EXECUTIVE SUMMARY

The Port Authority of Jamaica (PAJ) wishes to expand the infrastructure capacity at the Trans-shipment Terminal at Port Bustamante. This, with a view to increasing the berthing capacity (number and size) for ships at the port, as well as providing more container storage space. This will be done in two phases. This report deals with the Environmental Impacts of Phase 1.

Phase 1 involves:

A) The dredging of Channel and Turning Basin

It is proposed to dredge the east channel, which is exposed to strong and long swells to a depth of 17.4m. Part of this exercise involves the removal of a part of Rackhams Cay (20%) in order to provide a minimum channel depth of 18m through the opening between Rackham and Gun Cays. The width required for the east channel to safely accommodate the design ship is 230m. The outer harbour channel (less exposed to swell) would be dredged to 16.4m; while the inner harbour channel (protected from swell) would be dredged to 15.7m. Some of the dredged spoil would be used to reclaim a section of Hunt's bay to increase the storage capacity for containers.

The proposed options for disposal of the dredged material are as follows:

1. Place all of the dredged material in the proposed Hunts Bay reclamation platform.

2. Dispose of all the material at a suitable marine disposal site.

3. A combination of the above options with some material being placed in the Hunts Bay reclamation platform or some other land bank location.

B) Reclamation of Hunts Bay

The reclamation work for Hunt's Bay would involve the placement of suitable Rock Armory to create containment berm for fill material. Suitable dredged material would be used as fill for the proposed reclamation area, which is on the south east, adjacent to the Portmore Causeway. It is also proposed to reclaim the north-western corner of Gordon Cay.

In addition to supporting prime waterfront property, Kingston Harbour and its environs are known to contain several ecologically as well as economically important habitats. These environments are important to the short and long-term stability of the shoreline and therefore the sustainability of activities in and immediately around the environs of the harbour. Some of these lands have the potential to support shipping and container storage activities and at present support one of the premier transhipment ports in the region. The nearby barrier and fringing reefs around the Port Royal cays, the natural wetland ecosystems located nearby, the Hunts Bay/Fort Augusta area and surrounding water bodies support vibrant fishing communities of Helsinki, Hellshire, Greenwich Town, Rae Town and Port Royal.

ECOLOGY

Along with existing data from previous reports, six locations generating twelve different sampling transects were established to generate information that would serve to add to the database for the purpose of comprehensively evaluating the ecosystems involved:

Hunts Bay (marine - north, middle, south & terrestrial east/west) - Transects 1, 2 , 3 & 4

Gordon Cay (west & east) - Transects 5 & 6

Ship Channel (east of Fort Augusta & west of Port Royal) - Transects 7 &8

Rackhams Cay (north to south & east to west) - Transects 9 & 10

Gun Cay (east to west) - Transect 11

Farewell / Sea Buoy - Transect 12

Data on the substrate was obtained by a visual examination of the substrate at the various stations Examination of the terrestrial habitat in the vicinity of the proposed Hunts Bay reclamation site was carried out by sampling the vegetation along 20m transects within each sample site. Avifauna were sought by direct observation or by searching for indicators such as nests. Physical descriptions and vocal peculiarities of any bird that could not be immediately identified were noted and later verified with field guides.

Environmental Impact

The main impacts associated with dredging and disposal activities relate first of all to direct loss of habitat. Secondary effects are assumed to relate to the formation of sediment plumes which may affect fish or benthos because of the smothering (clogging) effect of highly turbid waters on the gills of bivalves or fish, inability to detect predators or the limiting of the photosynthetic process in corals and plants. Nets placed in very silty areas tend to accumulate fine mud particles on their weave and fish can see the net and avoid it or they slide easily off the net instead of becoming entangled in its mesh.

The Hunts Bay Habitat

Because of the already impacted nature of the south eastern shoreline and immediately adjacent waters and sublittoral area it is not anticipated that any significant impact would occur in this area due to reclamation activities. It is possible however that changing the contour of the shoreline could affect the existing circulation patterns within the bay. This might result in a shift of the hypoxic (or highly polluted) conditions westwards into the main body of the bay with the resulting degradation of the existing fishing grounds used by the fishermen. This would reduce their catch levels even further and be considered a negative, indirect, highly significant, long term impact.

Another scenario is that decreasing the space available in this eastern corner of the bay might decrease the retention time of water in Hunts Bay. This could create a more direct flow of water (with its entrained pollutants) into the main harbour and increase the levels of contaminants affecting the fauna in the seagrass beds, mangroves and water column in and around the Port

Royal mangroves. No impact on the avifauna or marine life of Hunts Bay is anticipated from loss of the mangrove trees on the eastern margin. Loss of this small and already impacted stand of vegetation is not considered significant to the ecology of the bay.

Kingston Harbour Fishery

The dredging of the areas H1- H3, will undoubtedly release quantities of sediments containing high levels of heavy metals such as Lead, and Chromium. But the direction of sediment movement would most probably be out of the harbour, i.e. moving off to the south and being slowly carried off the west in the longshore drift. The effects on fishable resources at the mouth of the harbour would be largely speculative at this juncture. It is possible that spring flood tides may briefly slow and possibly even reverse the flow of sediment and water from the western dredge sites.

Other considerations include the reported comments from fishers in Port Royal which suggests that where dredging is widespread or unconstrained, normal night time land breezes could move sediment plumes into the Port Royal mangrove area. Bivalve mortality could possibly occur in the short term.

Annual visits into these mangroves in the period September through November over the past 20 years (1980 to 2000), strongly suggest that mangrove prop-roots bivalve resources are becoming somewhat scarcer and more stressed, probably due to increased solid waste originating from Kingston. During the major annual rainfall seasons from October through to November and in May, the increased runoff from the Rio Cobre estuary and from the Sandy Gully, if combined with dredging in the H1 to H4 sectors, could produce conditions of high turbidity in the Port Royal mangroves for variable periods. The residence time of this sediment-rich water may be long enough to cause detrimental effects to biota including fishable resources in the Port Royal mangrove complex.

The proposed clearing of coral hummocks in the east ship channel just north and NW of Southeast cay is of some interest to fisheries. It is known that most daytime fishers traditionally avoid this area due to maritime traffic. Instead, this channel is used by Port Royal hook-and-line fishers as a night-time access route directly to the edge of the south island shelf near to the extreme eastern end of the Eastern Approaches, where the drop-off into deeper water (> 300 m) occurs. Clearing of the coral in the Eastern Approaches area by dredging would not adversely affect fishing activities to any significant degree in the short or long term.

Kingston Harbour, Hunts Bay and the adjacent Port Royal mangoves-seagrass complexes provide modest fisheries production. These catches are mainly based on the capture by nets of sprats and herring and other surface-dwelling fish species, as well as shrimp (Hunts Bay only). Fortunately, most of the gill-net fisheries activities in the harbour are located in the centre of the basin. Nocturnal handline fishing at the entrance to the Eastern Approaches supports many of the fishers at Port Royal township. Parts of the Port Royal mangroves with their adjoining seagrass beds are known to act as nursery areas for various types of fishable resources. However, the majority of these nursery areas lie outside and to the east of the sites identified for dredging activities. During heavy rainfall, it is likely that some turbidity from dredging could affect the Port Royal mangroves and adjacent seagrass bed resources in the outer harbour.

Rackham's Cay

This site is confirmed as a minor site for the securing of baitfish for hook-and-line purposes. If a part of this area was lost, the remaining bait-rich areas would include the other five Port Royal cays. Each of these possess shallow sandy areas over which small baitfish are regularly found. Quite apart from this, the major baitfish area of the Port Royal mangroves would still be available. Thus the partial loss of Rackhams Cay and the short-term sediment problem in the Eastern Approaches, should not be a major problem to fishers, as there are alternative areas. Any "loss" of baitfish areas nearby would represent a minor percentage of the whole. An approximate loss estimate would be less than 10% of the present baitfish areas.

The major problem with losing a part of Rackhams Cay is the effect on the reef, which would suffer a significant loss from the coral, gorgonian, sponge, seagrass and urchin communities. This impact can be mitigated.

Gun Cay

Negligible impacts are anticipated at this site as a direct result of dredging activities at Rackham’s Cay.

Eastern Ship Channel

Negligible impacts are anticipated at this site as a direct result of dredging activities due to the small size of the coral patches/hummocks to be affected.

ENVIRONMENTAL CHEMI\STRY

Kingston Harbour and Hunts Bay are known to receive low quality run-off from gullies as well as poorly treated sewage and industrial waste. In addition the harbour is affected by oil spills associated with operations of the Petrojam refinery and shipping in general. These factors are likely to contribute to the quality of sediment to be dredged.

The indicator parameters considered relevant to the assessment are as follows: total suspended solids (TSS), nitrate (NO_3), available phosphate (o-PO_4), heavy metals (Pb, Cr, Cu, Cd), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), hydrogen sulphide, coliform, and pesticides.

Five sampling stations have been established to provide background information on the following:

Offshore background conditions - Station 1

The channel (near Port Royal) - Station 2

The channel (near Fort Augusta) - Station 3

The turning basin (Gordon Cay) - Station 4

Hunts Bay (near Causeway) - Station 5

Water samples were collected, as were sediment samples. Leachate tests were carried out on the sediments and the sediments themselves were analysed.

Water quality data collected at sites to be dredged, indicate ambient levels of some indicators that exceeded NRCA draft ambient standards, as well as USEPA saltwater quality criteria. This was indicated mainly for two heavy metals, lead and chromium, and biological oxygen demand (BOD). Lead and chromium data appears to be at variance with data collected from a previous study, though some time has elapsed between both determinations. Nevertheless it is considered unlikely that the lead concentration in particular would be so high in the water column. The high nutrient conditions in the harbour identified by previous workers were confirmed, especially for Hunts Bay. Suspended solids were well within the NRCA interim ambient standard for this parameter. Dissolved oxygen levels indicated well oxygenated surface and sub-surface waters.

Sediment from areas to be dredged had levels of lead and chromium which far exceeded the NRCA draft effluent standards, and (BOD) which appeared to be significantly higher than the NRCA Draft stream loading effluent standard. Though the high sulphide levels represent total sulphide, it is expected that a significant portion of this is in the form of toxic hydrogen sulphide.

Environmental Impact

Significant increase in suspended solids levels over background levels is expected. In marine disposal of the spoil. The fact that lead and chromium were much higher in leachate than in pore water would suggest that dissolution of compounds of these metals may be facilitated in oxygen-rich waters. The leachate and pore water had levels of lead and chromium which suggest that the material to be dredged fit the profile of hazardous waste based on a recent classification system developed the USEPA.

The high BOD of the leachate suggests that the material to be dredged would decompose, exerting significant pressure on available oxygen, possibly resulting in an oxygen deficit in receiving waters.

The high level of sulphide in the sediment suggests that disposal of the dredged material could result in the increase of ambient levels of hydrogen sulphide. This could potentially have a negative effect on any fishery in the vicinity at the time of discharge.

COASTAL DYNAMICS

The STFATE model was used to simulate the marine disposal of the spoil. The output describes the simulated behaviour of the dredged material discharge at the surface, the sediment plume during descent, the dispersion of contaminants, and the sediment accumulation on the seabed. The model runs were parameterized for the designated offshore disposal site in 350 m water depth, which is the average depth between the 200 m and 500 m contours at the edge of the island shelf. It is assumed that the material is discharged from the trailer barge within 60 seconds and the behaviour of the resultant sediment plume and bottom accumulation is simulated for 1 hour after the material is discharged at the water surface. (Please note that the SFATE output is in feet, hence the results are presented as such).

Based on analysis of contaminant concentrations, the conservative tracer for the long-term simulation computations is lead, with the initial concentration of 156.70 mg/l. The output of the model simulation begins 30 seconds after disposal. The plume has an initial horizontal radius of 45 feet with its centroid at a water depth of 34 feet. The downward decent of the plume initially increases to as much as 16 ft/s within 35 seconds after discharge at the surface, then slows to 8 ft/s 60 sec after discharge, when the plume has increased its horizontal radius to 121 feet, and has a centroid at a water depth of 363 feet. At 95 sec after discharge, the plume is decending at a rate of 5 ft/s with the centroid of water depth at 597 feet water depth, a radius of 176 feet, and a lead concentration of 2.6 mg/l. The plume completes it convective descent 157 seconds after discharge when the centroid depth is 829 feet water depth, with a downward velocity of 2.7 ft/s, a horizontal radius of 230 feet, and a lead concentration of 1.2 mg/l. The bottom is not encountered during convective descent and the diffusion of the plume is greater than the dynamic spreading from the collapse.

The collapse phase of the plume occurs thereafter as the bottom of the larger or heavy sediment begins to encounter the seafloor and the finer sediments lag behind. Within 200 sec after discharge at the surface, the fall velocity reduces to 0.9 ft/s as the width of the cloud expands to 485 feet, having a lead concentration of 1.0 mg/l. At 303 sec after discharge at the surface, the cloud has begins a very slight upward movement as it becomes closer to neutral buoyancy. At this point the centroid of the cloud is 918 feet water depth, having a radius of 612 feet and a lead concentration of 0.96 mg/l. The centroid of the cloud begins to ascend to shallower depths, at a maximum upward velocity of 0.3 ft/s between water depths of 893 feet to 877 feet. The cloud reached neutral buoyancy at a centroid depth of 811 feet, 959 sec after discharge. At this point the cloud has a thickness of 71 feet, a radius of 1185 feet and a lead concentration of 0.56 mg/l.

Pipeline discharge impacts (Eastern Channel)

The cutter dredge to be used in the east channel would discharge waste by a pipeline to the sea floor. A zone of turbulence develops as the material exits the discharge point. This zone of turbulence extends the approximate width of the channel basin (580 m) at the northern end. Settling out occurs quickly, with the percent solids in the centerline of the plume decreasing from 30% at the point of discharge to about 0.3 % (3 g/L) at the end of the turbulent zone located approximately 100m south of the point of discharge. This would be an area of high turbidity at the surface due to the fine-sized constituents of the effluent. At approximately 120 m away from the discharge point, the plume is interpreted to have descended to the bottom, forming a dense fluid layer that begins underflow spreading with a plume thickness (height) of approximately 6 cm. As the bottom spreading of the dense plume continues, some entrainment of the underflow into the overlying ambient flow occurs, which increases the underflow volume and decreases viscosity, and thus increases spreading along the bottom. At approximately 400 m distance from the initial discharge, the underflow plume makes contact with the east bank. At a distance of about 500 m away from the initial discharge, the underflow plume has a thickness of about 23 cm with a 0.09 percent concentration of solids.

Reclamation of Hunt’s Bay

Hunts Bay is an almost fully enclosed basin, open to the sea only by the gap beneath the Causeway, and a few other canals. All the freshwater input must therefore leave through these channels, and this interacts with rising and falling tides to produce the strongest currents situated in the vicinity of these channels.

Reclamation of this area will not impact the overall stability of the bay. The proposed area for reclamation lies in perhaps what is normally the quietest area of Hunts Bay as far as water movement is concerned. However during periods of heavy rainfall these currents will be replaced by strong fresh-water runoff currents produced by input from the large gullies.

Proper stabilization measures of the newly reclaimed area must therefore be implemented to prevent erosion during periods of high storm-water runoff. The same is true regarding the location of the site for land-based disposal of the fines (if this option is selected). Care must be taken in designing the storm water run-off for the proposed area, as a number of drains enter the sea in this area.

SOCIO –ECONOMICS

The socioeconomic impacts assessment (SIA) study area included those areas surrounding the Harbour that might be impacted by the proposed expansion activities. The SIA also took into consideration direct and indirect users of the port (and water) area and other stakeholders. Information on the existing socioeconomic and cultural environment was obtained by desktop research, review of existing reports, and field investigations. The SIA included the description and assessment of the demography; employment; distribution of income, goods and services; merchandise trade and transhipment; fisheries and fishing activities around fish landing sites of Rae Town, Greenwich Town, Port Royal, Hunts Bay at Causeway, Harbour Head and Port Henderson; education, health, housing, solid waste disposal; recreation; community fabric/cohesion; cultural/historic properties; land use; and stakeholders and public consultations.

The stakeholders and public consultation component comprised two distinct activities: a) Public Forum held on 3 August 2000, and b) Follow-up meetings and interviews with representatives from the fishing communities and cooperatives. It was obvious that all stakeholders and users of the Harbour were very genuinely concerned and interested in the proposed development and in the best interest of the people and their environment. Fishermen were concerned about the impacts of dredging and disposal of material on the marine environment and hence their livelihood, given their past experiences of dredging activities in the Harbour. Suggestions and recommendations were taken into consideration and where appropriate, were incorporated into the EIA. Included were:

- Compensation,
- Formation of a watch dog committee,
- An integrated planning approach to the sustainable development of the Harbour and surrounding areas (including comprehensive clean up efforts and community development),
- Public access to the EIA document, and
- The call for the PAJ to organize a second public forum.

Perceived impacts included very significant, direct and indirect positive benefits to national development goals and the strategic development of the Port of Kingston in order to maintain its competitiveness within the region as a premier port. The project would potentially impact economic/employment in a positive, direct and very significant, short and long term manner with the creation of approximately 1,000 new jobs during dredging (200 direct and 800 indirect jobs), plus other employment opportunities during land reclamation, design and construction. No major disruption to fisheries activities or damage to resources would result from dredging as none of any significance existed at the time of field investigation of sectors. The development of the shipping capacity of the Kingston Harbour would also require increased/improved marine policing/security (including drug enforcement capabilities) and customs associated with increased transhipment and container cargoes.

In recognition of the need to move toward a holistic and sustainable approach for the development of Kingston Harbour, a strong recommendation would be the formulation of an Integrated Development, Management and Monitoring Plan (IDMMP), incorporating existing sector plans, initiatives and projects already approved and/or being implemented. The IDMMP should include key action and results areas for the rehabilitation as well as the long-term development of Kingston Harbour, collaboratively with community-based planning and development. It should be supported and owned by all user groups and the public with certain agencies such as the Port Authority of Jamaica, NRCA/NEPA, TPD, KSAC, Ministry of Tourism and Sports, Ministry of Agriculture and Mining, the private sector (such the Port Royal Redevelopment Company among others) and NGOs, positioned to assume certain key responsibilities and lead functions. It was also recommended that most of the unskilled construction and casual laborer positions be filled locally. As much as possible, local residents, especially from the fishing communities, should be given the first opportunity for employment. On the issue of compensation to fishermen (in the event of negative impacts resulting from the project), it was recommended that the NRCA/NEPA and the Fisheries Division in collaboration with the affected Fishing Cooperatives and communities and the PAJ, should agree and discuss reasonable compensation, and the manner of its disbursement should the need arise.

IMPACT OF DISPOSAL ALTERNATIVES

The perceived impacts from the spoil disposal alternatives are positive and negative, as well as national and local in nature:

Alternative 1: Place all of the dredged material in the proposed Hunts Bay reclamation platform

Alternative 2: Dispose all of the material at a suitable marine site

Alternative 3: A combination of the above options with some material being placed in the Hunts bay Reclamation platform or some other land bank location

1. Reclamation

Disposal on land

This alternative assumes disposal at a site that affords protection of ground water and isolation to prevent entry of contaminants into the food chain. While this option can provide precise control over the fate of contaminants, there are a number of factors to consider which would influence cost. These include site identification, site preparation, ground transportation and security. It is expected that the less contaminated material could also be used generally as fill without any serious environmental risk. The possible risk from resubmergence of toxic spoil as a result of some catastrophic “act of God” cannot be overlooked. Although the effect would be immediate and negative, its magnitude would also be impossible to predict. It is likely that a lot of other collateral damage would also occur.

Disposal at Hunt’s Bay

Disposal to a section of Hunt’s Bay would provide little or no dilution and could be a significant short–term and long-term source of lead and sulphide to the rest of the bay. Through an engineered solution, it may be possible to confine the sediment physically thus eliminating the impact from suspended solids. Preventing leaching to adjoining areas would be more difficult. This alternative would also result in further but marginal loss of habitat in addition to the area to be filled for the port expansion. Terrestrial vegetation lost during this activity would be ecologically insignificant.

Discussions with representatives from the Town Planning Department (TPD) and KSAC indicated that the proposed land use of the reclaimed land would be compatible with surrounding land uses. Once the land was reclaimed, a Site Plan should be developed by PAJ and sent to the TPD and KSAC. Potential impacts would be localized positive impacts related to ‘new’ lands being brought into use and national positive impacts related to the future development of port and transshipment activities and associated economic gains.

The stability of the existing Causeway Bridge needs to be safeguarded and the alignment of the future Causeway Highway needs to be considered. The pre-feasibility study for the new Causeway Highway was done more than 4 years ago including a proposal for the resettlement of the dwellers, fishing community and vendors. It was further understood that the PAJ had been in discussion with the Highway 2000 Team at the Ministry of Transportation and Works, and was given the ‘green light’ to proceed with works in the vicinity of the bridge, as the construction of highway would ‘work around’ the proposed development. Hence, depending on whether the measures to be implemented by the Ministry of Transportation and Works, were done in a timely manner, then potential impacts should be negligible, if not implemented on time, then potential impacts would be negative, short term and direct, until such time that the measures were put in place.

In addition, while fishing activities are minimal at the proposed reclamation site, the westward drift of the plume should be carefully monitored as it could negatively impact handline fishing activities on the western side of the bay. Also, given the composition of the material that would be dredged, and the fact that only a portion of the more compact and non-toxic material may be suitable for land reclamation, the rest of the material would have to be otherwise disposed.

2. Offshore Disposal

Disposal at sea alone would remove the economic benefits to be gained from land reclamation. It also introduces the complication of the possible effect that toxic substances might have on marine benthic and pelagic flora or fauna. Increased levels of bio-accumulation in these organisms may have immediate or deferred mortality impacts. This alternative would be the least favourable.

Offshore Disposal - 200 metre depth contour

A minimum dilution factor (worst case) based only on volume of receiving water and ignoring the dispersive effect of currents was determined to be around 100-fold. Assuming negligible contribution from the receiving water, and using the results of sediment/leachate analyses, maximum temporary contribution of lead from sediment deposited at the dump site could be around 0.5ppm (500ppb), while sulphide could be 5mg/l, and BOD 10mg/l. Based on the total material to be disposed of, average suspended solids could be 6mg/l. It is considered that factors such as prevailing currents as well as interval between discharge events could lessen these values considerably.

Offshore Disposal - 1000 metre depth contour

A minimum dilution factor (worst case) is determined to be around 1000-fold. Using similar assumptions as in the 200m analysis, it is suggested that a further reduction of at least one order of magnitude would be achieved. It is also likely that at this greater depth, oceanic currents would enable a greater level of dilution. The greater distance that would have to be travelled by the dredge would also provide a longer period between discharge events thus improving dilution even further.

If dumping of the spoil from the Gordon Cay/container port sections H5 to H1 is to occur between the Hope River outfall and Cow Bay, then this heavy metal-polluted material must be placed into very deep water (not less than 1,000 m) and as far south as is feasible in terms of travel time for the barge. This is to avoid the displacement of resident fish species. Cow Bay is known for deepwater fishes such as dolphinfish, kingfish and jacks, and is the site of a very small fishing beach

The heavier fractions will make up the mound of consolidated material and this will be thinner and cover a larger surface area, than if dumping were to take place at 200m. This could result in the complete leaching of all the contaminants from the mound to the surrounding waters taking place in a shorter time. Some finer fractions of the plume may become neutrally buoyant at depth and travel with the prevailing current at that depth.

Other parameters necessary for model input such as temperature, salinity, current regime stratification, have not been measured at these depths, and so we must consider the greater spreading as the worst case scenario.

3. Mixed Land/Sea disposal

This scenario assumes disposal of the more contaminated material on land at an adequately prepared site, and “clean” material in the marine environment. This assumes that the contaminated material is surface sediment, and that the quality of sediment improves with depth. For this option dumping could be at the 200m or 1000m contour. This option would be expected to have a minimal environmental impact especially where marine disposal is to the 1000m contour.

Based on the foregoing discussions, this alternative would be the most favourable. This option would take into consideration the concerns of the fishing communities, provide additional land space for the further development of container storage with significant potential economic benefits, and facilitate the disposal of toxic materials in a location that would not negatively or minimally impact on the livelihoods of the surrounding communities under normal circumstances.

MITIGATION

Water Quality

The unexpectedly high values obtained for the trace metals lead and chromium may be adequate reason to repeat these analyses on freshly collected samples. The data base could also be improved by carrying out analysis on the actual sediment dredged at different depths. Though the turn around time for these analyses would limit their usefulness in this exercise, it would assist in refining disposal plans for future dredging operations.

Development of the disposal strategy should take into consideration the possible need to identify different ways of disposing of sediment from different depths (especially in the harbour). Where possible consideration should be given to using sediment as fill for land based projects.

Sediment from the more obviously contaminated areas, namely, Gordon Cay, and the channel near Fort Augusta may have to be disposed of in a different manner than sediment from areas in the outer harbour. The following simple matrix relates sediment type with potential hazards, and disposal options recommended for consideration:

Environmental Chemistry Matrix: Sediment, Hazard and Disposal Options

SEDIMENT SOURCE	**POTENTIAL HAZARD ASSOCIATED WITH DISPOSAL**	**DISPOSAL OPTIONS RECOMMENDED FOR CONSIDERATION**
Outside Harbour	Increased Suspended Solids	Ensure safe distance from sensitive ecosystems e.g. seagrass beds, and coral reefs
Ship channel (Port Royal to Fort Augusta)	Increased suspended solids, possible hydrogen sulphide contamination, organic load	Ensure safe distance from sensitive ecosystems e.g. seagrass beds, and coral reefs, deep water disposal (>300m)
Ship channel (Fort Augusta to Turning Basin)	Increased suspended solids, significant hydrogen sulphide contamination, high organic load, possible leaching of lead and chromium	Land disposal at a sealed site, disposal in very deep water (>1000m), control of discharge rate.

Ecology

Suggested mitigation for the project includes the following: -

C Curtains placed on dredge to trap sediments and therefore limit the lateral movement of turbid water;

C Spoil dispersion outfall characteristics to be evaluated by collecting grab water samples during dredging operations and operations modified accordingly;

C Dredging to a slightly greater depth than absolutely necessary to pick up more, heavier, material so as to facilitate fallout of dredge spoil when released in open water;

C Dredging to a slightly greater depth than absolutely necessary so as to reduce the need for maintenance dredging;

C No dredging in periods of rapid water movements, for example, in the afternoon when trade winds are strong, or during the rainy season when large influxes of fresh water could move significant volumes of sediment laden waters across the harbour to the Port Royal mangroves;

C The connection of a conical reflective shield to the outlet as silt suppression and dispersion control mechanism;

C Careful mapping of seagrass areas directly affected by the dredge and replanting 130% of area affected to compensate for possible mortality. These techniques are well established for Kingston Harbour waters,

C Reseeding of mussel beds in the Port Royal mangroves to improve the bait population for the fishery;

C Removing corals, seagrasses, gorgonians and urchins at the Rackham's Cay area and relocating to Gun Cay or some other appropriate site;

C Preventative maintenance of equipment to mitigate negative environmental impacts such as leakages and spillages.

MONITORING PROGRAMME

Monitoring of the Development Programme

A lead role in monitoring should be jointly taken by the NRCA/NEPA and the Fisheries Division. As the Kingston Harbour Rehabilitation Steering Committee already existed, then efforts should be made to utilize existing mechanisms and to build synergy and collaboration. The terms of reference and mandate of the Committee should be reviewed to allow for comprehensive monitoring and accountability of development activities within the Harbour and surrounding areas that might impact on the harbour, including recommendations contained in this EIA. The Committee should comprise members of key government agencies including the NRCA/NEPA, and Fisheries Division, NGOs/CBOs, Fishing Cooperatives and community representatives, Student Network, private sector, international agencies, and the Port Authority of Jamaica.

Monitoring of Dredging Programme

It is recommended that during the actual dredging and disposal procedures, a monitoring program be implemented. This program should include the following:

C An examination of **all** important environmental parameters should be carried out during the first week of the operation. If no adverse effects are noted, monitoring should be fortnightly. This monitoring will be carried out more frequently during unusual weather conditions, or if adverse effects are noted.

C Turbidity and other sensitive water quality readings should be taken at all sensitive areas outside of the area of the screens initially, and at regular intervals throughout the operation.

C Current readings and examination of plumes should be taken on a spot check basis throughout the area of interest.

• Aerial photographs (unannounced) should be taken regularly to determine if the dredge is operating according to recommendations.

• Soundings should be taken fortnightly at the approved offshore dump site to monitor the effect over the period of deposition.

• A continuous record of wind speed and direction should be made throughout the period of dredging.

Fortnightly reports should be sent to the NRCA on the dredging activities unless conditions develop which warrant more frequent reporting. Spot checks should be done on nearby reefs to monitor any siltation at least once per month, preferably every two weeks

1.0 INTRODUCTION

In addition to supporting prime waterfront property, Kingston Harbour and its environs are known to contain several ecologically as well as economically important habitats. These environments are important to the short and long-term stability of the shoreline and therefore the sustainability of activities in and immediately around the environs of the harbour. Some of these lands have the potential to support shipping and container storage activities and at present support one of the premier transhipment ports in the region. The nearby barrier and fringing reefs around the Port Royal cays, the natural wetland ecosystems located nearby, the Hunts Bay/Fort Augusta area and surrounding water bodies support vibrant fishing communities of Helsinki, Hellshire, Greenwich Town, Rae Town and Port Royal.

The Port Authority of Jamaica (PAJ) wishes to expand the infrastructure capacity at the Trans-shipment Terminal at Port Bustamante. This, with a view to increasing the berthing capacity (number and size) for ships at the port, as well as providing more container storage space. This will be done in two phases. This report deals with the Environmental Impacts of Phase 1.

Phase 1 involves:

A. Dredging of Channel and Turning Basin

It is proposed to dredge the east channel, which is exposed to strong and long swells to a depth of 17.4m. The outer harbour channel (less exposed to swell) would be dredged to 16.4m; while the inner harbour channel (protected from swell) would be dredged to 15.7m.

Some of the dredged spoil would be used to reclaim a section of Hunt's bay to increase the storage capacity for containers, while the less suitable material would be disposed of at sea, beyond the 200m depth contour outside the harbour.

B. Reclamation of Hunts Bay

The reclamation work for Hunt's Bay would involve the placement of suitable Rock Armory to create containment berm for fill material. Suitable dredged material would be used as fill for the proposed reclamation area, which is on the south east, adjacent to the Portmore Causeway (see Figure 2). It is also proposed to reclaim the north-western corner of Gordon Cay.

C. Proposed construction of new 6-carriage way bridge to replace Portmore Causeway Bridge

It is proposed that a new 6-way carriage bridge be constructed to replace the existing Causeway bridge. Detailed planning on this option had not begun at the time of the impact assessment, so an evaluation of this activity could not be carried out.

1.1 Terms of Reference

The Terms of Reference as approved by the NRCA, as well as comments, are located in Appendix 1.

1.2 Scope

The E.I.A. included a systematic examination of the likely environmental consequences of the proposed development of the Kingston Transshipment Port (Phase 1).

The E.I.A. was carried out by a multidisclipinary team encompassing skills in the areas of project management /coordination, environmental impact assessment, environmental chemistry, coastal dynamics, ecology, socioeconomics including public consultation, and environmental engineering.

This final report details all the activities which have been carried out pursuant to fulfilling the terms of reference stated above, analyses the data, makes conclusions and recommendations, and provides an Impact Statement and Impacts Matrix.

2.0 DESCRIPTION OF PROJECT

2.1 Dredging Works

East Channel

The Proposed dredging plan (Figure 1) envisions the deepening and widening of the channel, in order to accommodate the larger vessels coming into service recently (described as "Post Panamax").

The east channel extends from the seaward end of the East Channel to Kingston Harbour Limit (Port Royal Point) (see Figure 1, on a bearing of 284 degrees). In order to secure the Port's future maritime access for the next 15- 20 years, it is estimated that a dredged depth of 18m would be required. This is to accommodate wave/swell induced vertical movements, even though the design ships' draught is 14.5m. There are several coralline high spots which would have to be lowered to the 18m contour. Further, the Port Authority intends to dredge the northern part of Rackham Cay to 18m in order to provide a minimum channel depth of 18m through the opening between Rackham and Gun Cays. The width required for the east channel to safely accommodate the design ship is 230m.

Outer Harbour

The outer harbour channel would be less exposed to swell, thus the proposed depth for dredging here would be 16.4m, and the width proposed would be a minimum of 170m. The sediment in the outer harbour is composed largely of sand and silt.

Inner Harbour

The inner harbour, which is protected from the swell effects, is to be dredged to 15.7m with a minimum width of 160m. The bed within the inner harbour is generally formed of soft materials such as soft clays, weak peaty clays silts, etc. There are also deposits of organic material of anthropogenic origin deposited by Greenwich sewage treatment plant. Other sources include industrial and other waste carried into the harbour by gullies and other drains over several years.

2.2 Reclamation Works

It is proposed to reclaim a small part of Hunts Bay (in the south east), adjacent to the Portmore Causeway. And the north western corner of Gordon Cay (see Figure 2). This would be to create more container storage space as part of the Port Expansion. This would involve the placement of suitable Rock Armory to create a containment berm for fill material. Suitable dredged material would then be used as fill.

2.3 Spoil Disposal Alternatives

The proposed options for disposal of the dredged material are as follows:

Alternatives:

1. Place all of the dredged material in the proposed Hunts Bay reclamation platform.

2. Dispose of all the material at a suitable marine disposal site.

3. A combination of the above options with some material being placed in the Hunts Bay reclamation platform or some other land bank location.

If dredging takes place to fully accommodate the “Post Panamax” vessels, the estimated total quantities of material to be dredged is 10,559,888m^3. Approximately 3,000,000m^3 of suitable material to be used as fill at Gordon Cay and Hunts Bay (see Figure x).

3.0 METHODOLOGY

3.1 Water Quality

The environmental chemistry component was carried out based on the assumption that the area of influence of the project includes, the heavily impacted Hunts Bay/Kingston Harbour system, as well as the relatively unpolluted Port Royal cays and reefs within the Palisadoes/Port Royal Protected Area.

The environmental chemistry assessment aims to provide critical information to the planning process to ensure that conflicts that arise during dredging and dredged material disposal can be reduced, thus resulting in economic growth and environmental protection.

The main objectives in Stage 1 of the environmental chemistry component of the assessment were as follows:

- Characterise water resources within the zone of influence of the project including potential marine disposal sites

- Characterise sediment to be dredged

- Project environmental impact of proposed development on water chemistry within the zone of influence

- Develop a plan to mitigate negative environmental impacts of the dredging and disposal of dredged material (spoil) on water quality.

The assessment was based on a review of existing information, the collection and analysis of sediment and water samples, and the conducting of leaching experiments in the laboratory. The programme of work was also designed to provide additional information in order to inform Phase 2 of the project i.e. the development of Fort Augusta.

Through literature review, typical values of indicator parameters have been established for the study area. A review of relevant local and international standards, and criteria has also been carried out to assist in the assessment of the material to be dredged and contribute to guiding the selection of an appropriate disposal option. Information sources for the literature review included UWI, NRCA, USEPA, and TEMN, and various web-sites.

Five sampling stations were established (See Figure 3) to obtain background information on the following:

Offshore background conditions - Station 1

The channel (near Port Royal) - Station 2

The channel (near Fort Augusta) - Station 3

The turning basin (Gordon Cay) - Station 4

Hunts Bay (near Causeway) - Station 5

Surface and sub-surface water samples were collected at all sites established using a Van Dorn sampler. Samples of sediment were collected by the biology team at the sites to be dredged (channel, and turning basin) using a core sampler.

Laboratory analyses were carried out by the Bureau of Standards, and Environmental Focus Ltd. in accordance with Standard Methods for the Analysis of water and wastewater (17) to determine the following: total suspended solids (TSS), nitrate (NO_3), available phosphate (o-PO_4), hydrogen sulphide, heavy metals (Pb, Cr, Cu, Cd), chemical oxygen demand (COD), biochemical oxygen demand (BOD), coliform. Organic residues were determined using Gas chromatography-mass spectrometry (GCMS). Dissolved oxygen (DO) was determined in situ using portable instrumentation.

Rationale for Selection of Water Quality Indicators:

Water quality parameters have been selected based on the known potential impacts associated with dredging, as well as an understanding of the issues affecting the quality of surface run-off and effluent quality entering the area to be dredged. Dredging, and the disposal of dredged material (spoil) can impact water quality in the following ways:

- Temporary increase in turbidity (suspended matter) at the site(s) being dredged and adjoining areas,
- Temporary increase in turbidity at the disposal site (for marine disposal),
- Trailing of spoil by barges conveying dredged material to disposal sites,

- Leaching of sediment during descent at disposal site,
- Shifting of dumped spoil from disposal site

The indicator parameters considered relevant to the assessment are as follows: total suspended solids (TSS), nitrate (NO_3), available phosphate (o-PO_4), heavy metals (Pb, Cr, Cu, Cd), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), hydrogen sulphide, coliform, and pesticides.

Total Suspended Solids was determined by filtration and gravimetry.

Nitrate was determined using the salt tolerant copper/cadmium reduction method.

Available **Phosphate (o-PO_4)** was determined by the molybdenum colorimetric method.

The heavy metals **Lead (Pb), chromium (Cr), Copper (Cu), and Cadmium (Cd)**, were determined by atomic absorption spectrophotometry using a Thermo Jarrel Ashe Video 11 spectrophotometer which features background correction for matrix interference.

Chemical oxygen demand (COD) was determined using colorimetry.

Biochemical oxygen demand (BOD) was determined by the bottle dilution method.

Dissolved oxygen (DO) was determined using the YSI Model 51B Oxygen meter, and Model 5739 Field Probe. The probe uses a Clark-type gas permeable membrane that covers polarographic electrode sensors. The system has a built in thermistor for temperature compensation, and temperature measurement. Measurement range of the instrument is 0 -15mg/l, and accuracy is better than 0.2mg/l when calibrated within + or -5^{o}C of actual sample temperature. Readability is better than 0.1mg/l.

Coliform was determined by the membrane filter method.

Organic residues (**pesticides** etc.) were determined using gas chromatography - mass spectrometry (GCMS).

Hydrogen Sulphide was determined in sediment and water samples using Standard Methods 450052-C, 450052-E. The method involves pre-treatment of samples with zinc acetate, sodium hydroxide, and iodine. Titrimetric determination of excess iodine provided the basis for calculation of hydrogen sulphide concentration.

Leaching experiments were performed on sediment taken from the channel, the turning basin (near Gordon Cay), and Hunts Bay. This involved 10 g sediment (collected from proposed dredge sites close to Gordon Cay) being leached with 250 mls water collected from Station 1 for 0.5 hrs (offshore site being considered for spoil disposal). In all cases, the filtered leachate was analysed to determine levels of all indicator parameters with the exception of dissolved oxygen.

In addition, wet sediment samples from near Gordon Cay were allowed to settle, and the supernatant decanted and analysed. These samples were assumed to represent pore-water/worst-case-leachate associated with the sediment from the more polluted section of the harbour to be dredged (the turning basin downstream of the Greenwich sewage treatment plant discharge near Gordon Cay).

3.2 Ecology

A survey of the existing literature relating to work carried out on Kingston Harbour, Hunts Bay and the Port Royal Cays area was carried out with a view to determining the present ecological status of the area. The review also helped to facilitate the identification of environmental parameters that justified further investigation in the context of the proposed dredge and fill activities.

Information from the literature review, available maps, marine charts and aerial photographs was used to establish the locations of sampling stations and of swim-line transects at each station. Transects were then examined with a view to obtaining a detailed assessment of floral/faunal composition and status of sublittoral areas at each station.

Along with existing data from previous reports, six locations generating twelve different sampling transects were established (Figure 3) to generate information that would serve to add to the database for the purpose of comprehensively evaluating the ecosystems involved:

Hunts Bay (marine - north, middle, south & terrestrial east/west) - Transects 1, 2 , 3 & 4

Gordon Cay (west & east) - Transects 5 & 6

Ship Channel (east of Fort Augusta & west of Port Royal) - Transects 7 &8

Rackhams Cay (north to south & east to west) - Transects 9 & 10

Gun Cay (east to west) - Transect 11

Farewell / Sea Buoy - Transect 12

Data on the substrate was obtained by a visual examination of the substrate at the various stations. The visual technique was based on an immediate estimation of a 0.2 m^2 quadrat placed on the substrate at randomly chosen locations along the swim-line transects. Videotapes were also taken of the substrate along the transect lines chosen. Substrate composition data was extracted from these videotapes by selecting random stills from the video tape and using the random point intercept method to analyze the content of the photographs.

The results of this assessment of the marine environment were recorded under the following headings:- **SEAGRASS** - \`r' species or climax communities; **ALGAE** - turf or macrophytic; **CORAL** - branching, boulder or encrusting; **MACRO FAUNA** - other cnidarians e.g. gorgonians, anemones or zoanthids; **SPONGES** - fleshy, boring or encrusting; **BARE SUBSTRATE** - bare rock, rubble, sand or mud.

Examination of the terrestrial habitat in the vicinity of the proposed Hunts Bay reclamation site was carried out by sampling the vegetation along 20m transects within each sample site. Along these transects the vegetation occurring within 1.5m of either side was noted and recorded under the following headings:-

- species - recorded as **TREES; SHRUBS; HERBS; FERNS; GRASSES; WEEDS; EPIPHYTES; VINES; CACTI;** and ranked using the DAFOR (dominant, abundant, frequent, occasional, rare) scale.

- tree diameter at a height of 1m above ground level

- average canopy height
- percent of ground covered by shrubs, herbs or grasses.

Trees were considered to be species with a trunk diameter greater than or equal to 4cm at 1m above ground level. Shrubs were considered to be species with a trunk diameter less than 4cm at 1m above ground. Herbs were considered to be species less than 1m tall. Identification of as much as possible of the existing species of flora was carried out on site. Photographs were taken and samples collected of the more obscure species for later identification in the Lab.

The following general terrestrial features were noted along each transect:

C Soil Type & Structure

- Leaf Litter depth

C Topography in vicinity of transect

The general land use within the area of the sampling stations was also noted.

Faunal community composition was recorded under the following headings: **AVIFAUNA; MACROFAUNA; INSECTS.**

Avifauna were sought by direct observation or by searching for indicators such as nests. Physical descriptions and vocal peculiarities of any bird that could not be immediately identified were noted and later verified with field guides. This method is only capable of identifying the most common birds found in an area. Rare, migratory or cryptic species can be under represented by this technique. The Point Count Method (without distance estimates) was used to sample the bird population. This method produced data that revealed the bird species present, their abundance and habitat preferences. It does not permit estimates of the total population size in the area.

Avifauna identified were ranked according to the following criteria:

R = resident 1 = common in suitable habitat

E = endemic 2 = uncommon

I = introduced 3 = rare

W = winter migrant 4 = vagrant/unexpected/accidental

S = summer migrant

Insects and other macrofauna utilising the site were recorded as encountered. No special searches were carried out.

Special note was made of ecologically or commercially important species of flora or fauna. Any other physical and/or ecological characteristics of interest were noted.

The methodology outlined above resulted in a stratified sampling routine in which the transects were not evenly spaced over the entire study area but were grouped to create sample sites in certain predetermined areas. The result of this approach was coverage of the area by points representing the major land use types distinguishable.

3.3 Coastal Dynamics

In order to predict the nature and movement of the disposed sediment, a U.S. Army Corps of Engineers computer model (STFATE) (Johnson, 1990, 1995) was used to examine the parameters of spoil released from a Hopper barge.

3.3.1 Model Setup for Hopper Barge Discharge

3.3.1.1 Modelling of Disposal of Dredged Material

The STFATE model incorporates state-of-the-art techniques for simulating short- and long-term fate of dredged material due to dredging disposal operations and environmental processes. The model was developed by the US Army Corps of Engineers, Waterways Experiment Station. The model predicts the distribution of dredged material through the water column and bathymetric distribution of dredged material on the seabed on the basis of individual disposal loads. The model accounts for various parameters including the type of disposal vessel, physical properties of the water column, and material properties.

STFATE estimates the behavior of dredged material as it is released in open water, passes through the water column, and encounters the seabed. Through its 25-year period of development, the model has been calibrated and successfully applied at *numerous locations. The following studies have used the STFATE model: Koh and Chang (1973), Brandsma and Divoky (1976), Bokuniewicz at al (1978), Bowers and Goldenblatt (1978), Johnson and Holliday (1978), Thevenot and Johnson (1994), Moritz and Randall (1995), Lillycrop and Clausner (1997), and Johnson et al 1998). It must be noted that STFATE is a tool that provide estimates of sediment behavior and related processes. The accuracy of STFATE model-generated results is highly dependent upon the parameters input to the model. Controlling parameters which must be properly specified within the STFATE model are physical characteristics of the dredged material, disposal operation sequencing, and forcing environmental conditions within the water column (waves, currents, density structure).*

The objectives of this short-term fate assessment were:

- Evaluate the overall size of the mixing zone for discrete discharges from the disposal vessel.
- Determine the concentration of the pollutant of most concern (lead) at various points in the water column and on the seabed.
- Estimate the distance that the disposed dredged material is displaced away from the point of release.
- Estimate the fall speed, density, and detailed aerial extent of dredged material as it encounters the seabed during disposal.
- Estimate the disposal mound geometry in terms of thickness and aerial extent after the placed material comes to rest on the seabed.

3.3.1.2 The Fate of Dredged Sediment Placed in Open Water

The operation of hopper dredges result in a mixture of water and solids stored in the hopper for transport to the disposal site. At the disposal site, the hopper doors in the bottom the vessel's hull are opened, and the entire hopper contents are released within a time-frame of tens of seconds to minutes.

When dredged material is released in open water by a disposal vessel, the material falls through the water column, mixing with ambient water, and forming a high-density plume which may contain blocks of solid material. This process is called convective descent. As the convecting plume descends in a hemispherical shape, it grows as a result of ambient water entrainment, and a fraction of material (typically 1 to 5 percent) and fluid with dissolved contaminants may be stripped away. When the diluted dredged material plume encounters the seabed (or arrives at neutral buoyancy), the plume spreads laterally along the seabed. This process is called dynamic collapse. Fine material may be lost to the water column at the top of the collapsing plume. After the plume has expended all of its momentum along the seabed, the dredged material slowly settles under the influences of gravity and the ambient current environment. This process is called passive transport and dispersion.

The fate of dredged material placed in open water is primarily governed by gravity, surface waves and currents. Dredged material falls from the release point of the disposal vessel through the water column, convects and diffuses laterally, and eventually comes to rest on the sea floor.

Within minutes to hours following disposal, dredged material can be spread out on the seabed to varying degrees, depending upon the speed of the disposal vessel upon release, water depth, water column currents, ambient bathymetry, and other variables.

Once dredged material has come to rest on the seabed it can be transported by waves and currents to varying degrees, depending on sediment grain size, bathymetry, and physical forcing, which, for surface gravity waves, decreases with depth. If the dredged material is cohesive, it can self-consolidate due to gravity. If many loads of dredged material are placed one on top of another to develop a mound on the seabed, the mound will tend to avalanche and material will be transported downslope. The combination of these processes determine the long-term fate of dredged material placed in open water. The time-frame for processes affecting the long-term fate of placed dredged material is days to years.

Several aspects influence the dispersion, accumulation quantity and shape of the disposal mound on the seabed:

- Speed of hopper dredge while dumping

- Current speed and direction in the water column

- Water depth and bathymetry at disposal location

The mound length and thickness is a function of vessel speed. Increasing current speed reduces mound height. Split-hull hopper dredges produce a thicker (higher) resultant mound than the multiple bottom-door hopper dredges. The most significant parameter affecting mound geometry (width and height) is water depth. As a general rule of the practice in shallow water, increasing the water depth by a factor of 3 will decrease disposal mound height for a single dump by a factor of 2. Increasing the water depth by a factor of 3 will increase disposal mound width for a single dump by a factor of 2.5.

3.3.2 Hopper Barge Spoil Disposal Logistics used as data input for model, as supplied by the dredging consultants

An 8,000 cubic metre capacity trailer will bottom dump its whole load in a minute or so and then spend a few more minutes cleaning out the hopper.

The total load carried can be estimated by assuming that the average hopper density is 1.35 t/cu.m. Past experience indicates that this material descends to the seabed in a large density current and that the amount stripped off during descent is about 5% of the dry solids distributed over the full water column.

The trailer proposed to be used has a hopper with dimensions 43m x 19m and the draft of the vessel would be 2.8 metres light and 7.5 metres laden.

The proposed disposal site marked on the maps drawn by Mott MacDonald is 1,200m x 3,000m. The model grid for the STFATE runs used is 1,829 x 2,438 m (6,000 x 8,000 ft); that is, it was necessary to use a grid height (x-direction) of about 400m greater in order to display the entire bottom dump within the grid. Therefore we can assume that the bottom material will extend past the boundaries of the disposal site in the northwest - southeast direction. An average depth of 350m (1148 ft) was used for the grid since the site is bounded by the 200m and 500m bathymetric contours.

** Note: Due to the varying nature of the ocean currents and the tendency of the tides to cause a rotation in the direction vector of the currents, it is prudent to assume the current may travel in all directions from the dump site at varying stages of the tide.

Note that a 0.7 fps (0.21 m/s) velocity for the water column flowing from the east (with a velocity within the bottom 30 m at 0.15 m/s) was used based on the field data recorded during the 1994 TEMN study, with a 0.1 fps downslope velocity component from the north. The barge was assumed to be stationary during disposal that takes 1 minute so as to minimize directional spreading of the material.

To set up the model as a realistic case, we assume the dredged material in the barge has two major layers, due to settling in the barge during transport to the dump site. The bottom layer of 5,352 cu meters (7,000 cu yds) has a higher volumetric concentration of sand, and a top layer of 2,648 cu meters (3,464 cu yds) has a lower concentration of sand and slightly higher concentrations of silts and clays. The bulk density for both layers is about 1.33 g/cc (close to 1.35 t/cu m).

The concentration of sand, 0.09 and 0.06 (in the two layers respectively) was used due to the fact that this project is excavating deeper, past the top layer in the channel that contains relatively less sand and more silt and clay; i.e. the deeper the dredging, the higher concentration of sand would be expected.

The model output (Appendix 3) gives "plots" for the surface water concentration of suspended material (relatively small) and sea floor accumulation of the settled material. See the last pages of the plots for total bottom accumulation. Other tables describe the dimensions and position of the plume in the water column.

Note that the suspended material values should be considered at radial distances from the disposal site, once again due to the varying direction of the currents.

Sediment #5 has the lowest total solids and highest concentration of lead at 96.89 ppm, which is equivalent to 156.7 mg/l. This is nearly identical to the Chromium values in the same sample. All the other sediment samples have lower concentrations.

Regulatory levels for both lead and chromium are 5.0 mg/l. These are the toxicity levels in Table 3. But in Table 2, the standards are different for lead and chromium; lead has a much lower allowable concentration. Therefore, lead is considered to be the "conservative" tracer. For the original disposal site using 350 m of water, and using the 156.7 mg/l concentration for lead, the maximum concentration of lead in the accumulation on the bottom is 8.9 mg/l.

3.3.3 Pipeline Discharge Modelling - Cutter Suction Dredge

The algorithms for modelling a continuous pipeline discharge were developed in the late 1970's and early 1980's, and are still evolving as a result of technological advances. A new model, D-CORMIX, is currently under evaluation for this application, but has not yet been sanctioned for use. The model used for this work, CDFATE, is part of the ADDAMS suite of environmental models recommended by the US Corps of Engineers, Waterways Experiment Station. It is based on a widely-used point source model, CORMIX, which assumes a Gaussian distribution for the plume shape. The model results presented in Section 6.3.4 are to be used as a rough estimate, and field experiments should ultimately determine the best dredging operation practices to use in this situation.

3.3.4 Cutter Suction Dredge Discharge

The input parameters used for CDFATE are as follows:

Mean depth of receiving water 20 m (Modelled as a straight, uniform channel)

Bottom roughness, Mannings coefficient 0.035

Mean velocity of receiving water 0.15 m/s

Water density profile Uniform

Density of receiving water at 20m 1020 kg/m3

Density of dredged material 1250 kg/m3

Distance from nearest bank 260 m

Depth of discharge 6 m (***The model not allow a discharge depth greater than 1/3 the total depth)

Discharge rate 0.24 m3/sec

Pipe diameter 0.75 m

Vertical angle of pipe with water surface 90 degrees

Angle pipe makes with the current 0 degrees

Solids in effluent 30%

The output for CDFATE is presented in Table 1 below. The x -axis is aligned from north to south, and the y-axis from east to west. The point of origin (0,0) is the point of discharge assumed to be at the north end of the channel basin, 260 m from the east bank. The channel basin is approximated in the model to represent the area between Rackham's Cay (east bank) and the West Middle Shoal (west bank) that is 20 m deep. The parameter BH is defined as the half width of the Gaussian plume measured horizontally. The ZLTMZUB parameter is interpreted to be the upper plume boundary minus the lower plume boundary in the vertical direction.

Table 1: CDFATE Model output

X	Y	Percent Solids in Plume	BH	ZLTMZUB
65.95	0.00E+00	0.3124	251.6	0.00E+00
78.9	0.00E+00	0.3028	265	0.00E+00
91.86	0.00E+00	0.2934	278	0.00E+00
104.8	0.00E+00	0.2842	290.8	0.00E+00
117.8	0.00E+00	0.337	118.7	-5.79E-02
129	0.00E+00	0.3353	130	-6.34E-02
129	0.00E+00	0.3353	130	-6.34E-02
130.7	0.00E+00	0.3279	130.4	-6.41E-02
143.7	0.00E+00	0.3241	133	-7.00E-02

156.6	0.00E+00	0.3144	135.7	-7.59E-02
169.6	0.00E+00	0.3048	138.3	-8.18E-02
182.5	0.00E+00	0.2956	141	-8.77E-02
195.5	0.00E+00	0.2865	143.6	-9.36E-02
208.4	0.00E+00	0.2775	146.2	-9.95E-02
221.4	0.00E+00	0.2688	148.9	-0.1054
234.3	0.00E+00	0.2604	151.5	-0.1113
247.3	0.00E+00	0.252	154.2	-0.1172
260.3	0.00E+00	0.244	156.8	-0.1231
273.2	0.00E+00	0.2361	159.5	-0.129
286.2	0.00E+00	0.2285	162.1	-0.1349
299.1	0.00E+00	0.2211	164.8	-0.1408
312.1	0.00E+00	0.2138	167.4	-0.1467
325	0.00E+00	0.2069	170	-0.1526
338	0.00E+00	0.2001	172.7	-0.1585
350.9	0.00E+00	0.1935	175.3	-0.1643
363.9	0.00E+00	0.1871	178	-0.1703
376.8	0.00E+00	0.181	180.6	-0.1761
389.8	0.00E+00	0.1749	183.3	-0.1821
414.2	-130	0.1116	881.9	-0.1932
438.6	-130	0.105	892.2	-0.2043
463	-130	9.91E-0201	902.5	-0.2154
487.4	-130	9.35E-0201	912.7	-0.2265

3.4 Socio-economics

The socioeconomic impacts assessment (SIA) study area of this project was the area including the proposed port expansion and surrounding areas within a 2 km boundary. It included areas surrounding the Harbour that might be impacted by the proposed expansion activities as well as direct and indirect users of the port (and water) area and other stakeholders. In some instances, for ease of description and discussion, the study area may be specifically divided into three distinct regions of Port Royal, Kingston, and Portmore/Causeway, but, should be viewed as part of the whole SIA area. Socioeconomic impacts may be both micro (local) and macro (regional and national) in extent. The local impacts were usually those perceived within the SIA area while macro impacts were those perceived nationally.

Information on the existing socioeconomic and cultural environment was obtained by desktop research and interviews with the Statistical Institute of Jamaica (STATIN), the Town Planning Department (TPD), Kingston and St. Andrew Corporation (KSAC) and the Port Authority of Jamaica (PAJ). The socioeconomic profile draws heavily from existing information contained in The Portmore Causeway Project (1996-7), The Strategic EIA - Port Royal Heritage Tourism Project (1998), and the Kingston Foreshore Road (1999). In the above mentioned Portmore Causeway Project (1996-7), a stratified random socioeconomic survey was administered and analyzed using SPSS.

Combined, these studies and other relevant reports such as the Kingston Harbour Rehabilitation Plan provided substantial information. To every extent possible, the information was then updated through projections, field investigations, and further research. Information was also obtained from the Public Forum on this porject held on 3 August 2000 by the PAJ. As a follow-up to the Public Forum, public interviews/ consultations were also held with representatives of the key fishing communities of Hunts Bay at the Causeway, Greenwich Town, Rae Town and Port Royal during 21 August to 15 September 2000. A land use survey was also conducted within the larger Hunts Bay - Causeway area - proposed site for land reclamation during May 21-22, 2000.

3.0 METHODOLOGY

3.1 Water Quality

The environmental chemistry component was carried out based on the assumption that the area of influence of the project includes, the heavily impacted Hunts Bay/Kingston Harbour system, as well as the relatively unpolluted Port Royal cays and reefs within the Palisadoes/Port Royal Protected Area.

The environmental chemistry assessment aims to provide critical information to the planning process to ensure that conflicts that arise during dredging and dredged material disposal can be reduced, thus resulting in economic growth and environmental protection.

The main objectives in Stage 1 of the environmental chemistry component of the assessment were as follows:

- Characterise water resources within the zone of influence of the project including potential marine disposal sites

- Characterise sediment to be dredged

- Project environmental impact of proposed development on water chemistry within the zone of influence

- Develop a plan to mitigate negative environmental impacts of the dredging and disposal of dredged material (spoil) on water quality.

The assessment was based on a review of existing information, the collection and analysis of sediment and water samples, and the conducting of leaching experiments in the laboratory. The programme of work was also designed to provide additional information in order to inform Phase 2 of the project i.e. the development of Fort Augusta.

Through literature review, typical values of indicator parameters have been established for the study area. A review of relevant local and international standards, and criteria has also been carried out to assist in the assessment of the material to be dredged and contribute to guiding the selection of an appropriate disposal option. Information sources for the literature review included UWI, NRCA, USEPA, and TEMN, and various web-sites.

Five sampling stations were established (See Figure 3) to obtain background information on the following:

Offshore background conditions	-	Station 1
The channel (near Port Royal)	-	Station 2
The channel (near Fort Augusta)	-	Station 3
The turning basin (Gordon Cay)	-	Station 4
Hunts Bay (near Causeway)	-	Station 5

Surface and sub-surface water samples were collected at all sites established using a Van Dorn sampler. Samples of sediment were collected by the biology team at the sites to be dredged (channel, and turning basin) using a core sampler.

Laboratory analyses were carried out by the Bureau of Standards, and Environmental Focus Ltd. in accordance with Standard Methods for the Analysis of water and wastewater (17) to determine the following: total suspended solids (TSS), nitrate (NO_3), available phosphate ($o\text{-}PO_4$), hydrogen sulphide, heavy metals (Pb, Cr, Cu, Cd), chemical oxygen demand (COD), biochemical oxygen demand (BOD), coliform. Organic residues were determined using Gas chromatography-mass spectrometry (GCMS). Dissolved oxygen (DO) was determined in situ using portable instrumentation.

Rationale for Selection of Water Quality Indicators:

Water quality parameters have been selected based on the known potential impacts associated with dredging, as well as an understanding of the issues affecting the quality of surface run-off and effluent quality entering the area to be dredged. Dredging, and the disposal of dredged material (spoil) can impact water quality in the following ways:

- Temporary increase in turbidity (suspended matter) at the site(s) being dredged and adjoining areas,
- Temporary increase in turbidity at the disposal site (for marine disposal),
- Trailing of spoil by barges conveying dredged material to disposal sites,
- Leaching of sediment during descent at disposal site,
- Shifting of dumped spoil from disposal site

The indicator parameters considered relevant to the assessment are as follows: total suspended solids (TSS), nitrate (NO_3), available phosphate (o-PO_4), heavy metals (Pb, Cr, Cu, Cd), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), hydrogen sulphide, coliform, and pesticides.

Total Suspended Solids was determined by filtration and gravimetry.

Nitrate was determined using the salt tolerant copper/cadmium reduction method.

Available **Phosphate (o-PO_4)** was determined by the molybdenum colorimetric method.

The heavy metals **Lead (Pb), chromium (Cr), Copper (Cu), and Cadmium (Cd)**, were determined by atomic absorption spectrophotometry using a Thermo Jarrel Ashe Video 11 spectrophotometer which features background correction for matrix interference.

Chemical oxygen demand (COD) was determined using colorimetry.

Biochemical oxygen demand (BOD) was determined by the bottle dilution method.

Dissolved oxygen (DO) was determined using the YSI Model 51B Oxygen meter, and Model 5739 Field Probe. The probe uses a Clark-type gas permeable membrane that covers polarographic electrode sensors. The system has a built in thermistor for temperature compensation, and temperature measurement. Measurement range of the instrument is 0 -15mg/l, and accuracy is better than 0.2mg/l when calibrated within + or -5^{o}C of actual sample temperature. Readability is better than 0.1mg/l.

Coliform was determined by the membrane filter method.

Organic residues (**pesticides** etc.) were determined using gas chromatography - mass spectrometry (GCMS).

Hydrogen Sulphide was determined in sediment and water samples using Standard Methods 450052-C, 450052-E. The method involves pre-treatment of samples with zinc acetate, sodium hydroxide, and iodine. Titrimetric determination of excess iodine provided the basis for calculation of hydrogen sulphide concentration.

Leaching experiments were performed on sediment taken from the channel, the turning basin (near Gordon Cay), and Hunts Bay. This involved 10 g sediment (collected from proposed dredge sites close to Gordon Cay) being leached with 250 mls water collected from Station 1 for 0.5 hrs (offshore site being considered for spoil disposal). In all cases, the filtered leachate was analysed to determine levels of all indicator parameters with the exception of dissolved oxygen.

In addition, wet sediment samples from near Gordon Cay were allowed to settle, and the supernatant decanted and analysed. These samples were assumed to represent pore-water/worst-case-leachate associated with the sediment from the more polluted section of the harbour to be dredged (the turning basin downstream of the Greenwich sewage treatment plant discharge near Gordon Cay).

3.2 Ecology

A survey of the existing literature relating to work carried out on Kingston Harbour, Hunts Bay and the Port Royal Cays area was carried out with a view to determining the present ecological status of the area. The review also helped to facilitate the identification of environmental parameters that justified further investigation in the context of the proposed dredge and fill activities.

Information from the literature review, available maps, marine charts and aerial photographs was used to establish the locations of sampling stations and of swim-line transects at each station. Transects were then examined with a view to obtaining a detailed assessment of floral/faunal composition and status of sublittoral areas at each station.

Along with existing data from previous reports, six locations generating twelve different sampling transects were established (Figure 3) to generate information that would serve to add to the database for the purpose of comprehensively evaluating the ecosystems involved:

Hunts Bay (marine - north, middle, south & terrestrial east/west) - Transects 1, 2 , 3 & 4

Gordon Cay (west & east) - Transects 5 & 6

Ship Channel (east of Fort Augusta & west of Port Royal) - Transects 7 &8

Rackhams Cay (north to south & east to west) - Transects 9 & 10

Gun Cay (east to west) - Transect 11

Farewell / Sea Buoy - Transect 12

Data on the substrate was obtained by a visual examination of the substrate at the various stations. The visual technique was based on an immediate estimation of a 0.2 m^2 quadrat placed on the substrate at randomly chosen locations along the swim-line transects. Videotapes were also taken of the substrate along the transect lines chosen. Substrate composition data was extracted from these videotapes by selecting random stills from the video tape and using the random point intercept method to analyze the content of the photographs.

The results of this assessment of the marine environment were recorded under the following headings:- **SEAGRASS** - `r' species or climax communities; **ALGAE** - turf or macrophytic; **CORAL** - branching, boulder or encrusting; **MACRO FAUNA** - other cnidarians e.g. gorgonians, anemones or zoanthids; **SPONGES** - fleshy, boring or encrusting; **BARE SUBSTRATE** - bare rock, rubble, sand or mud.

Examination of the terrestrial habitat in the vicinity of the proposed Hunts Bay reclamation site was carried out by sampling the vegetation along 20m transects within each sample site. Along these transects the vegetation occurring within 1.5m of either side was noted and recorded under the following headings:-

- species - recorded as **TREES; SHRUBS; HERBS; FERNS; GRASSES; WEEDS; EPIPHYTES; VINES; CACTI;** and ranked using the DAFOR (dominant, abundant, frequent, occasional, rare) scale.

- tree diameter at a height of 1m above ground level

- average canopy height
- percent of ground covered by shrubs, herbs or grasses.

Trees were considered to be species with a trunk diameter greater than or equal to 4cm at 1m above ground level. Shrubs were considered to be species with a trunk diameter less than 4cm at 1m above ground. Herbs were considered to be species less than 1m tall. Identification of as much as possible of the existing species of flora was carried out on site. Photographs were taken and samples collected of the more obscure species for later identification in the Lab.

The following general terrestrial features were noted along each transect:

C Soil Type & Structure

- Leaf Litter depth

C Topography in vicinity of transect

The general land use within the area of the sampling stations was also noted.

Faunal community composition was recorded under the following headings: **AVIFAUNA; MACROFAUNA; INSECTS.**

Avifauna were sought by direct observation or by searching for indicators such as nests. Physical descriptions and vocal peculiarities of any bird that could not be immediately identified were noted and later verified with field guides. This method is only capable of identifying the most common birds found in an area. Rare, migratory or cryptic species can be under represented by this technique. The Point Count Method (without distance estimates) was used to sample the bird population. This method produced data that revealed the bird species present, their abundance and habitat preferences. It does not permit estimates of the total population size in the area.

Avifauna identified were ranked according to the following criteria:

R = resident 1 = common in suitable habitat

E = endemic 2 = uncommon

I = introduced 3 = rare

W = winter migrant 4 = vagrant/unexpected/accidental

S = summer migrant

Insects and other macrofauna utilising the site were recorded as encountered. No special searches were carried out.

Special note was made of ecologically or commercially important species of flora or fauna. Any other physical and/or ecological characteristics of interest were noted.

The methodology outlined above resulted in a stratified sampling routine in which the transects were not evenly spaced over the entire study area but were grouped to create sample sites in certain predetermined areas. The result of this approach was coverage of the area by points representing the major land use types distinguishable.

3.3 Coastal Dynamics

In order to predict the nature and movement of the disposed sediment, a U.S. Army Corps of Engineers computer model (STFATE) (Johnson, 1990, 1995) was used to examine the parameters of spoil released from a Hopper barge.

3.3.1 Model Setup for Hopper Barge Discharge

3.3.1.1 Modelling of Disposal of Dredged Material

The STFATE model incorporates state-of-the-art techniques for simulating short- and long-term fate of dredged material due to dredging disposal operations and environmental processes. The model was developed by the US Army Corps of Engineers, Waterways Experiment Station. The model predicts the distribution of dredged material through the water column and bathymetric distribution of dredged material on the seabed on the basis of individual disposal loads. The model accounts for various parameters including the type of disposal vessel, physical properties of the water column, and material properties.

STFATE estimates the behavior of dredged material as it is released in open water, passes through the water column, and encounters the seabed. Through its 25-year period of development, the model has been calibrated and successfully applied at *numerous locations. The following studies have used the STFATE model: Koh and Chang (1973), Brandsma and Divoky (1976), Bokuniewicz at al (1978), Bowers and Goldenblatt (1978), Johnson and Holliday (1978), Thevenot and Johnson (1994), Moritz and Randall (1995), Lillycrop and Clausner (1997), and Johnson et al 1998). It must be noted that STFATE is a tool that provide estimates of sediment behavior and related processes. The accuracy of STFATE model-generated results is highly dependent upon the parameters input to the model. Controlling parameters which must be properly specified within the STFATE model are physical characteristics of the dredged material, disposal operation sequencing, and forcing environmental conditions within the water column (waves, currents, density structure).*

The objectives of this short-term fate assessment were:

- Evaluate the overall size of the mixing zone for discrete discharges from the disposal vessel.

  - Determine the concentration of the pollutant of most concern (lead) at various points in the water column and on the seabed.
  - Estimate the distance that the disposed dredged material is displaced away from the point of release.
  - Estimate the fall speed, density, and detailed aerial extent of dredged material as it encounters the seabed during disposal.
  - Estimate the disposal mound geometry in terms of thickness and aerial extent after the placed material comes to rest on the seabed.

3.3.1.2 The Fate of Dredged Sediment Placed in Open Water

The operation of hopper dredges result in a mixture of water and solids stored in the hopper for transport to the disposal site. At the disposal site, the hopper doors in the bottom the vessel's hull are opened, and the entire hopper contents are released within a time-frame of tens of seconds to minutes.

When dredged material is released in open water by a disposal vessel, the material falls through the water column, mixing with ambient water, and forming a high-density plume which may contain blocks of solid material. This process is called convective descent. As the convecting plume descends in a hemispherical shape, it grows as a result of ambient water entrainment, and a fraction of material (typically 1 to 5 percent) and fluid with dissolved contaminants may be stripped away. When the diluted dredged material plume encounters the seabed (or arrives at neutral buoyancy), the plume spreads laterally along the seabed. This process is called dynamic collapse. Fine material may be lost to the water column at the top of the collapsing plume. After the plume has expended all of its momentum along the seabed, the dredged material slowly settles under the influences of gravity and the ambient current environment. This process is called passive transport and dispersion.

The fate of dredged material placed in open water is primarily governed by gravity, surface waves and currents. Dredged material falls from the release point of the disposal vessel through the water column, convects and diffuses laterally, and eventually comes to rest on the sea floor.

Within minutes to hours following disposal, dredged material can be spread out on the seabed to varying degrees, depending upon the speed of the disposal vessel upon release, water depth, water column currents, ambient bathymetry, and other variables.

Once dredged material has come to rest on the seabed it can be transported by waves and currents to varying degrees, depending on sediment grain size, bathymetry, and physical forcing, which, for surface gravity waves, decreases with depth. If the dredged material is cohesive, it can self-consolidate due to gravity. If many loads of dredged material are placed one on top of another to develop a mound on the seabed, the mound will tend to avalanche and material will be transported downslope. The combination of these processes determine the long-term fate of dredged material placed in open water. The time-frame for processes affecting the long-term fate of placed dredged material is days to years.

Several aspects influence the dispersion, accumulation quantity and shape of the disposal mound on the seabed:

- Speed of hopper dredge while dumping

- Current speed and direction in the water column

- Water depth and bathymetry at disposal location

The mound length and thickness is a function of vessel speed. Increasing current speed reduces mound height. Split-hull hopper dredges produce a thicker (higher) resultant mound than the multiple bottom-door hopper dredges. The most significant parameter affecting mound geometry (width and height) is water depth. As a general rule of the practice in shallow water, increasing the water depth by a factor of 3 will decrease disposal mound height for a single dump by a factor of 2. Increasing the water depth by a factor of 3 will increase disposal mound width for a single dump by a factor of 2.5.

3.3.2 Hopper Barge Spoil Disposal Logistics used as data input for model, as supplied by the dredging consultants

An 8,000 cubic metre capacity trailer will bottom dump its whole load in a minute or so and then spend a few more minutes cleaning out the hopper.

The total load carried can be estimated by assuming that the average hopper density is 1.35 t/cu.m. Past experience indicates that this material descends to the seabed in a large density current and that the amount stripped off during descent is about 5% of the dry solids distributed over the full water column.

The trailer proposed to be used has a hopper with dimensions 43m x 19m and the draft of the vessel would be 2.8 metres light and 7.5 metres laden.

The proposed disposal site marked on the maps drawn by Mott MacDonald is 1,200m x 3,000m. The model grid for the STFATE runs used is 1,829 x 2,438 m (6,000 x 8,000 ft); that is, it was necessary to use a grid height (x-direction) of about 400m greater in order to display the entire bottom dump within the grid. Therefore we can assume that the bottom material will extend past the boundaries of the disposal site in the northwest - southeast direction. An average depth of 350m (1148 ft) was used for the grid since the site is bounded by the 200m and 500m bathymetric contours.

** Note: Due to the varying nature of the ocean currents and the tendency of the tides to cause a rotation in the direction vector of the currents, it is prudent to assume the current may travel in all directions from the dump site at varying stages of the tide.

Note that a 0.7 fps (0.21 m/s) velocity for the water column flowing from the east (with a velocity within the bottom 30 m at 0.15 m/s) was used based on the field data recorded during the 1994 TEMN study, with a 0.1 fps downslope velocity component from the north. The barge was assumed to be stationary during disposal that takes 1 minute so as to minimize directional spreading of the material.

To set up the model as a realistic case, we assume the dredged material in the barge has two major layers, due to settling in the barge during transport to the dump site. The bottom layer of 5,352 cu meters (7,000 cu yds) has a higher volumetric concentration of sand, and a top layer of 2,648 cu meters (3,464 cu yds) has a lower concentration of sand and slightly higher concentrations of silts and clays. The bulk density for both layers is about 1.33 g/cc (close to 1.35 t/cu m).

The concentration of sand, 0.09 and 0.06 (in the two layers respectively) was used due to the fact that this project is excavating deeper, past the top layer in the channel that contains relatively less sand and more silt and clay; i.e. the deeper the dredging, the higher concentration of sand would be expected.

The model output (Appendix 3) gives "plots" for the surface water concentration of suspended material (relatively small) and sea floor accumulation of the settled material. See the last pages of the plots for total bottom accumulation. Other tables describe the dimensions and position of the plume in the water column.

Note that the suspended material values should be considered at radial distances from the disposal site, once again due to the varying direction of the currents.

Sediment #5 has the lowest total solids and highest concentration of lead at 96.89 ppm, which is equivalent to 156.7 mg/l. This is nearly identical to the Chromium values in the same sample. All the other sediment samples have lower concentrations.

Regulatory levels for both lead and chromium are 5.0 mg/l. These are the toxicity levels in Table 3. But in Table 2, the standards are different for lead and chromium; lead has a much lower allowable concentration. Therefore, lead is considered to be the "conservative" tracer. For the original disposal site using 350 m of water, and using the 156.7 mg/l concentration for lead, the maximum concentration of lead in the accumulation on the bottom is 8.9 mg/l.

3.3.3 Pipeline Discharge Modelling - Cutter Suction Dredge

The algorithms for modelling a continuous pipeline discharge were developed in the late 1970's and early 1980's, and are still evolving as a result of technological advances. A new model, D-CORMIX, is currently under evaluation for this application, but has not yet been sanctioned for use. The model used for this work, CDFATE, is part of the ADDAMS suite of environmental models recommended by the US Corps of Engineers, Waterways Experiment Station. It is based on a widely-used point source model, CORMIX, which assumes a Gaussian distribution for the plume shape. The model results presented in Section 6.3.4 are to be used as a rough estimate, and field experiments should ultimately determine the best dredging operation practices to use in this situation.

3.3.4 Cutter Suction Dredge Discharge

The input parameters used for CDFATE are as follows:

Mean depth of receiving water 20 m (Modelled as a straight, uniform channel)

Bottom roughness, Mannings coefficient 0.035

Mean velocity of receiving water 0.15 m/s

Water density profile Uniform

Density of receiving water at 20m 1020 kg/m3

Density of dredged material 1250 kg/m3

Distance from nearest bank 260 m

Depth of discharge 6 m (***The model not allow a discharge depth greater than 1/3 the total depth)

Discharge rate 0.24 m3/sec

Pipe diameter 0.75 m

Vertical angle of pipe with water surface 90 degrees

Angle pipe makes with the current 0 degrees

Solids in effluent 30%

The output for CDFATE is presented in Table 1 below. The x -axis is aligned from north to south, and the y-axis from east to west. The point of origin (0,0) is the point of discharge assumed to be at the north end of the channel basin, 260 m from the east bank. The channel basin is approximated in the model to represent the area between Rackham's Cay (east bank) and the West Middle Shoal (west bank) that is 20 m deep. The parameter BH is defined as the half width of the Gaussian plume measured horizontally. The ZLTMZUB parameter is interpreted to be the upper plume boundary minus the lower plume boundary in the vertical direction.

Table 1: CDFATE Model output

X	Y	Percent Solids in Plume	BH	ZLTMZUB
65.95	0.00E+00	0.3124	251.6	0.00E+00
78.9	0.00E+00	0.3028	265	0.00E+00
91.86	0.00E+00	0.2934	278	0.00E+00
104.8	0.00E+00	0.2842	290.8	0.00E+00
117.8	0.00E+00	0.337	118.7	-5.79E-02
129	0.00E+00	0.3353	130	-6.34E-02
129	0.00E+00	0.3353	130	-6.34E-02
130.7	0.00E+00	0.3279	130.4	-6.41E-02
143.7	0.00E+00	0.3241	133	-7.00E-02

156.6	0.00E+00	0.3144	135.7	-7.59E-02
169.6	0.00E+00	0.3048	138.3	-8.18E-02
182.5	0.00E+00	0.2956	141	-8.77E-02
195.5	0.00E+00	0.2865	143.6	-9.36E-02
208.4	0.00E+00	0.2775	146.2	-9.95E-02
221.4	0.00E+00	0.2688	148.9	-0.1054
234.3	0.00E+00	0.2604	151.5	-0.1113
247.3	0.00E+00	0.252	154.2	-0.1172
260.3	0.00E+00	0.244	156.8	-0.1231
273.2	0.00E+00	0.2361	159.5	-0.129
286.2	0.00E+00	0.2285	162.1	-0.1349
299.1	0.00E+00	0.2211	164.8	-0.1408
312.1	0.00E+00	0.2138	167.4	-0.1467
325	0.00E+00	0.2069	170	-0.1526
338	0.00E+00	0.2001	172.7	-0.1585
350.9	0.00E+00	0.1935	175.3	-0.1643
363.9	0.00E+00	0.1871	178	-0.1703
376.8	0.00E+00	0.181	180.6	-0.1761
389.8	0.00E+00	0.1749	183.3	-0.1821
414.2	-130	0.1116	881.9	-0.1932
438.6	-130	0.105	892.2	-0.2043
463	-130	9.91E-0201	902.5	-0.2154
487.4	-130	9.35E-0201	912.7	-0.2265

<u>3.4 Socio-economics</u>

The socioeconomic impacts assessment (SIA) study area of this project was the area including the proposed port expansion and surrounding areas within a 2 km boundary. It included areas surrounding the Harbour that might be impacted by the proposed expansion activities as well as direct and indirect users of the port (and water) area and other stakeholders. In some instances, for ease of description and discussion, the study area may be specifically divided into three distinct regions of Port Royal, Kingston, and Portmore/Causeway, but, should be viewed as part of the whole SIA area. Socioeconomic impacts may be both micro (local) and macro (regional and national) in extent. The local impacts were usually those perceived within the SIA area while macro impacts were those perceived nationally.

Information on the existing socioeconomic and cultural environment was obtained by desktop research and interviews with the Statistical Institute of Jamaica (STATIN), the Town Planning Department (TPD), Kingston and St. Andrew Corporation (KSAC) and the Port Authority of Jamaica (PAJ). The socioeconomic profile draws heavily from existing information contained in The Portmore Causeway Project (1996-7), The Strategic EIA - Port Royal Heritage Tourism Project (1998), and the Kingston Foreshore Road (1999). In the above mentioned Portmore Causeway Project (1996-7), a stratified random socioeconomic survey was administered and analyzed using SPSS.

Combined, these studies and other relevant reports such as the Kingston Harbour Rehabilitation Plan provided substantial information. To every extent possible, the information was then updated through projections, field investigations, and further research. Information was also obtained from the Public Forum on this porject held on 3 August 2000 by the PAJ. As a follow-up to the Public Forum, public interviews/ consultations were also held with representatives of the key fishing communities of Hunts Bay at the Causeway, Greenwich Town, Rae Town and Port Royal during 21 August to 15 September 2000. A land use survey was also conducted within the larger Hunts Bay - Causeway area - proposed site for land reclamation during May 21-22, 2000.

4.0 THE ENVIRONMENTAL SETTING

4.1 Water Quality

Kingston Harbour and Hunts Bay are known to receive low quality run-off from gullies as well as poorly treated sewage and industrial waste. In addition the harbour is affected by oil spills associated with operations of the Petrojam refinery and shipping in general [1]. These factors are likely to contribute to the quality of sediment to be dredged.

In the case of marine disposal, as spoil descends through the water column some pollutants (e.g. hydrogen sulphide) may be leached, leading to increased ambient concentrations. In dispersive waters these increases are usually rapidly diluted. In small estuaries and sheltered coastal waters however, such leaching may adversely affect organisms in the water column. It appears to be rare however for pelagic organisms to bioacumulate metals and organic chemicals released from contaminated dredged material although detecting such impacts and attributing them to a particular waste type is difficult [2].

4.1.1 Discussion of Significance of Indicator Parameters

Total Suspended Solids (TSS): Solids settle under quiescent conditions and can directly smother reefs and coastal vegetation, while excess **nutrients** (especially **nitrates and phosphates**) promote the growth of algae which can eventually have the same smothering effect. The Draft National Policy for the Conservation of Coral Reefs (3) which mirrors international standards for coral reef protection, contains the following proposed criteria:

1. Nitrogen (< .1 mg/l NO3)
2. Phosphorous (< .01 mg/l o-PO_4)
3. Suspended Solids (< 10mg/l)

The ambient marine water quality standard proposed by the NRCA for phosphate is 0.001 - 0.055mg/l, while the range proposed for nitrate is 0.001 - 0.081mg/l. Recent work out of UWI has indicated an annual average nitrate level in Hunts Bay (near the causeway) of 0.5mg/l at the surface and 0.2mg/l at the bottom of the water column. Average phosphate level over the same period was determined to be 0.04mg/l at the same site (4). In the vicinity of the channel, a nitrate level of 0.1mg/l and phosphate < 0.05mg/l has been indicated from recent work (1).

Lead (Pb), C**hromium (Cr), copper (Cu), and cadmium (Cd)** are present in trace quantities in the environment, but due to pollution sources, may be expected to become concentrated in the sediments of harbours. Locally, the use of leaded gasoline for decades, in addition to little control over potential sources such as the final disposal of industrial waste may contribute to the build up of lead in sediment which reaches the coast via numerous paved and unpaved gullies.

A previous study (5) indicated levels for these parameters in Kingston Harbour as follows:

Pb - 1 - 6.0 Fg/L (ppb)

Cr - 0.6 – 13.0 Fg/L

Cu - 0.1 - 5.0 Fg/L

Cd - 0 - 4.0 Fg/L

There are no local ambient standards for these trace metals, but effluent standards have recently been established (6). These may provide a point of reference for the evaluation of sediment quality. Table 2 gives USEPA criteria maximum concentrations (CMC), and criterion continuous concentrations (CCC) for the selected trace metals in water (7) as well as NRCA's interim effluent standards. In addition, reference is made to recently developed USEPA criteria for classification of hazardous waste based on the level of a number of contaminants, among them, lead, chromium, and cadmium. (Table 3).

Table 2: USEPA Water Quality Criteria (Saltwater) & NRCA Interim Effluent Standards For Selected Trace Metals

Parameter	USEPA Criteria		NRCA
	CMC (Fg/L)	CCC(Fg/L)	(Fg/L)
Pb	210	8.1	100
Cr	1,100	50	1000
Cu	4.8	3.1	100
Cd	42	9.3	100

The potential impact of **lead** on human health has been well documented and is summarised in the USEPA Fact Sheet (8). These however relate mainly to long term exposure to levels above the USEPA action level (> 0.015 mg/L in more than 10 percent of tap water samples). Lead does not appear to bioconcentrate significantly in fish but does in some shellfish such as mussels. Evidence suggests (8) that lead uptake in fish is localised in the mucous on the epidermis, the dermis, and scales so that the availability in edible portions does not pose a human health danger.

Most of the **chromium** in soil can attach strongly and does not dissolve easily in water (9). Although most of the chromium in water binds to dirt and other materials and settles to the bottom, a small amount may dissolve in the water.

Soil generally contains between 2 and 250 ppm **copper**, while the average concentration of copper in lakes and rivers is 4 ppb. Lakes and reservoirs recently treated with copper compounds to control algae or receive cooling water from a power plant may have high concentrations of dissolved copper. Once in natural water, much of this copper soon attaches to particles or converts to forms that cannot easily enter the body [10].

Cadmium is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulphur (cadmium sulphate, cadmium sulphide). These compounds may dissolve in water but do not evaporate or disappear from the environment. All soils and rocks, including coal and mineral fertilisers, have some cadmium in them. The level of cadmium in most drinking water supplies is less than 1 ppb.

Table 3: Maximum Concentration of Contaminants For the Toxicity Characteristic

EPA HWEPA HW No.[1]	Contaminant CAS No.[2]	Regulatory Level (mg/L)
D004 Arsenic	7440-38-2	5.0
D005 Barium	7440-39-3	100.0
D018 Benzene	71-43-2	0.5
D006 Cadmium	7440-43-9	1.0
D019 Carbon tetrachloride	56-23-5	0.5
D020 Chlordane	57-74-9	0.03
D021 Chlorobenzene	108-90-7	100
D022 Chloroform	67-66-3	6.0
D007 Chromium	7440-47-3	5.0

EPA HWEPA HW No.[1]	Contaminant CAS No.[2]	Regulatory Level (mg/L)
D023 o-Cresol	95-48-7	[4]200.0
D024 m-Cresol	108-39-4	[4]200.0
D025 p-Cresol	106-44-5	[4]200.0
D026 Cresol		[4]200.0
D016 2,4-D	94-75-7	10.0
D027 1,4-Dichlorobenzene	106-46-7	7.5
D028 1,2-Dichloroethane	107-06-2	0.5
D029 1,1-Dichloroethylene	75-35-4	0.7
D030 2,4-Dinitrotoluene	121-14-2	[3]0.13
D012 Endrin	72-20-8	0.02
D031 Heptachlor (and its ep-oxide)	76-44-8	0.008
D032 Hexachlorobenzene	118-74-1	[3]0.13
D033 Hexachlorobutadiene	87-68-3	0.5
D034Hexachloroethane	67-72-1	3.0
D008 Lead	7439-92-1	5.0
D013 Lindane	58-89-9	0.4
D009 Mercury	7439-97-6	0.2
D014 Methoxychlor	72-43-5	10.0
D035 Methyl ethyl ketone	78-93-3	200.0
D036 Nitrobenzene	98-95-3	2.0
D037 Pentrachlorophenol	87-86-5	100.0
D038 Pyridine	110-86-1	[3]5.0
D010 Selenium	7782-49-2	1.0
D011 Silver	7440-22-4	5.0
D039 Tetrachloroehtylene	127-18-4	0.7
D015 Toxaphene	001-35-2	0.5
D040 Trichloroethylene	79-01-6	0.5
D041 2,4,5-Trichlorophenol	95-95-4	400.0
D042 2,4,6-Trichlorophenol	88-06-2	2.0
D017 2,4,5-TP (Silvex)	93-72-1	1.0
D043 Vinyl chloride	75-01-4	0.2

[1] Hazardous waste number.

[2] Chemical Abstracts Service number.

[3] Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

[4] If o-, m-, and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/l.

[55 FR 11862, Mar. 29, 1990, as amended at 55 FR 22684, June 1, 1990; 55 FR 26987, June 29,

1990; 58 FR 46049, Aug. 31, 1993]

Subpart D-Lists of Hazardous Wastes

Source: Environmental Protection Agency - Federal Register: July 1, 1996, Part 5. 40 Cfr Part 257, Et Al. Criteria For Classification Of Solid Waste Disposal Facilities And Practices; Identification And Listing Of Hazardous Waste.

Cadmium has many uses in industry and consumer products such as batteries, pigments, metal coatings, and plastics, and is also found in fertilisers.

Cadmium in soil can enter water or be absorbed by plants. Fish, plants, and animals take up cadmium from the environment. Cadmium is found at hazardous waste sites at average concentrations of about 4 ppb in soil and 5 ppb in water. The human body keeps most cadmium in a form that is not harmful, but too much cadmium can overload the kidneys' storage system and cause health problems (e.g. kidney damage, and fragile bones) (11).

Chemical oxygen demand (COD) is a measure of the total amount of oxidisable material in a sample. By using a strong oxidising material, non-biodegradable and recalcitrant (slowly degrading compounds) which are not detected in the BOD test are included in COD determination. The NRCA stream loading effluent standard for COD is 100mg/l.

Biological oxygen demand (BOD) is one of the most important indices in the assessment of biodegradable organic water pollutants. Dredged sediment can be a significant source of BOD depending on the quantity of biodegradable material present. The NRCA stream loading effluent standard for BOD is <30mg/l and proposed draft ambient standard for this parameter is <1.7mg/l. Recent work by TEMN [1] has determined BOD levels of 0mg/l to 2mg/l in Kingston Harbour in an area covering the Petrojam loading facility in the east to Gordon Cay in the west.

The level of **dissolved oxygen (DO)** in water dictates to a great extent the purpose for which it may be used, and in general gives an idea of the quality of the water (12). Waters in which all the oxygen has been used up appear dark in colour and have a foul odour. By exerting a BOD, dredged material can theoretically result in reduction of DO in overlying waters.

In aerobic organisms oxygen insufficiency results in reduction in cellular energy and a subsequent loss of ion balance in cellular and circulatory fluids. If oxygen insufficiency persists, death will ultimately occur, although some aerobic animals also possess anaerobic metabolic pathways, which can delay lethality for short time periods (minutes to days). Anaerobiosis is well developed in some benthic animals, such as bivalve molluscs and polychaetes, but not in other groups, like fish and crustaceans (13). There is no evidence that any free-living animal inhabiting coastal or estuarine waters can live without oxygen indefinitely. The USEPA's minimum concentration for saltwater dissolved oxygen criteria (14) (CMC), to ensure juvenile and adult survival is 2.3mg/l. The criterion continuous concentration (CCC) to ensure maximum growth effects is 4.8mg/l.

Hydrogen sulphide (H_2S) is a poisonous gas and a by-product of anaerobic (without-oxygen) decomposition of organic material. Un-ionised H_2S is the sulfide form considered the most toxic to aquatic fauna [15]. The USEPA saltwater criteria continuous concentration (CCC) for H_2S is 2.0l mg/l (7).

Organically enriched substrates such as those likely to be encountered in the harbour are essential to the energetics of benthic communities. However, harmful conditions may also arise as toxic metabolic byproducts (e.g., hydrogen sulfide) accumulate to excessive levels from decomposition of excess organic material. Literature review indicates effects on survival in 12 species of marine invertebrates (including a clam and two species of amphipods) at concentrations of 48 to > 50,098 mg/L. Effects on survival of two species of marine fishes also were reported at 17,892 - 23,856 mg/L (16).

Given the many sources of storm water run-off to Kingston Harbour, it was considered possible for the dredged sediment to contain significant amounts of the more persistent pesticides such as the organochlorines. It was also considered possible that deeper sediment could have residual levels of persistent pesticides no longer in use such as known carcinogens DDT and chlordane.

Some **coliform bacteria** occur naturally in soil while faecal coliform is an indicator of the presence of faecal mammalian waste. Given the discharge of raw sewage to the harbour, it was considered likely that faecal coliform would be detected in the water column.

4.1.2 Results and Observations

Water quality data collected at sites to be dredged are presented in Table 4. The results of sediment, and leachate/pore water analyses are presented in Table 5. Trace metals were determined at the parts per billion level in water samples, and at the parts per million level in sediment, leachate, and pore water. Sediment and ‘pore water’ samples collected in the channel and Hunts Bay had a strong odour of ‘rotten egg’ (hydrogen sulphide gas).

4.1.2.1 Water Chemistry Results

Trace metals

Copper and cadmium were absent from all water samples. However lead and chromium were determined to be present at much higher concentrations than detected through previous work in the harbour.

Table 4: Water Quality Data - Port Authority- Kingston Transhipment Port Expansion EIA

All measurements in mg/L unless otherwise stated

STATION ID	COORD. N17°W17°	TIME	DEPTH (M)	T°C	DO	NO_3	PO_4	BOD	COD	TURB. (NTU)	TSS	FC MPN/100mL	TC MPN/100mL	Pb (ppb)	Cr (ppb)	Cu (ppm)	Cd (ppm)
1T	N55.7′,W44.0′	722		28	6.1	0.1	<.05	26.4	25	0	6	<2	<2	376	240	n/d	n/d
1B		702	30	27.5	6.2	0.1	0.05	23	818	0	7			236	991	n/d	n/d
2T	N56.7′,W51.3′	852		26	6.2	0.1	<.05	22	32	0	0	<2	<2	26	824	n/d	n/d
2B		829	14	28	5.4	0.1	0.05	18	223	0	2			400	166	n/d	n/d
3T	N57.9′,W50.3′	925		26	6	0.1	0.05	22	246	0	0	<2	<2	2134	357	n/d	n/d
3B		905	13	25	5.4	0.1	0.05	23.4	524	0	0			371	239	n/d	n/d
4T	N58.8′,W49.8′	940		27	8.8	0.1	0.1	21	203	2	0	<2	1	983	986	n/d	n/d
4B		932	13	26	4.6	0.1	0.05	27	106	0	0			3142	2262	n/d	n/d
5T	N58.7′,W50.55′	1005		27	7.7	0.4	0.1	26.2	23	8	0	<2	7	461	883	n/d	n/d
5B		955	2	27.5	7.9	0.1	0.1	27	23	5	0			486	209	n/d	n/d
	*USEPA CCC				4.8							<200		<8.1	50	3.1	9.3
	USEPA CMC				2.3									210	1100	4.8	42
	NRCA Ambient Standard					0.1	<0.05	<1.75			<10	<200	<256				

Sample	Sulphide (mg/L)	Pb (ppm)	Cr (ppm)	Cu (ppm)	Cd (ppm)
PW(Gordon Cay Bottom)	98.5	0.175	0.165	n/d	n/d
PW(Hunts Bay Bottom #5)	87.9	1.39	0.436	n/d	n/d

The water samples contained sediment. The total solids content was not determined

Table 5: Sediment/Pore water/ Leachate Quality Data – Port Authority Kingston Transhipment Port Expansion EIA

	T S (%)	Sulphide (mg/l)	Pb (ppm)	Cr (ppm)	Cu (ppm)	Cd (ppm)	BOD (mg/L)	COD (mg/L)
Sediment TEMN/KTPE #3	69.07	599.7	44.56	5.02	n/d	n/d	1230	1150
Leachate TEMN/KTPE #3			62.27	37.4	n/d	n/d	1230	960
Sediment TEMN/KTPE #4	40.79	573.2	74.63	6.31	n/d	n/d	1040	8150
Leachate TEMN/KTPE #4			60.04	91.09	n/d	n/d	1410	210
Pore Water(Gordon Cay Bottom #4)		98.5	0.175	0.165	n/d	n/d		
Sediment TEMN/KTPE #5	36.27	699	96.89	95.96	13.57	n/d	1140	15650
Leachate TEMN/KTPE #5			68.1	6.39	n/d	n/d	1620	1920
Pore Water (Hunts Bay Bottom #5)		87.9	1.39	0.436	n/d	n/d		
NRCA Effluent Standard			0.1	1	0.1	0.1	30	
USEPA Maximum Concentration of contaminants (in leachate) for the Toxicity Characateristic			5	5				

Notes:
1) ND - Not Detected

The distribution of lead in the water column at stations established for this study is presented in Figure 4. Concentration of lead at all stations was determined to be in the range 26 ppb to 3142 ppb. The highest values were determined for the sample collected at Station 4 - Gordon Cay Bottom (3142 ppb), and Station 3 - the channel near Fort Augusta (2134 ppb). The lowest concentration of lead (26 ppb) was determined for the surface sample taken at Station 2 - the channel near Port Royal. Background level at Station 1 – 300m contour south of the Palisadoes strip near the gypsum loading pier (Figure 1) was also significant in surface and sub-surface samples (376 ppb and 236 ppb respectively).

Distribution of total chromium is represented in Figure 5. Chromium concentration for all stations monitored was in the range 166ppb to 2262 ppb, the highest value being recorded for the sub-surface sample taken at Station 4B - the turning basin (near Gordon Cay).

Dissolved Oxygen

Dissolved oxygen (DO) levels at the stations monitored are illustrated in Figure 6. DO was determined to be in the range 4.6mg/l to 8.8mg/l at all stations monitored. The highest level was determined at the surface for Station 4 - near Gordon Cay. Sub-surface waters at this site also had the lowest DO concentration.

Temperature

Figure 7 is a histogram of temperature measurements. Temperature was determined to be in the range 25^{o}C to 28^{o}C with temperature in the deep sample being 0.5^{o} C to 1.0^{o}C below that at the surface. The exceptions were Stations 2 - the channel near Port Royal, and Station 5 - Hunts Bay near the causeway. At Station 2 subsurface temperature was 28^{o}C while at the surface it was 26^{o}C. At Station 5 sub-surface temperature was 27.5^{o}C while at the surface it was 27^{o}C.

Nutrients

Nitrate (NO_3) distribution at the sampling sites is shown in Figure 8. With the exception of the sample collected from surface water at the Hunts Bay site (Station 5T) nitrate was determined to be 0.1mg/l. At Station 5T NO_3 was determined to be 0.4mg/l.

Phosphate (PO_4) distribution is shown in Figure 9. Phosphate level was determined to be .05mg/l or less at most stations. The exception was Station 5 - Hunts Bay where PO_4 was determined to be 0.1mg/l in samples taken from the surface and bottom of the water column.

Suspended Solids/Turbidity

Suspended solids and turbidity were low at all sites monitored (Figures 10, and 11). Suspended solids were determined to be in the range 0 - 7mg/l, while turbidity was 0 - 8NTU.

Coliform

No Faecal coliform bacteria were detected in any of the samples. Low levels of total coliform were indicated in samples from Station 4 - Gordon Cay and, Station 5 - Hunts Bay. Samples from these sites were determined to have total coliform of 1MPN and 7MPN respectively.

Biological Oxygen Demand (BOD)

BOD concentrations at the sampling sites are shown in Figure 12. BOD was determined to be in the range 18mg/l to 27mg/l at all sites monitored. The highest value was detected for Stations 4 (Gordon Cay), and 5 (Hunts Bay), in the sub-surface samples. The other values in that range were detected for Station 1 (TOP) - south of Palisadoes (26.4mg/l) and Station 5 (Top) - Hunts Bay (26.2mg/l).

Chemical Oxygen Demand (COD)

COD measurements ranged widely (23 - 818mg/l). The interference of chloride with the analytical method for the determination of this parameter limits its use as an indicator.

4.1.2.2 Sediment Chemistry Results

The results of sediment analysis and corresponding leachate analyses are presented in Table 5. Concentrations in sediment were determined on a dry weight basis, and water content for each sample was determined. With one exception, cadmium and copper were absent from all sediment samples. The exception was the sample taken at Station 5 - Hunts Bay that had no cadmium but was determined to have a copper concentration of 13.57ppm. Biological oxygen demand (BOD), chemical oxygen demand (COD), and sulphide concentrations were significant in all samples. All samples exhibited a strong ‘rotten egg’ (hydrogen sulphide) odour.

Trace metals

Lead in sediment was determined to be in the range 44ppm - 97ppm. The lowest value was determined at Station 3 - Ship Channel near Fort Augusta. The highest value was determined in sediment from the Hunts Bay site (Station 5), while at Station 4 (near Gordon Cay) lead in sediment was 74.63ppm. Lead in leachate was determined to be in the range 60ppm - 68ppm. The lowest value was determined at Station 4 - near Gordon Cay, while the highest value was found at Station 5 - Hunts Bay. At Station 3, lead in leachate was determined to be 62 ppm, and at Station 4 was determined to be 60ppm.

Lead in pore water was determined to be 0.175ppm at Station 4 (Gordon Cay), and 1.4ppm at Station 5 (Hunts Bay).

Chromium in sediment was determined to be 5ppm and 96ppm at Stations 3, and 5 respectively, while at Station 4 it was 6ppm. Chromium in leachate from Station 3 was 37ppm, at Station 4 it was 96ppm, and for Station 5 it was 6ppm. Pore water from Station 4 was determined to have a chromium concentration of 0.2ppm, while at Station 5 it was 0.4ppm.

Sulphide

Sulphide was determined to be 600ppm at Station 3 - channel near Ft. Augusta, 570ppm at Station 4 - Gordon Cay, and 700ppm at Station 5 - Hunts Bay. Pore water at Station 4 was determined to have a sulphide content of 99ppm, while at Station 5 sulphide in pore water was 88ppm.

Biological Oxygen Demand (BOD)

BOD of wet sediment from Station 3 was determined to be 1230mg/l, at Station 4 it was 1040mg/l, and at Station 5 it was 1140mg/l. Leachate produced an equal or higher BOD than the respective sediment. At Station 3 leachate had a BOD of 1230mg/l, at Station 4 it was 1410mg/l, and at Station 5 leachate BOD was 1620mg/l.

Organics

Gas chromatography mass spectrometry (GCMS) analysis did not indicate the presence of any pesticide residues in the sediment samples examined. However the presence of at least two hydrocarbons were indicated. These were 17-Pentatriacontine, (found at Station 3), Benzene 1-pentylheptyl, and Benzene 1-butylheptyl. The latter two were detected at Station 5.

4.2 Ecology

4.2.1 The Hunts Bay Habitat

The Hunts Bay area connects to the north-western portion of the harbour and consists of a shallow basin approximately 10 Km^2 in area with an average depth of 2.5m. The sediments generally consist of soft mud and the overlying waters experience regular and considerable changes in salinity, nutrient and contaminant levels due to inputs from the various rivers and drainage gullies that enter into it. Sources of these nutrients (nitrates and phosphates) and pollutants include fertilisers and insecticides used in agricultural activities upstream of the bay. The movement of layers of water with different salinities is modified by the restriction to outflow of water from the bay caused by the presence of a solid-fill Causeway with a narrow opening across the mouth of the bay. This counter clockwise circulation pattern within the bay (documented by UWI and Government of Jamaica researchers) appears to facilitate the retention and resultant stagnation of water masses in the general vicinity of the north eastern corner of the bay. This retention is reinforced during dry weather conditions and relaxes somewhat during the rainy season. The increased volume of water flowing into the bay during this time was reported to facilitate some limited flushing of this area of the bay and conditions improve for a short while before dry weather imposes itself on the cyclic hydrodynamics of the bay again. Most of the fishing activities are therefore concentrated in the middle and western portions of Hunts Bay. The results of a recent study (Webber, 1993) indicate that Hunts Bay may be even more impacted and degraded than other waters to be found in Kingston Harbour.

Studies on marine shrimps in Kingston Harbour by Chin (1994) indicated that at least two species lived for most of their life cycle in Hunts Bay and other western harbour muddy-bottomed areas. Further, Chin reported that shrimp regularly provided income for fishers operating from the Causeway bridge ("Helsinki") area.

Submerged transects 1, 2 & 3 (Figure 3) in Hunts Bay, had a thick layer of dense, anoxic mud. At a depth of 1.5m the visibility in the water column was 0.1 m. The substrate appeared to be abiotic and no fish or crustaceans were seen in the water column above or crawling on the mud bottom. This lack of faunal movement on or above the sediment could have been due in part to the high turbidity levels observed during the field visits.

Terrestrial transect No. 4 (Figure 3) demonstrated an impacted site that contained sparse grasses, shrubby vegetation as well as Seaside Mahoe and Mimosa trees on its landward margins towards the main road. This vegetation mixed with an associes of mature Black and White mangrove trees as one moved towards the perimeter of Hunts Bay. The shoreline was dried and no evidence of Red Mangroves was noted which would have been indicative of a healthier environment seeking to expand its boundaries into variably saline waters of the bay.

4.2.2 Hunts Bay Avifauna

At least sixteen (16) species of seabirds and colonial water birds were found in the mangroves and open waters of Kingston Harbour. The harbour was an important nesting area for two species of regional conservation concern, namely the Brown Pelican and the Magnificent Frigate Bird. Both species nested colonially in the mangrove trees around the harbour. Both species were also common in the Hunts Bay area where they congregated around the area of activity associated with the small fishing communities taking offal and other “handouts” opportunistically. The breeding status of these species in this section of the harbour was not known at the time of this study. They appeared to nest in the mangrove trees on the western side of the bay. No nesting or roosting activity was noted in the stand of mangroves on the eastern side of the bay that would be affected by reclamation activities.

Besides the nesting species, the area was an important roosting and feeding area for three (3) other species of regional conservation concern as is presented in the table (see Appendix 2). The harbour area was also an important over-wintering site for Laughing Gulls (***Larus atricilla)***, a species known to be uncommon in the wider Caribbean during the winter. Laughing Gulls nested on the Port Royal cays where the number of nesting pairs were reportedly small.

Apart from the previously mentioned species, all of which are seabirds, the mangroves of the western Hunts Bay area were also populated by several other species - primarily herons and egrets some of which nested in the mangroves in the vicinity.

A list of the species of Rail, Ibis, Herons and Egrets observed within this area in the recent times is given below:

Green Backed Heron**

Little Blue Heron **

Cattle Egret **

Snowy Egret **

Great Egret

Great Blue Heron

Yellow-crowned Night Heron**

Black-crowned Night Heron**

Tricolored Heron

White Ibis**

Clapper Rail**

NB: species marked by asterisks (**) breed in the area.

All the above species were considered to be relatively common in suitable habitat, with the exception of the White Ibis, which was rare. The White Ibis is known to nest on the Palisados side of Kingston Harbour in the mangroves. Great Blue Herons are winter visitors to the area during which time they are relatively rare.

4.2.3 The Kingston Harbour Habitat

This natural embayment receives approximately 114 million litres (30 million gallons) of raw or partially treated sewage per day. It has also been subjected to repeated episodes of major dredging activity at various locations within its confines. Beginning in 1956, dredging activities were part of the construction techniques used in the conversion of a Royal Navy airbase to a commercial facility known as the Norman Manley International Airport. In 1969, dredging activities were also a part of the construction of the Causeway used to create a direct road link between the city of Kingston and the adjacent communities including Hellshire, Portmore and Braeton. The establishment of Gordon Cay and the Rockfort Power Plant facilities, improving the port facilities at the Cement Company in the early and mid-nineties also required periods of extensive dredging activity in Kingston Harbour. Repeated maintenance dredging of the ship channel in the vicinity of Two Sisters, Burial Ground and Greenwich Buoys and at Berths 8 & 9 has been carried out during the last ten to fifteen years.

Initial studies by Wade et al in the mid-seventies documented the degraded state of the benthos in both the inner and the outer harbour as a result of its function as a receiving body for numerous storm water, industrial waste and municipal sewage out-falls over the years. More recent studies by investigators from the University of the West Indies, as well as Government contractors hired to assess the status of the harbour, have confirmed these initial findings. Anecdotal reports have been received over the years of significant mortality affecting the population of mussels that apparently once thrived on the mud floor of the harbour. An extensive area, ranging from Gunboat Beach in the east across Asprey Shallows and the Five Foot channel to the Two Sisters Buoy and north as far as the Pickering light, experienced mass mortalities of the mussel population. These episodes of mortality were reported to have been directly related to at least the first three to four of the earlier periods of dredging. Spoil was discharged within the confines of the harbour and large expanses of muddy water that wafted back and forth with the slow moving currents were reportedly observed by the fishermen in and around their commonly used fishing grounds. More recent dredging exercises that involved the disposal at sites outside the harbour, but still relatively close to the coastline, were reported to have affected the normal migration routes of fishes such as the red snapper for a period of two years. Nets used by the fishermen at depths of 16-20 fathoms were also negatively impacted by the mud and they reportedly had to go further out to sea or move further east along the coastline to maintain catch levels.

Marine transects 5 & 6 (Gordon Cay) and 7 & 8 (Ships Channel) (Figure 3) were also indicative of low diversity, highly stressed environments. Visibility was only slightly better at 0.3m - 0.5m, and no fauna were observed in the water column or on the substrate at any of these stations. Substrate composition was thick mud with a few small holes indicating the presence of burrowing polychaetes. These stations were noted to be subject to repeated disturbance from construction and maintenance dredging activities as well as prop wash from manoeuvring ships.

4.2.4 Kingston Harbour Fishery

While the ecological linkages between magroves, seagrasses and related fishes in Kingston harbour were first described by Goodbody (1969), the role of Kingston Harbour mangroves as nurseries for fishable resources (fishes, spiny lobster, shrimps and conch) has been investigated only to a very limited extent (Tolan & Aiken, unpublished). What was found in nursery research was that there were at least 15 species of fishes repetitively associated with the Port Royal mangroves and the adjacent seagrass beds over the study period (1990-1992). Fishes were dominated by the silverside (Atherinidae), dusky anchovies (Engraulidae), sea bream (*Archosargus rhomboidalis*, family Sparidae, maccabacks (Gerreidae), porcupine fishes (Diodontidae), parrotfishes (Scaridae) and wrasses (Labridae). Most of these fish were not true coral reef fishes, but were more associated with mangroves and shallow lagoons. Commonly found were crustaceans such as spiny lobster (Palinuridae) from visual censuses and in catches. Two penaeid shrimp species (*Penaeus schmittii* and *P. duorarum*) were found to use muddy parts of the Port Royal mangroves as nursery areas (Tolan & Aiken, unpub. data). In Kingston Harbour, the major habitats for fishes were in the mangrove and seagrass beds which, in recent times, at least, have been located adjacent to Port Royal and the outer (western) harbour. Catches in the harbour (whatever the fishing gear employed) tended to be dominated by small coastal pelagic fish species.

Catches dominated by thread herring were taken by gill nets from the harbour (Harvey, 1986, Goodbody, 1986). Thread herring from inside the harbour were significantly smaller than those from outside, suggesting that these protected waters acted as a large nursery for at least this species. Harvey (1986) also found that this was the case for other sprat and herring species as well. Some used the harbour as spawning sites and for feeding and fattening before attaining first sexual maturity.

In one of the first studies of fish nurseries in Jamaica, Ross (1982) examined a number of south coast sites, including the Port Royal mangroves and parts of the Port Royal Cays complex, among others. He found that fishes such as the maccaback (Gerreidae) species (***Eucinostomus argenteus*** and ***Gerres cinereus***) were the most abundant and dominant species and that overall species diversity was relatively low. Other common species at the time were the snook (***Centropomus undecimalis***) and schoolmaster snapper and grey snapper (Lutjanidae). The study also suggested that at that time, the density of juvenile fishes in the Port Royal mangroves was relatively high ($1.4/m^2$) compared with the five other study sites elsewhere to the west of Kingston.

Fishable resources located within sectors H5, H4 and H3 (Figure 1) were found to be minimal or even negligible. This conclusion is based on the fact that these areas arre located in the busiest part of the western part of the container port facility. Additionally, these same areas were themselves previously dredged in the development of the port in the late 1960s and again in the mid-1970s for the construction of Gordon Cay. As a result, the only surviving fishable resources since those times would have been located in the water column itself, for example, the occasional roving small pelagic fish such as sprats and herring (Clupeidae), leatherjacket jacks (Carangidae). All those resources on and in the substrate would have disappeared with the dredging at that time. None of these areas enumerated above have functioned, since the dredging, as fish or crustacean nursery grounds. These substrates are characterized by mud, sand and seagrasses and probably function as minor nursery areas for marine shrimp, spiny lobsters and fishes, along with other shallow areas to the east of them such as Mammee Shoal and the adjacent mangroves. The use of the prefix "minor" nursery area is centred on the observation that the specified areas (H3-H1) (Figure 1) are on the western fringe of the major shallow water nurseries nearby, and are within the Port Royal mangrove complex.

Recent studies of the benthos in the channel itself report that infaunal species diversity and numbers remain low (density of organisms approximately 0 - 2 per 0.1 sq. m) and typical of a highly stressed environment. Burrowing polychaete worms (***Sabella spp.***) seemed to be the only benthic animal to tolerate this environment with any measure of success for any length of time. The sediments in the main turning basin were found to be sandy silty red brown clay while at Greenwich they were grey sandy silt changing to silty sandy gravel at the Two Sisters & Burial Ground channel marker buoys.

Species diversity increased slightly on the sides of the channel. This, as the substrate changed from mud to sand especially in the shallower areas as the light and oxygen saturation levels in the water column improved.

4.2.5 Rackham’s Cay Habitiat

This small cay lies outside the harbour along the southern border of the East Ship Channel and consists of a semi submerged sand bar that is surrounded by extensive seagrass beds along its sheltered western and southern margins and coral rubble on its exposed eastern and northern margins in shallow water. In deeper water (>18m) the communities of sea urchins, gorgonians (sea fans), small coral heads and thickets of branching corals give way to a mud bottom on the steeply sloping sides of the ship channel. Fishermen claim to use the shallow water around Rackham’s Cay as a source of bait (silversides/white fry, juvenile sprats and herring) for their major fishing activity - trolling with a hook and line.

Trnsects 9 & 10 at Rackham’s Cay were indicative of a relatively healthy marine environment. As one moved north to south, from 18m depth up the slope into shallow water, perpendicular to the ship channel at least two reef environments were noted. At maximum depth the substrate was a steep slope consisting primarily of muddy sediments bearing the occasional whip gorgonian. Moving towards the surface (and shallow water) a series of relatively steep slopes and flat terraces ensued.

At 16m depth a muddy slope exhibited a substrate composition as follows:-

Bare Substrate	-	85%
Coral	-	2%
Algae	-	10%
Seagrass	-	0%
Macro fauna	-	3%
Sponges	-	0%

Main corals seen were largely solitary species adapted to higly turbid waters (such as *Eusmilia ffastigiata*, ***Mycetophyllia sp***. and flattened ***Agaricia sp)*** (Appendix 2, Photo's # 1-4). The gorgonians were represented by specimens of ***G. ventalina*** and ***G. flabellum spp.*** A few angel fish were also noted along with conch and lobster.

At 12m depth a flat terrace exhibited a substrate composition as follows:-

Bare Substrate	-	75%
Coral	-	5%
Algae	-	10%
Seagrass	-	0%
Macro fauna	-	5%
Sponges	-	5%

Main corals seen were ***Siderastrea siderea*** and ***Solenastrea sp.***

This continued up another steep slope passing through 11m depth until another flat terrace was encountered at 7m depth.

Substrate composition was as follows:-

Bare Substrate	-	55%
Coral	-	5%
Algae	-	18%
Seagrass	-	9%
Macro fauna	-	8%
Sponges	-	5%

Main corals seen were ***M. annularis*** and ***cavernosa spp., Porites porites***, ***Madracis mirabilis,*** star coral **–** ***Siderastrea spp.,*** Brain coral **–** ***Diploria spp.*** and ***Acropora cervicornis*** ***(***Appendix 2, Photos # 5-10)***.*** Several apparently intact cylinders of compressed industrial gas were noted lying on the bottom (Appendix 2, Photos # 11-12) in the vicinity of the Rackhams Cay navigational marker. These were felt to constitute an unusual hazard and would have to be moved before any dredging activities begin.

Moving east to west in transects 8-10 in shallow water (1-3m water depth), a rampart of ***Acropora palmata*** rubble interspersed with live ***A. cervicornis*** and *A. palmata* were noted on the windward side of the cay (Appendix 2, Photo's # 13-15).

Substrate composition was as follows:-

Bare Substrate	-	35%
Coral	-	25%
Algae	-	20%
Seagrass	-	0%
Macro fauna	-	13%

Sponges - 7%

This gave way to rubble interspersed with seagrass, gorgonians (sea fans), algal mats (*Halimeda* and *Dictyota* species) and urchins (***Diadema antillarum*** - 10 per sq .m.) as one passed nearest to the ship channel. On the leeward side of the Cay a much denser coverage of turtlegrass (Appendix 2, Photo's # 16 - 17) was found and urchin densities were even higher (12 per sq.m).

Substrate composition was as follows:-

Bare Substrate - 30%

Coral - 10%

Algae - 20%

Seagrass - 25%

Macro fauna - 10%

Sponges - 5%

4.2.6 Gun Cay Habitat

Transect 11 at the Gun Cay Station (5-7m depth) was rather similar to comparable depths at the Rackham's Cay transect in terms of coral cover and algae compared to the amount of bare substrate at this station

Substrate composition was as follows:-

Bare Substrate - 50%

Coral - 5%

Algae - 20%

Seagrass - 0%

Macro fauna - 15%

Sponges - 10%

Relativey large stands of ***Acropora spp.*** coral were noted alongside patches of rubble comprised mainly of these same species of coral but urchin (***D. antillarum***) density was not as high (3 - 4 per sq. m)

4.2.7 Eastern Ship Channel Habitat

Transect 12 at the Farewell/ Sea Buoy was apparently much healthier than the shallow water stations closer to Port Royal. Despite an obvious scarcity of urchins at this depth, a wide sandy plain supported patch reefs where the coral, sponge and gorgonian cover was significantly higher while the algae were much reduced

Substrate composition was as follows:-

Bare Substrate	-	5%
Coral	-	25%
Algae	-	5%
Seagrass	-	0%
Macro fauna	-	35%
Sponges	-	30%

The corals at this depth were apparently quite healthy with no sign of the usual diseases (black band or yellow band) found in some shallow water specimens.

4.3 Coastal Dynamics

Kingston Harbour is bounded on the south by the Palisadoes (a narrow sand spit linking a number of limestone knolls) which acts as a natural breakwater and shelters the harbour from the open sea. The harbour occupies an area of over 50 sq km, and has a maximum depth of approximately 14 metres. Currents are mainly density (fresh water vs. salt water), tidal and wind driven. Tidal variations are of the order of 0.3m.

Previous studies have shown that circulation in the harbour has to be considered on the basis of different zones and layers of water masses because different areas are affected to a greater degree by a combination of the above driving forces.

A recent thesis (Williams, 1997) gives a comprehensive outline of the interaction of the three major driving forces (density, wind and tide) of currents in the harbour.

The study concluded that circulation in the harbour is dependent on the characteristics of currents in the varying zones and layers of water masses that exist. Based on the bathymetric survey, the harbour was divided into two lobes (inner and outer). This was supported by the fact that the shallower regions of the inner harbour were influenced by circulation in the outer harbour.

Density was the main factor controlling the circulation patterns in the outer lobe, especially in the surface layer. During the dry season water leaving Hunts Bay radiates in both easterly and westerly directions. However, during the wet season, with high fresh water input, the depth of the density driven layer increased in the outer lobe. At times, wind would become a more controlling factor than density, increasing vertical mixing and influenced the formation of gyres.

Tidal currents in Kingston Harbour were important primarily in the bottom layers, and their effects were seen at a depth of 3 m and below. It was evident that during both ebb and flood tides there was predominantly outward flow in the surface layer. Occasionally, water would enter the harbour on the flood tide in the surface layer.

In the inner lobe, circulation patterns were governed chiefly by wind which:

- Influenced increased vertical circulation,
- effecting upwelling along the Palisadoes spit in the upper basin
- contributed to the formation of gyres in the upper basin

Also, within the inner lobe, the tidal currents were effective in the deep rather than surface layers.

Compared to previous studies, flushing time of the harbour increased significantly, while retention times were similar.

4.4 Socio-economic Assessment

4.4.1 Demography

The KMA is the primate urban centre in Jamaica, accounting for 56% of the total urban population. Using a nominal rate of growth of 1%, the Planning Institute of Jamaica (PIOJ) estimated that the KMA population would increase to 600,500 persons by the year 2000 with an average household size of 4.6 persons. The sex ratio (male: female) was almost 1:1.

In 1971, there were just over 6,000 people living in Portmore (including the Causeway). By 1991 Portmore's population was 93,806 with an annual rate of growth of 19.5%, much higher than Jamaica's annual rate of growth. By 2000, the population was estimated at 221, 851 in some 52 neighbourhoods. The population was relatively young with 72% of the males and 85% of the females less than 40 years old.

The NRCA's Draft Environmental Policy Framework Document for Port Royal (May 1998), estimated the town's population to be 1,700. This varied from the more conservative projection given by the Statistical Institute of Jamaica (STATIN). STATIN, using the annual growth rate of 0.8% for the intercensal period 1970-1991 estimated the population in 2000 at 1,234. This represented a small increase over the 1991 population of 1,127.

4.4.2 Employment, Distribution of Income, Goods and Services

At the time of this study, The labour force for the City of Kingston was 108,700, 85% employed and 15% unemployed. Agriculture accounted for 23% while the service industry (business and personal services, trading, communication and public utilities) accounted for almost 50% of the employed labour force. Mining accounted for less than 2%. Males accounted for more than 70% of the employed labour force. The major industrial sectors, agriculture, manufacturing and construction were areas where males were traditionally dominant. The average income per household was $2300-$3200 per week. Approximately 24.5% of the heads of households earned between $2000 and $3000, 12.9 percent each earned $1000-$2000, and less than 20% earned over $6000 per week.

Most of the population of Portmore worked in Kingston and St. Andrew. Many were young professionals in the middle income stream. Employment opportunities within Portmore were basically in the service sector – restaurants, night spots and roadside vending.

Employment opportunities in Port Royal were limited given the lack of industrial development and the low level of skills. Notwithstanding, 66% of the population worked within Port Royal, and others in Kingston or further afield (Database Marketing Services, 1997). The level of unemployment in Port Royal in the age group 14-65 was estimated at 24.0%, a figure significantly higher than the national average of 16.3% (STATIN, 1996). More than 70% of the unemployed were in the 15-39 age group, which indicated a pool of young people who were not gainfully occupied. This had implications for future employment opportunities. Outside of a few restauranteurs and bar owners, fishermen comprised the bulk of the working segment of the population. Port Royalists hold on to a 'fishing' tradition with great reverence, but unfortunately, it is an inadequate means of livelihood for the general populace. [1]

Along the Causeway, fishing was the main trade of the household head, followed by fish vending, higglering and skilled trade, with less than one percent being shopkeepers. There were 68 fish vendors in Helsinki Village, 12 in Pigeon Shoot and 2 in Port Henderson (total of 82 vendors). Of the 68 fish vendors in Helsinki Village 42 (61.76%) were also dwellers. The rest of the vendors resided elsewhere. All of the vendors at Pigeon Shoot resided at Pigeon Shoot. On average, a vendor received between 4 to15 customers per day, earning a net of $250 to $800. [2]

4.4.3 Merchandise Trade and Transhipment

The main point of handling, processing, entry and exit of goods is through the Kingston Transhipment Port (KTP), managed by the PAJ. In 1998 the value of Jamaica's total merchandise trade (exports and imports) was US$4,323.3m of which the total value of operations undertaken within the three Free Zones was US$270.1m. The major obstacles facing the export of items from the Free Zones were rising operational costs, security concerns and the frequent contamination of containers for exports. Bunker supplies and other items procured in Jamaican ports by foreign carriers were valued at US$27m in 1998, a decline by US$2.3m from 1997 due to a contraction in the value of fuel purchased by foreign carriers. Some 60% of all goods were traded with the USA, Canada or the UK, Jamaica's main trading partners. Within CARICOM, Jamaica's main trading partners were Trinidad and Tobago followed by Guyana.

The KTP commenced operation in 1975 with 2 gantry cranes, 640 m of berthing, 40 acres (16ha) of paved container storage area, at an initial capital investment of US$14m. By 1990, the port was operating with 5 modern ship to shore cranes, 36 ha paved container storage area, and a capacity of 400,000 TEU's. [3] However by 1994, the KTP began to experience severe logistical and capacity constraints and was forced to expand the Gordon Cay (South Terminal) at a cost of US$120m. The expansion was completed in 1996/7 and included an additional 610metres of berth, 5 new state of the art Post Panamax ship-to-store gantry cranes, 18 straddle carriers, 43 acres (17.4metres) of paved terminal area and 2 harbour tugs. Added to what existed before, the combined result was 800,000 TEU's comprising 1,250 metres of berth, 54 ha paved yard, 10 ship-to-store gantry cranes, 38 medium span straddle carriers, 446 reefer plugs. As a result of the expansion, container throughput increased from 51,000 TEU's (1975) to 577,000 TEU's in 1998, an annualized growth rate of 11.7%. Transhipment activities account for some 82% of total throughput. [4]

4.4.4 Fisheries

Fishing activities centre around six major known fish landing sites: Rae Town, Greenwich Town, Port Royal, Hunts Bay at Causeway, Harbour Head and Port Henderson. All, excepting Port Henderson, base their major landings within the Greater Kingston Harbour area. At the time of this study, more than 1000 full and part time fishermen with about 200 boats operated from the fishing beaches. About 71.4% owned their boats and employed at least 1-2 persons on the boat, 15% were actively involved in selling fish while 28.6% were also involved in vending. At least 50 metric tons of sprats and herrings per annum used large gill nets (Harvey, 1986; Goodbody, 1986). Also, taken were (small) quantities of maccabacks or mojarras, silversides or white fry, mackerels and kingfish, various jacks, barracudas, and several other groups of lesser commercial importance such as houndfish, snook and tarpon. There was a very small but apparently successful beach seine fishery along the Palisadoes peninsula whose catch consisted mainly of sprats, herrings, maccabacks, and sea bream, with smaller quantities of other species.

Fishing and its spinoff industries are the main forms of economic activity for the majority of people in Port Royal. At the time of this study, the average price obtained for their catch varied from $100-110 per pound depending on the species. A normal catch comprised parrot, jack, doctor, snapper and shrimp and ranged from 20lbs to 80lbs per day, some of the catch was used for household consumption. The average weekly income was $5,757 with a high of $20,000 and a low of $500. White fry and anchovies formed an important part in the provision of bait for Port Royal hook-and-line fishery. Molluscs such as the mangrove oyster and the false or flat oyster were taken from the prop roots of the red mangroves near Port Royal and formed the basis of a very small, but vibrant “oyster fishery" (Siung, 1976). The harvest was mainly sold in Kingston and on Hellshire beaches by roving vendors. The popularity of "oysters" collected from the Port Royal mangroves helped to inspire the formation of the U.W.I./I.D.R.C. Oyster Culture Project which attempted to promote raft-type oyster culture around the island in the 1980s.

An early assessment of shrimping showed that Kingston Harbour had some potential for marine shrimps (Iversen & Munro, 1969), however, during the 1980s, attempts of shrimp trawling using otter trawls deployed from decked vessels, met with limited success and was therefore short-lived. Shrimps mainly originating from the western portion of Hunts Bay provided significant earnings for fishers operating from the Causeway area. Push and shove nets were used in the shallows by these fishers, along with small, modified bottom trawls pulled by canoes over the deeper waters. During the two annual rainy seasons, significantly increased shrimp catches were reported (Galbraith, 1997). The dominant species was the pink-spotted shrimp. Occasionally (since 1995 to the present), dolphins have been observed in the outer harbour waters, near Port Royal. Such sightings may be an indicator of improved water quality in the harbour.

At the time of this study, Port Henderson was a large and growing fishing beach and the centre of a relatively new SCUBA-based lobster and conch fishery on the south shelf around Old Harbour. It came into existence during 1993/94 when considerable quantities of forfeited SCUBA gear from seized illegal Honduran offshore lobster and conch fishing vessels became available.

Despite the reduced productivity of the harbour fishery, the harbour played a significant support role for fishing in the Kingston area. The estimated present value of fish yield was calculated at J$210,544,990.00 or US$6.0m per year, approximately one half of what it was during the 1970s when there were twelve fishing beaches and over 2,000 fishermen operating in the harbour. [5]

4.4.5 Education

More than 18% of the households within the SIA area had at least one child in primary school, 11% had at least two children in primary school, while 4% had at least three children in primary school. Similarly, 18% of the households had at least one adolescent in secondary school. Overall, approximately 97% of the children were enrolled in primary schools.

4.4.6 Health

The population was a relatively healthy one. The most prevalent health issue was related to colds and fever - 13.9% of those interviewed indicated that they had either colds and/or fever within the past year. Of concern, however, was the relative absence and condition of sanitary facilities along the fishing beaches that pose public health and environmental problems.

4.4.7 Housing

The majority of houses within the SIA area and the sphere of influence of the Kingston Harbour were made from block and steel outer walls (91.3%), zinc (80%) and concrete (17.5%) roofs, with tiled (86.4%), concrete (9.7% or wooden floors (2.9%). Approximately 64.1% of all properties surveyed were single family dwellings, 9.7% were two family dwellings while 13.6 % were occupied by more than three families. The average number of bedrooms per house was 3.98, with the smallest house being a studio (quad) and largest having 11 bedrooms. Roughly 24% of all dwellings surveyed had 4 bedrooms while 22% had 3 bedrooms. More than 51% percent of those dwellings were occupied by their owners, 42.7% of whom also indicated that they possessed titles. Approximately 33 % were rentals, 11.7% were family properties, and 3.9% were occupied by squatters. Roughly 42% of the dwellings surveyed had pit latrines, 30% had soakaways, and 22.3% had septic tanks. The majority of dwellings (98%) had piped water. The majority of dwellings had access to electricity from the Jamaica Public Service and many had telephones. In general the dwellings in proximity to the fishing beaches with the exception of Port Royal were substandard, especially fishing sheds which were also used as dwellings in Rae Town, Greenwich Town and the Causeway. Many of those dwellings were informal, without basic amenities.

4.4.8 Solid Waste Disposal

Household waste (99%) in Kingston was usually trucked away once per week by the Metropolitan Parks and Markets. In fact, most households indicated that they also burned garbage in addition to it being trucked away. There was no organized system of garbage disposal in the vicinity of the Causeway, and Greenwich Town. Overall, 73.4% of all garbage was “dumped.” A similar trend was observed for sewage. Approximately 93.4% of the dwellers in Helsinki Village use the sea/bay compared to 30.8% in Port Henderson. Sixty nine percent of the dwellings in Port Henderson had pit latrines. The high level of sewage and solid waste being disposed directly into the sea/bay was a major pollutant and cause for concern. There were various sewage systems at Port Royal, including septic tanks, tile fields, soak-away and pits. Sewage from the central Brotherhood housing area went into 5 septic tanks, the overflow from which entered an open drain to the west, beside the wall of the Naval Hospital, and discharged into Port Royal Harbour.

That situation was unacceptable for human health and exacerbated pollution in Kingston Harbour. [6]

4.4.9 Recreation

In the 1960's, Kingston Harbour was often considered one of the most intensively used recreational areas in Jamaica supporting activities such as swimming, skiing, boating, line fishing, snorkeling and sunbathing. At the time of this study, most of those activities had since ceased except for limited boating and beach use. The Harbour no longer served as a prime recreational outlet. The Port Royal Cays were popular recreation spots, and were overcrowded on public holidays and weekends. Transportation to the Cays was via boats, operated by local boatmen or fishermen supplementing their income. The system was not regulated and deemed unsafe as some of the boats do not carry safety gear. Recently, efforts were being made to ensure that all the boats carry life jackets and were not overloaded.

4.4.10 Community Fabric/Cohesion

At the time of this study, several Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) were active in the KMA and Port Royal and were major stakeholders. The Port Royal Environmental Management Trust (PREMT) had a board of 20 and a growing membership of close to 100 persons. The Trust had been successful in fostering a greater sense of community cohesion among residents especially in the areas of environmental protection and preservation. The Friends of Port Royal, a fund-raising organization, was launched in 1987 and was heavily supported by persons residing outside of Port Royal. There were also several sports and church groups. The Jamaica Fishing Cooperative Society served as the umbrella agency for the fishing cooperatives. Fishing Cooperatives exist at Port Royal, Greenwich Town, and Rae Town. Although the cooperative is in the process of being formally established at Hunts Bay - Causeway, the group is already active in the community.

4.4.11 Cultural/Historic Properties

Port Royal's rich legacy as the most important 17th Century English Town in the Caribbean, historical buildings, archaeological treasures and monuments stand as stark reminders of a city still haunted by its past when much of it was destroyed and sunk during the 1692 earthquake. Twenty acres of land sank 10 feet below the present water level, while 13 acres slid 35 feet under the water. Three of the six forts were destroyed and a fourth was severely damaged. [7] Disasters and destruction continued with several more earthquakes and hurricanes thereafter, and the port sunk into an abyss, reminded of the past by its remaining structures - the dockyard and garrison. [8] The history of Port Royal is seen as a significant resource with implications for its further development as proposed under the Port Royal Heritage Tourism Project, 1998.

The history of Portmore and Hellshire also dates back to the 16th Century when it was believed that the Arawaks first settled there after migrating from the White Marl Village. The existence of a petroglpyh cave site, Two Sisters' Caves, located in the Hellshire Hills suggested that some of those settlements were permanent. Fort Augusta, the only female prison in Jamaica, adds to the historic significance of Portmore. Located off the Port Henderson main road, Fort Augusta was constructed in the mid-eighteenth century as a major fortification on the western side of the Harbour. Its architecture reflects the Spanish influence on the island.

4.4.12 Land Use

4.4.12.1 Land Use within 0.5km

The Town and Country Planning Authority (TCPA) formulates and coordinates strategic plans for area development in the form of Development Orders consistent with the Town and Country Act (1975). The project site is located within the Kingston Harbour, with existing and designated uses consistent with harbour and port related activities; specifically as "existing ship channel."

One of the options recommended in the Feasibility Study for the disposal of dredged material from the ship channel was to place it on the southeastern edge of Hunts Bay and to develop that reclaimed land as a container storage terminal for use by the PAJ. The proposed site comprises a small area of "dry mangroves"designated "conservation" by the Kingston and St. Andrew Development Order. The designated and existing land use of abutting lands is "industrial."

4.4.12.2 Land Use within the larger SIA Project Area

As the capital city, Kingston is the economic, cultural and administrative hub of the island. It is the most densely populated, commercialized and industrialized city in Jamaica and the "primate" centre for transportation, transhipment and telecommunications. Land use categories include residential, commercial, industrial and manufacturing, public open space, institutional, recreational and mixed-uses which were reflected in over 300 years of growth and various cycles of development. Functional areas include the Central Business District, mid-Kingston zone which comprises the business and commercial districts of New Kingston and Cross Roads, and uptown which comprises the commercial and retail centre of Half-Way-Tree; the residential areas of Constant Spring, and suburban residential areas which extends into the surrounding hills. The Kingston Waterfront and industrial zone including the Free Zone are part of the landward extension of the Kingston Harbour. The Waterfront houses the Bank of Jamaica, International Seabed Authority, Kingston Mall and many professional offices and institutions including the Port Authority of Jamaica.

Port Royal is located on some 30 acres of land at the tip of the Palisadoes. It has views of Kingston Harbour to the north, the Hellshire Hills to the west and of the open sea and cays to the south. Land-use is largely a reflection of the town's evolution and history and comprises a mixture of historic buildings: Fort Charles, St. Peter's Church, the Old Gaol, the Naval Hospital, Old Naval Dockyard, old streets and walls, gun batteries, residences, bars, restaurants, the Jamaica Defense Force Coast Guard (HMJS Cagway), University of the West Indies Port Royal Marine Laboratory, Morgan Harbour marina and Hotel, a fire station as well as a football pitch, parade ground and a small, dilapidated ferry pier. At the time of this study, a small squatter settlement was located adjacent to the police station. The residents were mainly fishermen who settled there some 10 years ago.

Portmore (including Hellshire communities) is located to the north and west of the Kingston Harbour, about 11km from the downtown Kingston's commercial centre and ocean port. Land uses are primarily residential, commercial and institutional. Portmore is primarily a dormitory town with complementary commercial uses such as shopping centres. The communities of Helsinki Village, Hunts Bay at Causeway, and Pigeon Shoot are a combination of illegal settlements, fishing communities and related activities such as fish vending.

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[1] Strategic EIA - Port Royal Heritage Tourism Project, Environmental Solutions Limited, November 1998.

[2] 1996 Household Survey of Helsinki, Pigeon Shoot, Port Henderson and the Causeway, updated in 2000.

[3] TEU - Twenty Foot Equivalent Unit

[4] Port Authority of Jamaica, 2000

[5] Strategic EIA - Port Royal Heritage Tourism Project, Environmental Solutions Limited, November 1998, p 61.

[6] Strategic EIA - Port Royal Heritage Tourism Project Executive Summary, Environmental Solutions Limited, November 1998

[7] Urban Development Corporation, 1993

[8] Op. Cit. Strategic EIA, p 119

5.0 STAKEHOLDERS AND PUBLIC CONSULTATION

The stakeholders and public consultation component comprised two distinct activities:

a) Public Forum held on 3 August 2000; and

b) Follow-up meetings and interviews with representatives from the fishing communities and cooperatives

5.1 Public Forum

As part of the stakeholders and public consultation process within the EIA, a Public Meeting was held on 3 August 2000 at 1700 hrs at the Jamaica Conference Centre. The meeting was chaired by Hon. B. Gloudon, OJ, who informed participants of the purpose and agenda and also introduced the members of the head table and resource persons. She informed participants that the Public Forum was organized as part of the EIA public consultation process in order to obtain their comments and concerns and to try to address them, as much as possible, in the EIA. It was noted that the consultation would be a continuous process with follow-ups through the EIA and by the relevant authorities. Therefore, any additional comments were to be sent to the Port Authority.

There were two scheduled presentations: (i) project overview by the PAJ and (ii) presentation on the EIA process and status of the EIA by TEMN. These were followed by an open floor discussion session. There were approximately 150 participants from government agencies, the private sector, University of the West Indies, students environmental network, ENGOs/NGOs, and the fishing communities of Hunts Bay at the Causeway, Greenwich Town, Rae Town, and Port Royal.

Table 6 below provides a summary of the comments, concerns, and an indication of the section in the EIA where concerns were addressed. (See Appendix 4 for list of participants, agenda and full transcript of the Public Forum).

Table 6: Public Forum - Summary of Comments, Concerns, Responses and related sections within EIA document.

Participant/Group	***Summary of Comment/Concerns***	**Summary of response given/related sections in EIA document**
Dr. David Smith Jamaica Conservation and Development Trust (p31)	-The channel goes very close to the tip of the Palisadoes, what effect will the dredging have on the sunken city, what would be the effect of spoil material being moved and possible drifting over the sunken city? - What kind of work have you done so far with regards to fishing knowing that lots of fishermen fish on the reef, where are you planning to divert the channel, could you expand on those?	The path of the channel is the current path, the proposal is to increase the depth from the current 12.8m to 15-18m.Spoil to be removed to a deep location to be determined, use of silt screens and other ways of reducing the transport of sediments generated from the dredging. With regards fishing, the bottom of the channel has been dredged on several occasions, presently filth and mud. Do not anticipate any significant impact in that particular area. In any case there should be no fishing in the ship channel. Adjacent to the ship channel are extensive seagrass beds, but do not anticipate any significant impacts if done properly using silt screens. ***Refer to sections 4.2.4, 4.4.4, 4.4.11, , 6..2.2, 6.3 of the EIA***
Mr. Hector Lim Jamaica Fisherfolk Cooperative, Port Royal Fishing Cooperative (p33)	- I know the effects of dredging, since the start of the airport. Here is an example of the mollusc, which is now totally wiped out, only a few shrimps left now. What will be the effects on the fishermen who live off shrimps? The main concern is where you are going to put what you dredge. I think that the best place is on the land, east of Fort Augustus, from Courage Gate to Two Sisters to Miami. - Given the information on the	Concerns voiced by most of the participants - to be addressed in the EIA and by the relevant authorities for the proposed project. ***Refer to sections 7.3, 7.3.1, 7.3.2 of the EIA***

Participant/Group	*Summary of Comment/Concerns*	**Summary of response given/related sections in EIA document**
	lead content and pollution, I am now wondering if the fish is wholesome to eat?	
Participant Fisherfolk Cooperative at Greenwich Town (p34)	- I confirm what the last person said. Since the last dredging, two seasons of fishing for 2 years in the Palisadoes has stopped. So we know the effect of the dumping of the material on the seabed, net, boat, everything full with mud, scorn everything. So would like the dredging organization to speak to that.	Concerns voiced by most of the participants - to be addressed in the EIA and by the relevant authorities for the proposed project. ***Refer to section 6.2, 6.2.1, 6.2.2 of the EIA***
Mr. John Maxwell (p35)	- If the concentration of chromium and lead in the spoil does not qualify it as toxic, is it legally possible (under the treaties) to dump it anywhere else? - If the circulation of the Harbour is where we think it is, when you dig up toxic waste from where it is going to circulate, then it is going to kill off everything inside the Harbour as well as the marine life where it is going to be placed.	Cannot dispose of toxic waste under current legislation, so need to look where we place it and also at various options including infinite dilution, which would still affect transient species for a short period. ***Refer to sections 4.1.4, 6.1.2, 6.3.1 – 6.3.7, 8.1 of the EIA***
Participant Fisherfolk from Rae Town Fishing Cooperative (p41)	-The dredging that has been done before, was there any compensation for fisherfolk for loss of earnings? - There was a boat that caused a fish kill, the boat is not there now and there was no compensation. When the PAJ tug pass, it mash up the engine, complaint was made. We need compensation!	No compensation discussed or offered. PAJ had given directives to the captains of the tug boats to proceed slowly, they have been conforming, have heard no further complaints, will monitor the situation to make sure that you are not adversely affected. ***Refer to section 6.4.1.3, 8.4.3 of the EIA***
Participant (p43)	- Nothing is said about the cleaning up of the entire	Response from NRCA: A proposal exists for the sustainable use of the

Participant/Group	*Summary of Comment/Concerns*	**Summary of response given/related sections in EIA document**
	Kingston Harbour. Did the people financing the plan take into account the many gullies flowing into the Harbour, absence of recreational activities, ecotourism for Port Royal, etc Is something being done to clean up the entire Harbour, not just for use by ships but for all users and for the best interest of the communities?	Harbour. The present situation is a result of piecemeal planning in the past. NRCA commends the PAJ for bringing this matter to the public before the NRCA required it. Proposals for the cleaning up of the Harbour require a new joint approach by the various users and stakeholders. The Port Royal Project for instance would not be successful unless the Harbour Rehabilitation Programme is proceeded with. No one wants to invest in a major project with the sort of water quality problems we have in the Harbour. ***Refer to section 8.4.1 of the EIA***
Mr. Errol Cameron Jamaica Fishermen Cooperative Union, Old Harbour Bay Fishermen Cooperative, Jamaica Coral Reef Action Plan (p49)	- Too often the resource users are left out of the planning, they need to know how that will be affected and to be a part of the planning process, it is not just about satisfying the Environmental Authorities. - With regards to the protection of endangered species, we should be protecting all species not only the endangered species. - On the compensatory part of the mitigation, I have yet to see a channel through which fishermen can really voice their opinions or make a representation in terms of getting compensation - Re cleaning up of the Harbour, we often go about setting up projects without addressing the basic needs of the environment, at this rate	To be addressed in the EIA and by the relevant authorities for the proposed project. ***Refer to section 5.1, 5.2.1-5.2.4, 5.3, 8.4.1 of the EIA***

Participant/Group	*Summary of Comment/Concerns*	Summary of response given/related sections in EIA document
	we will never get anywhere.	
Senator Anthony Johnson on behalf of Hon. Edward Seaga West Kingston Constituency (p53)	- Applaud effort of the public forum and would like to know what critical lessons were learnt from the effects of the past experience of dredging in the Harbour. Concern about what appears to be efforts to degrade Rakhams Cay (RC). Would like to know the current width of the channel, proposed new width, distance from RC. (Follow-up questions) Would like to know the size of RC and what portion will be taken off? RC, formerly used to hang people is considered a historic and cultural artifact. If RC has only 5% coral cover, if further reduced by this project, would it not threaten RC's existence? - Request that stakeholders with fishing interest be taken by PAJ on a tour of the channel, pointing out exactly where and what are being proposed. - Would like to know about the nature of the base of the channel, effects of dredging on it, and nature of spill overs.	Width of channel is approx 100m, propose to increase to 200m, require taking off approx 50% of RC. Not talking about taking 100m off the top of RC, but of widening the channel at the sides. Not sure at this time of the portion to be taken off but PAJ was told "no" to Gun Cay. Rakham was a notorious pirate, not sure if want to maintain him, however, only considering removing a portion of RC. 5% coral cover does not mean that 95% is dead, nor was there ever 100% coral cover, it indicates that 5% of the entire reef is made up of corals amount other plants and animals. Would be recommending that stipulation be made to physically hand pick and relocate corals hence minimal impacts. ***Refer to sections 4.2.5, 6.2.3 of the EIA***
Mr. Robert Stephens Port Royal Redevelopment Co. (p60)	- Commend PAJ for public forum. Need to look at the past experiences and analyse what caused the fish kill before. Suggest getting in touch with ESL re Port Royal EIA and look at linkages. Now is the time to clean up the entire Harbour, the benefits outweigh costs, should not have to wait for the next 16 year as planned.	No direct response required ***Refer to sections 3.4, 8.4.1 of the EIA***
Mr. Gladstone	- Need clarification on the 40 ha	Deposition of material would be a

Participant/Group	*Summary of Comment/Concerns*	Summary of response given/related sections in EIA document
Mitchell Hunts Bay Fishing Village at Causeway (p62)	dumping in Hunts Bay as mangroves on western side of Gordon Cay are not dry, it is a natural habitat for certain species of shrimp and fish. Existing industries are already polluting the area and affecting the marine habitant, hence urge that you reconsider what is being proposed as you are about to kill off what is left of our livelihood.	gradual process and would not include any toxic material, if any toxic material is placed there it would be completely covered up, but toxic material too soft and therefore unsuitable for reclamation. ***Refer to section 6.2.1, 7.3.2, 7.3.2.1, 7.3.3 of the EIA***
Ms Esther Beckford Student Environ. Network (SEN) (p65)	- By what standards do you consider the coral heads fit to be removed and what is the rate of survival?	Removal or corals successfully done in Ocho Rios and in Discovery Bay, albeit on a smaller scale. Survival rate was above 80%. ***Refer to section 8.2 of the EIA***
Ms Marva Lynch Causeway Fishing Beach	- Comment: Causeway is our livelihood, now not sure of our faith, would like to be informed. Need sanitary facilities and decent place to conduct business.	No direct response to comment, add to list of issues ***Refer to section 5.2.2, 6.4.1.1 of the EIA***
Participant (p67)	- Appreciation of positive move forward for Harbour, however, while thinking of dredging must also think of long term policy for Harbour.	No response required. ***Refer to sections 8.4.13 of the EIA***
Mr Lennox Lemard Causeway (p68)	- Everyone is mentioning removing the pollutants from the Harbour, but what are we doing about stopping the pollution from getting into the Harbour - dumping in gullies, industrial waste, etc.?	No direct response to comment, add to list of issues ***Refer to section 8.4.1 of the EIA***
Participant (p69)	- Historically, the Harbour was always used for fishing, industries have come in and polluted it and no compensation given to fishermen. The fishermen know and understand the Harbour and can help to solve the problem, need to work with fishermen.	Fishermen - an integral part of the consultation process. ***Refer to sections 5.0, 5.1, 5.2, ,5.2.1-5.2.4 of the EIA***

Participant/Group	*Summary of Comment/Concerns*	**Summary of response given/related sections in EIA document**
Mr. Warren Blake Scuba Club (p71)	- Have witnessed in the past the depletion of the corals and while recognizes the need to balance development with environment protection, however difficult to comment, suggest information be posted on a website, also provide hard copies in simpler terms so that people can really appreciate what is happening, need information. Have not done any scientific studies but would like to challenge the coral data for Gun Cay. For Rakham Cay, concern about the widening of channel to 200m and the effects on the sunken city.	No widening proposed close to sunken city, only deeping of the channel. ***Refer to section 4.2.5, 4.2.6 of the EIA***
Mrs. Donnette Ferguson-Buchanan Jamaica Conservation & Develop. Trust (p74)	- Have any studies been done on the effects of dredging on the Causeway and on Portmore?	Causeway and bridge in question being addressed in Highway 2000 Project. PAJ and Hwy. 2000 Team met and are coordinating activities. ***Refer to section 4.4.12, 6.3 of the EIA***
Mr. John Maxwell (p75)	- Follow-up to above question: Would the dredging change the geography of Hunts Bay?	Would be dependent on the results obtained in the EIA ***Refer to sections 6.3 of the EIA***
Mr. Henry Rambano Environmental Cttee for Oil Spill (p76)	- Would the dredging of the Harbour and larger ships help to bring back the City of Kingston as it used to be years ago? Who would it help or is it just for dropping off containers?	The expansion of the port has created tremendous economic activities, we are aspiring to keep the Port of Kingston alive. ***Refer to section 6.4.1.1, 6.4.1.2, 8.4.1 of the EIA***
Commander Brady Maritime Authority of Jamaica (p78)	- We have just completed a study on the impact on the economy of direct jobs created which showed that for every direct job created, four indirect jobs are also created.	No response required. ***Refer to sections 6.4.1.1 of the EIA***
Participant (p78)	- Suggestion: Hope that after the EIA it would be possible to have another public forum	Very likely that the NRCA would require such a forum. ***Refer to section 5.3, 8.4.4, 8.4.4.1 of***

Participant/Group	*Summary of Comment/Concerns*	Summary of response given/related sections in EIA document
		the EIA
Mr. McKenzie (p79)	- Comment: Would be sensible to clean up the whole Harbour now and not just the ship channel, as all the silt on the eastern side would simply flow back, piers 1 and 2 need attention to bring back the tourist, also for the Port Royal development.	No direct response required. *Refer to section 8.4.1 of the EIA*
Chairperson (p78)	- If you did not dredge the Harbour what would be the alternative? If ships cannot come in?	Ship cannot come in. Economic activity lost. ***Refer to sections 7.2 of the EIA***
Mr. Andrew James SEN (p80)	- If there is a proposal for reclamation at Hunts Bay, how would it be carried out with Sandy Gully and the Main River emptying there?	Reclamation is not very extensive, would serve to expand storage area for containers. Anther part of the reclamation area be considered is the western side of Gordon Cay. Would be addressed in the EIA. ***Refer to section 7.3.2, 7.3.2.1 of the EIA***

5.2 Follow-up meetings and interviews - Fishing Cooperatives/Communities

Following the Public Forum, EIA team members from the socio-economic and the ecology components made several visits and met with representatives of the Fishing Cooperatives and communities of Port Royal, Hunts Bay at Causeway, Greenwich Town and Rae Town. Below is a summary of the follow-up meetings/interviews

5.2.1 Port Royal Fishermen Cooperative Society: [1]

- Not supportive of the dredging because of past experiences, but felt that they cannot stop the dredging. Reiterated the extent of destruction of marine habitat and negative impacts on livelihood from the dredging activities for the Airport in the 1950-1960's, Causeway in 1970's when the disposal of material was inside the Harbour. Also the maintenance dredging of Berths 8 and 9 in 1980's, and dredging at Two Sisters in 1995-1996 - when materials were disposed outside of the Harbour, but was not taken far out enough or at depths where the impacts would be minimal. Resulted in destruction of "mussels" (used for bait and also consumed), native and migratory fish species, and nets and boats (very strong repugnant stench).

- Prefer waste material be used for reclamation rather than disposed at sea - minimal impacts on marine life.

- Fisheries Division need to have a stronger presence with regards their custodianship of fishing activities, support to fishing communities and at activities such as the Public Forum.

- Compensation was not discussed and none given. Strongly recommended that compensation be given to those adversely affected in the evident of negative impacts from the proposed dredging, based on loss of earnings. When asked for some idea of the type of monetary compensation that would be considered reasonable based on loss of earnings, an estimated sum of J$100,000 to J$300,000 per fisherman was given. Should be calculated based on loss of income for an agreed period depending on what was impacted and who were affected.

- Alternative to monetary compensation would also be welcomed such as 'giving back to the community' in the form of assisting the Fishing Cooperative to become established and regularized. Need land for fishing complex such as the piece of land known as "Coal Wharf." Assist the Cooperative to implement their Five Year Development Plan which included the establishment of a Sardine Factory.

5.2.2 Hunts Bay at Causeway Fishermen Group [2]

- Similar past negative experience as above, pollution from industrial activities resulting in fish kill. Suggest building of artificial reef/habitat, public education and capacity building - good fishing habits and security, important for sustainability.

- Industries must be held accountable for the effects of industrial pollution and sewage discharge.

- No objections to reclamation of land at proposed site in Hunts Bay; prefer the combined option of land reclamation and disposal at sea

- Compensation should be provided if project negatively impact on fishing, based on agreed loss of earnings (full time and part time fishermen). Prefer to explore other options such as strongly requesting the PAJ and Government to work in partnership with the fishing communities and assist them with basic infrastructure and amenities such as sanitary facilities and water. Many discussions held in the past about relocation of fishermen at the Causeway, where fishermen were told to identify suitable piece of land, but, fishermen do not know which parcel of land were owned by Government or were available. Need assistance from the Government and the Fisheries Division to identify land and to help develop fishing beach, including sheds for the fishermen.

5.2.3 Greenwich Town Fishermen Cooperative Society [3]

- Similar past negative experience as above.

- Felt that it was more appropriate to build Hunts Bay than dispose material at sea.

- Need to work with the fishing communities to assist them to develop, explore alternative employment opportunities such as employment on the project as well as long term employment, need to empower the people by providing skills training so that they could explore alternative employment other than fishing.

5.2.4 Rae Town Fishermen Cooperative Society [4]

- Similar past negative experience - dredging of Rockfort Power Plant in 1996. Concerned about tugs traveling at full tilt resulting in damage to fishing boats - no compensation provided.

- Supportive of reclamation of land at Hunts Bay than dispose material at sea.

- Main concern surrounds the need for larger boats to enable fishermen to go farther out to sea (fishes not longer in Harbour due to expansion and development), also to carry larger fishing teams, need sanitary facilities, water, electricity, assistance to renovate existing Fishing Cooperative Building. Also felt that government and the private sector should work with the fishing communities and assist in their development.

5.3 Summary of public forum and recommendations:

- Suggestions were made that PAJ/NRCA help to organize a watch dog committee comprising representatives of stakeholder groups and young conservationists.

- It was obvious that all stakeholders and users of the Harbour were very genuinely concerned and interested in the proposed development and in the best interest of the people and their environment. The problem was how to maintain the intricate balance between development and environmental concerns.

- The legality of moving toxic material needs to be determined, also its potential effects.

- There were continued concerns from the fishermen about the impacts of dredging and disposal of material on the marine environment and hence their livelihood, given their past experiences of dredging activities in the Harbour. The need for compensation (financial as well as other options such as working with and assisting the communities as discussed above) should be further explored.

- The need for integrated and sustainable planning of the Harbour, as well as comprehensive clean up efforts, including industrial pollution was identified. Should seek assistance from international companies where possible.

Make EIA document accessible to the public. Request PAJ to organize another public forum.

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[1] Mr Hector Lim - Director of Jamaica Fishing Cooperative, and Treasurer of Port Royal Fishing Cooperative Mr Society; Mr Leonard McKen - Vice Chairman.

[2] Mr Roy Johnson - Chairman; Mr Gerald Berlin - Member.

[3] Mr Trevor Harrison - Chairman

[4] Mr Miguel McKenzie - Property Manager; Mr Andrew Wilson - Member; Mr Peter Dale - Member

6.0 ENVIRONMENTAL IMPACT ASSESSMENT

This section examines the aspects of the environment which will be impacted by this project and indicates the type, extent, and magnitude of the impact. It also indicates whether mitigation is possible and assigns a weighting to the degree of impact. This is represented by an impact matrix relating the system and the impact, along with a residual impact matrix, which represents conditions after mitigation. The matrices are located in Appendix 5**.**

6.1 Water Quality

The data provide some indicators that were used to evaluate environmental conditions at specific sites within the marine environment proposed for dredging and port expansion.

Water quality data collected at sites to be dredged, indicated ambient levels of some indicators that exceeded NRCA draft ambient standards, as well as USEPA saltwater quality criteria. This was indicated mainly for two heavy metals, lead and chromium, and biological oxygen demand (BOD). Lead and chromium data appears to be at variance with data collected from a previous study, though some time has elapsed between both determinations. Nevertheless it was considered unlikely that the lead concentration in particular would be so high in the water column. Further sampling may be necessary to rule out, or establish the level of, sampling and laboratory error. The high nutrient conditions in the harbour identified by previous workers were confirmed, especially for Hunts Bay. Suspended solids were well within the NRCA interim ambient standard for this parameter. Dissolved oxygen levels indicated a well oxygenated surface and sub-surface waters.

Sediment from areas to be dredged had levels of lead and chromium which far exceeded the NRCA draft effluent standards, and BOD which appeared to be significantly higher than the NRCA Draft stream loading effluent standard. Though the high sulphide levels represent total sulphide, it is expected that a significant portion of this is in the form of toxic hydrogen sulphide.

Significant increases in suspended solids levels over background levels are expected. The results of leachate and pore water analyses provide some idea of what impact may be associated with marine disposal of the dredged material.

The fact that lead and chromium were much higher in leachate than in pore water suggests that dissolution of compounds of these metals was facilitated by oxygen-rich waters. The leachate and pore water had levels of lead and chromium which suggest that the material to be dredged fits the profile of hazardous waste based on a recent classification system developed by the USEPA.

The high BOD of the leachate suggests that the material to be dredged would decompose, exerting significant pressure on available oxygen, possibly resulting in an oxygen deficit in receiving waters.

The high level of sulphide in the sediment suggests that disposal of the dredged material could result in the increase of ambient levels of hydrogen sulphide. This could potentially have a significant, negative effect on any fishery relying on benthic or slow moving species in the vicinity at the time of discharge. Pelagic species would be unlikely to suffer mortality.

6.2 Ecology

The main impacts associated with dredging and disposal activities relate first of all to direct loss of habitat. Secondary effects are assumed to relate to the formation of sediment plumes which may affect fish or benthos because of the smothering (clogging) effect of highly turbid waters on the gills of bivalves or fish, inability to detect predators or the limiting of the photosynthetic process in corals and plants. Nets placed in very silty areas tend to accumulate fine mud particles on their weave and fish can see the net and avoid it or they slide easily off the net instead of becoming entangled in its mesh.

6.2.1 The Hunts Bay Habitat

Because of the already impacted nature of the south eastern shoreline and immediately adjacent waters and sublittoral area it is not anticipated that any significant impact would occur in this area due to reclamation activities. It is possible however that changing the contour of the shoreline could affect the existing circulation patterns within the bay. This might result in a shift of the hypoxic (or highly polluted) conditions westwards into the main body of the bay with the resulting degradation of the existing fishing grounds used by the fishermen. This would reduce their catch levels even further and be considered a negative, indirect, highly significant, long term impact.

Another scenario is that decreasing the space available in this eastern corner of the bay might decrease the retention time of water in Hunts Bay. This could create a more direct flow of water (with its entrained pollutants) into the main harbour and increase the levels of contaminants affecting the fauna in the seagrass beds, mangroves and water column in andaround the Prot Royal mangroves. This alternative would be considered a negative, indirect, highly significant and long term impact. No impact on the avifauna or marine life of Hunts Bay is anticipated from loss of the mangrove trees on the eastern margin. Loss of this small and already impacted stand of vegetation is not considered significant to the ecology of the bay.

6.2.2 Kingston Harbour Fishery

The dredging of the areas H1- H3, (Figure 1) will undoubtedly release quantities of sediments containing high levels of heavy metals such as Lead, and Chromium. But the direction of sediment movement would most probably be out of the harbour, i.e. moving off to the south and being slowly carried off the west in the longshore drift. The effects on fishable resources at the mouth of the harbour would be largely speculative at this juncture. It is possible that spring flood tides may briefly slow and possibly even reverse the flow of sediment and water from the western dredge sites.

Other considerations include the reported comments from fishers in Port Royal that their activities for baitfish (white fry or silversides (Atherinidae), dusky anchovies (Engraulidae) and shrimp (Penaeidae and Sicyonidae = rock shrimps) to be used in hook-and-line fishing, were negatively affected by previous dredging activities. This suggests that where dredging is widespread or unconstrained and especially where any dumping activities take place inside harbour waters, for example, extending in to the central portion of the harbour, then normal night time land breezes could move sediment plumes into the Port Royal mangrove area. Bivalve mortality could possibly occur in the short term.

It must be noted that annual visits into these mangroves in the period September through November over the past 20 years (1980 to 2000), strongly suggest that mangrove prop-roots (*Rhizophora mangle*) bivalve resources are becoming somewhat scarcer and more stressed, probably due to increased solid waste originating from Kingston (Green, 1994). Sediment plumes would likely complicate their status further. Unmitigated dredging in or near the Middle Ground area could cause turbid water to reach the Port Royal mangroves. However, Phase 1 dredging will be slightly to the north and west of Middle Ground. The resulting sediment plume and its turbidity effects should therefore be less than those from earlier dredging work. The plume may thus take a southerly course and quickly exit the harbour. It should be noted that during the major annual rainfall seasons from October through to November and in May, the increased runoff from the Rio Cobre estuary and from the Sandy Gully, if combined with dredging in the H1 to H4 sectors, could produce conditions of high turbidity in the Port Royal mangroves for variable periods. The residence time of this sediment-rich water may be long enough to cause detrimental effects to biota including fishable resources in the Port Royal mangrove complex.

If marine disposal of the spoil from the Gordon Cay/container port sections H5 to H1 is to occur between the Hope River outfall and Cow Bay, then this heavy metal-polluted material must be placed into very deep water (not less than 1,000 m) and as far south as is feasible in terms of travel time for the barge. This would avoid the displacement of resident fish species. Cow Bay is known for deepwater fishes such as dolphinfish, kingfish and jacks, and is the site of a very small fishing beach.

The proposed clearing of coral hummocks in the east ship channel just north and NW of Southeast cay is of some interest to fisheries. For the record, it is known that most daytime fishers traditionally avoid this area due to maritime traffic. Instead, this channel is used by Port Royal hook-and-line fishers as a night-time access route directly to the edge of the south island shelf near to the extreme eastern end of the Eastern Approaches, where the drop-off into deeper water (> 300 m) occurs. This drop-off is a major hook-and-line (drop-line) fishery zone for these fishers for many years. Catches taken in this area during the period 2000 hrs to 0600 hrs include representatives from the snappers (Lutjanidae), jacks (Carangidae), groupers (Serranidae), bigeyes (Priacanthidae), kingfish (Scombridae), grunts (Haemulidae) as well as other families. Trolling (a line with a surface hook trailed far behind the boat) back and forth between Port Royal and the entrance to the Eastern Approaches in daylight hours, sometimes produces modest catches of little tuna, blackfin tuna, barracuda, mackerels, and kingfish in the "winter" season (November/December to March/April). Clearing of the coral in the Eastern Approaches area by dredging would not adversely affect fishing activities to any significant degree in the short or long term.

Kingston Harbour, Hunts Bay and the adjacent Port Royal mangoves-seagrass complexes provide modest fisheries production. These catches are mainly based on the capture by nets of sprats and herring and other surface-dwelling fish species, as well as shrimp (Hunts Bay only). Fortunately, most of the gill-net fisheries activities in the harbour are located in the centre of the basin. Nocturnal handline fishing at the entrance to the Eastern Approaches supports many of the fishers at Port Royal township. Parts of the Port Royal mangroves with their adjoining seagrass beds are known to act as nursery areas for various types of fishable resources such as white fry, anchovies, certain snappers, spiny lobsters and some shrimp species. However, the majority of these nursery areas lie outside and to the east of the sites identified for dredging activities. During heavy rainfall, it is likely that some turbidity from dredging could affect the Port Royal mangroves and adjacent seagrass bed resources in the outer harbour.

6.2.3 Rackham’s Cay

In the proposed plan, Rackham's Cay would be significantly modified by widening the ship channel nearby. This site is confirmed as a minor site for the securing of silversides or white fry, as well as juvenile sprats and herrings, all for hook-and-line bait purposes. If a part of this area was lost, the remaining bait-rich areas would include the other five Port Royal cays. Each of these possess shallow sandy areas over which small baitfish are regularly found. Quite apart from this, the major baitfish area of the Port Royal mangroves would still be available. Thus the partial loss of Rackhams Cay and the short-term sediment problem in the Eastern Approaches, should not be a major problem to fishers, as there are alternative areas. Any "loss" of baitfish areas nearby would represent a minor percentage of the whole. An approximate loss estimate would be less than 10% of the present baitfish areas, leaving 90% virtually intact.

The major problem with losing a part of Rackhams Cay is the effect on the reef, which would suffer a significant loss from the coral, gorgonian, sponge, seagrass and urchin communities. This impact can be mitigated.

6.2.4 Gun Cay

Negligible impacts are anticipated at this site as a direct result of dredging activities at Rackham's Cay (see Section 8).

6.2.5 Eastern Ship Channel

Negligible impacts are anticipated at this site as a direct result of dredging activities due to the small size of the coral patches/hummocks to be affected. Mitigation similar to that proposed for Rackham's Cay in Section 8 would be beneficial to the area.

<u>6.3 Coastal Dynamics</u>

6.3.1 The Fate of Dredged Sediment Placed in Open Water

The STFATE model output describes the simulated behaviour of the dredged material discharge at the surface, the sediment plume during descent, the dispersion of contaminants, and the sediment accumulation on the seabed. The model runs were parameterized for the the designated offshore disposal site in 350 m water depth, which is the average depth between the 200 m and 500 m contours at the edge of the island shelf. It is assumed that the material is discharged from the trailer barge within 60 seconds and the behaviour of the resultant sediment plume and bottom accumulation is simulated for 1 hour after the material is discharged at the water surface. (Please note that the SFATE output is in feet, hence the results are presented as such - Appendix 3).

Based on analysis of contaminant concentrations, the conservative tracer for the long-term simulation computations is lead, with the initial concentration of 156.70 mg/l. The output of the model simulation begins 30 seconds after disposal. The plume has an initial horizontal radius of 45 feet with its centroid at a water depth of 34 feet. The downward decent of the plume initially increases to as much as 16 ft/s within 35 seconds after discharge at the surface, then slows to 8 ft/s 60 sec after discharge, when the plume has increased its horizontal radius to 121 feet, and has a centroid at a water depth of 363 feet. At 95 sec after discharge, the plume is decending at a rate of 5 ft/s with the centroid of water depth at 597 feet water depth, a radius of 176 feet, and a lead concentration of 2.6 mg/l. The plume completes it convective descent 157 seconds after discharge when the centroid depth is 829 feet water depth, with a downward velocity of 2.7 ft/s, a horizontal radius of 230 feet, and a lead concentration of 1.2 mg/l. The bottom is not encountered during convective descent and the diffusion of the plume is greater than the dynamic spreading from the collapse.

The collapse phase of the plume occurs thereafter as the bottom of the larger or heavy sediment begins to encounter the seafloor and the finer sediments lag behind. Within 200 sec after discharge at the surface, the fall velocity reduces to 0.9 ft/s as the width of the cloud expands to 485 feet, having a lead concentration of 1.0 mg/l. At 303 sec after discharge at the surface, the cloud has begins a very slight upward movement as it becomes closer to neutral buoyancy. At this point the centroid of the cloud is 918 feet water depth, having a radius of 612 feet and a lead concentration of 0.96 mg/l. The centroid of the cloud begins to ascend to shallower depths, at a maximum upward velocity of 0.3 ft/s between water depths of 893 feet to 877 feet. The cloud reached neutral buoyancy at a centroid depth of 811 feet, 959 sec after discharge. At this point the cloud has a thickness of 71 feet, a radius of 1185 feet and a lead concentration of 0.56 mg/l.

The tables below show samples of the model results.

Table 7: CONVECTIVE DESCENT RESULTS:

Time from Disposal (sec)	Plume Centroid Depth (feet)	Plume Radius (feet)	Tracer Concentration (mg/l)
30.0	0.0	44.9	156.70
59.1	34.2	121.1	7.94
90.1	566.9	168.9	2.93
121.1	709.4	202.4	1.71
150.2	807.5	225.4	1.24
158.0	828.8	230.4	1.16

Table 8: COLLAPSE PHASE RESULTS:

Time from	Cloud Centroid	Cloud Thickness	Cloud Maximum	Tracer Concentration

Disposal (sec)	Depth (feet)	(feet)	Length (feet)	(mg/l)
237.7	905.1	526.6	197.1	1.04
355.7	910.9	685.5	133.2	0.90
500.1	869.4	868.5	98.3	0.76
696.9	827.3	1051.9	79.8	0.64
906.8	812.5	1167.7	72.3	0.57
1103.6	813.0	1207.3	70.3	0.55

6.3.2 Evaluation of Water Quality Acceptability

Whenever contaminant concentrations within the dredged material are above water quality standards, upon disposal there will be a mixing zone in the vicinity of the release point where water quality standards may be exceeded. The size of the mixing zone depends on a number of factors including the contaminant or dredged material concentrations in the receiving water, discharge density and flow rate, water column velocity and turbulence, and the geometry of the disposal vessel.

6.3.3 Pipeline Discharge

Pipeline dredges are often used for open-water disposal adjacent to channels. Material from the dredging operation consists of slurry that may contain clay balls, gravel, or coarse aggregate materials. The coarse material settles quickly to the bottom. The mixture of dredging water and fine particles results in a high-density fluid and can descend to the bottom as a fluid mud layer and spread laterally. Characteristics of the plume are dependent on the discharge rate and configuration, the characteristics of the slurry, the water depth, currents, and the density profile. In the case of disposal in a semi-confined basin, the horizontal water velocity may vary with distance from the banks, and simple mixing-zone equations may not be applicable. The behaviour of the discharged plume is highly variable based on the discharge rate and orientation (and diffuser mechanism), receiving water basin geometry, vessel speed and direction, the proximity to the bottom, and bottom roughness.

The discharge rate, its proximity to the bottom, the positioning and vessel velocity and direction will all have an impact on the discharged turbidity plumes. It would be best if the cutterhead dredge can pump closely to the bottom at low velocity to minimize turbidity plumes.

The dispersal of the dumped material at the deepwater disposal site will vary based on the concentration of sand, silt and clay in the actual area being cut.

The suction nature of the dredge will tend to minimize turbidity plumes generated by dredging of silt and sand within the harbour. Also because of the depth of the existing channel relative to the draft of the dredge, prop-wash generated by the unit is expected to be negligible.

6.3.4 Pipeline discharge impacts (Eastern Channel)

A zone of turbulence develops as the material exits the discharge point. This zone of turbulence extends the approximate width of the channel basin (580 m) at the northern end. Settling out occurs quickly, with the percent solids in the centerline of the plume decreasing from 30% at the

point of discharge to abo ut 0.3 % (3 g/L) at the end of the turbulent zone located approximately 100m south of the point of discharge. This would be an area of high turbidity at the surface due to the fine-sized constituents of the effluent. At approximately 120 m away from the discharge point, the plume is interpreted to have descended to the bottom, forming a dense fluid layer that begins underflow spreading with a plume thickness (height) of approximately 6 cm. As the bottom spreading of the dense plume continues, some entrainment of the underflow into the overlying ambient flow occurs, which increases the underflow volume and decreases viscosity, and thus increases spreading along the bottom. At approximately 400 m distance from the initial discharge, the underflow plume makes contact with the east bank. At a distance of about 500 m away from the initial discharge, the underflow plume has a thickness of about 23 cm with a 0.09 percent concentration of solids.

The results of this model run seem reasonable when compared to the published literature. Measurements from a dredging operation very similar to this one reported (Lyashenko,et.al. 1987) concentrations at the surface of 5 g/L at a distance of 25 m away from the point of discharge. In that case the effluent discharge occurred right at the water surface. The solids concentration diminished to 0.045 g/L 410 m away from the point of discharge.

6.3.5 Cutter Suction Dredge for use at Rackam's Cay and Extreme Outer Sections of the Channel:

It is proposed to use a cutter with a discharge pipe of 750 mm diameter and a discharge velocity of 5.5 m/s. Maximum density of the mixture is assumed to be 1.4 t/cu.m. The mixture would be discharged through a diffuser at the sea floor and the diffuser would be hung from a pontoon which could be moved in a controlled fashion. The diffuser would be like a bell mouth, with a bottom plate and would discharge the dredged mixture at low velocity in all directions horizontally. The discharge location proposed is in the relatively deep water just to the south west of Rackhams Cay at 17° 55.5¢ North, 76° and 50.6¢ West. This is a location on the edge of the deep water "pocket between West Middle Shoal and Rackham's Cay.

6.3.6 Reclamation of Hunt's Bay

Hunts Bay is an almost fully enclosed basin, open to the sea only by the gap beneath the Causeway, and a few other canals. All the freshwater input must therefore leave through these channels, and this interacts with rising and falling tides to produce the strongest currents situated in the vicinity of these channels.

Reclamation of this area will not impact the overall stability of the bay. The proposed area for reclamation lies in perhaps what is normally the quietest area of Hunts Bay as far as water movement is concerned. However during periods of heavy rainfall these currents will be replaced by strong fresh-water runoff currents produced by input from the large gullies.

Proper stabilization measures of the newly reclaimed area must therefore be implemented to prevent erosion during periods of high storm-water runoff. The same is true regarding the location of the site for land-based disposal of the fines (if this option is selected). Care must be taken in designing the storm water run-off for the proposed area, as a number of drains enter the sea in this area.

6.4 Socioeconomic Impacts

The perceived socioeconomic impacts were those related to the two major proposed activities of actual dredging works and the disposal of spoil as summarized in the SIA Impacts Matrix.

6.4.1 Dredging Works Impacts

The perceived impacts from the proposed dredging works were both positive and negative. Positive impacts included economic/employment opportunities related activities while the perceived negative impacts included impacts related to fishing and the livelihood of the affected fishermen.

6.4.1.1 Economic/Employment Impacts

Economic impacts included employment opportunities created during dredging activities. While direct figures were not available for this development, the PAJ has estimated, based on similar engineering projects, that labour costs related to dredging works would be in the order of about 10% of the total project and would provide some 200 new jobs for the duration of the activities. Of that, some 75% would be casual labour and 25% skilled and semiskilled jobs including carpenters, masons, steelworkers and electricians. Based on the finding of the Maritime Institute of Jamaica, 4 indirect jobs will be created to every direct job created, some additional 800 jobs, an estimated total of 1,000 new jobs.

While the designs for the reclamation works were not yet finalized, preliminary estimates from the PAJ were approximately US$93,000/acre for the formation and sustainability of lands prior to the proposed development and US$180,000/acre for pavement design. Once the design was finalized, then further employment opportunities could be calculated, both for the short and long term.

The projected impact of the proposed project on economic/employment opportunities is positive, direct and very significant, over the short and long term.

6.4.1.2 National Development

The resource base of the Kingston Harbour had been utilized and developed by many competing user groups, each with their own particular objectives and agenda, and resultant high levels of pollution and piecemeal planning and development. In 1976, the harbour was described as one of the most intensively used recreational facilities in Jamaica. Among the activities then associated with it were swimming, skiing, boating, line fishing, snorkeling and sunbathing. Some of those activities had since disappeared and, except for boating and limited beach use, the harbour no longer served as a prime recreational location. An estimated potential recreational use value for beach use was J$8.9 million. [1] Similarly, the loss of bio-diversity in the harbour may be considerable, but no suitable quantitative data existed on which an adequate economic analysis could be undertaken. This was unfortunate since it could well be that loss of bio-diversity by itself (separate from its impact on economic production, e.g., fishing, shrimping, crabbing) could prove, over time, to be the single greatest economic loss resulting from pollution. Informal vending on the beaches of Kingston Harbour as well as at other choice locations alone justified the implementation of a rehabilitation program, given the present and potential values of the harbour.

Oil refining, cement production, electricity generation, flour milling, chemical manufacturing, fish processing, food production and garment manufacturing, estimated value of US$775.35 million, were only some of the industrial activities which depended to some extent on their proximity to Kingston Harbour for the services they require. Kingston Harbour had also been used as an educational and research centre (marine biology) since 1895. With the UWI's marine laboratory at Port Royal and the Jamaica Maritime Training Institute at Buccaneer Beach now operating full time, at an estimated combined annual value of US$350,000. [2]

The strategic location of Kingston Harbour, coupled with its unique physiographic features, makes it one of the finest natural harbours in the world and a major contributor to the island's economy. During 1995, earnings from shipping and related activities in the harbour amounted to approximately US$40 million however, the potential for greater earnings obviously exists and the Government of Jamaica is therefore promoting further development of the Port of Kingston in order to benefit from it. However, pollution of the harbour was a major constraint which should be mitigated by instituting antipollution measures, likely to cost from US$2.0 to 3.0 million. [3]

At the time of this study, the criterion for measuring efficiency of container handling was the number of box moves per hour. The existing level of container handling was 20 box moves per hour. With the implementation of the proposed development, it was estimated that the level of efficiency of container handling would increase by 50% to 30 box moves per hour. Similarly, it was estimated that the storage capacity for containers, which was 8,600 ground slots, would increase by more than 250% to 21,700 ground slots.

Table 9: ***Total Container throughput for the period 1996 to 2005***

YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Container Throughput	9.62	10.39	11.27	12.10	13.06	14.05	15.04	16.02	17.01	18.00
	0.48	0.57	0.65	0.73	0.85	0.97	1.08	1.20	1.31	1.43
Regional Container Throughput	4.99	5.49	5.77	6.03	6.51	6.90	7.18	7.49	7.70	7.94
Kingston Container Throughput										
Kingston Share (%)										
Transhipment	1.19	1.38	1.60	1.85	2.14	2.46	2.78	3.11	3.43	3.75
Regional Container Throughput	0.40	0.46	0.54	0.62	0.72	0.83	0.94	1.05	1.15	1.26
	33.61	33.33	33.75	33.51	33.64	33.74	33.81	33.76	33.53	33.60

Kingston Container
Throughput

Kingston Share (%)

Source: Port Authority of Jamaica, 2000

According to Ocean Shipping Consultants, Caribbean and Latin American economies had grown by an aggregate of 37.4% during the period 1984-1996. Regional container port throughput was approximately 9.6m TEU's of which transhipment accounted for 1.19m TEU's, refer to the table above. It was however estimated that the total regional container port throughput would increase to 18.0m TEU's by 2005, of which Kingston would capture a larger regional share of 7.94%, up from 5.77 % in 1998. Similarly, regional container throughput was estimated to increase to 3.75m TEU's, of which Kingston's share was estimated at 1.26 m TEU's, up from 0.54m TEU's in 1998. While that gave the impression of a twofold increase in volume, it does not mean that Kingston would command a larger share of the regional demand. In fact, that would merely allow Kingston to maintain its 33-34% of the regional transhipment share. [4]

A Technical Rehabilitative Plan had already been developed by the Kingston Harbour Rehabilitation Steering Committee and presented to the Government (CEL and LAL, 1998). The Plan included areas relating to the construction and operation of an advanced integrated sewage treatment system at Soapberry, St. Catherine, as well as other solutions to the problems of industrial waste waters, solid wastes, the harbour sediments (pollutant sinks), ship generated wastes and watershed management (for run-off control). Such actions were to be supported by other inputs of socioeconomic and legal/institutional nature. [5]

Given the tremendous increase in shipping activities within the Caribbean and Latin American Region over past 5 years and also within the Port of Kingston, and the increasing size and capacity (length and beam) of mother ships and feeder vessels, the proposed project would be considered critical in allowing competition with other Regional Ports such as Panama Canal, Freeport Bahamas, Florida, Dominican Republic, and Puerto Rico (many of which have already invested and increased their capacities). Panama Canal (port) and Port of Kingston are considered the two strategically located ports that would be able to provide service to ships that travel the “equatorial spin,” however, this is dependent on the investment and development made through this proposed project and in the future.

The dredging project would therefore be very significant, direct and indirect positive benefit in the overall national development goal of Jamaica and also as part of the total strategic development of the Port of Kingston in order to maintain its competitiveness within the region as a premier transshipment port.

6.4.1.3 Fishing Impacts

No major disruption of fisheries activities or damage to resources would result from dredging, as none of any significance existed at the time of field investigation of sectors H3 through H5. Dredging in sectors H1 and H2, however, were of possible concerns, especially in areas considered to be close enough to the dredge areas, southeast of the approaches to Gordon Cay and to Hunts Bay. The migration routes of red snapper and maccaback which were allegedly disturbed by earlier dredging was not documented and served to reflect the still incomplete state of knowledge of the fishable resources of the area. The fishers which may be most affected by the effects on fish migration routes would appear to be those from the Greenwich Town fishing beach.

The effects of the dredging of the areas (H1-H3) on fishable resources at the mouth of the Harbour would be largely speculative at this time. The reported comments from fishers in Port Royal that their activities for baitfish (used in hook-and-line fishing) were negatively affected by previous dredging was addressed in Section 6.2.3 of this EIA. The proposed clearing of coral hummocks just north and NW of Southeast Cay was of interest as the area was used by Port Royal hook-and-line fishers as a night-time access route directly to the edge of the south island shelf near to the extreme eastern end of the eastern approaches, where the drop-off into deeper water (> 300 m) occurs (a major hook-and-line fishery zone).

Nonetheless, should significant negative impacts result from the proposed project, then efforts should be made at discussing, mitigating and providing reasonable compensation and/or alternative assistance to the fishing communities, especially those directly affected. Even without any negative impacts, government, private sector and the PAJ would be urged to work in partnership to assist in community development.

6.4.1.4 Marine Policing/Security and Customs

The development of the shipping capacity of the Kingston Harbour would ultimately require increased/improved marine policing/security (including drug enforcement capabilities) and customs associated with increased transshipment and container cargoes. Discussion with Captain Delisser, Harbour Master, indicated that the Harbour Master Department was in the process of upgrading and moderization and would adequately cater for the increased demand due to the expansion of the port. Similar discussion with the Marine Police and Customs also indicated that the proposed expansion of the port was being taken into consideration with respective plans for upgrading. Hence, there should be no negative potential impacts. Positive impacts would be direct and long term - related to the upgraded facilities, potential creation of a few new jobs and improved efficiency and services.

6.4.1.5 Cultural/Historical Properties

The dredging of the ship channel wold not affect the "sunken city" nor would it compromise the ability of explorations or tours as the dredging would be confined to the existing channel. The potential for plumes of sediment to negatively impact on any sunken treasures would be negligible. (Refer to Table 6).

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[1] Strategic EIA - Port Royal Royal Heritage Tourism Project, 2000, p 66

[2] ibid.

[3] Ibid.

[4] Port Authority of Jamaica, 2000

[5] Barry Wade (1998) has criticized the plan as being unnecessarily slow and not achievable in less than 25 years. On the other hand, he has proposed a speeded-up plan to be achieved in 15 years.

7.0 ASSESSMENT OF ALTERNATIVES TO PROJECT

7.1 Dredging

This dredging activity is part of a larger project involving the total development of the Port of Kingston in order to maintain the port's competitiveness. Shipping activities have increased very significantly over the past five years. Further, the vessels are getting longer and the average number of containers per vessel has also increased. In the region as a whole shipping activities have doubled over the past five years, and it is anticipated that this activity will triple within the next 10 years. The capacity of the largest container ships (a function of size) has almost doubled in the last five years. It is expected that the Port of Kingston will have to accommodate vessels of this size within the next decade. If the port is not developed to handle these larger vessels and position itself as one of, if not, the major port in the region, it stands to lose some of the current clients to other ports which are currently carrying out development (e.g. Jacksonville, Fort Everglades, USA; Manzanillo, Cristobal and Balboa in Panama, San Juan in Puerto Rico, and Rio Haina in the Dominican Republic). It is therefore critical to the continued success of the Port of Kingston that the development project should continue. The dredging of the channel would ensure that the longer vessels now coming on stream could be accommodated in the Port of Kingston. This is a preferred alternative.

7.2 No Dredging

If the channel is not enlarged to accommodate the larger vessels now in use (and those anticipated) over the short to medium term, the Port of Kingston would lose clients. This would have a significant negative effect on the Jamaican economy. This alternative is not preferred.

7.3 Alternative Disposal Sites

The perceived impacts from the spoil disposal alternatives are positive and negative, as well as national and local in nature:

Alternative 1*: Place all of the dredged material in the proposed Hunts Bay reclamation platform*

Alternative 2: Dispose all of the material at a suitable marine site

Alternative 3: A combination of the above options with some material being placed in the Hunts bay Reclamation platform or some other land bank location

7.3.1 Reclamation

7.3.1.1 Disposal on land

This alternative assumes disposal at a site that affords protection of ground water and isolation to prevent entry of contaminants into the food chain. While this option can provide precise control over the fate of contaminants, there are a number of factors to consider which would influence cost. These include site identification, site preparation, ground transportation and security. It is expected that the less contaminated material could also be used generally as fill without any serious environmental risk. The possible risk from resubmergence of toxic spoil as a result of some catastrophic "act of God" cannot be overlooked. Although the effect would be immediate and negative, its magnitude would also be impossible to predict. It is likely that a lot of other collateral damage would also occur.

7.3.1.2 Disposal at Hunt's Bay

Disposal to a section of Hunt's Bay would provide little or no dilution and could be a significant short–term and long-term source of lead and sulphide to the rest of the bay. Through an engineered solution it may be possible to confine the sediment physically thus eliminating the impact from suspended solids. Preventing leaching to adjoining areas would be more difficult. This alternative would also result in further but marginal loss of habitat in addition to the area to be filled for the port expansion. Terrestrial vegetation lost during this activity would be ecologically insignificant.

With respect to land tenure, the land had been vested by the Commissioner of Lands to the PAJ.

Discussions with representatives from the Town Planning Department (TPD) and KSAC indicated that the proposed land use of the reclaimed land would be compatible with surrounding land uses. Once the land was reclaimed, a Site Plan should be developed by PAJ and sent to the TPD and KSAC. Potential impacts would be localized positive impacts related to 'new' lands being brought into use and national positive impacts related to the future development of port and transshipment activities and associated economic gains.

As pointed out in the Feasibility Study, the stability of the existing Causeway Bridge needs to be safeguarded and the alignment of the future Causeway Highway needs to be considered. The pre-feasibility study for the new Causeway Highway was done more than 4 years ago including a proposal for the resettlement of the dwellers, fishing community and vendors. It was further understood that the PAJ had been in discussion with the Highway 2000 Team at the Ministry of Transportation and Works, and was given the 'green light' to proceed with works in the vicinity of the bridge, as the construction of highway would 'work around' the proposed development. [1] Therefore, depending on whether the measures to be implemented by the Ministry of Transportation and Works are done in a timely manner, then potential impacts should be negligible. If not implemented on time, then potential impacts would be negative, short term and direct, until such time that the measures were put in place.

In addition, while fishing activities are minimal at the proposed reclamation site, the westward drift of the plume should be carefully monitored as it could negatively impact handline fishing activities on the western side of the bay. Also, given the composition of the material that would be dredged, and the fact that only a portion of the more compact and non-toxic material may be suitable for land reclamation, the rest of the material would have to be otherwise disposed.

7.3.2 Offshore Disposal

Disposal at sea alone would remove the economic benefits to be gained from land reclamation. It also introduces the complication of the possible effect that toxic substances might have on marine benthic and pelagic flora or fauna. Increased levels of bio-accumulation in these organisms may have immediate or deferred mortality impacts. This alternative would be the least favourable.

7.3.2.1 Offshore Disposal - 200 metre depth contour

A minimum dilution factor (worst case) based only on volume of receiving water and ignoring the dispersive effect of currents was determined to be around 100-fold. Assuming negligible contribution from the receiving water, and using the results of sediment/leachate analyses, maximum temporary contribution of lead from sediment deposited at the dump site could be around

0.5ppm (500ppb), while sulphide could be 5mg/l, and BOD 10mg/l. Based on the total material to be disposed of, average suspended solids could be 6mg/l. It is considered that factors such as prevailing currents as well as interval between discharge events could lessen these values considerably.

7.3.2.2 Offshore Disposal - 1000 metre depth contour

A minimum dilution factor (worst case) is determined to be around 1000-fold. Using similar assumptions as in the 200m analysis, it is suggested that a further reduction of at least one order of magnitude would be achieved. It is also likely that at this greater depth, oceanic currents would enable a greater level of dilution. The greater distance that would have to be travelled by the dredge would also provide a longer period between discharge events thus improving dilution even further.

If dumping of the spoil from the Gordon Cay/container port sections H5 to H1 is to occur between the Hope River outfall and Cow Bay, then this heavy metal-polluted material must be placed into very deep water (not less than 1,000 m) and as far south as is feasible in terms of travel time for the barge. This is to avoid the displacement of resident fish species. Cow Bay is known for deepwater fishes such as dolphinfish, kingfish and jacks, and is the site of a very small fishing beach.

The heavier fractions will make up the mound of consolidated material and this will be thinner and cover a larger surface area, than if dumping were to take place at 200m. This could result in the complete leaching of all the contaminants from the mound to the surrounding waters taking place in a shorter time. Some finer fractions of the plume may become neutrally buoyant at depth and travel with the prevailing current at that depth.

Other parameters necessary for model input such as temperature, salinity, current regime stratification, have not been measured at these depths, and so we must consider the greater spreading as the worst case scenario.

7.3.3 Mixed Land/Sea disposal

This scenario assumes disposal of the more contaminated material on land at an adequately prepared site, and "clean" material in the marine environment. This assumes that the contaminated material is surface sediment, and that the quality of sediment improves with depth. For this option dumping could be at the 200m or 1000m contour. *This option would be expected to have a minimal environmental impact especially where marine disposal is to the 1000m contour.*

Based on the foregoing discussions, this alternative would be the most favourable. This option would take into consideration the concerns of the fishing communities, provide additional land *space for the further development of container storage with significant potential economic benefits, and facilitate the disposal of toxic materials in a location that would not negatively or minimally impact on the livelihoods of the surrounding communities under normal circumstances.*

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[1] Project Meeting, Port Authority of Jamaica, July 2000Project Meeting of — between PAJ and TEMN

8.0 RECOMMENDED MITIGATION AND MONITORING

8.1 Water Quality

The unexpectedly high values obtained for the trace metals lead and chromium may be adequate reason to repeat these analyses on freshly collected samples. The data base could also be improved by carrying out analysis on the actual sediment dredged at different depths. Though the turn around time for these analyses would limit their usefulness in this exercise, it would assist in refining disposal plans for future dredging operations.

Development of the disposal strategy should take into consideration the possible need to identify different ways of disposing of sediment from different depths (especially in the harbour). Where possible consideration should be given to using sediment as fill for land based projects.

Sediment from the more obviously contaminated areas, namely, Gordon Cay, and the channel near Fort Augusta may have to be disposed of in a different manner than sediment from areas in the outer harbour. The following simple matrix relates sediment type with potential hazards, and disposal options recommended for consideration:

Table 10: Environmental Chemistry Matrix: Sediment, Hazard and Disposal Options

SEDIMENT SOURCE	POTENTIAL HAZARD ASSOCIATED WITH DISPOSAL	DISPOSAL OPTIONS RECOMMENDED FOR CONSIDERATION
Outside Harbour	Increased Suspended Solids	Ensure safe distance from sensitive ecosystems e.g. seagrass beds, and coral reefs
Ship channel (Port Royal to Fort Augusta)	Increased suspended solids, possible hydrogen sulphide contamination, organic load	Ensure safe distance from sensitive ecosystems e.g. seagrass beds, and coral reefs, deep water disposal (>300m)
Ship channel (Fort Augusta to Turning Basin)	Increased suspended solids, significant hydrogen sulphide contamination, high organic load, possible leaching of lead and chromium	Land disposal at a sealed site, disposal in very deep water (>1000m), control of discharge rate.

8.2 Ecology

Suggested mitigation for the dredging project includes the following: -

C Curtains placed on dredge to trap sediments and therefore limit the lateral movement of turbid water;

C Spoil dispersion outfall characteristics to be evaluated by collecting grab water samples during dredging operations and operations modified accordingly;

C Dredging to a slightly greater depth than absolutely necessary to pick up more, heavier, material so as to facilitate fallout of dredge spoil when released in open water;

C Dredging to a slightly greater depth than absolutely necessary so as to reduce the need for maintenance dredging;

C No dredging in periods of rapid water movements, for example, in the afternoon when trade winds are strong, or during the rainy season when large influxes of fresh water could move significant volumes of sediment laden waters across the harbour to the Port Royal mangroves;

C The connection of a conical reflective shield to the outlet as silt suppression and dispersion control mechanism;

C Careful mapping of seagrass areas directly affected by the dredge and replanting 130% of area affected to compensate for possible mortality. These techniques are well established for Kingston Harbour waters (Thorhaug et al 1985);

C Reseeding of mussel beds in the Port Royal mangroves to improve the bait population for the fishery;

C Removing corals, seagrasses, gorgonians and urchins at the Rackham's Cay area and relocating to Gun Cay or some other appropriate site;

C Preventative maintenance of equipment to mitigate negative environmental impacts such as leakages and spillages.

8.3 Socio-economics

8.3.1 Sustainable Development of Kingston Harbour

Given the impacts outlined in Section 6.4.1.2, and recognition of the need to move toward a holistic and sustainable approach for the development of Kingston Harbour, a strong recommendation would be the formulation of an Integrated Development, Management and Monitoring Plan (IDMMP). This Plan should incorporate existing sector plans, initiatives and projects already approved and/or being implemented. The IDMMP should include key action and results areas for the rehabilitation as well as the long term development of Kingston Harbour, collaboratively with community-based planning and development. It should be supported and owned by all user groups and the public with certain agencies such as the Port Authority of Jamaica, NRCA/NEPA, TPD, KSAC, Ministry of Tourism and Sports, Ministry of Agriculture and Mining, the private sector (such the Port Royal Redevelopment Company among others) and NGOs, positioned to assume certain key responsibilities and lead functions.

8.3.2 Employment Opportunities

Given the level of unemployment and underemployment of the young people in the surrounding communities, it is recommended that most of the unskilled construction and casual labourer positions are filled locally. As much as possible, local residents especially from the fishing communities should be given the first opportunity for employment.

8.3.3 Compensation

The issue of compensation to fishermen in the event of negative impacts resulting from the project was discussed in Section 5. The NRCA/NEPA and the Fisheries Division in collaboration with the respective affected Fishing Cooperatives and communities and the PAJ should agree and discuss reasonable compensation and the manner of its disbursement should the need arise. A lead role should be jointly taken by the NRCA/NEPA and the Fisheries Division.

8.3.4 Suggested Monitoring

8.3.4.1 Monitoring of the Development Programme

As discussed at the Public Forum, a Monitoring Committee should be formed, however, since a Kingston Harbour Rehabilitation Steering Committee already exists, then efforts should be made to utilize existing mechanisms and to build synergy and collaboration. The terms of reference and mandate of the Committee should be reviewed to allow for the comprehensive monitoring and accountability of development activities within the boundaries of the Harbour as well as activities in surrounding areas that might impact on the harbour, including recommendation contained in this EIA. The Committee should comprise members of key government agencies including the NRCA/NEPA, and Fisheries Division, NGOs/CBOs, Fishing Cooperatives and community representatives, Student Network, private sector, international agencies, and the Port Authority of Jamaica.

8.3.4.2 Monitoring of Dredging Programme

It is recommended that during the actual dredging and disposal procedures, a monitoring program be implemented. This program should include the following:

C An examination of **all** important environmental parameters should be carried out during the first week of the operation. If no adverse effects are noted, monitoring should be fortnightly. This monitoring will be carried out more frequently during unusual weather conditions, or if adverse effects are noted.

C Turbidity and other sensitive water quality readings should be taken at all sensitive areas outside of the area of the screens initially, and at regular intervals throughout the operation.

C Current readings and examination of plumes should be taken on a spot check basis throughout the area of interest.

- Aerial photographs (unannounced) should be taken regularly to determine if the dredge is operating according to recommendations.

- Soundings should be taken fortnightly at the approved offshore dump site to monitor the effect over the period of deposition.

- A continuous record of wind speed and direction should be made throughout the period of dredging.

Fortnightly reports should be sent to the NRCA on the dredging activities unless conditions develop which warrant more frequent reporting. Spot checks should be done on nearby reefs to monitor any siltation at least once per month, preferably every two weeks.

9.0 LEGISLATIVE AND REGULATORY FRAMEWORK

Jamaica had 52 statutes that have jurisdiction over matters of the environment. They range from public health to physical planning and land use with many instances of overlap in responsibilities and were in the process of being rationalised, coordinated and strengthened.

The proposed project will be executed by the Port Authority of Jamaica on behalf of the Government of Jamaica. The Town Planning Department/KSAC had a manual which provided guidelines for development, including projects in the coastal zone. The Natural Resources Conservation Authority Act, 1991, binds Crown lands. The Fisheries Division of the Ministry of Agriculture has distinct responsibilities for fishing activities island wide. Thus, the responsibility for regulating and facilitating sound environmentally conscious development rests with several disparate authorities and different pieces of legislation. Those relevant included the following:

The Port Authority Act authorises the Port Authority to declare harbours, and establish or alter boundaries of harbours. Established the Marine Board to make rules for the regulation and control of harbour and ship channels. It allows for the prohibition of the discharge of rubbish, earth, stone, ballast, mud, oil, mixtures with oil or its residues, as well as the removal of stones and gravel from reefs, shoals, or cays. Marine Divisions of the Port Authority regulated the construction of structures on or over the water, or dredging activities. It empowers the Authority to regulate the use of all port facilities in the port including berths and stations, and accompany and removal of vessels. It also allows the Authority to make by-laws for the control and management of the wharves and premises, regulate the loading and discharging of vessels, and carry out the compulsory acquisition of lands for bringng into effect any of the provisions of the Act.

The Harbours Act allows the Marine Board to make rules for the regulation and control of any harbour in the Island and of the channels and approaches leading thereto and of persons, boats and vessels using such harbour or approaches, and for all purposes connected with any such matters. According to the Act, the duty of the Harbour Master includes all matters relating to maintaining and protecting the harbour and shipping channels.

The NRCA Act (1990) established NRCA with primary responsibility for protection and management of the country's natural resources and control of pollution including atmospheric pollution. NRCA powers and responsibilities focus on the following:

- Establishing and enforcing pollution control and waste management standards and regulations;

- Guiding environmentally appropriate development through such tools as prescribing areas;

- Requiring environmental impact assessments, and granting permits and licences. In general, planning permission through the Permit and License System must first be sought from the NRCA. The Environmental Control Division (ECD) of the Ministry of Health and local planning authorities monitor construction work to ensure that all development restrictions and requirements are properly adhered to. The NRCA may also require implementation of an environmental monitoring plan.

- Maintaining a system of national parks and protected areas

- Promoting broad public awareness through information, environmental education, and outreach activities;

- Monitoring and enforcing environmental laws and regulations, especially those included in the NRCA, Beach Control, Watershed Protection, and Wildlife Protection Acts;

- Providing national environmental leadership, coordinate activities of other government agencies, and support local, non-government efforts at protecting and enhancing the environment.

The NRCA through the Environmental Action Programme (ENACT) and in collaboration with the Bureau of Standards and other key government and private sector agencies formed a national working group on developing guidelines and standards for Environmental Management Systems.

<u>The Land Acquisition Act</u> states that the Commissioner of Lands is responsible for the acquisition of all lands needed by the Government of Jamaica for public purposes. The Commissioner may acquire these lands either by way of private treaty or by compulsory acquisition (if there was no agreement).

<u>The Town and Country Planning Act</u> governs land use, in accordance to legal instruments known as Development Orders. Development Orders (broad based land use plans and regulations. Development Orders are to control both rural and urban land development, ensure proper sanitary conveniences, coordinate building of roads and other public services, protect public

amenities (conservation areas, wetlands, mangroves). Authorized issue of Tree Preservation Orders, provides for the protection of designated trees, groups of trees and woodlands. The Act establishes area-specific standards for land use, density and zoning. At present, Development Orders cover most of the urban areas of Jamaica, as well as the entire coastline up to one mile inland and a number of parishes.

The Local Improvements Act controls the subdivision of land and requires that anyone wishing to subdivide land for building, lease, sale, or other purposes, must provide the local planning authority with a plan for approval. The act is administered by the KSAC and the Parish Councils, which have the power to approve or deny subdivision applications within their boundaries, based on the advice of their Planning and Building Subcommittee and the local Fire Superintendent.

The Wildlife Protection Act prohibits the removal, sale, or possession of protected animals and the use of dynamaite, poison or other noxiuos material to kill or injure fish. It also prohibits the discharge of trade effulent or industrial waste into the harbour.

The Fisheries Industry Act establishes the Fisheries Division responsibility for licensing fishermen and fishing boats, protection of the fishery by establishment of closed season, creation of fish sanctuaries, and penalties for landing or sale of illegally caught fish.

Protected Areas Policy

Jamaica has a rich and diverse natural heritage created by its geographical location and its varied topography, geology and drainage. That diversity endowed the island with a scenic beauty sought after by Jamaicans and visitors. In the face of deteriorating environmental conditions, a system of protected areas provided the means to conserve and ensure the sustainable use of Jamaica's biological and cultural resources. The Palisadoes peninsula, its surrounding waters with mangroves and seagrass meadows and the adjacent Port Royal Cays and coral reefs comprised an ecological complex of significant social and economic value to Jamaica. That area was designated a protected area in September, 1998

Relevant International Treaties

< Specially Protected Areas and Wildlife (SPAW) Protocol encouraged the establishment of protected areas to conserve rare and fragile ecosystems and habitats.

< Cartagena Convention was an international treaty signed by all Caribbean nations, obligating them to marine pollution monitoring and control of ship borne and land based sources of hydrocarbon (oil) pollution.

< The Earth Summit Treaties signed by Jamaica at the UN Conference on Environment and Development including Agenda 21, the Biodiversity Convention, and the Framework Convention on Climate Change, the UN Conference on Small Islands Developing States, the UN Convention on the Convention on the Law of the Sea, the London Convention on the Prevention of Marine Pollution, all obligate Jamaica to take wide ranging measures in environmental protection and sustainable development, including enacting over-riding legislative authority in environmental matters to the Ministry of Land and Environment.

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