AUTORIDAD DEL CANAL DE PANAMA

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FEASIBILITY STUDY OF PALO SECO/FARFAN LAND RECLAMATION TO DEVELOP A PORT FACILITY

FINAL REPORT

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1 INTRODUCTION

As part of the expansion of the capacity of the Panama Canal and the possible construction of new sets of Locks, the Panama Canal Authority (ACP) has been conducting a series of studies related to the disposal and beneficial use of excavation and dredged materials. One of the potential uses for material from the Pacific side excavations involved the potential construction of an artificial island or peninsula that could be used for port operations or other activities.

Since completion of these studies in 2003 and 2004, the Government of Panama has also received a number of requests related to the potential to build a major container transshipment center on the Pacific Coast, close to the Canal.

Figure 1-1 shows the general location of the area of interest for this project.

While the development of the container port is an independent project and not linked to the proposals to expand the capacity of the Canal, much of the information and analytical work performed for the earlier studies is relevant to this new initiative.

Consequently, the Government has now requested the assistance of the ACP with the assessment of the potential to develop a new Container port within ACP controlled waters at the Pacific entrance to the Panama Canal.

The original studies sponsored by ACP focused on the beneficial use of rock and other material generated by the excavation and dredging needed for the New Pacific side Locks. However, the fill and rock material for the new container port could also come from traditional or new borrow sources independent of any decision to build the New Locks. The analyses of these other potential sources of fill are also presented in this report.

Note: Background courtesy of Tommy Guardia

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Figure 1-1
General Location Area of Proposed Project

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1.1 Background

The following recent studies and surveys related to the use of excavated materials from the Pacific Locks and Canal widening and deepening projects provide the basis for this study:

- Preliminary Study of Island Development at the Pacific Entrance to the Panama Canal, Moffatt & Nichol for ACP, December 2001
- Marine Geophysical Investigation to Characterize Seabed for Proposed Artificial Island Project, Golder Associates for Moffatt & Nichol and ACP, March 2003
- The Preliminary Study on Land Reclamation Alternatives at the Pacific Entrance to the Panama Canal, Japan External Trade Organization for ACP, March 2003
- Pacific Side Excavation and Dredging Material Disposal Alternatives Evaluation, Moffatt & Nichol for ACP, March 2004
- The Feasibility Study for the Construction of an Artificial Island at the Pacific Entrance to the Panama Canal, Japan External Trade Organization for ACP, March 2004
- Feasibility Study of Island Development at the Pacific Entrance of the Panama Canal, Moffatt & Nichol for ACP, May 2004

In addition to the above studies, a series of environmental, technical, transportation studies have been prepared, together with hydro-dynamic modeling of the study area and bathymetric, geotechnical and other field studies, as listed in Appendix G of this report.

One of the key studies undertaken by ACP was the geophysical survey of the area extending from Howard to the Panama Canal. The survey which was conducted January and February 2003 extended south from the shoreline to approximately 1.0 km north of Taboga Island.

One of the key findings was the discovery that the very shallow rock platform along the Palo Seco/Farfan shoreline drops to a depth of some 12 to 20 m below Mean Lower Low Water (MLWS), on an approximate line parallel to the Canal and 1,500 m from the Canal centerline.

This finding then led to the identification of the Palo Seco/Farfan site as a disposal option that could potentially be development as a port site at some time in the future.

This latest study builds on the findings of the geophysical survey with the added assessment of the potential to use materials from conventional marine or landside borrow areas, to accommodate the possibility that the construction of the port could precede the implementation of the Pacific Side Locks excavation work.

1.2 Objectives

Due to the high level of interest in this project the Panama Government wishes to receive an early report on the environmental, technical and financial feasibility of the proposed port project. Fortunately there is a substantial body of data, as indicated above and this study is based upon the results of these recent studies.

The impetus to develop the port on the Pacific Side comes from a number of the major shipping lines and international port operators, all of which see the Port as a major container transshipment center, along the lines of the Manzanillo terminal on the Atlantic side. The market forces driving the transshipment of containers are very different to those of import and export cargo and each of the major participants in this area of business have their own projections of potential cargo, some of which have been shared with the consultants.

Consequently, the forecasting elements of this study are being limited to a general profile of shipping patterns and an evaluation of user needs based on existing and potential future Canal transits and vessel size capabilities.

Based on these considerations, the overall objectives of this study are to conduct the following work tasks at feasibility level:

- **Planning Studies**
  - Develop container terminal concepts
  - Assess Service and support requirements
  - Assess Utility Needs
  - Develop Port Options
- **Technical Studies**
  - Review of Sources of Fill Material
  - Characterization of Fill Material
  - Assessment of Existing site characteristics
  - Fill Material Transportation and cost Analyses

    - Cargo Movement Assessment
    - Wave, hydrodynamic and Coastal Studies
    - Navigation Assessment
    - Concept Development
    - Preliminary Design Assessment
- **Environmental Impacts Assessment**
- **Socio-Economic Study**
- **Develop Cost Estimate**
- **Prepare an Implementation Program for the Project**

2 PLANNING STUDIES

2.1 Market Overview

As noted earlier, each company interested in presenting a proposal for a concession or lease to manage and/or operate the Port will prepare its own set of cargo forecasts and cost analysis in order to support its proposal and financial package.

In terms of demand, there are a number of market and other factors that favor Panama as a transshipment center for containers at this time. These include:

- Congestion at West Coast US ports
- Rapid growth of Asian trade to the US and establishment of new all water routes
- The move to larger container vessels on the main trade routes
- Expectations of strong growth in South American trade
- Lack of modern deepwater container terminals in many of the South American countries
- Success of Manzanillo and Balboa Terminals in Panama
- The recent rehabilitation of the Panama Canal Railroad by Kansas City Southern
- Expectations that the Panama Canal Authority will proceed with the construction of New Locks in the near future

2.2 Throughput Targets

According to a recent presentation[1] in Miami, the market for transshipment facilities in the Caribbean is expected to reach 8.4 million TEUs by 2015. Panama has 34% of the total transshipment volume at this time and is well positioned to increase its market share as capacity ceilings are reached by 2010 – 2012. Strong growth is also expected on the Pacific side as the main ports on the West Coast of South America continue to improve and update container terminals, coupled with optimistic trade growth projections for Chile, Peru and Colombia, plus the west coast of Central America.

There appears to be general agreement in the industry that the primary factor influencing the selection of a location for transshipment operations is location close to main trade routes as indicated by the success of Singapore and other major hubs in the world. The

[1] Strategic Port Planning in the 21st Century, Jorgen Steving of Maersk Sealand, Feb 2005

move to the all water route for Asian cargoes and expectations of expansion of the Canal indicate a strong geographical advantage for Panama at this time.

Given the volatility of the transshipment business and uncertainty of future Asian and South American trade patterns, it is clear that the proposed terminal must be large enough to offer considerable flexibility to accommodate all options, but not oversized to render it financially unattractive.

Based on discussions with several of the groups interested in the Port project, it would appear that there are expectations that the demand for additional transshipment facilities on the Pacific Coast could reach 3.0 million TEUs per year within the next 15 to 20 years.

The proximity of the former Howard Air Force Base also offers the potential for Panama to become a regional logistics and distribution center, and the terminal may also service local markets.

At this time, the composition of traffic through the main transshipment terminals of Manzanillo and Balboa is reported[2] to be as follows:

Transshipment ..... 80 to 90%

Local Demand ..... 5 to 10%

Interchange between coast by rail or truck ..... 5 to 10%

Reefer needs.....3 to 12% of totals

For the purposes of this study, a target throughput of 2.40 million TEUs per year is proposed, with the breakdown of containers as indicated above, while allowing that the actual construction of the port can be accomplished in phases.

2.3 Operational Overview & Objectives

2.3.1 Vessel Call Scenarios

A major advantage of Panama as a transshipment center is the Panama Canal, with or without expansion. Assuming the New Locks are constructed with a capacity to handle container vessels in the 8,500 – 9,500 TEU range[3], a single call at either the Pacific or Atlantic side can be made, with distribution of the unloaded containers via rail, truck or

[2] Informal figures given by existing operators

[3] The final dimensions for the proposed New Locks have not yet been finalized.

barge to the opposite coast, as well as by feeder vessel to both coasts of the US and South America.

Should the Canal expansion not proceed, these large vessels can then make direct calls to Panama with distribution as above, using Panamax vessels as feeder ships.

According to shipping specialists interviewed during the preparation of this report, there are expected to be a wide range of operating and load exchange patterns for the terminal. These may include:

- Transiting vessel dropping containers for South American Markets
- Post Panamax vessel calling at US west coast Ports and then arriving partially loaded at Panama before returning to Asian port (without Canal Expansion) or transiting Canal with expansion
- Direct Asia – Panama routes by Post Panamax ships with Panama being a regional distribution and transshipment center, before transit or return to Asian port.
- Lightening of Panamax or other vessels to reduce draft or improve visibility when transiting the Canal
- Exchange of containers between North and South American west and east coasts to eliminate vessel calls by large ships

2.3.2 Terminal Operational Scenarios

All of the major container port operators and carriers have their own operating style and terminal template. In order to provide a sound basis for the evaluation of the feasibility of the project, a generic container yard area module has been established to meet the fundamental operational criteria summarized in Section 2.4.7. These conceptual layouts are not necessarily representative of the final operating system or dimensional criteria that would be adopted by the company selected to run the new Port or to lease space within it. However, they provide a basis for invitation of proposals to manage and/or operate the port and indicate the capital investment requirements for the project.

As a result of discussions with interested carriers and terminal operators, two fundamental configurations were evaluated:

- A single line of marginal berths, designed to accommodate both mother ships and feeder vessels.
- A terminal that would provide berths for mother ships on one face and berths for feeder vessels at the rear of the terminal.

The reason for the second option is the reduction of the haul length for containers offloaded from the main line vessel and loaded onto a feeder ship berthed at the other end of the terminal. However, the location of an intermodal or land access corridor for this option requires careful consideration, in order that the efficiencies of cross terminal moves are not impeded by the need to access the rail or truck loading areas.

2.4 Facility Requirements

2.4.1 Craneage

The fundamental throughput indicator for a container terminal is the installed crane capacity. This can be determined by computing the potential ship to shore moves per crane, by the number of units provided.

Application of industry standards for modern Post Panamax container cranes indicates that a throughput of 2.4 million TEUs per year would require the installation of at least 18 cranes. Based on current operating practices for Post Panamax vessels, up to six cranes are expected to be deployed on any single mainline vessel.

2.4.2 Ship Size

The final dimensions and configuration of the new Locks are still under study and may change during the final design process. However they give an indication of the probable new standard for a Post Panamax, or New Panamax ship expected to use the Canal following the completion of the expansion program. According to ACP, the expected dimensions for the new Locks and the maximum vessels sizes under study at this time are as shown in Table 2-1.

Table 2-1 : Expected Dimensions for New Locks

	Length (m)	Breadth (m)	Depth (m)
Locks	**426.8**	**55**	**18.3**
Limiting Vessel Size	**360 to 385**	**46**	**15.0 (Draft)**

The transshipment terminal will also receive a wide range of container vessels, which may be short haul or regional feeders or larger feeder ships servicing all water routes to the US Gulf and East coasts.

Table 2-2 shows a range of potential vessel sizes and controlling dimensions for the classes of container ships that might be accommodated at the new terminal.

Table 2-2: Typical Dimensions of Existing and Future Container Vessels

Class of Vessel	*DWT*	*TEU Capacity*	*Containers across deck*	*Length (m)*	*Beam (m)*	*Draft (m)*
Line vessels						
1st generation		1,000		180	25	9
2nd generation		2,000		225	29	11.5
3rd generation		3,000	12	275	32	12.5
Panamax	70,000	4,000	13	294	32.6	12.5
Post-Panamax (1991)	75,000	4,400	16	275	39.4	12.5
Super Post Panamax	105,000	6,250 – 7,500	18	315	44	13.5 – 14.5
New Locks Standard	105,000+	8,500 – 10,700	19 - 20	360-385	46	15.0

2.4.3 Berth Requirements

Based on the parameters above, the berth length module should be based on the requirements for 385 m vessels, with a capacity of at least 8,500 TEUs, drawing 15.0 m fully loaded. However, as noted above, building plans for shipping lines such as COSCO Container Lines (COSCON) and other major carriers already envisage the use of 10,500 TEU ships on the trans-Pacific routes. Depending on the final decision on the dimensions of the New Locks, these ships may be too large to transit the Canal. However, it is quite likely that they could call at the new container port.

In order to maintain sufficient clearance between vessels for navigation safety and to give a satisfactory angle for bow and stern lines, the larger ships require approximately 25 m of stern and bow clearance from an adjacent vessel.

These requirements indicate a need to provide at least four berths to service 18 cranes and maintain an annual throughput of 2.4 million TEUs of primarily transshipment traffic, with a total berth length of 1,600 – 1,800 m, depending on the mix of vessel sizes to be accommodated. For the purposes of this study, a total berth length of 1,600 m has been selected to respond to the mix of mainline and feeder vessels expected to use the Port.

2.4.4 Terminal Area

Based on the above volume and distribution of container traffic for the proposed terminal, the Moffatt & Nichol proprietary terminal sizing model was used to assess the area requirements for the project.

Four different model runs were made to test the requirements for the following operating systems:

Run A ..... Rubber Tired Gantries (RTGs), six across x four high

Run B .....RTGs 6 x 4 with Top Pick (TP) access

Run C ..... RTGs 6 x 5

Run D ..... RTGs 6 x 5 with TP access

Slot requirements and storage capacities required to meet the projected throughput of 2.4 million TEUs under the four scenarios are indicated in Table 2-3 and Table 2-4 below.

Table 2-3: Terminal Storage Capacity Needs

Run	A	B	C	D
Net Yard Area (ha)	**85.3**	**111.2**	**72.5**	**94.1**
Storage Needs				
40 ft Wheeled (slots)	513	513	513	513
20 ft Wheeled (slots)	205	205	205	205
RTG (TEU)	73,032	73,032	73,032	73,032
Top Pick (TEU)	0	0	0	0
Side Pick (TEU)	0	0	0	0
Straddle Carrier (TEU)	0	0	0	0
Total Capacity (TEU)	**74,298**	**74,298**	**74,298**	**74,298**
Total Capacity (Containers)	**41,461**	**41,461**	**41,461**	**41,461**

Table 2-4: Estimated Container Yard Area Requirements

Required Areas (ha)	Minimum Density Wheeled Mode	Maximum Practical Storage Density	Maximum Density Grounded Mode
Net Container Yard:	293.10	87.33	86.22
Gate:	0.85	0.85	0.85
Buildings & Parking:	13.25	13.25	13.25
Rail yard:	9.70	9.70	9.70
Gross Terminal Area	**317**	**111**	**110**
Percent Net C.Y.	**90**	**72**	**72**
TEUs / Ha / Year	**7,348**	**19,857**	**20,041**

Note: Required yard area excludes berth, hatch set down area, gate approaches and access or perimeter roads

The depth of the container yard for a modern medium density terminal should approximate the berth length in order to optimize the distance moved by yard equipment. This is particularly critical for a transshipment terminal where the containers will be moving back out over the berths, rather than taken through a gate to inland destinations.

Based on the maximum practical storage density and area requirements indicated in Table 2-4, and the total berth length of 1,600 m indicated above, the required depth of the main container yard area is 545 m. Adding the berth width, hatch set down areas, space for rail access and gate plus a perimeter road outside the fenced terminal area then indicates that the island should have a width of at least 700 m.

Reefer Requirements

Much of the container traffic from South and Central America moves in refrigerated containers (reefers). These units can be stacked in bays, but all need special electrical outlets with a substantial power demand. Based on discussions with carriers and terminal operators, it is estimated that the fully developed terminal at Farfan/Palo Seco should offer at least 600 reefer positions within the main yard area. Ideally, two plugs should be provided for each bay, in order to connect to either end of a stacked container.

2.4.5 Intermodal Connections

Intermodal Access

One of the attractions of transshipment operations on the Pacific coast of Panama is the potential interaction between the terminals on the Atlantic coast. The recent upgrade of the Panama Canal Railroad and establishment of an Intermodal facility at Balboa offers the potential to move containers across the Isthmus on double stack trains. Other options for container interchange include truck haul, or barge service through the Canal.

Estimates of potential volume to support the rail or other intermodal link are not available at this early planning stage, but the existing terminal operators in Panama considered that some 10% of the annual throughput of the terminal could be interchanged between the two coasts. This would then imply the movement of 240,000 TEUs per year, equivalent to some 365 TEUs per day in each direction.

2.4.6 Support Facilities

Support facilities for the container operations will be required both on the island and on land. However, it is assumed that any indirect facilities, such as container stuffing or unstuffing, value added processing or logistics support would be located within the Howard development zone.

Table 2-5 shows the classes of support facility required for the terminal, with an indication of the preferred location for the specific installation. Intermodal yards are not included in the listing, since they are dealt with separately in this report.

Table 2-5: Support Requirements for Proposed Terminal

Facility	Preferred Location		Comments
	On Terminal	Off Dock	
Gatehouse & Security	◙		
Admin, Customs etc		◙	
Truck Holding/Pre Clearance		◙	
Terminal Operations	◙		
Maintenance Building	◙		
Rest rooms	◙		
Medical Facility		◙	Assumes immediate access to terminal
Emergency Services	◙		
Elect Sub Station	◙		
Water Tower		◙	
Waste Water Treatment Plant		◙	

2.4.7 Summary of Requirements

Consequently, the primary design criteria for the terminal are considered to be:

- Maximum Vessel Size [4] ..... 10,500 TEU
- Cranes required to meet projected throughput.....18
- Berth Length.....385 to 425 m
- Maximum loaded vessel draft.....15.0 m
- Recommended Dredged Depth for Initial Development.....16.5 m
- Net Container Yard area for 2.4 million TEUs per year.....87 ha
- Gross Terminal area .....111 ha
- Number of Berths Required.....4
- Minimum berth length for 2.4 million TEUs per year .....1,600 m
- Length of island/reclaimed area .....1,700 m
- Width of Island, including berths .....750 m

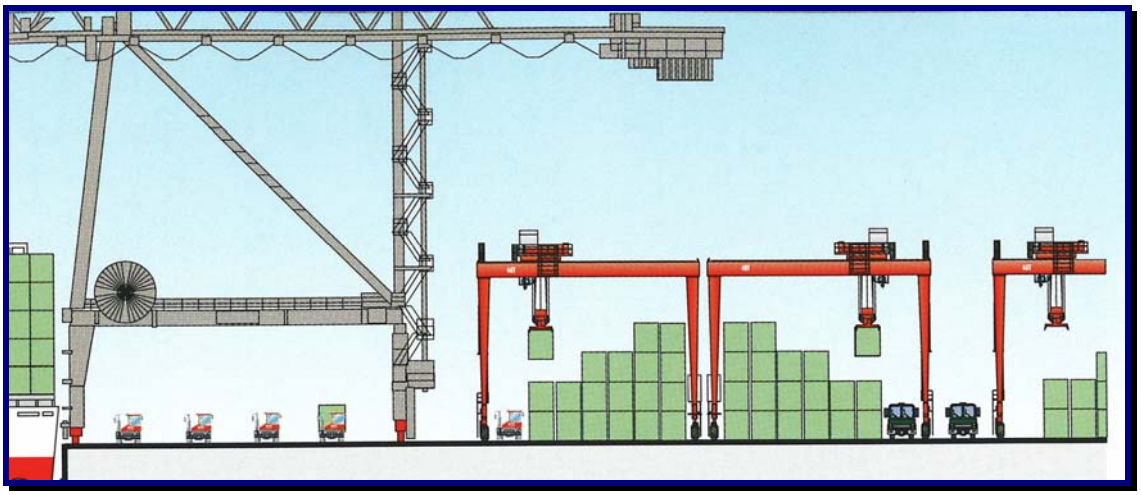
[4] Maximum vessel size should be used as a basis for navigation channel and marine structures design criteria.

2.5 Container Terminal Footprint

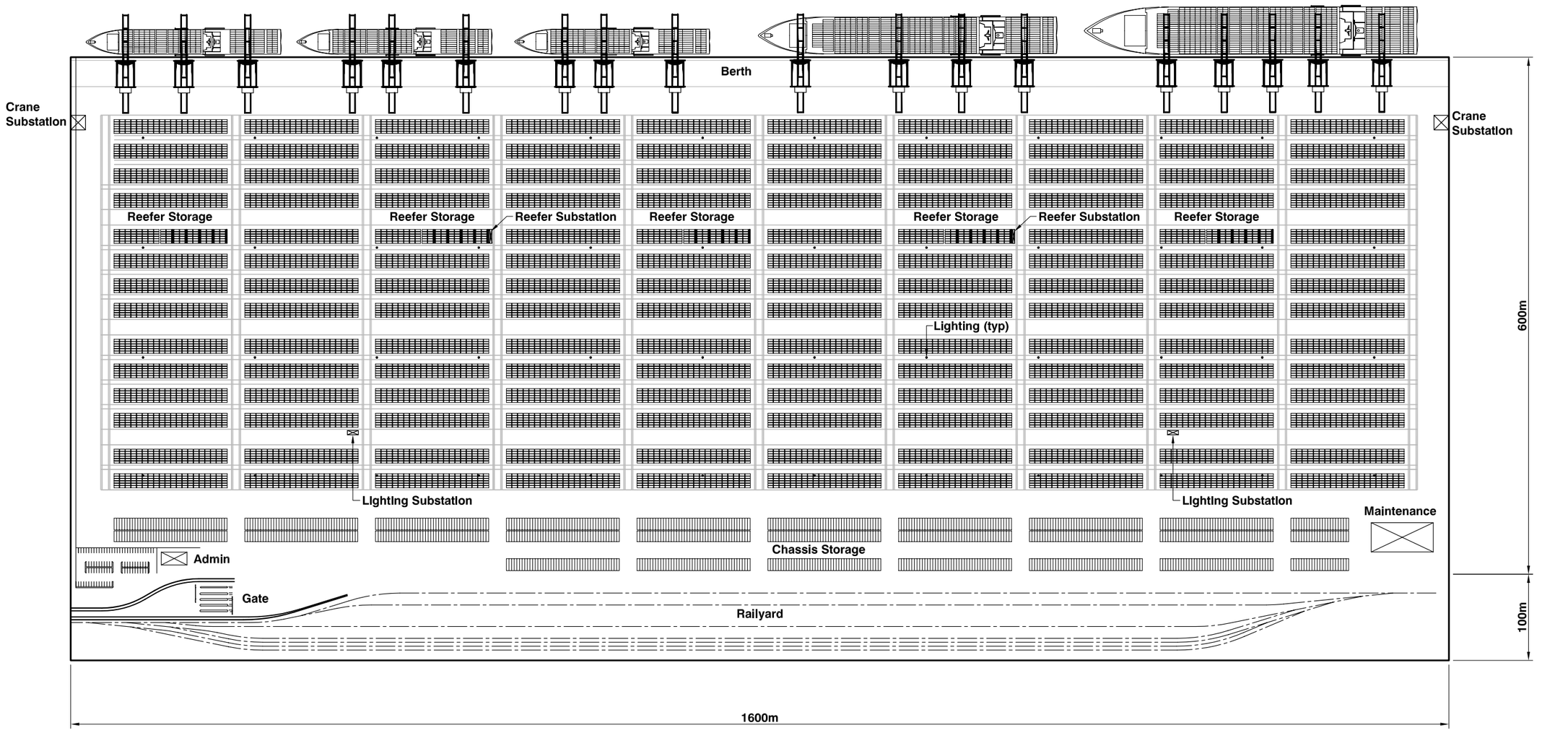
The final terminal configuration will depend to a large extent on the operational system implemented by the company selected to manage or operate the Port. For the purposes of this study, a medium to high density terminal is proposed, which should meet the general requirements of all potential users.

Based on the previous discussions, and taking into account recent trends in container terminal development for transshipment or high volume operations, it is assumed that the yard operating system will be based on the use of Rubber Tired Gantries (RTGs) or possibly Rail mounted Gantries (RMGs). Figure 2-1 shows a typical section of an RTG yard system. Figure 2-2 shows the basic container yard planning module developed for a four berth terminal meeting the planning criteria presented above.

Figure 2-1: Typical Cross Section of RTG Yard Arrangement



Graphic Courtesy of Kalmar Industries Oy Ab.



50m 0m 50m 100m

SCALE: 1 : 5000

Designed by: BTB
Dwn by: DJMac
Ckd by: MGH
Reviewed by: MGH
Submitted by: MGH
Date: April 2005
Design file no. AS SHOWN
Rev.
Drawing Scale: AS SHOWN
Plot scale: 1=1 (11"x17")

MOFFATT & NICHOL

GOLDER ASSOCIATES

ACP AUTORIDAD DEL CANAL DE PANAMA

FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Basic Planning Module for Proposed Container Port

Fig 2-2

558200_Fig02-02.dwg 28 Jun 2005 - 12:28am; jmacpherson; © Moffatt & Nichol

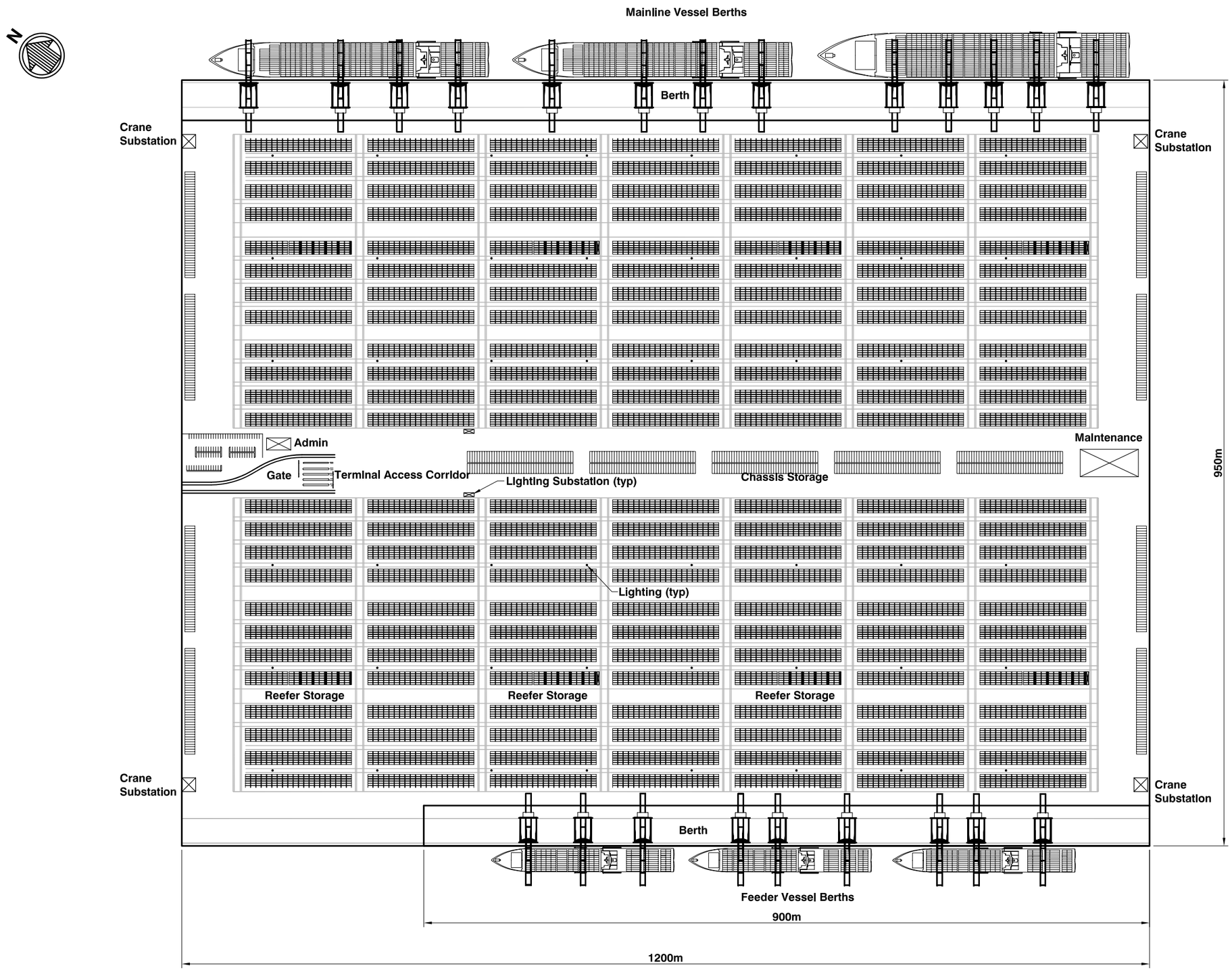
2.5.1 Alternative Terminal Concept

Several of the major port operating company representatives expressed an interest in a terminal concept that would permit berthing of mainline vessels on one face and feeders on the opposite side. The rationale behind this suggestion would be to reduce container move distances within the yard area. In order to optimize operations and eliminated duplicated berth construction costs, the terminal configuration would necessarily differ from the version shown in Figure 2-2.

Specific differences would probably include:

- Reduced berth length on main face of terminal for mainline vessels
- Wider fill area to provide the required terminal yard area
- Access corridor would be in the center of the yard area
- Any intermodal yard would be on the land, since it would interfere with cross terminal container moves
- Dredging is required on the west and south faces of the terminal

Figure 2-3 shows a possible concept under this configuration.



50m 0m 50m 100m

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Designed by: BTB		Date: April 2005	Rev.
Dwn by: DJMac	Ckd by: MGH	Design file no. AS SHOWN	
Reviewed by: MGH			
Submitted by: MGH		Drawing Scale: AS SHOWN Plot scale: 1=1 (11"x17")	

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GOLDER ASSOCIATES

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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Alternative Planning Module for the Container Port

Fig 2-3

558200_Fig02-03.dwg 28 Jun 2005 - 12:29am; jmacpherson; © Moffatt & Nichol

3 EXISTING SITE CONDITIONS

3.1 Bathymetry

Marine field investigations were carried out in 2003 as part of the Island and Materials Disposal studies covering the area south of the former Howard AFB to the Pacific entrance to the Canal, and south to Taboga Island. The survey was undertaken as part of a geophysical survey with the instrumentation cross linked to side scan sonar and seismic reflector equipment. More recently, ACP has undertaken additional bathymetric survey in the Pacific entrance area as part of ongoing work to widen and deepen the main navigation channel to Miraflores Locks.

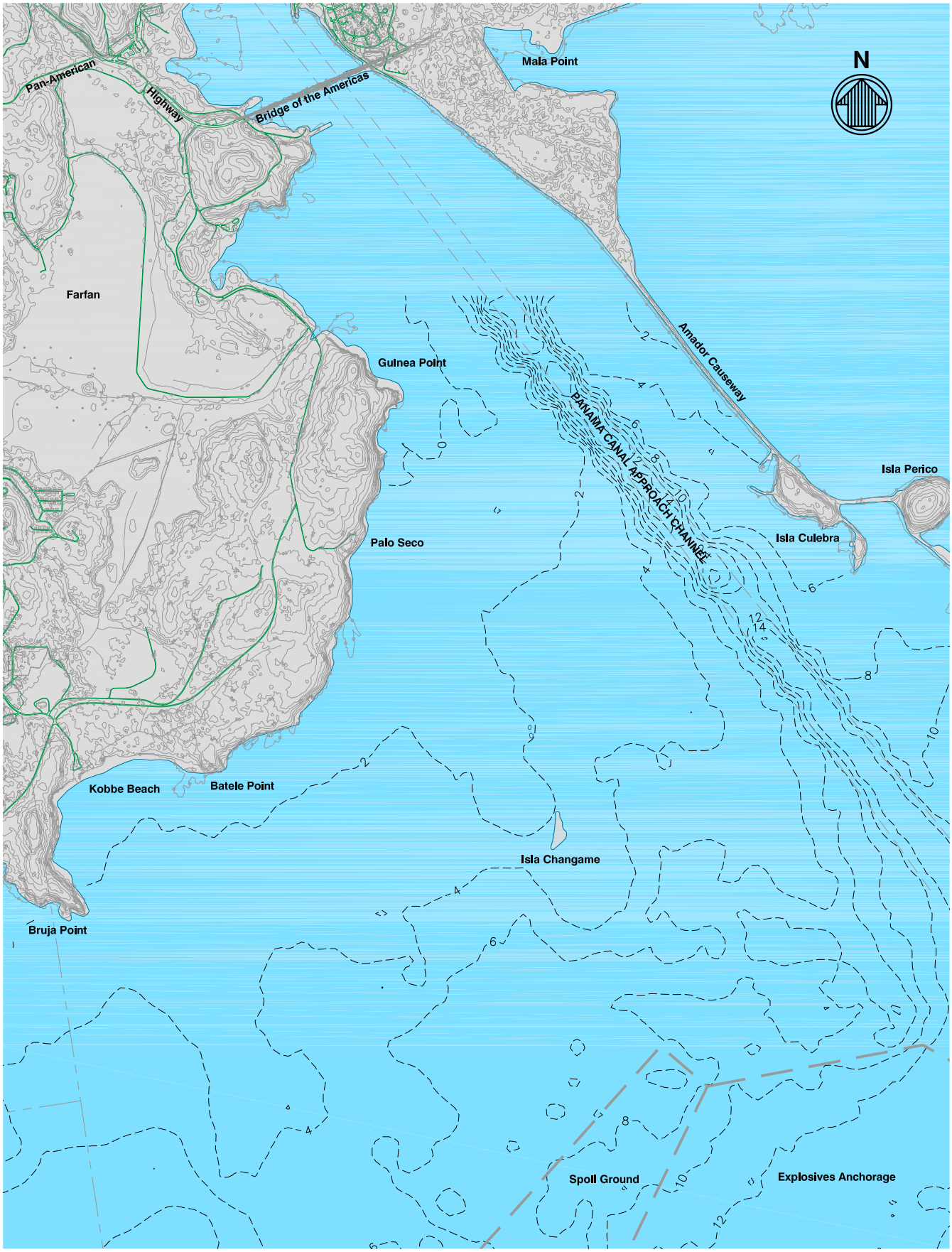
Figure 3-1 shows the bottom contours of the inshore study area, according to the bathymetry generated during the geophysical survey work carried out in 2003 and the recent work in the Pacific entrance. It is seen that the water is very shallow in front of the project site with depths ranging from -2.00 m to -8.00 m below MLWS. There are also numerous outcrops of rock in the project area.

3.2 Onshore Topography

At this time, there is no detailed topography of the shore side area of the project and all mapping used for this study is taken from ACP files or obtained from the Instituto Geografica de Panama (IGAC-Tommy Guardia), supplemented by aerial photographs from the same sources. The shoreline of the Palo Seco/Farfan area is characterized by a rocky shorefront rising to some 100 m above Mean Sea Level (MSL), and extending 600 – 750 m inshore. The presence of numerous rock outcrops of similar material to that encountered along the shoreline indicates that the hills are also mainly composed of Andesites or Basaltic materials.

The main road from the Bridge of the Americas to Howard and Veracruz is located approximately 700 m inshore at an elevation of 20 m above MSL in the vicinity of the project site.

Figure 3-2 shows the general contours of the study area overlain onto aerial photography taken by ACP in 2001.



Note: Contours shown referenced to MLWS.

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Figure 3-1
Bathymetry in Project Area

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558200_Fig03-01.dwg 28 Jun 2005 - 12:30am; jmacpherson; © Moffatt & Nichol

Fig 3-2

FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

General Topography and Ground Cover in Study Area to Port Site

ACP
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Designed by: DJMac		Date: April 2005	Rev.
Dwn by: DJMac	Ckd by: MGH	Design file no. AS SHOWN	
Reviewed by: MGH			
Submitted by: MGH		Drawing Scale: AS SHOWN	
		Plot scale: 1=1 (11"x17")	

3.3 Existing Land Use

3.3.1 Marine

As seen from Figure 3-1, the inshore area in front of the Palo Seco Hospital is too shallow for navigation by all but the smallest craft. The presence of numerous rock outcrops and the high tidal range make navigation hazardous and very few small craft transit the area inshore of Changame Island.

The rocky bottom, presence of outcrops and shallow water in the area make the area unattractive for commercial or recreational fishing with the result that this area is normally avoided by fishermen.

3.3.2 Jurisdictional Responsibilities

The proposed area under consideration for the new Port falls within the jurisdictional limits of the Autoridad del Canal de Panama (ACP) and no development can take place without prior ACP approval.

As shown in Figure 3-3, much of the area under consideration for the location of the Port falls within the designation of "Inalienable Patrimony" of ACP, while the shorefront close to Palo Seco is within the classification of "Economic Patrimony". As can be seen in the figure, the sub tidal zone in front of Palo Seco has also been used as dredge disposal site for the Panama Canal, while the areas south of Isla Changame are designated anchorages for vessels carrying explosives or hazardous cargoes.

3.3.3 Landside

The landside area inshore of the project site includes areas under the control of ACP, property under the jurisdiction of the Autoridad de la Región Interoceaníca (ARI)[5] and also the former Howard Air Force Base, which is now being developed under the management of the recently established Agencia del Area Económica Especial Panamá-Pacífico (AAEEPP). There have been a number of concessions authorized in the area,

[5] ARI was formed after the handover of former Canal Zone and US military bases in December 1999 to administer the transferred properties. It is scheduled to be disbanded in December 2005. Some functions will be taken over by the Ministry of Economy & Finance (MEF) and the development of the former Howard AFB will be taken over by the AAEEPP.

with the most important being the assignment of approximately 100 ha in the Kobbe Beach area to the Paradise Beach Corporation. Construction is in progress at this site, with the final development to include a resort hotel, beach front enhancements, golf course and links to the ecological reserve at Punta Bruja, located west of Kobbe Beach.

As noted earlier, the main access road from the Pan-American highway to the shoreline communities and Veracruz township is located some 700 m inshore of the coastline, and connects to the Bridge of the Americas. There are also highway connections into the Howard area, but these are not open to the public at this time. Given the expectation that the entire Howard area will eventually become a Free Zone it is likely that access restriction will remain in place in the near future.

West of Howard, the beaches of Veracruz are a popular recreation destination for people from Panama City with heavy bus and passenger car traffic at weekends and holiday periods. The only access to these beaches is via the road from the Pan-American Highway. There is also a link from the Howard base area directly to the coastal highway, but this is not normally open to the public.

As seen in Figure 3-2, the area north and east of the project site contains mainly low lying areas that have been used for dredged materials disposal from Panama Canal operations and wetlands in the drainage area of the Farfan River.

Figure 3-4 shows the existing land use and potential concession areas within the current ARI proposals for the area. It is seen from the figure that the main areas of concern for the Port project are plans to grant concessions for residential and commercial development along the hilly areas immediately inshore of the project site and the ongoing development of the Paradise Beach Corporation at Kobbe Beach.

It is also critical that the coastal highway is not impacted adversely by the Port project, as it is the only link to Veracruz, Kobbe Beach and the popular beaches west of the former Howard AFB.

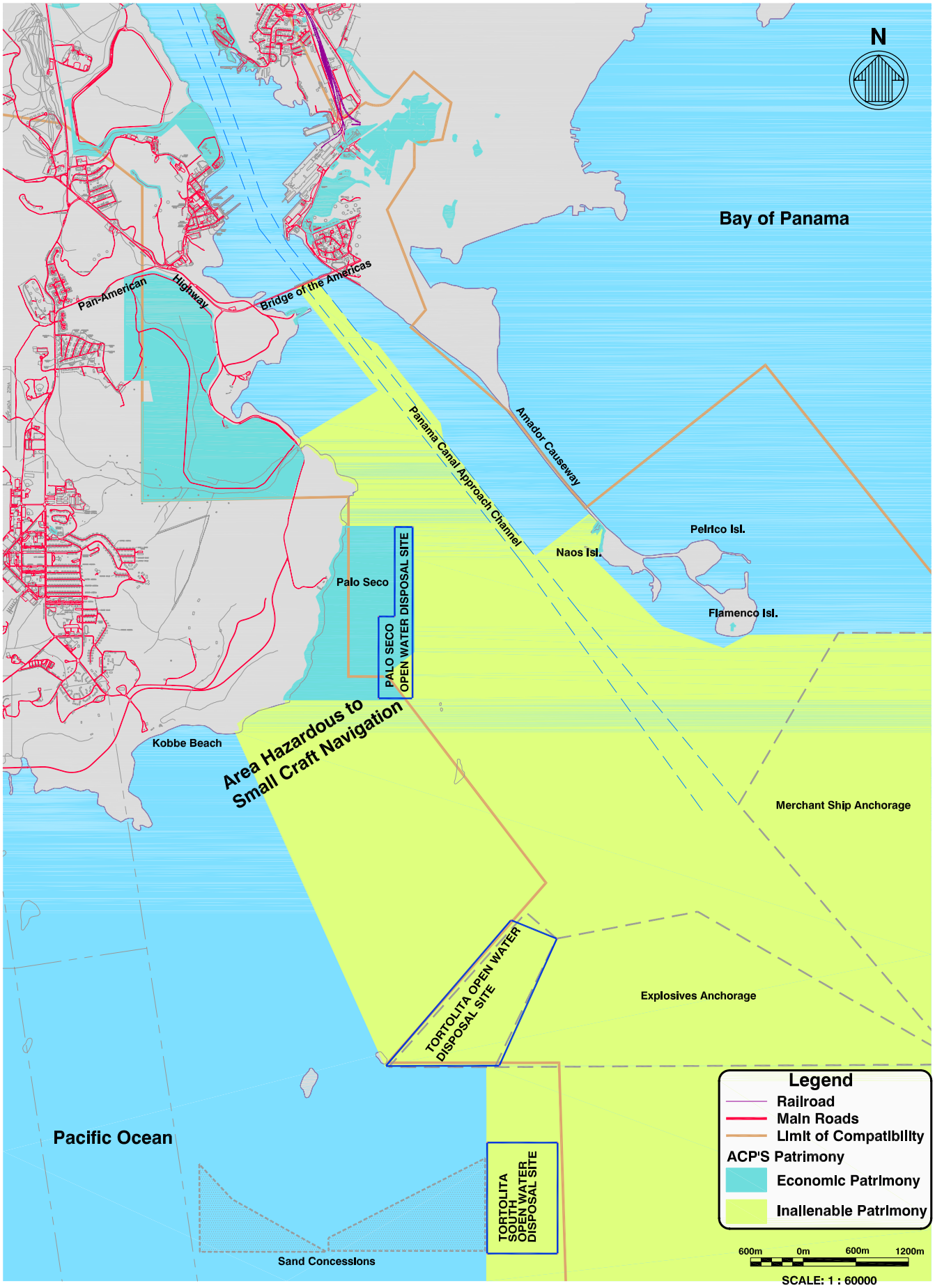

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Figure 3-3
Panama Canal Authority Economic/Inalienable Patrimony areas south of Bridge of the Americas.

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558200_Fig03-03.dwg 28 Jun 2005 - 12:34am; jmacpherson; © Moffatt & Nichol

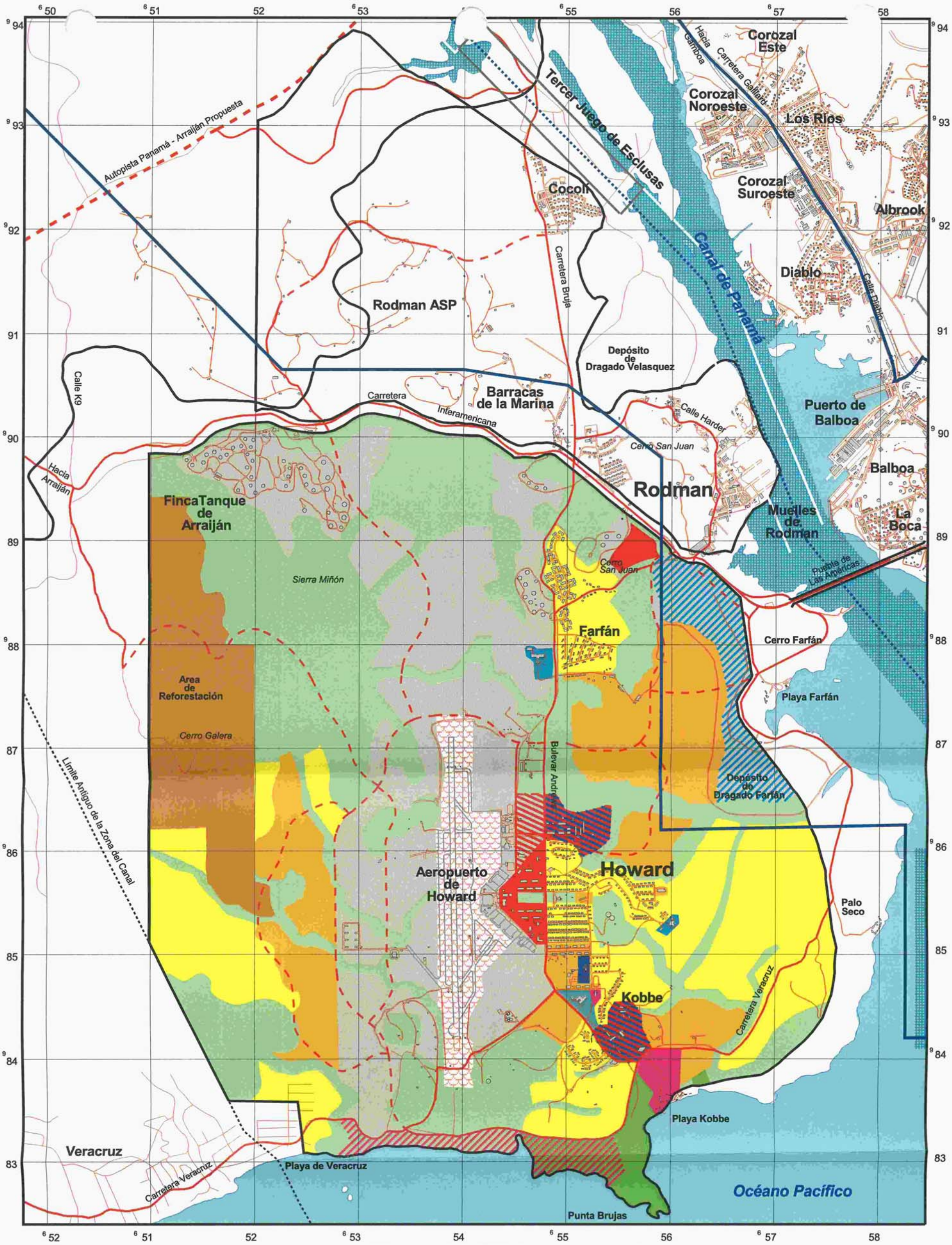

Figure 3-4
Land Use Mapping
Former Howard AFB

3.4 Access

3.4.1 Highway Access

As shown in Figure 3-5, the existing access to the project site is via the Coastal road that connects the Bridge of the Americas to the beach areas and Veracruz township. The road is a two lane highway, with unpaved shoulders over most of its length.

Figure 3-6 shows the connection to the Pan-American Highway which has limited sight lines and steep grades. In order to accommodate regular transit of commercial and construction vehicles it is essential that the safety of the connection is improved, requiring that this intersection be reconfigured.

Traffic moving west from the Bridge of the Americas exits the Pan-American highway and passes under the bridge. While some upgrade of the access ramp and filter lanes would be desirable, there are no significant issues connected with the continue use of this connection.

As seen in Figure 3-7, much of the road has a concrete slab base and topping with asphalt. The condition of the existing pavement is fair, but the road would not be suitable for regular transit of trucks with containers.

The connection from the main highway down to the shorefront is a narrow two lane asphalt paved road that is unsuitable for heavy traffic, due to its grade, width and pavement thickness.

The approximate elevation of the road at the intersection to the existing connection to the Palo Seco Hospital is 20 m above MSL and the road is some 700 m from the shoreline. It therefore follows that substantial cuts will be required to attain satisfactory gradients for the Port connection

Note: Aerial image courtesy of ACP

250m 0m 250m 500m

SCALE: 1 : 25000

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Figure 3-5
Existing Highway Access to Port Site

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558200_Fig03-05.dwg 28 Jun 2005 - 12:36am; jmacpherson; © Moffatt & Nichol

Figure 3-6: Existing highway connection at the Bridge of the Americas

Figure 3-7: Coastal Highway Pavement at Proposed Port site.

3.5 Geophysical and Geotechnical Conditions

3.5.1 Geophysical Mapping

Due to time and budget constraints, it was not possible to calibrate the geophysical data from the 2003 study by borehole investigations, but the use of jet probes provided good consistency with the survey readings. In general the comparison of the two sets of data showed the rock threshold to be within 1.00 m of the surveyed elevation, which is well within the normal tolerance anticipated for this class of preliminary sub bottom survey.

In 2003, the Japanese External Trade Organization (JETRO) commissioned three boreholes close to the site of the proposed artificial island project. In 2004 bidders for a deepening project in the Pacific entrance to the Canal undertook a series of boreholes along the line of the main[6] channel from Buoy #1 to the Miraflores Locks.

As can be seen from Figure 3-9, none of the two recent geotechnical field studies are within the area of the proposed container terminal site. However, they do show a general consistency with the geophysical survey results, which improves the confidence level in the results of the 2003 survey.

While this data is adequate for this feasibility level of analysis, detailed site investigations will be critical to the final engineering elements of the berth designs, navigation channel dredging, site filling for the project.

Figure 3-9 shows the elevation of rock that was encountered during the geophysical survey taken in 2003. According to the data, the rock is very shallow directly due south of the Palo Seco Hospital, but drops to 12 to 20 m below Mean Low Water Springs (MLWS) at a distance of approximately 1,200 m from the west bank of the Canal.

Figure 3-10 shows the depth of soft sediments over the project area, which vary from minimal due south of the Palo Seco shorefront and up to 18 m in the areas where rock is encountered at greater depths.

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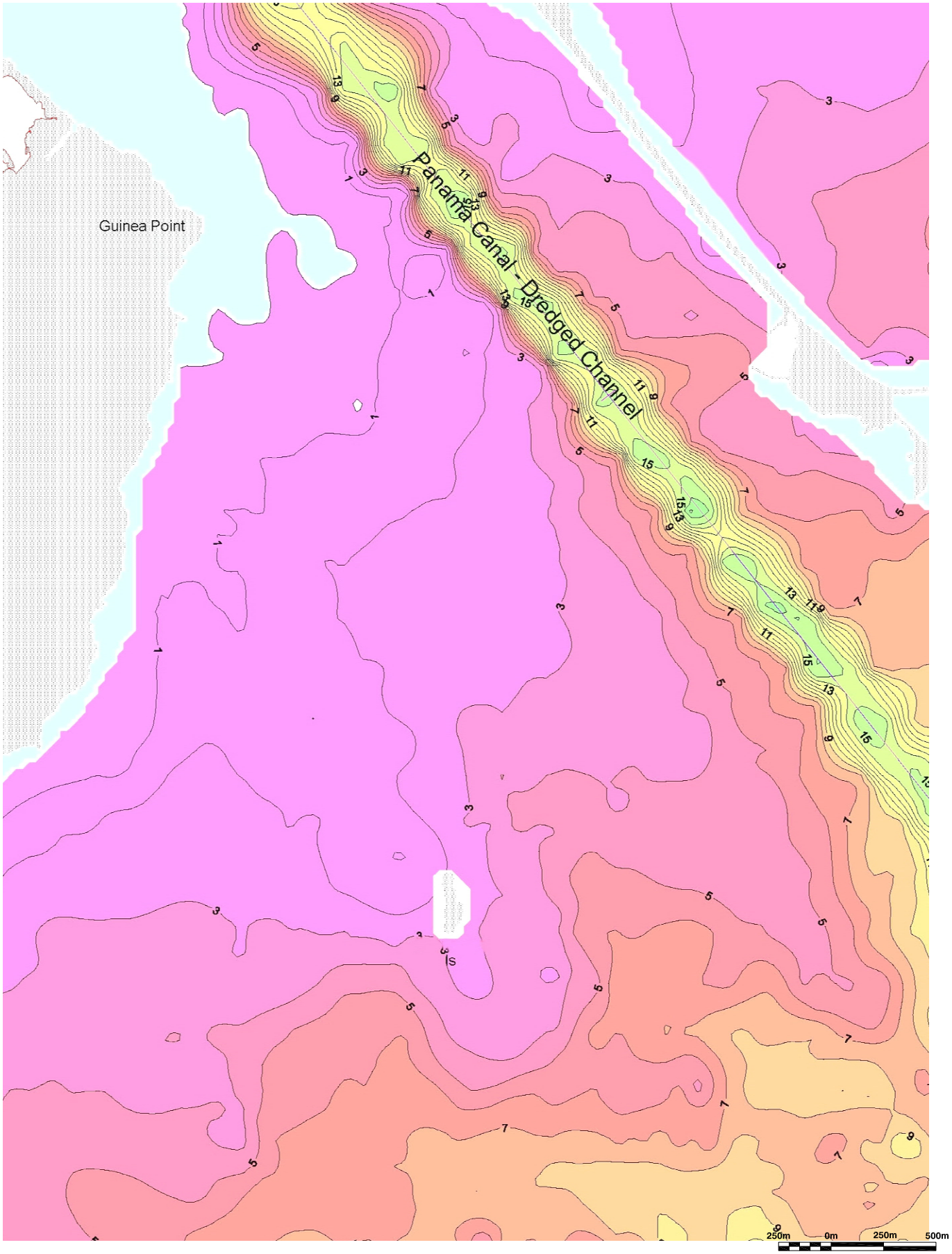
[6] The contractor was instructed by ACP to drill all exploratory boreholes outside the limits of the main channel to prevent interference with Canal operations.



Note: Contour elevations referenced to MLWS courtesy of Golder Associates.

SCALE: 1 : 25000

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Figure 3-8
Bathymetry of Study Area from 2003 Geophysical Survey

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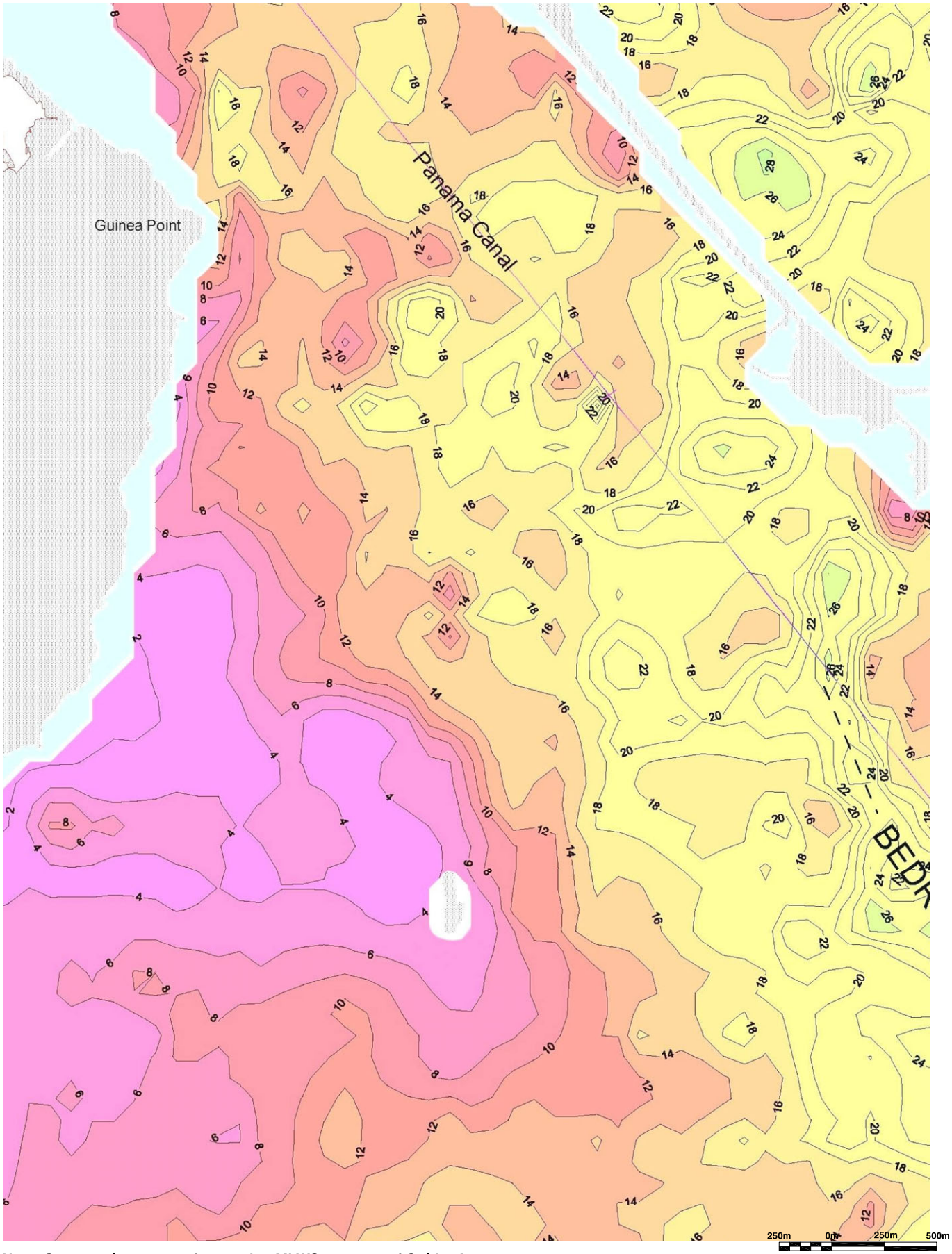
558200_Fig03-08.dwg 28 Jun 2005 - 12:37am; jmacpherson; © Moffatt & Nichol



Note: Contour elevations referenced to MLWS courtesy of Golder Associates.

SCALE: 1 : 25000

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Figure 3-9
Elevation of Competent Rock at Project Site

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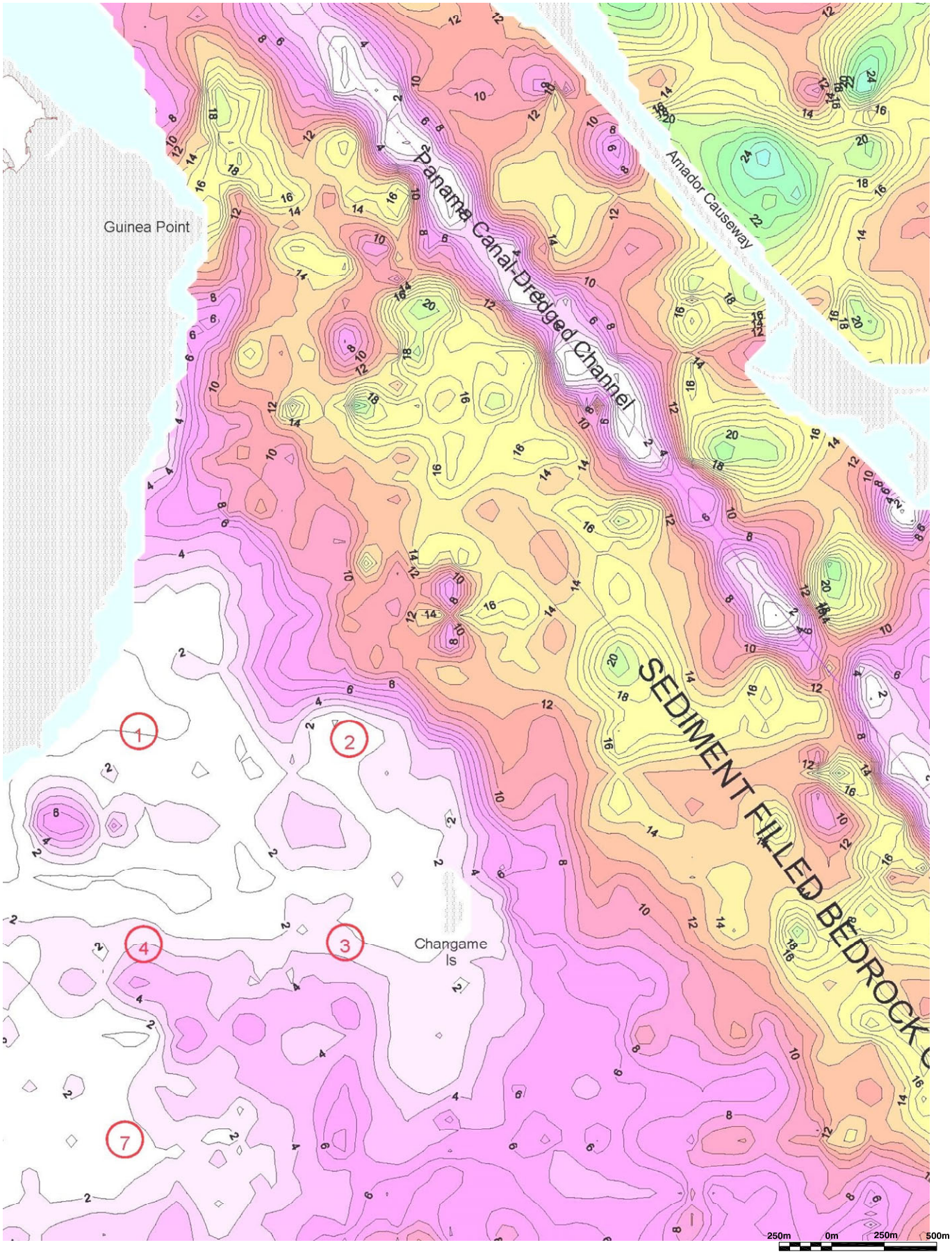
558200_Fig03-09.dwg 28 Jun 2005 - 12:40am; jmacpherson; © Moffatt & Nichol



Note: Contour elevations referenced to MLWS courtesy of Golder Associates.

SCALE: 1 : 25000

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Figure 3-10
Depth of Soft Sediments at Project Site

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558200_Fig03-10.dwg 28 Jun 2005 - 12:41am; jmacpherson; © Moffatt & Nichol

3.5.2 Geotechnical Conditions

Soft Sediments

As seen in Figure 3-10, the depth of soft sediments at the project site varies from 2.00 to 16.00 m. The site is characterized by shallow sediment depths to the south west of the study area and a drop from -4.00 m below MLWS to approximately -14.00 m running approximately on a parallel at 1,500 m west of the Canal centerline.

Unfortunately there is minimal information on the consistency and resistance of the soft sediments, except for information from the recent boreholes and experience gained during the construction of the Vacamonte fishing port in the mid 1970s.

This lack of information is critical to the final cost estimate for the project as the designer must have good information on the strength of the soft material to support the imported fill materials. Container terminals are extremely sensitive to settlement, due to the very flat grades needed for efficient operation of the storage areas. Pavement slopes of 1.5% are common and modest differential settlement can present severe problems for drainage and cause damage to containers.

Qualitative interpretation of the geophysical data indicates that the sediments in the project area are expected to be fine-to medium-grained (clay to sand) deposits. Available boring logs support the grain-size interpretation, with clay, sandy clay, and clayey sand encountered in boreholes both to the north and south of the area of interest.

Bedrock

Bedrock is shallow (2m-MLWS) beneath the thin sediment deposits east of Batele Point and increases in depth (14m-MLWS) to the northeast. The top of rock dips into a sediment-filled trench parallel to the Panama Canal Approach Channel and it is suggested this feature may be a structurally-controlled graben[7]

The types of bedrock expected in the area of the proposed terminal are mudstone, basalt, andesite, and agglomerate. The extent of the zone of weathered bedrock varies depending upon the parent rock material. Borings logged to the south of the proposed artificial island indicate 1 to 2 meters of weathered rock above andesite, a dark-colored, fine-grained igneous rock that MacDonald (1915) characterized as suitable for

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[7] Marine Geophysical Investigation to Characterize the Seabed for the Proposed Artificial Island Project, April 15, 2003.

breakwater and seawall construction due to the hard properties of the well-developed crystalline structure. A boring logged in Panama Formation agglomerate, also to the south of the proposed artificial island, does not indicate a weathered rock zone, although it is suspected the weathered layer is incorporated into the 7 meters of sediment shown above the agglomerate in the borehole. The boring record indicates a material change from clayey sand (5 m thick) to sandy fat clay (2 m thick); possibly indicating a portion of the profile is a weathered bedrock zone.

Other borehole records located in the vicinity of the proposed Port are within the dredged Panama Canal Approach Channel, to the northeast of the study area. The rocks encountered in these boreholes were basalt and mudstone. Observations of outcrops on land and core in fresh basalt near the terminal site indicate it is likely to be highly fractured. An approximation of the extent of weathered bedrock or sediment thickness is not possible from borehole records in this area due to the disturbance and removal of material for the construction and maintenance of the approach channel.

3.6 Climatology

3.6.1 Climatology

The climate in the area of the Project is classified as tropical humid with a rainy season from May to December and a dry season from January to April. Monthly climatology information on temperature, precipitation, relative humidity and wind velocities and direction has been obtained from ACP for the Balboa station for the period of 1985 to 2003 and is presented in Appendix B to this report.

3.6.2 Temperature

Daily temperatures vary little throughout the year. During the evening hours, however, the temperatures vary as much as 6 to 10 ºC. In the dry season, which is marked by strong north-easterly winds, known as the 'trade winds', day-time air temperatures increase slightly to around 30-31ºC or 86-88ºF, but night-time temperatures remain around 22-23ºC. Relative humidity average values are approximately 70 percent. The wet season commences around early May which is also one of the wettest months. The arrival of the rains cools down the region a little during the day as the trade winds disappear. Relative humidity increases quickly and may hover around 90-100% throughout the season.

3.6.3 Precipitation

Precipitation is typical of a humid tropical climate with an annual average of 2,032 millimeters (mm) or 80 inches. Records for Balboa, the nearest meteorological station, indicate that mid-December through April are the driest months with average monthly recorded precipitation of less than 81mm (3 inches) (January through April). Average monthly precipitation during this period varies from 20mm (0.8 inches) to 81mm (3.2 inches) with minimum and maximum monthly average precipitation ranging from 0 to 325mm (0 to 12.8 inches). During the Wet Season (May through mid-December) the average monthly precipitation ranges from 129 to 284mm (5.1 to 11.2 inches) with an minimum monthly average precipitation ranging from 5 to 152 mm (0.2 to 6.0 inches) and maximum monthly average precipitation ranging from 251 to 566mm (9.9 to 22.3 inches).

3.6.4 Winds

Average wind speed and direction for the study area are available at Balboa FAA station from the period 1985-2002. Table 3-1 presents the monthly average speed and wind directions at that station.

Table 3-1: Average Wind speed & direction at Balboa FAA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Wind Speed (m/s)	2.17	2.42	2.45	2.26	1.80	1.56	1.73	1.66	1.56	1.55	1.64	1.75
Avg. Wind Direction	333.4	338.6	341.9	336.4	299.2	296.6	308.3	308.8	263.9	255.4	296.0	325.0

During the rainy season the dominant wind direction in Panama is from the West – Southwest with speeds averaging 1.65 m/sec or 3.3 knots. From December to April the predominant winds are from the North-Northwest, when the northeasterly (trade) winds average 2.40 m/sec or approximately 5.0 knots. Surface wind data taken from Howard AFB records from 1973-1995 are shown in Table 3-2.

Table 3-2: Wind speed & Direction Records - Howard Air Force Base (1973-95)

Criteria	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pvlg. Wind Direction	16 pts	N	N	N	N	NNW	NNW	NNW	NNW	NNW	S	NNW	NNW
Mean Speed (Pvlg Dir)	kts	8	8	9	7	6	5	6	6	5	7	5	6
Mean Speed (All Obs)	kts	7	8	7	6	4	3	4	4	3	3	4	5
Max Peak Gust	kts	31	32	34	31	56	35	45	41	35	36	31	56
Pressure Alt	ft	295	281	300	304	300	286	276	284	292	284	292	339

Source: Howard AFB Panama; Prepared by: AFCCC/DOS, Oct. 1996; Period: Jan 1973 – Dec 1995

As seen from Table 3-2, peak gusts during the period from 1973 to 1995 were generally less than 40 knots, with the exception of readings of 56 knots taken in May and also in December. In both cases, the direction of these extreme winds was from the NNW.

3.7 Tides & Currents

3.7.1 Tides

Tides in Panama Bay are semidiurnal with two high waters and two low waters per day and with an approximate period of 12.25 hours. The average tidal range at the entrance of the Gulf of Panama is 1.5 m during neap tide and 3.4 m during spring tide. At Balboa the average tidal range is approximately 2.7 m during neap tide and on the order of 5.0 m during spring tide. Published tidal ranges for Balboa are shown in Table 3-3.

Table 3-3: Astronomical Tidal Datum Characteristics for Balboa, Panama

Tidal Datum	Height above Chart Datum (m)
Mean High Water Springs (MHWS)	4.9
Mean High Water Neap (MHWN)	3.8
Mean Low Water Neap (MLWN)	1.1
Mean Low Water Springs (MLWS)	-0.1

Source: British Admiralty Charts 1401, 1929, ACP 2004

3.7.2 Currents

Tidal Currents

The normal flood current direction is to the north while the ebb current is approximately south. The magnitude of the tidal currents varies with the tidal range presenting the highest values during spring tide and the lowest during neap tide.

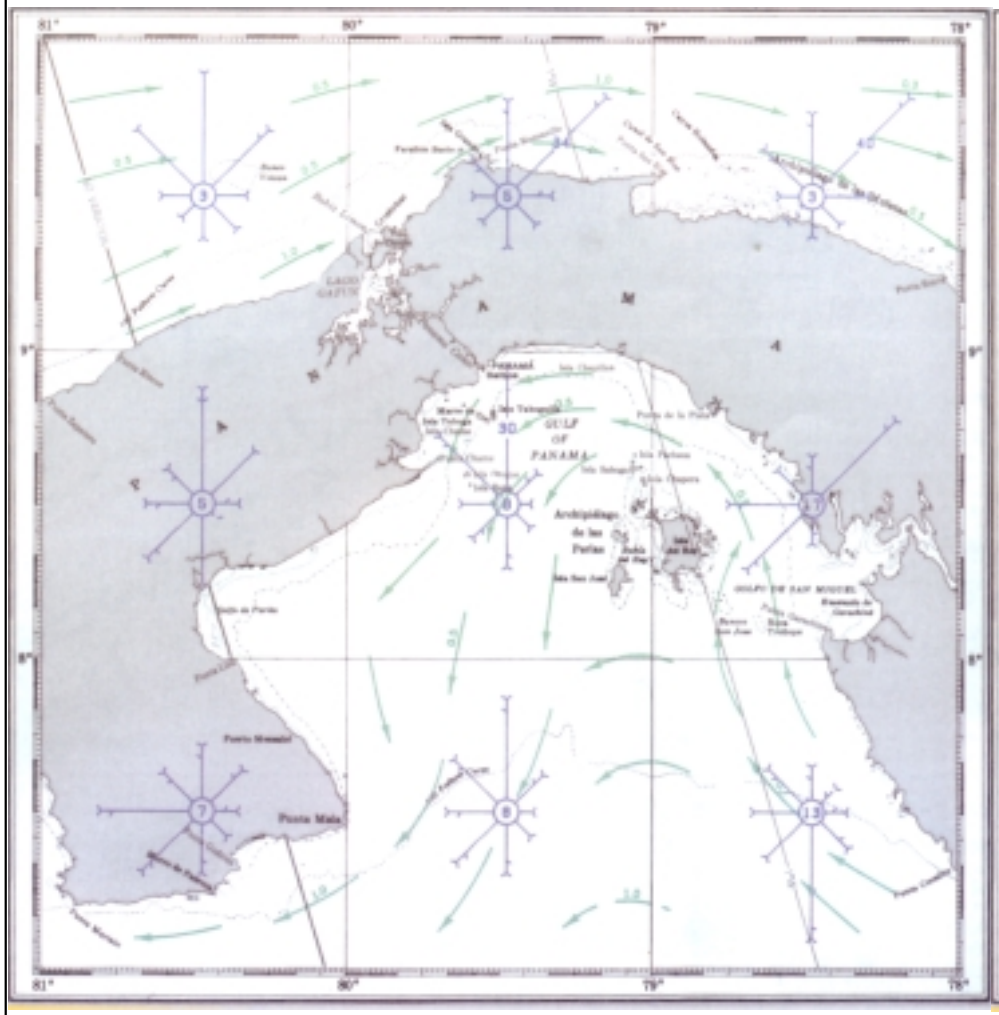
Oceanic Current

Estimates of the net current in the Gulf of Panama have been presented in a number of publications. The Atlas of Pilot Charts presents the net average current for each calendar month. Current readings in the project area were also taken in 2003 as part of the hydrodynamic model work for the Artificial Island Study.

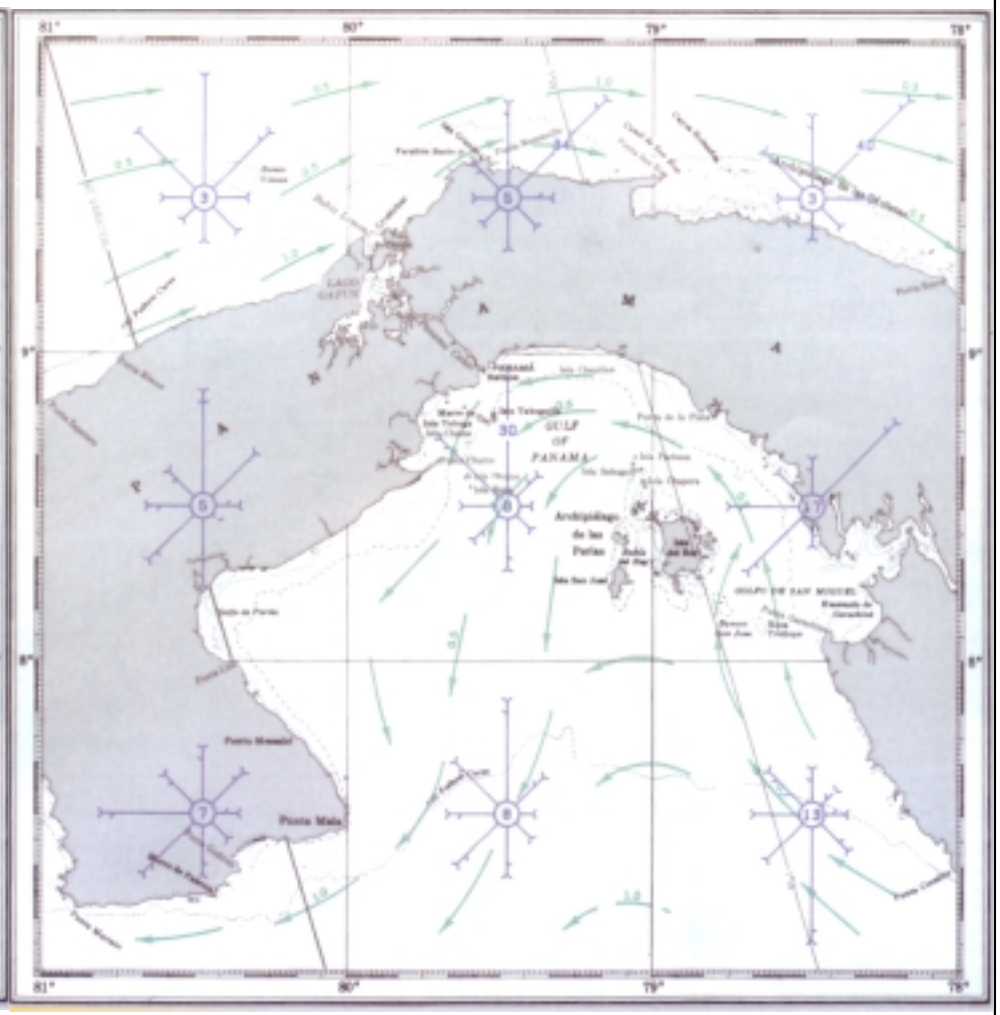
Figure 3-11 presents the currents chart for May and July (first and last month of the calibration period presented in this report). The currents have the highest values during the months of April, May and June being 0.5 knots (0.26 m/s) south of Taboguilla Island, 0.7 knots (0.36 m/s) west of Punta Cocalito and 1 knot (0.51 m/s) west of Punta Mala. The net average flow throughout the year at the northern end of the Bay is in the order of 0.3-0.5 knots (0.15 – 0.26 m/s).

The net current of the Gulf of Panama was also estimated in Bennett, (1965) using data collected by the former United States Navy Hydrographic Office in the western Gulf of Panama from late August to early October 1958. The measurements showed the net current to be about 0.35 knots (0.18 m/s) inshore at a depth of 55 ft (17 m) and 0.7 knots (0.35 m/s) offshore at approximately 100 ft (30 m) of depth.

Panama Bay currents from the Atlas of Pilot Charts



May



July

Prevailing directions of the ocean currents and averaged speed expressed in knots

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ACP

AUTORIDAD DEL CANAL DE PANAMA
ARTIFICIAL ISLAND FEASIBILITY STUDY

FIGURE 3-11:
Net Currents from the Atlas of Pilot Charts

3.8 Wave Climate

3.8.1 Offshore Wave Climate

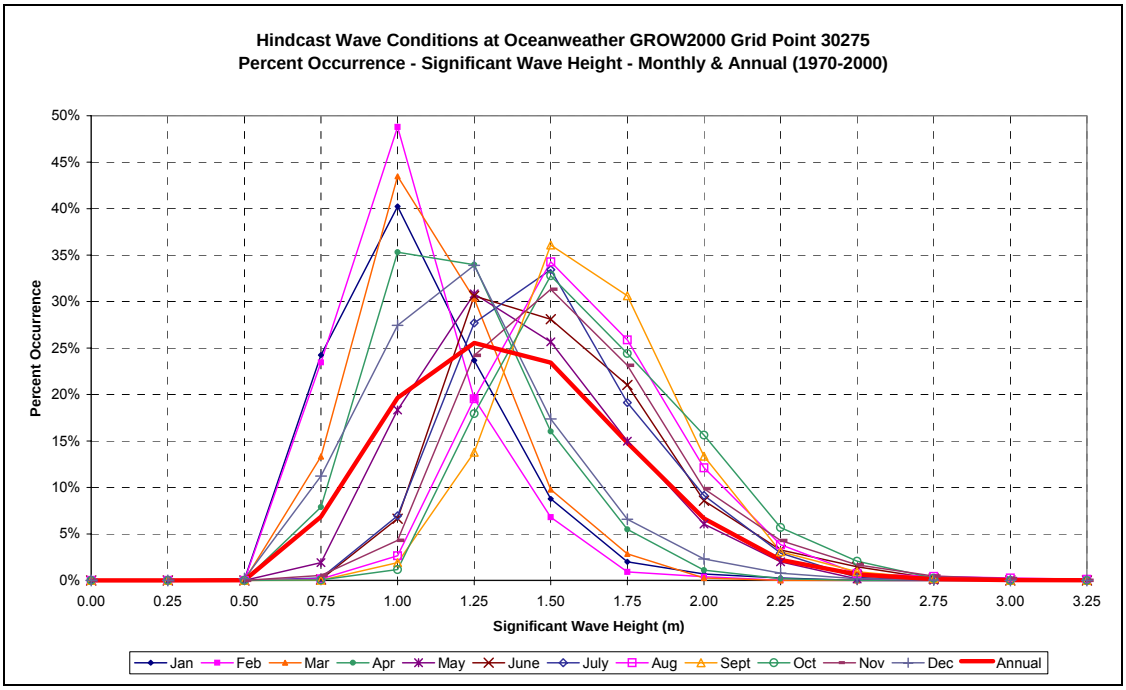
As seen in Figure 6-15, wave energy can only reach the entrance to the Gulf of Panama from a restricted direction due to the geometric shape of the Gulf itself and the surrounding geography. For this project, protection is further increased by the presence of the Amador Causeway and the shadow effect of Taboga and Taboguilla Islands.

Consequently, any waves at the site will primarily be the result of local winds, indicating shorter period waves of limited height and energy.

3.8.2 Significant Wave Height

As seen in Figure 3-12, most significant wave heights are 1.00 -1.25 m for the months of December to April and 1.50 -1.75 meters for the months of July to November.

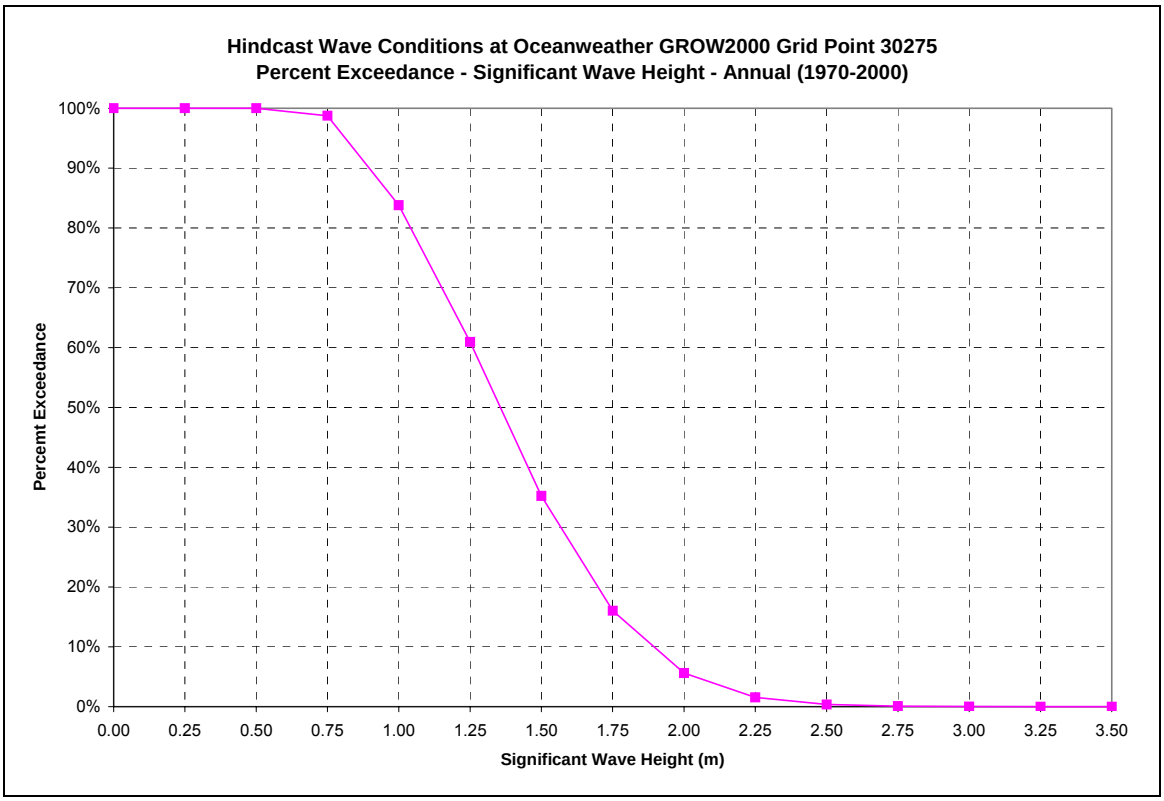
Figure 3-12: Percent Occurrence of Significant Wave Height



3.8.3 Offshore Wave Climate

From Figure 3-13, it is seen that the offshore wave climate is relatively mild, with significant wave heights rarely exceeding 2 meters.

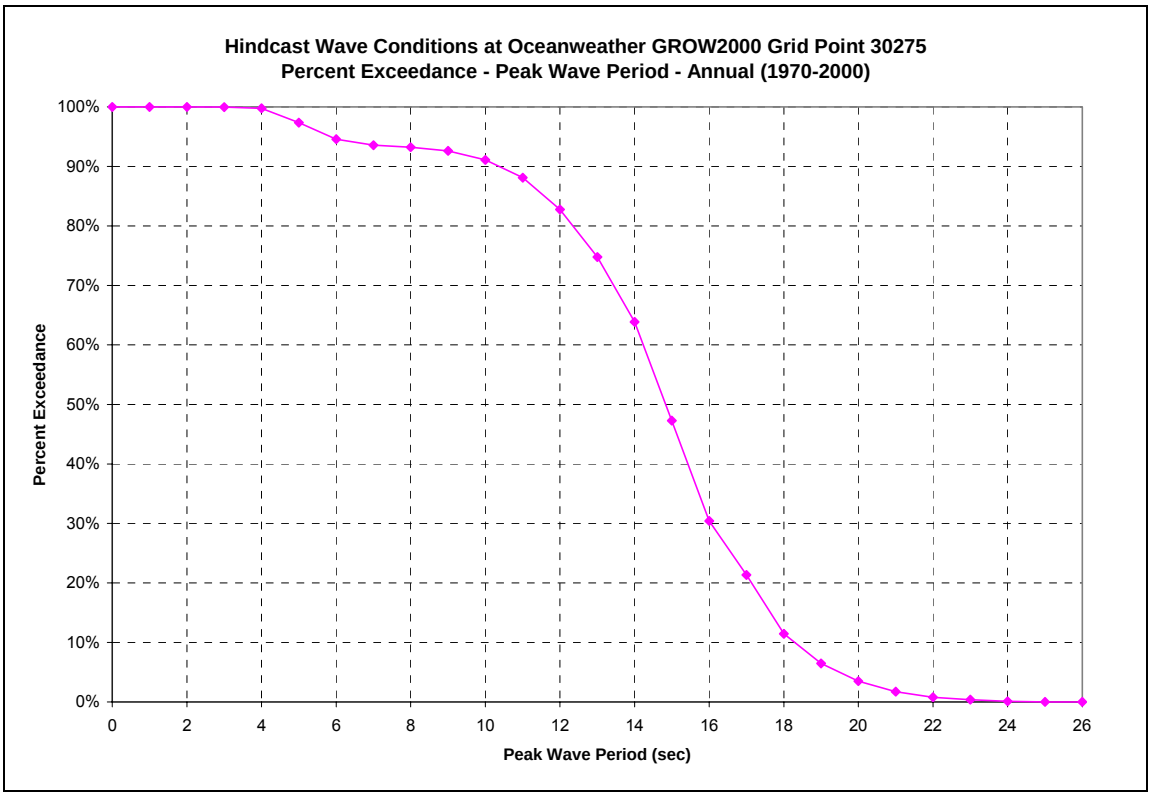
Figure 3-13: Percent Exceedance of Significant Wave Height



3.8.4 Wave Period

Figure 3-14 illustrates the percent exceedance of wave periods within the 31-year hindcast record. From the graph, it can be seen that over 80% of the peak offshore waves are of periods between 10 and 18 seconds.

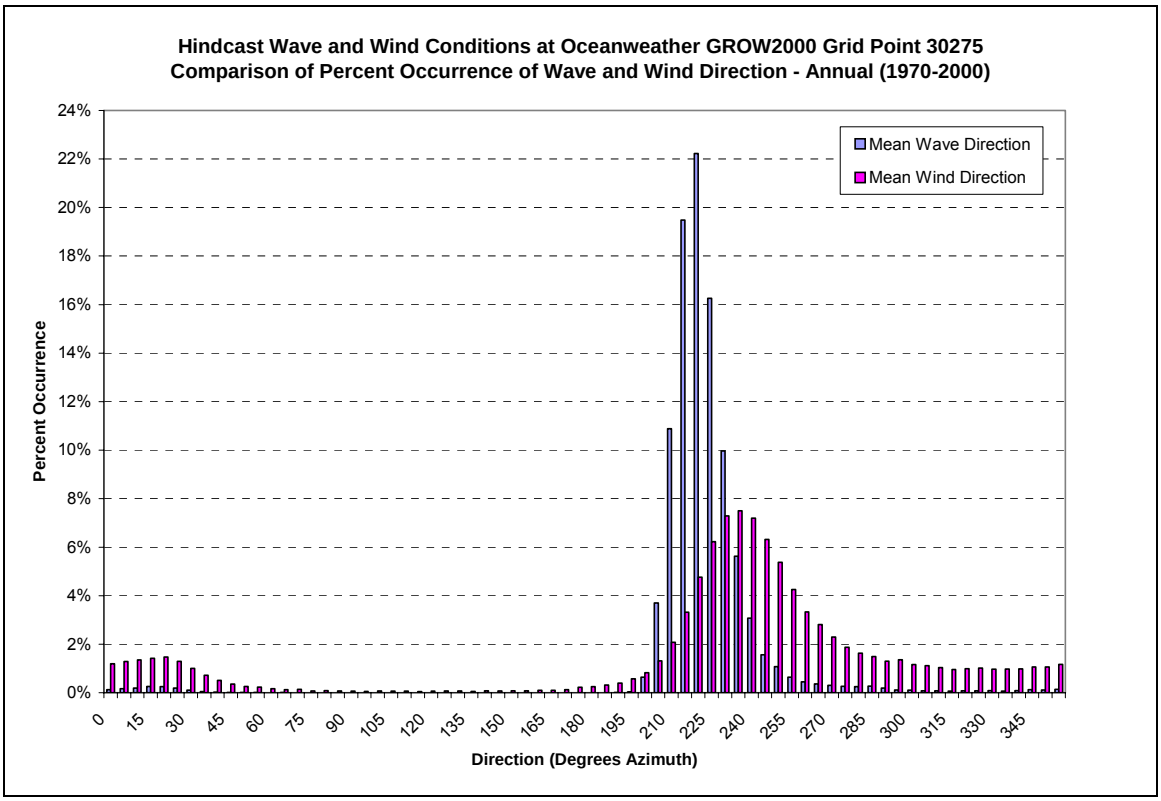
Figure 3-14: Percent Exceedance of Peak Wave Period



3.8.5 Wave and Wind Direction

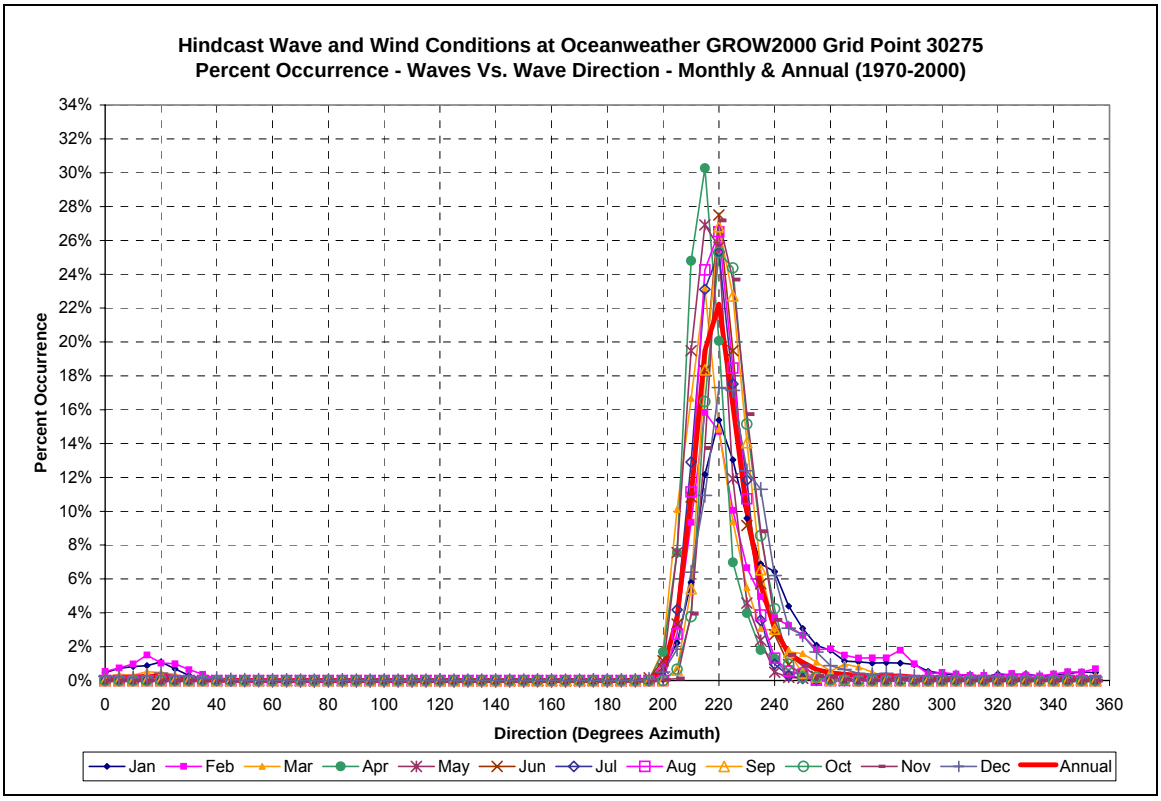
The relatively small range of offshore wave directions, limited by the geographic configuration of Central and South America, is clearly illustrated in Figure 3-15. Most waves arrive at the entrance to the Gulf of Panama from 200 to 250 degrees. The offshore hindcast wind field is slightly shifted from the mean wave directions and is more distributed. The wind is not constrained by the land configuration in the same manner as waves.

Figure 3-15: Percent Occurrence of Waves and Wind by Direction



The percent occurrences of waves by mean wave directions are graphed for monthly and annual conditions in Figure 3-16. This graph reveals little seasonal variation in the offshore wave direction.

Figure 3-16: Percent Occurrence of Waves vs. Wave Direction



4 ENVIRONMENTAL BASELINE CONDITIONS

4.1 Introduction

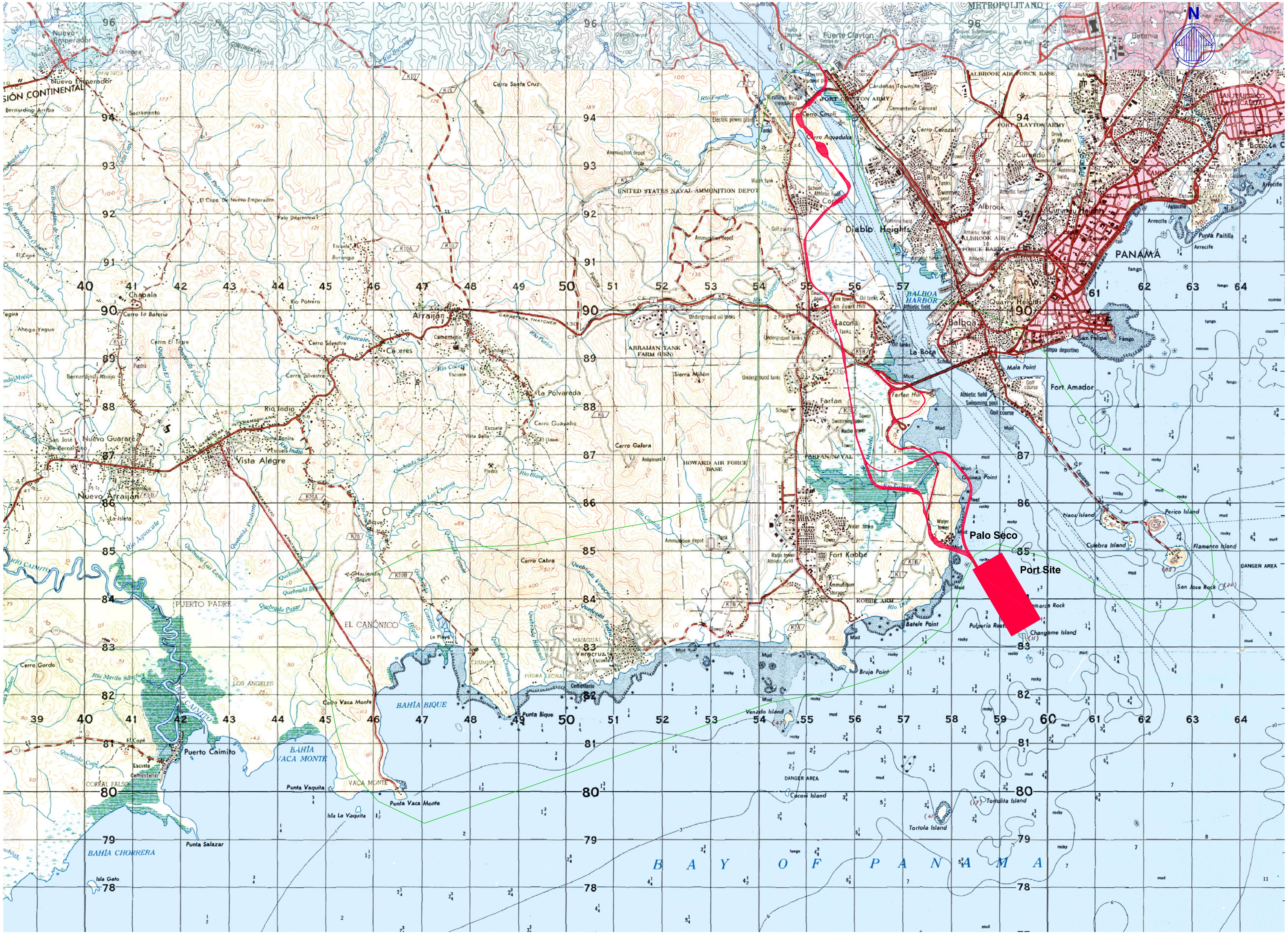
The information used for the baseline assessment is based on data provided by ACP and gathered from the existing data base of field studies and technical assessments that were prepared as part of the Artificial Island Study and Disposal Options Study by the Project team in 2004. Meetings were also held with the following agencies and interviews were conducted with appropriate environmental personnel.

- Panama Canal Railroad
- Panama Institute of Tourism-Instituto Panameño de Turismo (IPAT)
- National Environmental Authority-Autoridad Nacional del Ambiente (ANAM)
- Smithsonian Tropical Research Institute Library
- Howard Air Force Base
- Interoceanic Regional Authority -Autoridad de la Región Interoceánica (ARI)
- National Institute of Culture-Instituto Nacional de Cultura (INAC)

Previous studies describe current conditions of natural communities and land use characteristics of disposal sites close to the proposed terminal access and offshore terminal. The environmental characterization presented in these referenced studies included rapid ecological assessments, water quality analyses, and soil samples.

The environmental evaluation of existing conditions and potential impacts of this project were established by the use of Direct Impact Areas (DIA) which consist of the footprint of the proposed container island and the road and rail associated with the project. The Indirect Impact Areas (IIA) shown in Figure 4-1 includes those areas and communities potentially impacted by the proposed new infrastructure.

More detailed information on the baseline environmental conditions within the area of influence of the project can be found in Appendix B to this report.



LEGEND

Direct Impact Area

Indirect Impact Area

800m 0m 800m 1600m

SCALE: 1 : 80000

Designed by: -	Date: April 2005	Rev.
Dwn by: DJMac	Ckd by: MGH	Design file no. AS SHOWN
Reviewed by: MGH		
Submitted by: MGH	Drawing Scale: AS SHOWN	Plot scale: 1=1 (11"x17")

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FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Direct Impact Areas and Indirect Impact Areas

Fig 4-1

558200_Fig04-01.dwg 28 Jun 2005 - 12:42am; jmacpherson; © Moffatt & Nichol

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4.2 Environmental Quality

4.2.1 Air Quality

Air quality deterioration from transiting ships, port activity and other transportation sources in the project area is low and has not meaningfully changed for many years (Panamá Canal Gaillard Cut Widening Feasibility study, 1987).

4.3 Biological Environment

4.3.1 Marine

General Characterization of the Coastal Area

The shoreline from Farfan Hill to Veracruz is mainly rocky, although there are some pocket beaches and areas of deposited silt. The silt deposits, or mudflats in the Farfan and Rodman area are important feeding habitat for wading birds and semi-terrestrial crabs during periods when they are exposed or when water levels are very low. The mudflats are also important feeding areas for fishes and other marine organisms when they are flooded.

The rocky, intertidal areas along the shoreline provide habitat for juvenile stages of various species of fish, portunid crabs, fiddler crabs, various species of semi-terrestrial crabs, and various types of mollusks.

The largest areas of silt deposition are located at the mouth of the Farfan River, between Farfan Hill and Guinea Point and west of Punta Bruja. An extensive mangrove community exists at the mouth and along the banks of the Farfan River. A control structure is located at the mouth of the Farfan River to regulate the amount of seawater that flows back into the river during high tides.

Beach areas exist at Farfan, Palo Seco, Kobbe, and Veracruz. Kobbe Beach has recently been augmented as part of construction of a resort development.

For the most part, the shoreline is heavily wooded between Farfan Hill and Punta Bruja, except for the area cleared for the Kobbe Beach resort development. Forest areas are generally classified as dry forest, which is becoming increasingly rare in Central and South America, or mangrove. Large areas of shoreline between Punta Bruja and Veracruz were previously cleared for construction of the access road and the town of Veracruz.

4.3.2 Coastal and Marine Resources

Mangroves

Research carried out as part of the Canal Alternatives Study (ANCON and University of Panama, 1993) identified the presence of mangroves in Perequete, Caimito, Veracruz, Balboa, and Juan Diaz. Mangrove communities were also observed at Rio Farfan, adjacent to Howard Air Force Base (Rio Venado) and Kobbe Beach during reconnaissance conducted in February as part of this study. Mangroves were estimated to cover 6% of the vegetated area of the Former Howard AFB, with the greatest areas of mangroves associated with the Rio Farfan and Rio Venado (Arden & Price, 2001).

Sea grasses

Little is known about the location or abundance of sea grass on the Pacific coast. Research by ANCON and University of Panama (1993) indicated the presence of sea grass located in Punta Bruja on a reef flat behind an area of living coral and reef rock. The sea grass was patchily distributed and limited to the protected area behind the reef. It is not known if the coral mentioned at this site is still living.

Coral

Historically, coral communities existed close to the Pacific entrance of the Panama Canal near Taboga, Urabá, Taboguilla, and Otoque (ANCON and University of Panama, 1993). Most of these communities have disappeared and now only a few remain around Taboga and Urabá Islands (Morales and Muñiz, 1988 in Moffatt Nichol et al., 2004b). Currently, the only known population in the eastern Pacific of *Siderastrea glynni*, a coral species endemic to Panama, exists near the island of Urabá (Moffatt Nichol et al., 2004b).

Fishes

Fishes were sampled in the Pacific for the biological inventory conducted as part of the Canal Alternatives Study (ANCON and University of Panama, 1993). In the Pacific, five littoral stations and seven sublittoral stations were sampled in July, August, and November of 1992, and February and May of 1993. Species diversity was highest at the beginning of the rainy season (75 species) and generally decreased through the dry season.

In the Pacific, the sampling stations with the highest mean abundances and diversity (sublittoral zone) were located in the vicinity of the Chame estuary. Fish collected from the sublittoral zone ranged in size from 5.0-135.20 cm and weight from 0.06-2,969.00 g. Carangidae and Sciaenidae were the most dominant families in the catch. Additional information on the biological inventory monitoring is presented in Appendix B.

Coastal Birds

Each year from December to April, millions of birds migrate from their summer breeding grounds in North America to their wintering grounds in South America, using the Bay of Panama as a staging area. Typically most species are associated with the tidal mudflats, but some can also be found in wetland and grassland habitats. Especially high numbers of seabirds are also present during seasonal upwelling events (December - April), which bring high numbers of anchovies and smelt to the nearshore areas (RPI, 2004).

The island of Taboga contains a 252 hectare protected area that is an important nesting area for waterfowl and coastal birds. Approximately 55,000 to 70,000 individuals nest in the southwest corner of the island and feed in the Bay waters and shallow areas close to the Pacific entrance of the Canal. The majority of the birds nesting on Taboga are Brown pelicans and paticuervos (ANCON and University of Panama, 1993). The Taboga Island colony is one of the largest breeding colonies of brown pelicans in the world (RPI, 2004).

Marine Mammals

Megaptera novaeangliae (humpback whales) have been reported near the island of Taboga between June and September. Bottlenose dolphins and other cetaceans are present year round in the area (RPI, 2004).

Protected, Rare, or Commercially Important Species

Rare and Protected Species

The biological inventory conducted by the University of Panama and ANCON discovered the coral *Siderastrea* sp. *nova* at Uraba Island near the Pacific entrance to the Canal. This was the first report of this genus in the eastern, central, and western Pacific. Although sea turtles were not observed during the biological inventory, the following endangered species are known to frequent the Panamanian coast: *Chelonia agassizi* (East Pacific green turtle), *Eretmochelys imbricata* (hawksbill), *Caretta caretta* (loggerhead), *Lepidochelys olivacea* (olive ridley), *Dermochelys coriacea* (leatherback).

Commercially Important Species

The most important fisheries resources within Panama are located within the Gulf of Panama. Annual revenue from the export of sea products is around $100 million, with shrimp representing $65 to $70 million (MICI, 1990 in ANCON and University of Panama, 1993).

The extractable biomass in the Gulf of Panama may be around 400,000 metric tons per year, but most of this is mainly demersal fish and squid which are not fished. The annual catch of penaeid shrimp is approximately 5,000-6,000 metric tons/yr (ANCON and University of Panama, 1993).

Artisanal fishery activities are one of the fastest growing fishery activities in Panama. The most common landings are snappers, Spanish mackerel (scombrid), jacks (carangid), corvinas (scianid), lobsters and scallops (*Argoppecten circularis*) (ANCON and University of Panama, 1993). Local fishermen are known to collect the bivalves *Protothaca asperrima*, *Mytella guanensis*, *Anadara* sp., and *Donax* sp. during low tide for their own consumption or sale at local markets (Moffatt & Nichol et al., 2004b).

4.3.3 Freshwater and Terrestrial Resources

General Description of the Project Area

The section of the road that will connect the port to the main highway passes through a generally undeveloped area and crosses wetlands and disposal sites for dredged materials from Panama Canal maintenance works.

A rail link may connect the container port to the Miraflores Locks area, passing through a mixture of urban areas, commercial/industrial areas, secondary forests, and wetlands. Most urban development on the route is at the towns of Cocolí, Lacona, and Farfan. Portions of the access route may pass through the former Howard Air Force Base, which has been divided into multiple commercial and industrial concession areas.

Forest Resources

Palo Seco Area

The coastal forest areas between Farfan Hill and Kobbe Beach are secondary forest, the majority of which is characterized by dry forest vegetation. This area is classified as Pre-Montaine Humid Forest according to the Holdridge Zone of Life Classification System and Semi-deciduous Tropical Lowland Forest according to UNESCO (Moffatt & Nichol, 2004a).

Approximately 88 hectares of this area was deforested during construction of the Palo Seco Hospital (now a retirement home) and access roads. Additional areas have recently been cleared for the Kobbe Beach resort development. Although the coastal area of Palo Seco has been disturbed, it still serves as a biological corridor between

Guinea Point and Punta Bruja, and the forested areas of the former Howard Air Force Base (Moffatt & Nichol, 2004a).

Howard Air Force Base Area

Arden & Price undertook an evaluation of the natural resources at the former Howard Air Force Base in 2004 (Arden & Price, 2001). The study found that there were seven main terrestrial ecosystem types in the area, including mixed forest; high forest; low forest; deciduous forest; savanna and grassland (herbazal).

Wetlands

The majority of wetlands in the study area appear to be mangrove forests or other types of wet forest. The largest area of mangrove forest is associated with Río Farfán.

Marshland occupies approximately 10 percent of the total vegetated area of the Howard complex (Arden & Price, 2001). The largest areas are located south of Farfan, west of Howard AFB, and north of Fort Kobbe. The dominant species in this area are *Eleocharis fistulosa* and *Typha dominguensis*

Fauna

Reptiles and Amphibians

Palo Seco Area

Three species of amphibians and nine species of reptiles were observed during the transect surveys conducted at Palo Seco as part of the Pacific Side Excavation & Dredging Materials Disposal Study (Moffatt & Nichol et al., 2004a). Three of the species observed are protected by Panamanian law and are listed in CITES: *Crocodylus acutus* (American crocodile), *Boa constrictor*, and *Iguana iguana* (green iguana). The American crocodile is also listed as Vulnerable by the IUCN.

Howard AFB Area

Numerous species of reptiles and amphibians were reported at the former Howard AFB. The greatest number of species of reptiles and amphibians was associated with mixed deciduous forest vegetation cover. Two species protected under Panamanian law were observed: *Iguana iguana* and *Boa constrictor*. Green iguanas were observed in deciduous forests and low semi-deciduous forests. Boa constrictors were observed in mixed semi-deciduous forest. Two species of poisonous snakes were observed in tall

semi-deciduous forest: *Bothrops asper* (Central American lancehead) and *Micrurus nigrocinctus* (coral snake) (Arden & Price, 2001).

Birds

Two hundred and twenty-nine (229) species of birds representing 47 families and 19 orders were identified near the South Entrance of the Canal as part of the Biological Inventory for the Canal Alternatives Study (ANCON and University of Panama, 1993).

Mammals

Eleven species of mammals were observed during the transect surveys conducted at Palo Seco as part of the Pacific Side Excavation & Dredging Materials Disposal Study, including four species of fructiferous bats (Moffatt & Nichol et al., 2004a). Five of the species observed are protected under Panamanian law:

5 SOCIO-ECONOMIC, CULTURAL, & ARCHAEOLOGICAL ENVIRONMENT

5.1 Introduction

Due to the preliminary nature of this study, no direct contact was made with community leaders, potentially interested parties or local residents. Data was obtained from previous studies conducted as part of the Island Development and Disposal Studies at the Pacific Entrance of the Panama Canal and other published sources as cited. The data compiled in the on the Island Study was reported to have been obtained from public sources such as the Comptroller of the Republic of Panama. A site visit to these communities that are likely to benefit or impacted from the proposed project was made to verify the data previously collected in the previous studies and to update the information, if applicable.

5.2 Jurisdictional Background

The marine area of the Proposed Container Terminal is in an area subject to the control of the ACP, as shown earlier in Section 3. Certain landside areas adjacent to the Pacific entrance and east of the former Howard Air Force Base are also used for the disposal of dredged material from the Canal and under ACP jurisdiction.

The Palo Seco area is adjacent to the former Howard Air Force Base which covers 3,707 acres and other military bases such as Rodman Naval Station and Kobbe. As such much of the land use east of Howard Naval Base has been restricted from development for security reasons. The presence of steep hills along the shoreline and marsh/wetland systems and low lying areas east of Howard has also contributed the lack of development of the area.

Several small communities that are west of the former Howard AFB may experience benefits from the overall development at Palo Seco from such projects as the Kobbe Beach Resort, the proposed Container Terminal as well as continuing redevelopment of Howard and the Amador Causeway.

5.3 Social Characteristics of Panama

The following communities are located within a distance of the project that they may be potentially impacted be the construction and operation phase of the Container Terminal.

- Amador Causeway
- Howard Air Force Base/Kobbe
- Vacamonte
- Veracruz
- La Boca
- Cocolí
- Fort Clayton
- Pedro Miguel
- Paraiso

Although the above communities have specific social characteristics, they all share certain social conditions that are common to all of Panama and can be viewed in the context of the existing social conditions for the entire Republic as described below. More details on specific socio economic conditions and data can be found in Appendix B to this report.

5.4 Economic Profile

According to preliminary data from the Contraloria General de la Republica de Panama, the gross domestic product (GDP) of Panamá was $13 billion (U.S.) in 2004. The ratio of gross domestic investment to GDP for the same time period was estimated at 27.6 and the ratio of exports of goods and services to GDP was 29.0. Panamá's economy is highly dependent on world trade trends due to the strategic importance of the Panamá Canal, shipping and port services. In FY2004 transits of ocean going commercial vessels were reported to be 12,506, representing an increase of almost 7% over 2003, while Canal cargo tonnage volumes increased from 188.27 to 200.19 million long tons over the same period, a 6.3 percent increase, to the previous year[8]. The outlook for world economic growth is 3.2 percent for year end 2003.

[8] Panama Canal Traffic, Fiscal Years 2002 though 2004. ACP Corporate Planning & Marketing Division.

5.5 Social Surroundings

5.5.1 Amador Causeway

Amador Causeway is located at the south-eastern tip of the Pacific entrance to the Panama Canal south of the Bridge of Americas. The causeway connects the mainland to three small islands, Naos, Perico, and Flamenco and is one of the most desirable recreational destinations in Panama. The Causeway roadway is a narrow single lane paved road with no shoulders.

The northern part of the Causeway which is part of the mainland, houses an international hotel, the Balboa Yacht Club, a convention center and several restaurants. Investments projected for the next 20 years are anticipated to be around B/400 million based on the Strategic Plan for Tourist Development of Amador, 1996.

The Causeway extending from the mainland to Flamenco Island is designed as a pedestrian greenbelt with well maintained landscaped areas, paved walkways.

Naos Island is the first island in the Causeway that houses the Smithsonian Tropical Research institute marine laboratories, an ACP Canal Pilots station and the Marine Exhibition Center. Perico and Flamenco islands are the next islands traveling south on the Causeway. Perico faces Panama Bay and houses several restaurants. Flamenco Island houses several restaurants, a marina and a new cruise port and shopping facility.

The Causeway is used widely during the weekends and evenings, which has resulted in heavy congestion to vehicular traffic. Studies are underway to evaluate the construction of a mono-rail or some other form of transportation to the end of the causeway to reduce the number of automobiles.

5.5.2 Palo Seco Long Term Care Facility

Known for many years as the local hospital for victims of leprosy, the Palo Seco Hospital located on the shoreline is now used as a long term care facility for elderly patients of limited resources. The wooden buildings are reported to be in poor condition, and it is understood that plans are in hand to move patients to another building located within the Howard AFB area. The hospital is connected to the main highway by a narrow two lane road that is suitable for smaller vehicles.

5.5.3 Howard AFB & Kobbe Beach

The Palo Seco area includes the former US military complex of Howard Air Force Base, along with the neighboring Fort Kobbe and the Farfan residential zone which were turned over to the Panamanian government in late 1999. Howard Air force Base covers 3,707 acres. Rodman Naval Station and other former military bases such as Kobbe, Cocoli and Farfan lie north of Howard. The former Rodman Naval Station has a port facility with three docks and 87 housing units, warehouses, office buildings and other supporting facilities over a 600 acre site.

The projected uses for Howard include industrial zones, residential communities, and urban developments. The Dell Computer Customer Calling Center is one of many uses of the existing buildings located at the Base. Other industrial operations such as a leather processing facility are currently in the planning stages. Overall development of the Kobbe as well as Howard Air Force Base is overseen by the Special Economic Agency for Pacific Panama (AAEEPP). The intentions of this agency are to develop the area as a mixed-use land combining commercial, tourists and urban activities.

The Kobbe Beach Resort currently under construction represents the first major tourist development in the area. The hotel and resort is located in a cove south of the proposed project in an area well shielded by coastal vegetation and the natural topography in an area that was a popular beach destination for the US military. The complex, which will be completed in late 2005 will offer 300 rooms and be managed by the Intercontinental Hotel chain.

5.5.4 Veracruz/Bique Bay/Vacamonte

Communities west of the Project site and Howard include the small fishing settlement of Bique Beach and the communities of Veracruz and Vacamonte. All three communities are located in the Arraijan District along the shoreline of the Pacific Ocean.

Bique Bay

Bique Bay is mostly a fishing community involved in artisan fishing and processing shrimp in Vacamonte Port. Other sources of employment consist of women employed as domestic employees in nearby villages, as well as temporary and permanent employment in Panama City, Arraijan, La Chorrera and Vista Alegre.

Veracruz

The majority of the population of Veracruz is employed in the public and private sectors in areas of fishing, mining and excavation, manufacturing, service industry (hotels, restaurants), transportation, construction, and social and health services. Fishing is another important economic in the area. Several companies provide services to the fishing economy such as Veracruz International shipyard (ship repairs); Advance Marine Propulsion Systems (equipment sales) and Pesquera Taboguilla S.A. (fish meal processing). In addition local artesian fishing takes place in the area with an average monthly production of 8,400 pounds of fish and an associated income of B/5,200.

Vacamonte City

Vacamonte City has 252 reported companies operating in the port area engaged in exporting and processing of shrimp, poultry and pork. White and red shrimp are processed for exportation to the United States, Mexico, Venezuela and Spain.

5.6 Historical & Cultural Resources

Prehistoric, pre-Colombian and colonial archaeological sites have been discovered in Panama, including some larger sites associated with prehistoric chiefdoms on the Pacific slope. One of the most notable finds was at Venado Beach, formerly part of Fort Kobbe, where refuse beds and burials were unearthed during land clearing activities conducted by the U.S. Military. A total of 369 bodies were recorded at the Venado Beach burial grounds in individual and grouped graves. Burial urns and elaborate gold jewelry were found with some of the bodies. Many of the jewelry pieces found at the Venado burial site are believed to be trade pieces that were produced elsewhere and brought to the Venado region (Lothrop, 1956). The Venado Beach site has been given a radiocarbon date of 227-60 A.D. from a typical burial urn at the site (Deevey, et al., 157 in Bull, 1965).

A refuse deposit midden that contained fire-cracked rocks and soil as well as large quantities of sherds was discovered at Farfan Beach during the 1940s. The pottery discovered at the Farfan midden fall into three distinct categories: dishes, bowls, and bottles. Sherds, shells (conch and scallop), stone artifacts (manos, a celt, and a sharpening stone), and burial urns were located in disturbed soil. Human bone fragments were found inside one of the urns. The age of the site and the length of occupation were undetermined (Marshall, 1949).

An archaeological discovery was also made at Palo Seco. This is often called the Engineer's Hill site. The site was first excavated in 1980 and was excavated again in 1981. The site was a fairly large habitation with a large accumulation of shells, ceramics, and stone materials. The stone tools found include a mano, "nutting stones", an

elongated stone that appeared to be an axe, and flake tools. Sherds of labial flanged globular and necked globular vessels were found as well as two fragments of Spanish majolica. The cultural material examined from the site appears to be within Phase IV as defined by Dr. Richard Cooke, dated between 150 and 450 A.D. (Aguilú, 1980; Yanguez, 1981).

In spite of the important finds in the Palo Seco region, no systematic surveys have been conducted there. Undiscovered or unrecorded archaeological remains are likely to exist in the area. The submerged areas of the coastal shelf may also be archaeologically significant since some 50 km of former dry land along the southern shore of Panama Bay has been inundated since the end of the Pleistocene era by rising sea levels (Moffatt & Nichol et al., 2004b).

5.7 Visual Landscape

The existing visual character of the area is primarily undeveloped and densely vegetated along the coastline with the exception of the hospital located at the shoreline of the proposed location of the project. The project lies in an area that is designated as with the industrial activities associated with the operation of the Panamá Canal at the Pacific entrance, and commercial and tourist establishments along Amador Corridor.

The large scale of infrastructure associated with a container port includes cranes, vessels, and storage container units, as well as lights and noise associated with the operation will result in various degrees of adverse visual impacts.

A full assessment of the visual impacts will be required for this project. It should quantify the level of visual impact likely to be experienced from an envelope predominantly across the Amador Causeway which will require computer modeling techniques.

6 TECHNICAL STUDIES

6.1 Materials Source Options

The studies carried out in 2003 and 2004 examined the Palo Seco/Farfan site as a potential disposal option for excavated material from the Locks excavation, dredging or Pacific entrance dredging projects. However, this new assessment is driven by a need to provide additional container facilities on the Pacific Coast of Panama and is no longer tied to potential to receive material from the Canal expansion projects.

Therefore there are three basic sources of materials that can be used for the island.

- Excavated Material from the Locks Program.
- Imported sand from a borrow site at an acceptable distance from the Project location, combined with rock from local quarries close to the Port site.
- The use of material already excavated from the 1939 Locks Expansion project at Miraflores.

6.1.1 Excavated Material from New Locks Project

Given the significant quantities of good quality (rock) material that will be excavated at the New Locks site and the possibility that excavation work could start as early as late 2006, this source of fill material remains a viable option for the Palo Seco/Farfan Container terminal project.

6.1.2 Imported Sand Fill

Most artificial island or large scale reclamation projects are constructed using material that is either dredged from the seabed or imported from land fill sources. A common technique involves the import of hydraulically dredged sand, which is pumped into the site and contained by rock dikes or other retaining structures. The advantage of this type of construction is the ability of the sand to rapidly obtain its final consolidation. It is also one of the most cost effective means of creating new land, as long as a good source of clean sand can be located relatively close to the project. Disadvantages are concerns over liquefaction potential in a seismic event and the long term settlement when the sand is placed over an area of soft sub bottom materials.

6.1.3 Previously Excavated Material at Miraflores Locks Area

Finally, there are significant amounts of previously excavated rock material located near the 1939 Locks excavation site, close to the Miraflores Locks. Part of this site may fall within the area of the New Locks construction and there is no detailed information on the amount of material in the deposits. However it does offer a potential source for fill or containment dike material.

6.2 Fill Materials Assessment

6.2.1 Excavated Materials from the Locks Project

Rock Materials

Five rock formations are represented on geologic plans and profiles prepared by ACP following extensive borehole investigations in the excavation area for the third locks project. These are described in detail in the Island Study and appendices which show that Basaltos, Pedro Miguel and La Boca Formations are most common in the excavation area, while the Cucaracha and Culebra Formations are encountered less frequently. Generalized characteristics and behaviors of the rock formations, as derived from analysis of the available boring logs, are described in Table 6-1.

Overburden

The rock formations are overlain in most areas by overburden consisting of weathered rock, residual soil, and/or fill material from previous canal excavations. According to the boring logs, the thickness of the overburden ranges from 0 to 52 meters. The overburden soils are quite variable in respect to their particle size, consistency, moisture content, plasticity, and dry strength.

The logs indicate that the fill material is commonly gravelly and often contains boulders. Fill consisting primarily of hard basalt boulders has been noted in several borings, with zones ranging in thickness from 3 to 12 meters.

Table 6-1: Generalized Characteristics of Materials in the Proposed Excavation Area[1]

Formation[2]	Material	Hardness	Strength	Weathering	Specific Gravity	Joint Spacing	Joint Width	Joint Descriptions	Bedding	Grain Size	Clast Description	Matrix	Other Notes
Basaltos	**Weathered Basalt**	Medium Soft to Hard	Weak to Strong	Moderately to Highly Weathered	2.7	Close to Very Close (<0.06 m to 0.2 m)	Closed to Open (1 mm to 30 mm)	Stepped, Undulating, Planar, Rough, few are Smooth and Slickensided Dip angles: **30º**,45º,70º, 90º	N/A	Varies	N/A	N/A	
	Sound Basalt	Hard to Very Hard	Strong to Very Strong	Slightly Weathered to Sound	2.7	Moderately Close to Close (0.06 m to 0.6 m)	Very Closed to Moderately Open (<1 mm 10 mm)	Stepped, Undulating, Planar, Smooth to Rough, Occasionally Slickensided Dip angles: **30º**,45º, 60º, 70º, 90º	N/A	Varies	N/A	N/A	
Pedro Miguel Formation	**Weathered Agglomerate**	Soft to Medium Hard	Weak to Moderate	Slightly to Completely Weathered	2.4	Very Close to Close (<0.06 to 0.2 m)	Closed to Open (1 mm to 30 mm)	Rough Dip angles vary	N/A	Very Fine to Fine 1/16 to 1/4 mm	Angular to Sub-rounded Basaltic, Andesitic, and Tuffaceous Clasts	Massive, Tuffaceous	
	Sound Agglomerate	Medium Hard to Hard	Medium Strong to Strong	Slightly Weathered to Sound	2.4	Close to Wide (0.06 m to 2.0 m)	Closed to Moderately Open (1 mm to 10 mm)	Rough, Planar, Stepped Dip angles: 70º,45º, 50º, 30º, 40º, 60º	Occasionally Thinly Bedded or Laminated	Very Fine to Fine 1/16 to 1/4 mm	Angular to Sub-rounded Basaltic, Andesitic, and Tuffaceous Clasts	Massive, Tuffaceous	
La Boca Formation	**Tuff**	Medium Soft	Weak	---	2.1	Very Close (<0.06 m)	Open (10 mm to 30 mm)	Slickensided	Massive	Very Fine to Fine 1/16 to 1/4 mm	N/A	N/A	Hydrates, Swells, and Disintegrates Upon Exposure to Air
	Sandstone	Medium Soft to Medium Hard	Weak to Moderate	Sound to Moderately Weathered	2.2	Close to Wide (0.06 m to 2.0 m)	Closed to Open (1 mm to 30 mm)	Planar, Stepped, Rough, Occasionally Slickensided Dip angles: 30º and 45º	Usually thin (0.06 to 0.2 m), Often dip 30º	Very Fine to Medium 1/16 to 1/2 mm	N/A	Some Is Calcareous	Hydrates, Swells, and Disintegrates Upon Exposure to Air
	Siltstone	Soft to Medium Hard	Weak to Moderate	Moderately to Highly Weathered	2.2	Very Close to Moderately Close (<0.06 m to 0.6 m)	Closed to Open (1 mm to 30 mm)	Planar, Stepped, Undulating, Rough, Smooth, Slickensided Dip angles: 45º and 30º	Varies, Often dips 30º	Very Fine to Fine 1/16 to 1/4 mm	N/A	N/A	Hydrates, Swells, and Disintegrates Upon Exposure to Air
	Conglomerate	Soft to Medium Hard	Weak to Moderate	---	2.3	Close (0.06 m to 0.20 m)	Open (10 mm to 30 mm)	Slickensided	N/A	Fine to Medium 1/8 to 1/2 mm	Angular to Sub-rounded Clasts/Pebbles	Sandy, Tuffaceous	Hydrates, Swells, and Disintegrates Upon Exposure to Air
Cucaracha Formation[3]	**Shale**	Soft to Medium Hard	Weak	---	2.2	Very Close	Open	Slickensided	Massive	Fine 1/8 to 1/4 mm	Contains Calcareous Concretions	Sandy	Hydrates, Swells, and Disintegrates Upon Exposure to Air
	Sandstone	Mediium Soft to Medium Hard	Weak to Moderate	---	2.2	Moderately Close to Wide	Open	Slickensided	Massive	Fine 1/8 to 1/4 mm	N/A	Tuffaceous	Hydrates, Swells, and Disintegrates Upon Exposure to Air

Notes:
[1] This table represents only the *typical* characteristics of frequently encountered materials as deduced from limited data including boring logs, index test results, and prior analyses by other agencies.
[2] The Culebra Formation is also included in the excavation area to a very limited extent. This formation includes alternating layers of sandstone, siltstone, and conglomerate of varying thickness.
[3] The Cucaracha Formation occasionally contains a weak conglomerate with a tuffaceous matrix.

Key Considerations for the Project

Most of the material from the Locks excavation will make excellent fill for the proposed terminal. According to analyses presented in earlier reports, it is primarily rock, that will probably be excavated in pieces of less than 60 cm diameter.

The primary considerations for its use are:

- Approval of the New Locks project by ACP and also by the people of Panama
- Schedules for excavation of the Locks and construction of the Container Terminal
- Requirements for other elements of Locks program (aggregates etc)
- Transport cost and impacts of transport system to the project site
- Sequencing of excavation and disposal or use of overburden materials
- Construction implications of rock fill for terminal area (piling concerns, excavation for utilities, etc)

Project Scheduling

The New Locks project is contingent upon final ACP and Government approvals and a positive result of a proposed referendum to be placed before the Panamanian voters. No official date has yet been fixed for the referendum, but it is expected to take place late in 2005 or early 2006.

Assuming a positive outcome from the referendum, excavation work could begin shortly afterwards as the first element of a phased construction program. In this case, material could be available for the container port project by mid to late 2006. If excavation is to be scheduled to await completion of the final designs on the Locks, the material would not be available until about 2008 to 2010.

Competing Uses for Locks Excavation Material

It has been proposed that much of the material to be excavated from the Pacific side locks project will be ssuitable for conversion to aggregate for both the Atlantic and Pacific Locks and also used for base preparation and structural fill. Given the expectation of an excavation volume of 60 million m3 and the container terminal expected needs of 13 million m3, it is expected that there will be sufficient material for both projects.

Sequencing of Excavation

Early work on the Locks excavation will require the removal of overburden material that is not likely to be satisfactory for underwater fill at the project site. However it can be used for the creation of haul roads or preparation of a rail bed if that alternative was adopted. There are also fill requirements for embankments around the Locks area, which may accommodate some or all of the material. It is therefore critical that the sequencing of the materials removal for the Locks project should be carefully considered when assembling the construction schedule of the container terminal fill project.

Construction Issues

Although the rock material to be removed from the Locks is well suited as fill for the container yard areas, the presence of rock near to the surface of the fill will complicate the installation of pilings for buildings and the construction of utility trenches and other underground features. These issues can be avoided by the definition of zones where smaller rock would be used, or the assignment of a cut-off elevation, above which all rock would be reduced to a size that will not conflict with future construction needs. Based on experience at other locations, it is generally assumed that most pile types can penetrate rock fill where the largest diameter of the material is less than 150 mm, and where at least 50 percent of the material is less than 100 mm in diameter.

Transportation cost

Cost models prepared for the earlier studies and updated for this study covered the following options:

- Truck Haul over dedicated haul road using off-road large sized dump trucks
- Rail transport, with the expectation that the rail would remain for future use
- Barge transport.

Figure 6-1 to Figure 6-3 show the routes that were examined for the truck haul, rail and barge systems. One of the key findings of the earlier cost study was that volume was a major factor in the selection of the preferred haul system. This was particularly critical for the rail and conveyor options, less so for the truck and barge haul options.

Other issues that need to be re-examined since the preparation of the original model are the recent increases in fuel, steel, cement and operating costs for the various modes of transportation evaluated in the earlier studies.

Consequently the transportation cost model was updated and rerun on the basis of an anticipated total fill requirement of 16.5 million m3. Details of the specific transportation cost models for each mode are presented in Appendix E to this report.

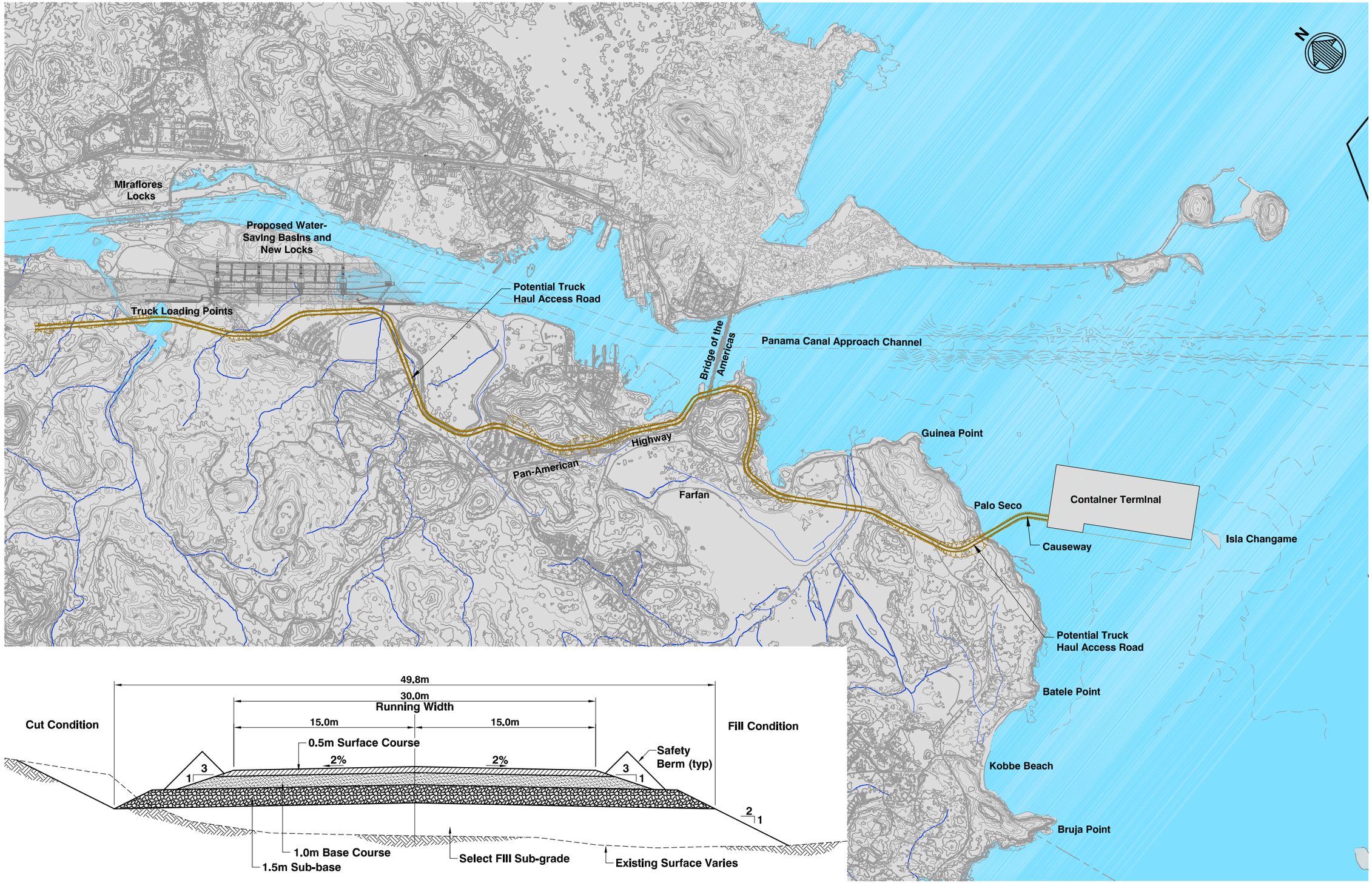
The estimated cost of movement of excavated and dredged material from the Locks area to the project site by the three primary transport options is shown in Table 6-2

The table indicates that the barge system is likely to be the cheapest option, assuming a volume of 16.5 million m3 of material, with an estimated unit transportation cost of $7.16 per m3. Both rail and truck haul costs are similar at $10.97 per m3, but in both cases, it is important to note that each system requires significant investment in infrastructure, which may be of benefit to the final project once the materials haul process is complete.

It therefore follows that the difference of $3.81 per m3, or $62.86 million, between the cost of a rail or truck system and the use of barges as a haul method can be set against the cost of provision of a rail highway links to the Atlantic coast as part of the permanent operations of the Port.

Table 6-2: Transport Cost for Materials from Locks Excavation

Transport Mode	Unit Cost (US$/m3)	Total Cost for 16.5 million m3 (US$millions)	Comments
Truck Haul	$10.97	$181.03	Includes dedicated haul road from Miraflores to Project site (20 km approx)
Rail Transport	$10.97	$181.93	Includes new trackage to Miraflores area but excludes Locks crossings
Barge System	$7.16	$118.11	Requires barge transfer station and short truck haul at Excavation site



Typical Haul Road Section

Scale - 1:300

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Dwn by: DJMac
Ckd by: MGH
Reviewed by: MGH
Submitted by: MGH
Date: April 2005
Design file no. AS SHOWN
Rev.
Drawing Scale: AS SHOWN
Plot scale: 1=1 (11"x17")

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GOLDER ASSOCIATES

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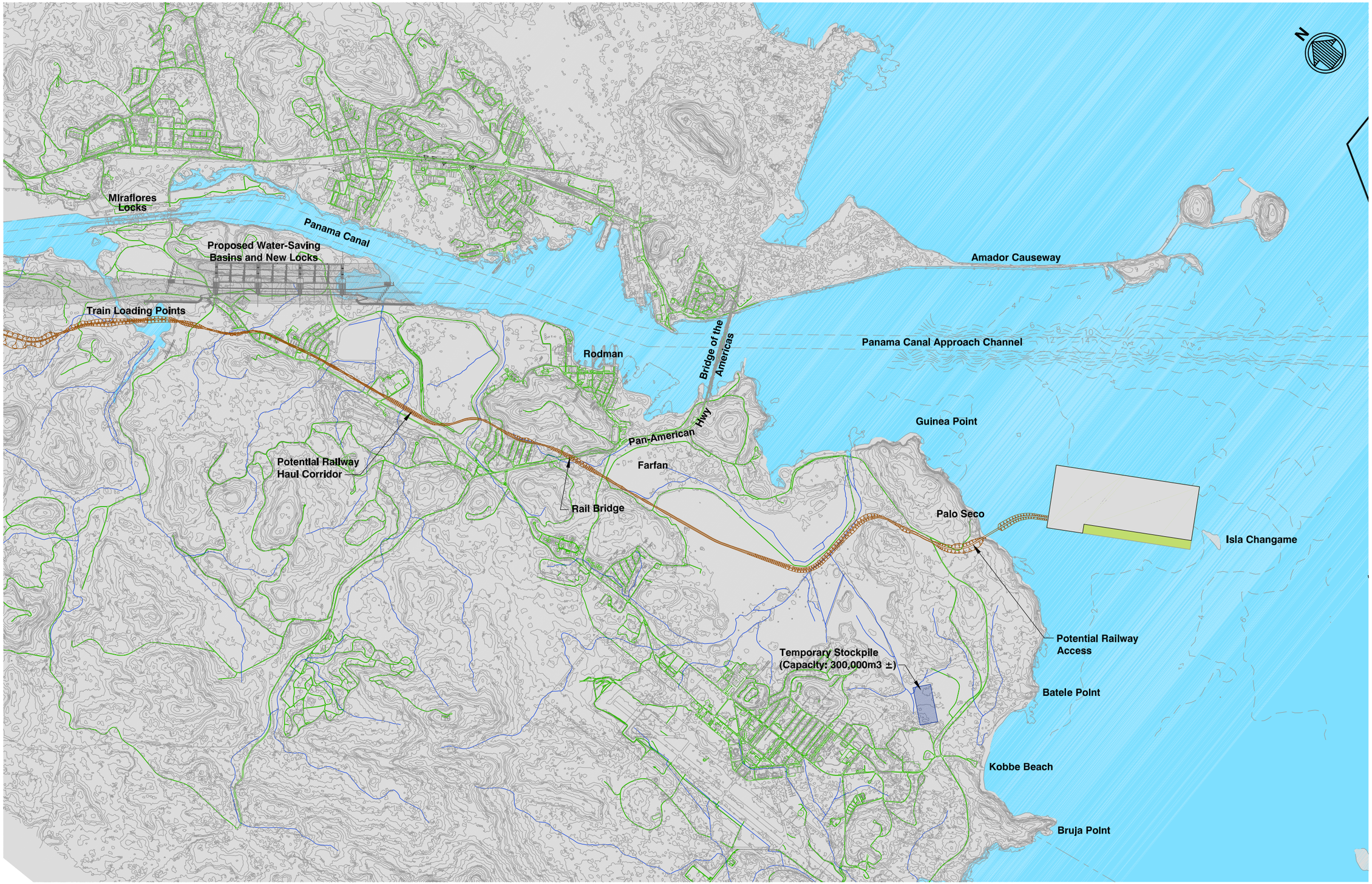
FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Potential Off-Road Truck Haul Access from New Locks to Port Site

Fig 6-1

558200_Fig06-01.dwg 28 Jun 2005 - 12:43am: jmacpherson; © Moffatt & Nichol



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FEASIBILITY STUDY FOR
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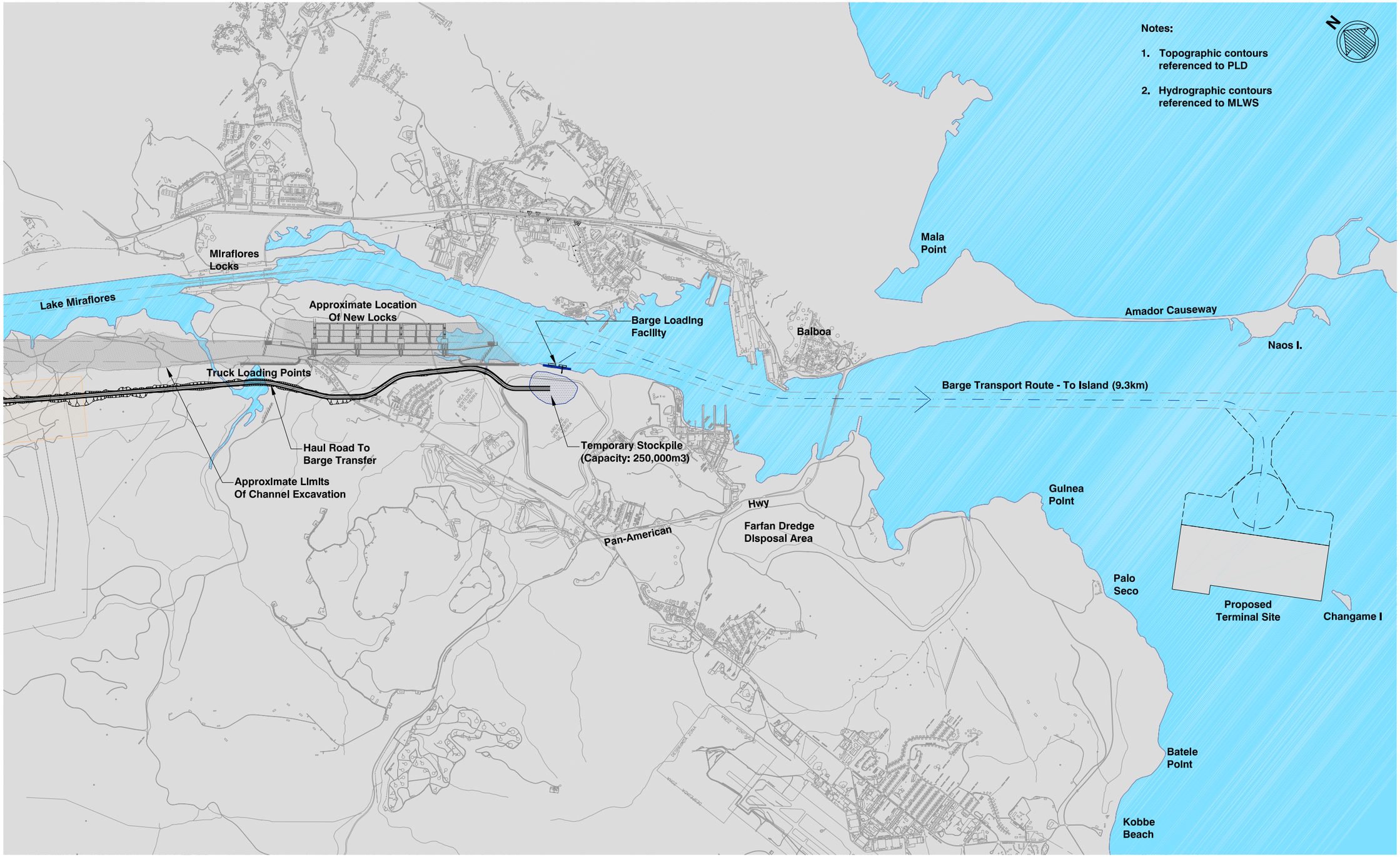
Potential Rail Haul Route from New Locks to Port Site

Fig 6-2

558200_Fig06-02.dwg 28 Jun 2005 - 12:47am; jmacpherson; © Moffatt & Nichol



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Submitted by: MGH
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Drawing Scale: AS SHOWN
Plot scale: 1"=1 (11"x17")

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FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Potential Barge Haul Route from New Locks to Port Site

Fig 6-3

558200_Fig06-03.dwg 28 Jun 2005 - 12:48am; jmacpherson; © Moffatt & Nichol

6.2.2 Material from the 1939 Locks Excavation

A second fill option would be to use stockpiled material that was originally removed from the two lagoons excavated in 1939 for the Third Locks project. There are substantial deposits of this material close to the excavations, but it is not known exactly how much material still remains[9]. As the Locks project design proceeds, there may be also be a limitation on the quantity of this material that can be removed, since the deposit appears to be located within the expected working area of the new locks.

In terms of materials characteristics and transportation costs for truck and barge haul, this material can be considered as similar to the excavated material discussed in the previous paragraph. Hence the primary issue related to its potential for the container terminal project is the need or otherwise for this material as part of the Locks project.

Given the strong possibility that there is insufficient material for the total fill requirement for the port project, and the location or rock quarries closer to the project site, it is most unlikely that this site would be used as a source of bulk fill material for the project.

6.2.3 Hydraulic Fill Materials Option

Many major reclamation projects around the world have been constructed using hydraulically dredged sand fill within a containment area, which is constructed from rock or other locally available materials. There are substantial deposits of sand in Panama Bay, extending from Taboga in the east to the Costa Rican coastline and beyond. Sand has traditionally been dredged and extracted for building and construction projects from the Punta Chame area until this activity ceased in the early 1990s. At the time of cessation of this sand extraction, property owners in the Punta Chame area were expressing concern that erosion was taking place on the beach front and requesting a prohibition on future concessions in this area.

---

[9] Informal assessments by ACP indicate the presence of approximately 1.5 million m3 at this site, although no detailed surveys have been undertaken.

In the mid 1970's, the reclaimed areas at the Port of Vacamonte were developed using this technique, using sand taken from approximately 5 km south of the project area.

Figure 6-4: Dike & Sand Fill Reclamation Project at Vacamonte - 1976

Source: Personal photos, Michael Horton.

Location and Characteristics of Sand Deposits

More recently, applications for concessions[10] to remove sand from the area north of Taboga were supported by samples and laboratory tests but no extraction of sand has taken place in this area to date. Three soil samples taken within the proposed concession area were identified as fine sands with approximately 90 and 65 percent passing the #4[11] and #10 sieves respectively. According to the laboratory analysis of the samples, the material would be classified as coarse sand.

---

[10] Estudio de Impacto Ambiental II, Solicitud de Concesión Minera para la Extracción de Arena Submarina, Panama Environmental Services S.A. for Energy Consultants S.A., November 2000

[11] ASTM sieves #4 and #10 have openings of 4.75 mm and 2.00 mm respectively.

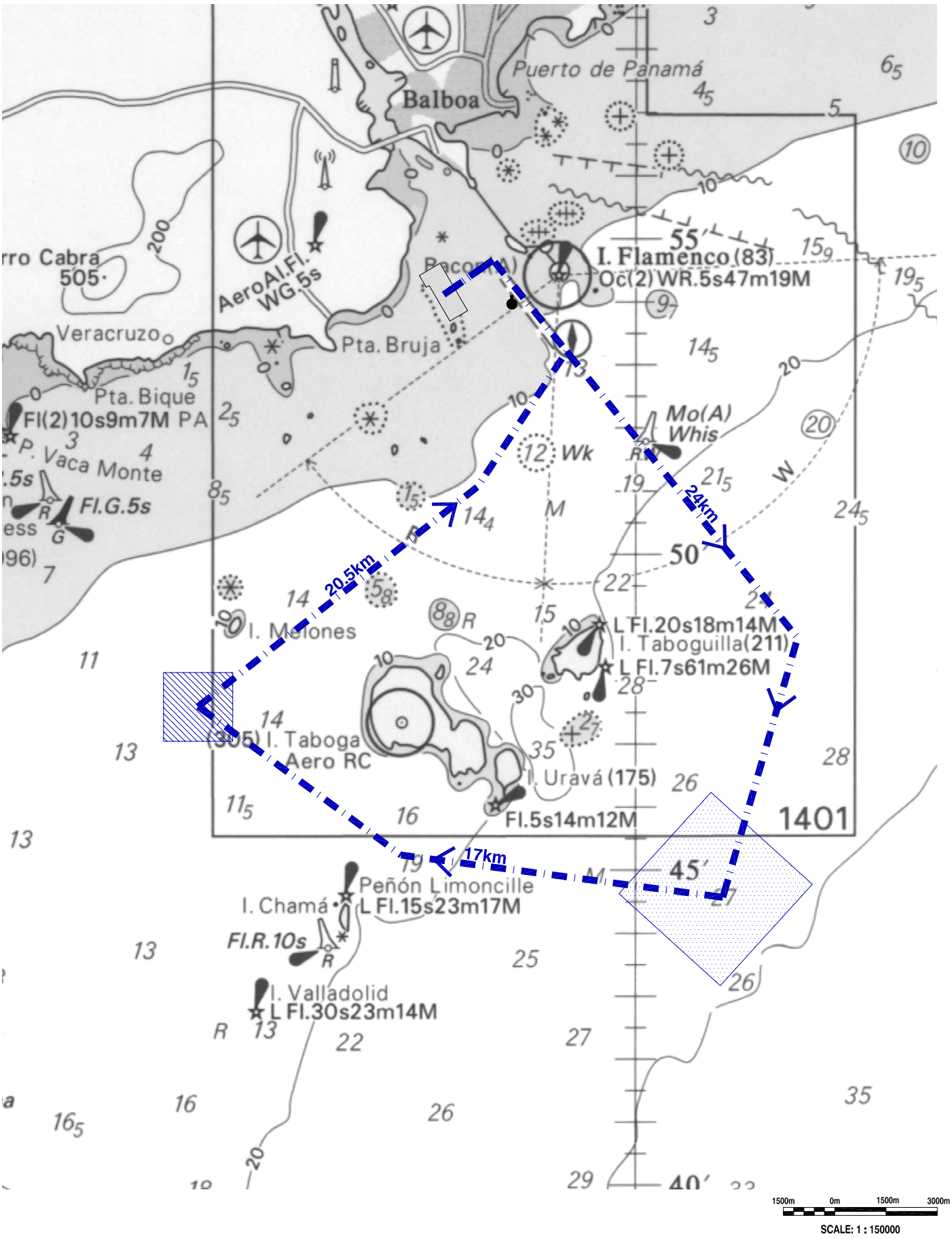
With the exception of these three samples, there is very little reliable information on the characteristics and extent of the sand deposits in the project area, but the geophysical and other studies indicate that the transition from soft silts to sands takes place at approximately the -10.00 m contour. There are also indications that the finer material is located to the east, close to Taboga, with more coarse sands being located in the area from Vacamonte to Punta Chame and beyond.

Suggested location for Sand Borrow Site

The construction of the island will require the dredging of soft and hard materials and the import of fill. Preliminary assessments of the required volumes, presented in Table 6-4 indicated that the total volume of dredging is close to the amount of fill required for the project.

This balance then offers the potential to combine a dredge disposal operation with the sand borrow activities in order to generate significant cost savings for both elements of the project. This technique is common for projects of this nature and was used for the disposal of soft sediments and reclaimed area construction for the Vacamonte project in the 1970's.

While more detailed studies will be required at the final design phase, it is suggested that a deepwater dredged materials location due south west of Taboga Island, and clear of the Vacamonte entrance channel would then represent a good combination with a sand borrow site in the same general vicinity. Figure 6-5 shows the tentative location of the two sites.



558200_Fig06-05.dwg 28 Jun 2005 - 12:50am; jmacpherson; © Moffatt & Nichol

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Figure 6-5
Location of Potential Dredged Materials Disposal and Sand Borrow Sites

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Transport Costs

The US Army Corps of Engineers (USACE) dredge cost model was used to prepare estimated sand dredging and transport costs based on the tentative locations shown in Figure 6-5. The model runs are based on the need to dispose of approximately 12.0 million m3 of soft material and fill requirements of some 13.5 million m3. Consequently unit prices are developed for a one way fill haul and also for the round trip option discussed in the previous paragraphs.

When adjusted for Panama fuel and labor costs, the model indicates typical unit costs of $7.03 per m3 for recovery and transport of fill material with a one way haul and $6.09 per m3 for a combined operation. In reviewing the difference in costs for the combined operation, it is important to note that the major component of the sand borrow cost is the extraction of material, which will require a separate dredge operation at the borrow site. The principal saving for the combined operation is then the avoidance of an empty return haul for the disposal or fill operation.

Location and Characteristics of Dike Material

Much of the shoreline and sub bottom area from the Canal to the Port of Vacamonte shows evidence of significant rock deposits at shallow depths. The existence of numerous outcrops of rock in the high areas along the shoreline in the vicinity of the project site also indicates the presence of rock deposits close to the project area.

As shown in Figure 6-6, there are also a number of commercial and private quarries that have been developed in the immediate project area. The closest rock source to the project is located at the south end of the Howard runway where material was used to build an extension to the runway some years ago.

The rock material from all of these sources is as described in Section 3 of this report, and has been used for many of the shoreline projects in Panama.

558200_Fig06-06.dwg 28 Jun 2005 - 12:51am; jmacpherson; © Moffatt & Nichol

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FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Location of Existing Rock Quarries Close to Project Site

Fig 6-6

6.2.4 Cost Analysis of Materials Source Options

A cost model was run of the various materials options that could be used for the reclamation and fill elements of the project. These models were based on the same computer simulations that were created for the Artificial Island and Materials disposal studies. However, given the significant increase in fuel and other key costs since the preparation of the original evaluation in 2003, the input to each transport model was updated to take into account inflation and the more critical cost items.

Dredging and transportation costs for sand borrow operations were computed using the USACE cost model methodology, which has already been updated to reflect 2005 values. The cost analyses cover the following options:

1 - ACP materials from new Locks project

- 15 million m3 of rock material using:
  - Rail
  - Truck Haul
  - Barge Haul

2 - Sand Borrow from a location due west of Taboga

- 13.5 million m3 of imported sand, hydraulically placed
  - Assumes a combined borrow and dredge disposal operations

3 - Rock from Quarry at Howard runway south end

- 1.5 million m3 of quarry run rock, transport by truck

4 – Rock from quarry at Bique – Transport by barge

6.2.5 Fee for fill material

For a commercial contractor, the extraction of material from the seabed or the purchase of rock from ACP will require payment of a license or fee on a volume or tonnage basis. It is understood that contracts for recent purchases of ACP material have involved a materials fee of $2.50 per m3, and also that a similar fee would be required for sand extraction.

However, since this is likely to be a Government sponsored project, it is suggested that either ACP or the relevant government department may wish to waive the fee for all classes of material from state owned or controlled sites. In this way, the government can make an in-kind contribution to the project with a value of approximately $42 million.

The cost estimates presented in this comparison all assume that there would be no fee payable for materials extraction. Other suggestions to defray infrastructure costs are presented later in this report.

6.2.6 Transportation Cost Analyses

The results of the transportation cost analyses are presented in Table 6-3. While it is acknowledged that there are many variables associated with the cost comparisons and analyses, it would appear that the use of imported sand and local quarry material represents the most cost effective option from a pure transportation point of view. However, difference in cost is small and the full impact of the cost variations cannot be evaluated until a global cost estimate is prepared for the project taking into account the differences in construction techniques and berth designs associated with each class of fill material. As an example, the use of sand fill requires the construction of retaining dikes and also requires a transfer station and hydraulic pumping to move the material to the fill location inside the diked area. The use of rock from the Locks excavation does not require the retaining dikes and the fill can be end dumped from trucks or rail cars. However, the top elevation of the rock fill should be limited to some 3.00 m below the paved area to allow for drainage and utility corridors and the installation of other underground structures.

Full details of the cost models for each mode and location are shown in Appendix E to this report.

Table 6-3: Transportation Costs for Alternative Materials and Sources

Material/Source	Transport Method	Estimated Volume (m3)	Unit Transport Cost ($/m3)	Total Transport Cost ($)
Excavation from Locks Project	Truck	16,500,000	$10.97	$181,005,000
	Rail	16,500,000	$10.97	$181,005,000
	Barge	**16,500,000**	**$7.16**	**$118,140,000**
LOWEST COST USING LOCKS MATERIAL				***$118,140,000***
Sand Fill from Borrow Site				
As return leg after dredge disposal	**Barge**	**16,317,400**	**$6.09**	**$99,372,966**
As independent voyage	Barge	16,317,400	$7.03	$114,711,322
Quarry Material from Howard	**Truck**	**1,915,000**	**$7.50**	**$14,362,500**
Quarry Material from Bique	Barge	1,915,000	$12.25	$23,458,750
LOWEST COST USING IMPORTED SAND FILL				***$113,735,466***

Lowest cost options are highlighted
In place sand fill volume is increased by 10% to compensate for compaction
Quarry material costs include blasting and face clearance.

6.2.7 Summary of Materials Options

Based on this preliminary assessment, the most cost effective option for construction of the island appears to be the use of imported hydraulic sand, contained within rock dikes from the Howard quarry or possibly from a quarry used to develop the 700 m road connection from the Coastal Highway to the Port site. However, the construction of the haul road for moving Locks material is a direct contribution to the cost of the permanent works for the project. At the same time, the implementation of a dredged materials disposal operation combined with the hydraulic fill option offers reductions in cost for both elements of the work.

With relatively few work items and high materials volumes, modest changes in the bid prices for the materials movement contracts can make major changes in the final total of the work. Given that the difference in the lowest cost Locks material option and the

imported sand option is less than 10%, either alternative is considered to be attractive from a lowest cost standpoint.

However the major advantage of the use of imported sand is that the work schedule for the Port will not be tied to the implementation and work program for the New Locks project. This is a major advantage and indicates that the use of imported sand will be the island construction method of choice, assuming that all permits and approvals can be obtained for its extraction.

6.3 Foundation Conditions Assessment

6.3.1 Container Yard Area

Site Stabilization Requirements

At the sites under consideration, the thickness of the alluvial sediments that overlay the weathered rock varies from 2.5 m to 10 m. Based on the limited boring information available, the sediments appear to comprise very soft silty clays. An average water depth of 2.5 m and an average top of fill elevation of 8.00 m above Mean Low Water Spring Tides (MLWS) translates to a fill thickness of approximately 10.5 m.

There are two stabilization techniques that can be used for this project:

- Predredge all the soft sediments within the island footprint down to top of rock, then backfill with sand and vibrocompact the sand fill.
- Predredge the soft sediments that underlie the marginal bulkhead structure and retention dikes. Place the sand fill hydraulically over the remaining soft sediments, then install wick drains and place a rolling surcharge embankment.

Given the high volume of soft sediments to be removed and backfilled with sand, Alternate 1 is considerably more costly than Alternate 2.

The ratio of estimated settlement to thickness of the soft sediments under the weight of the sand fill is about 0.20. Accordingly, estimated long term settlement under the filled areas will range from 0.5 m to 2.0 m. Loads and vibrations from container yard operations will induce additional settlements.

To minimize these long-term settlements, the site can be preloaded with a surcharge embankment until the primary consolidation under the design loading is achieved. Typically, the height of the surcharge embankment is 3.0 m over finished grade. It appears the most practical way to progress the surcharge operation is in three

longitudinal increments beginning at the inboard edge of the marginal wharf and proceeding toward the expansion area.

To accelerate the time needed to achieve the design primary consolidation, prefabricated vertical wick drains can also be installed. The time required for surcharging then becomes a function of the wick drain spacing, not the thickness of the compressible layer. A wick drain spacing of 1.5m will reduce the surcharging time to 9 to 12 months, which would then permit paving to be placed within an acceptable construction schedule. The wick drains should be installed in all areas where the thickness of compressible sediments exceeds 2.0 m. The length of the wick drains can be reduced by installing them after the elevation of the sand fill has reached 5.0 m.

6.4 Port Location Assessment

As seen in the previous sections, the geophysical survey of the area undertaken in 2003 revealed shallow rock depths directly in front of the Palo Seco Hospital, with the elevation of the hard rock interface dropping to -12.00 m to -20.00 m below MLWS out towards the Pacific Entrance channel to the Panama Canal.

A number of location assessments were run to test the base construction cost of the island. These evaluations examine the following key criteria or requirements:

- Elimination of rock dredging in main channel and also under the berth areas
- Optimization of the quantity of soft materials to be removed to meet settlement criteria
- Optimization of fill quantities
- Provision of satisfactory grades for vehicular and rail access
- Selection of the most economic form of berth construction

Interest was also expressed in the potential to place berths on both sides of the fill structure. Consequently two locations were selected to meet this option and costs were generated for comparison with three other potential island locations.

6.4.1 Location 1

Location 1 places the front of the berth area along an alignment where the hard rock is at a depth of approximately 10 m below Chart Datum[12]. As shown in Figure 6-7, the fill

[12] Chart Datum is 0.1m above MLWS or 2.22 m below Precise Level Datum (PLD) used by ACP

area is connected to the land side with a 200 m trestle. While this option maintains the island in the shallow area closest to the shoreline, the 20 m elevation difference from the island to the main coastal highway necessitates considerable excavation to maintain a satisfactory grade. Even with significant cuts into the hills adjacent to the project site, it will be difficult to provide rail access to the island and meet the maximum recommended grades of 2.0 to 2.5%.

6.4.2 Location 2

As seen in Figure 6-8, this option moves the island approximately 900 m offshore. A 200 m open piled trestle is connected to a 700 m rubble mound causeway to permit tidal flows and flushing along the existing shoreline. However the movement of the island southwards increases the visual exposure from both the Amador Causeway and also from the proposed resort at the former Kobbe Beach area. The south end of the island also extends and surrounds Changame island requiring additional fill in the deeper water at this location

6.4.3 Location 3

The third location for the island is designed to facilitate berth construction and minimize excavation in rock prior to the placement of the berth structures. Filling will be in areas of increased depth to the hard rock layers, which will necessitate removal of significant volumes of soft material to prevent long term settlement of the container yards. The island is also moved some 300 m further east when compared to Locations 1 and 2, which will decrease the visual impact on the Kobbe Beach development projects.

As seen in Figure 6-9, the island is no longer parallel to the Canal, although this is not considered to be detrimental to navigation safety or wave protection at the berths.

6.4.4 Location 4

This option is the first of two locations evaluated with the objective of providing berths for feeder vessels on the west face of the island, in addition to those for main line vessels on the east face. A new channel is cut to the south face of the island and as seen from Figure 6-10, navigation access to the feeder berths will involve significant quantities of rock dredging.

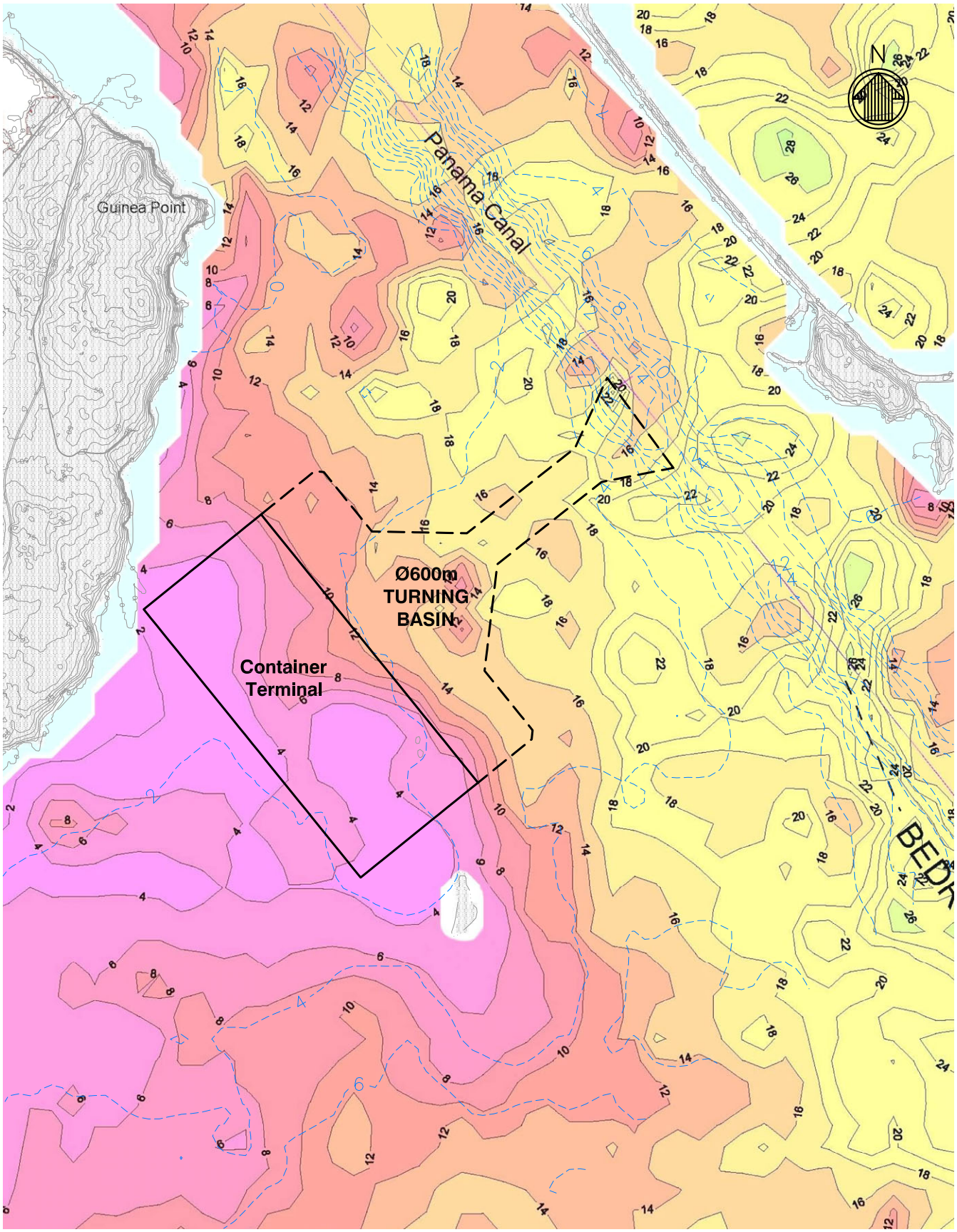
6.4.5 Location 5

The location shown in Figure 6-11 also examines the potential to place berths on both the east and west faces of the island. However, in order to minimize rock dredging for

the berths on the west face, the island was placed as close to the Canal as possible. There are significant navigational issues to be resolved with this option, which are discussed later in this report. The filling of the main reclamation area is over very soft material, which may have to be partially or fully removed to avoid long term settlement problems, depending on the outcome of detailed site investigation studies.

6.4.6 Location 5A

To provide a direct cost comparison with Locations 1 to 3, Location 5A involves the construction of a terminal close to the western limits of the Canal, at the same location as Option 5, but without feeder berths on the west face of the terminal.



Notes:
1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m
SCALE: 1 : 25000

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Figure 6-7
Port Location Option 1

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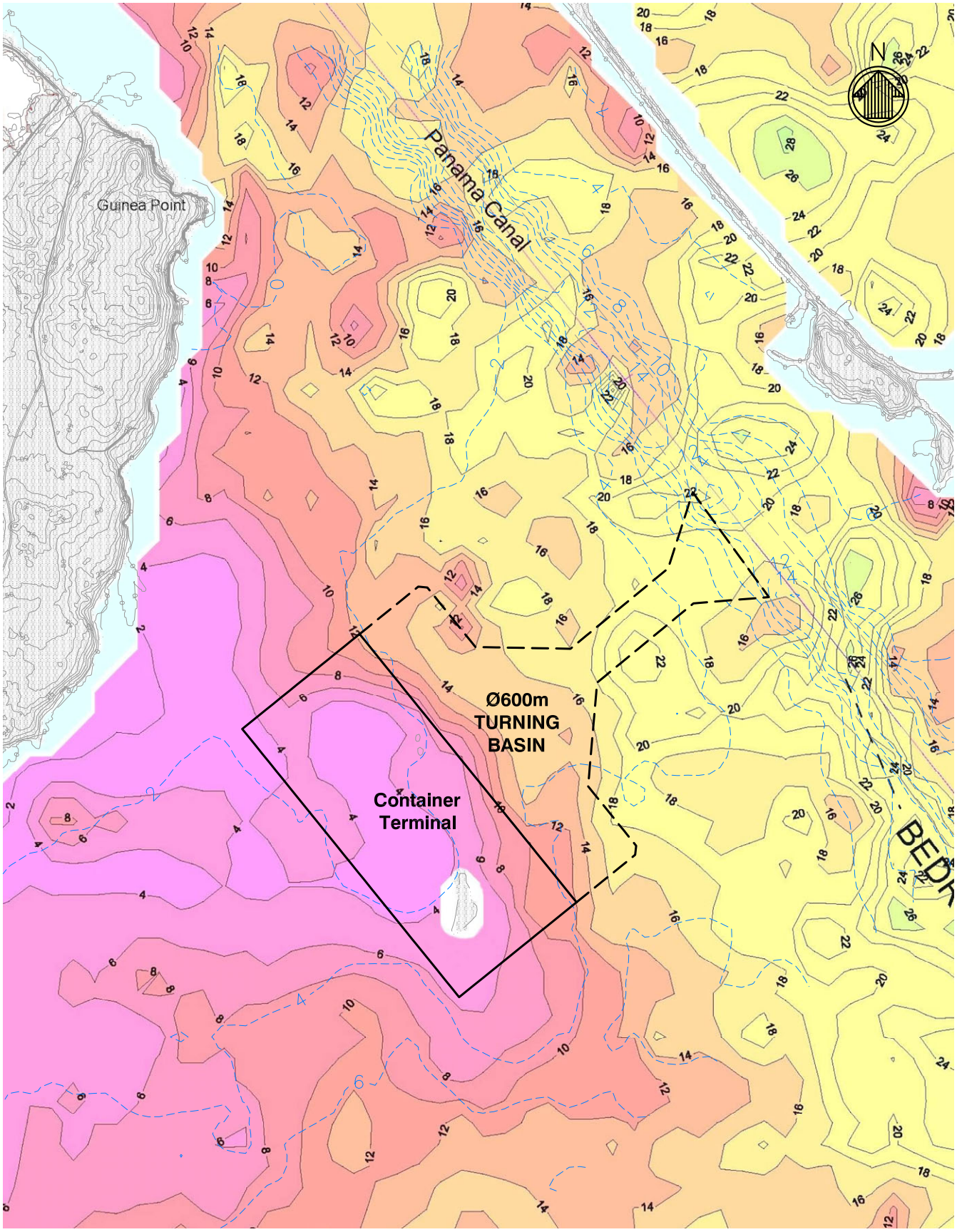

Notes:
1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m
SCALE: 1 : 25000

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Figure 6-8
Port Location Option 2

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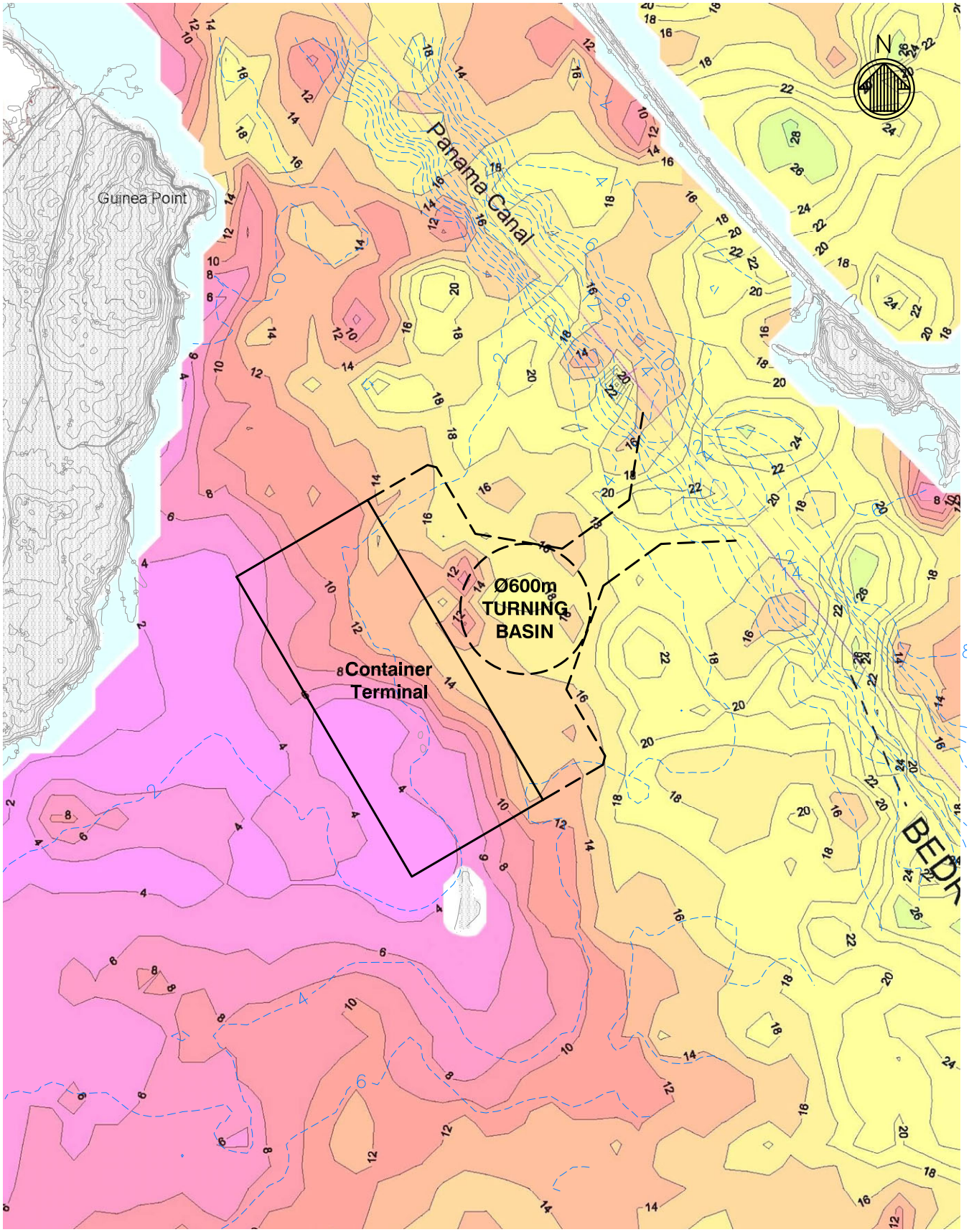

Notes:
1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m
SCALE: 1 : 25000

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Figure 6-9
Port Location Option 3

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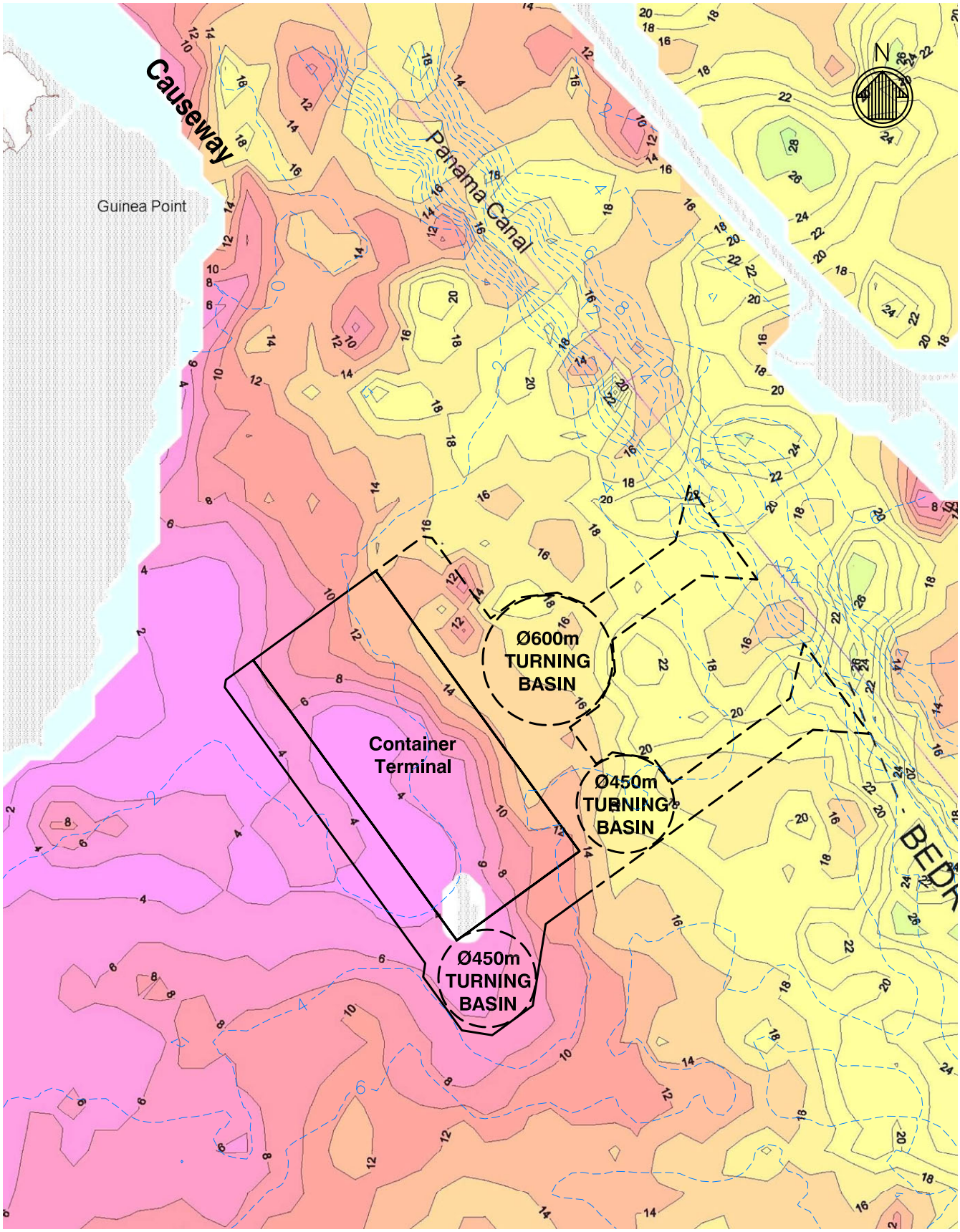

Notes:

1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m

SCALE: 1 : 25000

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Figure 6-10
Port Location Option 4

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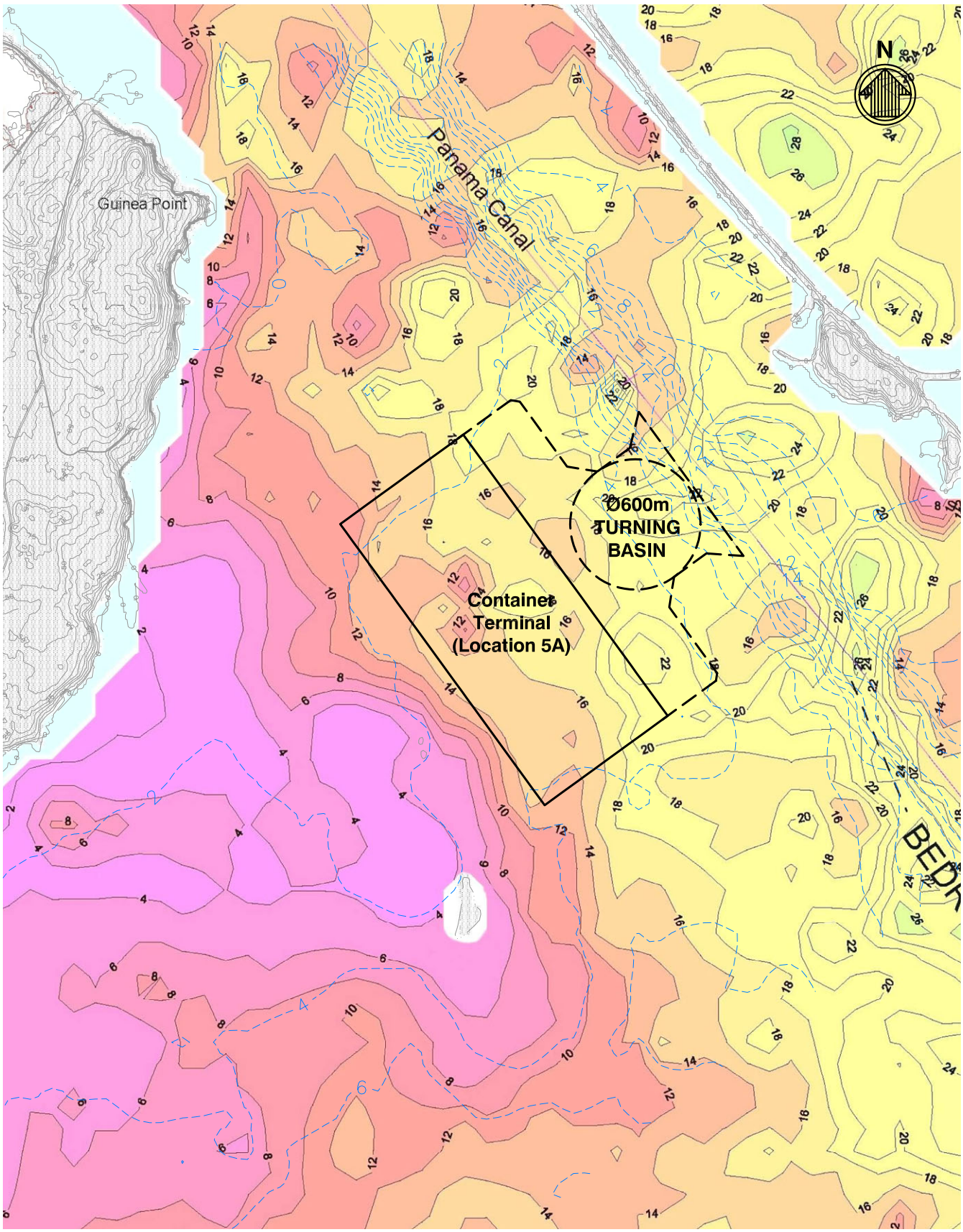

Notes:

1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m

SCALE: 1 : 25000

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Figure 6-11
Port Location Option 5

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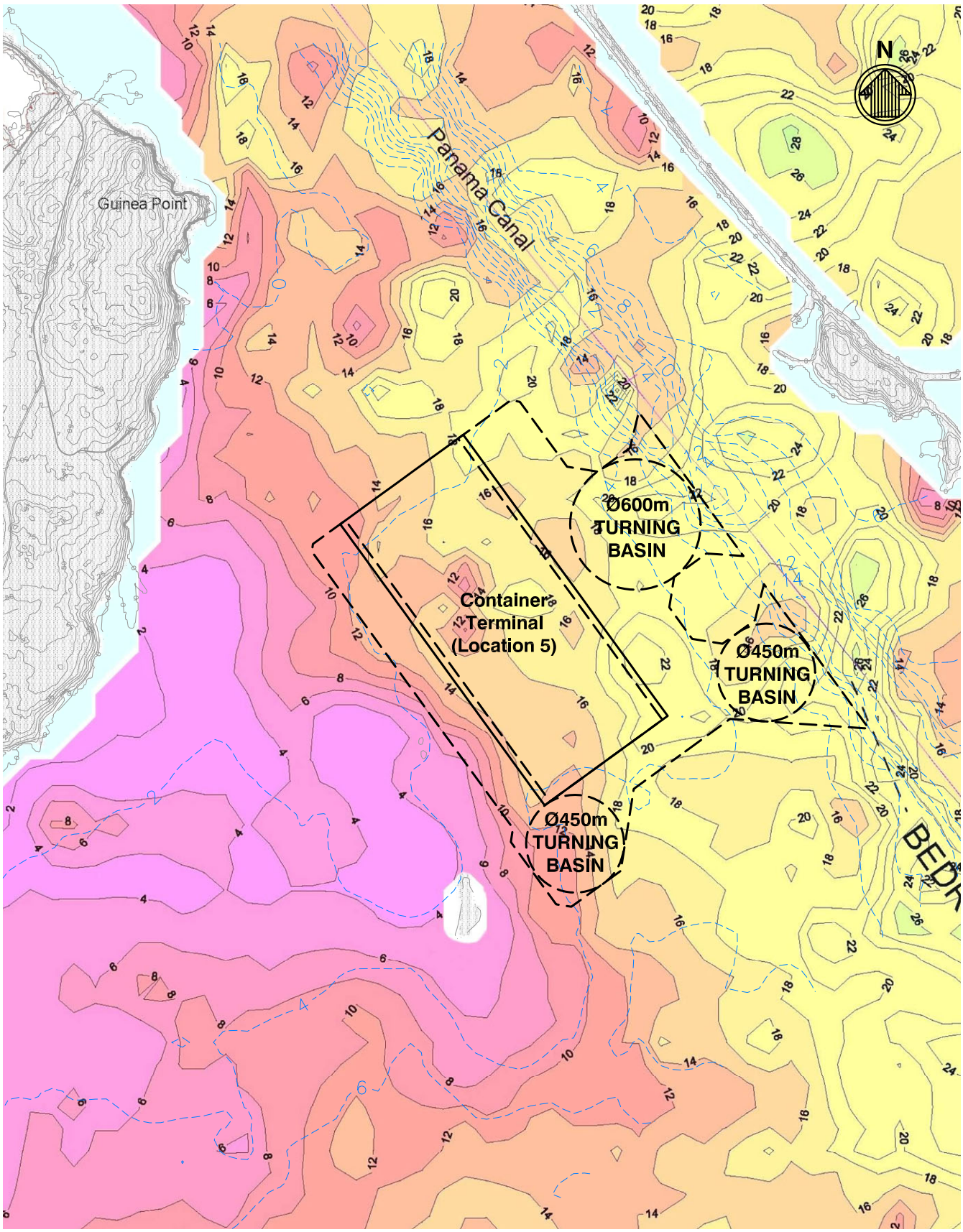

Notes:

1. Contours Referenced to MLWS
2. Seabed Contours Shown Thus ----2---- Bedrock Contours Shown Thus ——8——

250m 0m 250m 500m

SCALE: 1 : 25000

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Figure 6-12
Port Location Option 5A

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6.4.7 Cost Comparison of Options

Table 6-4 shows a comparison of base costs of construction of the island at the five locations presented earlier. The costs presented in the comparison cover the following project elements:

- Trestle/causeway connection from shoreline to island
- Pre dredging of soft materials in fill and berth areas
- Dredging of access channel, berthing area and turning circles
- Dredging of rock
- Dikes or revetments to retain fill, assuming imported sand option
- Fill material

It is important to note that this is not a total estimate for the island project. Items such as berths, terminal paving, rail connections, utilities etc., which are common to all locations are not presented, since they do not impact the outcome of the selection process

Based on the assessment, it would appear that Location 5A is the least cost location for the island, with a base infrastructure cost of $249.3 million, although extensive ground treatment will be required to accelerate the consolidation of the soft material. Location 3 is the next lowest cost at $257.4 million. Operationally, there may also be limitations on the development of Location 5 and 5A, since the (east) berths will be relatively close to the Pacific entrance channel to the Canal.

It is also important to note that the cost of the marine structures may vary at each location. It is therefore critical to generate total cost estimates of the favored alternatives before any conclusions can be developed on the preferred location for the proposed Port.

Table 6-4: Island Location Analysis

	Description	Unit	Unit Rate (US$)	Location 1	Location 2	Location 3	Location 4 Expanded Berths	Location 5 Expanded Berths	Location 5A	Comments
	General Data									
1	Island Area	Ha		112.0	112.0	112.0	112.0	112.0	112.0	
2	Causeway	m		0	750	600	870	950	950	causeway length varies in relation to island location
3	Trestle	m		200	200	200	200	200	200	assume identical trestle length for all locations
4	Average Settlement Allowance	m		0.8	0.7	1.3	1.1	2.8	2.8	20% of sediment layer
	Fill Factors									
5	Shrinkage Factor	%		90%	90%	90%	90%	90%	90%	
	Island Fill/Grading Calculations									
6	Pre-dredge soft material for dike	m3		460,000	830,000	1,100,000	540,000	2,224,000	4,783,000	
7	Fill Material Required (unfactored)	m3		11,285,000	12,050,000	11,842,000	11,880,000	12,750,000	12,750,000	to top of bedrock (add vol displaced by cell excvn)
8	Extra Fill to Allow for Settlement	m3		873,600	784,000	1,411,200	1,276,800	3,113,600	3,113,600	
9	Fill Material for Cell Pre-Dredge	m3		1,284,000	1,172,000	1,165,000	2,347,000	640,000	1,173,000	rock excavated for cell placement
10	Dike Core Material Required	m3		1,150,000	1,479,000	1,546,000	518,000	910,000	3,633,000	costed separately under items no. 13 to 15
11	Total Fill Material (7 + 8 + 9 - 10)	m3		12,292,600	12,527,000	12,872,200	14,985,800	15,593,600	13,403,600	
12	Total Material Required (incl shrinkage)	m3		13,658,444	13,918,889	14,302,444	16,650,889	17,326,222	14,892,889	
	Retaining Dike/Revetment Calculations									
13	Island Revetment/Dike Armor Stone	m3		225,000	258,000	225,000	71,400	98,000	420,000	
14	Island Revetment/Dike Underlayer Stone	m3		144,000	159,000	144,000	43,400	56,000	240,000	
15	Island Revetment/Dike Core Stone	m3		1,150,000	1,479,000	1,546,000	518,000	910,000	3,633,000	calculated per item no. 10
	Dredging Calculations									
16	Dredging in Soft Material	m3		12,238,000	12,528,000	13,545,000	19,074,000	21,396,000	11,009,000	Includes pre-dredging for cell installation
17	Dredging in Weathered Rock **	m3		1,201,000	1,125,000	755,000	1,915,000	613,000	103,000	Includes pre-dredging for cell installation
18	Dredging in Dense Rock	m3		2,337,000	1,733,000	535,000	5,073,000	313,000	3,000	Includes pre-dredging for cell installation
19	Dredging Totals	m3		15,776,000	15,386,000	14,835,000	26,062,000	22,322,000	11,115,000	Calculated from DTM
Cost Summary										
	Transportation/Construction Costs									
20	Pre-dredge soft material for dike	m3	$ 6.00	$ 2,760,000	$ 4,980,000	$ 6,600,000	$ 3,240,000	$ 13,344,000	$ 28,698,000	transport soft material to offshore disposal site
21	Sand from offshore borrow source	m3	$ 6.00	$ 81,950,667	$ 83,513,333	$ 85,814,667	$ 99,905,333	$ 103,957,333	$ 89,357,333	required for island fill
22	Armor Stone	m3	$ 20.00	$ 4,500,000	$ 5,160,000	$ 4,500,000	$ 1,428,000	$ 1,960,000	$ 8,400,000	required for retaining dike
23	Underlayer Stone	m3	$ 15.00	$ 2,160,000	$ 2,385,000	$ 2,160,000	$ 651,000	$ 840,000	$ 3,600,000	required for retaining dike
24	Core Stone	m3	$ 10.00	$ 11,500,000	$ 14,790,000	$ 15,460,000	$ 5,180,000	$ 9,100,000	$ 36,330,000	required for retaining dike
25	Causeway	Lm	$ 10,000.00	$ -	$ 7,500,000	$ 6,000,000	$ 8,700,000	$ 9,500,000	$ 9,500,000	based on calcs from island study (escalated)
26	Cofferdam Cells	Lm		$ -	$ -	$ -	$ -	$ -	$ -	cell construction is made same at all locations
27	Berth Structure	Lm		$ -	$ -	$ -	$ -	$ -	$ -	berth construction is made same at all locations
28	Trestle	m	$ 22,977.11	$ 4,595,421	$ 4,595,421	$ 4,595,421	$ 4,595,421	$ 4,595,421	$ 4,595,421	
29	**Total Construction Costs**			$ 107,466,088	$ 122,923,755	$ 125,130,088	$ 123,699,755	$ 143,296,755	$ 180,480,755	
	Dredging Costs									
30	Dredging in Soft Material	m3	$ 6.00	$ 73,428,000	$ 75,168,000	$ 81,270,000	$ 114,444,000	$ 128,376,000	$ 66,054,000	
31	Dredging in Weathered Rock **	m3	$ 25.00	$ 30,025,000	$ 28,125,000	$ 18,875,000	$ 47,875,000	$ 15,325,000	$ 2,575,000	rate includes drilling and blasting
32	Dredging in Dense Rock	m3	$ 60.00	$ 140,220,000	$ 103,980,000	$ 32,100,000	$ 304,380,000	$ 18,780,000	$ 180,000	rate includes drilling and blasting
33	**Total Dredging Costs**			$ 243,673,000	$ 207,273,000	$ 132,245,000	$ 466,699,000	$ 162,481,000	$ 68,809,000	
34	**Totals**	**$**		**$ 351,139,088**	**$ 330,196,755**	**$ 257,375,088**	**$ 590,398,755**	**$ 305,777,755**	**$ 249,289,755**	
35	**Island Area**	Ha		112.0	112.0	112.0	112.0	112.0	112.0	
36	**Cost per m2**	$/m2		$ 313.52	$ 294.82	$ 229.80	$ 527.14	$ 273.02	$ 222.58	

*** Assumed weathered rock layer thickness of 1.5m*

6.5 Marine Structures

6.5.1 Design References, Standards, and Codes

Design References, Codes and Design loads for the preliminary structural assessments are presented in Appendix D to this report. In all cases, the design criteria and loading conditions were developed to be consistent with the state-of-the-art facility requirements for a Super Post-Panamax container terminal.

6.5.2 Wharf Structural Alternatives

The selection of the preferred berth structure requires an assessment of design criteria, water depth, vessel characteristics, foundation conditions, life cycle requirements, maintenance considerations and the need to provide lateral support requirements for the filled material.

While there are numerous design approaches for marine terminals, the three fundamental classes of structure are:

- Gravity structure, using concrete or stone blocks
- Open piled wharf with concrete decking (steel or concrete piles)
- Cofferdam or caisson structures

For this project, the water depth at the berth face eliminates consideration of a gravity structure, which is also difficult to deepen in the future. This then effectively leaves the open piled berth or the caisson type structure as valid alternatives for further analysis.

Open-type structures are pile supported and use a berm or dike underneath the wharf structure to retain fill and provide lateral resistance. Some structure configurations include precast box beams, flat slabs with piles, pile supported composite panels, and pile supported cast-in-place slab and bents.

A solid-type marginal wharf structure has a continuous vertical face at or near the face of the structure. Such structures include cellular cofferdams, sheet pile bulkheads, concrete gravity walls, or any type of structure that contains backfill while providing a safety factor against sliding and overturning.

For the Palo Seco/Farfan project, the main reclamation material may well be imported sand that must be retained around the periphery of the site. Given a crest elevation of 8.30 m above MLWS and potential long term water depth of 18.5 m below MLWS, the materials requirements for the retaining structure under the berth face is significant.

Consideration of the cofferdam alternative is therefore a valid approach, given its ability to provide the fill containment structure and also support the berth apron and imposed loads from container cranes etc.

Both open- and solid-type structures have advantages and disadvantages which must be weighed alongside site geotechnical and foundation conditions as well as other operational and maintenance considerations to determine the structure alternative that best combines function, constructability, and maintainability at the most reasonable cost.

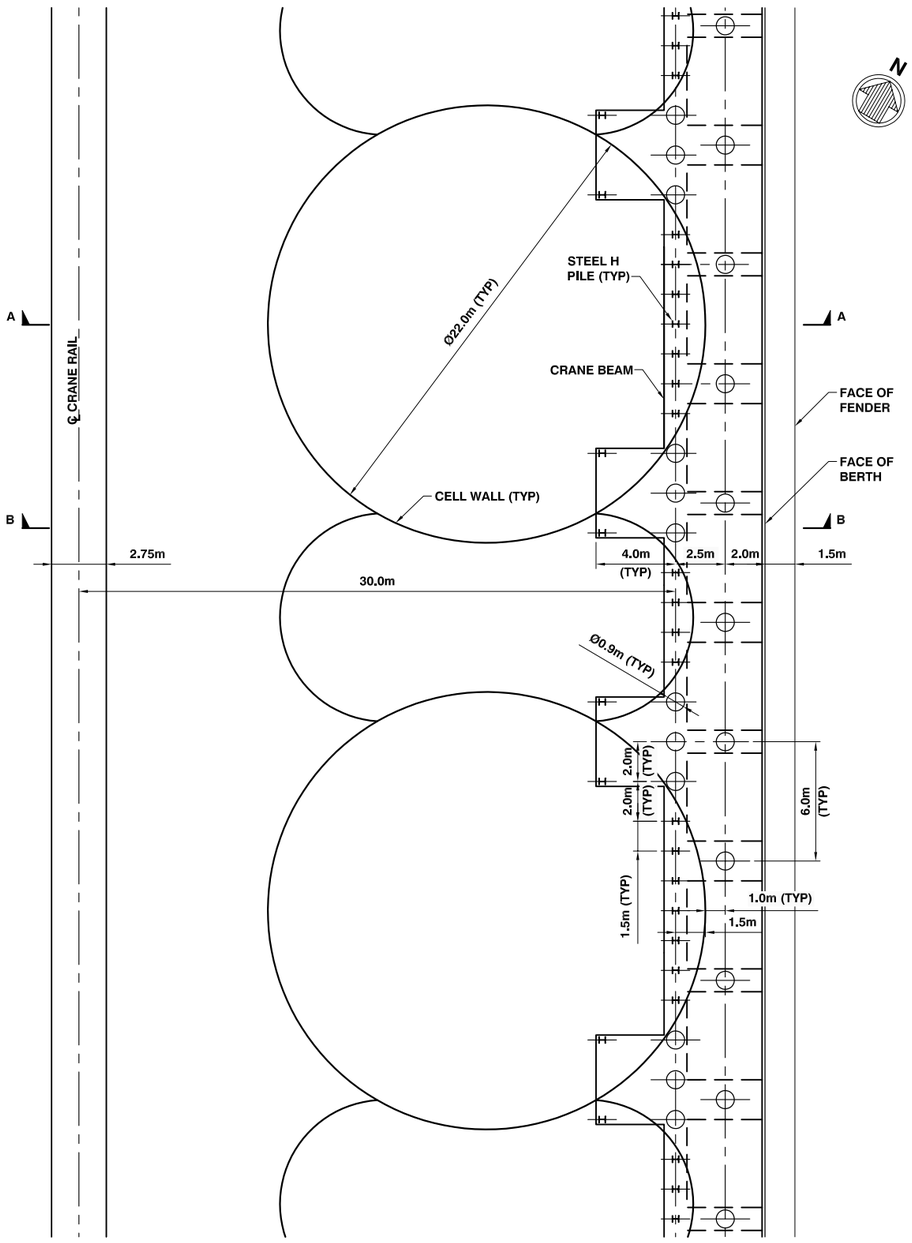
6.5.3 Structural Alternatives

Cellular Cofferdam Structure

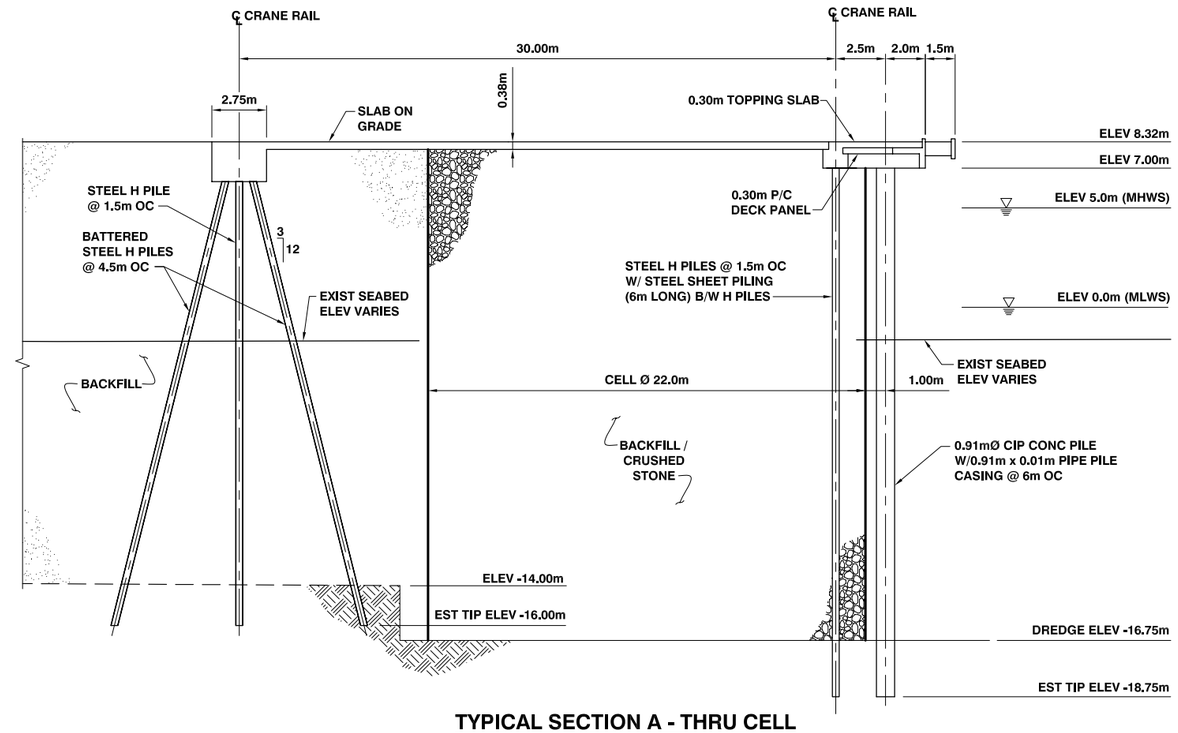
The concept shown in Figure 6-13 consists of a cellular cofferdam with a composite panel superstructure. Rock is dredged to elevation -16.75 m through to the back of the cells. With the cells positioned 3 m from the face of the berth. The crane beam is located 1.5 m inside the face of the cell where it is supported by steel H piles and steel sheet piles. For the section between the circular cells and the arcs, the beam is carried by concrete filled steel pipe piles spaced at 2 m centers.

Open Piled Structure

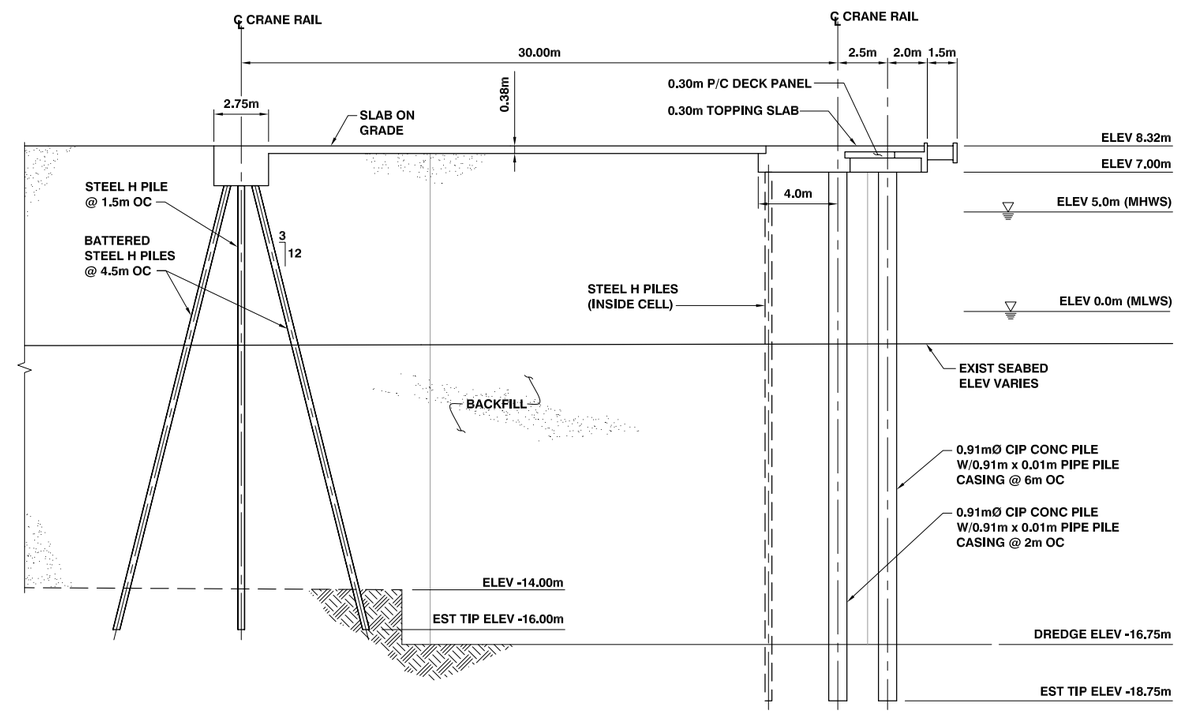
The second conceptual alternative is a typical pile supported open-type wharf structure with a composite panel deck with cast-in-place bents on a rock dike, as seen in Figure 6-14. As seen in the figure, the volume of rock required for the dike structure below the wharf can be substantial. It is also critical that the rock is small enough for piles to penetrate without deviation, which generally indicates that no pieces should be larger than 150 mm in diameter. Selection or crushing of the dike material is then critical to the successful implementation of this construction method.



PLAN - OPTION 2: LOCATION: 3



TYPICAL SECTION A - THRU CELL



TYPICAL SECTION B - OUTSIDE CELL

3m 0m 3m 6m
SCALE: 1 : 300

Designed by: MP
Dwn by: ARS
Ckd by: MLB
Reviewed by: MGH
Submitted by: MGH
Date: April 2005
Design file no. AS SHOWN
Rev.
Drawing Scale: AS SHOWN
Plot scale: 1=1 (11"x17")

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GOLDER ASSOCIATES

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FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Cofferdam Berth Structure

Fig 6-13

558200_Fig06-13.dwg 28 Jun 2005 - 12:58am; jmacpherson; © Moffatt & Nichol

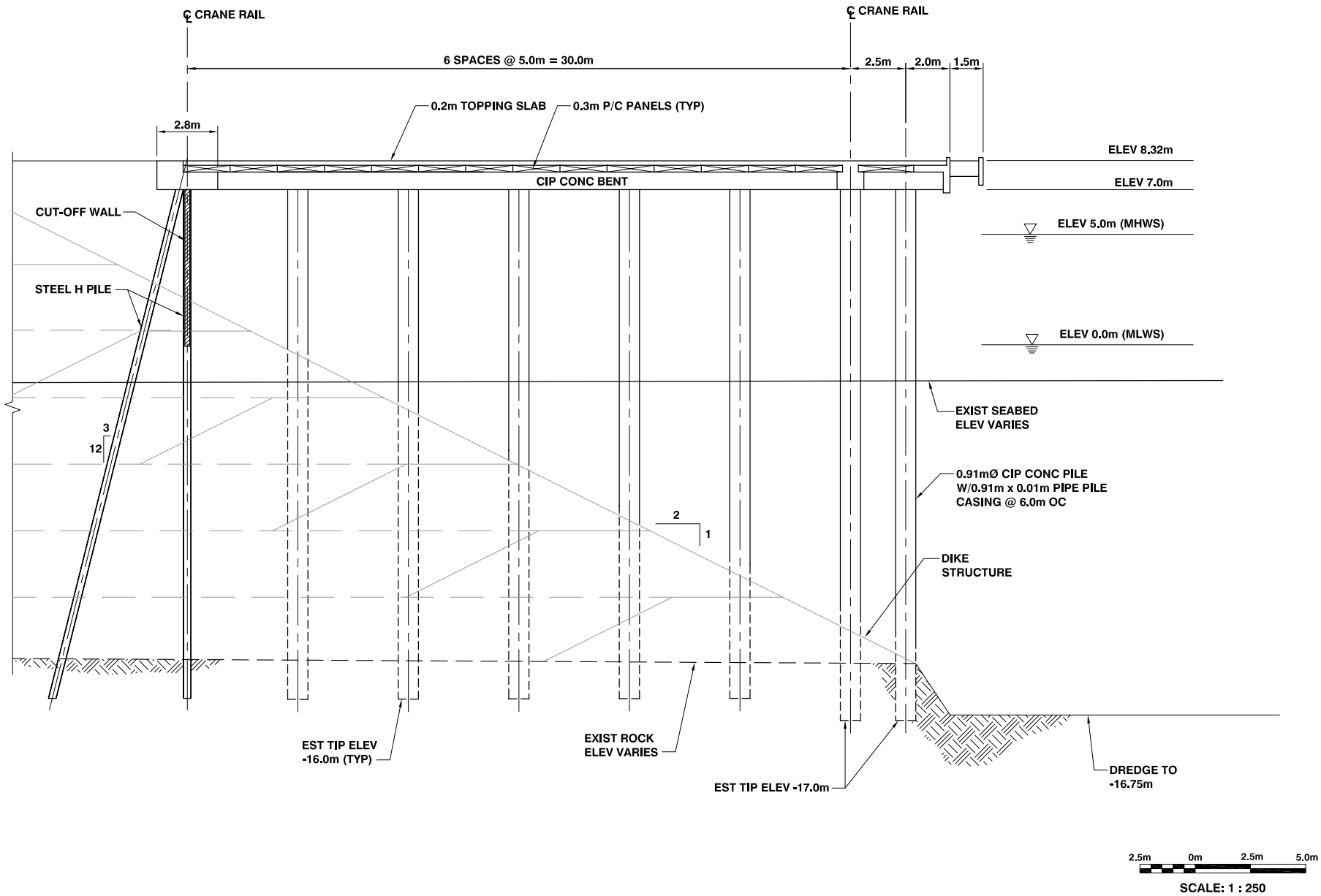

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Fig 6-14
Typical Section of Open-Piled Berth Option

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558200_Fig06-14.dwg 28 Jun 2005 - 12:58am; jmacpherson; © Moffatt & Nichol

6.5.4 Foundation Design Criteria

The weathered rock or rock beneath the sediments at the site is expected to provide an adequate foundation for both classes of berth structures. For the feasibility study, it is recommended that an allowable bearing pressure of 2,000 kPa (40 psf) be adopted, with an allowable coefficient of friction for sliding resistance of 0.47 for cellular structures supported on weathered rock or rock. The sheet piles for the coffer dam option are not expected to penetrate more than one to two meters into the weathered rock and pre-drilling may be needed to get them to penetrate into un-weathered rock. Thus, reliance on passive pressure on the front side of the sheet piles is not recommended for improving sliding resistance because of the potential for future dredging to remove the material.

Steel H-piles and concrete-filled pipe piles are being considered for support of the wharf and crane rails. Based on the information available at this time it is assumed that the piles will penetrate about 2 m into weathered rock and develop allowable capacities of 900 kN (100 tons) for HP-89 piles and 1,300 kN (140 tons) for 36 inch diameter pipe piles filled with concrete. Where the weathered rock is removed by dredging, pre-drilling the piles at least 2 m into the rock is recommended to develop the same capacity as indicated for weathered rock and to provide lateral stability.

6.5.5 Cost Comparison of Berth Options

Preliminary cost assessments were made of the cofferdam alternative and the open piled structure concept. These were then reduced to an equivalent cost per linear meter for incorporation in the global cost estimates for the preferred location alternatives for the project. Table 6-5 and Table 6-6 indicate that the cofferdam alternative appears to be the most economical berth section for this project, with an equivalent cost of approximately $1,120 per square meter or slightly less than $60,000 per linear meter of wharf. More detailed discussion and estimates for the berth options are presented in Appendices D and E of this report.

Table 6-5: Cost Estimate - Cofferdam Cell Option

Item	Cost (Location 3)
Cofferdam Cell	*$34,469,648*
Piles	*$24,272,100*
Deck	*$22,792,500*
Vessel Associated Hardware	*$3,520,000*
Crane Rails	*$2,435,000*
Associated Crane Items	*$4,295,560*
Miscellaneous :	*$884,000*
Civil/Infrastructure	*$2,769,000*
TOTAL	$95,437,808
Cost per meter	$59,625
Cost per square meter	$1,122

Table 6-6: Cost Estimate – Open Piled Berth Option

Item	Cost (Location 3)
Piles	*$64,896,250*
Deck	*$53,147,000*
Vessel Associated Hardware	*$3,520,000*
Crane Rails	*$2,435,000*
Associated Crane Items	*$4,295,560*
Miscellaneous :	*$1,134,000*
Civil/Infrastructure	*$2,769,000*
TOTAL	$132,200,000
Cost per meter	$82,625
Cost per square meter	$1,555

6.5.6 Pavement

General

The combination of very high wheel loads and channelized traffic patterns for the modern container terminal requires robust pavement sections. Factors that must be considered in the design process include:

- Soil characteristics below fill elevation
- Sub grade characterization
- Pavement and material properties
- Terminal traffic repetitions
- Container equipment wheel loads
- Operational and maintenance considerations

Sub grade

Substantial filling of the site is required to achieve the pavement sub grade elevations. Accordingly, the sub grade will consist of hydraulically placed sand (or rock) that should be preloaded with a surcharge embankment. A resilient modulus of 10,000 psi can be assumed for preliminary design.

Pavement Material Properties

The different materials that comprise the pavement sections are:

- Asphalt Concrete (AC): Superpave gradation with PG-70 binder for base and PG-82 binder for surface. A modifier such as Trinidad Lake Asphalt or various polymers should be added to the surface binder.
- Portland Cement Concrete (PCC): Minimum compressive strength of 6,000 psi and minimum flexural strength of 750 psi.
- Cement Treated Base (CTB): Mixture of crushed rock aggregate and cement. Minimum compressive strength of 1,600 psi.
- Crushed Aggregate Base (CAB): Crushed rock aggregate with a minimum CBR value of 100.

Traffic Repetitions

Since the mode by which the container yard will be operated has not yet been established, the pavement must be conservatively designed to provide maximum flexibility. Although the yard layout presented in Section 2 of the report is predicated on

using rubber tired gantry cranes, toploaders may be employed to augment the RTG operation. Toploaders impose the maximum stress repetitions and for estimating purposes the pavement section is based on 4,000 loaded toploader repetitions and 20,000 unladen toploader repetitions. If PCC runways are constructed for the RTG pads, then the runways should be designed for unlimited repetitions.

Container Equipment Wheel Loads

Characteristics of the various types of container handling equipment typically used for pavement design purposes are presented in Table 6-7, below:

Table 6-7: Container Equipment Characteristics

Equipment Type	Model	Stacking Height	Gear Configuration	Tire Inflation Pressure	Maximum Front Axle Load (pounds)
Empty Handler	Kalmar DCE90-45E8	8 High	4 Tires Front 2 Tires Rear	145 psi	84,000
RTG	Kalmar 6+Lane Wide	6 High (1 over 5)	8 Tires (4 Ea Side)	165 psi	62,200 (single wheel)
RTG	Kone 6+Lane Wide	5 High (1 over 5)	16 Tires (4 per Corner)	130 psi	31,600 (single wheel)
Straddle Carrier	Kalmar CSC-440	4 High (1 over 3)	8 Tires (4 Ea Side)	145 psi	29,200 (single wheel)
Reach Stacker	Kalmar DRD450-80S4X	5 High	4 Tires Front 2 Tires Rear	145 psi	126,100
Top Loader	Taylor TEC-950L	5 High	4 Tires Front 2 Tires Rear	115 psi	219,500

Static Loads

In addition to loading from container handling equipment, port pavements are typically subjected to static loading from corner castings on containers and either dolly wheels or sand shoes on chassis. While containers may be stacked in a block arrangement up to four high, it is unlikely that all containers in the stack will be fully loaded.

Design Procedures

Rigid pavements are typically designed using Portland Cement Association (PCA) publications based on the theory of theory of fatigue consumption. The pavements in the

entrance gate area and for the access roadways can be designed using the procedures set forth in the AASHTO “Guide for the Design of Pavement Structures”.

Recommended Pavement Section

Alternate pavement sections for the various operational areas are shown in Table 6-8, below.

Table 6-8: Pavement Design Alternates

Operational Area	AC	PCC	CTB
Wharf		14” PCC 6” CAB	
Grounded CY		17” PCC 6” CAB	3” Mod AC 22” CTB 6” CAB
Entrance Gate	3” Mod AC 6” AC 8” CAB	10” PCC 8” CAB	

AC – Asphalt Concrete
CTB – Cement Treated Base
CAB – Crushed Aggregate Base
Mod AC – Modified Asphalt Concrete
PCC – Portland Cement Concrete

6.6 Wave Protection Assessment

Wave studies were connected for the Artificial Island project by Moffatt & Nichol and also by JETRO. In both studies, the wave climate in the region of the potential island construction due to Pacific Ocean waves was evaluated to determine wave protection requirements and potential ship motion characteristics for marine terminal options. This analysis involved the development and evaluation of the offshore metocean data and the transformation of the offshore wave climate to the study region.

An overview of the results of the evaluation is presented in this section and the reader is referred to Appendix F of the Artificial Island Study for a more complete discussion on the offshore and near shore wave climates.

6.6.1 Wave Hindcasts

Methodology

A 31 year wave hindcast was obtained from Oceanweather Inc., covering the period from early 1970 through the end of the year 2000. The hindcast process involves the collection of historical wind and wave data from a number of locations and the transfer of the wave data to a given site, based on wind data, bathymetry and physical characteristics of the study zone.

The hindcast used Oceanweather's Global Reanalysis of Ocean Waves (GROW) model to produce a time series of wave parameters at a location just offshore of the entrance to the Gulf of Panama as shown in Figure 6-15.

Figure 6-15: Location of Deep Water Wave Model Grid Point

Model Results

The wave climate due to ocean waves in the area of the proposed project is relatively mild with the geometry of the Gulf of Panama and South America limiting the directions of waves entering the region. The 100-year return period significant inshore wave height was computed to be 0.7 meters with a 17 second period. These long period waves are generated by storms in the Pacific and can cause considerable movement of a vessel at an unprotected or partially protected berth. This in turn can lead to accelerated fender damage, inefficient or restricted cargo operations and other operational difficulties.

More details on the wave modeling for the project can be found in Appendix C to this report.

6.6.2 Locally-Generated Waves

Wind Speed and Direction

Wind speed and direction data were obtained from the Balboa FAA records for the period 1985 through 2001. These data were then used to hindcast the locally-generated waves that would impact the various island locations. The records show that maximum hourly average wind speeds from any direction are generally less than 16 knots, with slightly less than one percent (0.94%) of the recorded winds in the 11 to 16 knot range, which is typical of the tropical coastal conditions.

Wave Hindcast Computations

Wind-generated wave calculations were completed for the southwest and east directions. In accordance with procedures recommended by the U.S. Army Corps of Engineers (USACE), Coastal Engineering Manual (CEM) (USACE 2001), a radially averaged fetch distance was computed for the two directions (70 km from east and 24 km from southwest as stated above).

Hindcast results presented in Table 6-9 predicted significant wave heights of about 1.0 m from the east and 0.6 m from the southwest. These wave heights are comparable to those from the Pacific Ocean that have been reduced due to protection from the Pearl islands and from Taboga and Taboguilla.

These waves could impact operations on the west face of the island in the event that additional berths are constructed at the rear and south faces of the Container Terminal.

Table 6-9: Locally-generated Significant Wave Heights (m), Maximum Wave Heights ($H_{2\%}$), and Peak Spectral Wave Periods (sec)

Wave Direction	H_S	$H_{2\%}$	T_P
East	1.0	1.8	4.1
Southwest	0.6	1.1	3.1

6.6.3 Conclusions

Panama Bay is well protected from ocean swells generated in the Pacific Ocean, which limits the expected 100 year significant wave height at the island site to 0.70 m from the south or south west, with a 17 second period. In general terms, any wave period in excess of 7 seconds is considered to be “long” and possibly problematic from a ship motion standpoint. Given the high level of protection afforded by Taboga and Taboguilla to the south and the Amador Causeway to the east of the project site, it is not expected that long period waves will be a significant concern for vessels at the main berth face.

However, as a cautionary measure, it is strongly recommended that a wave gauge with the capability to detect long period waves should be installed for at least a 12 month period at the project site before final design work is commenced on the project. This gauge may be either bottom mounted or a wave rider style with capabilities for automatic transfer of data to a receiving station plus a storage capacity within the unit itself.

Locally generated wind waves are higher at 1.0 m from the east, with a 4.1 second period, but the site is well protected by the Amador Causeway.

According to the wind data used for this analysis, the 1.8 m maximum wind generated wave from the south and southwest is of very short duration. The new location for the Container port is well protected, but the potential for a short duration storm and the high tidal range at Panama could cause damage to inadequately protected faces of the island.

6.6.4 Wave protection Needs

As noted in the previous section, the most severe exposure on the island is from the south and southwest, although the berth areas will also be subject to wash from ships entering and leaving the Canal.

Coastal Armor Protection

A 1.0 meter, 4.1 second wave was used as the design wave condition to size the armor stone and select the class of materials to be used.

The stone size for a 2:1 side slope was computed to be 1.0 tonne, and consists of two layers of placed rock for a total layer thickness of 1.5 m. The Shore Protection Manual (USACE 1984) recommends that under layer stone range of 1/10 to 1/15 of the armor weight. This results in a relatively large under layer that permits surface interlocking with the armor and gives a more permeable structure and improved stability. For the coastal

structures, the under layer will be sized at 0.1 tonnes, 1/10 of the armor weight and the thickness of the under layer would be 0.5 m.

The computed size of rock is well within the range of armor stone that can be obtained from the local quarries identified in earlier sections of this report.

Toe stability is essential because failure of the toe will generally lead to failure throughout the entire structure. The structures will include a 5 meter bench of 1.0 tonne armor stone overlying smaller quarry run stone on the bottom.

Overtopping formulae developed by van der Meer (1992) indicated that the recommended crest elevation for armor stone is 5.5 meters above MLWS.

6.7 Navigation Assessment

6.7.1 Navigation Access & Dredging

Navigational Requirements

Ships calling at the new terminal will access the berths from the Panama Canal using a connection channel to a maneuvering area in front of the berth area. This channel will be on the order of 1.0 to 1.25 km in length, depending on the final location of the filled area.

Operational Criteria

Since operations at the new terminal will be controlled to a large extent by the schedule of container vessels transiting the Canal, the following operational considerations are critical:

- Unrestricted, 24 hour transit for all but the largest cargo vessels
- State of the art vessel traffic control system.
- Tug assistance will be provided for all vessel berthing operations
- Pilotage will be required for all vessels

6.7.2 Impact on Panama Canal Operations

Clearly the location of the new channel within the Pacific entrance to the Canal will have an impact on Canal operations, similar to the entrance to the existing Port at Balboa. Close coordination of the final orientation and location of the navigation approaches to

the Port will be required with relevant ACP divisions in order to provide the solution that is satisfactory to all parties.

6.7.3 Design Criteria

Design Standards

The navigation channel dimensional recommendations are based on a synthesis of the following publications:

- Permanent International Association of Navigation Congresses (PIANC), International Commission for the Reception of Large Ships (ICORELS), "Optimal Layout and Dimensions for the Adjustment to Large Ships of Maritime Fairways," Report of Working Group IV, 1980.
- National Ports Council (NPC), "Port Approach Design- A Survey of Ship Behavior Studies," London, U.K, 1975.
- US Army Corps of Engineers, "Hydraulic Design of Deep-Draft Navigation Projects, " EM 1110-2-1613, 1983.
- TERMPOL - Canadian Coast Guard (1977)
- US Navy, Naval Facilities Engineering Command, Design Manual DM-26.1 "Harbors," 1981.

Other pertinent publications are referenced in subsequent paragraphs where appropriate. However, the above references provide the basis for channel depth, channel width, and turning basin requirements.

Channel Depth

Channel depth requirements are taken from the above referenced U.S. Army Corps of Engineers document. The required channel depth relative to a referenced water level must be based on:

- Loaded vessel draft including trim
- Squat
- Wave induced motions
- Safety Clearance
- Dredging Tolerance

- Advanced Maintenance Dredging

All dredging depths and drafts are referred to Mean Lower Water Spring tidal elevations (MLWS) which is equivalent to 2.32 m below Precise Level Datum (PLD) as defined in the Panama Canal Clearance Diagram.[13]

Loaded Draft

For the purposes of this report, a fully loaded draft of 15.00 m has been used for planning purposes.

Squat

The position of a vessel's keel relative to the channel bottom will lower as the vessel speed increases. This phenomenon results when increased water velocities flowing past a moving ship hull produce a localized lowering of the water surface. In general, squat is a function of the vessel speed, under-keel clearance, channel width, channel depth and vessel dimensions.

Wave-Induced Motions

Given the protection of the channel by the Amador Causeway to the east and Taboga and Taboguilla islands to the south, wave induced motion is unlikely to exceed 0.5 m. However vessels at berth will be susceptible to ship wash from ships transiting the Canal. Assuming that vessel speeds in the Canal in the Pacific Entrance will be less than 12 knots, wave heights from ship wash are unlikely to exceed 1.0 m. Since the duration and period of the wave motion is relatively short, it is not expected to cause any significant motion of the vessels at berth.

Safety Clearance

A detailed subsurface investigation program is necessary to determine the extents of potential hard spots within the channel area. However, based on existing data presented later in this report, the dredged bottom in the channel and at the berth face may be a mix of silts and hard rock areas. For this study, a safety clearance of 0.75 m has been adopted.

[13] Panama Canal Clearance Diagram, Drawing Ref 6120-30C, Panama Canal Authority July 1999

Dredging Tolerance

There are inherent difficulties in dredging a uniform and highly accurate depth and the application of a dredged tolerance is a widely accepted standard. An additional depth of 0.5 m should therefore be included as a pay item..

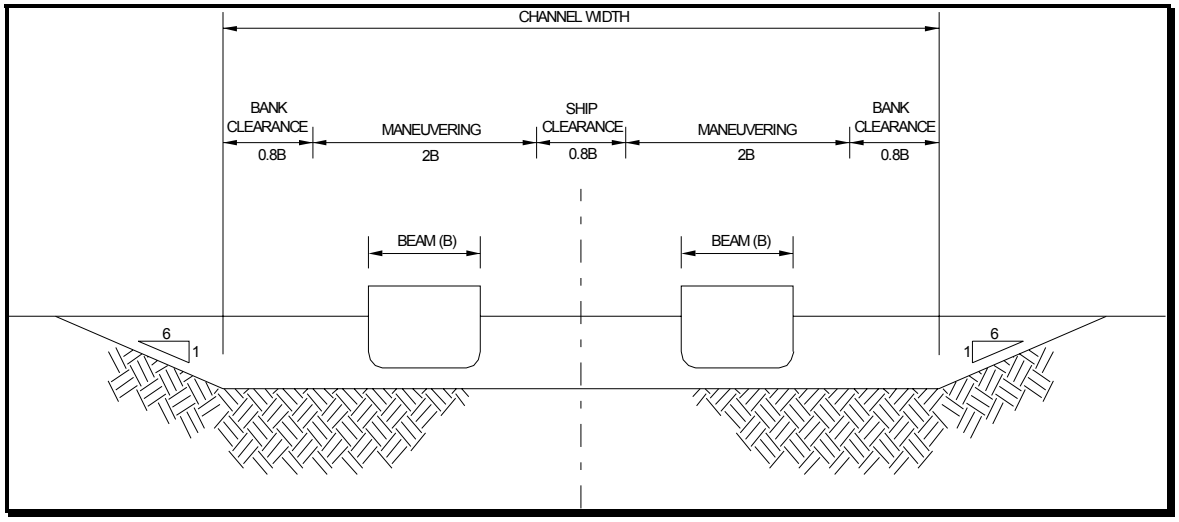
Advanced Maintenance Dredging (AMD)

Additional depth can be added to the channel in order to allow for accumulation of sediment between maintenance dredging events. This prevents the premature loss of project depth and increases the length of time between dredging events. Given the apparent stability of the bottom contours in the area and in the absence of any indications of high sediment rates in the Canal, an allowance for AMD is not required as part of the capital dredging work.

Channel Width

The minimum width of a straight channel depends on the size and maneuverability of the vessel navigating the channel, the type of channel bank, the effect of other vessels in the channel and the effects of wind and currents. The width standards shown in Figure 6-16 take into account space for a maneuvering lane, ship clearance and bank clearance.

Figure 6-16: Typical Width Dimensions of a Straight Dredged Channel



Recommendations

Navigation access to the new terminal will be required from the south and north directions.

A wide range of vessels will use the connecting channel, ranging from small feeder vessels of less than 1,000 TEU capacity to ships capable of carrying ten times that volume of containers[14].

Given that the channel will be relatively short, it is unlikely that two of the larger ships will be permitted to pass in the access channel. However, it is quite possible that a large and a mid size or smaller vessel could be maneuvering in the port area simultaneously. Consequently, the following operating conditions were assessed in order to determine the optimum width and dimensions for the approach channel

Case 1.....One way traffic - Post Panamax vessel, 8,500 TEU s

Case 2..... Two way traffic – feeder vessels

Case 3.....Two way traffic – Panamax Vessels

Channel Width

Table 6-10 sets out the criteria for channel width under the considerations noted above.

[14] China Shipping Container Lines (CSCL) have announced plans to build 9,400 TEU vessels to be followed by a 10,500 TEU series of ships. Star News, 2004

Table 6-10: Access Channel Width Recommendations

Factor	1 Way Super Panamax	2 Way Feeder	2 Way Panamax
Basic maneuvering lane	1 x 1.8	2 x 1.8	2 x 1.8
Addition for speed	0	0	0
Addition for cross wind	0	0	0
Addition for cross current	0	0	0
Addition for longitudinal current	0	0	0
Addition for waves	0	0	0
Addition for Nav. Aides	0.1	0.1	0.1
Addition for bottom surface	0.2	0.2	0.2
Addition for waterway depth	0.4	0	0.2
Addition for cargo hazard	0	0	0
Passing Distance	0	1	1
Bank clearance	2 x 0.5	2 x 0.5	2 x 0.5
Total B	3.5 B	5.9B	6.1B
Design B (m)	46	19	32.6
Required B (m)	161	112	199

Based on the above, it is recommended that initial channel width should be set at 200 m, with potential for expansion to at least 300 m later as traffic and financial resources permit.

Channel Depth

As seen in Table 6-11, the initial channel depth is set at 16.75 m to accommodate a loaded vessel draft of 15.00 m, to match the vessel sizes and design parameters for the Third Locks project. However, since it is generally considered that ships of 12,500 TEU capacity will be constructed within the next 10 to 15 years[15], provision should be made for future deepening to at least 18.50 m.

[15] World Port Development, April 2005.

Table 6-11: Channel Depth Criteria

Criteria	Allowance (m)
Loaded vessel draft including trim	15.00
Squat	0.15
Wave induced motion	0.30
Safety Clearance	1.00
Dredging Tolerance	0.25
Advanced Maintenance Dredging	0
Channel Controlling Depth (m)	**16.50 m**
Recommended Cut Depth (m)	**16.75**

Turning Basin

Maneuvering basin dimensions range from 1.25 to 1.75 x vessel length according to wind and wave exposure, number of tugs and horsepower and proximity of lee shores or hazards. For this project, a factor of 1.5 x vessel length is recommended, which approximates a requirement for a 577 m diameter circle for a 9,500 TEU vessel. In the event that a 10,500 TEU ship enters the new port, the required diameter will increase by approximately 25 to 50 m.

For cost estimating and planning purposes it is therefore recommended that the diameter of the turning basin for large vessels should be set at 600m, with potential to expand to 700 m later if necessary.

6.7.4 Side slope assessment

Based on the preliminary assessment of the borehole data pertinent to the soft material in the vicinity of the project area, the recommended long term side slopes for the dredged channel and berth areas is set at 1V to 5 H. In all likelihood, the channel will be stable with a slope of 1V to 3H, but the more conservative value is recommended for preliminary cost estimating purposes.

6.8 Hydrodynamic Model Update

6.8.1 Model Description

The analysis of the hydrodynamic conditions at the project location is an extension of the work done previously for the Feasibility Study for the Construction of an Artificial Island at the Pacific Entrance to the Panama Canal, for ACP by Moffatt & Nichol in November 2002 and the Panama Bay Island Alternative P1-A Assessment of Impacts on Existing Hydrodynamic and Water Quality Conditions draft report submitted to ACP by Moffatt & Nichol in January 2003. An expanded report on the model update is presented in Appendix C of this report.

The hydrodynamic model for this study was developed using the Delft3D modeling system. Figure 6-17 shows the refined model grid coverage in the new model setup together with the extent of the existing local model grid.

Figure 6-18 shows a detailed view of the model grid and bathymetry at the project area. Model bathymetry has also been supplemented by information from ACP in 2003 and a channel survey in the Pacific entrance area, carried out by APC in early 2005.

6.8.2 Effects of Locks Discharge

Predicted peak discharges at the Puente de las Americas are on the order of 1,500 m^3/s during spring tide and about 800 m^3/s during neap tide. These values are much higher than the normal operational discharges through the Miraflores Locks. Hence, discharges through the locks are not critical to the model results and have not been included in the simulations.

Figure 6-17: Hydrodynamic Model Grid

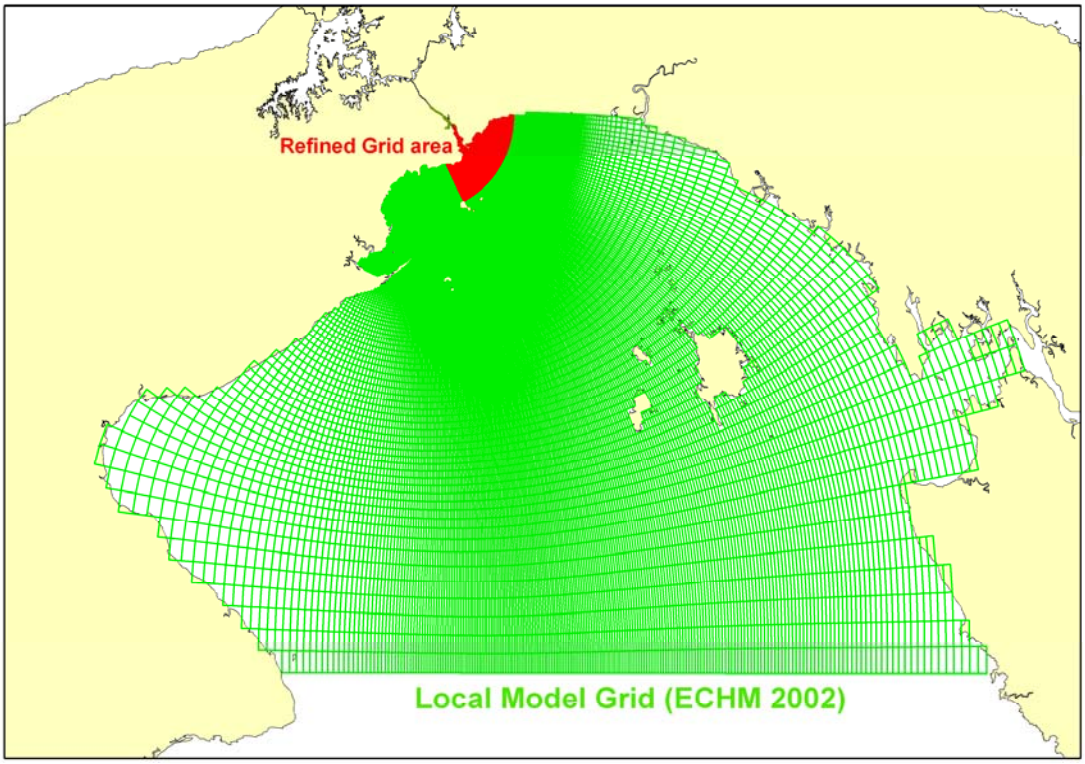
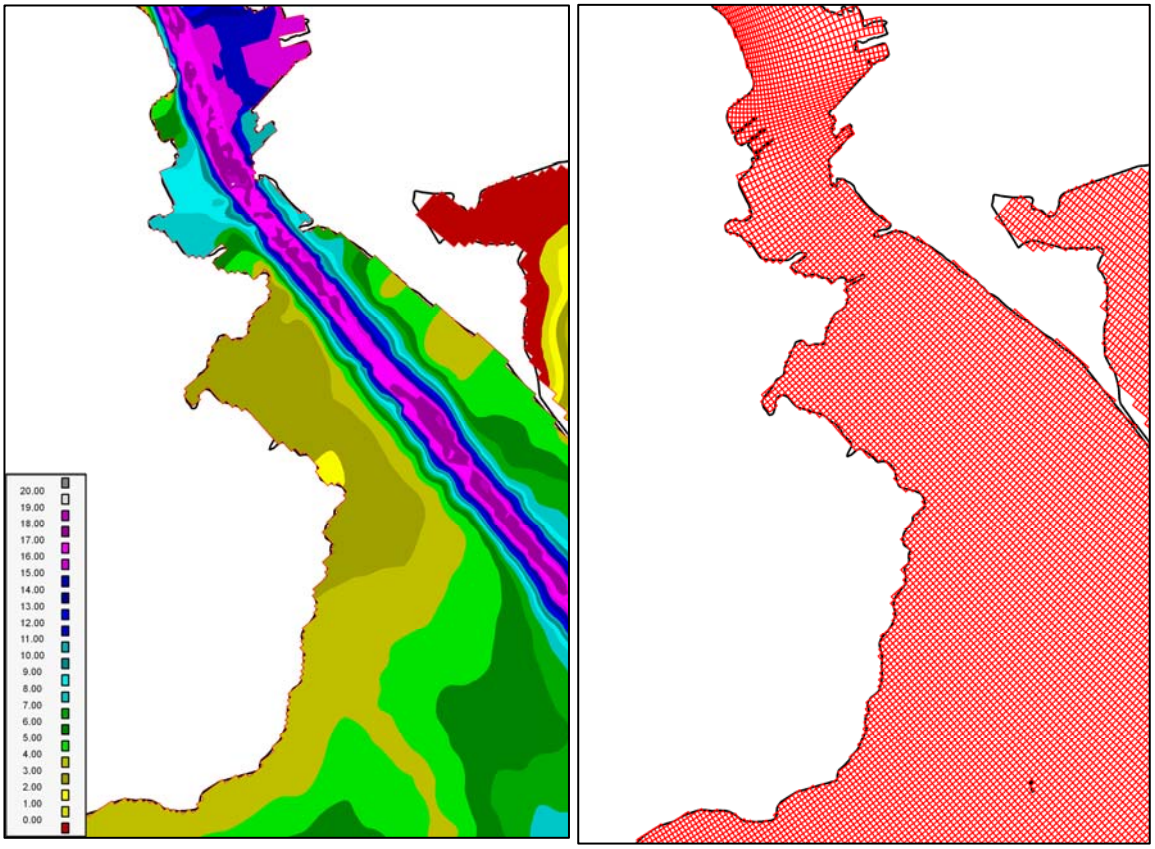


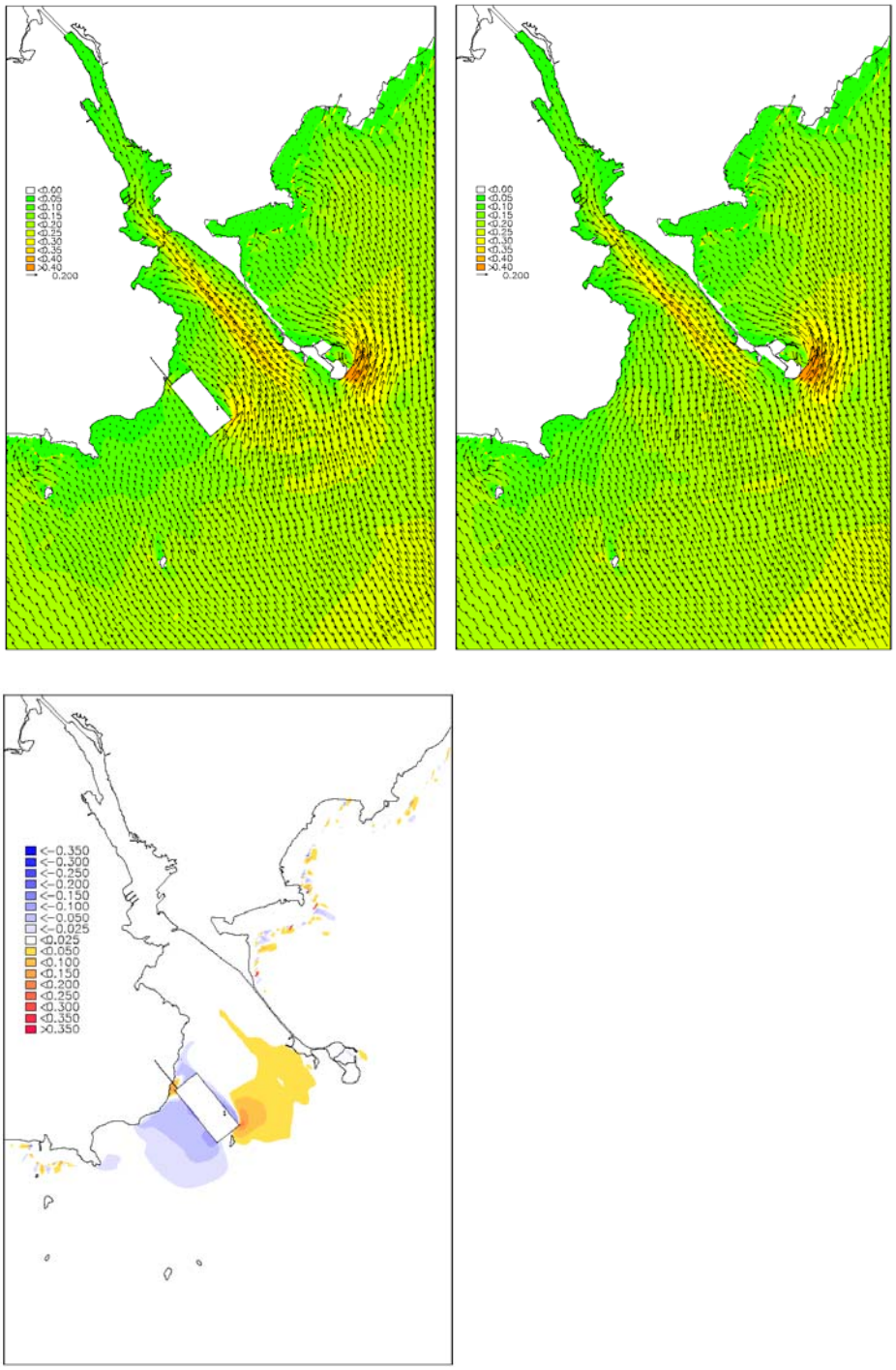
Figure 6-18: Detail model bathymetry (Left) and grid (Right) in the vicinity of the project area and entrance channel



6.8.3 Hydrodynamic impact assessment

Comparison of model results for existing and proposed conditions were carried out for spring and neap tides at the four stages of the tide. Figure 6-19 presents a typical flow patterns from the existing condition model during peak flood stage at Spring tides. Flow patterns from other states of the tide are presented in Appendix C to this report.

Figure 6-19: Flow patterns during Peak Flood Spring Tide - existing and project conditions.



6.8.4 Model Results

The effects of the island on the flow patterns are localized in the vicinity of the project. For most of the tidal stages an increase of velocities is seen at the south and south-east and north-west tips of the island and at the gap between the island and the shore. Maximum observed current magnitude under with project condition at the tip of the island is in the order of 0.3-0.35 m/s at Peak Flood and Peak Ebb during Spring Tide.

A reduction in the magnitude of the currents is observed mainly at the west side of the island and to a minor degree north east of the island, due to the blocking effect of the project to southwest and northeast moving currents. The largest reduction is observed during Peak Ebb at Spring Tide extending from the island west to Punta Bruja. Area west and northeast of the Island will be relatively quiescent and prone to increased sedimentation as a combination of the possible wave sheltering and the current reduction.

The increase in current magnitude at the navigation channel and area between the artificial island and the Amador Causeway is between 2.5-5 cm/s during Peak Flood and Peak Ebb at Spring tide, when the current magnitudes are maximum (0.35-0.4 m/s). During the other tidal stages, changes at the navigation channel are less than 2.5 cm/s.

In general, the largest changes in flow patterns are observed during Peak Flood and Peak Ebb situations. These changes (less than 5-10 cm/s in magnitude) are limited to the area surrounding the project. In addition, the flows through the area where the island is located are dominated by the tidal exchange and little influence of the coastal current is observed since this area is sheltered of this westward moving current by the Amador causeway.

Hydrodynamic effects on the currents will be limited to areas in the immediate vicinity of the project. The separation of the island from the shoreline by a distance of at least 200 m will assist the circulation of the water flows along the Palo Seco/Farfan Shoreline area.

6.8.5 Conclusions

Based on the model results the hydrodynamic impacts of the proposed new island south of the Palo Seco area are summarized below:

Impacts on Coastal Resources

The artificial island does not produce any change in the flow patterns in the vicinity of Isla Otoque and the areas where coral growth can still be found.

Impacts on Beaches and Western coastline

The shoreline located immediately west of the project could experience a slight increase in sedimentation carried by the water along the modified shoreline as it clears the island area. The shoreline located at the northwest tip of the artificial island could experience some exposure of the rock faces due to the higher velocities through that narrow area. However, the headland at the eastern end of Kobbe Beach is expected to act as a barrier to material moving westwards between the island and the existing shoreline.

Sedimentation in the Panama Canal access channel

Velocities will increase slightly during Spring Tides in the area of the entrance channel following the construction of the island. This may lead to a slight reduction in sedimentation of the Canal Pacific Entrance.

6.9 Infrastructure Network

As a Greenfield project, the primary utilities must be extended to the site and a new network established. In particular, the electrical loading for up to 20 gantry cranes will be high and power demand for up to 600 reefer outlets will be substantial

6.9.1 Primary Requirements

Power

The estimated design power demand for the fully developed port with electrically powered gantry cranes is 30MW with actual loads being approximately 15 MVA.

The closest supply connection to the port site is the Dugan substation at Howard, which services the entire Howard area. This facility is connected to the ACP system through a 44 kN line with an approximate capacity of 36MW. At this time, is reported that the load of the Dugan station is low, at 2.5 MW, compared to the estimated demand of 12.5 MW when the base was functional. While the Dugan station can meet the average loading criteria for the new Port, any increase in use at Howard and peak demands at the Port would overstress the system.

The next connection point that could be used to service the Port is at Miraflores, some 15 km from the project site, where the Miraflores Thermoelectric Power Plant is located. This plant has a capacity of 90 MW[16] and serves the Howard and Rodman areas. For

[16] Howard Rodman Land Use report, Intercarib and Nathan Associates, 1997

redundancy, it has been suggested[17] that two circuits could be brought from the Miraflores station to the Dugan sub station and to service the Port. Additional sub stations will then be located within the terminal area.

Water

The closest main water line to the project site is a 12 inch pipe connected to the Miraflores water treatment plant. Storage tanks in the area of Cocoli have a nominal capacity of 737,500 gallons. The 12 inch line at Howard passes along the main highway. Connection to the line would be relatively straightforward and a storage tank could be located on the high ground immediately adjacent to the Port site. The estimated length of this connection is 4,200 m.

Fire fighting

The demands for firefighting at a major port are substantial. Most modern ports are now adopting saltwater firefighting systems which require a lower investment and also do not pose the risk of running out of water during a major fire event. Indeed, it is common for freshwater firefighting systems to have saltwater pumps as back up to avoid this emergency situation.

For this project, it is therefore recommended that the fresh water supply be limited to potable water, firefighting systems within buildings and possibly for ship service, in the event that the operator considers it to be a necessary vessel service.

Potable Water

Based on the above assumption, water demands for the Port are relatively modest and can be served by a 6 or 8 inch diameter line and a storage capacity of less than 500,000 gallons.

Waste water treatment

The existing water treatment plant at Howard is located to the west of the Runway and some 5 km from the project site. Demand at the Port will be relatively modest and it is recommended that a port waste treatment facility be built independent of the Howard system. Given the high priority for container stacking in the main yard area, the preferred location for the treatment plant is on land, serviced by lift stations from the port site. The estimated size of the land required for the plant is less than 2,500 m2.

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[17] Informal discussions with representatives from ACP Water & Electrical Division. April 2005

Communications

The trunk lines with fiber-optic and microwave telecommunications systems extend into the Howard and Rodman areas. In 1997, Howard had 3,520 lines in use, and it is understood that less than one quarter of these lines are in use at this time.

Extension of the main trunk lines to the Port site is relatively straightforward and cell phone coverage is already established in the area.

6.10 Highway Access

The coastal road that connects the Bridge of the Americas to the Port site and also to the beach areas and Veracruz township is a two lane highway, with unpaved shoulders over most of its length. Much of the road has a concrete slab base and topping with asphalt. The condition of the existing pavement is fair, but the road is not suitable for regular transit of trucks with containers.

In order to accommodate regular transit of commercial and construction vehicles it is also essential that the safety of the connection to the Pan-American Highway is reconfigured to reduce the approach grade and improve sight lines.

Finally, substantial cuts will be required to attain satisfactory gradients for the connection from the road to the new Port

6.10.1 Construction Access

The construction of this major project will generate significant volumes of heavy traffic and there will also be a need to move over-legal loads to the site. Clearly this will cause disruptions to the existing traffic flows and could also cause difficulties for emergency vehicles.

It is therefore recommended that a dedicated haul road be built alongside the existing highway to separate all heavy construction traffic from the existing road. Once the project is complete, final paving would take place and the existing road can be upgraded and incorporated into the highway to offer four lanes and conditions suitable for frequent movement of containers and chassis. The width of the road and depth of base is very much dependent on the materials source option selected by the contractor for this project. In the event that high volumes of rock are carried over the road, a right of way of 75 m will be required to accommodate the large volume off road dump trucks. This

would reduce to some 30 m for a standard construction road for highway legal heavy vehicles.

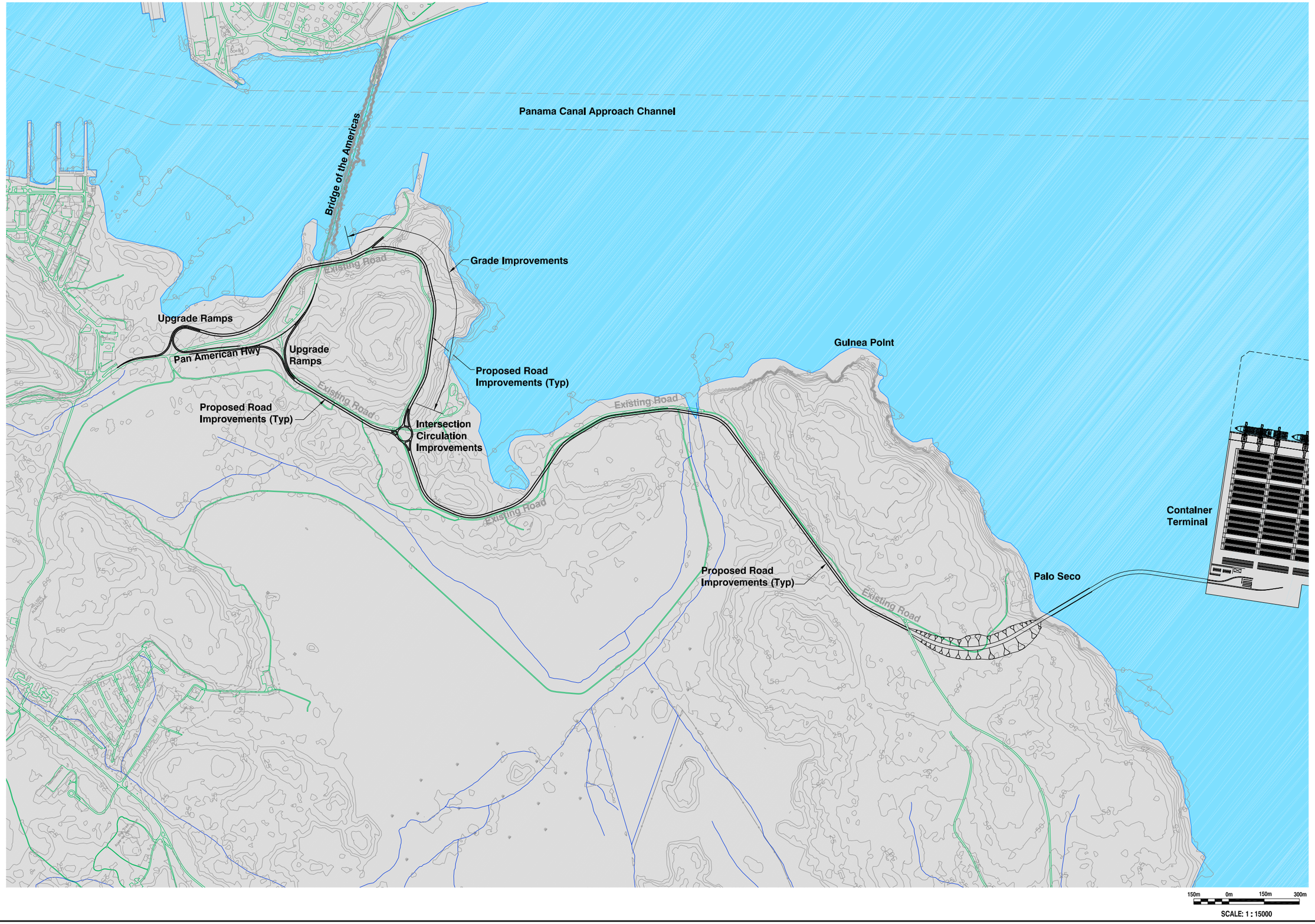
6.10.2 Improvements to Existing Network

Preliminary estimates indicate that approximately 10 percent of all containers through the Port could move to or from the Atlantic side by intermodal transfer. Depending on the transport mode adopted, this could generate as many as 400 trips in each direction per day. In the case of highway transport, it is most likely that at least 80 percent of these trips will take place between the hours of 8:00 am and 7:00 pm. As a major container center and also taking into account the access requirements for visitors to the developing areas around Howard and also through to Veracruz, it is expected that a four lane divided highway will be required to handle this traffic and the increased public traffic in the area.

Figure 6-20 shows a suggested alignment for the access road section from the Bridge of the Americas to the Port site. The intersection at the Bridge should be regraded and reconfigured to improve sight lines and access and significant cuts are required at the connection to the trestle leading to the Port site.

The preliminary layout of the improved highway and connections is based on topography from existing maps, which shows certain sections with relatively steep grades. However, not all of these grades are apparent from a visit to the site, and a more detailed study will be required before the vertical and horizontal alignments of the road can be finalized. There may also be a requirement for a modest amount of shoreline fill where the road passes under the spans of the Bridge of the Americas.

The alignment shown in this report is therefore considered to be very preliminary, but gives an indication of the general configuration that will be required to meet the needs of the project. Figure 6-21 shows a cross section of the construction haul road and final expanded highway.



Designed by: DJMac
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Date: April 2005
Design file no. AS SHOWN
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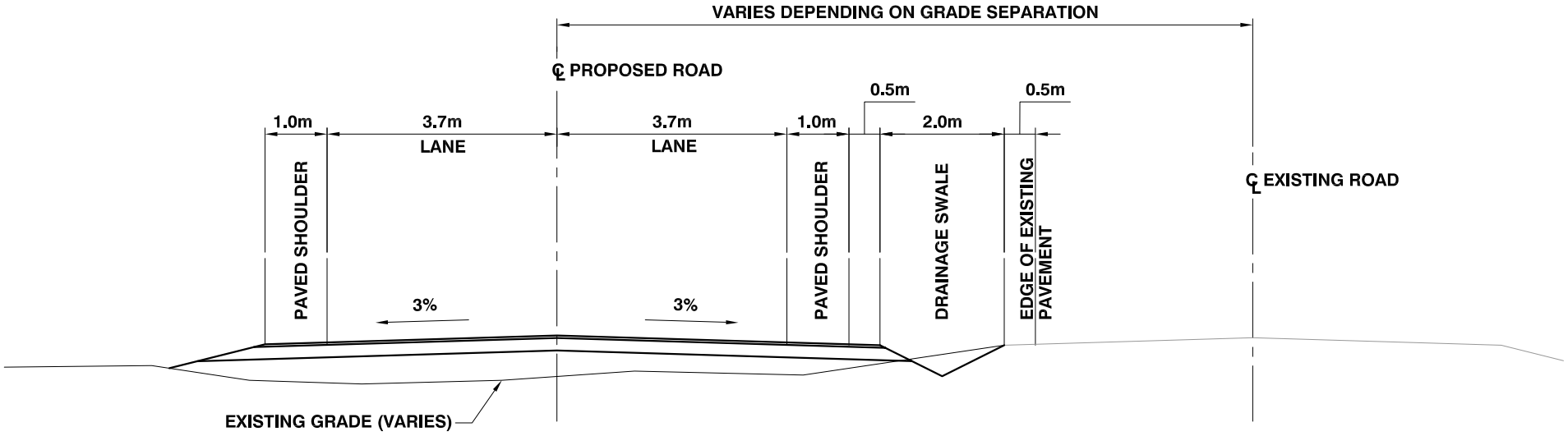
FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Recommended Alignment of Upgraded Site Access Roads

Fig 6-20

558200_Fig06-20.dwg 10 Jul 2005 - 10:20pm; jmacpherson; © Moffatt & Nichol



1m 0m 1m 2m

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Fig 6-21

Typical Section of Haul Road and Highway Connection fo the Port

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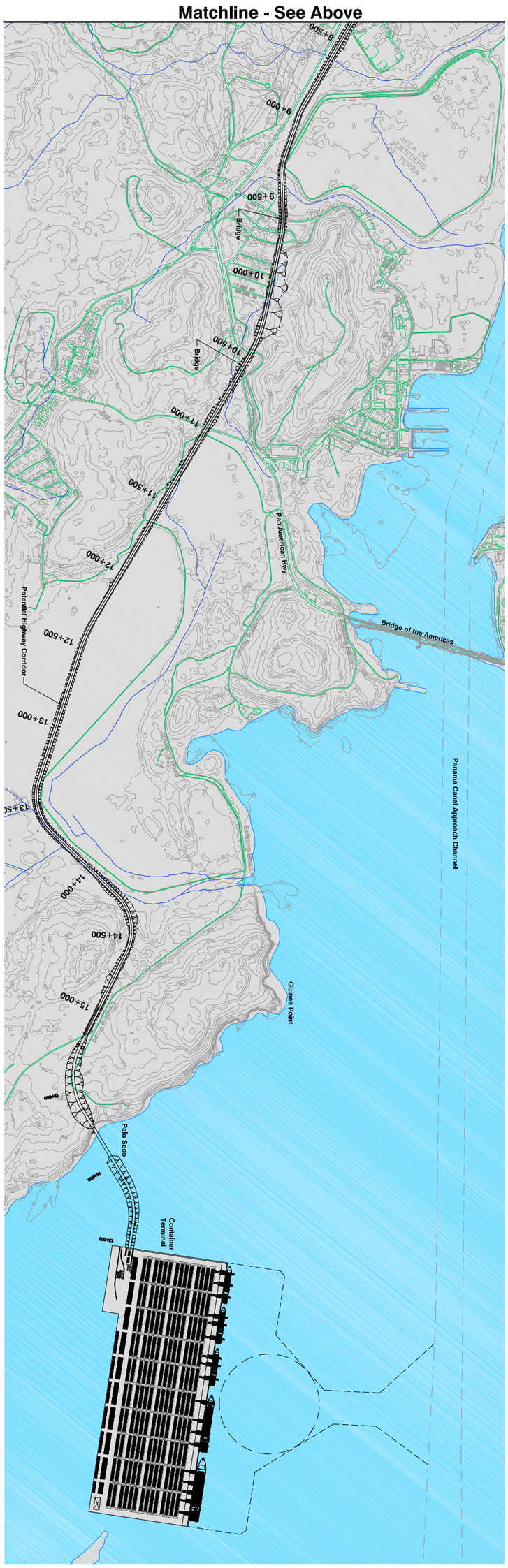
558200_Fig06-21.dwg 10 Jul 2005 - 10:21pm; jmacpherson; © Moffatt & Nichol

6.10.3 Future Highway Connections

With the recent completion of the Centenario Bridge, north of Pedro Miguel, there is now an opportunity to establish a new highway corridor from the Howard/Port area to the Atlantic coast, avoiding congestion on the Bridge of the Americas and Panama City. It is also understood that the main Trans-Isthmian highway to the Atlantic side will be widened and substantially improved in the near future. The combination of the new bridge, an upgraded trans-Isthmian highway and a link to the port area will improve the efficiency and attractiveness of the transshipment terminals and related activities on both sides of the Isthmus.

At this time, the primary link from the new bridge is projected to connect the Pan-American highway at Arraijan. However, the improvement of the existing road running west of the Canal offers the possibility of a direct connection to Howard and to the Port. Figure 6-22 shows several alternatives for the connection, which could avoid or include the use of the Pan-American Highway. Assuming an order of magnitude cost of US$850,000 per kilometer for the expanded road and new sections and a new crossing over the Pan-American Highway, the connection to the Centenario Bridge would cost on the order of $18 to 25 million, excluding the improvement of the section from the Bridge of the Americas to the Port site.



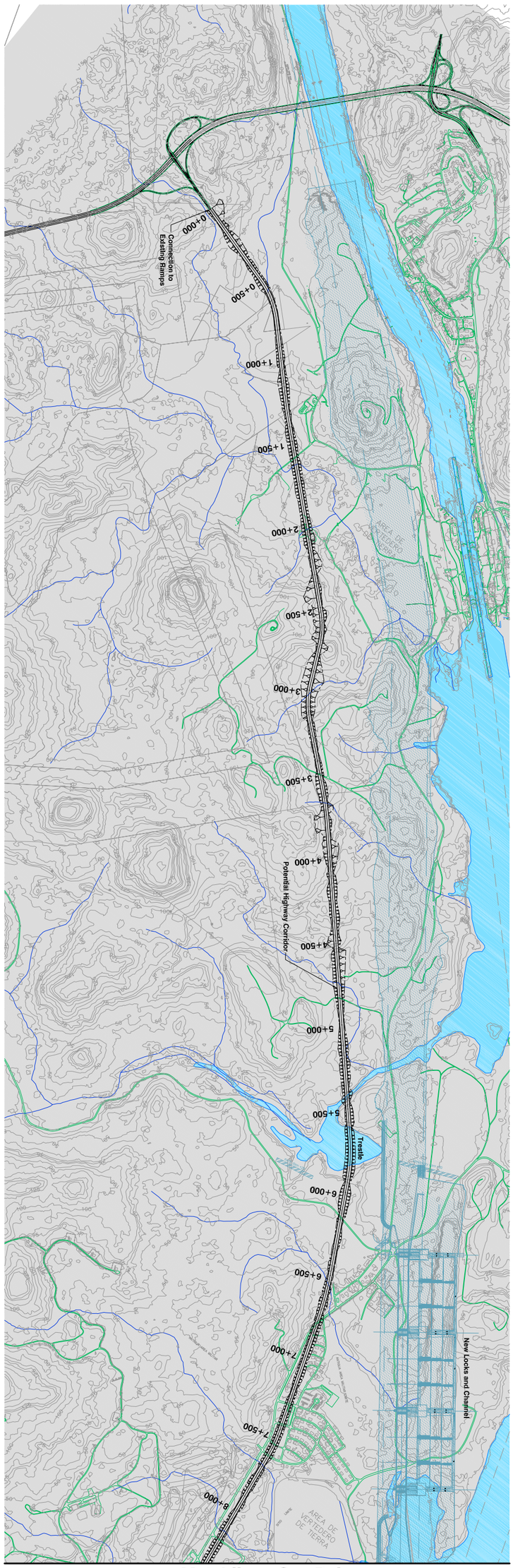


Fig 6-22

FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Potential Highway Connection to the Centenario Bridge

ACP AUTORIDAD DEL CANAL DE PANAMÁ

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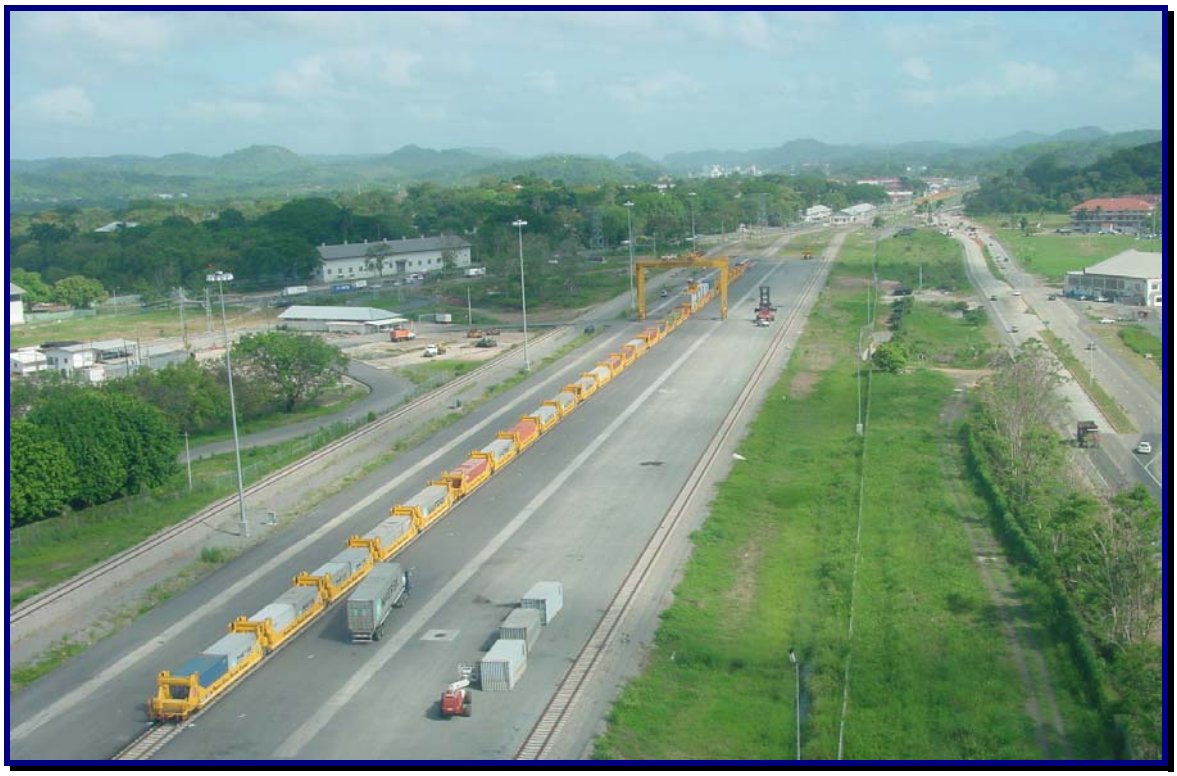
Submitted by: MGH		Drawing Scale: AS SHOWN Plot scale: 1=1 (11"x17")	

6.11 Rail Access

A number of potential Port operators have expressed an interest in the provision of a rail connection from the Port to the recently upgraded Panama Canal Railroad (PCR), which terminates in Balboa.

This connection will then enable the efficient interchange of containers between the Atlantic and Pacific Coast container terminals. At this time, it is estimated that the PCR currently moves some 50,000 containers a year across the Isthmus. Figure 6-23 shows the existing intermodal yard of PCR, which is located between the Panama Ports Terminal in Balboa and the Albrook airfield.

Figure 6-23: Existing Panama Railroad Intermodal Yard at Balboa



6.11.1 Alternative Connections to Panama Canal Railroad

There are no hard statistics to support the financial analysis of the rail connection to the port, but operators of the Manzanillo terminal on the Atlantic side estimate that some five to ten percent of annual traffic crosses the Isthmus by rail or by truck.

Assuming a target volume for the new Port of 2.4 million TEU s per year, this then indicates a need to provide capability to move some 240,000 TEU s or 120,000 TEU s per year in each direction. Assuming 300 operating days for the connection, this then equates to some 400 TEU s per day in each direction when the new Port is at full capacity.

At this time, there is no rail connection across the Bridge of the Americas, and it is not included in the recently completed Centenario Bridge north of the Pedro Miguel Locks.

However, there is a swing bridge at the south end of the Miraflores Locks and the structure seen in Figure 6-24 has provision for a single rail line. The bridge is not used for regular traffic and is only opened for maintenance or testing or to move heavy equipment from one side of the Locks to another.

Figure 6-24: Existing Swing Bridge at Miraflores Locks

In order to cross the Canal at this location, and assuming the construction of the New Locks goes ahead, a second swing bridge will be needed to complete the link.

Alternatives to provide a connection from the Port to the existing rail yard at Balboa, or to the Atlantic Side include:

- Construction of a new line from the port to the locks area
- Moving containers by truck from the Port to the Balboa Rail Yard
- Establishment of a Barge service
- Truck haul across the Isthmus

6.11.2 Construction of a New Rail Corridor

The materials transportation cost models developed for the Artificial Island and Materials Disposal studies indicated that rail was the most economic option for movement of large volumes of material from the Locks Excavation to the project sites. At the time of preparation of the study, it was estimated that the cost for transport of almost 90 million m3 of unprocessed rock and overburden material from the Locks site to the island was expected to be $4.83 per m3.

As can be seen in Figure 6-25, the route of the proposed rail corridor passed close to the proposed container terminal, although the total length of the corridor extended the full length of the Locks excavation in order to collect the excavated material from the entire area.

The cost estimate included the provision of a dual rail line, civil works, a bridge crossing the Pan-American Highway and the construction of a stockpiling yard at the project site.

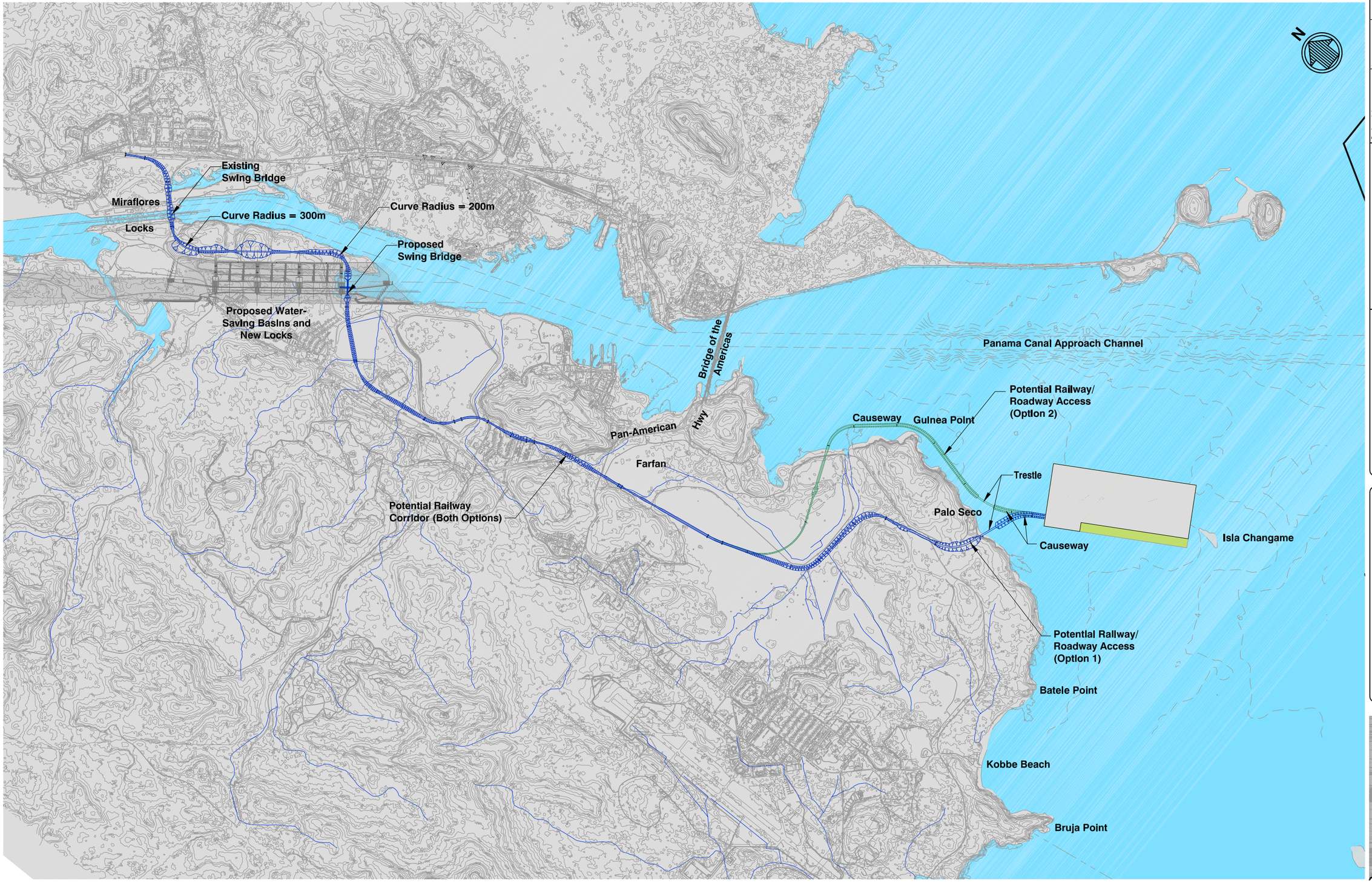
The main advantage of the rail option for the island project was the potential for establishment of a permanent rail link, similar to the options now under consideration for the Container Port.

However, sensitivity tests run on the cost model indicated that the unit rates would increase with reductions in volume. It was further determined that the break even volume for rail, when compared to the next most economic option, estimated to be approximately $5.80 /m3, was 40 million m3, based on the analysis prepared in 2003.

It therefore follows that the unit costs for movement of the 15 to 17 million m3 of material for the container terminal project would be higher. Recent increases in fuel, steel and other key cost items are also significant and it is certain that the numbers generated from the 2003/2004 model are no longer valid.

Consequently a new estimate has been prepared to evaluate the capital cost of the construction of a rail corridor from the Port to the Miraflores area, using most of the alignment and field data developed for the previous study.

Figure 6-25 shows the required rail alignment adjusted to terminate at the new Port site and also including the crossings at the existing and proposed new Locks.



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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Potential Rail Corridor and Connections from Port to Miraflores Area

Fig 6-25

558200_Fig06-25.dwg 10 Jul 2005 - 10:26pm; jmacpherson; © Moffatt & Nichol

The main issues pertinent to the construction and operation of the rail link are:

Operational Considerations

Clearly the rail crossing cannot be permitted to interfere with navigation of vessels to the existing and new Locks. Under the current traffic management system, a south to north one way flow of ships is maintained until mid-day, when the flow of ships reverses, with about one to one and a half hours between lockages at Miraflores. This is essentially the only time a train could be permitted to cross the locks, except in an extreme emergency situation.

Train traffic volumes will almost certainly vary seasonally or daily, but it is estimated that a double stack 50 car crane will have a length of 750 m and carry 200 TEU s, roughly equivalent to the daily one way volume expected at full build out if the 10 percent assumption of rail transfer is attained. At an average speed of 15 to 20 kph this train will traverse the 3,000 m crossing in approximately 15 minutes. Adding time for headway clearance and opening and closing of the bridges indicates that the total time necessary for two trains to cross the Locks area is likely to be on the order of 45 minutes, which is within the turn round period for Canal traffic flow.

However, it must be recognized that ACP continues to evaluate the optimum traffic control patterns to achieve the most efficient use of water and maximize throughput capacity of the Canal and the existing one way flow procedures may well change in the future, with or without the construction of the new locks.

It is therefore important that the operational implications of the provision of the rail crossing should be closely studies once a definite proposal is made to construct the rail link.

Miraflores Bridge

The existing swing bridge is old and has not been used for regular traffic in many years. While the consultants do not have access to any detailed assessment reports on its condition and suitability for regular rail use, it is assumed that it would require a major overhaul and upgrade for this project.

New Locks Crossing

A new bridge will be required to cross the new locks. As seen in Figure 6-30, it is suggested that the optimum location for this bridge is at the south end of the new Locks. In this way the haul distance is reduced and the 10 m vertical elevation difference at the north end of the locks is no longer an issue.

Consideration was given to the construction of the bridge independent from the locks, but the added span required to permit safe navigation of vessels and tugs at the entrance to the Locks is beyond the capacity of a lifting bridge.

Bridge Options

Based on this preliminary assessment the bridge crossing the New Locks would be mounted on extensions to the Lock walls. Given the anticipated dimensions of the new Locks, the probable span of the new bridge is expected to be on the order of 70 m. Options for the bridge structure are:

Bascule Bridge. This class of bridge, shown in Figure 6-26, can be single leaf or double leaf. However, the double leaf bridge has fallen out of favor with railroads after the failure of the locking mechanism caused a train to fall in the water. Railroad bascule spans are now almost exclusively single span.

Figure 6-26: Example of Single Leaf Bascule Bridge

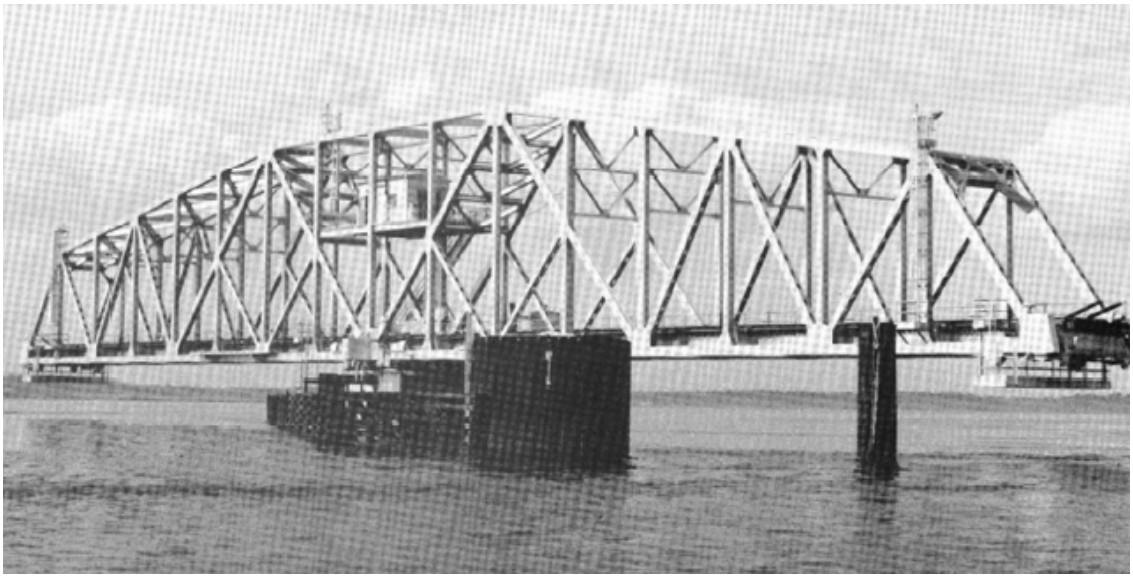
Vertical Lift bridges. The vertical lift bridge is one of the more efficient concepts and avoids the need for cantilevered spans. They are typically used for longer spans to avoid deflection of the cantilevers and are the preferred concept for spans exceeding 75 to 80 m, as other types of bridge then become less economical and more difficult to construct.

For this application, the vertical clearance will be a key issue. While it is common to see vertical lift bridges with an air draft of more than 50 m, the visual impact of the towers and raised span is substantial.

Figure 6-27: Example of Vertical Lift Bridge

Swing Bridge. Figure 6-28 shows a typical swing bridge for rail operations. These bridges typically have two spans that pivot on a central pier, often constructed in the center of a navigation channel. A critical element of the concept is the need for clearance for rotation of the back section of the bridge, which should not be a major issue at this location. Costs for this bridge are comparable to the vertical lift bridge and a bascule, with typical base costs, excluding approaches etc, on the order of $60 million for the expected span requirement of 70 m.

Figure 6-28: Typical Swing Bridge - Open Position



Based on this very preliminary assessment, the preferred concept for the new Locks crossing would be either a swing or bascule bridge, mounted on an extension to the lock walls with the rotating or lifting mechanism and tower kept clear of dock walls for Navigation safety, as shown in Figure 6-29. In this way the tugs[18] can control the movement of the vessel until it is clear of the bridge area and there are no limitations on navigational access at the entry to the Locks. The anticipated cost of both classes of bridge is $24 million, excluding engineering costs and contingencies, based on recent studies[19] for a similar project.

In all cases, it would appear that the bridge can be built to accommodate a double track to reduce the impact on Canal traffic without a significant increase in capital construction cost.

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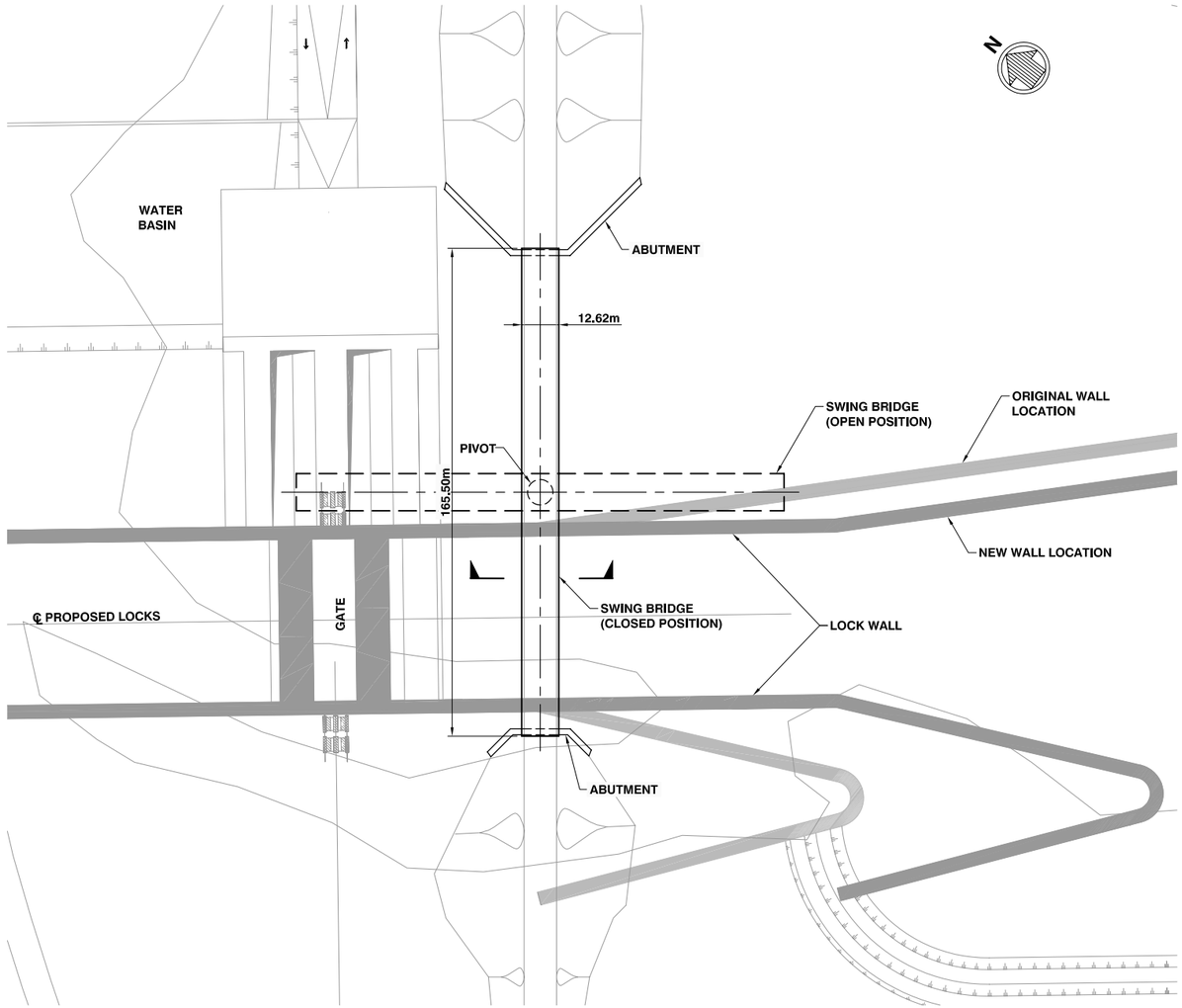
[18] Tugs will be used to position the vessels within the New Locks, instead of the locomotives currently used at the existing locks.

[19] Cerritos Channel Crossing Third Track Rail Bridge Feasibility Study. Alameda Corridor Engineering Team for Alameda Corridor Transportation Authority, November 2004



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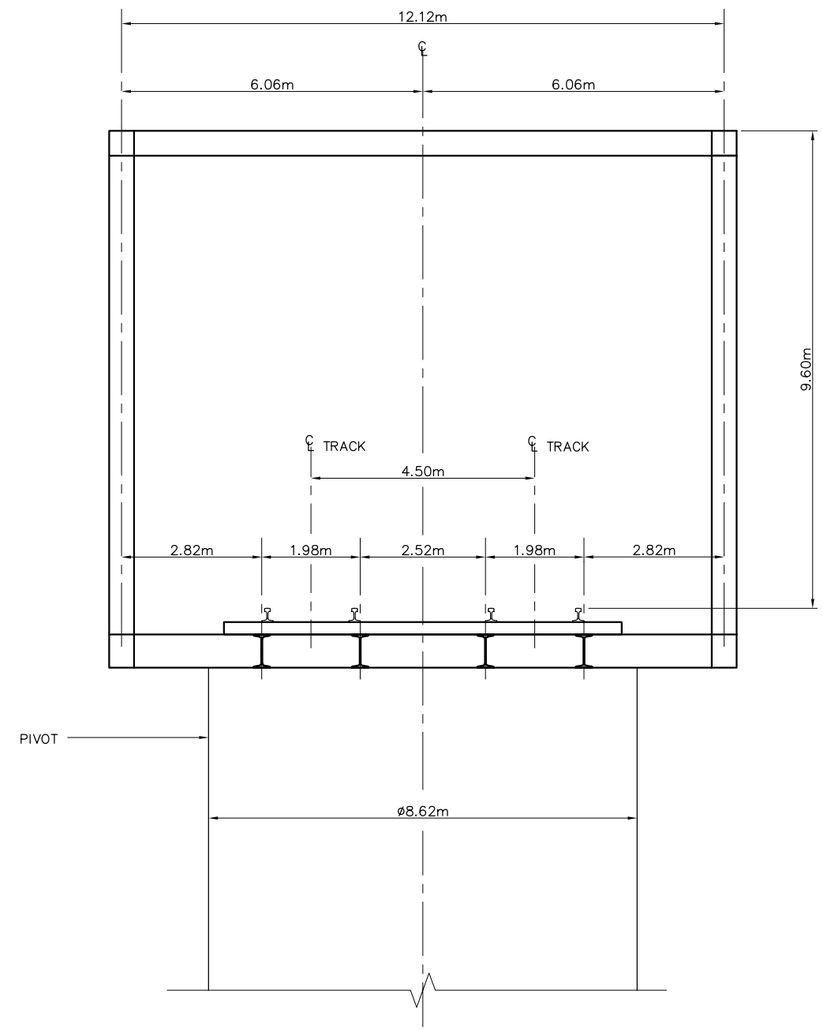

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NOTE:

Locks shown are a preliminary design courtesy of ACP.

1m 0m 1m 2m
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20m 0m 20m 40m
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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO
Schematic of Swing Bridge at South End of New Locks

Fig 6-29

558200_Fig06-29.dwg 10 Jul 2005 - 10:28pm; jmacpherson; © Moffatt & Nichol

Highway crossing at Pan-American Highway.

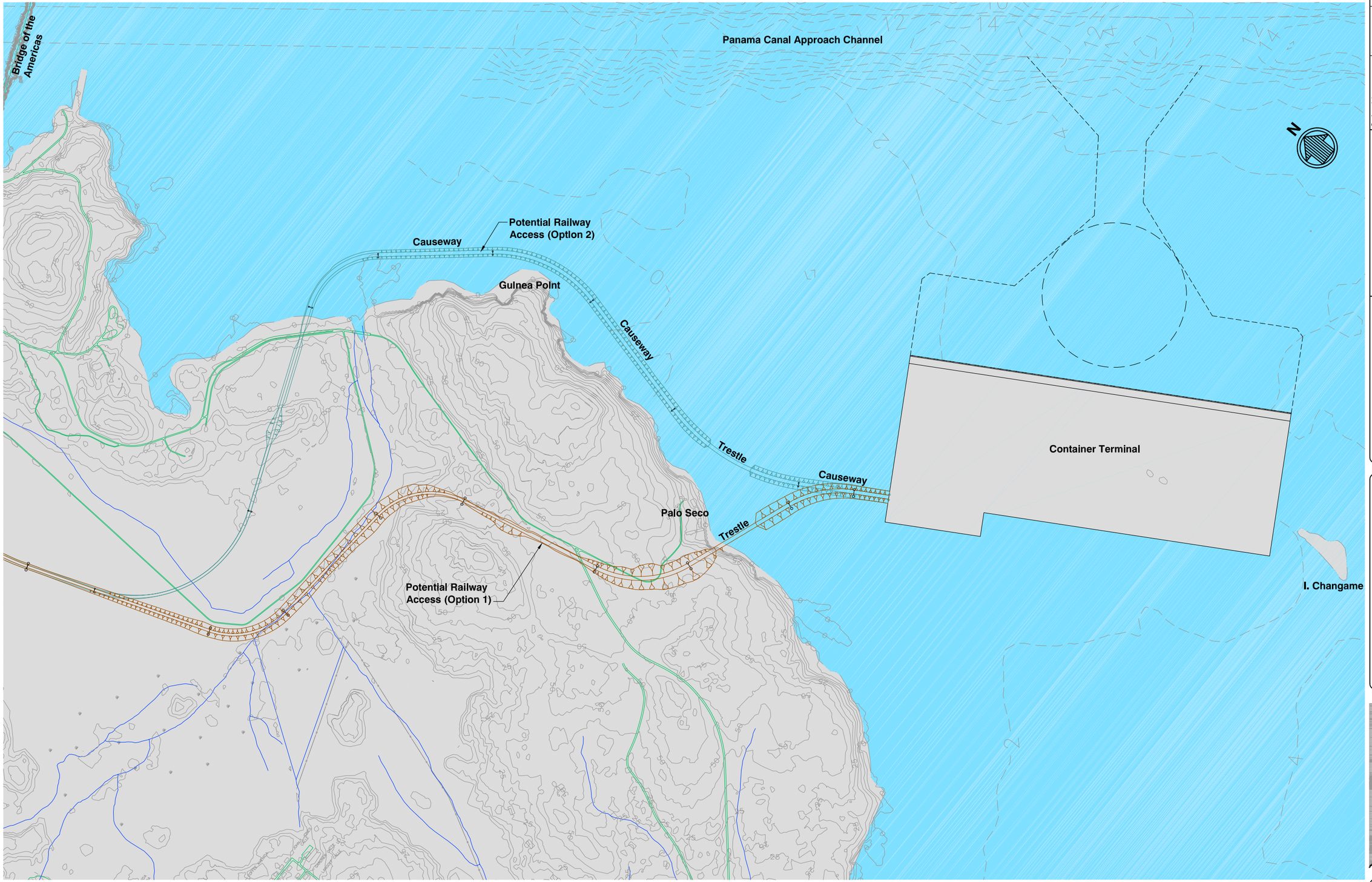
The rail link developed for the original island study included provision for a high level crossing over the Pan-American highway. This will also be required for the proposed rail connection to the container port site and provision for the cost of the bridge and approaches must be included in the capital investment estimate for the rail project.

Rail connections to the Port Site

As noted above, the elevation difference between the existing uplands and the proposed container yard poses a challenge for the final section of the rail connection. Two alternative alignments are shown in Figure 6-30. The coastal route would involve the construction of an open pile trestle along the shorefront, thereby avoiding the need for major excavation in the connection.

However, the impact on the shoreline, and the concerns over the maintenance of the habitat of the mud flats at Farfan Beach make this an unattractive option from an environmental and visual standpoint. At the same time, significant excavation will be required to provide a satisfactory vehicular entrance to the port from the existing coastal highway, and the additional work required to incorporate the rail within this same corridor is not significant in the overall cost of the project.

It is therefore suggested that the direct connection is the preferred option. However, given the uncertainty over the number of containers expected to move from one coast to the other by land transport methods, the installation of the entire rail corridor does not necessarily need to form part of the initial development of the container port.



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FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Potential Rail Connections To Port Site

Fig 6-30

558200_Fig06-30.dwg 10 Jul 2005 - 10:29pm; jmacpherson; © Moffatt & Nichol

Intermodal Yard Needs

Containers for cross Isthmus transfer will be collected and delivered at an intermodal yard (IY) within or close to the Port site. In order to minimize the footprint of the island and reduce costs, the technical and environmental implications of placing the IY on the land side were assessed, in addition to the placement of the Yard within the main container terminal area on the island.

Off dock Intermodal Yard. Figure 6-31 shows a potential location for the intermodal yard on the landside and adjacent to the existing coastal road. The existing road would be diverted to the west of the new yard, with an at-grade crossing north of the new IY.

The area for the yard is within the designated dry forest zone discussed in more detail in the environmental section of the report and there are serious concerns over further fragmentation of this critical area and the loss of the ecological corridors for the forest.

The topography of the area is undulating and significant cut and fill is required to prepare the area for the intermodal yard, which then eliminates much of the cost advantage of moving it off the island.

On dock Intermodal Yard. This option places the intermodal yard at the rear of the container yard on the island. A major advantage of this location is elimination of the need to move containers from the terminal area to an off dock facility. The 20 m vertical height differential between the existing Coastal Highway and the port require that the island be separated from the shoreline by some 700 m in order to maintain a satisfactory grade to the main line. This will require significant excavation from the existing highway to the shoreline. However, it is expected that much of this material will be rock and suitable for dikes or fill in the main port area.

Based on this assessment, it is recommended that the preferred location for the intermodal yard is on the island. It is also recommended that the fill area for the IY should be considered as optional, with a decision to build to be made at the convenience of the concession holder or terminal operator.

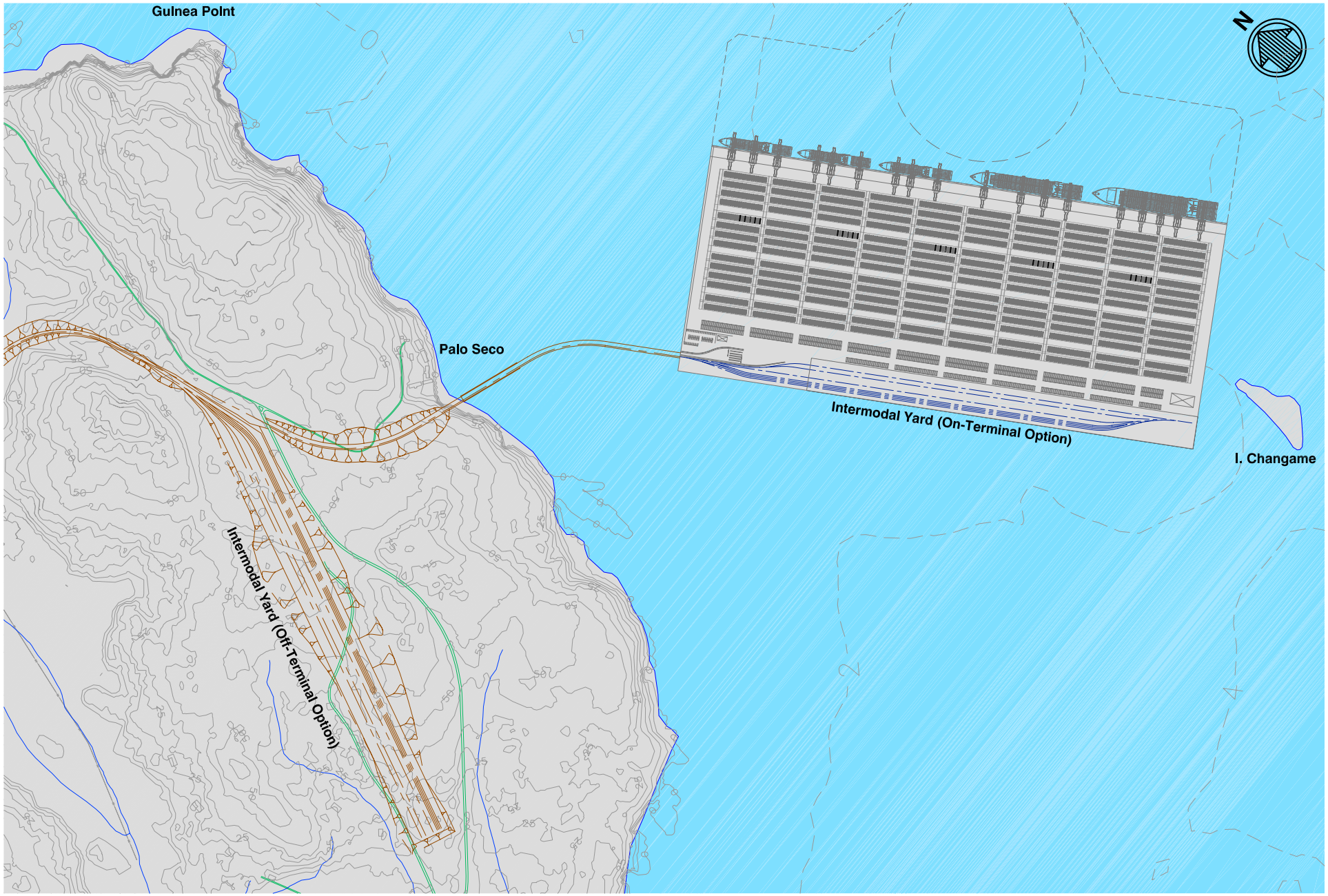

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Fig 6-31
Options for Location of Rail Intermodal Yard

ACP AUTORIDAD DEL CANAL DE PANAMÁ

558200_Fig06-31.dwg 10 Jul 2005 - 10:31pm; jmacpherson; © Moffatt & Nichol

6.11.3 Cost Estimate for Rail Connection

Based on the assumptions noted in the previous sections, a capital cost estimate for the rail connection and intermodal yard is presented in Table 6-12. These costs assume that the intermodal yard will be located on the island but added after the initial development has been completed.

Table 6-12 : Preliminary Estimate for Rail connection & Intermodal Yard

Description	Amount
Mobilization & Demob	**$6,712,976**
Intermodal Yard	**$27,856,381**
Extend dikes on island	$3,557,340
Miscellaneous Fill	$11,600,023
Armor to Revetment	$626,401
Pavement Base	$2,062,226
Paving	$6,874,088
Rail	$1,675,559
Lighting & Utilities	$1,460,744
Rail Line	**$48,180,374**
Clearing & Stripping	$652,501
Formation & railbed	$29,000,058
Ballast & Rail (single track)	$16,111,143
Service road	$2,416,672
Crossings	**$50,750,341**
Pan-American Highway	$4,350,009
Culverts and small bridges	$3,490,748
Swing Bridge at New Locks	$24,650,288
Extend Wing walls at New Locks	$4,833,343
Upgrade Miraflores Swing Bridge	$13,425,953
Sub Total - Rail corridor and Intermodal Yard	**$133,500,072**
Add contingencies	$25,587,524
Admin & Engineering Costs	$13,522,445
Estimated Project Cost	**$172,610,041**

Assuming amortization of this investment over a 20 year period, with interest rates of 7.0 percent, the annual payment requirement will be $18 million. Converting this to a rate per TEU at the maximum expected flow then indicates a need to recover $72.00 per TEU to amortize the cost of the capital investment. Operating costs for a rail service are not

available at this time, but it would appear to be reasonable to apply the current Panama Canal Railroad tariff to cover operating and overhead costs, indicating a target charge of approximately $220.00 per TEU for the coast to coast transfer.

6.12 Other Intermodal options

Given the extremely high cost of the rail connection, primarily due to the need for new and upgraded rail bridges at the Miraflores Locks, it is prudent to evaluate other options to connect the Atlantic and Pacific Coast Ports.

The three options evaluated are:

- Drayage of containers to the Existing Balboa Yard
- Establishment of a Barge service – Port to Port
- Truck haul across the Isthmus

6.12.1 Truck Transfer to Balboa Rail Yard.

Assuming the use of 40 ft trailers, and an average daily flow in each direction of 200 vehicles, and 80% of all trips being undertaken in the daylight hours, the added vehicle movements on the coastal and Pan American Highway will be approximately 16 per hour in each direction once the terminal is at full capacity.

With the construction of the New Centenario Bridge, there will be less pressure on the Bridge of the Americas and the added traffic load is not considered to be a major issue, particularly if restrictions are placed on the working hours. At this time, heavy vehicles are prohibited using from the Amador exit of the Bridge and trucks would be required to travel along the Avenida de los Martires and on to Albrook via the newly completed roads and interchanges, for a total one way distance of approximately 10.5 kilometers.

Assuming an average trip time of one hour for a 40 ft or two 20 ft containers, the haul cost should be on the order of $45.00 per TEU. With overhead and profit, a charge of $80.00 would be reasonable assuming an outside contractor. In the event that a return container can be collected from the rail yard, these costs can then be reduced significantly.

Containers at the Balboa Yard must then be moved to the Atlantic Ports. At this time, it is understood that the cost for this service is $150 per TEU, indicating a total coast to coast transfer cost of between $190 and $230 per TEU, depending on back haul and other factors.

6.12.2 Barge Service to Atlantic Ports

Given sufficient volume, a container barge service could be established as a concession or directly operated by the terminal management company. There are a number of operational and pilotage issues to be resolved with this option, but a 400 ft flat deck barge would have the capacity to move 400 TEUs stacked six across and three high. A 1,500 hp tug would be adequate to move the unit through the protected waters of the Canal.

Barges would be loaded by the terminal(s) gantry cranes with departures scheduled to take advantage of tandem lockages to minimize impacts on Canal traffic. Using costs developed for the Materials Disposal study, the operating cost of a single tug and flat barge will approximate $10,500 per operating day assuming recovery of equipment costs, labor, overhead and profit. This translates to approximately $35 to $40.00 per TEU excluding Panama Canal fees, estimated to be $49.00 per TEU in 2006 and increasing to $54 per TEU in 2007.

6.12.3 Truck haul from Port to Atlantic Coast Ports.

The final option would be to move containers by truck directly from Port to Port, using the Trans-Isthmian Highway. Total distance from point to point is approximately 50 km, and under present conditions, the round trip would be completed in a single working day.

It was reported to the study team that the current market cost of moving a container between the coasts is on the order of $120 to $150 at this time. Again, the acquisition of a return haul would reduce the costs significantly.

As noted earlier, the establishment of a modern highway link from the Port to Colon, via the Centenario Bridge will reduce the travel time and operating costs of this option significantly.

6.12.4 Conclusions

Based on this very cursory assessment, it would appear that barge and truck haul from coast to coast are the most cost effective options for intermodal transfer or containers.

While the barge cost appears to be the cheapest, a balanced directional flow of containers is required as the Canal fees for a return empty or partially loaded trip will be the same as for a full load, unless special exceptions are made.

With improvements in the highway connections to Atlantic coast and a new link to the Centenario Bridge, truck transfer would also be very competitive and efficient.

7 ENVIRONMENTAL & SOCIO ECONOMIC IMPACT ASSESSMENT

7.1 Introduction

The objectives of this environmental assessment are:

- To identify the potential beneficial and adverse environmental and socio-economic impacts that could potentially result from the construction and operation of the Project and its related infrastructure.
- To assess potential temporary, residual, and cumulative impacts produced by the construction and operation of the Project.
- To assess the magnitude of the impacts identified in terms of duration and spatial context.
- To rank the potential impacts identified according to their importance with regard to the environmental setting in the Project area

The impacts described in this report are potential in nature with varying degrees of occurrence and are based in many cases on worst-case scenarios assuming static environmental conditions, which in reality vary naturally and may actually heighten or lessen impacts.

7.1.1 Methodology

The environmental assessment has been performed through a review of existing environmental reports and data, site visits, and an interactive process between ACP, and the engineering and environmental consulting team and meetings with Panamanian Institute of Development and Tourisms (IPAT), National Authority of the Environment (ANAM), National Institute of Culture (INAC), Panama Canal Railroad Company, and Interoceanic Regional Authority (ARI). The interaction between ACP and the consultants allowed the evaluation of design options and the planning of the Project during this preliminary phase in order to minimize the adverse impacts and to maximize the beneficial impacts during the construction and operation phases.

Site visits were conducted on February 14-17 and April 11-13, 2005. The February site visit consisted of a reconnaissance to the project site, access roads and nearby communities such as Veracruz, Vacamonte, Amador Causeway, as well as interconnection points to the existing rail corridor west of the Miraflores Locks to identify those facilities that would be affected by the proposed construction and operation of the

container terminal and associated rail/access road. The site reconnaissance consisted of a road tour consisting of viewing the site from Amador Causeway, a visit to the site (existing retirement/hospital), Kobbe Beach Resort, Veracruz and Vacamonte. In addition, potential access roads north of Miraflores locks were evaluated as well as sources of borrow material.

The April 12th site reconnaissance was conducted to evaluate the marine environment along Palo Seco and covered the intertidal area stretching from Farfan Beach and the mouth of the Farfan River, the proposed project shoreline near the hospital to Kobbe Beach.

An analysis of the potential impacts associated with the construction and operation of the Project was performed during the desk-top environmental assessment, by overlaying the proposed activities on the existing environmental conditions as established during the site visits and based on a review of available literature.

A qualitative and quantitative identification and assessment of environmental impacts using modified Leopold cause-effect matrices was conducted by the environmental specialists based on information provided by review of available literature, field studies, identification of sensitive areas, and their interaction with project design and implementation activities.

Detailed information on the methodology and impacts identified can be found in Appendix F to this report.

7.2 Identification of impacts

The potential environmental impacts were identified based on the activities related to the construction and operation of the Project alternatives or options as defined in this preliminary study. The actions or agents that can potentially lead to a change of an environmental indicator, when the activity is implemented, were identified for each of the Project activities.

7.2.1 Project Options or Alternatives

Although a number of island locations or positions are under consideration from a geotechnical and cost perspective all have similar environmental and social impacts due to their proximity to each other.

The preferred road alignment follows the existing roads between the site and the Bridge of the Americas. The first railroad alignment (Option 1) would begin at the Port, run

through Palo Seco and along the eastern edge of the former Howard Air Force Base to connect to the Miraflores Locks area. The second (Option 2) would begin at the island and run on a trestle or pilings around the coastal edge of Palo Seco to near the mouth of the Farfan River where it turns to the west, and follows the same route as the first alignment to reach Miraflores locks. Two rail terminal locations were also evaluated. The first location would be on the artificial island itself, while the alternative would be on land in Palo Seco. In the event that the land based rail terminal location is chosen, any rail alignment chosen would begin at that location.

The following options or alternatives were evaluated as part of this study:

- Artificial island - access through upgraded existing roads and intersections only
- Artificial island - access through upgraded existing roads and intersections with rail/road alignment Option 1
- Artificial island - access through existing roads and intersections with rail/road alignment Option 2
- Rail terminal located on the artificial island
- Rail terminal located on land in Palo Seco

Figure 7-1 shows a composite illustration of the options assessed for environmental impacts.

558200_Fig07-01.dwg 28 Jun 2005 - 1:06am; jmacpherson; © Moffatt & Nichol

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GOLDER ASSOCIATES

Figure 7-1
Project and Access Options Assessed for Environmental Impacts

ACP AUTORIDAD DEL CANAL DE PANAMÁ

7.2.2 Project Activities

The following activities are anticipated during the construction phase of the Project:

- ***Transportation and Mobilization,*** includes all the activities related to the transportation of equipment, machinery, supplies and personnel to and from the proposed container terminal site. Transportation activities are anticipated to take place over land and water.
- ***Site Preparation*** includes all the activities related to earthwork (cut and fill) that is required on the landward (rail and access roads) and seaward portions of the site for the construction of the proposed container island, laydown areas, storage, and construction support-building areas.
- ***Construction of Infrastructure and Utilities*** includes the construction of access roadways and rail, administrative buildings, power, firewater system, effluent treatment system and other services to support the construction of the proposed terminal and associated infrastructure.
- ***Construction of Container Terminal*** includes the construction of a container port island including the placement of select structural fill and foundations for the gantry crane.

The following activities are anticipated during the operation of the Project:

- ***Operating the Container Terminal*** consists of the operation of the terminal and the management of container vessels, terminal and associated infrastructure.
- ***Operating the Access Road and Rail*** includes all of the operations associated with the proposed access road and rail.
- ***Maintenance of the Terminal and Related Structures*** includes all the activities required to ensure the proper civil, mechanical, electrical and automatic operational systems of the terminal and associated infrastructure.
- ***Closure of Operations and Abandonment*** includes all the activities related to the closure of the container port terminal and its installations at the end of the estimated useful life and the activities related to the proper abandonment of the installations and the rehabilitation of the site.

7.2.3 Environmental Components & Change Indicators

Based on the information collected during the preparation of an existing conditions report for the various physical, biological, socio-economic and cultural components represented in the Direct Impact Area (DIA) of the Project, change indicators have been identified based on the susceptibility of the component to exogenous agents. This analysis is summarized in Table 7-1. A code was assigned for each of the indicators identified in each environmental component analyzed. These codes will be used to facilitate the information management in the process of impact identification and its easy representation in the matrix of environmental impact assessment.

Table 7-1: Change Indicators

Environmental Component	Code	Change Indicators	Effects
Air	A-1	Alteration in the air quality	Refers to the environmental effects such as: dust and particulate generation (PM10), atmospheric emissions of mobile sources associated with the transportation of fill during construction and transportation of containers during the operation of the terminal (NO2, SO2 and CO).
Noise	R-1	Increase of the noise levels	Considers the increase of environmental noise above baseline levels due to the temporary/permanent introduction of noise levels.
Water	H-1	Increase in turbidity	Refers to the direct increase in suspended particulate material in Bay of Panama and the alteration of the aquatic habitat.
	H-2	Alteration of physical-chemical quantity and quality of Bay of Panama	The physical quality refers to changes in the water flow and volumes and their relation to the typical sediment transport associated with the development of a terminal island. This indicator also refers to changes in the physical or chemical quality of the water that may be produced by accidental spills of hydrocarbons (such as combustibles, greases and oils) or other substances related to discharges that deteriorate the quality of the resource.
Soils and Landforms	SU-1	Alteration of the physical-chemical quality	The physical quality refers to the erosion caused by container port island or water-related transport of sediments, or the combination of both. The chemical quality refers to characteristics of the soil that may be affected by accidental hydrocarbon spills (such as combustibles, greases and oils) or other substances related to discharges that

			deteriorate the quality of the resource.
	SU-2	Alteration of landforms	Refers to the alteration of landscape caused by cut and fill activities and soil compaction during the construction phase for the road and rail access and the loss of shoreline and caused by the proposed terminal.
	SU-3	Alteration of Morphology	Refers to the changes in the deposition of sediments patterns caused by the interaction with new terminal island on the Bay of Panama.
Terrestrial and Aquatic Flora and Fauna	FF-1	Loss of upland and wetland terrestrial vegetation cover/habitat	Refers to the removal of upland and/or wetland vegetation at the proposed location of the new access road and rail access to the container port island.
	FF-2	Alteration of marine habitats	Refers to the loss of hard bottom and other habitat due to the construction of the container port island.
	FF-3	Changes in the fish catch	Effects to the artisan fishery and the change in fish and shellfish catch due to the construction of the container port island.
	FF-4	Reduction in the threatened or endangered terrestrial and aquatic fauna	Refers to the decrease in the number of sightings in the area or the direct eradication of species with conservation ranking that are directly related to accidental contacts with Project elements or indirectly related due to the effects on their habitats.
	FF-5	Reduction in coastal and migratory birds	Refers to the decrease in the number of sightings in the area or the direct eradication of species that are directly related to accidental contacts with Project elements or indirectly related due to the effects on their habitats.
Social	S-1	Nuisance to the population	Refers to the impacts on the population living in the areas of indirect impact near terrestrial or aquatic corridors used for transporting equipment, machinery, supplies and personnel required for the project and the increase in vehicular traffic and the potential for accidents. Also refers to the impacts on the population due to noise and light pollution due to operation of the container port terminal
	S-2	Interruption of infrastructure	Refers to the impacts on the transit conditions and on structures such as roads, bridges and waterways that impede the normal traffic flow and the planning and permitting that will take place to prevent damage to infrastructure.

	S-3	Restrictive access to fishing facilities	Refers to the restrictive access to artisan fishing and shellfish collection areas due to the construction of the container port island.
	S-4	Visual impacts	Refers to the impacts to nearby populations, businesses, tourism, and future development
Economic	E-1	Increase in the capacity to move goods from one side of Panama to the other	Refers to the increased capacity or ability to move containers from one side of the country to the other, without increasing traffic or congestion through the canal.
	E-2	Increase in the demand of goods and services	Refers to the increase in the purchase of supplies, goods and services directly related to the construction and operation of the proposed container port terminal, which will result in the increase of available quality and the supply of some goods and services at local, regional and national levels.
	E-3	Job Creation	Refers to the demand of workers (skilled and non-skilled) that the Project will require throughout the construction of the proposed container port terminal, access and rail corridors and the operation of the terminal. The development of this project will produce two types of employment: direct employment, during the construction of the Project which will help alleviate the levels of unemployment in the area; and indirect employment created by the increase in the demand for local goods and services.
Cultural	AR-1	Alteration or destruction of archaeological resources	Refers to unknown archaeological resources uncovered during the construction activities.

7.3 Evaluation of Impacts

The evaluation of impacts consisted of defining the attributes to be assessed for each of the impacts analyzed and assigning a relative value for each of these attributes. The process developed a ranking of each of the impacts generated by the Project activities during the construction and operation phases of the project as described as follows.

7.3.1 Evaluation Criteria

In the process of assessing the environmental impact of the Project options or alternatives, the attributes and the values were defined for the impact analysis. The attributes established for the environmental impacts were based on the characteristics and the behavior produced by the interaction of the project activities and the environmental component affected.

The attributes defined for the evaluation of the potential impacts included:

- Type
- Geographic extent
- Length
- Magnitude
- Probability of occurrence
- Frequency
- Reversibility

7.3.2 Evaluation of Impacts

The evaluation of impacts performed by a multi-disciplinary team was carried out using a Leopold modified matrix, in which the environmental and social factors potentially impacted and the Project activities that can lead to a potential impact were represented.

The evaluation method used for the matrix consisted of assigning values, in a relative scale, to all the attributes of the impact analyzed for each of the interrelations of project activity to environmental effect.

Table 7-2 represents the relative scale of values established for each of the attributes shown previously.

Table 7-2: Scale of Values for Ranking of Impacts

Type (C)			Duration (Du)	
Negative	-1		Long-Term	3
Positive	1		Medium-Term	2
Neutral	0		Short-Term	1
Magnitude (M)			***Frequency (F)***	
High	3		Permanent	3
Medium	2		Periodic	2
Low	1		Temporary	1
Probability of Occurrence(Po)			***Reversibility (R)***	
High	1		Irreversible	3
Medium	0.9-0.5		Reversible at medium-term	2
Low	0.4-0.1		Reversible at short-term	1
Geographic Extent (E)				
Regional				3
Local				2
Direct				1

The information obtained from the literature review, field studies, observations, suggestions and recommendations from the engineering and environmental representatives of the consulting team and ACP were reviewed prior to assigning values to each of the impacts according to their attributes. Appendix F contains all of the assigned values and final scores given to all potential changes for each project component or alternative location that may occur during the environmental and social component interactions with the Project activities.

To visualize the quantitative and qualitative characteristics of the impact analyzed in the matrix of interactions, a rank of values was established assigning a color code to each one as shown below in Table 7-3.

Table 7-3: Ranking of Values and Color Code

Ranks of Value				
			Predicted Effect	**Color Code**
15	To	+.1	Positive	
0		0	NEUTRAL	
-5	To	-.1	Slightly negative	
-10	To	-5.1	Moderately negative	
-15	To	-10.1	Highly negative	

7.4 Overview of Impacts

7.4.1 Physical Environment

Air Quality

Construction Phase

Project construction activities most likely to affect air quality in the region will be associated with the transportation of equipment to the site, site preparation and construction of the proposed container port terminal and access routes. The maximum air quality impacts during construction are anticipated to be temporary and intermittent from construction sources.

The proposed container port terminal site and most of the road and rail access routes are located within the Canal Operating Area where the air quality is considered to be relatively good and representative of rural tropical areas. Ambient air quality impacts associated with the construction phase are considered insignificant.

Operation Phase

The air quality impacts during the operation of the container port terminal are expected to be slightly worse than the existing air quality due to increases in vessel, vehicular, and rail activities. The predicted air quality in the Direct and Indirect Impact Areas is

predicted to be significantly below the World Bank Ambient Air Quality Guidelines (World Bank, 1999).

Noise

Construction Phase

All construction activities will be carried out in areas that are more than 2.0 kilometers from the nearest residences or businesses, such as the Kobbe Beach Resort.

Some construction activities, such as grading, compaction, blasting, and pile driving will increase instantaneous and short-term ambient sound levels significantly. However, noise levels generated during the construction phase are expected to be localized and of short-term duration and do not constitute a significant adverse impact.

Noise levels produced during construction may cause the wildlife in the area to migrate temporarily away from the Project site to areas were they will not be disturbed.

Operation Phase

Noise levels from the operations phase of the Project will be at greater levels than those currently in the project area and to be fairly constant as the container port will run 24 hours per day. Noise generated from the road and rail alignments are expected to be intermittent dependent on shipping schedules.

Soils and Landforms

Construction Phase

The most significant impact to soils and landforms will occur during the construction of the artificial island and the road and rail connections. To a lesser extent other impacts are anticipated with the construction of infrastructure such as temporary access roadways, temporary construction field offices, and temporary laydown areas required to support the construction phase.

The modification of soils and landforms at the location of the road and rail alignments will require blasting, excavation, and compaction of soils that will result in a permanent impact to the soil structure landscape of the footprint. Clearing of vegetation will result in soil removal, mixing, and compaction by heavy equipment which will result in a destruction of their matrix system consisting of both soil nutrients and root matrix that will expose the soil to extreme temperatures, direct and intense rainfall resulting in erosion, landslides, and decomposition of the humus zones.

The potential for alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills during the construction (machinery, equipment and motor vehicles) estimated as low since appropriate control and handling measures will be applied for counteracting these types of incidents.

Operation Phase

The impacts associated with operation of the container port terminal island are related to the potential changes in coast line morphology as a result of changes in currents, hydrodynamics, erosion, and sediment transport related to the presence and position of the artificial island. The alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills or other process-related substances during the operation of the Project is estimated as a slightly negative impact.

Water Resources

Construction Phase

During the construction phase, water will be used for dust control, soil compacting and concrete mix. Water required for these activities will be extracted from a permitted location, while potable water for construction workers will be delivered to the project. Estimated water volume that will be extracted daily during the construction phase cannot be established at this time, but the quantities should not be significant.

Dredging and reclamation work will produce a temporary increase in the ocean turbidity in the project area. The degree of re-suspension of the material in the water is related to several factors such as sediment characteristics, wind and currents prevailing during the execution of these activities and the type of construction and methods used. The turbidity plume can adversely affect the aquatic species and habitats causing a reduction of light and obstructing the respiratory mechanisms of the aquatic species. The effects of the turbidity with proper mitigation can vary from a negative to slightly negative. Deposition of suspended materials may render previously suitable areas unsuitable habitat for certain aquatic species. The impact takes into consideration that the species and habitats in the construction areas have some level of tolerance to the increase of suspension materials and to the light reduction and are able to migrate to avoid temporary increases in turbidity.

The alteration of the physical and chemical quality of the water by accidental hydrocarbon spills (fuel, grease and oils) or other substances from work barges and

ships, equipment and machinery used during the water construction activities are considered as a slightly negative impact. All possible precautions will be taken during the construction phase to avoid hydrocarbon spills. The potential for a spill should be minimized by using trained fuel handling personnel, establishing spill prevention procedures, maintaining spill cleanup equipment, and preparing a contingency plan.

Operation Phase

The impacts related to the management of surface drainage and discharge of effluents from the Port and associated infrastructure during the operation phase are considered as slightly negative. However, the magnitude of the effect will be reduced when all the systems designed for its management and treatment are completed and the monitoring of the effluent discharge parameters for ensuring the compliance with both Panamanian and international discharge standards are implemented in order to establish adequate controls.

A potential impact to the water environment is the discharge of contaminated water to Panama Bay. However, this impact can be managed by including treatment systems for sanitary sewage and storm water run off prior to discharge.

- An API oil/water separator for surface water runoff contaminated with oil and grease,
- A waste water treatment plant will be used to treat sanitary waste from the container port terminal.

Water collected from the process areas and utility areas will be routed to the API oil/water separator. Collected oil is stored in appropriate tanks and is then trucked to an offsite disposal at an approved recycle/disposal facility.

Effluent from the container port terminal should be monitored to ensure compliance with Panamanian and/or applicable World Bank Guidelines for Liquid Effluents for Process Wastewater, Domestic Sewage and Contaminated Stormwater Discharge to Surface Waters effluent limits for those parameters applicable.

7.4.2 Biological Environment

Terrestrial and Aquatic Flora and Fauna

Construction Phase

The project study area provides habitat for a variety of flora and fauna, many of which are considered rare, threatened, or endangered. Several thousand species of flora and fauna are found near the Panama Canal. Many of these species are included in conservation rankings established in international conservation agreements and some are protected by Panamanian laws. Several animal and plant species with conservation rankings are reported from areas adjacent to the Project and the area is known to be a stopover location for migratory birds.

Impacts to flora and fauna associated with the transportation and mobilization phase of construction are anticipated. Most transportation activities would take place by boat or by land over existing roadways. Increased road traffic may cause additional mortality of animals crossing roadways for dispersal, foraging, or breeding. Wildlife crossings and fish friendly culverts should be part of the design of the road and rail access alignments to reduce road mortality and to facilitate dispersal and migration.

The impacts to flora and fauna associated with site preparation vary among the different options or alternatives. Earthwork associated with site preparation would cause permanent irreversible loss of forest lands, wetlands, seafloor, and ocean habitat, which would result in habitat loss for species utilizing these areas. Motile species may be able to move to unimpacted habitats near the project; however, it is unclear whether these habitats would be able to support the influx of new individuals. Less motile or non-motile species would be directly and adversely impacted by earthwork associated with site preparation. Short-term, temporary increases in turbidity and sedimentation are likely to cause temporary alteration in the structure and composition of plankton and benthic communities, which may have impacts on fish abundance and diversity. Aquatic species previously present in areas impacted by turbidity and sedimentation during site preparation are expected to re-colonize these areas once disturbance ceases, provided sedimentation is not so great as to permanently alter the habitat.

Operation Phase

Maintenance of the artificial island container port terminal and related structures is not likely to result in loss of terrestrial vegetative cover. These activities may result in temporary localized changes in the structure and composition of aquatic communities, but these communities are expected to return to their original condition once

maintenance operations cease. Maintenance operations are not expected to impact rare or endangered fauna as all structures would be located within areas that have been previously or are currently disturbed by human activities.

Closure of operations and abandonment may result in some loss of terrestrial vegetative cover as structures are demolished or decommissioned. However, native vegetative may be planted or allowed to colonize these areas once human activities cease. These impacts are expected to be positive as the areas would move towards a more natural condition. Impacts to rare or endangered species are expected to be neutral to slightly positive since these species are not expected to be found in areas of human activity. Over the long-term, rare or endangered species may benefit from closure or abandonment as these areas may evolve through succession into needed habitats. Due to the magnitude of this project, it is unlikely that any of the major operations would cease. Likewise, closure and abandonment of the spillway or other major structures is not anticipated.

7.4.3 Social, Economic and Cultural Environment

Social

Construction Phase

Nuisances to the Population

The construction activities related to this Project will include the transportation and mobilization of equipment, machinery, supplies and personnel to the project site. Personnel and equipment will be transported overland or water during the mobilization phase of the project and will create temporary nuisances to the population living close to the transportation routes. Control measures will be implemented to minimize the impacts associated with these activities.

Interruption and Deterioration of the Infrastructure

A temporary construction road will be built alongside the existing public highway to avoid the interruption of the normal traffic patterns during the construction of the project caused by transporting oversize and large heavy equipment and machinery. However, some impacts on the existing highway system will be inevitable at the entrance to the project site and the intersection with the Bridge of the Americas. Transportation of equipment over water will be conducted using work barges, cranes and other similar construction equipment.

Access Restriction to Fishing Areas and Recreational Activities

The purpose of restricting access to certain portions of Farfan/Palo Sec shoreline and coastal zone during construction is to protect the fishermen and individuals passing through the area from hazards related to the construction of the Project. The access near the artificial island and other facilities during the construction phase will be restricted because of risk management concerns during the construction.

Economic

The proposed project will result in a significant capital investment, exceeding US$500 million. The resulting project would permit an increase in the capacity to move goods from one side of Panama to the other without increasing Canal traffic. Historically, investment in canal related projects has had a multiplicative positive impact on the Panamanian economy such as an increase in tax revenues and fees, an increase in demand for goods and services and job creation. For all these reasons, the impacts associated with the construction phase of the project are considered highly beneficial.

Increase in Demand of Goods and Services

At a national level, benefits will be derived from the Project. The Project will cause a general increase in business activity which will affect local, regional and national economies in a positive manner. The construction activities will generate and increase in the demand for goods and services directly and indirectly associated with the Project. This increase in demand will enhance the local economy by the production of goods and supplies of construction materials, local support services (hotels, restaurants, transportation, stores and warehouses) and an increase in trade among the districts. The Project will require a high standard of goods and therefore this demand may result in an increase in the quality and the supply of some goods and services offered locally. For all of the above reasons mentioned above, the effect on goods and services during the construction phase is considered as highly positive.

Job Creation

Considering the level of unemployment and the limited available low wage jobs at the local level, the construction of the Project provides a new source of temporary employment that could increase per capita income of some qualified local residents in the Project's direct area of influence, and could result in an indirect benefit to the construction sector.

The creation of new employment opportunities will allow an influx of capital to areas that have been traditionally lacking of funds to meet basic necessities. Such increases in

employment may lead to the improvement of social conditions such as housing, health, education, etc. from the added tax revenues associated with the Project. In addition to the direct employment, it is estimated that construction activity generates at least three to five indirect jobs for each direct job position. Therefore, induced jobs will be derived from the construction of the Project. Approximately 1,000 permanent full-time jobs at the container port terminal are expected to be created through the construction of the Project.

Operation Phase

Access Restriction to Fishing Areas

The access near the proposed will be restricted during the operation of the Project because of risk management concerns. Non-authorized personnel will be restricted in certain areas to assure their safety and the safety of others working at the container port terminal.

Economic

Increase of the Demand of Goods and Services

At a national level, benefits will be derived from the Project during the operational phase. The Project will cause a general incremental increase in business activity which will affect local, regional and national economies in a positive manner. This will enhance the local economy by the production of goods and supplies of construction materials, local support services (hotels, restaurants, transportation, stores and warehouses). The Project will require a high standard of goods and therefore this demand may result in an increase in the quality and the supply of some goods and services offered locally. For all of the above reasons mentioned above, the effect on goods and services during the operation phase is considered as highly positive.

7.4.4 Cultural

Alteration or Destruction of the Archaeological Heritage

The review of existing information shows that the possibilities of finding archaeological resources in the areas where earthworks will be performed are high. Archaeological surveys are recommended before earthwork is performed in previously undisturbed areas to identify and remove archaeological resources prior to land disturbance

activities. Protocols will be required for handling archaeological resources found during land disturbing activities.

7.4.5 Visual Impacts

The introduction of the port into the view from Amador and the Palo Seco/Farfan area will change the characteristics of the area. As a 24 hour operation, the nighttime vista will also change as the vessels, cranes and yard area will be illuminated by powerful lighting and high mast light pole systems.

The reaction to this modification of the visual characteristics of the area will vary according to the perspective and preferences of the viewer. Some may see the port as a logical extension of the Canal traffic and economic activities that are important to Panama, while others may object to any change of the natural views of the area.

Clearly the public reaction to this project will be an important element of the approvals process for the new Port.

7.5 Summary of Impacts

Table 7-4 below presents an estimate of the impacted area for each island location and alignment option.

Table 7-4: Estimated Direct Impact Area (m^2) for Each Island Location and Alignment Option

Location/Alignment	Total Area Impacted	Seafloor Impacts	Wetland Impacts
Island Locations 1, 2, and 3	2,417,830[20]	2,417,830	0
Island Location 4	3,452,000	3,452,000	0
Island Location 5(a)	2,240,000	2,240,000	0
Land-based Intermodal Terminal	270,000	0	0
Upgrades to Existing Roads	100,000	0	20,000
Rail/Road Alignment Option 1	600,000	20,000-55,000[21]	131,000
Rail/Road Alignment Option 2	560,000	400,000	27,000

The full results of the evaluation process are presented in a series of matrices in Appendix F of this report. Typical matrices covering the option with access through upgrades to the existing roads and a railroad terminal on land are presented in Table 7-5 and Table 7-6.

[20] The estimated impact area for Locations 1, 2, and 3 was assumed to be the same due to their similarity in size and location.

[21] Varies according to Island location

Table 7-5: Evaluation of Impacts, Port with Upgraded Existing Roads and Intersections

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

Table 7-6: Evaluation of Impacts, Rail Terminal at Palo Seco

Environment	Component	Change Indicators	Project Phase							
			Construction				Operation			
			Transportation and Mobilization	Site Preparation	Construction of Infrastructure and Utilities	Construction of Container Port Island	Operation of Container Port Terminal	Operation of Access Road and Rail	Maintenance of Terminal and Related Structures	Closure of Operations and Abandonment
Physical	Air	A-1								
	Noise	R-1								
	Water	H-1								
		H-2								
	Soil and Landforms	SU-1								
		SU-2								
		SU-3								
Biological	Terrestrial and Aquatic Flora and Fauna	FF-1								
		FF-2								
		FF-3								
		FF-4								
		FF-5								
Social	Social	S-1								
		S-2								
		S-3								
		S-4								
	Economics	E-1								
		E-2								
		E-3								
	Cultural	AR-1								

7.6 Summary and Conclusions

For a project of this magnitude, detailed studies, including bottom surveys of aquatic species and habitat, are required to accurately identify the potential impacts associated with the location options selected for further analysis. However, the construction of an artificial island at any of these locations will result in a loss of marine bottom habitat that may be utilized by benthic invertebrates, shrimp, spiny lobsters, bivalves, and certain fishes. The large rip-rap that will be placed on three sides of the artificial island may provide habitat for certain types of invertebrates and fish, but it should not be considered in-kind replacement for habitat lost through construction.

Upgrading the existing roads and intersections to provide automotive access only to the artificial island would have the least environmental and social impacts because only a minimal amount of new alignment would be needed and most construction would occur in the existing right-of-way or already disturbed areas. However, this option would provide automotive access only and if rail access is added at a later date, the cumulative impact of the separate projects may be more than that of a combined road and rail project. Of the two rail/road access alignments, the routing of the line along the shoreline is not recommended, as it would impact a large portion of the nearshore marine habitat utilized by invertebrates, fishes, and coastal and migratory birds. Providing access through upgrading the existing roads and intersections is recommended to minimize environmental and social impacts of the Project.

Also considered as part of this Project were two locations for the rail terminal (intermodal facility). The first location placed the rail terminal on the artificial island with the container port. The second location was on the coast of Palo Seco in an area of dry forest and allowed a greater portion of the island to be used for containers. Locating the rail terminal on the artificial island would minimize environmental and social impacts because all construction would occur on a previously disturbed site. Construction on the landside would require destruction of dry forest habitat, which is becoming rare in Central America, and may also unearth or destroy previously undiscovered archaeological objects. For these reasons, it is recommended that the preferred location for the rail terminal should be on the artificial island, in the event that it is considered to be a financially viable element of the Project.

Finally, the port will change the visual landscape as seen from Amador and also from the Palo Seco and Farfan areas. This may or may not become an issue of concern, but clearly a public participation program or reaction assessment will be required to ensure that the Port does not become a controversial issue in the public arena.

7.7 Mitigation and monitoring

7.7.1 Mitigation

The government of Panama has established a system of tariffs or mitigation fees associated with projects involving the loss of natural resources. According to representatives from ACP, the tariffs for primary and secondary forest are $5,000 and $3,000 per hectare, respectively. The tariff for mangroves is $10,000 hectare[22]. It is unknown at this time if tariffs are required for the destruction of other habitats, such as marine bottom.

The estimated footprint of impacts associated with each project option is approximately 160 ha, for the island, trestle and highway improvement land requirements. On this basis, and assuming an average tariff of $5,000 per ha for the loss of the sub tidal and upland zones, the allowance for mitigation is expected to be approximately $800,000. Once the complete footprint of impact is determined for the preferred or final construction option, and following agreement with the government of Panama over mitigation tariffs for the project, a final cost estimate can be presented.

Mitigation projects may possibly be used in lieu of or in conjunction with tariffs to offset negative environmental and social impacts associated with the proposed Project. Potential mitigation projects could include enhancement of local beaches, environmentally sensitive areas, or important habitats. Potential mitigation projects suggested in the Island Feasibility Study (Moffatt & Nichol et al., 2004) included:

- Protection of the dry forest at Palo Seco
- Restoration of contaminated intertidal areas in the Rodman area that are used by migratory birds
- Enhancement of the protected forest area at Punta Bruja
- Beach enhancements or improvement of shore side facilities at Veracruz
- Community benefit projects, such as a road link from Veracruz to the Vacamonte Highway.

[22] Mitigation/tariff information provided by ACP.

Compensation payments were suggested in the Island Feasibility Study (Moffatt Nichol et al, 2004) as means to compensate for shrimp habitat destroyed by the construction of the artificial island. Although not fished, due to the shallow depths and rock outcrops in the area, the sub tidal areas under the island may be shrimp habitat. If the island location is determined to be prime shrimp habitat, then appropriate mitigation measures should be determined by a team of government and industry representatives.

7.7.2 Monitoring

A monitoring program should be developed to ensure that the Project construction and operation activities are incompliance with all applicable regulations. Possible monitoring provisions could include:

- Stormwater runoff from construction areas and from the container port terminal once it is operational
- Water quality in the vicinity of the artificial island and where the road or rail alignments cross streams or wetlands
- Wildlife mortality associated with crossing road or rail alignments
- Noise levels associated with construction activities and with operation of the container port terminal and associated road and rail access
- Air quality in the vicinity of construction areas and the container port terminal once it is operational
- Fisheries surveys of the coastal area of Palo Seco and the artificial island
- Birds surveys (coastal and migratory) of the coastal area of Palo Seco and the artificial island.

8 COMMUNITY BENEFIT PROJECTS

This project, together with the development of the resort at Kobbe Beach and the conversion of the former Howard AFB to commercial use will provide a significant number of employment opportunities. Clearly the Veracruz community is well placed to take advantage of the construction and long term jobs that will be created as this major cargo, logistics and value added processing center develops.

Other employment opportunities for Veracruz also involve the fisheries operations at the Port of Vacamonte, which are more akin to the traditional skills of the inhabitants of Veracruz and Bique.

At this time, residents of the township must walk some three kilometers from the end of the existing highway in Veracruz to access the main road to Vacamonte and it has been suggested that the construction of a link between the town and the Vacamonte highway would be beneficial to those persons wishing to follow the traditional work skills of the community. This project would also offer visitors and residents of Veracruz and alternative access to the Pan-American highway, thereby reducing return traffic on the Coastal Highway which currently only has one outlet at the Bridge of the Americas.

Other community benefit projects include the provision of bus and vehicle parking zones along the Veracruz beach areas and the construction of rest facilities for weekend visitors.

8.1 Highway connection to Vacamonte

8.1.1 Existing Conditions

As seen in Figure 8-1 to Figure 8-3, the existing Coastal highway from the Bridge of the Americas to Veracruz is a mix of two lane paved highway, partially completed divided highway and unpaved sections.

Figure 8-1: Coastal Road to Veracruz

Figure 8-2: Narrow road within Veracruz Township

Within the township, the road is typically a two-lane concrete or asphalt construction, with houses or private property limits close to the edges of the paved section. As seen in Figure 8-3, a number of minor bridges cross the highway and the main water and electricity supply lines closely follow the highway alignment.

Figure 8-3: Typical Bridge Crossing on Main Highway in Veracruz

8.1.2 Recommended Alignment of Improved Highway

The houses and stores in the town area are close to the main highway which is also used heavily by local population for walking or just congregating. Given the impacts of an improved or widened road and increased traffic, the reconnaissance assessment considered routing the road connection around the north of the town.

As can be seen in Figure 8-4, all of the potential access routes that could be used for a northern by pass to the town are narrow and have development even closer than the main road areas. It was therefore determined that the impact of construction of a new road at the foot of the hills north of Veracruz would have much more impact on the

community than the expansion of the existing highway and construction of the link to the Vacamonte road.

Figure 8-4: Typical South-north road in Veracruz

Figure 8-5 shows the preferred alignment of the connector road to Vacamonte, based on this very preliminary assessment of the available options and project needs. Given that there is little potential or need to move heavy traffic through the township, it is suggested that the road can be a simple two land paved highway suitable for low volume urban and light commercial traffic.

Fig 8-5

FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Suggested Alignment of Connector Highway to Vacamonte

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8.1.3 Cost Estimate

Very preliminary estimates of the cost of the highway improvements and the new connector are presented in Table 8-1, below. The reader is cautioned that the estimates are based on a visual inspection of the route and typical costs for similar projects. Clearly a full engineering evaluation will be required before any funding commitment can be assigned to this project.

Table 8-1: Estimated Cost of Vacamonte Connector & Highway Improvements

Description	Quantity	Unit	Unit Cost	Amount (US$)
Improve surfacing (Port to Veracruz)	6.35	km	250,000	$1,587,500
Widen section (Town to Hospital area)	1.5	km	300,000	$450,000
New paved road on existing routing	3	km	450,000	$1,350,000
New Road and link to Vacamonte highway	4.5	km	750,000	$3,375,000
Large Stream crossings (new bridges)	5	each	175,000	$875,000
Small culverted crossings	15	no	40,000	$600,000
Electrical cable replacements/relocation	5	km	100,000	$500,000
water main replacements/relocation	3	km	125,000	$375,000
Right of Way Purchase/Condemnation	15.4	ha	50,000	$770,000
Property Purchase for widened section	15,000	m2	10	$150,000
Property Modification for widened section	20	no	25,000	$500,000
Sub Total				**$10,532,500**
Admin & Engineering	10%			$1,053,250
Field Studies	1	sum	125,000	$125,000
Legal Costs	1	sum	15,000	$15,000
Contingencies	25%			$2,931,438
Estimated Total Project Cost				**$14,657,188**

9 RECOMMENDED PROJECT CONCEPT

9.1 Selection of Preferred Alternative

Based on the technical, environmental and cost analyses presented in the previous chapters, a number of conclusions can be made as to the preferred location, configuration and components of the port project. These include:

1. A net terminal area of 111 ha is required to meet the projected throughput target of 2.4 million TEUs per year.
2. A total berth length of 1,600 m is needed to accommodate four vessels at the expected size limit of the new Panama Canal Locks
3. The maximum ship size for the new Locks is likely to be less than the maximum size of container vessel within the next ten to fifteen years
4. The two most cost effective locations for the Port are
   - Directly in front of Palo Seco
   - A location within 700 m of the Panama Canal Entrance Channel
5. The preferred construction method is the use of hydraulically dredged sand pumped into a diked containment area
6. Dredging and disposal operations can be efficiently matched to a sand mining and transport system if appropriate permits are obtained.
7. The most cost effective berth structure will be a cofferdam
8. The most cost effective fill retaining structure will be a rock dike, except under the berth areas.
9. Recommended dredged depth is 16.75 m below MLWS, provision should be made for future dredging to at least 18.50 m.
10. Removal of all of the soft material is not required below the fill area
11. Rock dredging is required to achieve the project depths
12. The provision of rail service to the Port carries a high cost and should be regarded as a future addition to the project based on operator needs
13. It would be prudent to incorporate provision for a rail bascule or swing bridge into the design of the south end of the New Pacific Side Locks
14. The preferred method for highway access during construction is a temporary road alongside the existing Coastal Highway to avoid interference with existing traffic
15. The temporary road should be paved and the existing road upgraded and widened on completion of the project

16. A new interchange is needed at the Bridge of Americas to improve safety for vehicles traveling to Panama City.
17. A highway link to the Centenario Bridge will provide an efficient connection to an improved Trans-Isthmian Highway in the near future.

9.2 Recommended Project Concept

The two options that offer the most cost effective locations for the project are Option 3, as identified in Section 5 of this report, and Option 5, which is closer to the Pacific entrance to the Panama Canal. The locations and general configuration of these two options is shown in Figure 9-1.

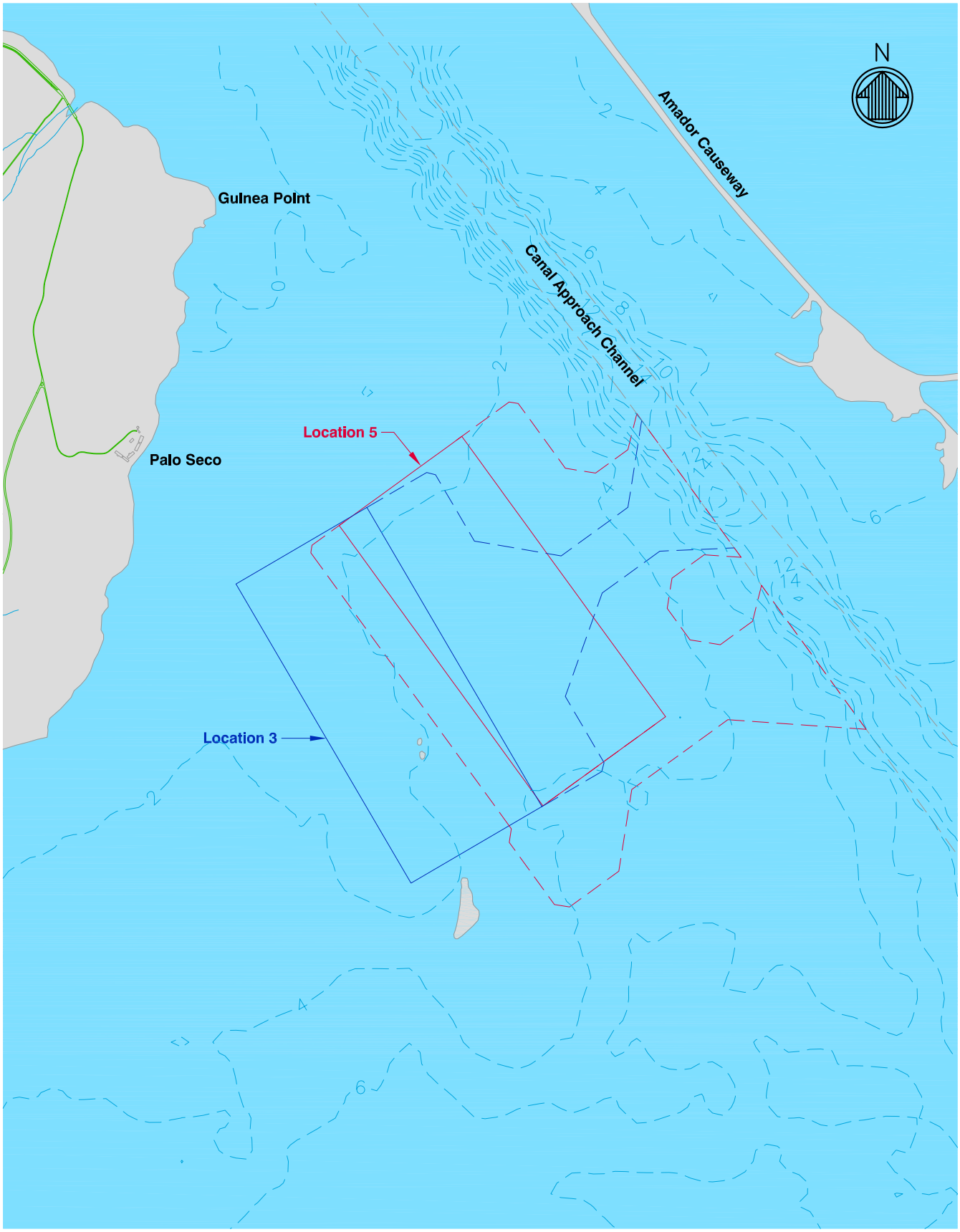
There are significant differences between the two locations, although the estimated cost of development for each is relatively similar. These differences include:

Location 3 (Palo Seco)

- Closer to shoreline, shorter trestle length
- Closer to Kobbe Beach area, possible higher visual impact
- 1.5 km from Amador, lesser visual impact
- Short trestle necessitates significant cut to access existing road
- More dredging than Location 5
- Better foundation conditions for terminal area
- Improved navigation access (clear of Canal traffic)
- Berthing only possible on east face
- Potential minor impact of project on shoreline processes

Location 5 (Close to Canal)

- Longer trestle, flatter grades are attainable
- Further from Kobbe, lesser visual impact
- Closer to Amador, higher visual impact
- Reduced dredging needs
- Poorer foundation conditions for terminal area
- Potential for interference with Canal Operations for vessels entering Port area
- Offers potential for reconfiguration to permit berthing on east and west faces
- No expected impact on shoreline processes



Note: Contours Referenced to MLWS.

250m 0m 250m 500m

SCALE: 1 : 25000

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Figure 9-1
Preferred Locations for Container Terminal

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It should be noted that the impacts of both projects on the marine environment are relatively similar, with the exception of visual impacts. In this respect, the two areas of concern are the ongoing resort development at Kobbe beach and the continued expansion of the commercial and recreational facilities at Amador Causeway.

9.3 Navigation Access

A key consideration with regard to the location and configuration of the navigation channel to either of the two preferred locations is the potential impact of vessels slowing and entering the channel from the same channel as the Panama Canal. While this is currently the situation for vessels entering and leaving the existing Balboa Port, the addition of a second access channel in this relatively short stretch of the Canal may give rise to concerns.

There are a number of alternatives that can be developed to alleviate or avoid this situation, including the provision of angled "in and out" channels or the provision of a new channel that would begin outside the south channel marker of the Pacific Entrance to the Canal.

The selection of the preferred navigation channel alignment should be made in close cooperation and discussion with the relevant divisions of ACP. Extensive navigation simulations will also be required once the project moves to the detailed design phase.

Given that it is not possible to resolve all of these key issues at this time, the alignment shown in the following illustrations serves as a starting point for these discussions and also gives a cost basis that is considered to be representative of all of the potential alternatives.

9.4 Container Port at Location 3.

Using the assumptions and selection criteria noted earlier, Figure 9-2 shows the recommended concept for the container Port at Location 3. The terminal has an overall footprint of 1600 m x 700 m, offering a total reclaimed area of 111 ha and a projected ultimate capacity for 2.4 million TEUs per year, assuming 80% transshipment cargo.

As seen in Figure 9-2, the terminal is connected to the Pacific Entrance channel of the Panama Canal by a new channel with an initial depth of 16.75 m and a width of 200 m.

Future expansion would deepen the channel to 18.75 m, although this would involve the need to remove substantial volumes of hard rock. Similarly, the channel could be widened for two way traffic of main line vessels, with an expected width of some 300 m.

A 600 m turning circle is provided at the mid point of the terminal. Depending on the results of detailed geotechnical studies and field investigations, it may be possible to adjust the location of the channel and turning circle to avoid or minimize rock dredging without impact the operational efficiency of the Port.

9.4.1 Yard construction

The cross sectional view shown in Figure 9-3 illustrates the shallow depth of soft sediments over most of the fill area, which reduces the cost of consolidation for the main yard area. Depending of the results of detailed geotechnical investigations, the area will be surcharged to an expected height of 3.00 m and wick drains installed to accelerate the consolidation process. Each surcharge load would be left in place for nine to twelve months before being moved to a new filled area.

9.4.2 Berth Structures

As recommended earlier, the berth construction is based on a cofferdam structure that is also used to retain hydraulically pumped material or alternatively can be used to retain excavated material from the Locks project. The caissons are filled with rock for lateral stability. Provision is made for gantry cranes with 100 ft rail gauge, based on the assumption that this will remain the standard for container crane design to vessels up to a maximum size of 12,500 TEU.

9.4.3 Shoreline Connection

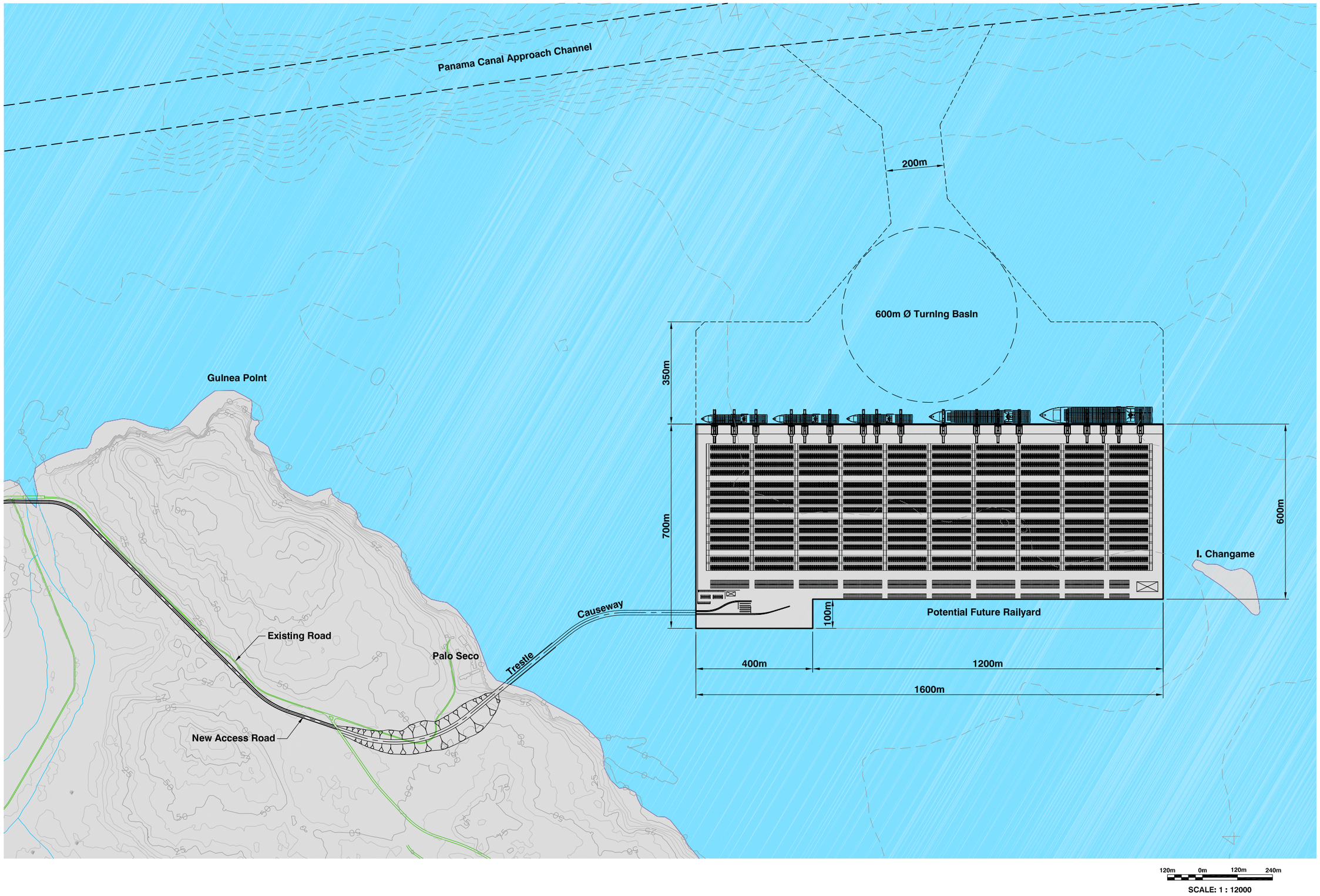
The 111 ha yard is connected to the shoreline by a combination causeway and trestle with an overall length of 700 m. The open piled section of the land connection has a length of 200 m and is designed to accommodate two lanes of traffic, with 3.00 m shoulders on either side.

As seen in Figure 9-4, allowance is made for pedestrian access and a utilities corridor is provided, giving an overall trestle width of 21.40 m. A rail corridor is not recommended at the initial stage due to the extreme high cost of the overall rail connection. In the event that it is required in the future, it can either be placed on a separate trestle or an extension to the example illustrated.

Subject to more detailed environmental assessment, it will be more economic to construct approximately 500 m of the shoreline access road as a rubble mound causeway. For stability and drainage purposes, the causeway shown in Figure 9-5 is wider than the trestle, with an overall crest width of 37.9 m.

9.4.4 Future Expansion Potential – Location 3

Options for future expansion of the Port at Location 3 are shown in Figure 9-6. The preferred first expansion phase would be towards the north where wave protection is good and an additional 1,200 m of berth could be built, offering a possible throughput increase of some 1.25 million TEUs per year. Extension of the port to the south beyond approximately 800 m would be subject to satisfactory results from wave penetration and ship motion analyses as the protection afforded to the Amador Causeway is lost.



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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO
Container Terminal Concept at Location 3

Fig 9-2

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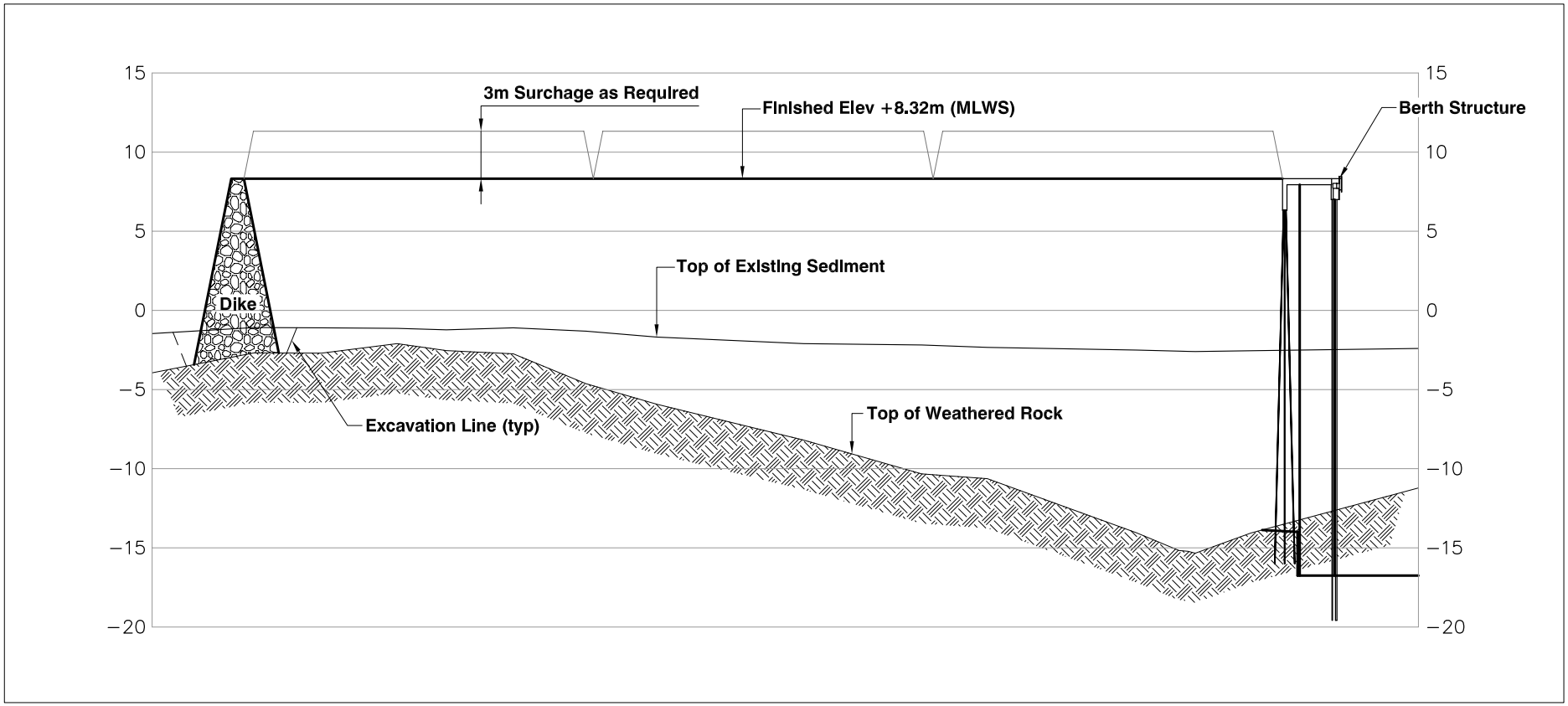

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40m 0m 40m 80m
HORIZ SCALE: 1 : 4000

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Fig 9-3
Cross Sectional View of Island Location 3

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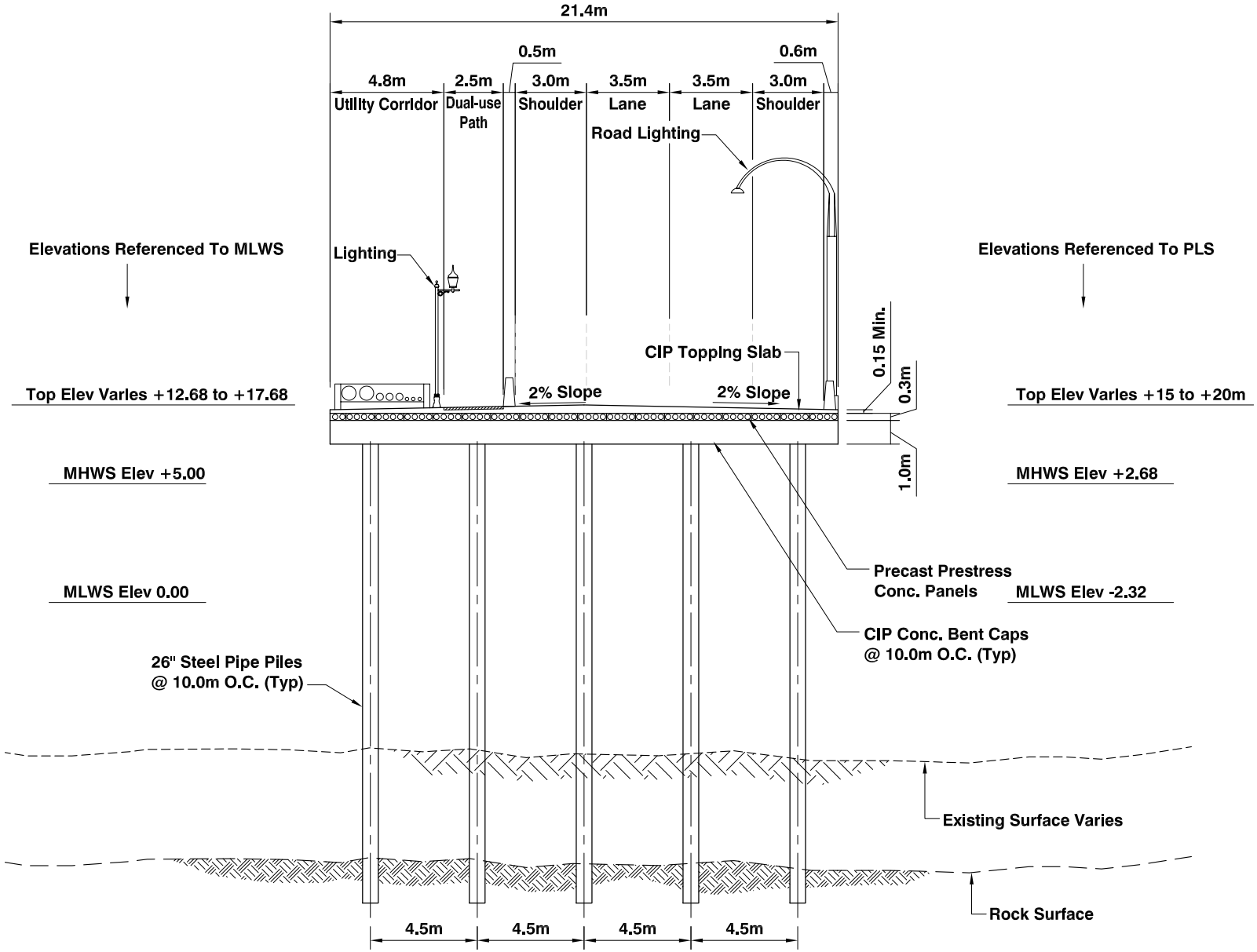

2.5m 0m 2.5m 5m

SCALE: 1 : 250

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Fig 9-4
Typical Section of Open-Piled Trestle

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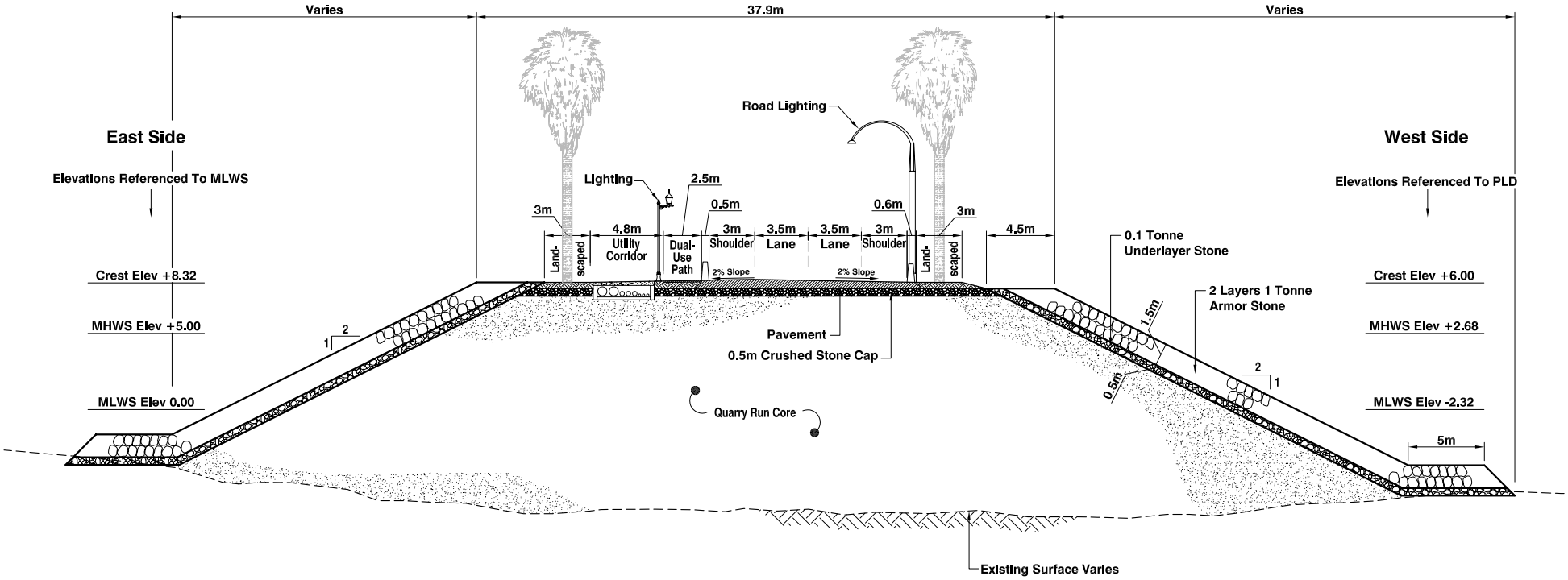

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Figure 9-5
Typical Section of Rubble Mound Causeway

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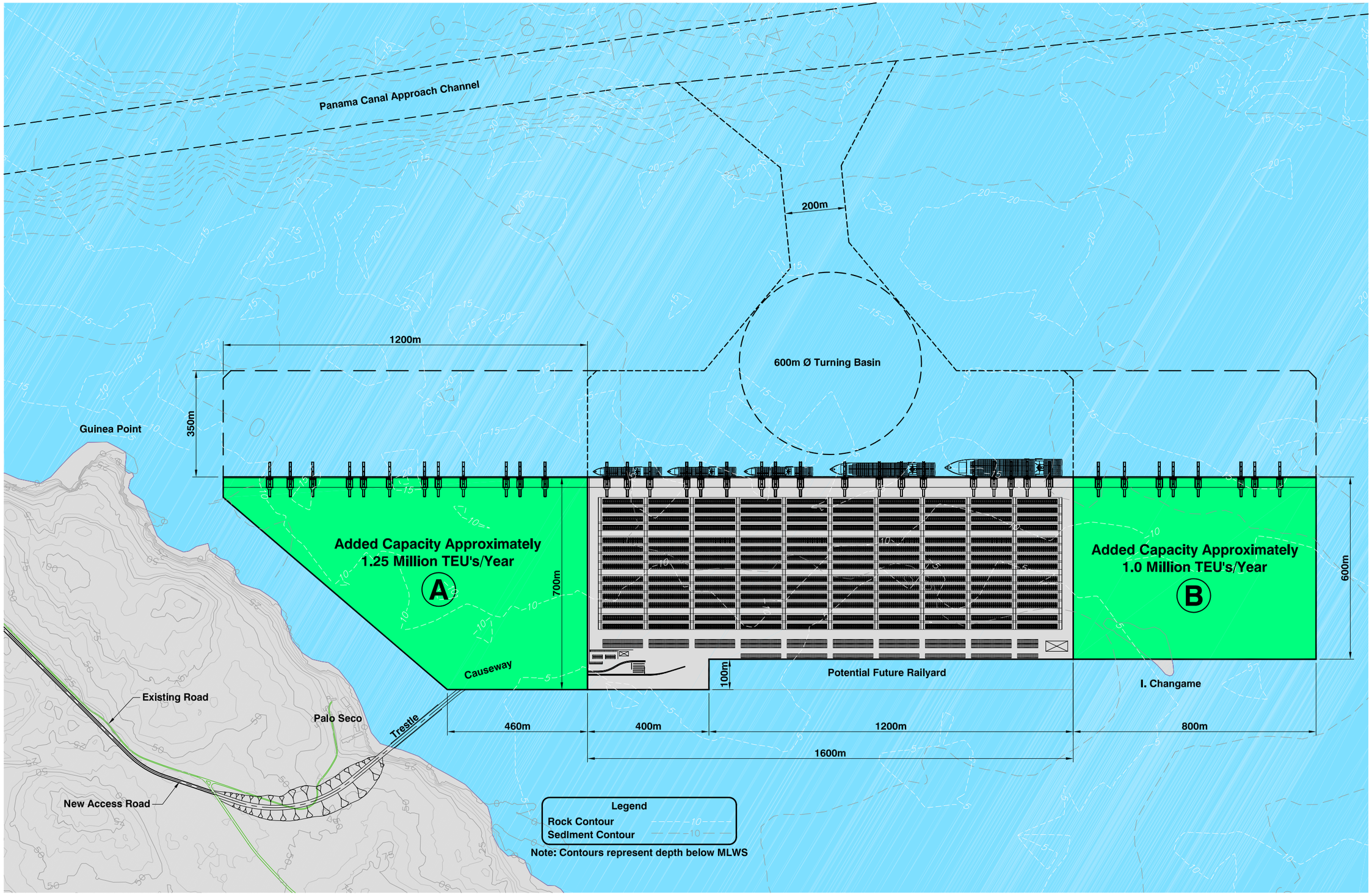

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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Potential Expansion Areas for Port at Location 3

Fig 9-6

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9.5 Container Port at Location 5

This option was originally developed as a result of a request for the consultants to evaluate the potential to berth ships on both the east and west faces of the filled areas. However, the initial cost assessment for the base construction of the island indicated that the cost of development of this site was actually the least cost option compared to the other four locations assessed, although very close to the cost of Option 3 shown in the previous section.

This finding then offers a potentially cost effective location for a container terminal having the berths on the east face, as developed for the other location options and shown in Figure 9-7 and Figure 9-8.

9.5.1 Navigation Access

As can be seen from Figure 9-7, the port is located much closer to the west bank of the Pacific Entrance channel than Location 5. While this reduces the length of the channel to some 700m, there may be navigational concerns over the impact of maneuvering vessels on the flow of Panama Canal traffic. This key issue must therefore be resolved before any commitment is made to this option, as failure to obtain an agreement with ACP on the location of the Port within its area of jurisdiction represents a fatal flaw in this concept.

9.5.2 Terminal Area

The main terminal area is now located in an area with relatively shallow water and a substantial depth of soft material before rock is encountered. This will then require a more intensive ground improvement program and long term settlement is a more serious concern in the main yard area than for Location 3.

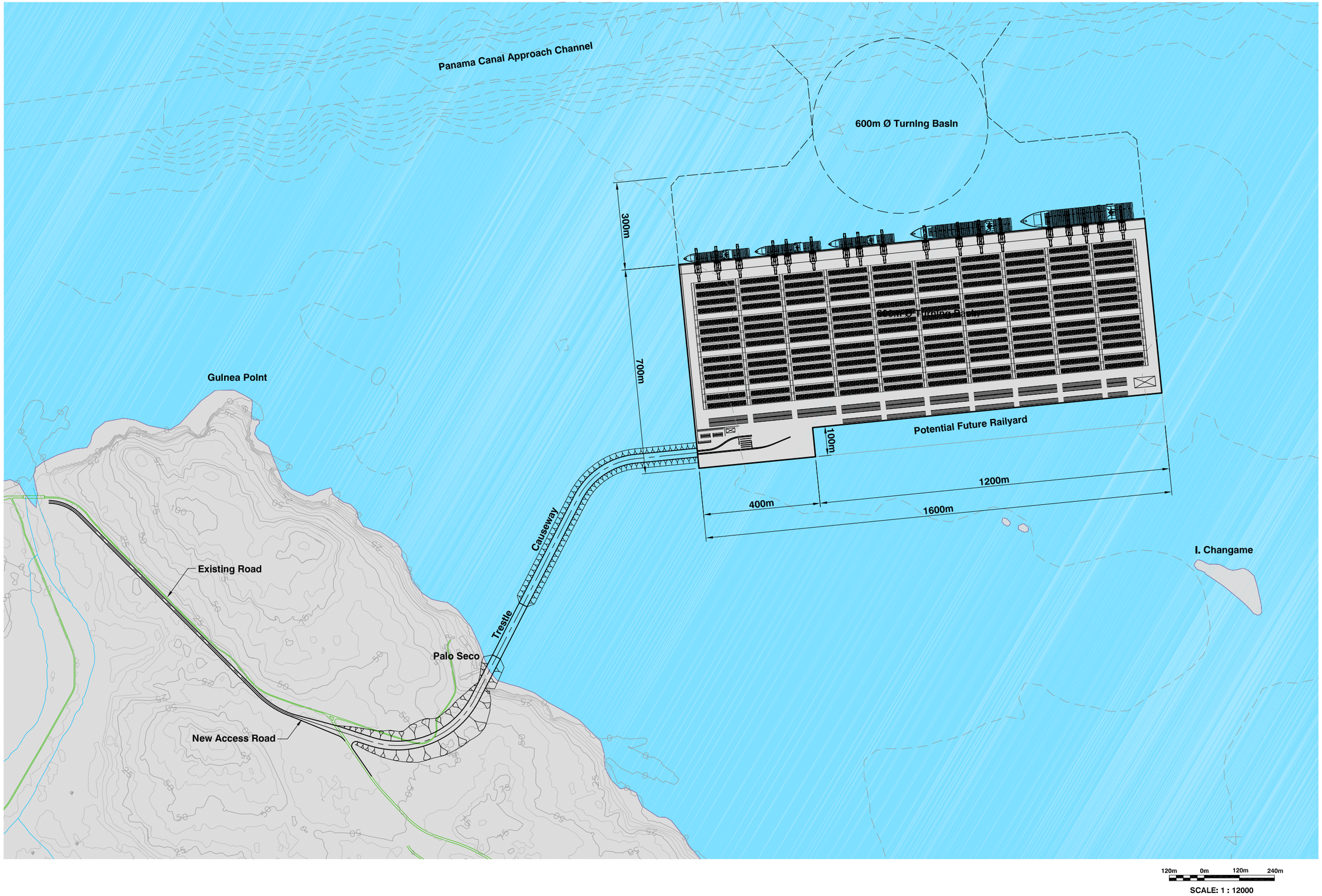
9.5.3 Land side Access

The rail and highway connections to the terminal are similar to those illustrated for Option 3 and will not be repeated here.

9.5.4 Future Expansion Potential – Location 5

Location 5 offers a wide range of expansion options, as indicated in Figure 9-9. Approximately 1,600 m of berth and back up area can be added north of the first phase development, offering some 1.75 million TEUs of additional capacity. Alternatively, the port can be extended westwards which would permit feeder vessel berths to be constructed on the west face of the first stage development and a new terminal to be built to share the main access channel. Total added capacity for this alternative would be approximately 2.5 million TEUs per year.

This option is not practical for Location 3, as the new main line and feeder vessel berths would be located in an area where the rock elevation is extremely shallow.



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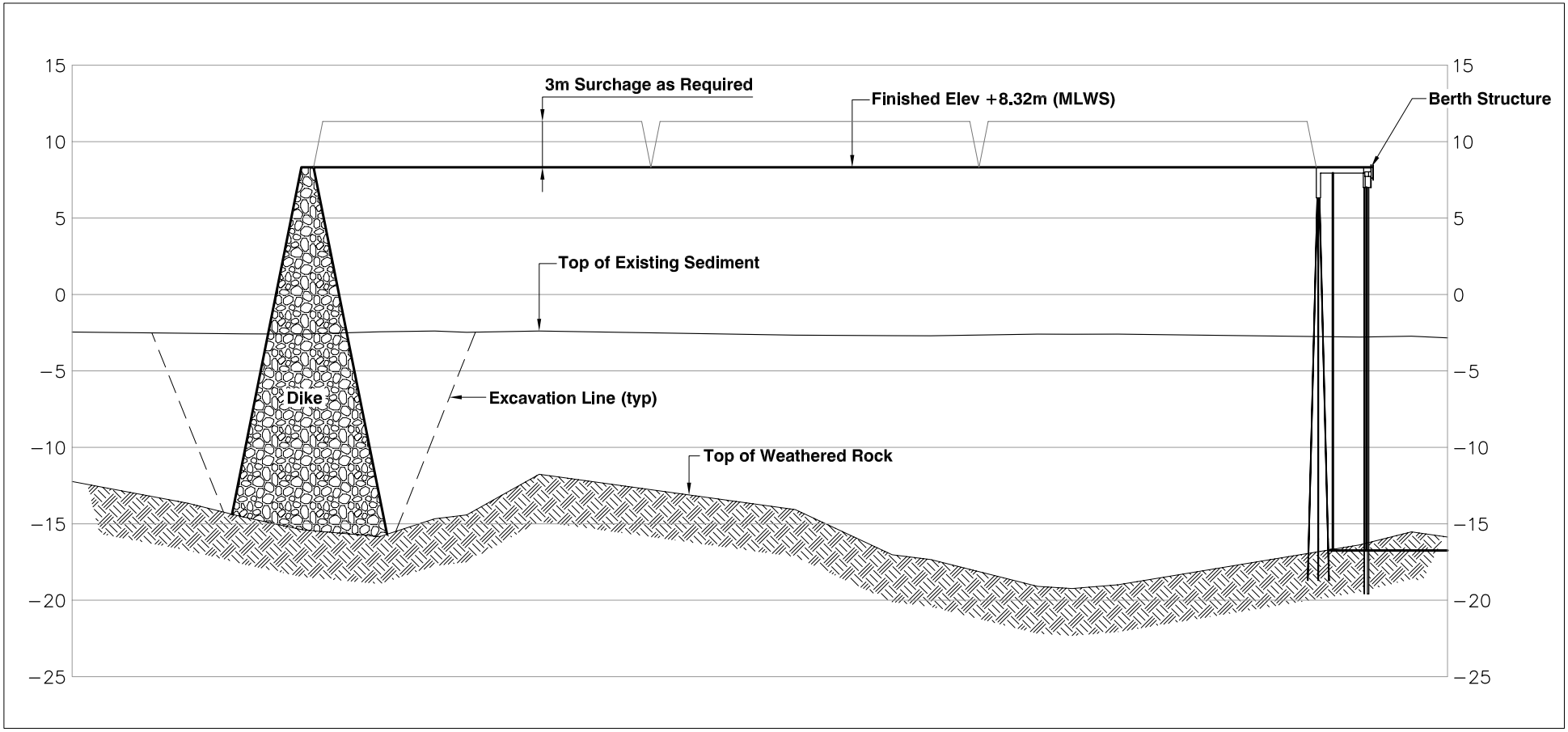
FEASIBILITY STUDY FOR PORT DEVELOPMENT AT PALO SECO

Container Terminal Concept at Location 5

Fig 9-7



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HORIZ SCALE: 1 : 4000

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Fig 9-8
Cross Sectional View of Island Location 5

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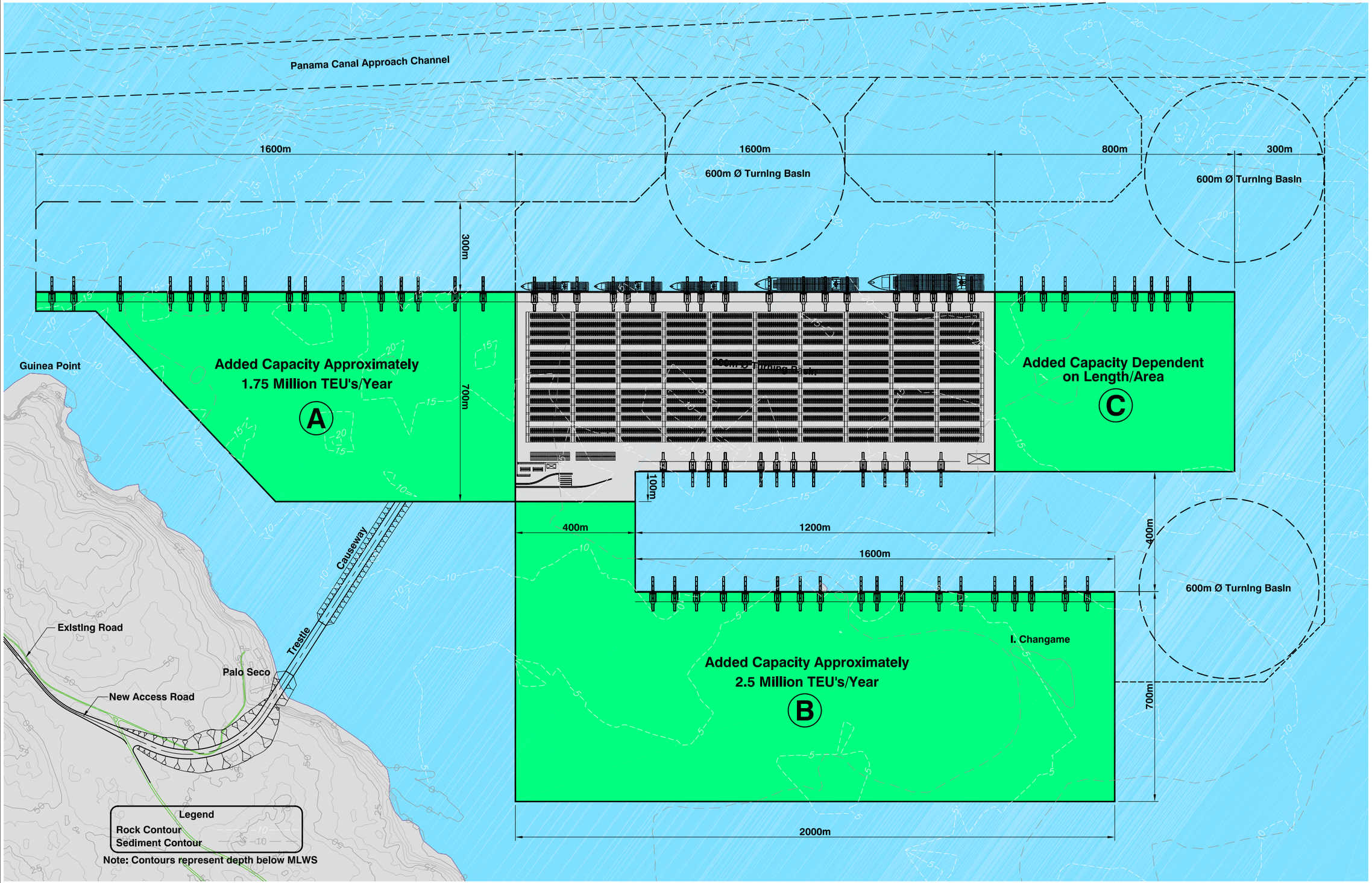

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FEASIBILITY STUDY FOR
PORT DEVELOPMENT AT PALO SECO

Potential Expansion Areas for Port at Location 5

Fig 9-9

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9.6 Development Phasing

9.6.1 Initial Phase

There are a number of considerations that will control the potential phasing of the construction of the island and the port facilities. Not the least is the growth expectation of the operator and the volume of containers it can bring to the first phase development.

However, phasing the construction of the base reclamation and the marine and terminal infrastructure offers an opportunity to a potential operator to limit the initial investment and establish a revenue stream before embarking upon the full capital investment required to meet the projected capacity ceiling of 2.4 million TEUs.

For the purposes of this study, it is suggested that the first phase of operation of the Port will require at least two of the berths indicated above, with the appropriate terminal yard area to support the berth throughput. It then follows that the first phase could be limited to two berths and an overall length of 800 m.

Depending on construction costs and interest in the dredging and reclamation aspects of all of the area required to meet the long term needs of the project. However, there is no reason why this cost could not also be defrayed to a later date if the terminal operator wished to minimize the initial investment requirements for the project.

However, it is worthy of note that the postponement of the second phase of the island construction will require duplicated mobilization and demobilization of the marine equipment, which could increase the cost of the second phase by some 10 to 20%.

10 COST ESTIMATES

10.1 Basis for costing

This is a particularly difficult time for the preparation of construction cost estimates, due to the recent increases in fuel costs, high demand levels for construction materials and financial uncertainty in the construction sector. As a result, the projection of costs for anything but short term projects is risky. Consequently, public sector and private project sponsors are seeing a much wider spread of bids on projects than traditionally observed.

This project is particularly vulnerable to a wide spread of cost outcomes, as it also involves high volumes of materials and relatively few major work items. Based on an initial assessment, almost 50 percent of the cost is in dredging and reclamation work and another 15 percent in the berth construction. Small variations in unit costs for the dredging and reclamation work will therefore have a large impact on final cost, while steel and cement cost increases can make a significant difference to the final cost of the marine structures.

In order to provide a realistic response to this situation, a series of cost sensitivity analyses were run for the two preferred concepts, in order to both identify the most sensitive items and also to present the likely spread of costs that can be tested financially.

10.2 Estimating Methodology

The estimating technique used for this project takes into account the potential variations that may impact materials quantities and unit costs for the work. The user is permitted to enter a range of values for each variable, which can then be refined as the project moves forward, giving a higher level of confidence in the final output.

With the variables in place, the application can generate an extensive series of statistical trials using a Monte Carlo simulation to determine the range and probability of total cost outcomes. The user is then free to select the range of probability most appropriate to its purposes.

One major advantage of this technique is the reduction in the magnitude of the contingency item, which is normally assumed to be 30% for a feasibility level analysis that does not have the benefit of detailed site investigation data. However, the level of confidence of certain items, such as berth aprons and paving is much higher than work

such as dredging or foundations and the application of the same contingency factor to all construction elements is unrealistic.

The output from the cost simulation run essentially indicates the probability that the final cost will not exceed a specific value. While it is hoped that the final cost will approach the mean value generated by the model, it is prudent to use a higher probability factor for budgeting purposes. Experience has shown that an acceptable value for the budgeting requirements for a major marine project is the 85 percentile probability value, which is recommended for this project. As more information is obtained from the field work or more detailed technical analyses, the spread on the final cost curve then narrows. Hence it is reasonable to maintain the 85 percentile value for all stages of the project.

10.3 Cranes & Equipment Costs

As a major transshipment terminal, it is most unlikely that any public sector agency will directly operate this port. Assuming a concession or leasing arrangement, it is expected that the operator will implement its own management system and provide its own equipment. Consequently, the cost estimates presented in this report do not include equipment or any of the mobile assets of the project. The estimates are therefore limited to fixed assets, which would permit an operator to run the terminal on a short or long term contract without major investment in facility construction.

10.4 Environmental Mitigation Costs

As presented earlier, ANAM have established a range of mitigation allowances for projects based on the footprint of the direct impact area. Unit costs vary according to the type of impact and class of development and would be agreed during the final environmental Impact assessment and approvals process. However, in order to ensure that provision is made for this cost, an allowance of $5,000 per ha of the island footprint is included in all cost estimates. Based on a surface area for the island of 111 ha and assumed right of way and landside area of 38 ha, this then equates to an allocation of approximately $800,000 for the project.

10.5 Marine Terminal Facilities

10.5.1 Container Port at Location 3

Table 10-1 below shows the statistically developed range of cost outcomes for the development at Location 3 using the cost simulation techniques described above. From the table, it can be seen that there is an 85 percent probability that the final cost of the

project will not exceed $598 million. The table also indicates that the cost of the project is not expected to be less than $464 million or more than $671 million, with a mean value of $567 million. Based on experience with other projects, it is recommended that the 85 percentile outcome should be used for financial evaluations and budgeting purposes until more detailed information can be obtained on the major cost variables. Based on this approach, the total cost of the port facilities at Location 3 is expected to be $607 million, excluding land acquisition, cranes and yard equipment and licensing fees for sand and rock fill. The estimate also does not include rail access, long term improvements to the Coastal Highway or community enhancement projects, all of which are discussed in other sections of the report.

Table 10-2 shows a breakdown of the cost items comprising the 85 percentile outcome for the estimated budget requirement for the project. More detailed breakdowns of unit costs and quantities for the main project components can be found in Appendix E to this Report.

Finally, Figure 10-1 shows the relative sensitivity of the variable items, indicating those work areas where additional study and site investigation will produce the highest return.

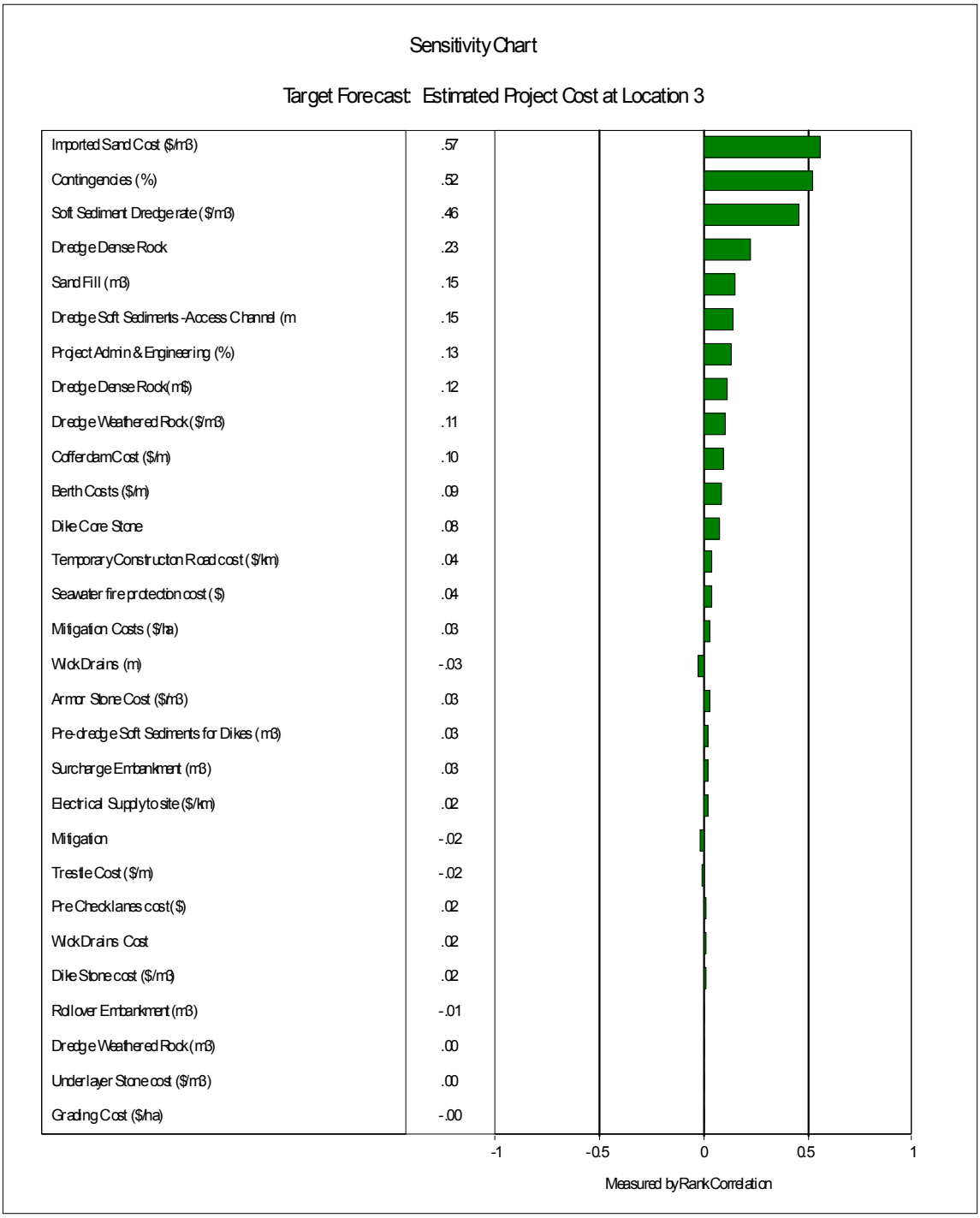
Table 10-1: Range of Outcomes for Construction Cost - Option 3

Probability of Exceedance	Estimated Project Cost (US$)
0%	$476,539,200
10%	$520,963,002
20%	$533,670,265
30%	$544,394,735
40%	$553,984,414
50%	$563,037,478
60%	$570,991,525
70%	$579,935,045
80%	$591,461,693
85%	$598,238,940
90%	$605,816,975
100%	$675,602,136

Table 10-2: Cost Breakdown of 85%ile Outcome - Port at Location 3

Description	Cost (US$)
Dredging and Reclamation	**$265,948,573**
Dredge Soft Sediments - Access Channel & Dikes	$84,209,572
Dredge Weathered Rock	$15,045,356
Dredge Dense Rock	$28,503,913
Sand Fill	$78,881,995
Sand License fee	$0
Dike Core material & Armor	$23,573,005
Rock License Fee	$0
Cofferdam Cell Retention Structure	$35,734,732
Marginal Wharf and Access Trestle	**$71,716,425**
Marginal Wharf	$63,656,045
Access Trestle	$8,060,380
Site Stabilization	**$26,558,965**
Surcharge material & Rollover	$14,239,352
Wick Drains	$12,319,612
Terminal Infrastructure	**$89,668,181**
Grading & Storm Drainage	$7,431,688
Fire Protection Systems	$3,195,291
Extend Water Supply to Site & Tank	$773,054
Potable Water & Ship supply	$1,443,035
Sewage and Waste Water Treatment Plant	$983,325
Electric Power to Site - Landside	$1,855,330
Electric Power Distribution - Terminal	$8,658,209
Communications Networks	$3,504,513
Highmast Lightpoles	$4,019,883
Reefer Plugs (2 per reefer bay)	$5,194,925
Yard Pavement	$52,608,927
Construction Road and Highway Improvements	**$16,601,343**
Excavation in connection to Port	$10,416,908
Temporary Haul road	$6,184,435
Right of Way Acquisition	$0
Entrance Gates and Buildings	**$7,467,705**
Precheck Lanes	$1,638,875
Administration & Maintenance Buildings	$5,828,830
Mitigation	**$665,857**
SUBTOTAL	**$478,627,049**
Contingency	$83,759,734
Planning, Engineering and Project Management	$35,852,157
ESTIMATED BUDGET REQUIREMENT (85 Percentile)	**$598,238,940**

Figure 10-1: Cost Item Sensitivity Ranking - Location 3



10.5.2 Container Port at Location 5

Using the same assumptions and exclusions as indicated earlier for Location 3, the expected cost of the terminal project at Location 5 is seen in Table 10-3 to range from a low of $518 million to a high of $782 million. The wider range of outcomes is a product of the foundation conditions and the unknown strength of the soft materials, which may require additional ground treatment to reach a satisfactory consolidation rate in time for completion of the work.

The 85 percent probability cost for the project is seen to be $672 million or approximately $73 million higher than Location 3.

Table 10-4 shows the main cost items from the 85% probability outcome, while Figure 10-2 indicates the relative ranking of the variables in terms of impact on final cost.

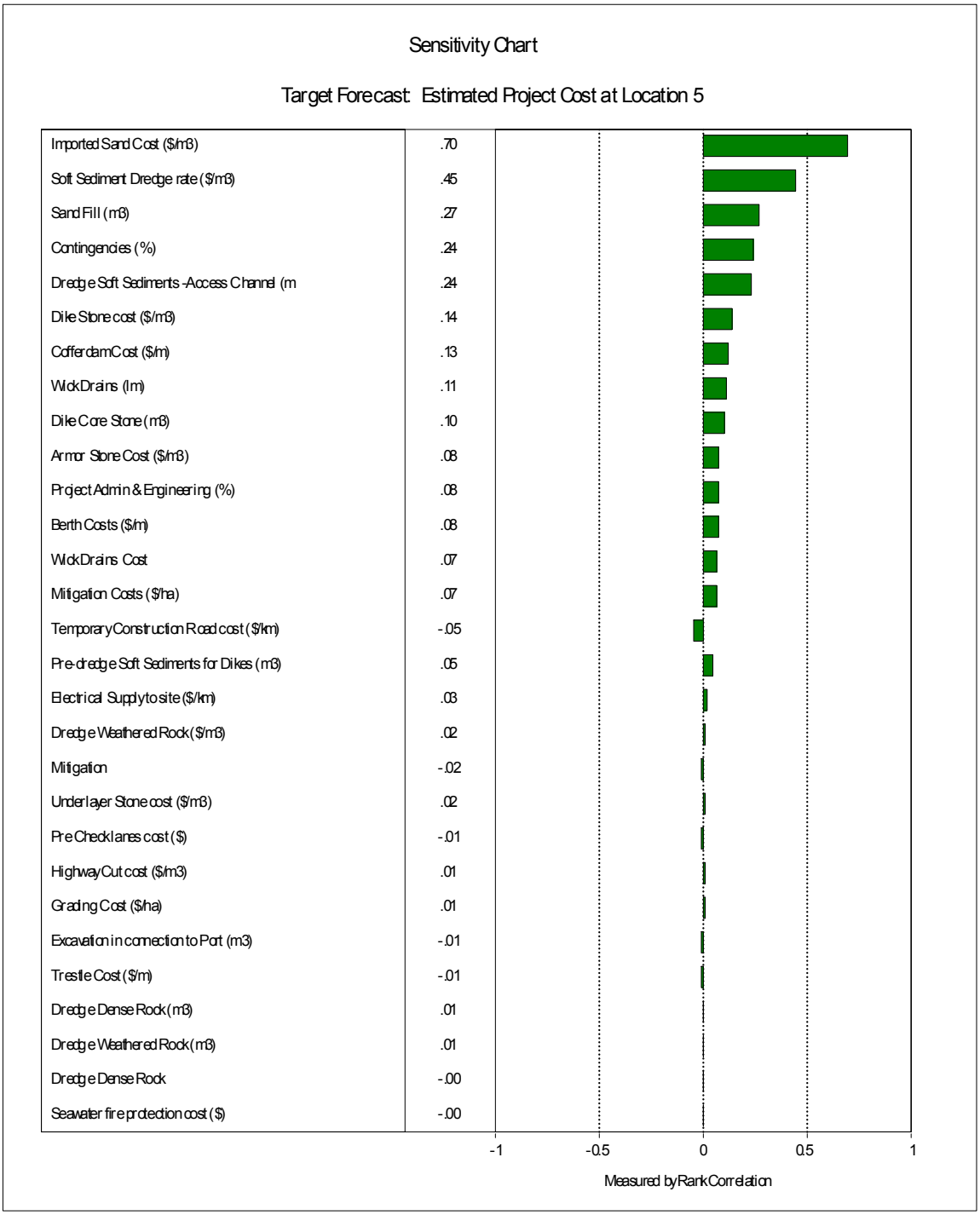
Table 10-3: Range of Outcomes for Construction Cost - Option 5

Probability of Exceedance	Estimated Project Cost (US$)
0%	$518,621,760
10%	$570,389,176
20%	$585,786,595
30%	$600,152,525
40%	$612,110,479
50%	$625,075,506
60%	$635,165,907
70%	$648,530,996
80%	$663,376,621
85%	$671,684,942
90%	$681,616,823
100%	$781,610,444

Table 10-4: Cost Breakdown of 85%ile Outcome – Port at Location 5

Description	Cost (US$)
Dredging and Reclamation	**$300,100,641**
Dredge Soft Sediments - Access Channel & Dikes	$100,153,618
Dredge Weathered Rock	$3,055,504
Dredge Dense Rock	$762,120
Sand Fill	$107,204,720
Sand License fee	$0
Dike Core material & Armor	$52,396,621
Rock License Fee	$0
Cofferdam Cell Retention Structure	$36,528,058
Marginal Wharf and Access Trestle	**$73,308,559**
Marginal Wharf	$65,069,235
Access Trestle	$8,239,324
Site Stabilization	**$47,036,175**
Surcharge material & Rollover	$14,555,471
Wick Drains	$32,480,704
Terminal Infrastructure	**$91,658,853**
Grading & Storm Drainage	$7,596,674
Fire Protection Systems	$3,266,228
Extend Water Supply to Site & Tank	$790,216
Potable Water & Ship supply	$1,475,071
Sewage and Waste Water Treatment Plant	$1,005,155
Electric Power to Site - Landside	$1,896,520
Electric Power Distribution - Terminal	$8,850,425
Communications Networks	$3,582,315
Highmast Lightpoles	$4,109,126
Reefer Plugs (2 per reefer bay)	$5,310,255
Yard Pavement	$53,776,868
Construction Road and Highway Improvements	**$16,969,899**
Excavation in connection to Port	$10,648,167
Temporary Haul road	$6,321,732
Right of Way Acquisition	$0
Entrance Gates and Buildings	**$7,633,491**
Precheck Lanes	$1,675,259
Administration & Maintenance Buildings	$5,958,232
Mitigation	**$680,640**
SUBTOTAL	**$537,388,258**
Contingency	$94,042,945
Planning, Engineering and Project Management	$40,253,739
ESTIMATED BUDGET REQUIREMENT (85 Percentile)	**$671,684,942**

Figure 10-2: Sensitivity Chart on Major Cost Items - Location 5



10.6 Highway Improvements

As noted earlier, it is recommended that construction traffic for the project be taken over a new road to be built alongside the existing Coastal Highway. This will reduce the traffic conflicts with existing and future users and reduce possible obstructions to the passage of emergency vehicles. In order to accommodate heavy construction traffic, but assuming that little or none of the island fill material will be imported over this route, the recommended right of way for the haul road will be 75 m. In keeping with the suggestion that materials license fees and land costs be considered as a public sector contribution to the project, no cost allowance is made for the acquisition of the right of way.

On completion of the project, the existing road would be upgraded and expanded to include the new width of the haul road, in order to provide a four lane highway and improved interchanges that would be capable of handling substantial container traffic and increased demands from the commercial and other developments from Howard to Veracruz.

Table 10-5 presents a preliminary cost estimate for the conversion of the haul road and upgrading of the existing highway to meet this requirement. However, the construction of the temporary haul road is considered to be an integral part of the island construction and was included in the estimates presented earlier.

Table 10-5: Estimated Cost of Permanent Four Lane Highway to Port Site

Description	Amount (US$)
Pave Temporary Haul road	$5,400,000
Drainage and culvert reinforcement	$250,000
Regrade existing highway	$1,500,000
Add two lanes over existing highway	$5,850,000
Landscaping and drainage	$600,000
Lighting	$660,000
Sub Total	**$14,260,000**
Contingencies	$4,278,000
Engineering & Administration	$1,297,660
Estimated Project Cost	**$19,835,660**

10.7 Summary of Project Costs

Table 10-6 shows the estimated budget required to meet the 85 percentile probability outcome of the cost simulations for construction of the base island, terminal development, rail and highway access and the community enhancement project. As noted earlier, with the exception of the road extension project from Veracruz to Vacamonte, the estimates do not include land or right of way acquisitions or materials source concession fees. All costs from simulations testing are based on the 85% probability totals.

Table 10-6: Summary of Project Costs (Location 3)

Project Element	Estimated Cost ($2005)
Container Terminal & Access (location 3)	
Dredging, Reclamation & Site Stabilization	$320,941,934
Wharf & Access Trestle	$134,941,934
Terminal & Utilities	$112,076,820
Entrance Gate & Buildings	$9,333,931
Construction Road & Highway Access	20,750,122
Mitigation & Miscellaneous	$832,259
Total for Container Terminal at Location 3	**$598,238,940**
Permanent Highway Improvements	$19,835,660
Estimated Total Cost – Container Port & Access	**$618,074,600**
Optional Items	
Rail Connection to Miraflores	$172,610,041
Community Benefit Project	$14,657,188
Total for Optional Projects	**$187,267,229**

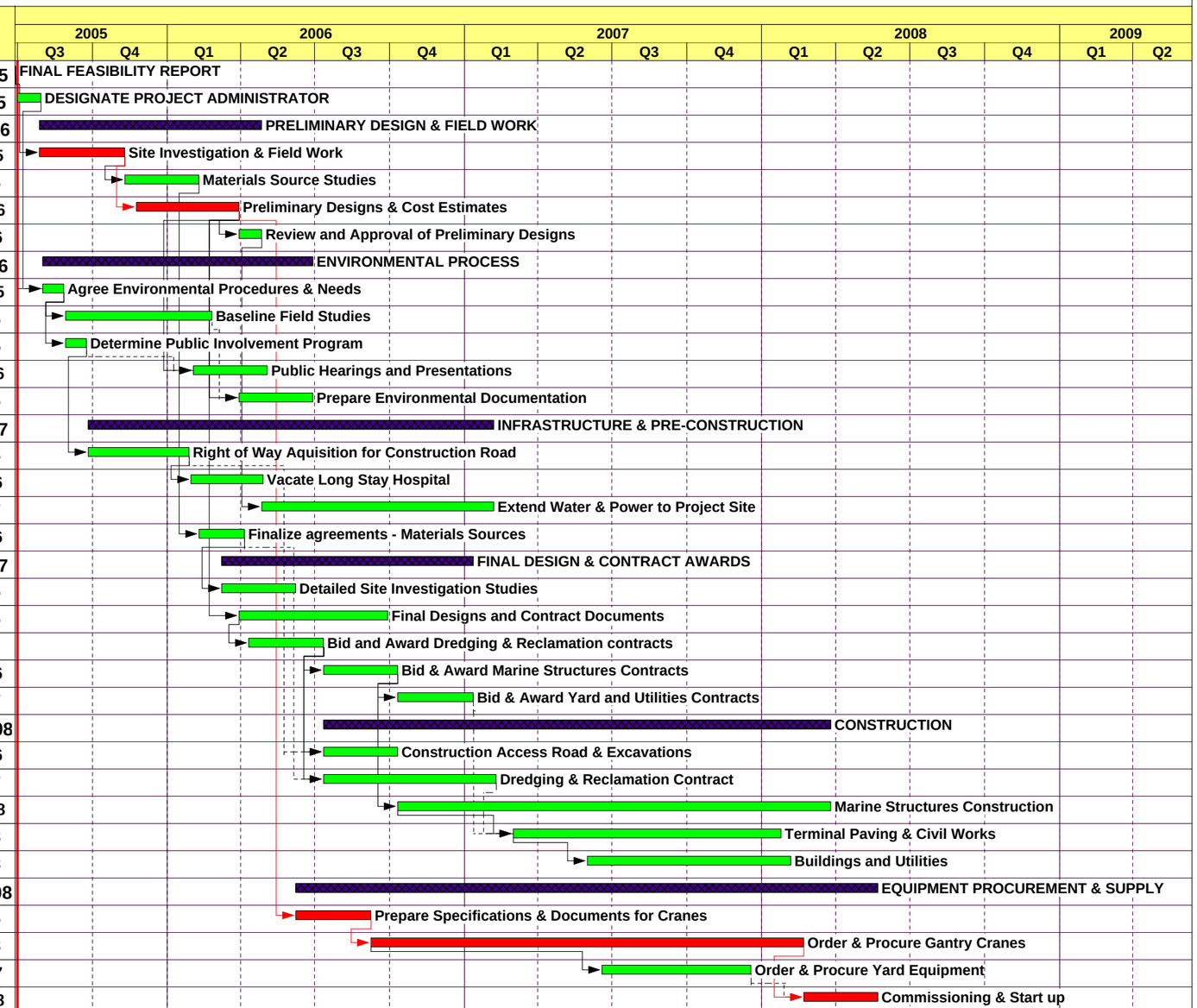
11 IMPLEMENTATION PROGRAM

An implementation plan for the design, procurement and construction elements of the project is presented in Figure 11-1.

Assuming an immediate decision to proceed with the site investigation and preliminary engineering works for the project, and depending on the acquisition of all approvals and environmental documentation for the work, a phased construction sequence would enable the new Port to be functioning by May of 2008.

Figure 11-1: Project Implementation Schedule

Activity ID	Description	Orig Dur	Early Start	Early Finish
1070	FINAL FEASIBILITY REPORT	0	01JUN05	28JUN05
1000	DESIGNATE PROJECT ADMINISTRATOR	4w	01JUL05	29JUL05
1030	PRELIMINARY DESIGN & FIELD WORK	39w *	28JUL05	26APR06
1210	Site Investigation & Field Work	15w	28JUL05	09NOV05
1240	Materials Source Studies	13w	10NOV05	08FEB06
1200	Preliminary Designs & Cost Estimates	18w	24NOV05	29MAR06
1190	Review and Approval of Preliminary Designs	4w	30MAR06	26APR06
1020	ENVIRONMENTAL PROCESS	47w3d	01AUG05	28JUN06
1230	Agree Environmental Procedures & Needs	4w	01AUG05	26AUG05
1150	Baseline Field Studies	26w	29AUG05	24FEB06
1160	Determine Public Involvement Program	4w	29AUG05	23SEP05
1170	Public Hearings and Presentations	13w	02FEB06	03MAY06
1180	Prepare Environmental Documentation	13w	30MAR06	28JUN06
1340	INFRASTRUCTURE & PRE-CONSTRUCTION	70w3d	26SEP05	05FEB07
1350	Right of Way Aquisition for Construction Road	18w	26SEP05	27JAN06
1360	Vacate Long Stay Hospital	13w	30JAN06	28APR06
1370	Extend Water & Power to Project Site	40w	27APR06	05FEB07
1390	Finalize agreements - Materials Sources	8w	09FEB06	05APR06
1040	FINAL DESIGN & CONTRACT AWARDS	43w3d	09MAR06	11JAN07
1400	Detailed Site Investigation Studies	13w	09MAR06	07JUN06
1250	Final Designs and Contract Documents	26w	30MAR06	28SEP06
1270	Bid and Award Dredging & Reclamation contracts	13w	11APR06	11JUL06
1280	Bid & Award Marine Structures Contracts	13w	12JUL06	10OCT06
1140	Bid & Award Yard and Utilities Contracts	13w	11OCT06	11JAN07
1050	CONSTRUCTION	88w *	12JUL06	25MAR08
1410	Construction Access Road & Excavations	13w	12JUL06	10OCT06
1310	Dredging & Reclamation Contract	30w	12JUL06	08FEB07
1320	Marine Structures Construction	75w	11OCT06	25MAR08
1330	Terminal Paving & Civil Works	46w2d	02MAR07	24JAN08
1420	Buildings and Utilities	35w	01JUN07	05FEB08
1060	EQUIPMENT PROCUREMENT & SUPPLY	101w *	08JUN06	22MAY08
1480	Prepare Specifications & Documents for Cranes	13w	08JUN06	07SEP06
1430	Order & Procure Gantry Cranes	75w	08SEP06	21FEB08
1440	Order & Procure Yard Equipment	26w	19JUN07	18DEC07
1450	Commissioning & Start up	13w	22FEB08	22MAY08



Start date	28JUN05
Finish date	22MAY08
Data date	01JUL05
Run date	08JUL05
Page number	1A

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ACP CONTRACT CMC 146911 - FEASIBILITY STUDY OF PALO SECO/FARFAN LAND RECLAMATION TO DEVELOP A PORT FACILITY

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Summary point
- Start milestone point
- Finish milestone point

12 SUMMARY & RECOMMENDATIONS

The study results indicate that the selected location meets the objectives of a technically and financially viable container terminal project that does not generate unacceptable environmental or socio-economic impacts on the immediate and surrounding areas. Key conclusions from the analyses are summarized below.

12.1 Berth, Crane & Yard Requirements

Given a target throughput goal of 2.4 million TEUS per year, at least 18 Post Panamax gantry cranes will be required to respond to the projected demand at full capacity. Based on the expected size of the proposed new Locks for the Panama Canal, the new Port should have the capacity to accommodate at least an 8,500 TEU vessel, which will have a length of 385 m and a draft of 15.00 m. This then requires a water depth of 16.75 m at the berth face. However, there are clear indications that major carriers will be ordering and dedicating vessels of 10,500 and even 12,500 TEU capacity within the next ten to fifteen years. It is therefore recommended that provision be made for deepening the approach channel and berth areas to at least 18.75 m below MLWS.

The maximum number of cranes expected to be used on a Post Panamax vessel is six, with five cranes being an acceptable future average. This then indicates that at least four positions for Post Panamax ships should be provided, each with a length of at least 400 m. Berthing of feeder vessels will be accommodated within the arrival and work patterns of the mainline vessels, as is common at other major transshipment terminals.

For operational flexibility and efficiency of crane allocation, all berths should be in a straight line, thereby indicating that the total length of the terminal should be on the order of 1,600 m.

12.2 Terminal Footprint

The throughput simulation assumes that 80% of all container moves are pure transshipment with the remainder divided between cross Isthmian land transfers and Import and Export boxes. At full capacity and assuming a medium high density yard operation, 111 ha of terminal area is required.

12.3 Preferred Location

The bottom and sub bottom conditions in the project area are characterized by shallow depths, below which soft sediments overlay hard rock deposits. The average water depth in the study area is 2.0 to 5.0 m below MLWS and the results of geophysical surveys in 1999 and 2003 indicate that rock will be encountered at depths from 2.0 to 20.0 m below MLWS.

Five locations were tested on the basis of dredging and reclamation costs and it was determined that the most cost effective location is directly south of the Palo Seco long stay hospital facility, where the berth alignment approximates the zone where the rock depth drops from 3.00 m to some 15.0 to 18.0 m. The next lowest cost alternative places the terminal as close to the Pacific entrance Channel of the Canal as functionally possible. However, the depth of soft sediments at this location is on the order of 15.00 to 20.00 m, and extensive ground treatment will be required to accelerate the consolidation process.

12.4 Navigation Access

Navigation access to the preferred port locations is taken directly to the Pacific entrance to the Panama Canal. However the operational and navigational safety aspects of the approaches to the new Port must be carefully considered before the final configuration and alignment of the approach channel is developed. Alternatives that could have merit include the dredging of separate channels for vessels traveling north and south in the Canal or a completely independent channel that would exit outside the final marker of the Canal entrance.

12.5 Highway Access

The preferred source of materials for the project is imported sand from the Taboga – Chame deep water areas, contained within rock dikes built from quarry material from Howard or other nearby sources. Consequently, it is not expected that the highway connections to the port will need to support high traffic levels of vehicles carrying fill materials.

However, this is a major construction project which will place substantial demands on the existing Coastal Highway from the Bridge of the Americas to Veracruz. It is therefore recommended that a temporary construction road be built alongside the existing highway, and that this road should then be converted, with the existing road, to a four lane highway on completion of the construction. Intersection and sight line

improvements are also essential and should be incorporated into the temporary and permanent designs. The estimated cost of the conversion of the temporary road and existing highway connection to the Port is $19.84 million.

12.6 Rail Access

Interest has been expressed in the provision of rail service from the Port to the recently upgraded Panama Canal Railroad on the east side of the Canal. Preliminary estimates of potential cross Isthmian transfer needs vary from five to ten percent of all container traffic, indicating a potential for some 200 TEU transits each working day in each direction at full terminal capacity.

The preferred crossing point for the rail link would be at Miraflores, necessitating the reconstruction or upgrade of the existing swing bridge and the construction of a second bridge over the south end of the new Locks. The distance from the crossing to the Port site is on the order of 15 km. Intermodal transfer yard locations at the Port were evaluated as on-dock or off dock installations but there was little cost savings for the off dock option which would also be located in an area of environmental sensitivity. Consequently, the preferred location for the Intermodal Yard is on the filled area within the terminal area.

However, the construction of the bridges, rail line and intermodal yard is expected to cost $176 million, which is unlikely to be justified on the basis of the expected traffic volumes. Other options include the establishment of a barge transfer service between the Pacific and Atlantic ports or trucking of containers to the existing Intermodal yard in Balboa. In the event that the trucking option is adopted, it is essential that the four lane highway should be provided.

12.7 Environmental Assessment of Project

The most severe environmental impacts generated by the project are the shoreline impacts, concerns over wetlands in the landside access areas and the need to preserve the consistency of the dry forest areas that surround the project area. On the marine areas, concerns exist over loss of habitat under the footprint of the terminal, although the project area is outside the fishing grounds due to the shallow water depth and presence of numerous rock outcrops.

The project will have a significant visual impact from Amador Causeway and also from the Kobbe beaches and Punta Bruja area. The reaction to this impact will vary according to the viewer's personal image of the area, and may or may not be a significant cause of

objection to the project. It is therefore important that public reaction to the project should be tested at the earliest opportunity possible.

Socio economic impacts are expected to be positive, with up to 1,000 employment opportunities created once the terminal is at full capacity and other support activities are developed. The Port will also be a cornerstone of the logistics and value added activities of the Howard area and will assist the overall success of the regional economic development program for this multi-modal center.

12.8 Community Enhancement Project

Concerns have long been expressed over the fact that the Coastal Highway to Veracruz does not have a second link to the Pan-American highway. At this time, workers living in Veracruz and working in Vacamonte or locations west must walk some 4 km over a trail that connects the township with the main highway linking Vacamonte Port to the Chorrera Autoroute.

The cost of extension of the existing roads and the upgrade of the road within the town of Veracruz is expected to be $14.7 million. However, there are limited opportunities for the construction of a ring road that would accommodate heavy traffic and the project to connect the highway to the Vacamonte road envisages a simple two lane road within a 10 to 15 m right of way. Anything more ambitious will require significant property acquisition and a substantial increase in project cost.

12.9 Cost Estimates

Cost simulations were run on the two preferred locations for the container terminal. Costs were based on 2005 unit rates and do not include cranes, terminal equipment or other mobile assets which would normally be provided by a concession holder or lessee of the terminal.

The estimated final cost of the project is particularly sensitive to the unit cost of dredging, fill materials and the need to drill and blast rock in the navigation approaches. Modest variations in unit costs for these high volume items will make a significant difference in the total project cost. It is also recommended that much of the soft sediments should be left in place and ground treatment applied to accelerate the consolidation process. The final requirements for this approach can only be determined following detailed site investigations and analysis of the soft sediments, which again can have a significant impact on the final project cost.

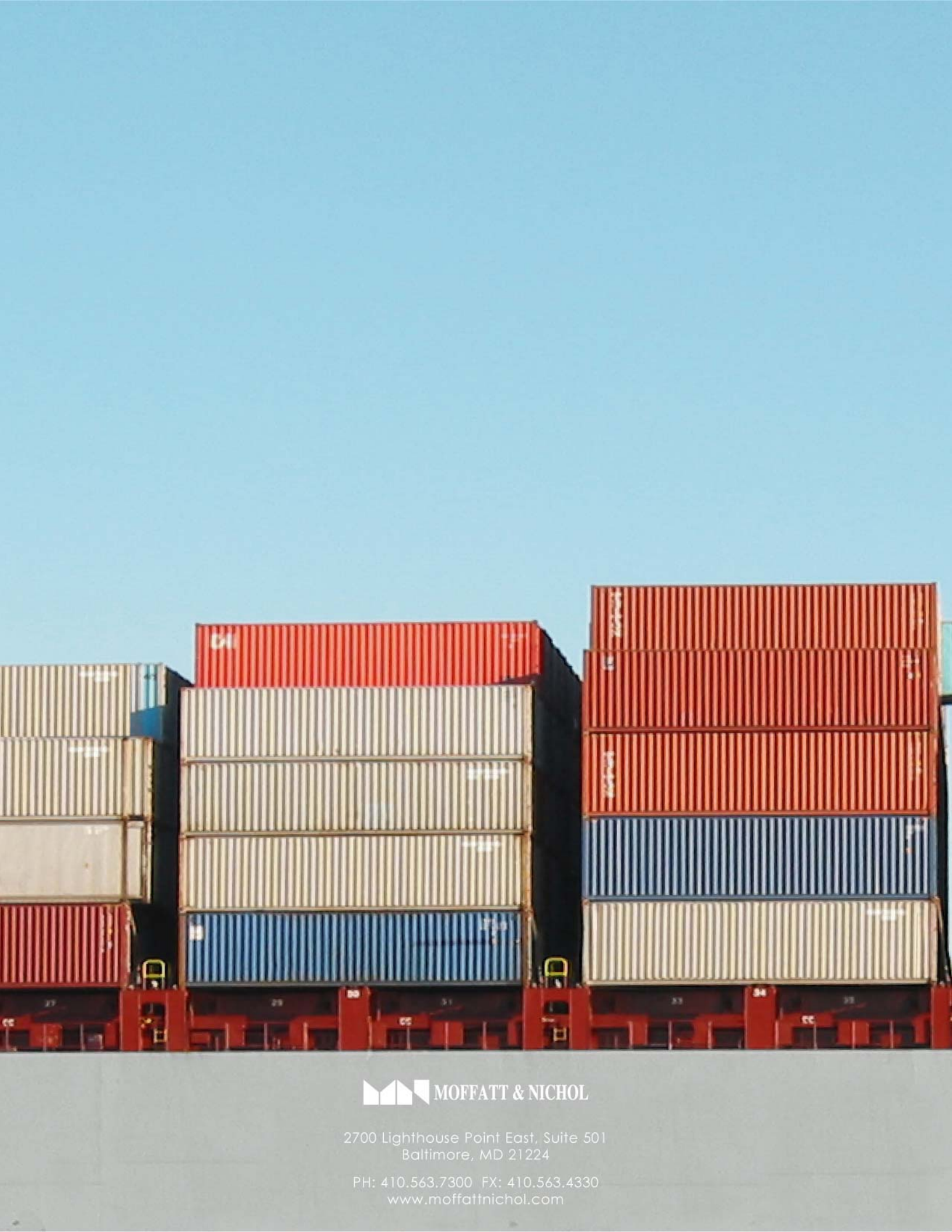
The cost simulation models indicate an 85% level of confidence that the cost will not exceed $598 million at Location 3 or $672 million at Location 5, closer to the Canal. This is considered to be a reasonable target for the budget for this project.

However, this project is particularly sensitive to the unit costs of dredging, fill materials and the need to drill and blast rock in the navigation approaches. Modest variations in unit costs for these high volume items will make a significant difference in the total project cost.

Consequently it is recommended that an intensive field investigation program should be initiated to provide the highest quality of geotechnical information to support the preliminary engineering and final design studies.

12.10 Implementation Schedule

The implementation programs presented in this report is aggressive but could be fast–tracked in the permits, leasing or agreement periods and crane delivery lead times could be reduced. Compressing these key elements could lead to a potential reduction in the project completion date of some nine to twelve months.



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