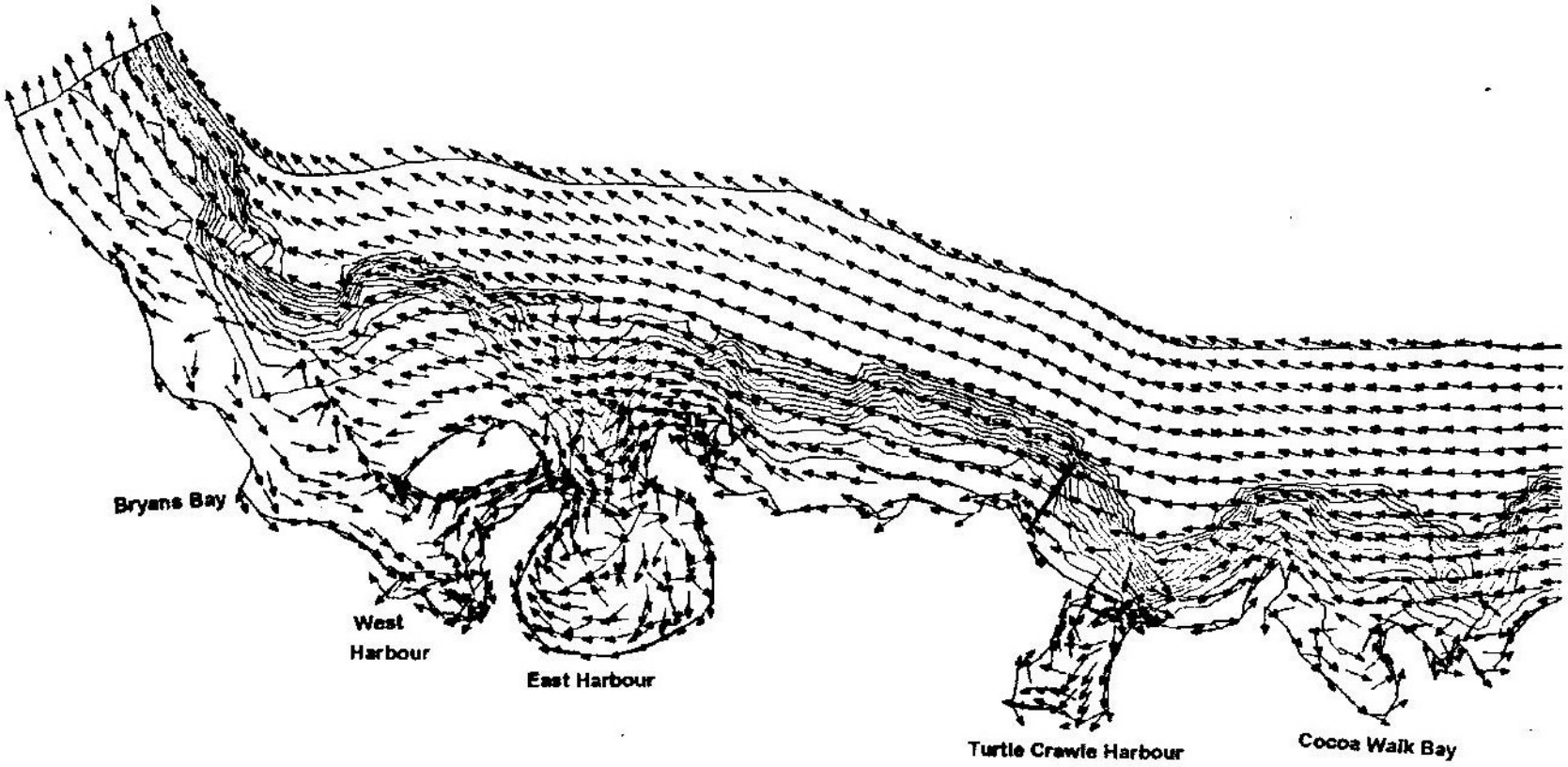


Figure 4.12. Dominant Currents along the Port Antonio Coast

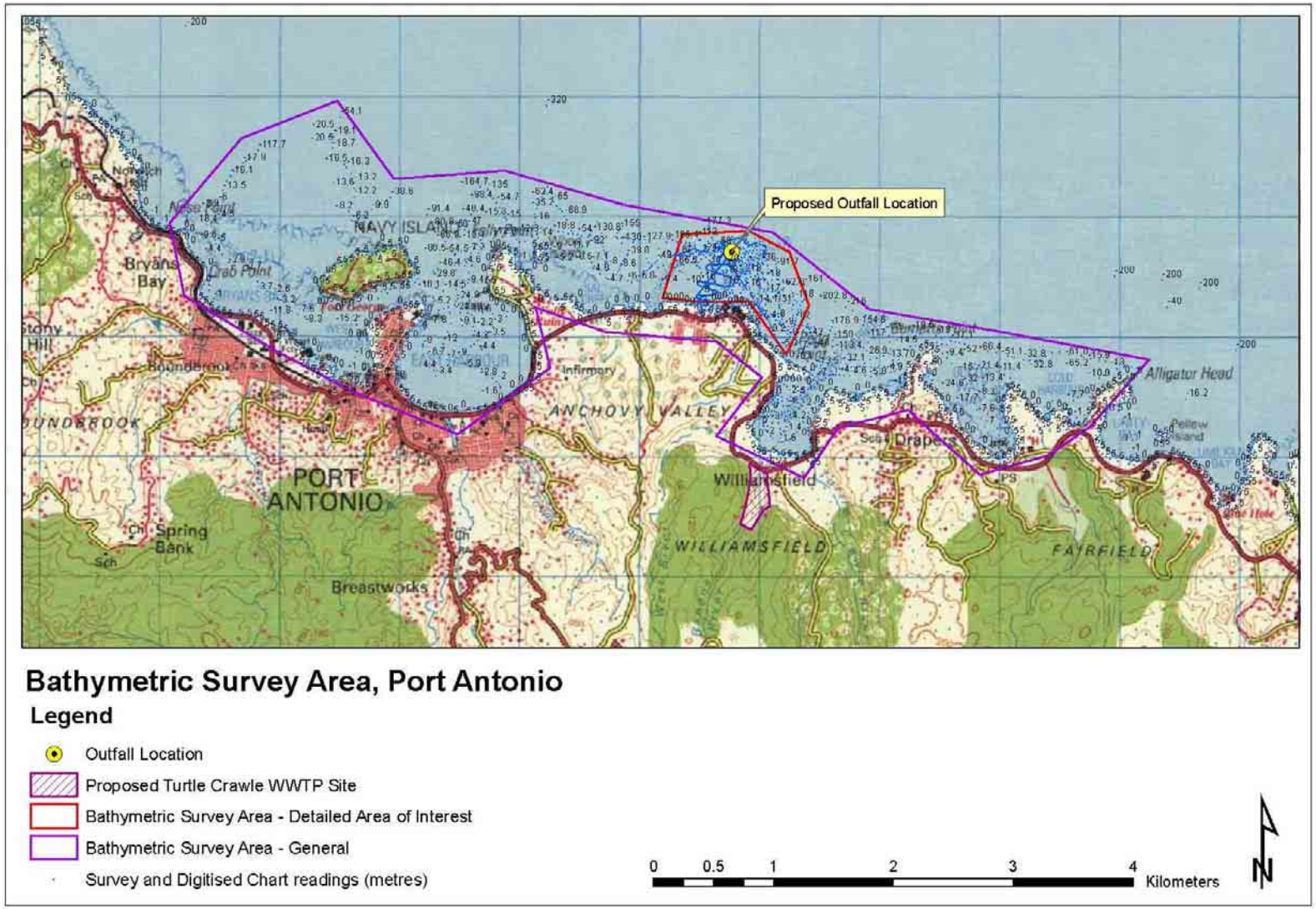


Figure 4.13. Bathymetric Data along the Port Antonio Coast

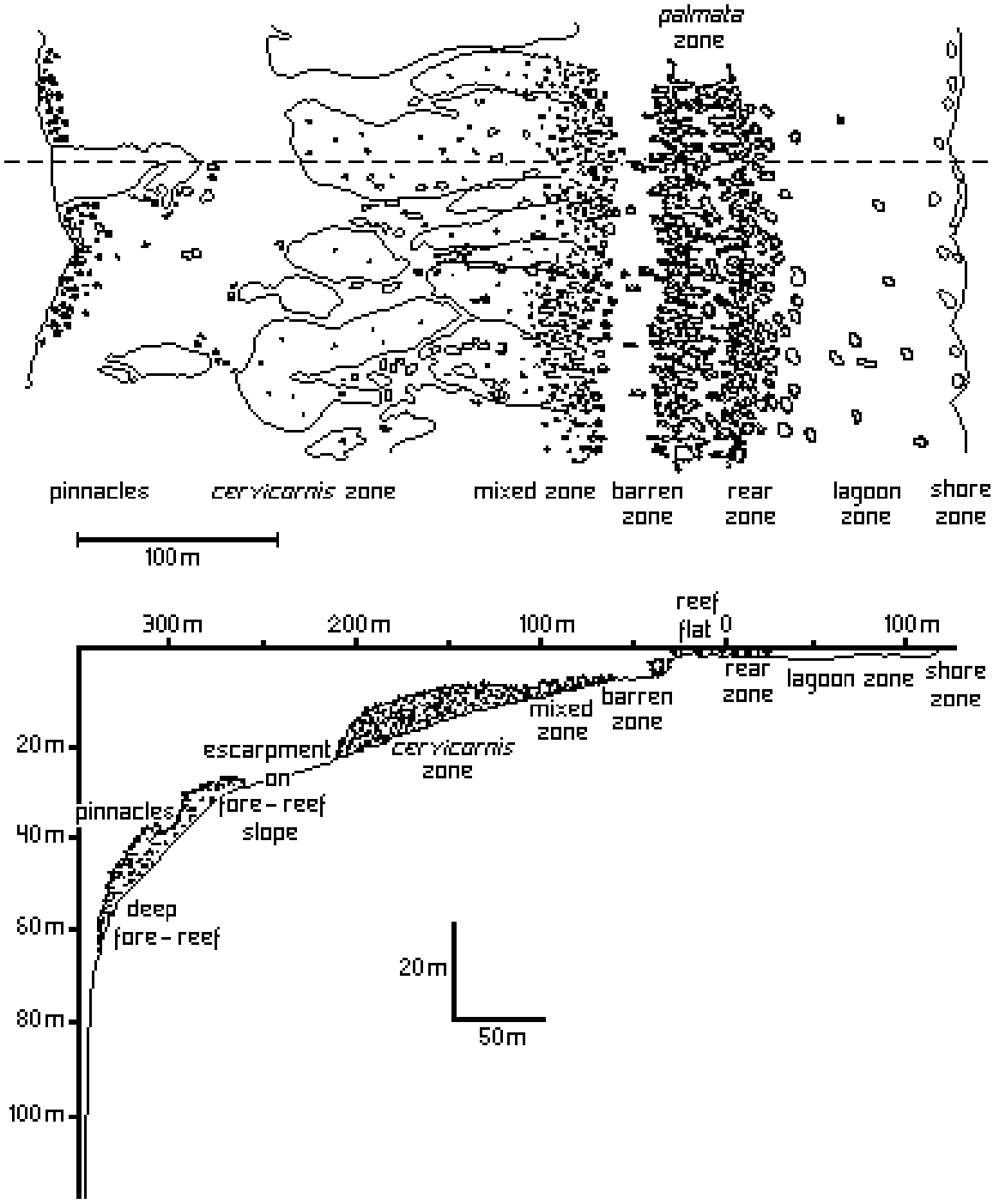


Figure 4.14. The Zonation of Coral on the North Coast of Jamaica

4.76. In most areas the reefs have been significantly degraded with coral being replaced by fleshy algae which overshadow coral and prevent them from settling, support limited fish populations, reduce water clarity and offer no coastal protection or new sand[14].The cause for this degradation is complex but factors include:

- **Hurricane damage:** Hurricanes Allen in 1980 and Gilbert in 1988 are now recognised to have inflicted severe damage on coral reefs. Recent hurricanes have also left damage but the full magnitude and extent may not be known for some years;
- **Surface water drainage:** After heavy rainfall watercourses discharge high volumes of suspended solids and nutrients, and areas in the immediate vicinity of river mouths may have reduced salinities;
- **Ground water discharge:** Foreshore and submarine freshwater springs are often high in nutrients, particularly nitrate from natural vegetation debris and water-rock interaction, and there is an inverse relation between nitrate and salinity, to which coral is very sensitive;
- **Natural erosion:** Storm surges and peak surface water discharges can seriously erode coral surfaces;
- **Over fishing:** The removal of herbivorous fishes has allowed the proliferation of algae which over-shade and smoother healthy coral;
- **Disease and Predation:** Diseases, such as White Band have had a serious effect on coral populations at times when they are most vulnerable, for example after suffering hurricane damage. The presence of the coral-eating snail *Coralliophila caribbea* has increased because its predators have been lost through over-fishing. After Hurricane Allan in 1980, 98% of surviving stony corals *Acropora cervicornis* were eliminated by disease and predation[15]. The sea urchin *Diadema antillarum* played an important role in maintaining a low level of algal cover on the corals until it was virtually eliminated by disease in 1983.
- **Deforestation and soil erosion:** The clearance of hillsides for agriculture has resulted in soil erosion, increasing the volumes of suspended solids and nutrients discharged into the sea;
- **Agricultural discharge: T**he discharge wash water from cattle sheds, pig stys and other hard standings puts large quantities of nutrients into rivers and ultimately the sea;
- **Port and harbour maintenance:** Dredging for the creation, expansion or maintenance of access to ports and harbours destroys coral and the dumping of dredged materials can smother them;
- **Shipping activities:** The dragging of anchors, the disposal of contaminated bilge water and the intentional dumping or accidental spillage of fuel pollute coral environments;
- **Untreated sewage discharge:** Uncontrolled discharge of untreated sewage increases nutrients, particularly nitrogen and phosphorous, leading to eutrophication and the growth of algae. Even absorption pits and septic tanks discharge nutrient-rich water into the surrounding soil, to drainage ditches and shallow groundwater, which eventually finds its way to the sea;
- **Direct human contact:** Most seriously the collection of coral for illegal trade, but also the removal of coral by dive tours and even the use of strong lighting for underwater photography can hinder coral;
- **Climate change:** Reefs are sensitive to long term increases in the average intensity or occurrence of storms, and rises in sea level;

[15] *Coral Reefs, Sewage, and Water Quality Standards*. Goreau, T.J., and Thacker, K. Caribbean Water and Wastewater Association Conference, Kingston, October 1994.
[15]*Predation on Caribbean Staghorn Coral: Threshold Models and their Implications.* Knowlton, N., J.C. Lang, B.D. Keller. *Proceedings of the 6th International Coral Reef Symposium*, **2**:83-88, 1988.

4.77. The increasing abundance and diversity of algae species suggests eutrophication has become a general phenomenon island-wide. Along the North Coast of Jamaica between 1977 and 1993 average coral cover dropped from 52% to 3% while the abundance of seaweed increased from 4 to 92%[16]. Each of the causes of reef degradation discussed above has been cited and the Port Antonio area has not been exempt, with eutrophication now reported to be visible in all the populated bays, but generally absent off un-populated shores.

4.48. The critical levels of nitrogen and phosphorous below which reefs remain healthy without being overgrown by weedy algae are suggested to be 0.014 mg/l N (0.040 mg/l NO^3) and 0.003 mg/l P (0.007 mg/l PO_4) respectively[17]. Port Antonio is, relative to other areas, little populated, but a survey of nitrate levels conducted in all major freshwater sources along the proposed Port Antonio Marine Park shoreline in 1994 showed even these would need to be diluted between 2 and 45 times to meet these requirements. Port Antonio's freshwater discharge are therefore not 'coral-friendly'.

4.79. More recently, there may have been some degree of recovery rather than, as previously assumed, continual decline[18], with areas showing an increased population of the sea urchin *Diadema antillarum* recording less algal cover and more juvenile coral. This emphasizes the importance of algae-feeding organisms in the maintenance of healthy reefs. It also supports one school of thought that the key to controlling the abundance of algae is to increase sea urchin, fish and other herbivore populations rather than control nutrients. With the exception of rare epidemics it is easier to control the decline in fish and other beneficial species through the enforcement of existing fishing regulations, than significantly reduce the input of nutrients, many of which originate well way from the coast.

The Route of the Proposed Long Sea Outfall

4.80. The means of ultimate disposal proposed for treated effluent from the Turtle Crawle treatment plant is to the sea via a long sea outfall with a landfall just west of Daniel's Harbour and outflow diffusers some 500 m NNE in water nearly 29 m deep. The wealth of detailed bathymetric information collected as part of the present project is shown on **Figure 4.15** and summarised on **Figure 4.16**.

4.81. The site of the outfall was first identified in the 1996 Master Plan and confirmed subject to detailed survey in the 2002 Review. As part of the present project the precise route has been determined from the biophysical survey of sea bed along the previously identified route, with the final line determined so as to coincide with sand channels through the reef rather than traversing healthy live coral.

[16] Hughes, T. P. Science 265, 1994.
[17] *Modification of Benthic Community Structure by Natural Eutrophication: The Belize Barrier Reef.* Lapointe, B., Littler, M. and Littler, D. Proceedings 7th International Symposium on Coral Reefs, 317-328, 1993.
[18] *Recovery of* Diadema antillarum *reduces Macroalgal Cover and Increases Abundance of Juvenile Corals on a Caribbean Reef*. Edmunds, P. J. & Carpenter, R. C. Proc. Natl. Acad. Sci. 98, 2001

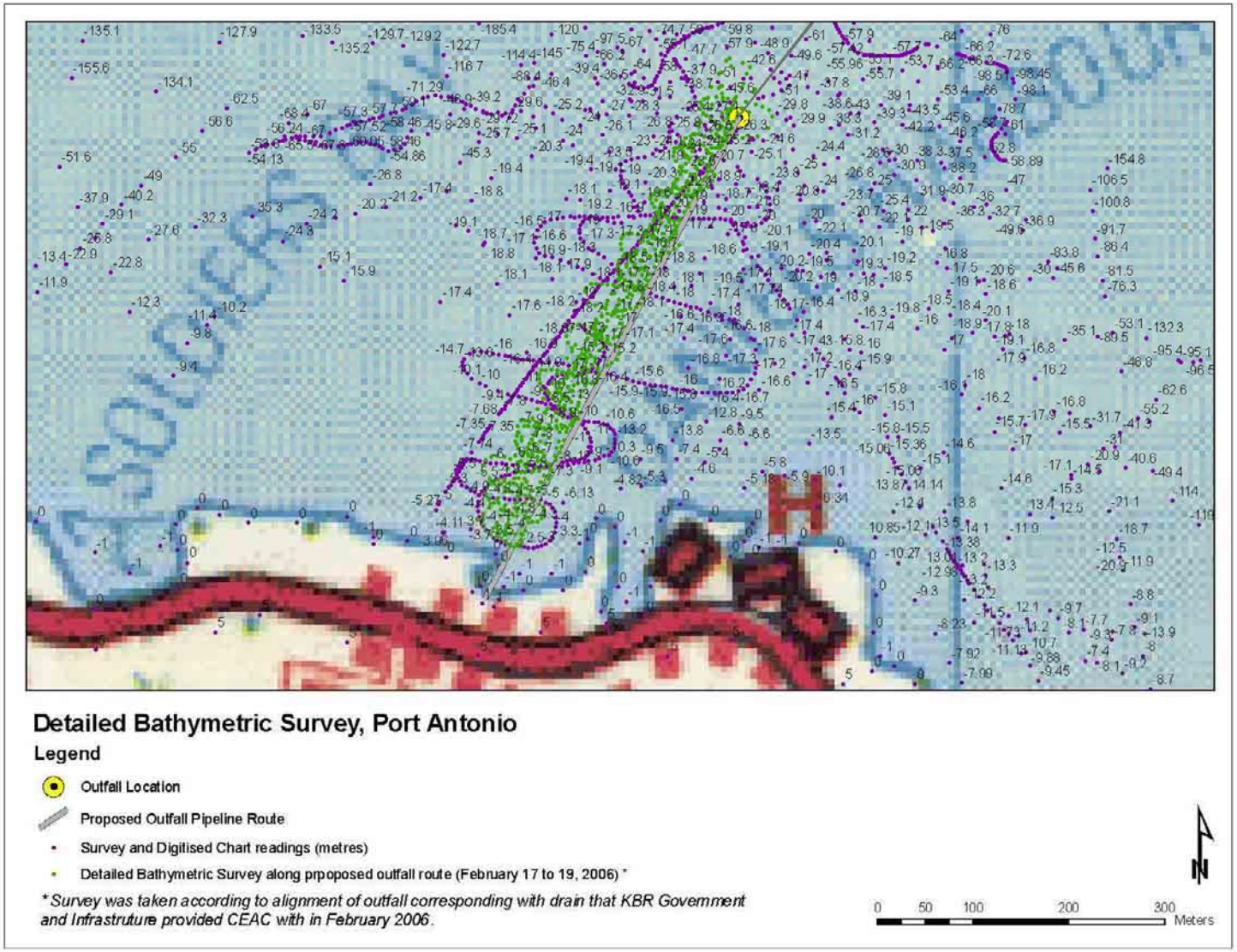


Figure 4.15. Bathymetric Data in the Vicinity of the Proposed Long Sea Outfall

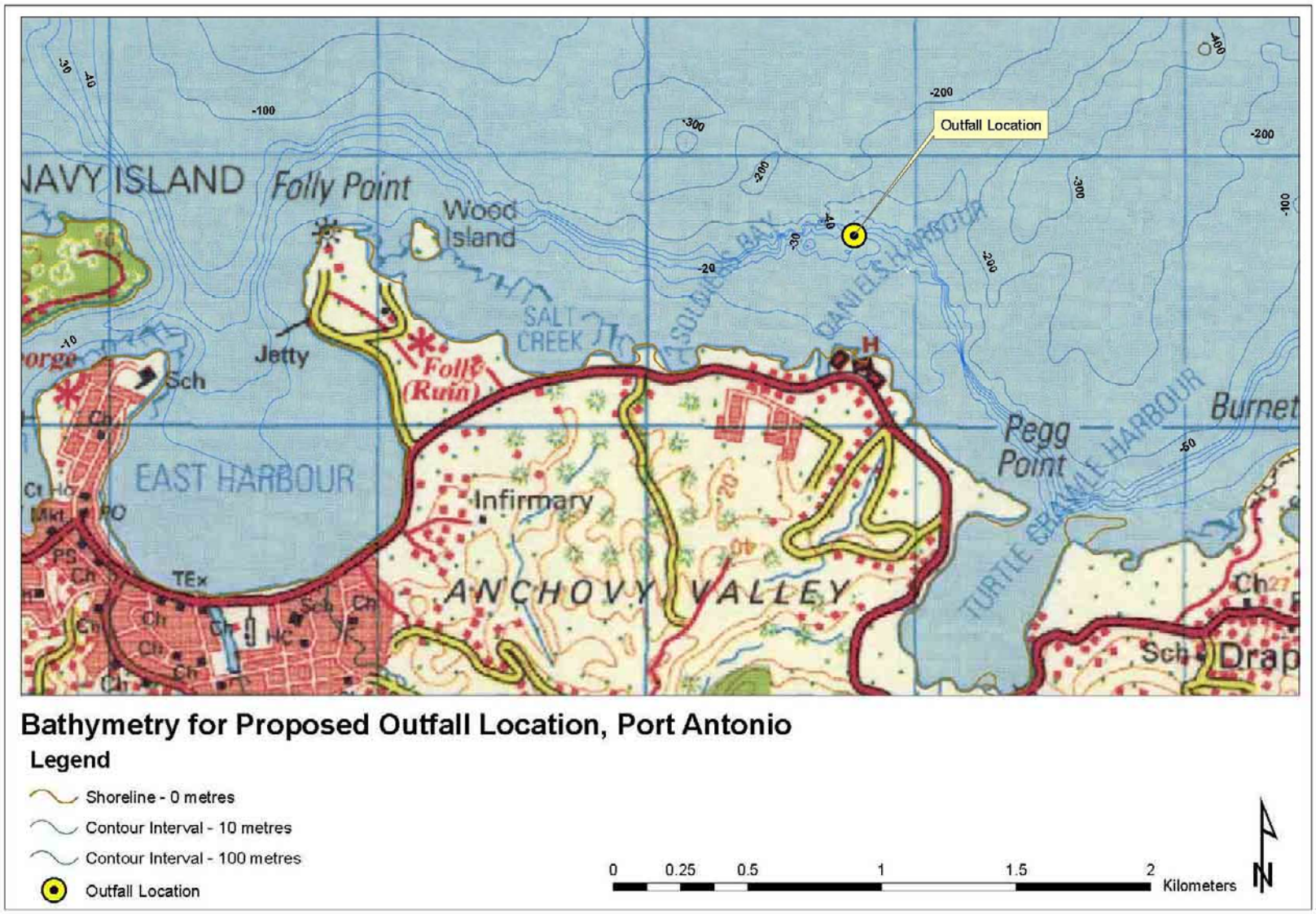


Figure 4.16. Summary of Bathymetric Data in the Vicinity of the Proposed Long Sea Outfall

4.82. The proposed route has been videotaped to record sea bed conditions and the status of coral communities. The salient features for each 10 m interval from the end of the outfall and working inshore are given in **Table 4.9.** The percentage of coral cover for each interval are also plotted in **Figure 4.17**.

Table 4.9. Dominant Seabed Characteristics of the Proposed LSO Route

Location	Coral Cover	Dominant Characteristics
0-10m	3%	Thick deposits of bare coarse sand and low density small dead coral rubble and sponge fragments with intermittent macro-algae covered dead coral head. At 40m a significant reef formation (R1) is located to the west of the transect line. At 40-50m, the transect is parallel to the base of this reef formation in a sand channel.
10-20m	11%	
20-30m	4%	
30-40m	3%	
40-50m	10%	
50-60m	7%	
60-70m	18%	Single live reef section, the majority intermittent portions are dead with significant macro-algal growth. Some bare sand and rubble. At 65-75m, the transect crosses a sand channel and clips reef (R2) east of R1.
70-80m	3%	Thick deposit of bare coarse sand and low density small dead coral algae encrusted rubble and sponge fragments.
80-90m	15%	Macro-algal encrusted dead coral and rubble fragments.
90-100m	Nil	
100-110m	20%	Dead coral colonised by boring sponges, macro and calcareous algae and occasional live soft corals with intermittent hard reef building mound star corals.
110-120m	7%	
120-130m	26%	
130-140m	23%	
140-150m	15%	
150-160m	25%	
160-170m	9%	Reef margins sediment impacted transitioning to bare sand.
170-180m	Nil	Bare sand.
180-190m	Nil	
190-200m	Nil	
200-210m	Nil	
210-220m	Nil	Bare sand with small macroalgae cluster
220-230m	Nil	
230-240m	30%	Transition from bare sand to live reef margins with some hard coral specimens. Dead coral colonised by macro and calcareous algae and occasional live soft corals.
240-250m	33%	Live reef impacted by significant algal competition, overgrowth and coral mortality
250-260M	21%	
260-270m	21%	
270-280m	34%	
280-290m	Nil	Bare sand
290-300m	Nil	
300-310m	Nil	Bare sand with macro-algae encrusted dead coral rubble.
310-320m	Nil	
320-330m	11%	Filamentous macro and calcareous algal encrusted and sedimented dead coral heads and rubble fragments with intermittent live coral cover under stress.
330-340m	27%	
340-350m	22%	
350-360m	16%	
360-370m	24%	
370-380m	19%	
380-390m	18%	
390-400m	13%	
400-410m	11%	Part sediment and filamentous macro-algae encrusted coral rubble; part clear, hard and unfouled substrate.
410-420m	31%	Substrate clear and hard with low algae density due to presence of invertebrate grasing urchins. High juvenile coral recruitment.
420-430m	28%	
430-440m	30%	
440-450m	24%	
450-460m	13%	Increasing in macro-algae, less clean clear hard substrate.
460-470m	7%	Macro-algae covered dead coral rubble and highly sedimented substrate surface.
470-480m	Nil	
480-490m	2%	
490-500m	7%	

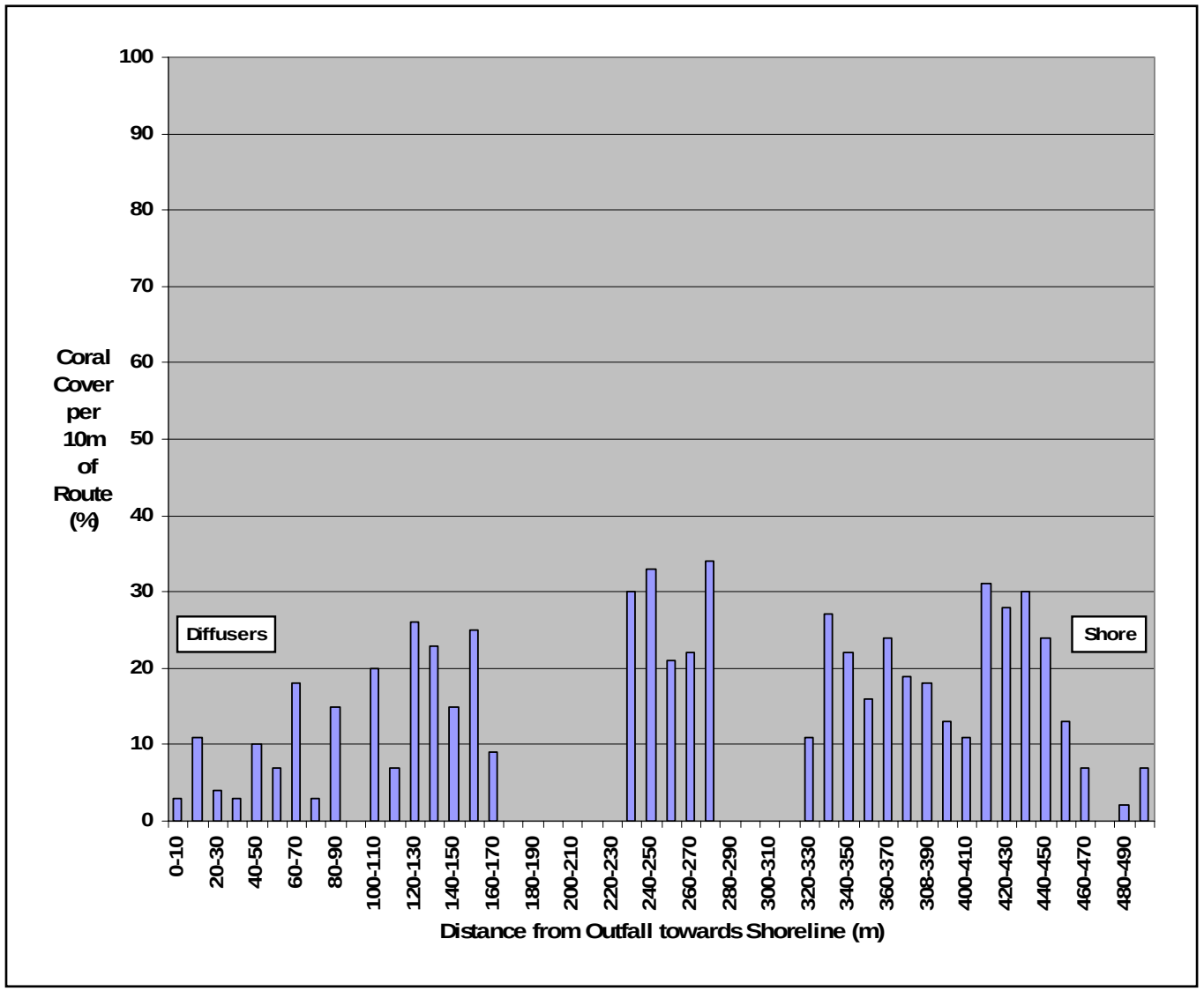


Figure 4.17 Coral Cover per 10 m Section of the Proposed Outfall Route

4.83. The reefs cannot easily be divided into discrete classical fringing and bank reef systems. Rather, there is a gradual transition towards the shore from shore-perpendicular and radiating deepwater 'bank' reef spurs to intermittent sand zones and ultimately to a shallow wave swept/scoured hard substrate platform at the base of the shoreline cliffs. Coral coverage, formation diversity and relative reef health is highest along the flanks of offshore reef sections, at depths of 25-30 m, and lowest on the reef crest and approaching the bare sand substrate. The main species present are listed in **Table 4.10**.

Table 4.10. Principal Species observed along the Proposed LSO Route

Common Name	Scientific Name
Star Coral	Madracis spp, Montastrea cavernosa, Montastrea faveolata, Solenastrea spp
Boulder star coral	Montastrea annularis
Bumpy star coral	Montastrea franksi
Starlet coral	Siderastrea siderea, Siderastrea radians
Brain coral	Diploria strigosa
Mustard hill coral	Porites astreoides
Finger coral	Madracis spp, Porites spp.
Maze coral	Meandrina meandrites
Saucer coral	Agaricia fragilis, Agaricia lamarcki,
Scroll coral	Agaricia undata
Lettuce coral	Agararicia agarites
Blade fire coral	Millepora complanata
Bent Sea rod	Plexaura flexuosa
Porous sea rods	Pseudoplexaura
Slit pore sea rod	Plexaurella spp
Sea fans	Muricea pinnata, Gorgonia spp
Sea plume	Muriceopsis flavida, Pseudoptogorgia spp.
Sargassum algae	Sargassum spp
Y Branched algae	Dichyota spp.
Oval blade	Caulerpa spp.
Tubular thicket	Galaxaura spp.
Y twig	Amphiroa spp.
Reef cement	Porolithon pachydermum
	Halimeda

4.84. Macro-algae are most abundant 200-400 m from the outfall where numerous hard coral are noticeably suffering increasing mortality due to bleaching and other diseases, colonization by encrusting and boring sponges, and sedimentation. Algae are least close inshore where there are relatively high populations of the black grazing sea urchin *Diadema antillarum*, greater juvenile coral recruitment, and young fish.

4.85. There was a significantly low abundance of all types of reef-resident, territorial and transient fish assemblages; herbivores, top predators and even cryptic species. Heavy fishing was evident from the large fish-pots deployed. There was also an absence of significant assemblages/populations of motile macro-fauna. Without intervention to protect the reefs from over-fishing, mortality will increase and the progression towards an even less species diverse reef will continue unabated. Even today, the reef is experiencing stress and is in places approaching significant ecological recession.

4.86. The outermost 300 m of the proposed outfall route almost coincides with a channel of sand substrate and minor adjustments in route alignment, 2-3 m, will be made to maximise the use of this channel and significantly mitigate the physical destruction of the reefs.

4.87. From 300-400 m from the end of the outfall there is little option but to cross reef that is already experiencing mortality, macro-algal overgrowth/out-competition, bleaching and disease. An alternative route on sandy substrate is available but would require changes in orientation and the adoption of both unacceptably complicated and more expensive construction.

4.88. There is a c.40m wide zone of 'sensitive habitat' from 410 to 450 m from the end of the outfall (50-90 m from the shore) where the substrate is clean, hard, devoid of significant macro-algal overgrowth and actively supporting juvenile coral recruitment.

4.89. With the route alignment already amended to protect deeper water communities, there is no practical alternative to the pipeline crossing this zone. However, its footprint is relatively small and juvenile coral specimens could be removed and transplanted in the vicinity or replaced in the same spot after the pipeline has been buried.

4.90. It is therefore possible to route the proposed outfall with minimal significant impact upon reef ecosystem providing the pipe alignment is amended to follow sandy bottom substrate for much of its length and a limited number of live organisms are relocated.

Sea Water Quality

4.91. Water sampling to monitor the quality of sea and influent river water within the Port Antonio area was undertaken for both the 1996 Master Plan and during the recent marine survey. The sampling locations used in the Master Plan and those used for routine monitoring by NEPA are shown in **Figure 4.18**. Of the Master Plan sites, 13 were within 5 km of the proposed outfall location and the results from those most relevant to the present study are given in **Tables 4.11 and 4.12** for sea water and river water respectively. During the present EIA study, further background water quality data was collected from Turtle Crawle and the proposed outfall site, the results of which are given in **Table 4.13.**

4.92. The results show that coastal waters are significantly impacted by sewage discharges from the shore and via polluted freshwater discharges from rivers and storm water drains. During the most recent sampling the highest nitrate values were recorded in the vicinity of the proposed long sea outfall.

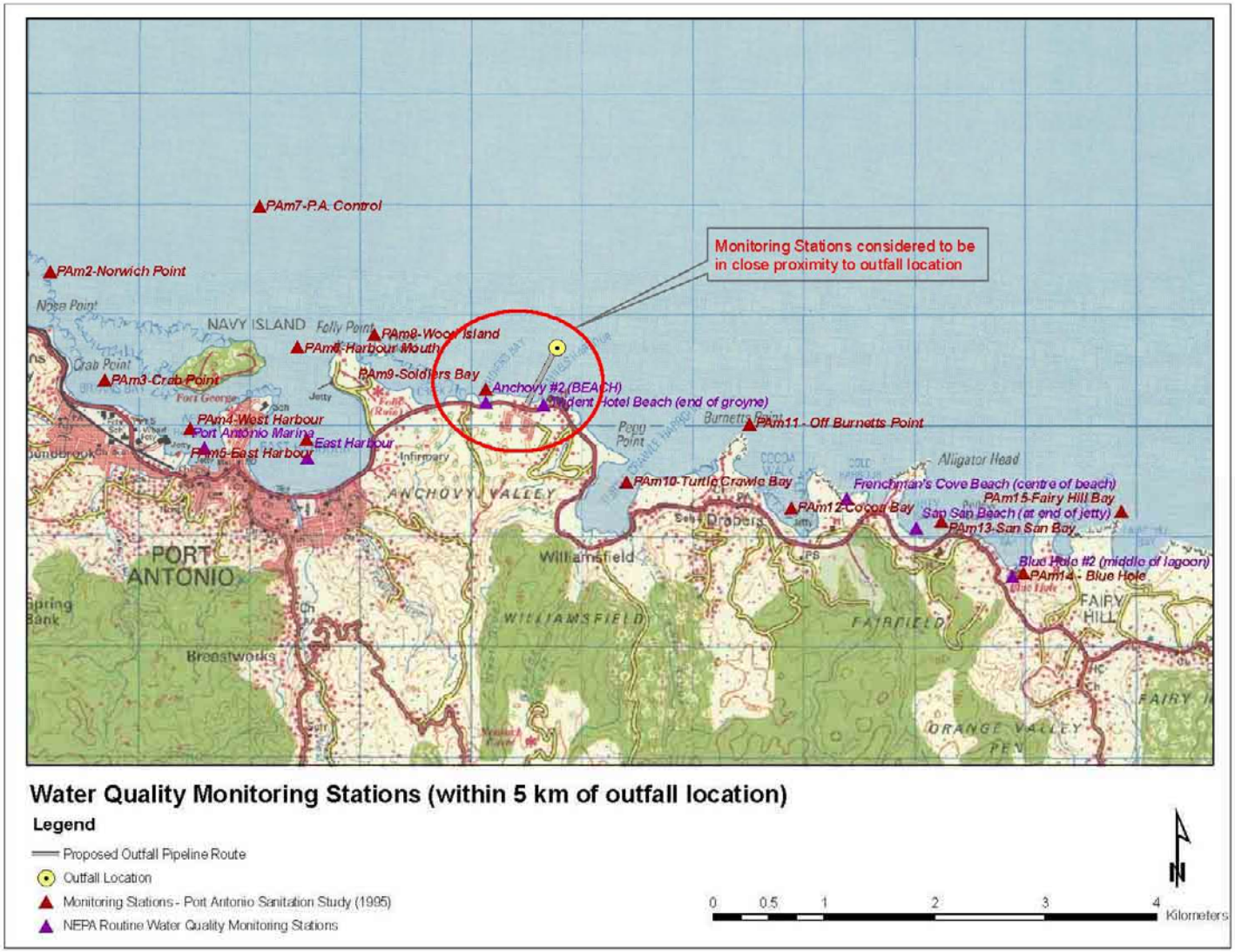


Figure 4.18. Sea Water Quality Sampling Locations

Table 4.11. Sea Water Quality Data January to November 1995

Location	1995	pH	Total Suspended Solids (mg/l)	Total Nitogen (µmols/l)	Ammonia (µmols/l)	Nitrate (µmols/l)	Total Phosphorous (µmols/l)	Phosphate (µmols/l)	Dissolved Oxygen (mg/l)	Biochemical Oxygen Demand (µmols/l)	Total Coliforms (MPN/100ml)	Faecal Coliforms (MPN/100ml)
Soldier's Bay	Jan	8.33			<1.11	2.53	0.21	<.11	6.7	1.28	<100	<100
	Feb	8.12	10.6	9.92	<1.11	7.27	0.95	0.11		0.17	<100	<100
	April	8.02	6.9	4.33	<1.11	2.71		0.11	6.5	0.40	<100	<100
	June	8.27	8.8	1.83	1.11	0.10	2.26	0.11	6.4	0.65	0	0
	Aug	8.15	3.1	2.45	1.11	0.56	0.53	0.11	6.6	0.30		
	Nov	8.26	5.3		1.11	0.39	0.84	0.11	6.6	0.50	0	0
Turtle Crawle Harbour	Jan	8.22			1.11	<0.71	0.11	<.11	6.0	1.03	1,600	100
	Feb	8.09	10.3	10.06	1.11	7.27	1.79	0.11		0.38	>10,000	>100,000
	April	8.03	6.9	7.40	1.11	2.79		0.11	6.3	0.30	<100	<100
	June	8.28	2.9	5.07	4.44	0.07	1.61	<0.11	6.0	0.23	2,800	0
	Aug	8.18	3.9	2.69	1.11	0.59	0.11	0.11	7.4	0.70	4,600	930
	Nov	8.02	6.9		1.11	0.38	0.11	0.11	6.5	0.60	0	0
Off Burnett's Point	Jan	8.31			1.11	2.53	0.11	<.11	6.0	0.99	<100	<100
	Feb	8.21	9.1	9.58	1.11	6.35	0.32	<0.11		0.28	10,000	10,000
	April	8.05	4.5	6.04	1.11	2.50		0.11	6.2	<0.1	100	<100
	June	8.27	3.9	11.08	10.00	0.66	1.94	<0.11	6.7	0.45	4,300	0
	Aug	8.21	3.2	1.91	1.11	0.05	0.53	<0.11	7.7	0.42	930	0
	Nov	8.04	4.9		1.11	0.05	0.21	0.11	6.9	0.90	400	400

Location	1995	Turbidity (NTU)	Copper (ppb)	Manganese (ppb)	Zinc (ppb)	OC Residue (ppb)	OP Residue (ppb)
Soldier's Bay	Nov	0.52					
Turtle Crawle harbour	Feb		57.00	<2	81.00	<0.004	<0.004
	Nov	0.63	26.60	23.00	28.10	0.299	trace
Off Burnett's Point	Nov	0.54					

Table 4.12. River Water Quality Data January to November 1995

Location	1995	pH	Total Suspended Solids (mg/l)	Total Nitogen (µmols/l)	Ammonia (µmols/l)	Nitrate (µmols/l)	Total Phosphorous (µmols/l)	Phosphate (µmols/l)	Dissolved Oxygen (mg/l)	Biochemical Oxygen Demand (µmols/l)	Total Coliforms (MPN/100ml)	Faecal Coliforms (MPN/100ml)
West River	Jan	7.60				<0.71						
	Feb	7.77	0.3	22.77	<1.11	21.06	1.47	0.11		0.27	>10,000	>100,000
	April	7.94	13.6	254.60	1.67	5.79		0.32	7.8	1.47	>20,000	>200,000
	June	7.95	14.6	23.10	8.33	13.57	1.94	0.63	7.7	0.38	15,000	1,500
	Aug	7.90	6.5	15.26	0.7	10.71	0.95	0.63	7.1	0.90	>24,000	>240,000
	Nov	7.61	0.9		1.11	12.85	1.05	0.53	6.0	0.98	400	400
Banana River	Jan	7.97			3.58	7.33	11.89	0.11	6.6	1.17	1400	<100
	Feb	7.56	1.3	11.70	<1.11	10.63	1.68	0.21		0.40	10,000	>100,000
	April	8.07	3.6	6.54	<1.11	1.86		0.42	6.6	2.65	127,000	8,8000
	June	7.96	2.0	20.32	9.44	10.00	3.23	0.84	8.0	0.53	9,300	1,500
	Aug	7.58	5.0	7.58	0.0	5.00	0.84	0.21	8.2	0.60	11,000	15,000
	Nov	7.98	4.2		1.11	7.86	1.36	1.15	8.5	0.53	4300	4300
Turtle Crawle River	Jan	8.22			2.15	16.93	64.74	0.00	4.0	1.32	>5000	100
	Feb	8.10		14.28	7.88	11.87	0.84	0.21		0.50	>10000	>100000
	April	8.00	2.0	21.51	3.33	11.43		0.74	4.0	0.22	>20000	19000
	June	7.67	4.4	22.81	5.56	17.86	1.61	0.21	7.0	0.75	4300	4300
	Aug	7.52	19.4	17.30	0.7	2.14	0.95	0.42	5.2	1.53	>24000	>240000
	Nov	7.73	10.0		1.11	16.43	1.89	1.89	7.2	0.68	46000	46000

Location	1995	Turbidity (NTU)	Copper (ppb)	Manganese (ppb)	Zinc (ppb)	OC Residue (ppb)	OP Residue (ppb)
West River	Nov	0.75					
Banana River	Nov	2.94					
Turtle Crawle River	Feb		57.00	<2	33.00	0.229	<0.004
	Nov	6.55	10.50	12.00	5.50	trace	trace

Table 4.13. Water Quality Data February 2006

Parameter	Units	Turtle Crawle						Proposed Outfall Route	
		Banana River	West River	TC River Upstream	TC River Mouth	Harbour Mid-Bay	Harbour Mouth	300m from Shore	500m from Shore
Turbidity	NTU	0.14	0.42	0.08	0.43	1.8	0.33	0.24	0.11
pH		8.3	8.3	8.2	7.9	8.3	8.3	8.3	8.3
Conductivity	µmho/cm	370	386	396	8,680	49,300	50,100	50,100	49,600
Total Solids	mg/l	202	201	208	5872	39,381	39,641	40,061	40,255
Total Alkalinity	mg/l	177	189	194	563	751	939	1,127	1,127
Total Hardness	mg/l	200	204	211	1358	6,206	9,309	6,594	6,594
Nitrate	mg/l	1.2	1.8	2.2	2.1	2.8	2.6	2.7	2.9
Calcium	mg/l	69.1	54.4	71.7	77.7	310	621	466	388
Magnesium	mg/l	6.7	16.6	7.8	283	1,320	1,885	1,319	1,367
Chloride	mg/l	7.0	8.0	7.0	2,000	17,000	28,000	18,000	19,000
Orthophosphate	mg/l	0.14	0.11	0.15	0.09	0.01	0.01	0.06	0.04
BOD_5	mg/l	0.10		0.25	0	0.20	0.35	0.45	0.25
Total Coliforms	MPN/100 ml	300	16,000	280	1,600	<2	<2	<2	<2
Faecal Coliforms	MPN/100 ml	130	5,000	220	170	<2	<2	<2	<2

Legal Status of Habitats

4.94. The proposal for the nearly 18 km of coastal zone from the mouth of the Rio Grande in the west to Fairy Hill in the east to be designated as *The Port Antonio Marine Park*, as shown in **Figure 4.19,** has been under consideration for more than 10 years[19] but no formal recognition or protected status has yet been granted. The ability to reduce pollution from raw sewage discharges along this coast provided by PAWSDP may encourage formal acceptance.

4.95. The area extending from the locally-recognised Blue and John Crow Mountains National Park to the coast between West River and Salt Creek Bay, shown in **Figure 4.20**, has been proposed as a *Conservation Corridor and Buffer Zone* to accord with GoJ's *Ridge to Reef* policy. This has also been under consideration for the last decade and similarly awaits approval. The area contains several unsewered villages and what was once considered a prime site, the lower Turtle Crawle Valley, is, as discussed above, already seriously degraded and of little ecological interest.

4.96. Notwithstanding this, it was never intended that within the Marine Park or the Buffer Zone development would be barred; merely that it should be implemented is accordance with a sound and sustainable environmental management policy.

Conservation Practices

4.97. Over the last decade the Jamaican Government has embarked on a number of initiatives towards the effective management conservation and protection of the natural resources within the context of sustainable development[20] and Section 3 of the present report has highlighted some of the large body of statutes that seek to address environmental protection. Of particular significance to the present project are the *Wildlife Protection Act* and the *Endangered Species Act*. As is normal, enforcement of these regulations is somewhat more difficult in practice. Recent policy initiatives and draft proposals related to the management of natural resources and the promotion of sustainable development include *Towards a Beach Policy for Jamaica*, the *Coral Reef Protection and Preservation Policy and Regulation*, and the *Wetlands Policy*.

4.98. Portland is fortunate to have one of leading and most active local environmental NGO's, the Portland Environmental Protection Agency (PEPA) who are proactive in all conservation issues throughout the parish.

[19] Before the publication of the 1996 Master Plan
[20] Jamaica's Commitment to the Conservation and Management of Natural Resources: Ten Years in Retrospect. NEPA, March 2002.

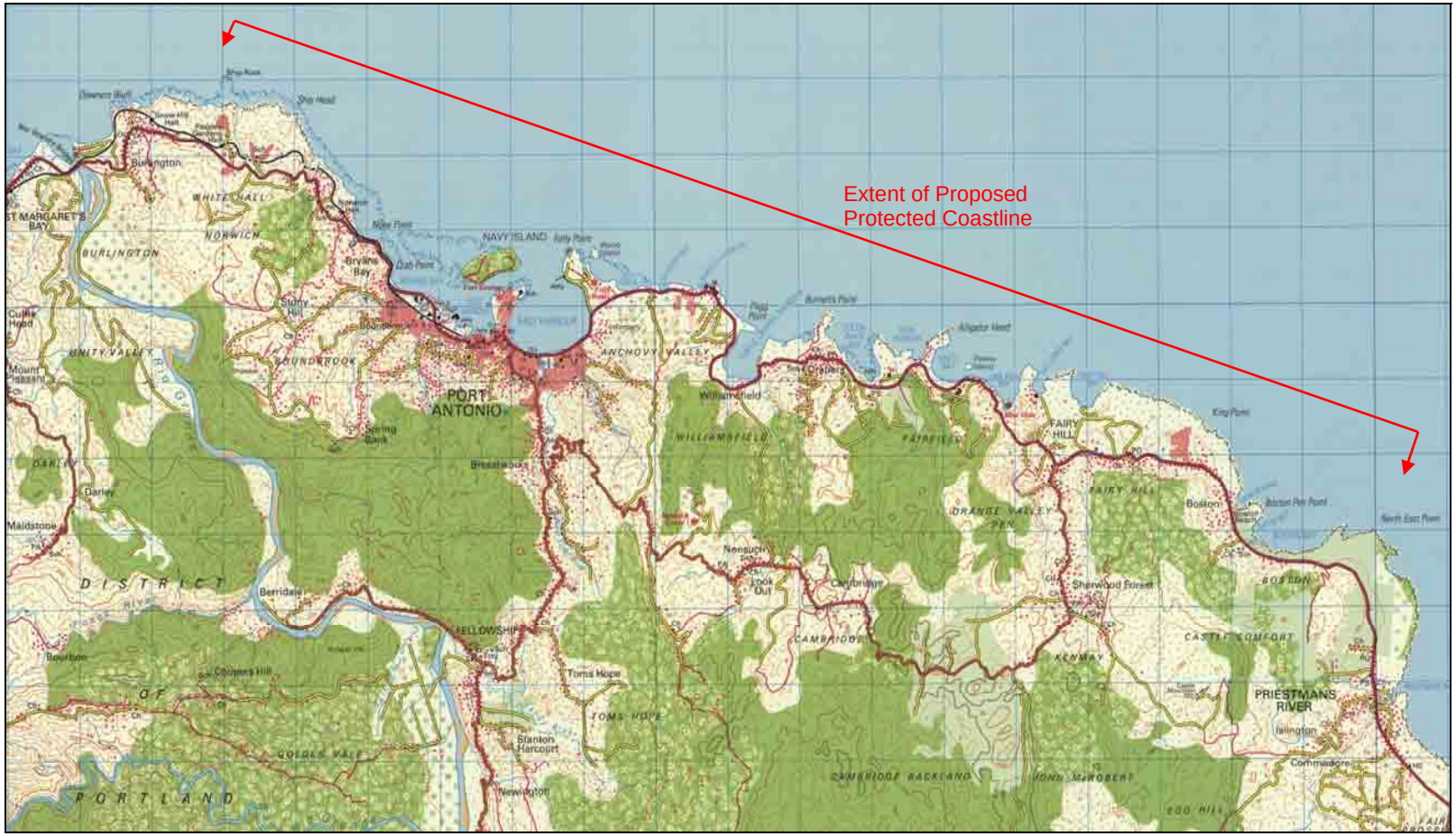


Figure 4.19. The Proposed Port Antonio Marine Park

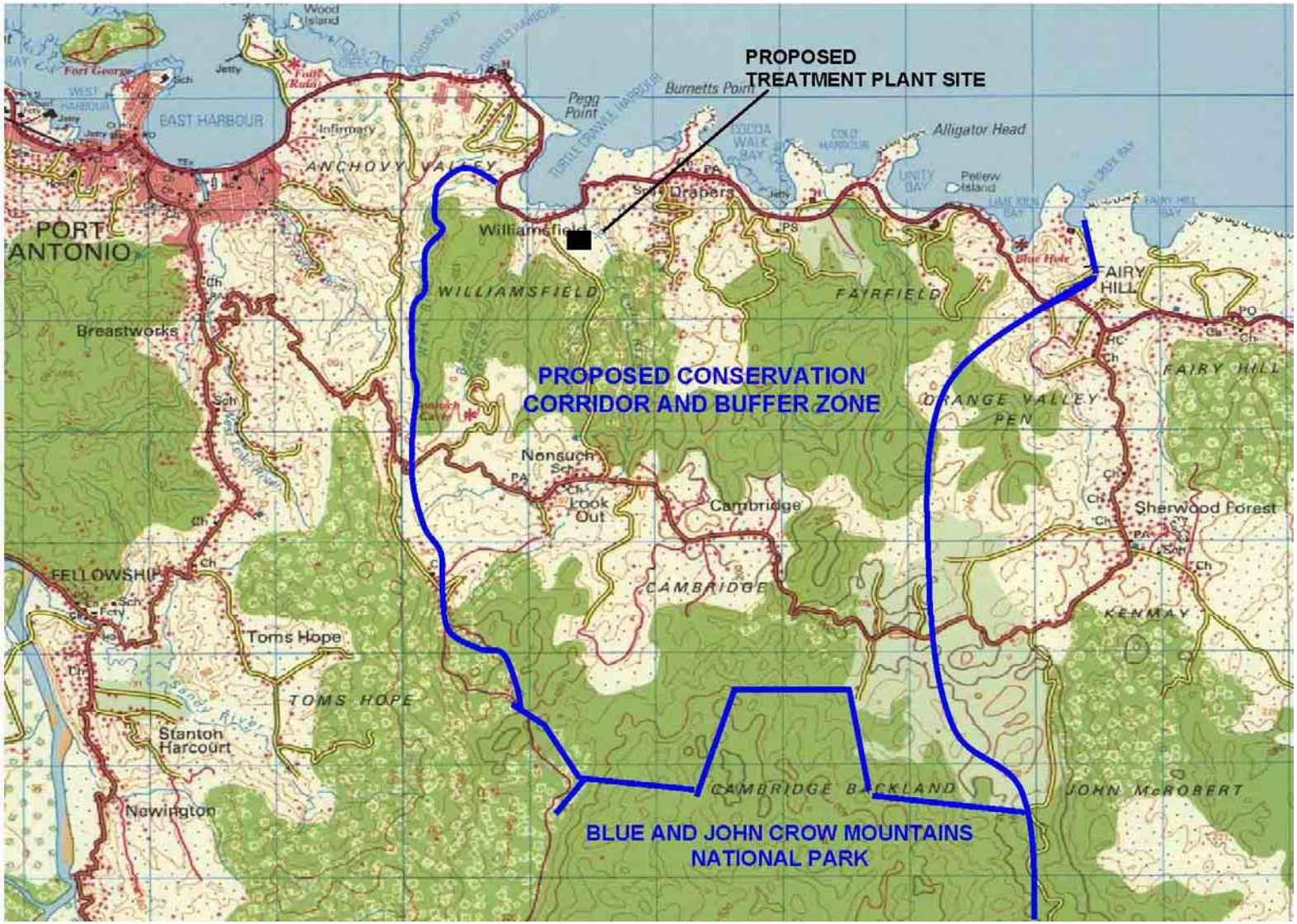


Figure 4.20. The Proposed Conservation and Buffer Zone

Air Quality and Noise

4.99. Air pollution in Jamaica mainly comes from industrial activities and motor vehicles. The main industrial air polluters are bauxite/alumina mining and processing, electricity and steam generation, cement and lime manufacture, chemical and petroleum refining. The motor vehicle fleet doubled between 1993 (171,000 vehicles) and 1999 (348,000 vehicles). Even before this increase vehicle contributions to air quality were substantial[21] as shown in **Table 4.14**.

Table 4.14. Estimated Emissions from Motor Vehicles 1993

Emission	Quantity
Carbon Dioxide (CO_2)	65,415 tonnes
Nitrous Oxides (NOx)	11,230 tonnes
Volatile Organic Carbons (VOCs)	9,867 tonnes
Lead (Pb)	156.8 tonnes

4.100. GoJ has been successful at reducing the per capita consumption of ozone-depleting chlorofluorocarbons (CFCs) from 424 tonnes in 1990 to 49 tonnes in 2000.

4.101. While there is currently no island-wide routine air quality monitoring a number of standards and regulations have been introduced to prevent further deterioration. These include:

- Ambient Air Quality Standards 1996;
- Vehicle Emission Standards 1996;
- Stack Emission Standards 1996; and,
- Ambient Air Quality and Stack Emission Regulations (Draft) 1999.

4.102. The vehicle emission standards currently apply to heavy duty vehicles, light duty vehicles and light duty trucks such as those common on construction projects. Other than motor vehicles, there are no particularly significant air polluters in Port Antonio.

4.103. The Noise Abatement Act of 1997 primarily deals with the noise generated at public and political meeting, through the use of public address and other amplification equipment. Where a noise occurs in the vicinity of any dwelling house, hospital, hotel infirmary, nursing home or guest house between 0200 and 0600 hours on a Saturday or Sunday morning and is audible for a distance exceeding 100 m it is automatically presumed to be causing annoyance. For other days of the week the prescribed time period is midnight to 0600 hours.

[21] From NEPA web site.

4.104. The *Ambient Air Quality and Stack Emission Regulations* have still to be enshrined in law but NEPA routinely apply them when assessing permit and licence applications. The essential requirements may be summarised as follows:

- In respect of air quality,
  Particulate Matter up World Bank Health and Safety Guidelines to 10 micrometres, PM_{10}, must not exceed 150 microgram/m^3 in any 24 hour period; and,
- In respect of noise,
  the maximum allowable limit is 70 dB(A) 50 m from the perimeter of the site on which the noise is emitted.

4.105. There are no Jamaican limits on sulphur dioxide, nitrous oxides, carbon monoxide or other air quality parameters regulated in other countries. There is also no differentiation of acceptable noise levels between day and night, or between residential, commercial and industrial areas. Given that the majority of people are unable to sleep soundly with ambient noise greater than about 50-55 dB(A), the requirements would seem lax.

Indigenous People

4.106. The Blue Mountains were once the stronghold of the Windward Maroons[22] and communities still remain at Moore Town, 16 km south of Port Antonio and at Nanny Town, a further 16 km south-west on the north-eastern flank of Blue Mountain Peak. Moore Town, the largest Maroon settlement in Portland was founded in 1739 and affords clearer signs of an African origin than many Jamaican villages. Other larger maroon communities are found in the Parishes of Trelawny and Westmoreland in the west of the island.

4.108. Today the Maroons are almost fully integrated into Jamaican society although communities such as Moore Town are run semi-autonomously and while they are remote from the impact of PAWSD Stage 2 construction they will benefit generally, as will other villages, from the long term improvement in services and economic potential of their regional centre.

Historical and Cultural Heritage

4.109. Port Antonio surrounds what is reputed to be one of the most beautiful harbours in the Caribbean. It is a quiet town of narrow streets centres on the square with a clock tower and backed by a redbrick Georgian Courthouse topped by a cupola. North of the square is the Village of St. George, a 3-storey complex with a Dutch-style frescoed exterior. Other fine Georgian buildings include the neo-Romanesque Anglican Church (1840), the gingerbread Demontevin Lodge (1881) and several dozen other houses on the Titchfield Peninsular, and Fort George (1729). Just outside the town on a prominent headland lies the ruin of Michell's

[22] Recognised as an Indigenous People by UNESCO.

Folly (1905), a 60-room mansion constructed from concrete in pseudo-Grecian style, and Folly Point Lighthouse (1888). Navy Island, just off the twin harbours, was once owned by Errol Flynn.

4.110. Recent harbour redevelopment to accommodate cruise ships has been the first step in the process of rejuvenation. There are no large resort complexes and all efforts at revitalising Port Antonio's flagging tourist industry are focused on those who wish to experience the beauty and tranquillity of the area. Among the many attractions are hiking or rafting through the deep valleys of the Rio Grande, trekking across the forest-covered hillsides of Blue Mountains and John Crow Mountains to Nonsuch Caves and Somerset Falls, or the less energetic pleasures afforded by the beaches of Fisherman's Cove, Boston Beach, Long Bay and Blue Lagoon.

Waste Stabilisation Pond Technology

4.111. Within the context of Baseline Conditions it is convenient to outline the aspects of the proposed technology it is proposed to adopt for the PAWSDP.

4.112. Waste stabilisation ponds (WSPs) are one of a number of natural low rate biological treatment systems that are very efficient in the removal of pathogens. They perform best in climates with high ambient temperatures and long hours of sunshine, and are common throughout the Caribbean and West Africa. In Jamaica, WSP systems are already in use at Negril, Montego Bay and Ocho Rios.

4.113. WSPs are non-mechanical, relatively cheap to construct and operate, and ideal for communities where there is a shortage of skilled treatment experience and the raw sewage is primarily domestic. The main disadvantages are that they take considerably more land than high-rate mechanical processes and their effectiveness quickly diminishes if overloaded.

4.114. WSP systems are designed to achieve different types of treatment in up to three stages depending on the organic strength of the inflow and the required effluent quality. Most commonly they comprise Anaerobic, Facultative and Maturation ponds, constructed singly or in series, with others added in parallel as the raw sewage inflow increases with urban expansion. For Port Antonio there is sufficient space for primary facultative ponds and no need for anaerobic ponds, which due to potential saltwater infiltration to the collection network might be the source of considerable odour.

4.115. The primary facultative ponds are loaded in such a way as to develop two layers within the wastewater body, an aerobic layer at the surface and an anaerobic layer with the sludge at depth. Oxygen produced by surface aeration and photosynthetic algae affects the reduction in BOD.

4.116. Solids from the inflow and excess biomass produced in the pond settle out and the anaerobic organic breakdown releases soluble residues to the water above. Organic matter dissolved or suspended in this water is metabolised by bacteria as in a conventional aerobic process. However, unlike conventional processes, the dissolved oxygen depleted by the bacteria is, if efficiently managed, replaced by microalgae photosynthesis rather than by mechanical aeration. High temperatures and ample sunlight create conditions

which encourage the algae to utilise the carbon dioxide released by the bacteria in breaking down the organic content and take up nutrients, mainly nitrogen and phosphorus, thereby contributing to the removal of BOD. For this to be sustained the organic loading on a facultative pond needs to be carefully controlled. The dissolved oxygen concentration varies both diurnally and with depth. Typically, the process will be primarily aerobic during the day and anaerobic at night. Mixing of the organic layer is therefore essential to prevent thermal stratification but this is often achieved by natural air movement across a pond surface. Depending on the initial loading, BOD removal within a facultative pond may be 70-80% providing the surface is kept free of scum and emergent vegetation to optimise the transfer of atmospheric oxygen.

4.117. The effluent from a facultative pond treating predominantly domestic wastewater will normally contain at least 50 mg/l BOD and this will be reduced by at least 50% in the maturation ponds. However, the most important function of maturation ponds is the removal of pathogens. Protozoan cysts and helminths are removed by sedimentation in each of the stabilisation ponds and a series of ponds with the appropriate retention time may be expected to produce an effluent free of these.

4.118. For the proposed Port Antonio treatment plant tertiary treatment a rock filter has been added to the end of the WSP system to provide final 'polishing' of the effluent prior to discharge

Shortcomings in Biophysical Baseline Data

Aquifer Characteristics

4.119. As discussed above, there is no information on aquifer depth and composition at Grant's Level. The available data on well hydraulics is of uncertain origin and incomplete, and individual well yields are not known. To overcome these shortcomings the leak detection survey includes for the installation of flow meters on each well for future monitoring. The drilling programme will commence with three new monitoring wells that will also provide data on aquifer depth and composition before the design of the new wells has to be finalised. The subsequent testing of the new wells is designed to provide information on both individual well and overall wellfield performance so that the final installed capacity for ground water abstraction will be shown to be safe and sustainable.

Geotechnical Conditions at the Turtle Crawle Treatment Plant Site

4.120. Some of the planned geotechnical investigations for the proposed treatment plant were curtailed due to the inaccessibility of much of the site without significant clearing of vegetation. While it had been hoped to limit disturbance of the site prior to construction the design engineers subsequently decided the information they had was insufficient to permit a sustainable design to be completed and a further round of trial pits and boreholes was approved by NWC as the present EIA was being completed.

Turtle Crawle River Hydrology

4.121. Although the hydrology of the Turtle Crawle River is not known in detail, sufficient subjective information is available to be confident that the conservative approach taken to the design of the waste stabilisation ponds is adequate for future flood events.

Ecology of the Turtle Crawle Wetlands

4.122. Both the 1973 and recent ecological surveys of the Turtle Crawle wetland area have been 'snap shots' of the condition and occupancy at specific times. Nevertheless, they afford confidence that all significant species have been identified and that no endangered, specifically protected or otherwise rare species of flora or fauna have gone unreported. However, the sustainable presence of the American Crocodile (*Crocodylus acutus*) is in some doubt and a number of questions regarding the apparent community need to be addressed if GoJ is to uphold its responsibilities for protecting this endangered species.

4.123. It is therefore recommended that as soon as possible, and definitely prior to the start of construction, NWC funds a study of the crocodiles, starting with tagging to record and trace their movement. Should the same individuals not always present, or they routinely migrate to another area, they may be happily left to decide their own future. Should the same individual be permanently present and the limitations of their range results in food deprivation or they show signs of stress from construction activity, the option of relocation should be considered.

3. POLICY AND LEGAL FRAMEWORK

3.1. This section presents an overview of the policy and legal framework under which the Port Antonio Water, Sewage and Drainage Project (PAWSDP) has been designed, the present EIA prepared, and the proposed works will be executed.

Policy Framework

3.2. Sustainable Development is one of the stated goals of the Government of Jamaica (GoJ) and the objectives inherent in this explicit policy include (i) effective conservation of the environment, and (ii) sustainable use of natural resources. The basis for action was *The Framework for Local Sustainable Development Planning in Jamaica* which provides opportunities for 'greening' both government and private sector environmental performance. This framework was published by the Statistical Institute of Jamaica which act as the technical clearing house for environmental management systems. The draft *EMS Policy and Strategy* was developed by NEPA and sent to Cabinet in January 2001. Almost concurrently the *Draft Policy on Ocean and Coastal Zone Management* (Green Paper 9/01) was issued. An earlier paper, *Towards National Biodiversity Conservation Strategy and Action Plan* (Green Paper 3/01) was Jamaica's response to the Convention on Biological Diversity.

3.3. Following the publication of *Jamaica Environment 2001 - Environmental Statistics and the State of the Environment* by NEPA/STATIN, Local Sustainable Development Plans (LSDPs) were produced with aid from the Canadian International Development agency for Environmental Action (ENACT). Achievements include the adoption of LSDPs by Parish Development Committees. In Portland, a *Sustainable Development Profile* and a *Vision for Sustainable Development in Portland* have been produced.

3.4.1. In 2001 Cabinet established the National Integrated Watershed Management Council to provide a considered approach to watershed issues. This included NEPA's 'Ridge to Reef' policy for watershed management, started in the Great River and Rio Grande watersheds.

3.4.2. The *Jamaica National Environment Action Plan* was first drafted in 1995 and has been updated in 1999/2000. It has several strategies on environmental management in Jamaica, e.g. environmental education, national parks, watershed management, forestry reserves, etc.

Legislative Framework

3.6. Jamaica is a signatory to the following international environmental conventions and treatises:

- Vienna Convention and the Montreal Protocol on substances that deplete the Ozone Layer;
- UN Framework Convention on Climate Change and the Kyoto Protocol;
- Convention on Biological Diversity and Biosafety Protocol;

- Convention in the International Trade of Endangered Species of Wild Fauna and Flora (CITES);
- Convention on Wetlands of International Importance especially as Waterfowl Habitats (RAMSAR);
- The Basel Convention on the Trans-Boundary Movement of Hazardous Waste;
- International Convention on the Prevention of Pollution by Ships (MARPOL);
- Convention for the Protection and Development of the Marine Environment to the Wider Caribbean Region; and,
- The UN Convention to Combat Desertification in those counties experiencing Serious Drought and/or Desertification

3.7. Jamaica already enjoys significant legislation for the protection of the environment with responsibility for execution and enforcement resting with different Government departments and agencies. Those most relevant to the execution of the PAWSDP proposals are:

- The Natural Resources Conservation Authority (NRCA) Act, 1991;
- The Town and Country Planning Act, 1958;
- The Land Development and Utilisation Act, 1966;
- The Watershed Protection Act, 1963;
- The Beach Control Act, 1956;
- The Endangered Species (Conservation and Regulation of Trade) Act, 2000;
- The Wildlife Protection Act, 1975;
- Fishing Industry Act, 1968; and,
- The Forest Act, 1995.

3.8. **The Natural Resources Conservation Authority (NRCA) Act** provides for the management, conservation and protection of Jamaica's physical environment through the Natural Resources Conservation Authority. Section 9 provided for the declaration 'Prescribed Areas' in which specified activities require a permit for which applicants are obliged to provide an Environmental Impact Assessment. *The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order* of 1996 declares the entire island Prescribed and lists the categories of enterprise, construction or development that require a permit. The Act also addresses sewage and trade effluent discharges.

3.9. The 1991 Act requires new environmental regulations to incorporate the 'polluter pays' principle. Although NRCA responsibilities were transferred to the National Environment and Planning Agency (NEPA) in 2001, the Act remains the primary instrument of environmental and planning legislation pending the passing of a NEPA Act at some future date.

3.10. In addition to the NRCA Act, the principal laws for controlling environmental and associated issues are the following:

- **The Town and Country Planning Act** is administered by the NEPA and designates the Government Town Planner and the Town and Country Planning Authority as the responsible agencies for with planning control the legislation;
- **The Land Development and Utilisation Act** is also administered by the NEPA and designates the Land Development and Utilisation Commission as the responsible agency for land development. Development Plans for designated areas are written under this Act.
- **The Watershed Protection Act** provides for the protection of watersheds and adjacent areas, and the preservation of promotion of water resources. It makes provision for watershed conservation through improved soil conservation practices;
- **The Beach Control Act** provides for the proper management of Jamaica's coastal and marine resources through the licensing activities on the foreshore and seabed. The Act also addresses access to the shoreline and other rights associated with fishing and public recreation, and marine protected areas;
- **The Endangered Species (Conservation and Regulation of Trade) Act** of 2000 concerns with the protection of specified species of fauna but recent review has identified the need for amendments to address the management and conservation of natural resources and the inclusion of flora. This Act was promulgated to document Jamaica's obligations under the Convention for the International Trade in Endangered Species and governs international and domestic trade in endangered species in and from Jamaica;
- **The Wildlife Protection Act** is concerned with the protection of particular species of fauna declared under the Act. It has undergone review, particularly in the areas of increased fines and the number of animals now enjoying protected status. Further amendments are being undertaken to address a variety of other issues relating to the management and conservation of natural resources, and the inclusion of flora;
- **The Fishing Industry Act** is aimed at the management of the fisheries resources of Jamaica and the establishment of fish nurseries and sanctuaries. It has, however, has not kept pace with the evolution of fishing and the attendant resource management issues, and a new Act which will provide an institutional framework for the management, planning, development and conservation of fisheries resources is being drafted;
- **The Forest Act** addresses the sustainable management of forests on lands in the possession of the crown and vests management responsibility in the Conservator of Forests. The Act provides for the establishment of forests reserves, the establishment of protected areas, the promotion of forestry research areas, reforestation initiatives and the preparation of a Forestry Management Plan, and
- **The Public Health Act** is enforced by Inspectors working with the Parish Councils across the island and the Environmental Control Division of the Ministry of Health. Standards and practices to ensure public health are set, including that persons involved in construction, repair or alteration must take precautions to prevent particulate matter from becoming airborne.

Forthcoming Legislation

3.11. A number of new legislative instruments are currently under preparation:

- **The National Environment and Planning Agency Act (Draft)** is intended to combine the Environment and Planning Laws now administered by NEPA under one Act;
- **The Wetlands Policy Natural Resources Conservation Authority (Draft)** will attempt to set out a management strategy for the protection of wetlands. It identifies five goals that are aimed at the sustainable use of wetlands, including the development of guidelines for any development of wetlands and the preservation of biological diversity;
- **The Coral Reef Protection and Preservation Policy and Regulation, October 1997 (NRCA) (Draft)** recognizes that coral reefs are among the earth's most biologically diverse, oldest and species rich ecosystems, and aims to ensure their conservation to sustain their ecological and socio-economic functions. Also associated with this initiative is the Jamaica Coral Reef Action Plan; and,
- **The Policy for the National System of Protected Areas** is being formulated pursuant to Section 5 of the 1991 NRCA Act and describes the protected areas system as having a common underlying foundation of environmental protection purposes, and a standardized approach to planning and management, within the over goals of economic development, and environmental conservation.

Environmental Assessment Legislation and Procedures

3.12. Under Section 10 of the 1991 NRCA Act an Environmental Impact Assessment is required before defined categories of industrial, development and other projects are given a permit. These categories are defined under Section 38(1)(b) and the PAWSDP Stage 2 proposals are subjected to the EIA process on the basis they encompass:

- pipelines and conveyors over 15 cm diameter;
- river basin development; and,
- water treatment (water, desalination, sewage and industrial wastewater).

3.13. The scope and required content of an EIA is explained in *Guidelines for Conducting Environmental Impact Assessment* (NRCA, July 1997). Once Terms of Reference to a particular project have been approved by NEPA the expected content of the EIA report includes the following:

- Executive Summary;
- Policy, Legal and Administrative Framework;
- Description of the environment;
- Description of the Proposed Project in detail;
- Significant Environmental Impacts;
- Socio-economic analysis of Project Impacts;
- Identification and Analysis of Alternatives;

- Mitigation Action/Mitigation Management Plan;
- Environmental Management and Training;
- Monitoring Programme;
- Public Involvement;
- List of References;
- Appendices including;
- Reference documents, photographs, unpublished data;
- Terms of Reference;
- Consulting team composition; and,
- Notes of Public Consultation sessions.

3.14 The EIA report is submitted to NEPA for review and construction permitting, in which other government agencies may participate. The essential elements of the EIA process are illustrated in **Figure 3.1** and further discussed below.

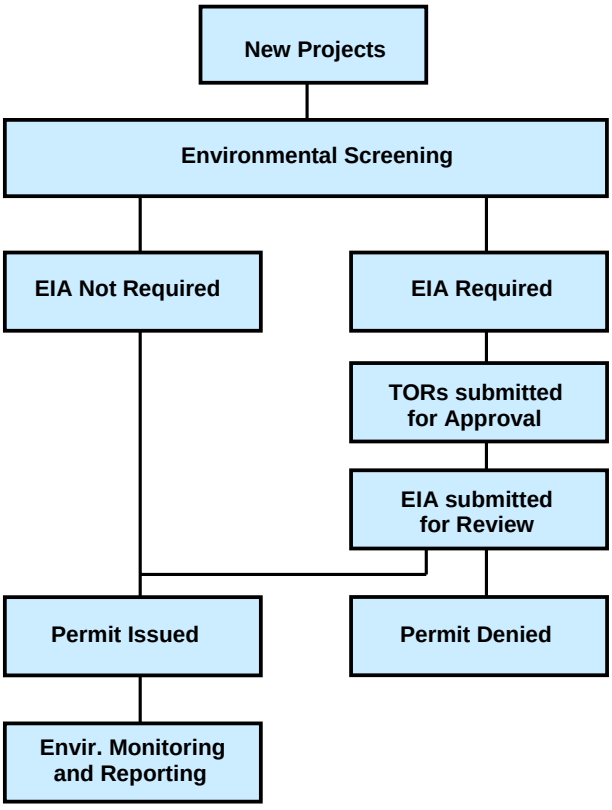


Figure 3.1. NEPA's EIA Review and Permitting Process

Institutional Framework

3.15. The varying responsibilities of the principal organisations, governmental and non-governmental, national and local, planning and environmental issues are summarised below.

Central Government Agencies

3.16. Central government agencies include:

- **The Planning Institute of Jamaica** initiates and coordinates the plans, programmes and policies for the economic, financial, social, cultural and physical development of Jamaica, provides technical support to Cabinet, and is the main interface with international funding agencies and donors; and,
- **The Statistical Institute of Jamaica** collects, compiles, analyses, and publish statistical information in relation to commercial, industrial, social, economic and other activities, including the organization of national censes.

Ministry of Land and Environment

3.17. The Ministry promotes sustainable development for Jamaica by effectively managing the environment and natural resources through strategic planning, policy formulation and implementation and the utilization of appropriate technology. Component agencies of the Ministry of Land and Environment relevant to the PAWSDP include:

- **The National Environment and Planning Agency** (NEPA) was formed on 1st April 2001 by the merger of the National Resources Conservation Authority, the Town Planning Department and the Land Development and Utilisation Commission, to *promote sustainable development by ensuring protection of the environment and orderly development*. NEPA's core functions as they relate to the PAWSDP include planning and development, environmental permits and licenses, change of agricultural land use, beach use and, sewage discharge. Until a National Environmental and Planning Act is promulgated NEPA operates under the mandate of the NRCA Act and other core environmental legislation. The organisation of NEPA is shown in **Figure 3.2**;
- **The National Meteorological Service** is concerned with the observation and forecasting of weather conditions over and around the island and provides weather forecasting services for general dissemination. It maintains a continuous Hurricane Watch during the hurricane season and is responsible for the issuance of severe weather warnings. The service also operates an island-wide network of rainfall and climate stations and processes the data recovered for a wide variety of needs.
- **The Mines and Geology Division** is the geological research and development arm of Government and is charged with developing a comprehensive understanding of the geology of Jamaica and directing the orderly development of mineral resources, in accordance with mining and environmental legislation. It has a modern analytical laboratory and a library, and is the sole distributor of blasting licenses.

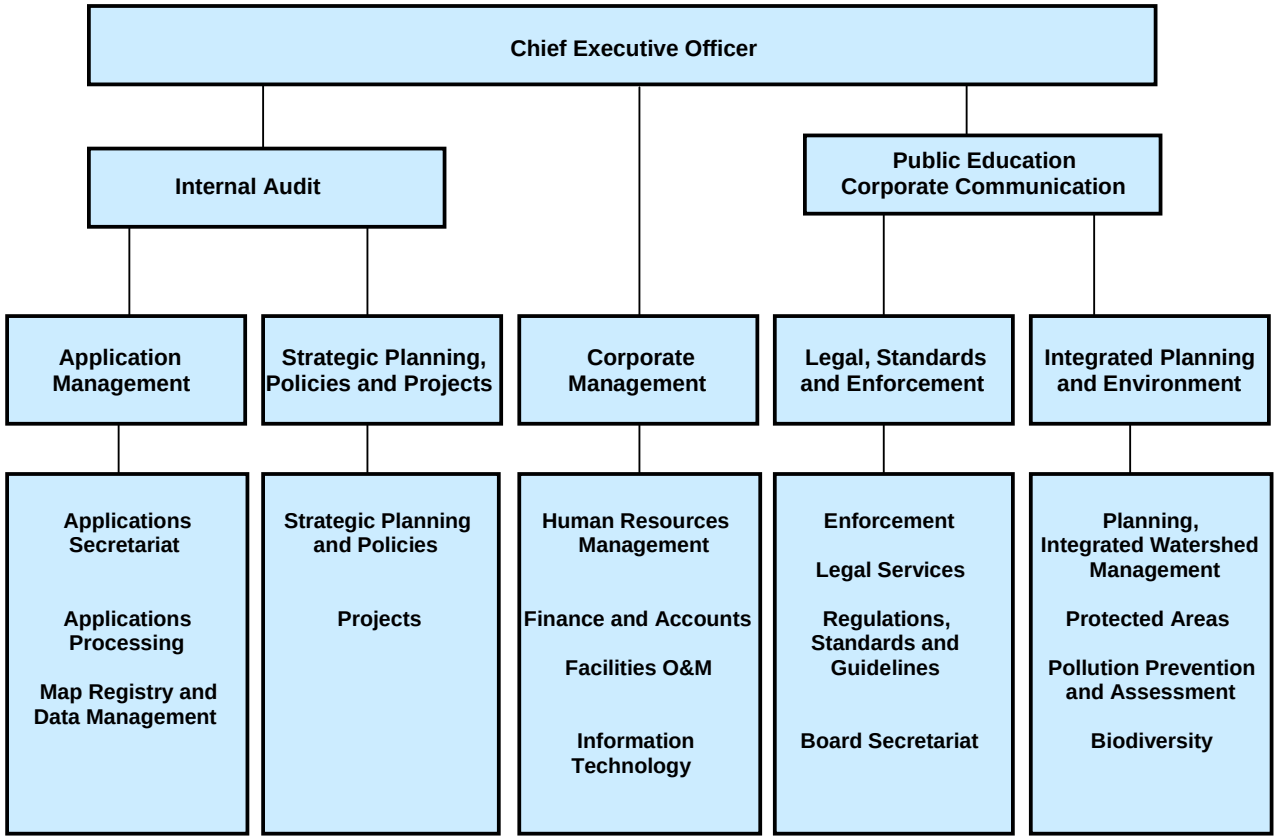


Figure 3.2. NEPA Organisation Chart

- **The National Land Agency** was established by the merger of the Office of Titles, the Survey Department and the Land Valuation and Lands Department to bring together core land information functions and provide for the integration of land titling, survey, valuation and management to create a modern national land information system to support sustainable development and the efficient management and administration of land.
- **The Council on Ocean and Coastal Zone Management** provides a formal mechanism integrated coastal zone management. Participants include representatives from local government, private sector, shipping, fishing, marine interests, marine park management entities, and selected international/regional agencies involved in marine and ocean management.

Ministry of Water and Housing

3.18. The Ministry seeks to achieve affordable housing solutions for all and provide clean potable water for all its citizens. Component agencies of the Ministry of Water and Housing include:

- **The National Water Commission** (NWC) was established in 1980 to be the statutory organisation responsible for providing potable water and wastewater facilities within the context of the Government's goal to provide universal access to potable water by 2005 and the installation of sewerage systems in all major towns by 2020. While the first of these goals may have slipped, the Agency currently produces over 90% of all potable supplies and provided 25% of the population with sewerage. NWC is the PAWSDP proponent; and,
- **The Water Resources Authority** has statutory responsibility for the management, protection, and controlled allocation and of Jamaica's surface and ground water resources. Its duties include hydrologic data collection, compilation, and analysis; water resources investigation, assessment, and planning; water resources allocation; and environmental monitoring and impact assessment. The Authority processes applications for the permitting of well drilling and testing and for the licensing of surface and ground water abstraction. It will therefore be the prime agency involved in approving the PAWSDP proposals for increased abstraction from the Grant's Level wellfield.

Ministry of Transport and Works

3.19. The Ministry of Transport and Works was created in January 1998 and includes functions and programmmes drawn from the former Ministries of Local Government and Works, Public Utilities and Transport. The Corporate Plan reveals the initiatives that will be taken to encourage national growth and development within the context of the National Industrial Policy. As the name suggests, the Ministry is responsible for the island's land, sea and air

transport as well as the majority of road network, including bridges, drains, embankment etc. Through its various agencies, including the National Works Agency, the Ministry fulfills its mandate of providing a safe and efficient transportation system as well as the building and maintenance of quality roads for its populace and others who have to travel on them.

Ministry of Health

3.20. The Ministry of Health will promote and safeguard the physical, mental and social well-being and enhanced quality of life of the Jamaican people by empowering individuals and communities and ensuring access to adequate health care through the provision of cost-effective promotional, preventive, curative and rehabilitative services delivered by adequately trained and motivated personnel.

Portland Parish Council

3.21. The Parish Council is the local government institution responsible for planning in Portland. All development plans for Portland must be approved by the Parish Council.

Other Organisations

3.22. Other organizations with interests allied to those of the PAWSD include:

- **The United States Agency for International Development** (USAID) is primarily involved in assisting GoJ improve the quality of key resources in environmentally and economically significant areas through support in the development of a number of environmental policies including the Sewage Connection Policy, the National Policy on Ocean and Coastal Zone Management and the National Environmental Management Systems Policy. Port Antonio has been a particular focus of the USAID programme, with environmental audits and 'Green Globe' certification for small hotels and manufacturers, and the strengthening of civil society groups and local agencies to better plan and implement environmental protection policies and strategies. Technical assistance on the introduction of the Blue Flag Beach Safety and Environmental Certification Scheme has also been provided. Of specific interest to the PAWSDP, USAID is providing technical assistance to strengthen the institutional capacity of public and private sector wastewater operators, the Jamaica Wastewater Operators Association and Wastewater Advisory Monitoring Committees.
- **The Global Coral Reef Alliance** based in Massachusetts is a non-profit organization dedicated to growing, protecting and managing coral reefs. It primarily focuses on reef restoration, marine diseases and other issues caused by global climate change, environmental stress and pollution. Over the last 16 years it has produced many useful papers specifically about or pertinent to the coral reefs of Jamaica.

- **The Jamaican Hotel and Tourism Agency** implements Environmental Audits for Sustainable Tourism (EAST) under which 'green properties' obtain ISO 14000 registration under the Green Globe Programme of the World Travel and Tourism Council. An EAST programme operates in Port Antonio.
- **The Portland Environment Protection Association** (PEPA), founded in June 1988, is an association of community organizations, service clubs and civic organizations, bound together by our common interest to protect the natural environment of the Parish of Portland specifically and of Jamaica in general. There are currently there are over 60 organisational members and more than 100 individual members of PEPA.

Project Environmental Assessment Framework

3.23. As required by the KBR Contract, the present EIA study has been undertaken in general accordance World Bank requirements[1] and more specifically with the NEPA requirements discussed above. As required under NEPA procedures, Draft Terms of Reference were submitted for approval on 6th December 2005 and formally approved on 6th February 2006. Preparation of the Stage 2 EIA commenced on 25th January and was submitted to NWC for review on 8th 2006. Information Participation and Consultation activities have included:

- Meetings of the NWC/Port Antonio Wastewater Advisory Committee;
- Visits to concerned groups and individuals to introduce the project;
- Visits and interviews with Project Affected Persons;
- An EIA Scoping Session;
- Public Notices issued to the Press;
- Public Exhibition and Meeting to disseminated the results of the EIA; and,
- The opportunity for the public to submit their views in writing.

3.24. All IPC activities are reported in Section 13. In accordance with NEPA's requirements, a period of not less than three weeks from the date of submission of an EIA has to be allowed for the document to be available for public inspection and comment in council offices, schools, police stations or other pubic places. At the end of this period the Project Proponent will hold a public meeting at which the project and the EIA are presented and attendees given the opportunity to air their comments.

[1] *The World Bank Operational Manual. Operational Policies PO 4.01.* World Bank, January 1999

2. PROJECT DESCRIPTION

2.1. This section outlines the need for and objectives of the *Port Antonio Water Sewage and Drainage Project* (PAWSDP), discuses the 'Without Project' situation, and describes the proposed construction.

Project Need and Objectives

2.2. Port Antonio surrounds what is reputed to be one of the most beautiful harbours in the Caribbean. It is a quiet town of narrow streets lined with many fine Georgian buildings. Once renowned as the world's banana capital it became an early holiday destination when returning banana boats brought the first tourists. While many once-popular attractions have closed for the want of visitors the area is generally considered by tour operators to be *the next big thing in Jamaican tourism*[1]. Among the attractions on offer are the scenic Rio Grande Valley set within rolling tropical forest covered hillsides, and spectacular coastal scenery with beautiful secluded beaches such as Frenchman's Cove, Boston Beach, Long Bay and Blue Lagoon.

2.3. Recent harbour redevelopment to accommodate cruise ships has been the first step in the process of rejuvenation. There are no large resort complexes and the aim is to attract the type of tourists who wish to experience the beauty and tranquillity of the area. The second step, the upgrading of the extremely poor road links with Ocho Rios and Montego Bay along the North Coast Highway, is already being implemented.

2.4. At the present time there are insufficient water resources to provide a 24-hour pressurised supply and much of what is distributed is lost before it reached consumers. Since the 1996 Master Plan NWC has made significant progress in metering but this has only highlighted the problems of leakage, estimated at 70% of water released into supply, and the need for extensive network repair and replacement. To reduce leakage the outlet valve at West Retreat reservoir is closed each night. Empty pipelines create negative pressures and soil water, often highly saline and/or may infiltrate from absorption pits and septic tanks, seeps in through poorly-sealed pipe joints. When the reservoir valve is opened each morning any contaminated water is delivered to consumers' taps.

2.5. Port Antonio has no centralised sewerage system and no means for safe wastewater treatment and disposal. The many individual septic tanks and absorption pits are a source of odour, and septic seepage finds its way into the harbour and adjacent bays, elevating the nutrient content to the detriment of yachtsmen, fishermen, bathers, marine vertebrates and coral. Some properties are only served by pit latrines while a few remain without any formal means of disposing of septic waste.

2.6. The problems of water distribution and the lack of sewerage are exacerbated in those areas of the town below sea level, where property is prone to flooding from inadequate drainage capacity. Flood waters

[1] *Jamaica*. Lonely Planet, 2006.

increase infiltration to empty water lines and enter poorly sealed septic tanks and absorption pits causing overflow. The spread of septic drainage by flood water poses a serious possible threat to public health.

2.7. The aim of the PAWSDP is therefore to improve the availability of water, to provide for the safe and sustainable treatment and disposal of sewage, and to reduce the risk of flooding, in order to achieve the broader objective improving the public health of direct and indirect beneficiaries, reducing pollution of both terrestrial and marine environments, and supporting further commercial development of the town.

The 'Without Project' Situation

2.8. The lack of an efficient water supply system, a modern sewerage network and adequate drainage has long been recognised as an obstruction to future economic growth, improved public health and environmental protection. If PAWSDP is not executed the economy of the area will remain stagnant, its residents will continue to suffer the consequences of poor water supply and sanitation, increased flooding, and continued environmental degradation.

2.9. If only Stage 1 of PAWSDP is constructed, the town will be left with better storm water drainage but inadequate potable water despite an improved distribution network, and new sewers that either cannot be connected to properties or discharge collected flows into West Harbour. This would be the worst possible outcome as the pollution and risks to public health would be greater than those afforded by the present situation. Stages 1 and 2 of the project therefore need to be constructed in their entirety.

Project Location and Proponent

2.10. Port Antonio is located near the eastern extremity of Jamaica's north coast, 105 km by road east of Ocho Rios and 95 km ENE of Kingston. It is the main town within the Parish of Portland and is administered by the Portland Parish Council.

2.11. The PAWSDP area extends from the mouth of the Rio Grande 4 km west of Port Antonio to Fairy Hill 7 km to the east and embraces the immediate spheres of influence of the town. The southern boundary of the project area is demarcated by the valley of the Rio Grande as far as Fellowship, up to Breastworks, eastwards along the road serving Nonsuch, Cambridge and Sherwood Forest, and north to Fairy Hill.

2.12. The full scope of PAWSDP works extends from the Annotto River, around West Harbour, through the Titchfield Peninsula and around East Harbour as far as Caneside River. Beyond Caneside River a trunk sewer and water transmission main follows the coast road to Turtle Crawl where the sewage will be treated prior to discharge to the sea near Daniel's Harbour. The project also includes work at the Grant's Level wellfield adjacent to the Rio Grande River at Berridale, 5 km south-west of the town. The PAWSDP area and the principal Stage 2 structures are summarised in **Figure 2.1**.

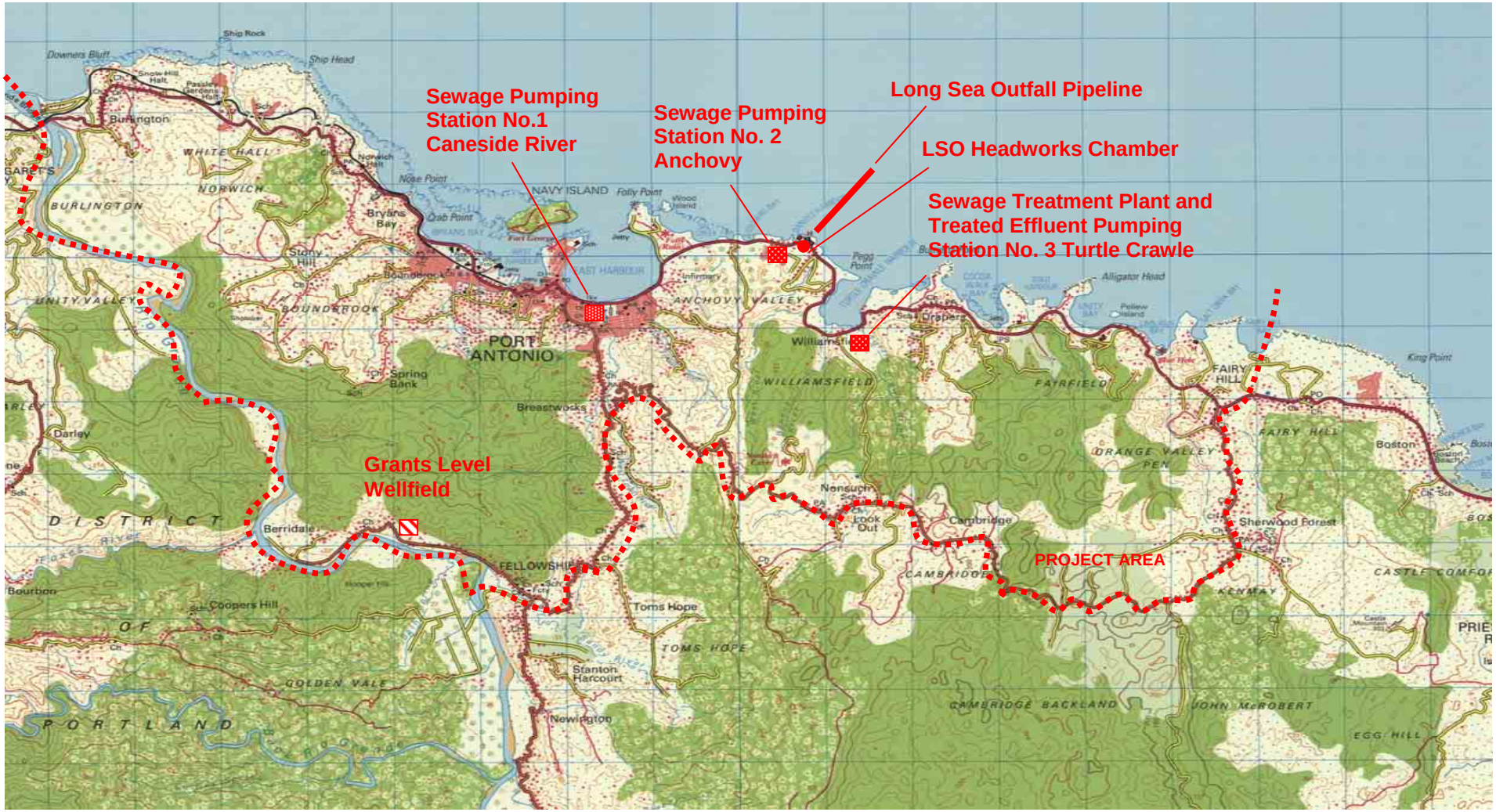


Figure 2.1. Project Area and Principal PAWSDP Stage 2 Structures

2.13. The Proponent of the Port Antonio Water, Sewerage and Drainage Project is the Government of Jamaica through the National Water Commission whose contact address is:

National Water Commission,
4, Marescaux Road,
Kingston 5,
Jamaica.

Stage 2 Project Description

2.14. The work to be executed under the project is divided into two stages, which may be tendered and awarded separately or together. The Stage I works comprising the water, sewerage and drainage infrastructure throughout the built-up area of Port Antonio are the subject of a separate EIA.

2.15. The Stage 2 PAWSDP works comprise the following, for which detailed location plans are presented in **Appendix A**.

- Upgrading water resources development at Grant's Level by (i) the drilling, testing, and equipping of up to 4 new production wells to provide the 2025 requirement of 21,720 m^3/d, (ii) the installation of new chlorination facilities to ensure adequate disinfection and potability, and (iii) the replacement and/or addition of 'high-lift' pumps to deliver the increased abstraction to the service reservoir at West Retreat.
- A new c.5 km 300 mm diameter water transmission main from East Palm Avenue to Turtle Crawle;
- A new raw sewage pumping station (Pumping Station No.1) at the Allan Avenue (A4) crossing of Caneside River and a 5.5 km 200 mm diameter gravity and rising main trunk sewer to take collected flows eastwards along the A4 via an intermediate lift station (Pumping Station No.2) at Anchovy to a treatment plant at Turtle Crawle;
- Entrainment of the Turtle Crawle River over a distance of some 400 m upstream from the proposed treatment plant to provide flood protection;
- Demolition of the existing NWC 450 m^3/d sewage treatment facility at Anchovy and re-levelling the site;
- A new 2,000 m^3/d waste stabilisation sewage treatment plant comprising two facultative ponds, three maturation ponds and a rock filter at Turtle Crawle;
- A dual function pumping station (Pumping Stations Nos.3a and 3b) each 2000 m^3/d at the intersection of the A4 and the unsurfaced access track from Turtle Crawle to Nonesuch to (i) lift raw sewage into the treatment plant and (ii) pump treated effluent westwards back along the coast road to east of Daniel's Harbour through a 2.1 km 450 mm diameter pipeline; and,
- A new headworks control chamber by the side of the A4 east of Daniel's harbour and a c.500 m 350 mm diameter sea outfall heading approximately NNE and ending at grid coordinate E349360 N2011657 in 28 m of water.

Design Guidelines

2.16. The design philosophy and engineering concept adopted by NWC for which KBR have primarily been adopted from the recommendations of the 1996 Master Plan and the 2002 Review/Feasibility Study. The PAWSDP Design Horizon is 2025.

2.17. The criteria for KBR's detailed engineering design have primarily been based on the following:

- *Developer's Manual*. Draft Edition, NWC, 2003;
- *Guidelines of Design and Construction of Housing*. Volumes 1, 2 and 3[2]. Jamaican Institution of Engineers, 1984;
- KBR's own in-house Design Manuals compiled over time from proven engineering practice and industry 'best practice' in the UK and overseas; and,
- Advice from acknowledged experts engaged on the present project.

2.18. KBR has produced separate Design Reports for the Stage 1 and Stage 2 works[3]. Since much of the Stage 1 works are extended in Stage 2, the Stage 1 report is the essential reference for basic criteria such as population and development forecasts, water demand projections, and sewerage flow data.

2.19. To ensure engineering design is founded on accurate and site-specific information the following surveys and studies were completed during the design stage of the project:

- **Topographical Survey** to provide spot levels along public roads and watercourses, and detailed site surveys for the pumping stations, sewage treatment works and the outfall headworks. A network of permanent marker stations has been established for use during construction;
- **Marine Survey** to assess bathymetry, current tide and wind conditions, salinity, temperature and turbidity, and seabed composition for the design of the long sea outfall; and hydrodynamic, plume and effluent dispersal modelling to assess its expected performance;
- **Aquifer Production Study** to confirm the availability of the sustainable resources needed to increase abstraction from Grant's Level wellfield;
- **Pesticide Study** along the lower Rio Grande Valley to identify any residues present in the water and river sediment, and to assess any potential impact on future abstraction at Grant's Level;
- **Geotechnical Investigations** to assess the ground conditions that may be expected along pipeline routes and at the pumping station and treatment plant sites;
- **Socio-Economic Survey** to identify the requirement for property and asset take at the sewage treatment plant site together with the number and status of Project Affected Persons (PAPs); and,
- **Ecological Survey** of the treatment plant site to provide an overview of its habitats and communities.

[2] Covering drainage sewerage and water supply respectively.
[3] *Port Antonio Water, Sewage and Drainage Project: Design Report Stage 1*. KBR Doc.XU0396-400-RP-0002, Sept. 2005
Port Antonio Water, Sewage and Drainage Project: Design Report Stage 2. KBR Doc.XU0396-400-RP-0003, March 2005

Principal Design Criteria

Water Transmission Main

2.20. The design of the transmission main is based upon each consumer receiving the estimated per capita demand of 193 l/d in 2005 and 211 l/d in 2025. To eliminate the risk to water quality resulting from lines running dry, positive pressure will be maintained at all times.

2.21. The EPANET simulation package has been used to model extended hydraulic behaviour of the proposed networks. However, the ability of the local networks supplying coastal communities along the route of the transmission main to maintain a 24-hour supply falls outside the scope of the project. Fire fighting demands have also not been considered but this will not adversely affect the suitability of the design.

'Proposed' and 'Extended' Sewage Systems

2.22. While detailed design of the sewerage system has been undertaken for a specific area it will be eventually expanded to other areas. The design therefore considers two scenarios; the 'Proposed System' and the 'Extended System' based on population and development projections to 2025.

2.23. The 'Proposed System' will be constructed under PAWSDP. Only catchments between the Annotto and Caneside Rivers, designed in Stage 1, with a total flow (peak and infiltration) of 5,428 m³/day have been considered. East of the town, between Caneside River and Turtle Crawle only the flows (peak and infiltration) of 1,998 m³/day from the Anchovy Housing Scheme and the Trident Hotel are considered as only these have existing treatment facilities. The total sewage flow for the Proposed System is therefore 6,748 m³/day, including 1,984 m³/day Dry Weather Flow (DWF) and infiltration and using a Peak Factor of 3.4.

2.24. The 'Extended System' reflects the total build out of the system for Port Antonio and areas to the east up to Turtle Crawle. The total DWF including infiltration for the Extended System is 4,257 m^3/day. The total peak flow including infiltration for the Extended System is 12,719 m^3/day using a Peak Factor of 3.0.

Trunk Sewers and Sewage Pumping Stations

2.25. **Table 2.1** presents the basic design criteria adopted for trunk sewers and pumping stations assuming M&E plant (pumps, motors, switchgear and standby generators) have a design life of 10 years and can be easily replaced as the system is extended. Civil elements have a greater design life as replacement or upgrade would be more costly and disruptive.

2.26. The derivation of sewage flows was completed during Stage 1 and is presented in the Stage 1 Design Report. To account for the ingress of storm and ground water an allowance of 15% DWF has been made, an increase on the 10% DWF allowed in the Master Plan because the depth of sewers along the coastal road is greater than previously anticipated.

Table 2.1. Design Criteria for Trunk Sewers and Sewage Pumping Stations

Element	Criteria
Trunk Sewers	Minimum velocity 0.75 m/sec at ultimate peak flow, checked for proposed flow system.
Rising Mains	Maximum velocity 3 m/sec for extended system peak 2025 flow. Minimum velocity at proposed peak flow 0.75 m/sec.
Gravity Sewers	Minimum Velocity 0.75 m/sec where this is achievable and not below 0.6 m/sec in branch lines
Pumping Station Sumps	Sized on a maximum of 10 pump starts per hour at extended system peak 2025 flow and with a safety factor of 1.2 against flotation.
Pumping Station Buildings	Sized to accommodate equipment for ultimate flow condition.
Pumps, Motors, Switchgear & Standby Generator	Sized to accommodate 2025 peak flow, including infiltration.

2.27. The Colebrook White and the Continuity Equation were used to model the hydraulic characteristics of rising mains, while the design of gravity sewers utilised Micro-Drainage software. The minimum slope for rising mains is 2% and 1 in 500 for gravity sewers. Air valves and washouts are located at the high and low points respectively.

2.28. The pumping stations will be equipped for the 'Proposed System' duties listed in **Table 2.2.**

Table 2.2. Design Duties for Sewage Pumping Stations

Station	Location	Peak Flow	Dynamic Head
1	Caneside River	63 l/s	27.78 m
2	Anchovy	77 l/s	16.34 m
3a	Turtle Crawle (Incoming raw sewage)	77 l/s	17.96 m
3b	Turtle Crawle (outgoing treated effluent)	78 l/s	20.15 m

2.29. Each station will be equipped with two fixed speed submersible pumps to give 100% stand-by capacity, a stand-by generator with auto switchover and fuel storage for up to 4 days operation, all with switchgear controls for automatic operation. All flows will pass through a trash basket to remove pieces of wood, plastic, stones and other coarse debris, and a silt trap to remove finer material. Pumping Station No.3b is designed to achieve self cleaning velocity in the outfall.

2.30. The area of each station allows space for pumps and sufficient working space for maintenance. Security will be provided by a 2.4 m high chain link boundary fence around the reinforced concrete building in which all doors and vents will be secured to prevent malicious damage;

Sewage Treatment Plant

2.31. The selected treatment stream is waste stabilisation ponds with a rock filter designed in accordance with latest internationally-recognised procedures[4]. Since there is sufficient space for primary facultative ponds there is no need for anaerobic ponds, which might have otherwise resulted a serious odour problem due to high sulphates from potential saltwater infiltration.

2.32. The basic design parameters are those concerned with inflow, raw sewage quality, required effluent quality and ambient temperature. Inflow was calculated on the basis described above. Raw sewage quality characteristics were supplied by NWC from their routine monitoring at treatment plants in Montego Bay, Ocho Rios and elsewhere. The required treated effluent quality is specified by the *Jamaican National Sewage Effluent Standards 1996*. The design flow was 2,000 m^3/d and the mean monthly design temperature 23.25˚C. The assumed incoming sewage quality, predicted final effluent quality and effluent quality standards are shown in **Table 2.3.** Also shown are intermediate quality values during the treatment process.

Table 2.3. Sewage Treatment Plant Inflow and Outflow Quality

Parameter	Assumed Raw Sewage Quality	After Facultative Ponds	After Maturation Ponds	Final Effluent Quality	Jamaican National Effluent Standards
BOD (mg/l)	250	48	30	15	20
Suspended Solids (mg/l)				c.15	20
Total Nitrogen (mg/l)	50	31	4.5	4.5	10 (0.081)
Phosphorus (mg/l)	10			c.3	4 (0.055)
Faecal Coliforms (MPN/100 ml)	5×10^7	9×10^5		200	200

The Jamaican National Effluent Standards cited are for discharge 150 m or more from coral reef.
The lower requirements for nitrogen and phosphorous if discharged within 150 m of coral are shown in brackets.

2.33. The proposed treatment stream is as follows, laid out as shown in **Figure 2.2**.

- Preliminary treatment through a trash basket located at the raw sewage pumping station;
- Two primary facultative ponds in parallel, each with a mean retention time of 11.9 days;
- Three secondary maturation ponds in series, each with a mean retention time of 3.4 days; and,
- A final 'polishing' rock filter.

[4] *Domestic Wastewater Treatment in Developing Countries*. Mara, D.D.. Earthscan Publications, London, 2004.

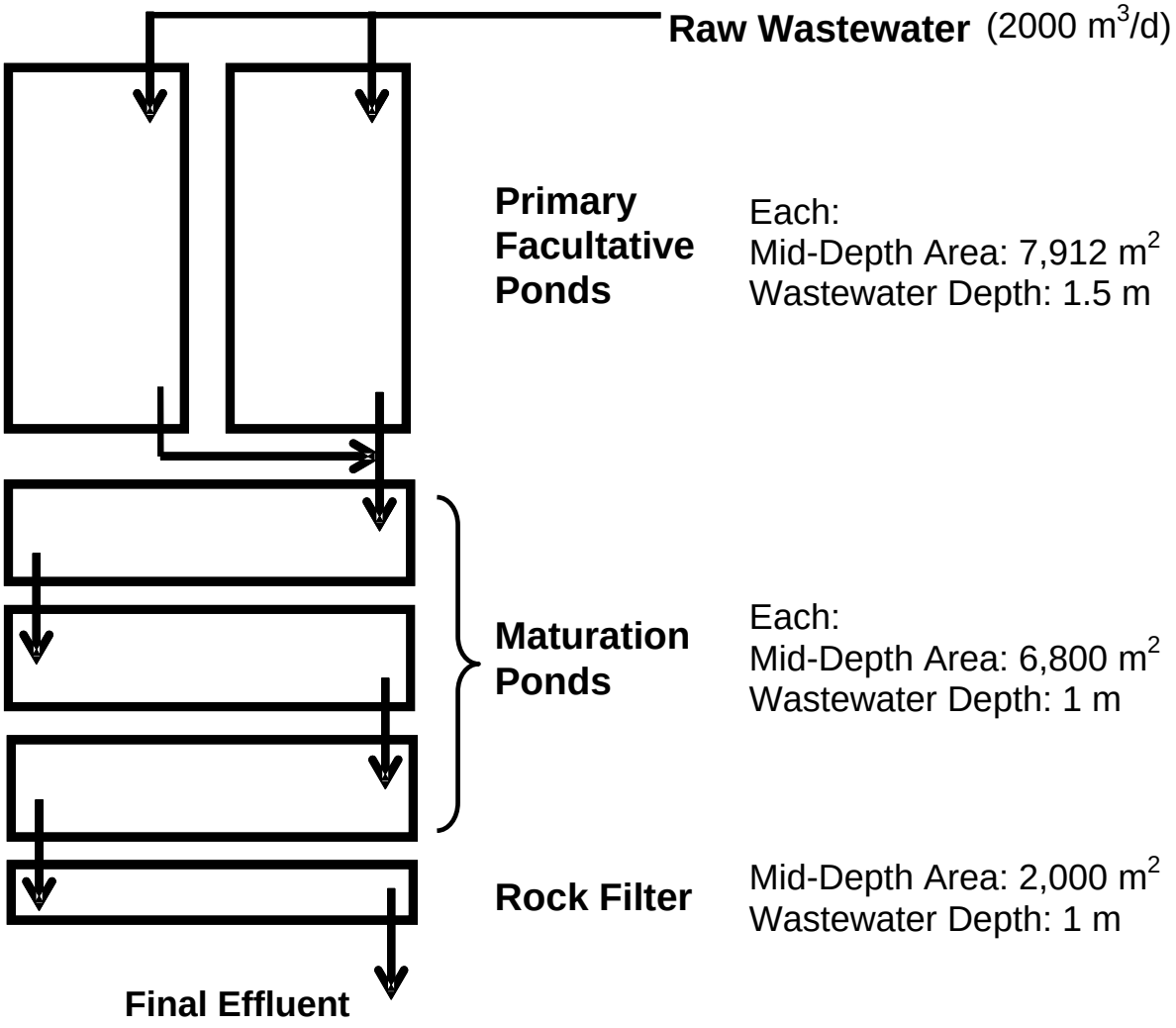


Figure 2.2. Proposed Waste Stabilisation Treatment Stream

2.34. To prevent heavy rainfall overwhelming the treatment process, two overflows allow excess water to be taken out. Overflow 1 will be located after the second maturation pond and before the rock filter, while Overflow 2 will be at the treated effluent pumping station. Rain falling into the early ponds and mixing with sewage that has undergone minimal treatment will be retained and pass through the treatment process. No diluted raw or 'nearly-raw' sewage will be discharged via either overflow. The discharge from Overflow 1 will have gone through all the treatment stages except final filtration, while that from Overflow 2 will have undergone the full treatment process.

2.35. Septage pumped from absorption pits and septic tanks and delivered to the treatment plant by tanker will be relatively low, possibly up to 10 tanker-loads per day, which with a 10 m^3 tanker is 100 m^3/day. Given the design flow and loading of the plant is designed for 2025, there will be sufficient capacity until at least 2015 to accept Septage. When flow and loading reach around 50% of their design allowances two small septage lagoons may be needed at the top end of the process stream. The overall design of the plant site provides space for these lagoons as and when they are required.

2.36. The ground conditions at the site are very poor, essentially comprising uncemented sands, gravels and clays with considerable thicknesses of peat and a naturally high water table. Detailed engineering design has yet to e completed but it is likely the pond embankments will be surcharged to prevent subsequent settlement.

Long Sea Outfall

2.37. The basic design criteria for the long sea outfall are essentially the volume of treatment plant outflow, 2,000 m^2/d, the location of the headworks chamber, and the direction and length of pipeline to reach a sea bed position where the depth of water and prevailing currents are such that the effluent is quickly diluted and will not return to the shore.

2.38. Engineering design and pipeline material selection follows regional guidelines[5]. The minimum flow velocity will be 0.75 m/s to prevent setting within the pipeline, and the maximum 3.5 m/s. From the foreshore to a water depth of 18 m the pipeline will be buried to avoid damage from up to 1 in 100 year storms. Thereafter to the end of the pipeline, in water some 28 m deep, the pipe will be laid on the sea bed weighted down with a concrete collar. Design drawings for the long sea outfall are also given in **Appendix A**.

Design for Extreme Conditions

2.39. The design of the PAWSDP works provides for the impact of extreme conditions in respect rises in sea level and storm surges, hurricanes, and seismic activity as follows:

[5] *Submarine Outfalls: General Overview, Basic Design Concepts and Data requirements for Latin America and the Caribbean.* Pan American Centre for Sanitary Engineering and Environmental Sciences Ops/Cepis/Pub/00.58,1988.

- **Sea Level Rise** of 5 mm/year, widely accepted as being appropriate to the Caribbean, has been allocated wherever appropriate;
- **Storms and Storm Surges** up to those with a 1 in 100 year return period have been catered for in the design of the long sea outfall. Elsewhere a 1 m storm surge has been allowed for;
- **Hurricanes** and other strong winds have been allowed for in accordance with the *Caribbean Building Code (CUBiC): Section 2 Wind Loads* and with *British Standards BS 6399 Part 2 1995: Wind loads for Structural Design*; and,
- **Seismic Activity** has been allowed for through the application of the *Seismology Committee of the Structural Engineers Association of California: Recommended Lateral Force Requirements, 7th Edition 1999* and *ACI Manual of Concrete Practice, Part 3 1999.*

Proposed Construction Materials

2.40. The construction materials to be used for constructing the proposed works are proven by common experience to be 'fit-for-purpose' and are summarised in **Table 2.4**.

Table 2.4. Proposed Stage 2 Construction Materials

Item	Proposed Materials
Well casing and screen	Stainless steel or thermoplastic
Water transmission pipelines	uPVC
Sewage pumping stations	Cast in-situ reinforced concrete
Sewage rising main pipelines	Concrete lined ductile iron
Sewage gravity main pipelines	uPVC
Inspection chambers (manholes)	Reinforced concrete with cast iron access covers
Sewage treatment ponds	Over-compacted marl embankments above stone columns, with HDPE liner over non-moving geotextile on inner faces, vehicle wearing course along crests, non-moving geotextile on outer faces away from river, and stone rip-rap on outer faces adjacent to river
Sewage Treatment pipework	Ductile iron and uPVC
Turtle Crawle river entrainment	Gabion rock-filled baskets on Reno mattress along river frontage beneath compacted fill covered with Reno mattress below HDPE liner
Treated effluent pipeline	HDPE
Long sea outfall pipeline	HDPE with reinforced concrete weights

13. REVIEW OF INFORMATION PARTICIPATION AND CONSULTATION PROGRAMME

13.1. This, the final section of the EIA, reviews the programme and outcomes of the various consultations that have been undertaken to inform stakeholders about the PAWSDP and provide the opportunity for them to give their comments.

Advisory and Monitoring Committee

13.2. The process of public involvement in community infrastructure development is well practiced and GoJ is committed to project implementation becoming a partnership between agencies such as the NWC and affected communities.

13.3. Previous new sewerage networks and treatment plants at Negril, Montego Bay and Ocha Rios were successfully completed following the involvement of Advisory and Monitoring Committees (AMCs) The composition of these committees comprises the project proponent, other government agencies, local administrators, elected representatives, local and national NGOs, the police, the local chamber of commerce and other stakeholders.

13.4. Based on this positive experience a Stakeholders Workshop was facilitated by USAID/NEPA's Coastal Water Quality Improvement Project (CWIP) and held on Tuesday 5th February 2002, where it was agreed an AMC for Port Antonio be established to offer the same level of public participation as had benefited similar projects elsewhere.

13.5. The Port Antonio AMC met several times prior to the award of the detailed engineering design and construction management to KBR. The first informal meeting was held on Wednesday 15th May 2002 in the NWC offices at Smatt Road in Port Antonio. The agenda included a review of the CWIP Workshop, presentation of the water and wastewater plans for Port Antonio, and public consultation on the Sewage Effluent Regulations and recent water quality monitoring results.

13.6. A second informal meeting was held at Port Antonio Marina on Wednesday 19th June 2002, when 17 attendees discussed the Sewage Effluent Regulations.

13.7. Wednesday 16th April 2003 witnessed a milestone in the project with the public launch of the *Port Antonio Wastewater Advisory and Monitoring Committee*. Those present at included a the Minister of Water and Housing, the MP for East Portland, the Chief Executive of NEPA, an NWC Vice President, the Mayor of Port Antonio and the Director of USAID Jamaica.

13.8. The next meeting was held on Wednesday 11th February 2004 when 34 persons attended. A further meeting was planned for Wednesday 5th May 2004.

13.9. The first meeting at which KBR, the PAWSDP designer and construction manager was present was held on Thursday 14th April 2005 when NWC's Project Manager gave an update of the proposals.

13.10. The meeting of Thursday 14th September was the first to be held in the new Ken Wright Pier at Port Antonio Marina. The KBR Project Manager reported on the current status of the project, the scope of the proposed construction, explained the various studies that had been initiated, and presented a provisional programme to some 30 attendees.

13.11. The meeting on Thursday 26th January witnessed another milestone in the project. After KBR had presented a further update of project activity, the company's Environmental Consultant explained the need for an Environmental Impact Assessment and the EIA process. Discussion was then open to the floor and the Scoping Session elicited a wide range of questions and concerns in respect of the potential impacts of the project on both the biophysical and socio-economic environment.

13.12. The primary concerns expressed at the Scoping Session in respect of the Stage 2 works can be summarised as follows:

- Increased abstraction from the Rio Grande would reduce rafting activities;
- Once constructed, properties would not be quickly connected to the sewage network;
- Operation and maintenance would not be undertaken effectively;
- There would not be meaningful and effective public participation;
- Disruption due to traffic, noise and dust during construction would be intolerable;
- The ecology of Turtle Crawle and its wetland would be adversely impacted;
- Any involuntary resettlement would not be sympathetically handled;
- The discharge from the long sea outfall would return to the shore; and,
- The current start date for construction coincided with the beginning of the tourist season.

13.13. All comments and concerns expressed were recorded and KBR undertook to take them forward into the present EIA study. The available records from all AMC meetings are presented in Appendix E.

Public Presentation

13.14. In accordance with NEPA's EIA procedures, a period of three weeks from the date of submission of an EIA has to be allowed for the document to be available for public inspection and comment in council offices, schools, police stations or other pubic places. At the end of this period the Project

Proponent is required to hold a public meeting at which the project and the EIA are presented and attendees given the opportunity to air their comments.

13.15. The NWC will follow this requirement and closely coordinate with NEPA on the arrangements. Full details of the public presentation, the comments forthcoming and any necessary amendment of the EIA will subsequently be presented as an Addendum.

PAP Survey at Turtle Crawle

Scope and implementation

13.16 Significant long term negative impacts on the population within the project area will only accrue at the proposed treatment plant site at Turtle Crawle from where existing residents need to be resettled and the land taken into public ownership.

13.17 Since the PAWSDP environmental assessment is required to be undertaken in accordance with World Bank Operational Procedures and *OP 4.12 Involuntary Resettlement* has been used as the primary point of reference for dealing with this issue. The economic and social impacts to which OP 4.12 deals are defined, in the context of the present project as *the involuntary taking of land resulting in relocation or loss of shelter; loss of assets or access to assets; loss of income or means of livelihood, whether or not the affected persons must relocate*. Particular attention is to be paid to vulnerable groups such as those living below the poverty line, the landless, the elderly and infirm, women and children, ethnic minorities and other displaced persons who are not protected through national land compensation legislation. The Procedures require a Resettlement Action Plan to be developed to explain how PAPs will in practice be protected from exploitation.

13.18 The land at Turtle Crawle is privately owned by three separate parties not living in the area and the present residents and users have no legal entitlement or Customary Right of occupation. Nevertheless, their plight will be dealt with sympathetically. Not to do so will risk delay to the construction programme, subsequent damage to the installation and the environment, impoverishment, and the breakdown of households and of social structure. Their losses must therefore be recognised and compensated to the full extent provided by Jamaica Law.

13.19 The persons affected at and in the vicinity of the treatment plant site comprise:

1. Those resident on the site;
2. Those resident elsewhere but using part of the site for income-generating activities;
3. Those in the vicinity who may suffer a variety of temporary impacts during construction and potentially visual impairment, loss of natural landscape, noise and odour permanently; and,
4. Those distant from the site who may suffer from some restriction of access during construction.

13.20. For those PAPs in Groups 1 and 2 above, a short but formal socio-economic survey has been undertaken to assess the likely numbers involved and the expected level of impact they will suffer. For those in Groups 3 and 4, numbers and level of impact have been broadly estimated without a formal survey. The survey was undertaken in February 2006. The scope of the survey and the socio-economic questionnaire used for PAP Groups 1 and 2 are given in Appendix X. The results have been discussed in Sections 5 and 7 above.

Resettlement Action Plan

13.21. All aspects of land acquisition including the resettlement of those currently occupying the treatment plant site are being handled by the Legal Department of NWC in accordance with the provisions of Land Acquisition Act 1947and other relevant aspects of Jamaican law.