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Nicaragua Canal Project Description

HKND GROUP

ERM

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ACRONYMS AND ABBREVIATIONS

CDF	confined disposal facility
CRB	Caribbean side
CRCC	China Railway Construction Corporation
DWT	Dry Weight Tonnage
EBRD	European Bank for Reconstruction and Development
EMPA	Excavated Material Placement Area
ERM	Environmental resources Management
ESIA	Environmental and Social Impact Assessment
g/cc	grams per centimeter
H	hours
ha	hectare
IFC	International Finance Corporation
kg/m^3	kilogram per cubic meter
km	kilometer
km^2	square kilometers
kW	kilowatt
kV	kilovolt
L	liter
m^2	square meters
m^3	cubic meters
m^3/s	cubic meters per second
MARENA	Ministerio del Ambiente y los Recursos Naturales
mm	millimeter
Mm^3	Million cubic meters
MW	megawatts
NA	not applicable
PCF	Pacific side
RAP	Resettlement Action Plan
SIN	National Interconnected System
SNT	Sistema Nacional de Transmisión
TEU	twenty-foot equivalent units
TOT	total
ULBC	ultra-large bulk carriers
USACE	U.S. Army Corp of Engineers
VLCC	very large crude carriers

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1. INTRODUCTION

The Canal de Nicaragua (Project) is a major infrastructure project with the potential to transform global trade and make Nicaragua a major center for transport and global logistics. The Project would be one of the largest civil works projects ever undertaken. This Project Description is being released by HKND to inform the Government of Nicaragua, affected communities, and other stakeholders about the current status of Project design. Engineering studies are still on-going that may affect aspects of this Project Design, as may stakeholder recommendations, but at this point, this paper describes the current Project Description. Comments on this Project Description can be submitted via email to Environmental Resources Management (ERM) at Nicaragua.Canal@erm.com.

The Project facilities are described below in as much detail as is available at this stage of the Project design. The following Project Description relies heavily on preliminary engineering prepared by China Railway Construction Corporation (CRCC)/ChangJiang (overall Project technical feasibility, concept design, and engineering), MEC (earthworks strategy and engineering), and SBE/Deltares (lock design and operations, freshwater availability, and salinity management). Additional engineering design is needed to firmly quantify project impacts and finalize appropriate mitigation measures before an Environmental and Social Impact Assessment (ESIA) can be completed.

2. GENERAL PROJECT DESCRIPTION

The Project would be located in southern Nicaragua. It would traverse the country from the Pacific shoreline near Brito, up the Rio Brito valley, over the continental divide, and down the Rio Las Lajas valley to Lago de Nicaragua approximately 4 kilometers south of the town of San Jorge. It would then cross Lago de Nicaragua approximately 4 kilometers south of the Isla de Ometepe, reaching the eastern Lago de Nicaragua shoreline about 8 kilometers south of the town of San Miguelito. It would then move up the Rio Tule stream valley and over the Caribbean highlands, with a maximum elevation along the canal alignment of 224 meters. It would then traverse down the Rio Punta Gorda valley to the Caribbean shoreline about 1 kilometer north of the mouth of the Rio Punta Gorda (see Figures 2-1 and 2-2).

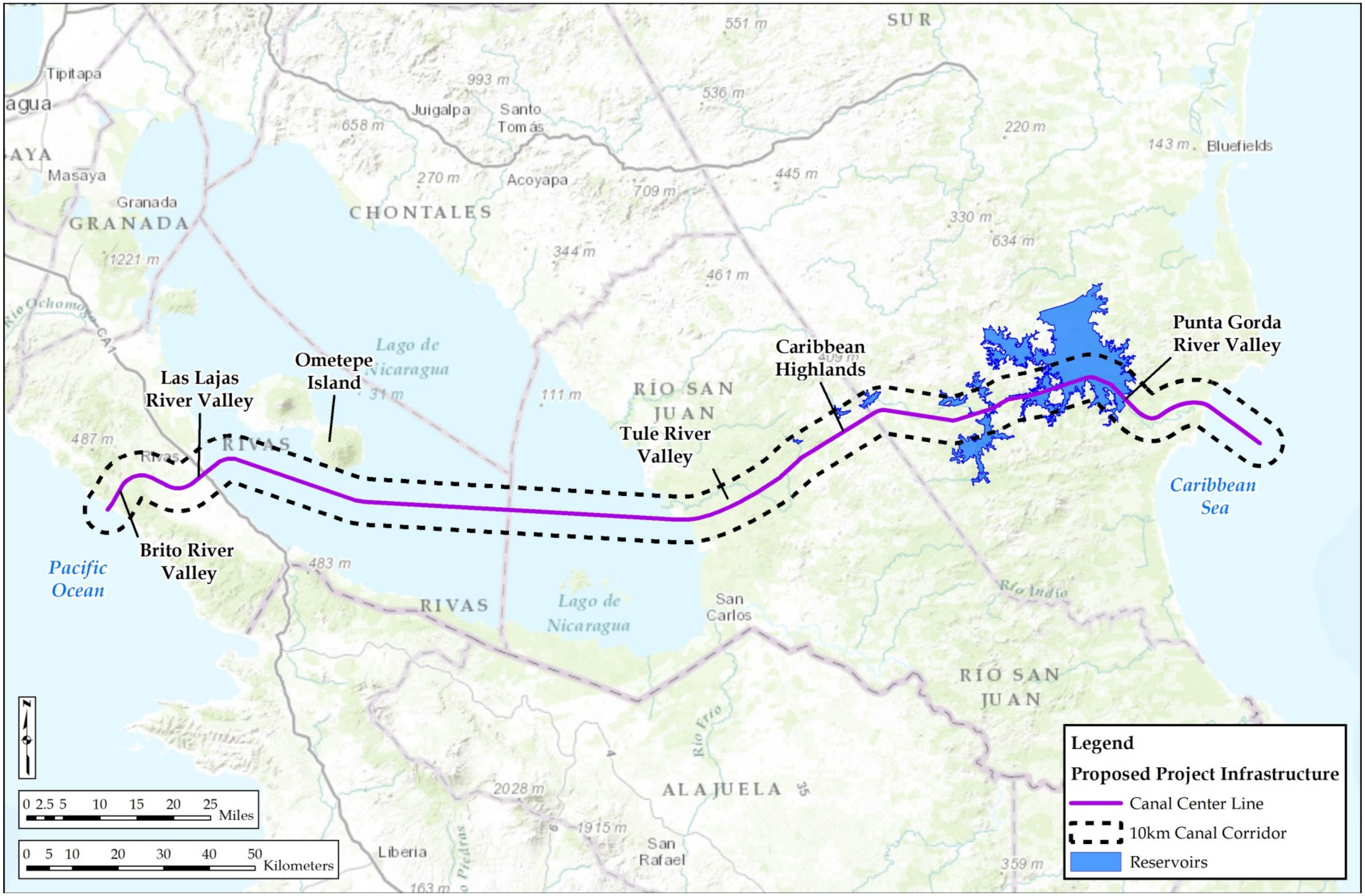


Figure 2-1: Project Location

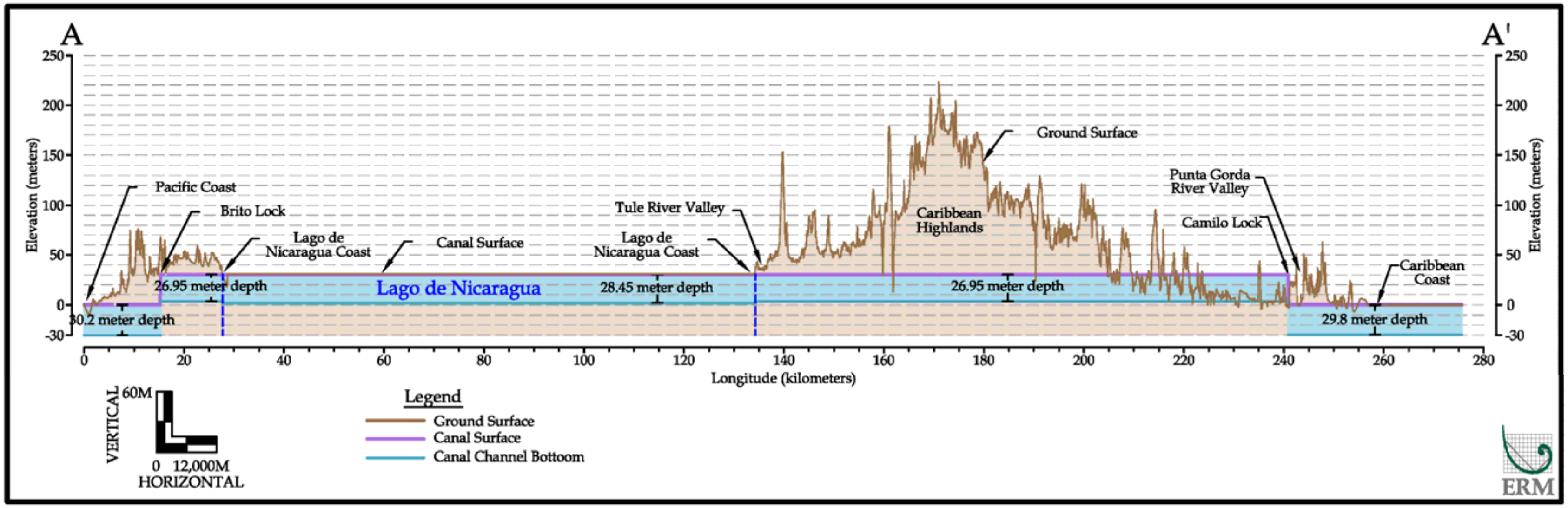


Figure 2-2: Canal Cross Section (200 Vertical Exaggeration)

3. PROJECT FACILITIES

The Project includes the following facilities:

- The canal; two locks and associated impoundments upstream; dredge disposal areas and excavated material placement areas; a dike; a stand-alone dam; and breakwaters/training walls at the canal's Pacific, Caribbean, and Lago de Nicaragua entrances;
- Ports at the canal's Pacific and Caribbean entrances;
- Associated Project Facilities, including transport improvements (e.g., access and maintenance roads, a bridge for the Pan-American Highway over the Canal, and a ferry); power generating and transmission facilities to deliver the power required to operate the canal; and two cement plants and associated aggregate quarries; and minor improvements to the existing Corinto and Bluefield ports.

A detailed Project Map is provided for both paper and electronic copies of this Project Description document.

Other facilities have been proposed, including a Free Trade Zone and associated commercial developments, tourist hotels, and an airport. Construction of these facilities would begin when the canal construction is advanced, which is 5 or more years in the future. Further, little information exists at this time to allow a full impact assessment of these facilities. For these reasons, these other facilities are not included as part of the proposed Project

3.1 CANAL FACILITIES

3.1.1 Canal Design

3.1.1.1 Canal Length

The canal will extend 259.4 kilometers from the Pacific shoreline, across Lago de Nicaragua, to the Caribbean shoreline. The Project would also require dredging of marine approaches to achieve required shipping depths of approximately 1.7 kilometers in the Pacific Ocean and 14.4 kilometers in the Caribbean Sea. Combined, these create a total length of about 275.5 kilometers.

This Project Description and some of its figures reference "stations" along the canal. These stations reflect locations along the centerline of the canal and are shown in 5 kilometer intervals starting at the Pacific coast (Station 0) and extending to the Caribbean coast (Station 259.4).

For purposes of this Project Description, the canal is divided into five segments (see Figure 3.1-1):

- **Pacific Ocean** – the marine approach from the outer limit of required dredging to the Pacific shoreline (1.7 kilometers).
- **West Canal** – from the Pacific shoreline to Lago de Nicaragua, including the West or Brito Lock and the Brito Port (25.9 kilometers). This segment is sometimes subdivided into:
  - **Pacific Slope –** the portion that drains directly to the Pacific Ocean (18.4 kilometers); and
  - **Lake Slope –** the portion that drains to Lago de Nicaragua (7.5 kilometers).

- **Lago de Nicaragua** – from the western to the eastern shorelines of Lago de Nicaragua (106.8 kilometers).
- **East Canal –** from Lago de Nicaragua to the Caribbean shoreline, including the East or Camilo Lock (126.7 kilometers). This segment is sometimes subdivided into:
  - **Lake Slope –** the portion that drains to Lago de Nicaragua (37.4 kilometers); and
  - **Caribbean Slope –** the portion that drains directly to the Caribbean Sea via the Rio Punta Gorda (89.3 kilometers).
- **Caribbean Sea** – the marine approach from the outer limit of required dredging to the Caribbean shoreline, including the Aguila Port (14.4 kilometers).

The various canal segments, to include typical widths and design canal bottom elevations, are presented in Table 3.1-1.

Table 3.1-1: Canal Dimensions

Canal Sections	Length (km)	Bottom Elevation	Design Minimum Depth	Typical Canal Bottom Width
Pacific Ocean	1.7	-30.2 m	29.0 m	280 m
Pacific coast to the Brito Lock	12.5	-30.2 m	29.0 m	280 m
Brito Lock to Lake Nicaragua	13.4	3.25 m	26.9 m	230 m
Lago de Nicaragua[1]	106.8	1.75 m	28.4 m	280 m
Lake Nicaragua to Camilo Lock	105.6	3.25 m	26.9 m	230 m
Camilo Lock to the Caribbean coast	21.1	-29.8 m	29.0 m	280 m
Caribbean Sea	14.4	-29.8 m	29.0 m	280 m
Total length	275.5	NA	NA	NA

km = kilometers; m = meters; NA = not applicable

[1] Average water elevation in Lago de Nicaragua is approximately 31.3 meters, and the canal's operating range is from elevation 30.2 meters to 33.0 meters.

[2] Some optimization might be required during detailed design of the canal.

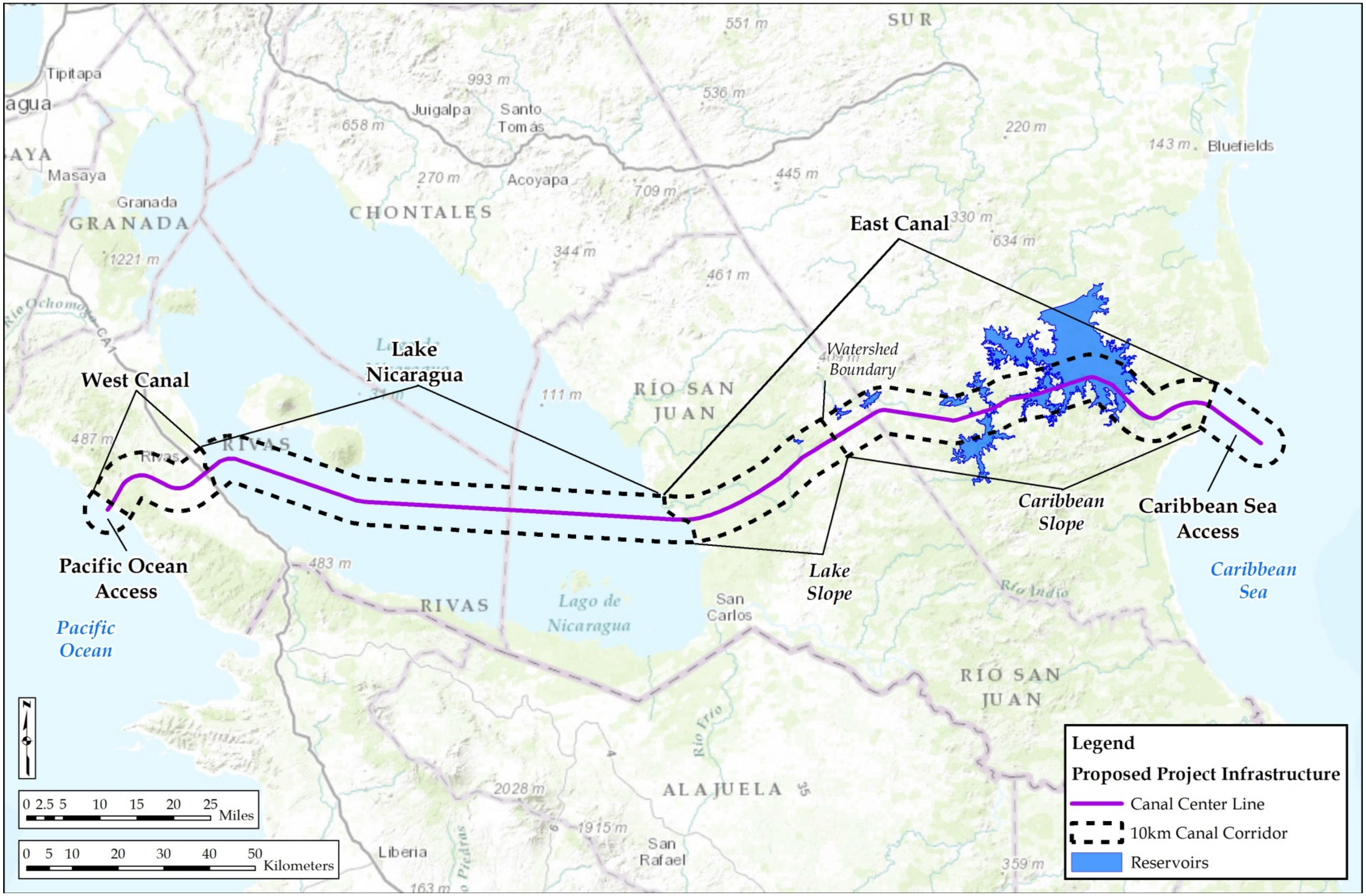


Figure 3.1-1: Canal Segmentation Landscape

3.1.1.2 Target Vessel

The canal design is based on The World Association for Waterborne Transport Infrastructure (PIANC) report *Approach Channels, A Guide for Design* (PIANC 1997). The critical component in the design of the waterway is the selection of the "target" vessel. In evaluating the waterway maneuvering parameters, the target vessel is normally the largest vessel that the waterway is expected to accommodate safely and efficiently.

The parameters required for the target vessel are:

- Length
- Beam
- Maximum draft
- Speed

As discussed in Chapter 1.0, Introduction, the Canal de Nicaragua is intended to primarily provide transit for ships too large for the expanded Panama Canal. The canal cross section is dictated by these “target vessel” it is intended to accommodate. The typical dimensions of these target vessels are provided in Table 3.1-2. The largest container ships are currently 19,300 twenty-foot equivalent units (TEU) containers, so the 25,000 TEU ship dimensions are estimates. The Canal de Nicaragua as constructed is itself likely to influence the actual dimensions of the largest ships, as has the Panama Canal.

Table 3.1-2: Target Vessel Dimensions

Boat Type	Dry Weight Tonnage (DWT) Ship Vessels Container Capacity (TEU)	Overall Length (m)	Type Width (m)	Fully loaded draft in seawater (m)
Container Ships	25,000 TEU	500	72	18
Very Large Crude Carriers (VLCC)	320,000 DWT	330	60	20
Ultra-large Bulk Carriers (ULBC)	400,000 DWT	365	65	23.5

TEU = twenty-foot equivalent units; m = meters

3.1.1.3 Canal Width and Depth

In addition to the target vessel dimension, environmental conditions such as the following can also affect the channel design required to accommodate the target vessels:

- **Cross Winds** – affect the width of the maneuvering lane for the target vessels. The wind speed assumed for channel design is near gale force winds of 28 to 33 knots (i.e., Force 7 on the Beaufort Wind Scale). At higher wind speeds, the canal will stop operating and vessels will safely anchor.
- **Waves** – affect the effective water depth; waves were assumed to be up to 1 meter in height at the canal approaches.
- **Currents –** affect the target vessel’s ability to maintain course and to maneuver. The water velocities within the canal between the shipping locks are assumed to be negligible. In the sections between the locks and the Pacific/Caribbean, tidal current effects are considered.

- **Water Density** – salt water (1,025 kilograms per cubic meters [kg/m^3] density) is more buoyant than freshwater (1,000 kg/m3 density), so the same target vessel would require more draft in the freshwater segments of the canal than in the saltwater segments.
- **Tidal and Lake Water Depth Range** – the Pacific Ocean tides vary about 2.5 meters between maximum high and minimum low tide elevations; the Caribbean Sea tides vary about 0.5 meters between maximum high and minimum low tide elevations; and the water level in Lago de Nicaragua generally varies between elevations 30 and 33 meters above mean sea level (amsl).

Taking these factors into consideration, which allow for adequate under keel clearance and appropriate safety considerations, HKND proposes normal water depths of approximately 29 meters in salt water (taking into consideration tidal fluctuation, waves, and water density); 26.9 meters for the inland freshwater canal segments (assuming a minimum lake water elevation of approximately 30.2 meters); and 28.4 meters for Lago de Nicaragua (again, assuming a minimum lake water elevation of approximately 30.2 meters). These depths are presented in Table 3.1-1.

Canal bottom width is determined by taking into consideration the following factors:

- Beam of the target vessels
- Bank clearance
- Vessel speed
- Prevailing cross winds
- Prevailing cross currents
- Prevailing longitudinal currents
- Significant wave height
- Presence of aids to navigation
- Bottom surface (rough versus smooth, soft versus hard)
- Depth of waterway
- Cargo hazard level

Based on these factors, HKND proposes a 280 meter canal bottom width in open waters subject to cross currents/winds and a 230 meter canal bottom width in the confined canal segments between each lock and Lago de Nicaragua.

These typical canal cross-sections assume only one-way traffic in any canal segment at any moment in time. Two passing bays are planned – one in Lago de Nicaragua southeast of Isla de Ometepe and one in Lago de Atlanta – that will allow for ships to anchor while oncoming ships pass. The canal width would be expanded in these passing bays to 520 meters for approximately 5 kilometers.

3.1.1.4 Canal Bend Radius

The canal alignment curves, or bends, to minimize excavation and environmental and social impacts. The sharpness of these bends is determined by:

- Maneuverability of the target vessel
- Canal depth/draft ratio
- Cross currents
- Cross winds
- Waves

Based on these factors, HKND proposes a minimum bend radius of between 2,000 meters and 5,000 meters.

3.1.1.5 Canal Side Slope (Batter) Design

Except for short distance on the Pacific and Caribbean entrances and through Lago de Nicaragua, the canal will need to cut through uplands. The slope of these cuts (often referred to as the batter slope - vertical height / horizontal distance) is very important in that it strongly affects both the excavation volume and slope stability. Steeper slopes reduce excavation volume, but generally increase the risk of slope instability, while gentler slopes increase excavation volume, but may improve slope stability. Based on geotechnical analysis which takes into consideration both the type of excavated material and its weathered state, generic batter slope ratios are presented in Figure 3.1-2.

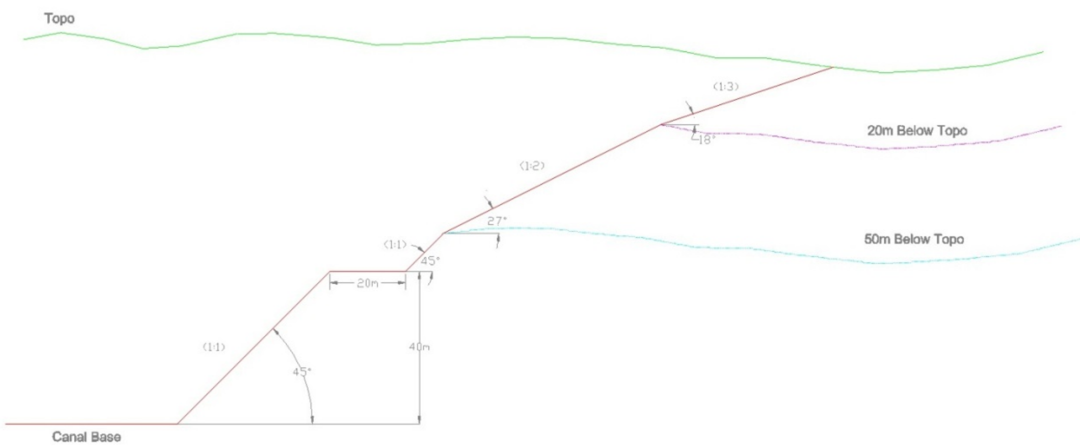


Figure 3.1-2: Generic Batter Slopes

3.1.1.6 Canal Navigation Aids and Lighting

In order for ships to safely transit the canal, HKND would provide navigation aids in accordance with international guidelines. These navigation aids would include various beacons (e.g., acoustic, wireless), warning signage (e.g., cables, pipelines crossings), channel markers, buoys, and the following lighted navigation aids:

- **Lighthouses** (4) – one 30-meter high lighthouse lantern would be on both the Pacific and Caribbean coastline, each with a lighting range of greater than 22 nautical miles. In Lago de Nicaragua, one 20-meter high lighthouse would be on both the west and east lakeshores, each with a lighting range greater than 22 nautical miles.
- **Large sailing buoys** (2) – to mark each side of the Pacific and Caribbean channel entrance, each buoy would be approximately 2 nautical miles from the shoreline and would be equipped with lights having visibility greater than 10 nautical miles.
- **Light buoys** (2) - to mark the channel entrance on both sides of Lago de Nicaragua, each buoy would be approximately 2 nautical miles from the shoreline and would be equipped with lights having visibility greater than 10 nautical miles.

- **Navigation Control Center (1)** – one at the Pacific canal entrance to control all ships in and out of the canal covering from the ocean approaches.
- **Lock Control Centers (2) –** one each at the Brito and Camilo Lock to control the lock and direct ships to sail safely into and out of the lock.

Lighting would also be provided at the locks, ports, breakwaters, and along the canal maintenance roads. This lighting would follow the minimum intensity required to assure safe working conditions and would be directional so as to minimize the effect of light pollution.

3.1.2 Locks

A lock is a structure that allows for the raising and lowering of ships between water bodies of different elevations. In this case, one lock is proposed on each side of Lago de Nicaragua:

- **Brito Lock** – located in the West Canal Segment near Rivas Mico Negro, approximately 14.5 kilometers inland from the Pacific Ocean; and
- **Camilo Lock** – located in the East Canal near the confluence of the Rio Punta Gorda with Camilo Cano, approximately 13.7 kilometers inland from the Caribbean Sea.

These two locks would raise and lower ships between sea level at the Caribbean Sea/Pacific Ocean and the water level of Lago de Nicaragua (30.2 to 33.0 meters).

The two locks would have essentially the same design and each would consist of three consecutive chambers, or steps, that would raise the ships about 10 meters per chamber, for a total of approximately 30 meters. The locks are massive with an effective dimension of each of the three lock chambers of 520 meters (length) × 75 meters (width) × 27.6 meters (threshold depth). The effective length and width of the lock chamber is determined by the 25,000 TEU container vessel estimates, and the effective minimum depth of the lock chamber is determined by the 400,000 dry weight tonnage (DWT) ultra-large bulk carrier. Each lock will require approximately 4.5 million cubic meters (Mm^3) of concrete.

Figure 3.1-3 shows the schematics of the Canal and the three steps needed to raise and lower ships between the ocean waters and Lake Nicaragua on either side of the Canal.

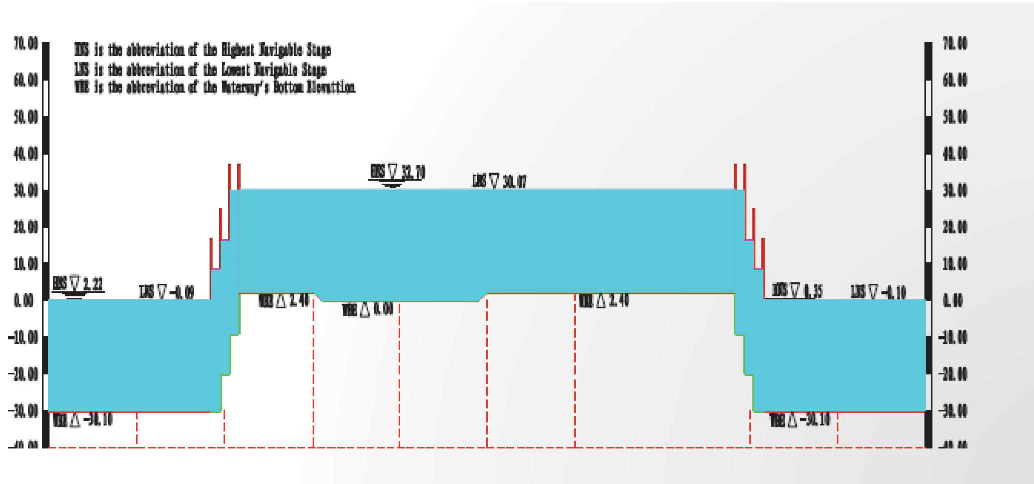


Figure 3.1-3: Schematics of Water Level Change

The locks will be designed to meet international seismic design standards (i.e., *Code for Seismic Design of Water Transport Engineering* [JTS 146-2012], *Standard for Classification of Seismic Protection of Building Construction* [GB 50223-2008], and *Specification for Seismic Design of Hydraulic Structures* [SL 203-97]), including a 5,000 year return period for the Brito Lock, which is in the more seismically active area. Additional details will be provided in the ESIA.

The Project has been designed to have no net use of Lago de Nicaragua water. The location of the locks, which would capture flow from much of the Punta Gorda watershed that would otherwise flow to the Caribbean, and the provision of supplemental water would be provided through the Agua Zarca Reservoir. In addition, the locks have a system for conserving water that consists of nine water saving basins, or ponds, to recycle water at both the Brito and Camilo locks (three basins associated with each of the three chambers that form the lock). The three proposed water saving basins per chamber should reduce overall lock water demand by 60 percent. The water saving basins would have the same length as the lock, but would add an additional 240 m to the overall lock width (i.e., 80 meter width per water saving basin). An oblique sketch of the concept lock with the three chambers and nine water saving basins is illustrated in Figure 3.1-4. A plan view of the Brito (Figures 3.1-5 and 3.1-6) and Camilo (Figures 3.1-7 and 3.1-8) locks are also included below.

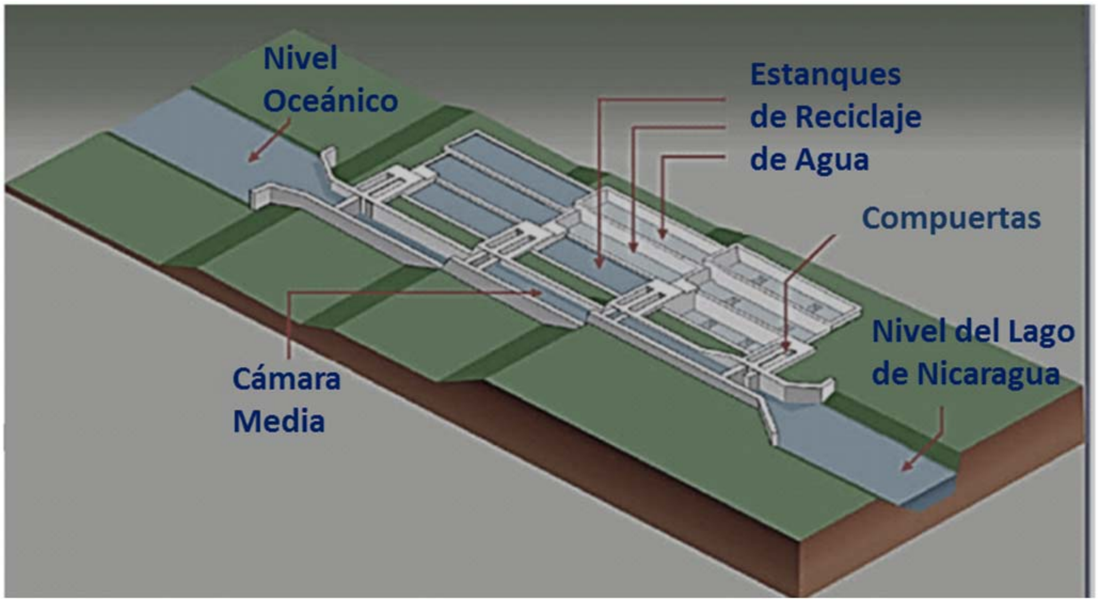


Figure 3.1-4: Concept Lock with 3 Chambers and 9 Water Saving Basins

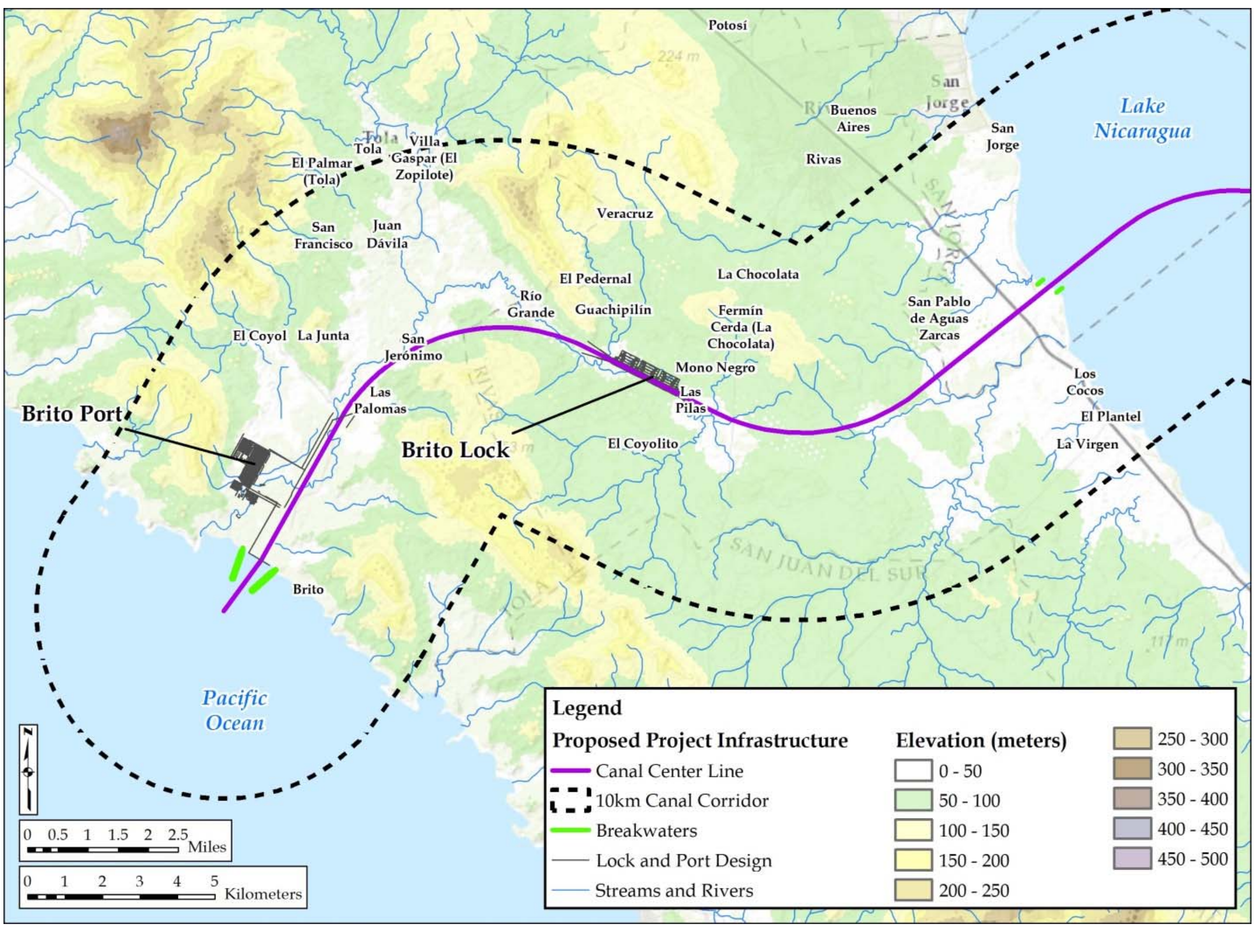


Figure 3.1-5: Brito Lock Location (Zoomed Out)

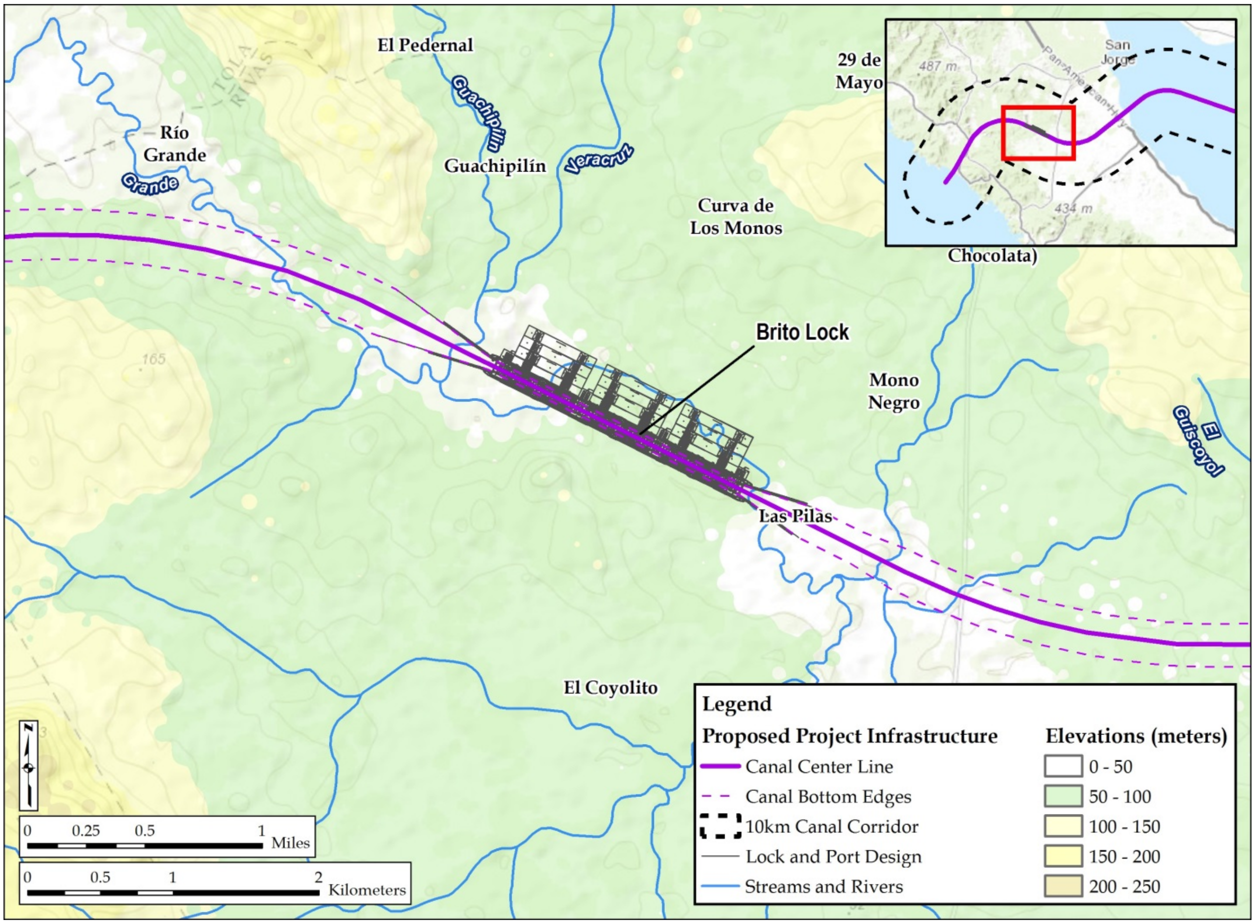


Figure 3.1-6: Brito Lock Location (Zoomed In)

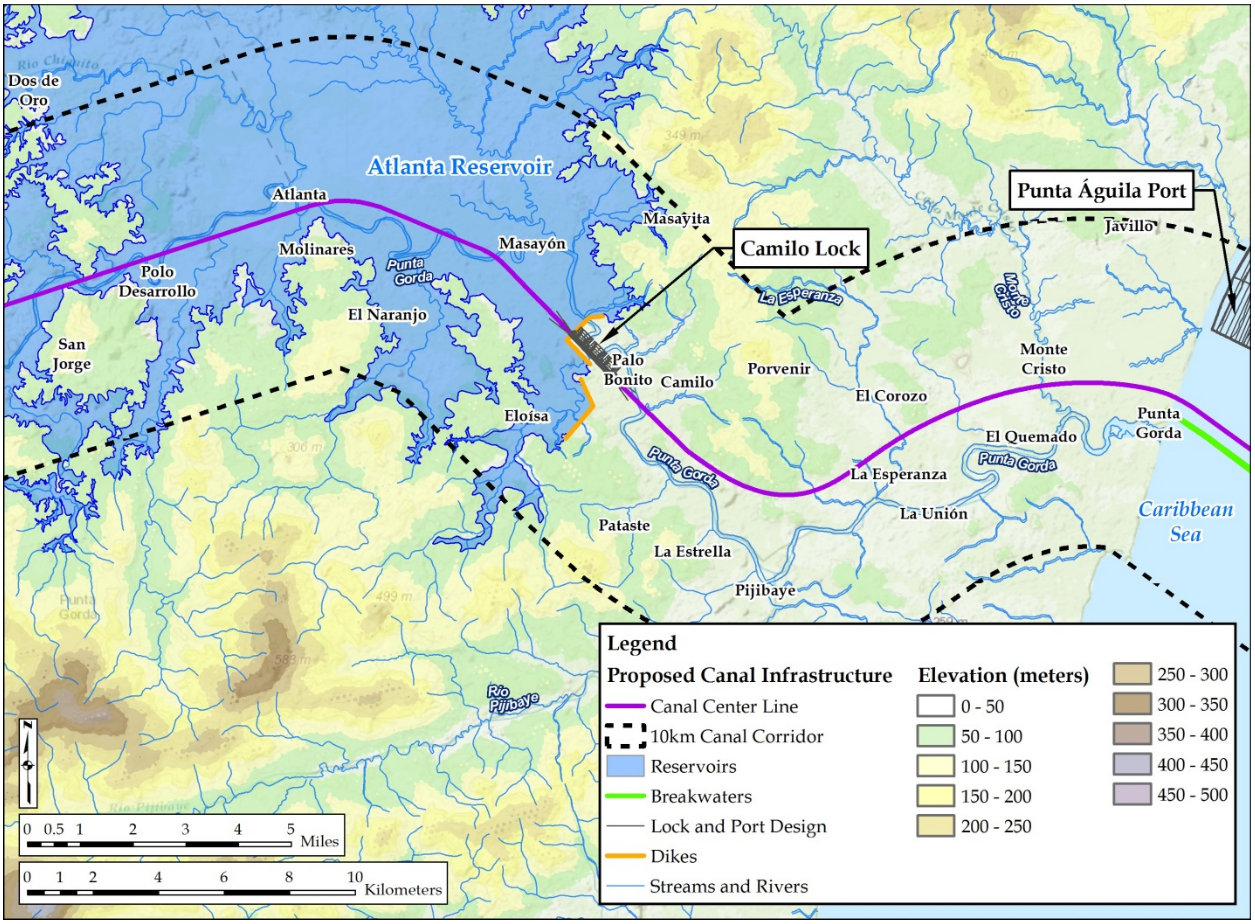


Figure 3.1-7: Camilo Lock Location and Plant View (Zoomed Out)

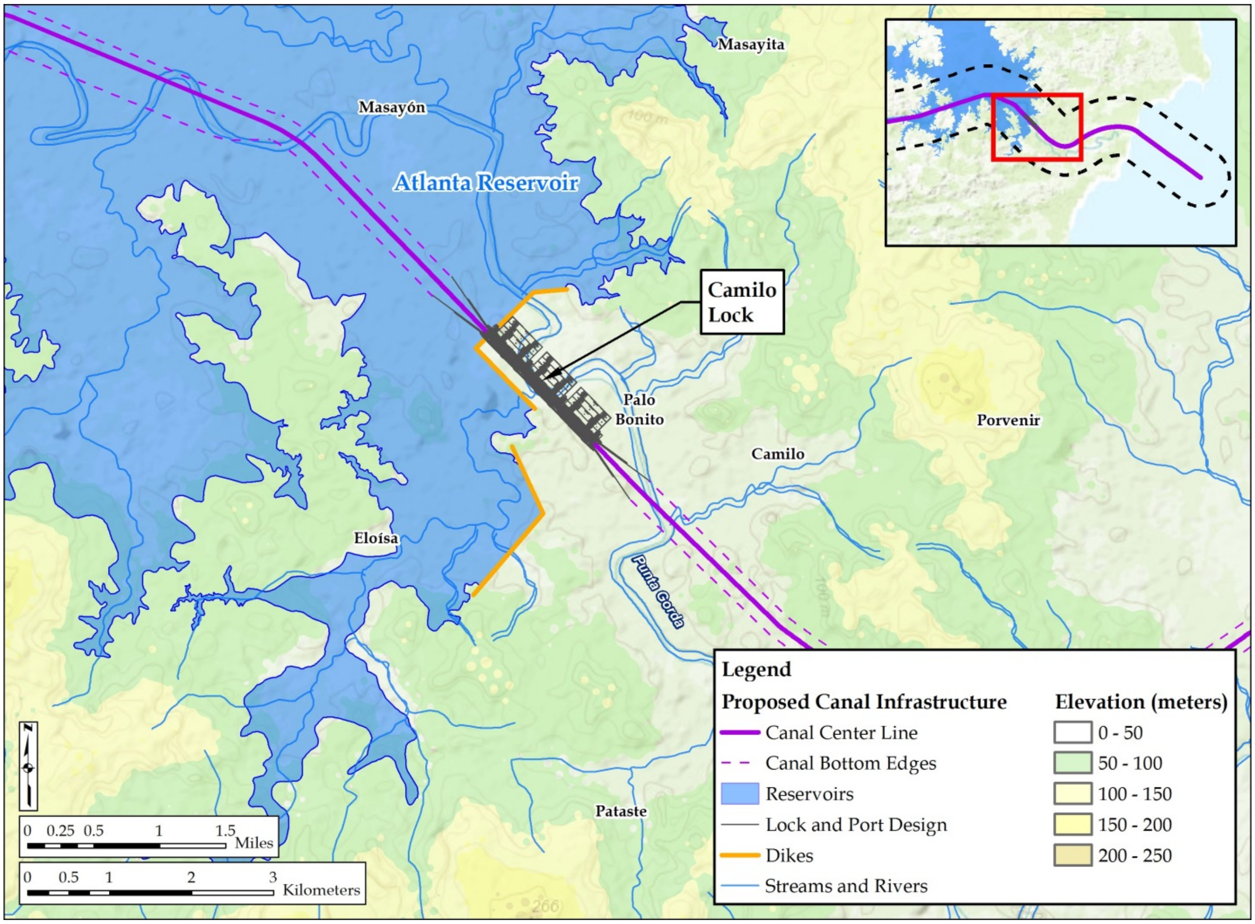


Figure 3.1-8: Detail of Camilo Lock with Associated Dam Structure (Zoomed In)

The proposed lock locations considered safety as well as environmental, social, and economic factors. In an emergency (e.g., extreme flooding within the Rio Punta Gorda), excess water could be released to the Rio Punta Gorda via a sluice gate located downstream of the Camilo Lock to maintain water levels within the canal's operable range. The Camilo Lock location was also selected to allow for construction in bedrock, overall constructability, and to avoid any disturbance or flooding of the Indio Maiz Nature Reserve, although an alternative location for the Camilo Lock is still under evaluation. Likewise, the Brito Lock location would allow the lock to be constructed in bedrock rather than the sandy alluvium found in the lower Brito River valley. In addition, the Brito Lock's inland location would reduce the risk of flooding from tsunamis.

3.1.3 Lock Impoundment

The Camilo Lock requires a dam over the Punta Gorda River and a dike to keep the water from spilling into the Bluefield Bay watershed. The lock, its associated dam/s, and the dike would create an impoundment (artificial lake) upstream of the lock near the community of Atlanta, with a surface area of about 395 square kilometers (km^2): herein referred to as Lake Atlanta. This impoundment would accumulate runoff from the Rio Punta Gorda and two of its tributaries, in particular (i.e., Rio Chiquito and

Masaya), and store it behind the lock at the same elevation as Lago de Nicaragua; therefore, this impoundment would essentially function as an extension of the lake. In other words, the canal between the two locks and the artificial Lake Atlanta would fluctuate at the same water elevation as Lago de Nicaragua. Accordingly, Lake Atlanta would not be a reservoir that could store water above the level of Lago de Nicaragua.

The Project has been designed such that sufficient water would be stored in this impoundment, in combination with normal Rio Punta Gorda flows and the proposed Agua Zarca Reservoir (described in Section 3.3, Associated Project Facilities, below), in order to operate both the Camilo and Brito locks with no net use of Lago de Nicaragua water or effect on Rio San Juan flows, even in periods of extended El Nino weather occurrences.

In order to minimize the footprint of the Atlanta Lake and/or to prevent water from spilling over into the adjacent Bluefields watersheds, an approximately 10,000 meter-long dike is proposed. This would be an earth and rock filled dike with an impermeable clay core to prevent seepage and designed to normal dam structure standards and specifications.

3.1.4 Excavated Material Placement Areas

The Project would be the largest civil earthmoving operation in history, requiring the excavation of approximately 5,000 Mm^3 of material. The excavation will include about 4,019 Mm^3 of "dry" uplands material (e.g., rock and soil) and 980 Mm^3 of marine and freshwater dredging. Table 3.1-3 below presents the earthwork quantities by segment and type (dry excavation versus marine dredging versus freshwater dredging). Figure 3.1-9 illustrates the volume of excavation by station.

Table 3.1-3: Earthwork Quantities by Type and Canal Segment

Segments	Marine Dredging (Mm^3)	Freshwater Dredging (Mm^3)	Dry Excavation (Mm^3)	Total (Mm^3)
Pacific Ocean (Marine Approach)	7	0	0	7
West Canal	102	14	439	555
Lago de Nicaragua	0	715	0	715
East Canal	78	10	3,230	3,318
Caribbean Sea (Marine Approach)	54	0	0	54
Other (e.g., roads, dikes, contingency)	0	0	350	350
Total[1]	241	739	4,019	~5,000

[1] Excavation for locks, water savings basins, and lock entrances not included.

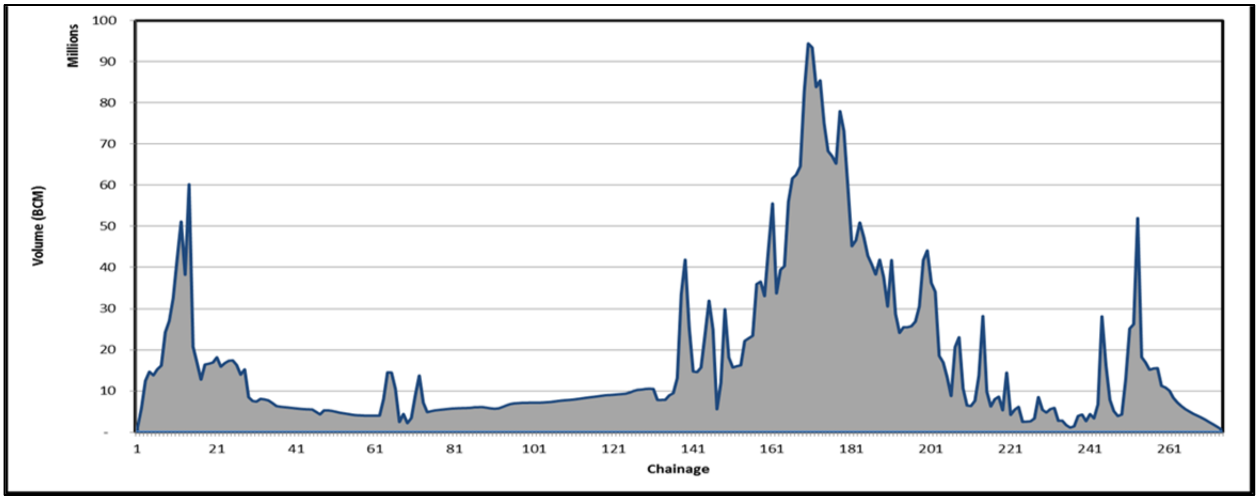


Figure 3.1-9: Canal Excavation Volumes by Station

HKND proposes to beneficially reuse most of the excavated and dredged material to create farmland, the Aguila Port, and Lago de Nicaragua island habitat, as described below.

3.1.4.1 Upland Excavated Material Placement Areas

The material excavated to create the canal would be placed in up to 35 Excavated Material Placement Areas (EMPAs) located along the canal, with a storage volume of 3,400 Mm^3 occupying a total land area of 179 km^2 (see Table 3.1-4, Figure 3.1-10, and Figure3.1-11). These EMPAs generally need to be within about 3 kilometers of the canal as it is cost prohibitive to haul excavated material longer distances. These placement areas have been located to minimize environmental and social impacts (e.g., avoid primary rain forest and large communities).

Table 3.1-4: Excavated Material Placement Area Characteristics

Placement Area ID # (see Figures 3.1-10 and 3.1-11 for location)	Storage Volume (Million m^3)	Surface Area (ha))	Existing Land Cover %Agr/Scrub/Forest	Number of Existing households
West-01	58	430	70/18/12	47
West-02	9	60	47/15/38	0
West-03	218	980	73/17/10	37
West-04	311	1,590	78/13/9	295
West-05	52	880	90/7/3	82
West-06	38	410	84/5/11	31
West-07	45	530	92/5/3	24
West Subtotal	**731**	**4,880**		**516**
East-01	329	1,820	21/28/51	41
East-02	497	1,970	19/37/44	97
East-03	507	1,960	22/31/47	100
East-04	1,437	4,610	33/24/43	154
East-05	180	1,510	35/22/43	23
East-06	612	1,980	41/20/39	20
East-07	1,601	5,830	28/21/51	135

Placement Area ID # (see Figures 3.1-10 and 3.1-11 for location)	Storage Volume (Million m^3)	Surface Area (ha))	Existing Land Cover %Agr/Scrub/Forest	Number of Existing households
East-08	557	1,620	32/25/43	38
East-09	44	360	29/24/47	8
East-10	183	1,360	25/18/57	53
East-11	193	860	30/18/52	14
East-12	35	480	25/15/60	10
East-13	226	970	40/21/39	36
East-14	23	240	31/27/42	14
East-15	219	1,050	33/21/46	36
East Subtotal	**6,644**	**26,620**		**779**
Grand Total	**7,375**	**31,500**	**NA**	**1,295**

Source: MEC

m^3 = cubic meters; ha = hectare; %/Agr = percent agriculture; %Scrub = percent scrub/shrub habitat; %Forest = percent forest; NA = not applicable

The final surface of these areas will be graded such that they can be restored for agricultural or forestry purposes.

3.1.4.2 Lago de Nicaragua Dredge Disposal Areas

Construction of the Canal in Lago de Nicaragua will ultimately require dredging of approximately 715 Mm^3 of lake sediments. This dredged material will primarily be disposed of in three dredged material disposal sites in Lake Nicaragua (see Figure 3.1-12). Some of the dredged material from the eastern portion of Lago de Nicaragua will be placed in an upland excavated material disposal area located adjacent to the lake and immediately south of the Canal (EMPA East-01) (see Table 3.1-5).

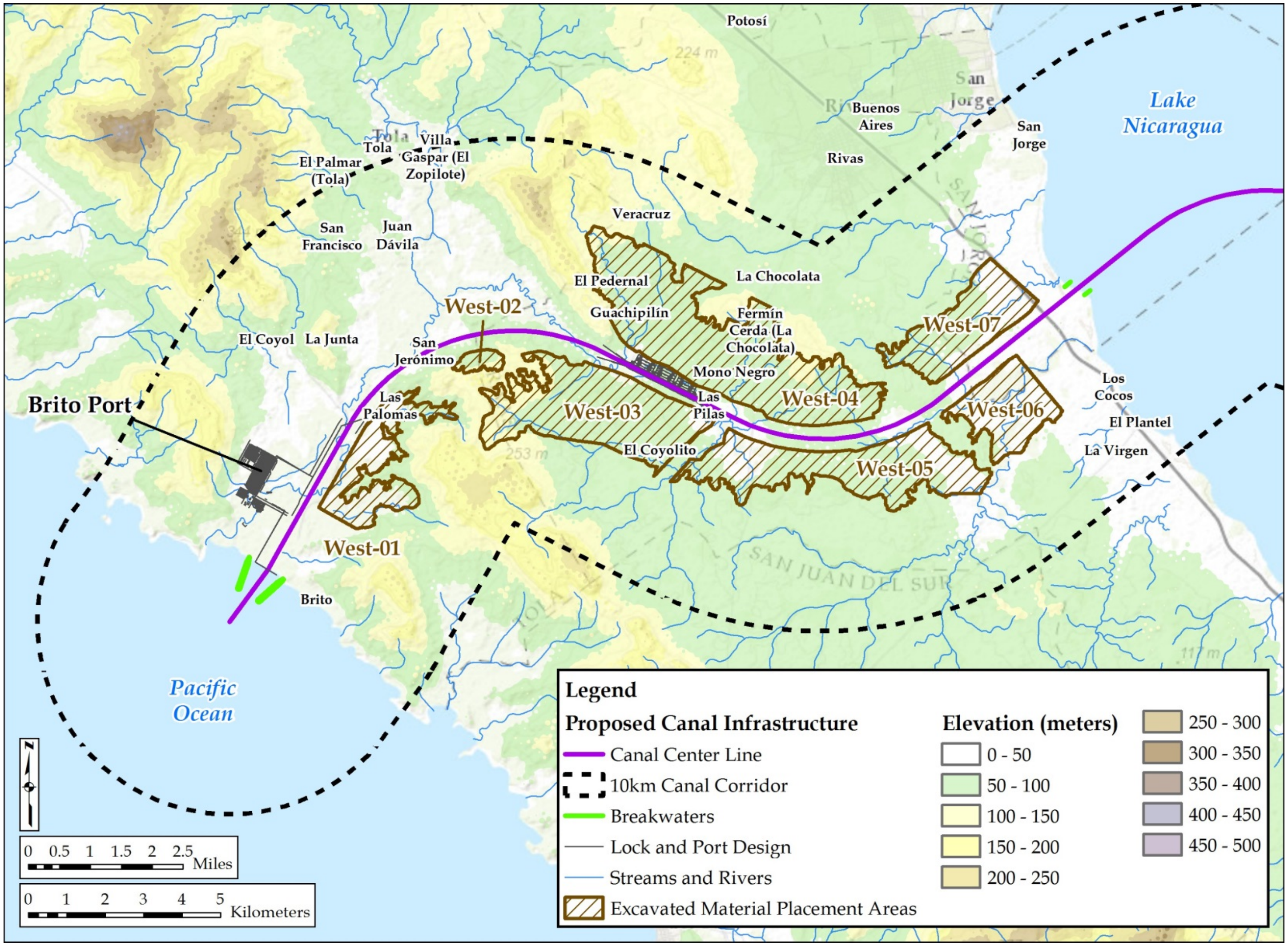


Figure 3.1-10: West Canal EMPAs

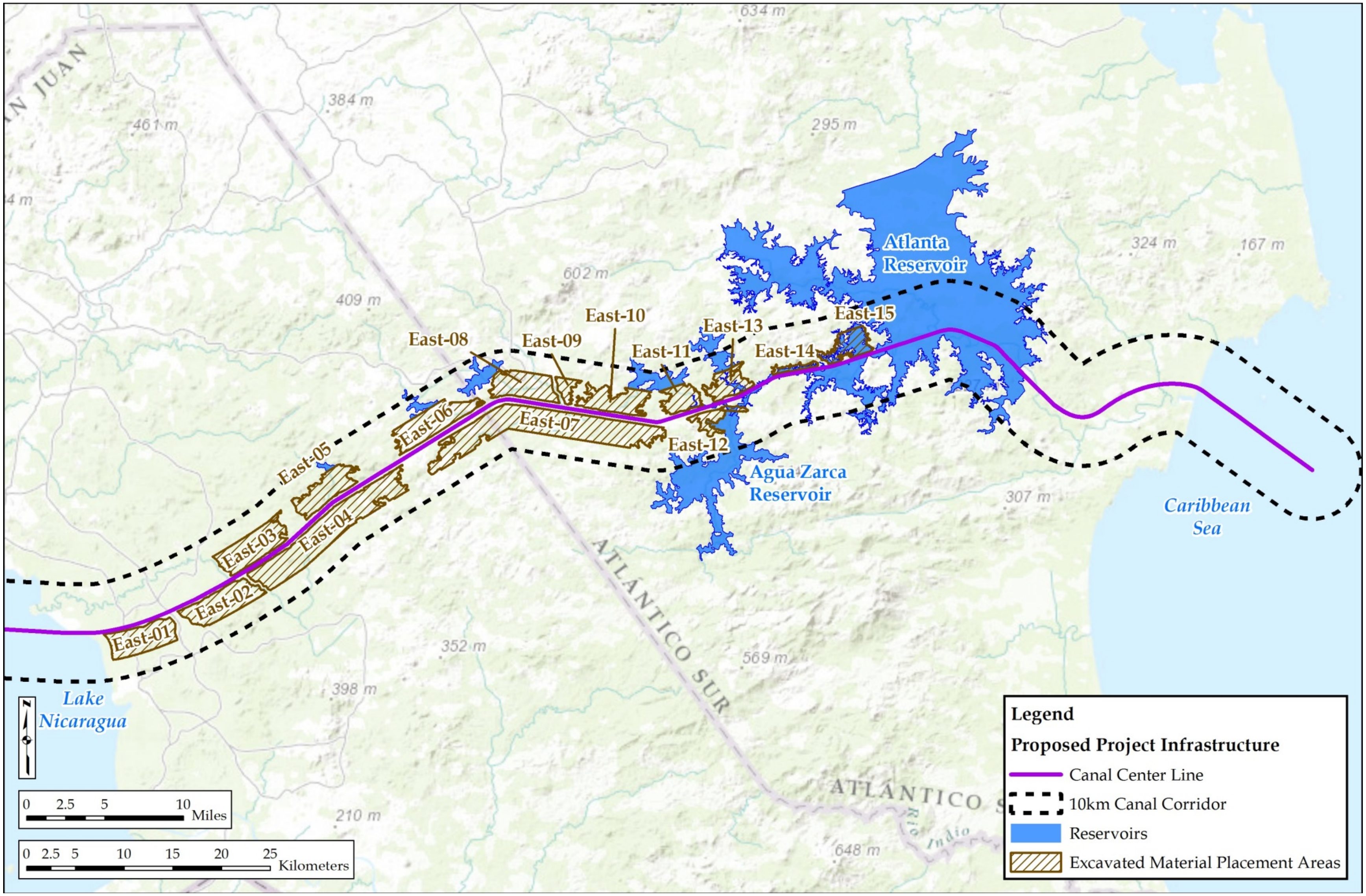


Figure 3.1-11: East Canal EMPAs

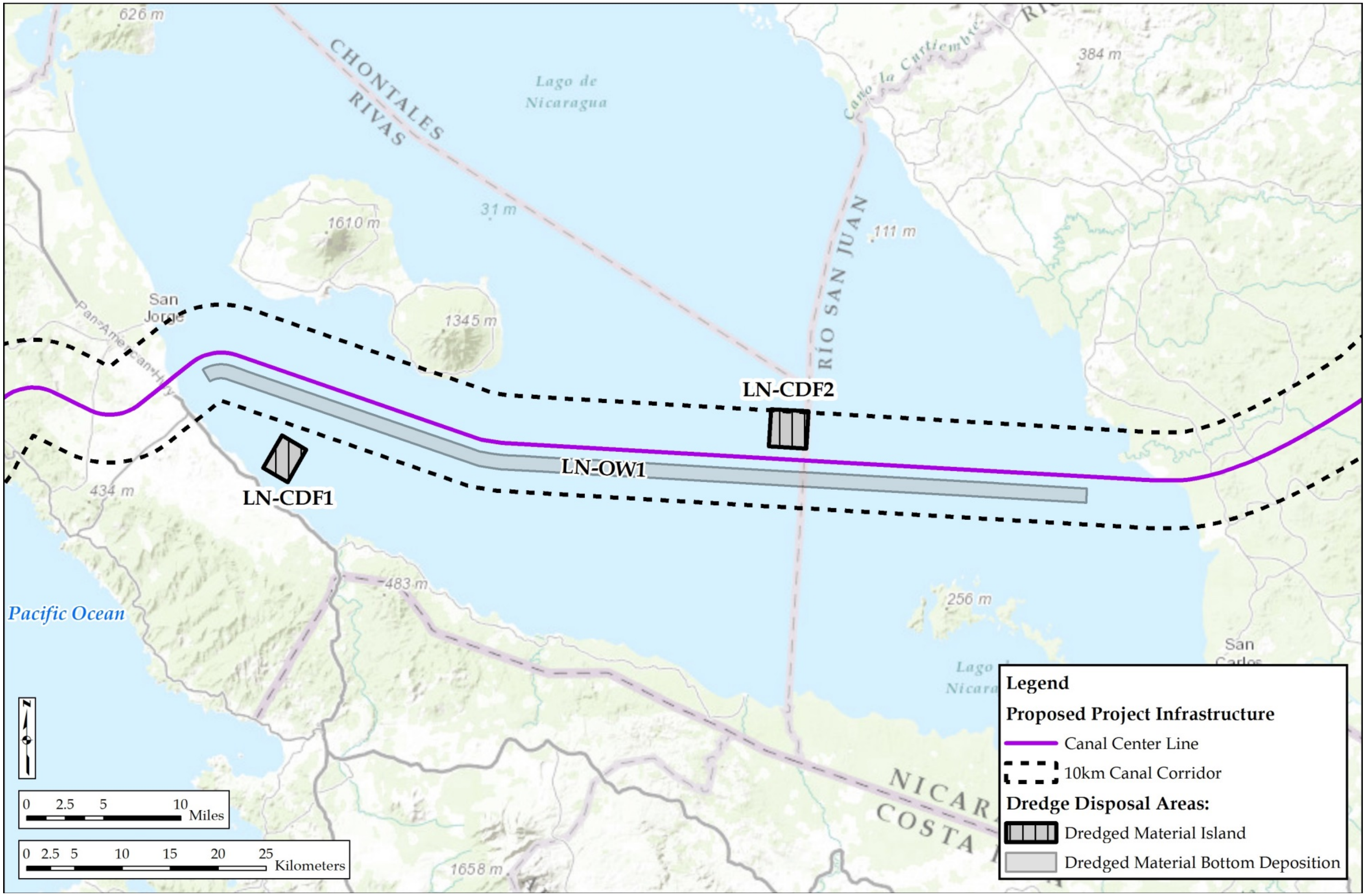


Figure 3.1-12: Lago de Nicaragua Dredge Disposal Areas

Table 3.1-5: Lago de Nicaragua Dredge Disposal Areas

Placement Area ID # (see Figure 3.1-12 for location)	Location (Station)	Estimated Existing Water Depths (m)	Footprint Surface Area (km^2)	Storage Volume (Million m^3)
LN-CDF1	40	5 m	12	100
LN-CDF2	90	10 m	15	150
LN-OW1	30 – 125	Varies from 3 to 32 m	139	360
Total	NA	NA	166	610*

m = meter; km^2 – square kilometer; m^3 = cubic meter; NA = not applicable

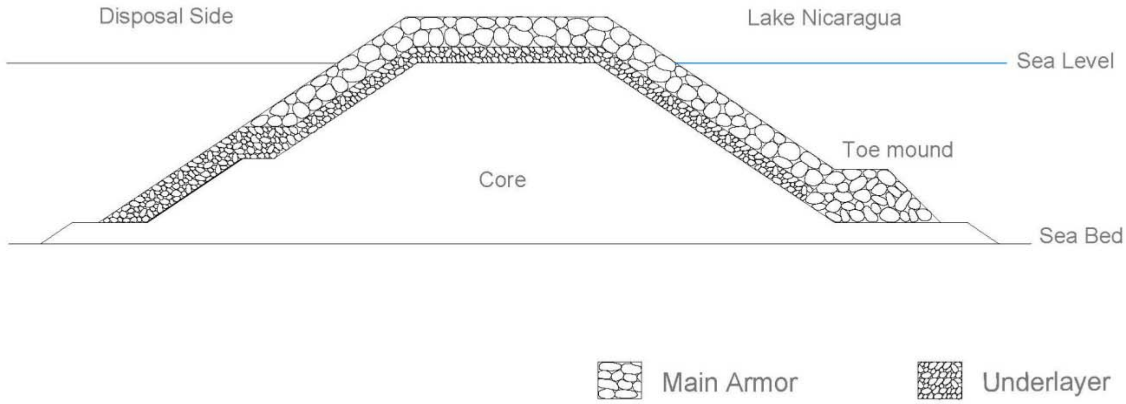
Note: The remaining dredge spoil removed from Lago de Nicaragua will be placed in upland Excavated Material Placement Area East-01.

The surficial fine sediments would be disposed of in two confined disposal facilities (CDFs) surrounded by an engineered dike or seawall (i.e., LN-CDF1 and LN-CDF2) that would ultimately form islands in Lago de Nicaragua, and on land at the eastern side of the lake. An in-water CDF is an engineered structure consisting of dikes or other structures that extend above the water surface and enclose a disposal area for containment of dredged material, isolating the dredged material from adjacent waters.
Figure 3.1-13 provides an example of a CDF.

Source: Uncredited Photo 2014

Figure 3.1-13: Example of a Confined Disposal Facility (CDF)

The dikes/seawalls are typically constructed with an inner core of rubble or even sand covered by progressively larger stones with large armor rock (sourced from upland excavation areas) placed on the outside face of the dike to protect against wave action (see Figure 3.1-14). The dike, which is at least initially permeable, encircles the disposal area where the dredged material is placed. As dredged material is pumped or placed in the CDF, the sediment particles settle out in the disposal area and excess water either evaporates or percolates through the dike (USACE 1987).



Source: Image created by HKND

Figure 3.1-14: Typical Cross Section of a Confined Disposal Facility (CDF) Dike

These facilities would accept the fine surficial silts and clays dredged for the canal and would help prevent that material from impacting turbidity and contaminant levels in Lago de Nicaragua. Water quality monitoring at existing island facilities has confirmed that that CDFs are highly efficient at retaining the sediment solids and any attached contaminants (Great Lakes Commission 2000).

The third dredged material disposal area is an open water disposal site (LN-OW1). This facility would only accept coarser material like sands and excavated rock that underlie the fine surficial silts. This material is heavy and would sink to the bottom of the lake with little potential to cause any turbidity issues and typically has little or no contamination. HKND has indicated that the open water disposal site would not be more than 3 meters in height above the lake bottom to avoid interfering with lake navigation.

3.1.4.3 Marine Dredge Disposal Areas

HKND proposes three marine dredged material disposal areas, one in the Pacific and two in the Caribbean (see Table 3.1-6).

Table 3.1-6: Marine Dredge Disposal Areas

Placement Area ID #	Storage Volume (Million m^3)	Surface Area (km^2)	Distance offshore (km)	Estimated Water Depths (m)
P-OW1	7	0.8	15 km	>150 m
C-OW1	54	~8.0	~35 km	>100 m
C-CDF1	182	14	0 – 2 km	~7 m
Total	143	~22.8	NA	NA

NA = not applicable

The Pacific disposal area (P-OW1) would accommodate the estimated 7 Mm^3 of marine excavation required to achieve the required depth for the Pacific approach channel.

The Caribbean disposal area (C-OW1) is intended to only accommodate the initial dredging of surficial fine sediments from the Aguila Port site and from the lower Rio Punta Gorda. The exact location of this disposal site has not yet been determined, but it will be required to meet the following siting criteria:

- Minimum of 100 m depth of water;
- Minimum of 15 kilometers offshore (likely to be at least 35 kilometers to achieve water depths of 100 meters);
- Lack of nearby hard rock habitat; and
- Located at a latitude south of Booby Cay to ensure marine currents do not carry turbidity to the Booby Cay/Monkey Point/Bank 105 important habitat areas.

All other dredge material that is suitable (e.g., sand) would be used as fill to create the Aguila Port reclamation area (i.e., C-CDF1). The Aguila Port has the capacity to accept a large volume of dredged material, and would therefore serve as the primary disposal location for East Canal maintenance dredging for the foreseeable future.

3.1.5 Breakwaters

The canal would include breakwaters at the Pacific, Caribbean, and Lago de Nicaragua canal entrances. All breakwaters would follow the basic design as illustrated in Figure 3.1-15, with a 10 meters wide crest, about 6.5 meters clearance amsl, and 1.5:1 slopes to the sea bed. The breakwaters would create an effective canal width at the various entrances of approximately 500 meters.

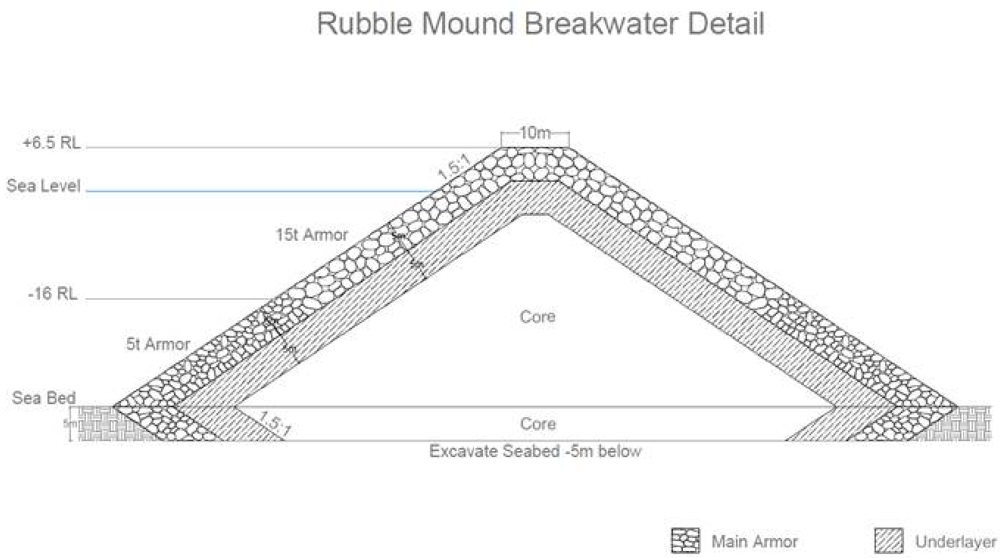


Figure 3.1-15: Typical Cross Section of the Breakwater Structures

3.1.5.1 Pacific Breakwater

The Pacific breakwater would extend approximately 800 m from the shoreline on both sides of the canal. It will be constructed with armor rock sourced from the Brito Lock excavation with tri-bar armor at the ends (see Figure 3.1-16). The overall footprint of each breakwater will be about 62,000 square meters (m^2), or 124,000 m^2 total for the two breakwaters.

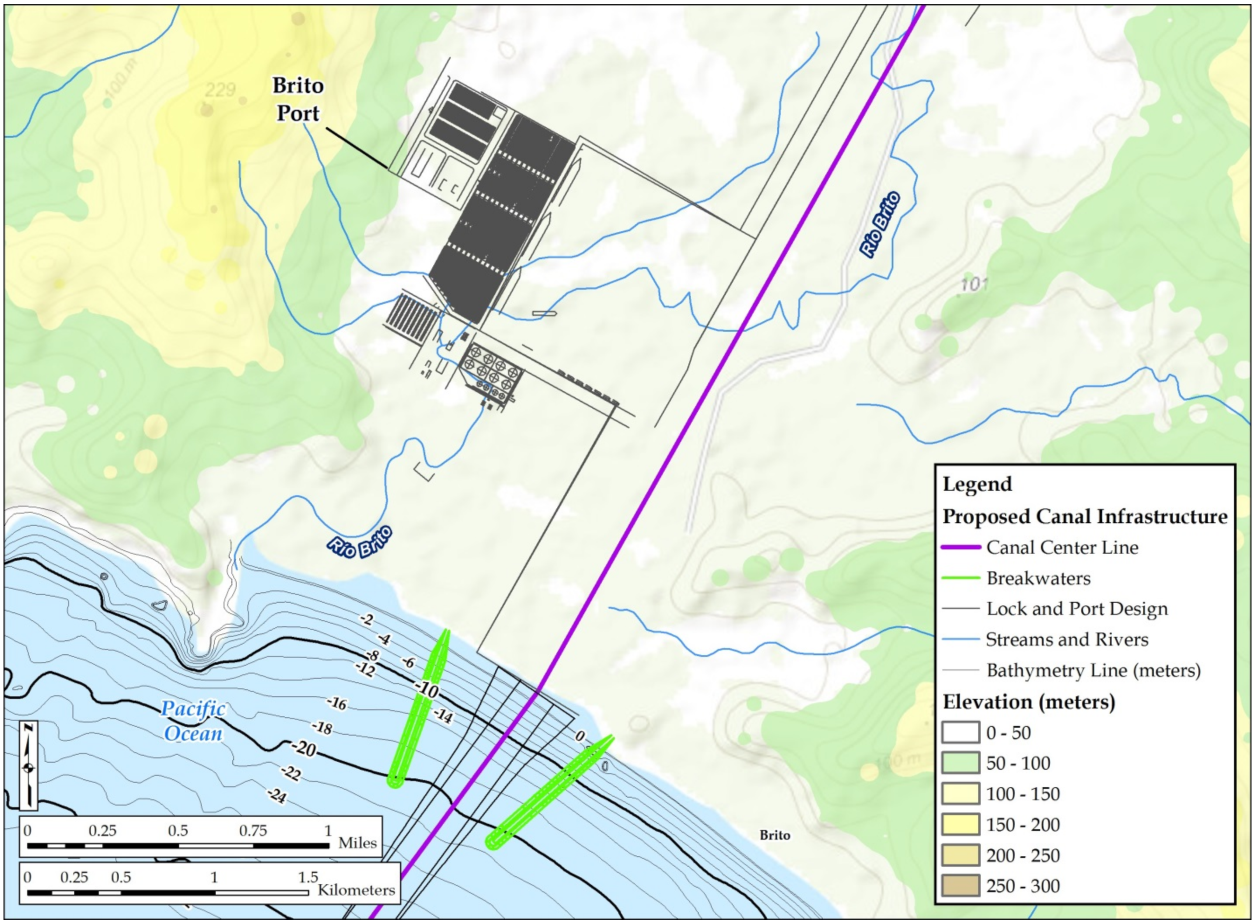


Figure 3.1-16: Pacific Entrance Breakwater and Brito Port

3.1.5.2 Caribbean Breakwater

The Caribbean breakwater would include two different structures, one at each side of the canal. The breakwater located to the north of the canal would extend south from Punta Aguila approximately 7 kilometers to a location about 3 kilometers southwest of Booby Cay. The breakwater located to the south of the canal would be located about 1 kilometers north of the mouth of the Rio Punta Gorda and would be oriented perpendicular to the shoreline and extend approximately 3.5 kilometers (see Figure 3.1-17). The overall footprint of north breakwater would be about 238,000 m^2. The overall footprint of the south breakwater will be about 105,000 m^2. Combined, this would be approximately 343,000 m^2 total for the two breakwaters.

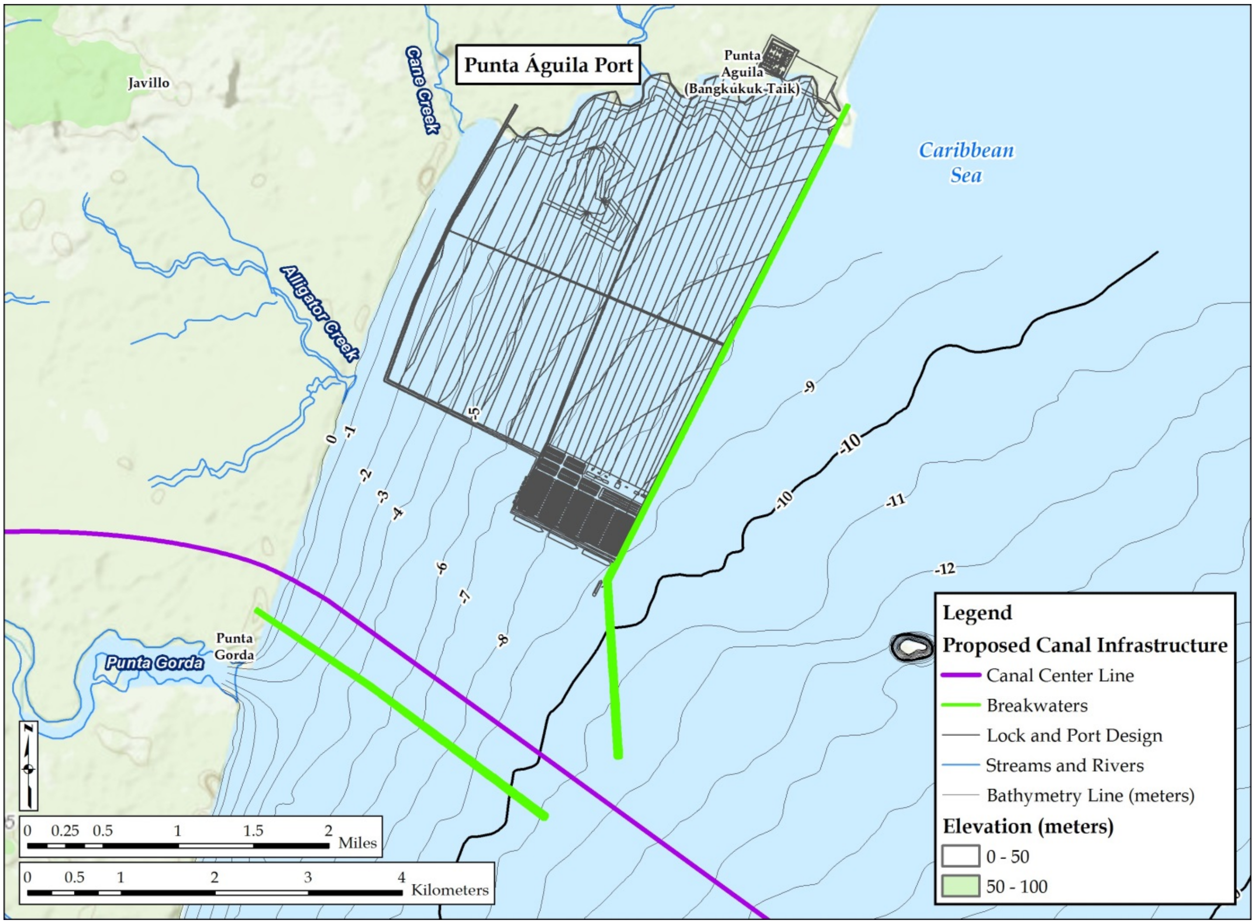


Figure 3.1-17: Caribbean Entrance Breakwaters and Aguila Port

The breakwaters at the two Lago de Nicaragua entrances would be smaller and intended to control sediment deposition, and help stabilize the lake shoreline at the canal entrances. Two breakwaters would occur on either side of the canal at both canal entrances and would extend approximately 200 meters from shore. The overall footprint of each breakwater would be about 9,000 m^2, or 18,000 m^2 total for the two breakwaters.

3.2 PORTS

Canal construction would require the import of approximately 21M tons of materials and supplies, most of which are anticipated to be transported by ship to the Corinto and Bluefields ports. HKND proposes to use these existing ports to transfer these materials and supplies to shallow draft barges that would be used to transfer these materials to two proposed Project ports, one on the Pacific called the Brito Port (approximately 4 km^2 in area) and one on the Caribbean called the Aguila Port (14 km^2 in area). The ports would provide logistical support during the construction of the canal and would afterwards serve as international ports. These ports would support growth of the Nicaraguan economy by providing improved transport connections for agricultural and other Nicaraguan producers with major Atlantic market destinations. These ports would serve as trans-shipment ports for container handling and normal cargo loading.

3.2.1 Brito Port

The Brito Port (see Figure 3.1-16) would have a design capacity of 1.68 million TEU/year and would include the following facilities:

- North Wharf structure, approximately 1,100 meters long, capable of supporting a 200,000 dry weight tonnage (DWT) bulk carrier or 25,000 TEU container ship;
- West Wharf berthing facilities, approximately 1,200 meters long, accommodating:
  - Three 70,000 DWT container berths;
  - One 30,000 DWT oil/fuel jetty;
  - 13 workboat berths; and
- Other miscellaneous supporting facilities.

3.2.2 Aguila Port

The Aguila Port (see Figure 3.1-17) would have a design capacity of 2.5 million TEU/year and would include the following facilities:

- Wharf structure design capable of supporting a 200,000 DWT container ship;
- Berthing facilities, approximately 1,300 meters long, accommodating:
  - Three 150,000 DWT container berths;
  - One 30,000 DWT oil/fuel jetty;
  - Eight workboat berths; and
- Other miscellaneous supporting facilities.

3.3 ASSOCIATED PROJECT FACILITIES

3.3.1 Vehicular Transportation Improvements

3.3.1.1 Pan-American Highway Bridge

HKND proposes to build one bridge as part of this Project for the Pan-American Highway. A ferry is proposed where the canal would cross Nicaragua Route 25 (Acoyapa-San Carlos Road). The canal would not cross any other major roads that would warrant construction of a bridge or provision of a ferry.

The Pan-American Highway Bridge would use a span arrangement and provide 80 meters clearance over the average canal water level (approximate elevation of 31.3 meters), and an overall length of 4,930 meters. Structural arrangement is shown below in Figure 3.3-1.

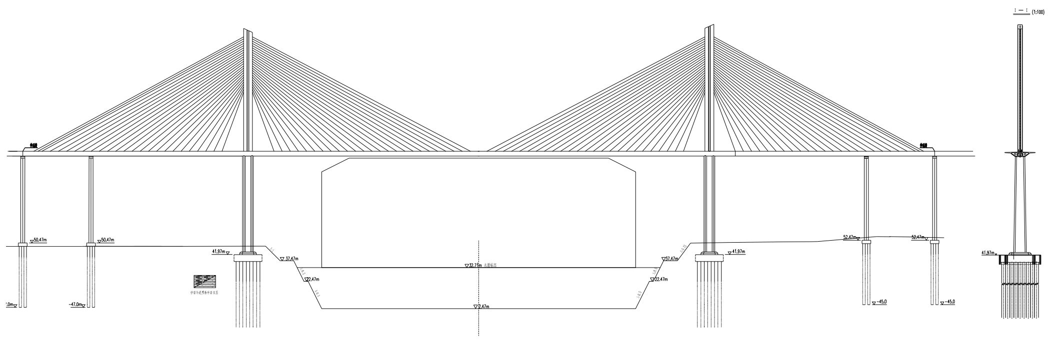


Figure 3.3-1: Proposed Pan American Highway Cable-Stayed Bridge Profile

3.3.1.2 Ferry

HKND proposes a vehicular ferry in lieu of a bridge where the canal crosses the Acoyapa-San Carlos road (Nicaragua Route 25). Ferry terminals would be constructed on both sides of the canal, and a ferry would operate on an approximately hourly basis at no cost to users until a reasonable substitute is available.

3.3.1.3 Permanent Public Roads

Road access to most of the western section of canal is available through the existing road network, although improvements would be required. Similarly, road access to both sides of Lago de Nicaragua is also available. However, access by road to the eastern section of the canal is currently available only at its western end near San Miguelito.

To provide reliable public access to critical Project facilities, HKND proposes to improve or construct three roads:

- Pan-American Highway to Brito Port Road; and
- Nueva Guinea to Aguila Port Road.

Table 3.3-1 presents the basic design parameters for these roads. Figure 3.3-2 presents a typical cross section for these roads.

Table 3.3-1: Basic Road Design Parameters

Road Section	Road Type	Length	Width	Surface Material
Brito Port to Pan-American Highway	Public	23 km	12 m	Asphalt
Aguila Port to Nueva Guinea	Public	103 km	12 m	Asphalt

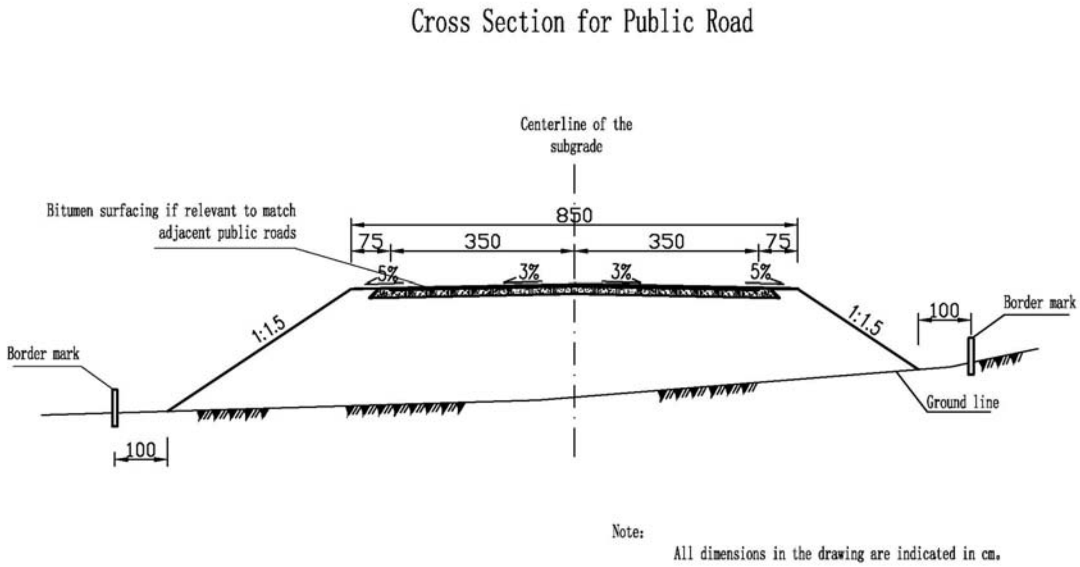


Figure 3.3-2: Cross-section of Public Roads

In addition, HKND proposes to construct permanent paved roads to provide access to the reclaimed EMPAs. The exact location of these roads has not yet been determined, but they would generally be located within a 100-meter-wide corridor alongside the top of the batter slope.

3.3.1.4 Permanent Private Maintenance Roads

In addition to the facility access roads, HKND intends to build 5-meter wide gravel maintenance roads on both sides of the canal along most of the route, except on the East Canal between the Camilo Lock and the Caribbean Sea on the north side of the canal and between the Agua Zarca Reservoir and the Caribbean Sea on the south side for biodiversity conservation. Vehicular access to these private maintenance roads would be limited to canal-related traffic. Figure 3.3-3 presents a typical cross section for these roads.

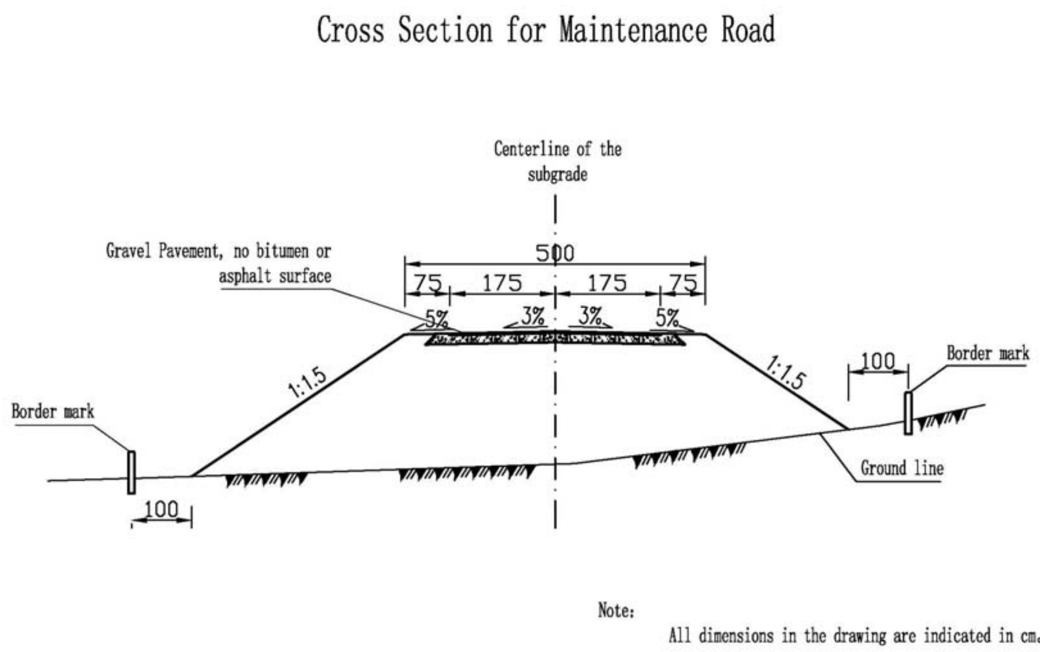


Figure 3.3-3: Cross-section of Maintenance Road

3.3.1.5 Camilo Lock Maintenance and Access Road

HKND would construct an approximately 8-kilometer-long asphalt spur road to connect the Nueva Guinea to Aguila Port Road to the Camilo Lock. This would be a private access road. Vehicular access would also be included in the design of the Camilo Lock so as to provide maintenance access across the Camilo Lock to the Atlanta Dam. Limited public access across the lock would be allowed, but only for local residents with appropriate identification.

3.3.2 Power Generation and Transmission Lines

During construction, the Project might connect to the Nicaraguan electricity grid for power, but would primarily rely on diesel generators to provide required power. During operation, the Project would obtain power from the Agua Zarca Hydropower Project supplemented and possibly with securing power from the Nicaragua electrical grid.

3.3.2.1 Agua Zarca Hydropower Facility

The Agua Zarca Hydropower Facility would be located on the south side of the canal at approximately Station 205 kilometers. It would consist of an approximately 65-meter high dam, creating a reservoir on the Agua Zarca River with a surface area of approximately 48.5 km^2 and a storage volume of approximately 1,100 gigaliters. The facility is predicted to generate over 10 megawatts (MW) of power, assuming an average annual flow of 24 cubic meters per second and a gross head of approximately 55 meters. An approximately 22-kilometer-long transmission line will connect the Agua Zarca powerhouse to the Camilo Lock substation, which would cross and then run along the north side of the canal. The Agua Zarca Hydropower Project would be operating by the time canal operations commence and will provide power for the operation of the Camilo Lock.

3.3.2.2 Connection to the Nicaragua Electrical Grid

Subject to reliability and availability analysis, both the Camilo and the Brito locks would be connected to the Nicaragua electrical grid for power during operations. This would require constructing new electrical transmission lines totaling 125 kilometers and a new 69 kilovolt (kV) electrical substation near each lock as presented in Table 3.3-2 and Figure 3.3-4. Both locks would also have diesel generators for emergency power.

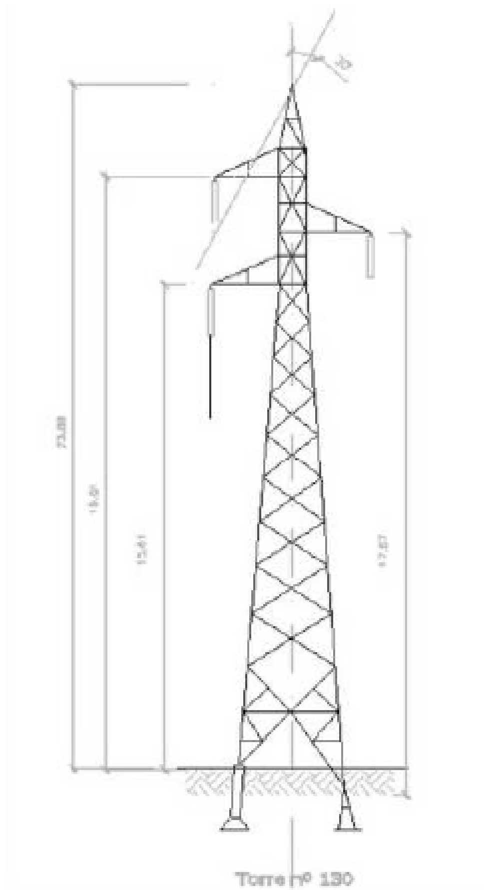


Figure 3.3-4: Proposed Electrical Transmission Towers

Table 3.3-2 provides characteristics of the two transmission lines and substations that would be needed to supply power from the national grid during construction.

Table 3.3-2: Transmission Lines

Starting Line	End of Line	Voltage Rating	Number of Loops	Total Length (km)
RIVAS Substation 138kV	Brito Substation	69kV	Double circuit	11
COROCITO Substation 69kV	Camilo Substation	69kV	Double circuit	114

kV = kilovolt; km = kilometer

3.3.3 Concrete Batch Plants

Approximately 10 Mm^3 of concrete would be needed primarily to construct to the two locks, but would also be used for the breakwaters, building, and other miscellaneous facility construction. The batch plant combines sand/aggregate with cement to make concrete. HKND would import cement and source aggregate locally (see Section 3.3.4, Aggregate Quarries). The exact location for these plants has not yet been determined, but one plant would be located near each lock or its quarry.

3.3.4 Aggregate Quarries

The concrete would be made by combining cement with aggregate (sand and crushed stone). The cement would likely be imported. The aggregate would be sourced from the following two locations (see Table 3.3-3): one near the Brito Lock (Rio Grande quarry) and one near the Camilo Lock (Camilo quarry).

Table 3.3-3: Aggregate Quarries

Aggregate Quarry	Location	Estimated Surface Area	Volume of Aggregate Needed/Available	Used for
Rio Grande quarry	1 km from Brito Lock	2.2 km^2	9.2 Mm^3 / 158 Mm^3	Brito Lock and Pacific breakwater
Camilo quarry	5 km northeast of Camilo Lock	1.1 km^2	9.9 Mm^3 / 35.1 Mm^3	Camilo Lock and Caribbean breakwater

km2 = square kilometers; Mm^3 = million cubic meters

3.3.5 Borrow Areas

Three borrow areas are proposed to source material for dam core walls (see Table 3.3-4).

Table 3.3-4: Borrow Areas

Borrow Area	Location	Average Thickness	Area	Available Volume
#1	2,200 m west of the dam	2.0 m	15.1 km^2	30 Mm^3
#2	600 m southwest of the dam	2.5 m	1.4 km^2	3.5 Mm^3
#3	3,700 m southwest of the dam	2.5 m	3.1 km^2	7.7 M m^3

M = meter; km^2 = square kilometers; Mm^3 = million cubic meters

3.3.6 Offices and Worker Camps

HKND plans to locate a construction management/operations office near Rivas. The exact location for this facility is not yet known, but it is anticipated that they would rent or purchase an existing office building. Project construction would require approximately nine worker camps along the canal route – three for the West Canal and six for the East Canal, as follows (exact locations are not yet available):

- West Canal
  - Near the Brito Port site
  - Near the Brito Lock site
  - Near the Pan-American Highway Bridge
- East Canal
  - Near Lago de Nicaragua
  - Three in the highlands region spaced between Rt. 25 and Polo Desarrollo
  - Near the Camilo Lock
  - Near the Punta Aguila Port

Each Worker Camp would also include an equipment repair plant, general storehouse, and an oil depot; some would also have an explosives magazine located a safe distance away from the rest of the camp. HKND has committed that these worker camps would be located within the existing Project footprint and would not require additional habitat disturbance.

HKND would construct a lock control center at each of the two locks, in addition to the overall canal headquarters in Rivas. Each of the operations centers would have a water treatment facility that would treat water from the Rios Brito and Punta Gorda for potable purposes.

3.3.7 Fuel Storage

HKND would require large quantities of both diesel (for power generation and construction equipment) and bunker oil (for dredgers). These fuels would be primarily stored at fuel storage depots at the Brito and Aguila ports, but each worker camp would also have its own fuel storage. HKND commits to providing secondary containment around all fuel storage containers.

3.3.8 Corinto and Bluefields Ports

HKND intends to import construction equipment and materials (e.g., steel) through the existing Corinto (Pacific) and Bluefields (Caribbean) ports, where these materials would be transferred onto barges for shipment to the Project’s Brito and Punta Aguila ports, or directly into the new Brito and Camilo ports once they have suitable facilities established. It is anticipated that the Project could require minor improvements at Corinto and Bluff ports to accept canal-related deliveries and enhanced cargo handling/transfer capabilities. It is anticipated that these improvements could be made within the existing port footprints.

3.3.9 Infrastructure Crossings

Construction of the canal would cross some existing infrastructure along its route, which would be managed as described in Table 3.3-5.

Table 3.3-5: Canal Construction Crossings and Mitigation

Crossing	Mitigation
Le Fee Windfarm (remove two wind turbines)	Relocation or payment
Pan-American Highway	Replace highway segment with a bridge
Nicaragua Route 25	Provide free ferry service across the canal
SIN 230 kV transmission line	Rebuild or relocate transmission line
SNT 230 kV transmission line	Rebuild or relocate transmission line
Communication cables	Relocate or rebuild as submerged cable

kV = kilovolt; SIN = National Interconnected System; SNT = Sistema Nacional de Transmisión

4. PROJECT CONSTRUCTION

4.1 SCHEDULE

HKND proposes to complete Project construction in approximately 5 years, including an initial mobilization period of approximately 6 months, with canal operations beginning in 2020 (see Figure 4.1-1). This is a challenging schedule and would create significant logistical, procurement, and workforce challenges.

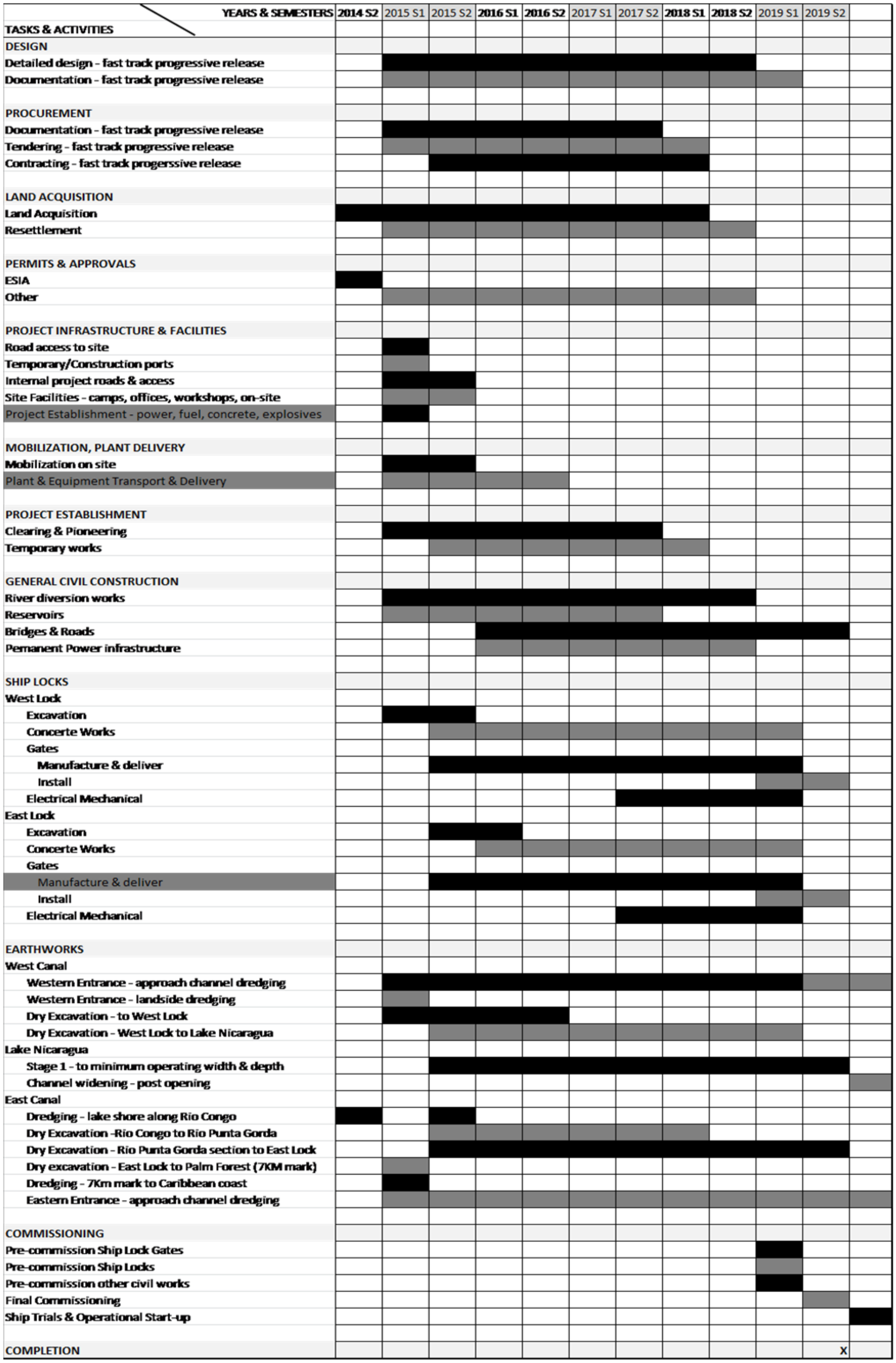


Figure 4.1-1: General Construction Schedule

4.2 WORKFORCE

An estimated average annual workforce of approximately 50,000 employees is anticipated during the 5-year construction period. HKND anticipates that up to 50 percent of the workforce would be recruited from within Nicaragua. It is likely, however, that a core contingent of experienced personnel (e.g., management staff, training personnel, selected equipment operators) would be required to be employed on an expatriate basis, with about 25 percent from China and 25 percent from other countries.

4.2.1 Skilled/Unskilled Workforce

The Project would require approximately 1,500 office/administrative positions and approximately 48,500 field-based positions. Nicaragua has a very limited highly skilled workforce readily available. This has major implications for staffing of the Project, as a significant investment in training would be required, specifically for maintenance personnel and equipment operators.

Typical job types during construction would include:

- Maintenance
  - Level 4: Leading hand
  - Level 3: Skilled tradesman
  - Level 2: Semi-skilled tradesman
  - Level 1: Apprentice
- Equipment Operator (Truck driver)
  - Level 3: Excavator operator/ Leading hand
  - Level 2: Skilled operator
  - Level 1: Semi-skilled operator
- Laborer

Training requirements would be extensive, particularly for roles required to operate and maintain heavy equipment. For these roles, it is likely that several months of training would be required for each person with a period of practical experience. Trainers would be drawn initially from a worldwide supply of experienced operator trainers, with a preference for those with Spanish language skills.

To satisfy the Project's immediate needs, skilled equipment maintainers, equipment operators, and trainers would need to be recruited from across the Americas and/or worldwide. Spanish language skills would be an advantage. Management and technical staff are also likely to be recruited internationally. Expatriate excavator operator-trainers would be employed to operate the large diesel hydraulic excavators (at least initially) in order to provide training for locally engaged operators.

4.2.2 HKND Hiring Procedures

HKND would limit hiring of workers within Nicaragua to designated hiring centers in a few regional centers (e.g., Managua, Rivas, Nueva Guinea, Bluefields) in order to limit the potential for in-migration to the construction areas. No hiring would occur at the construction site. Appropriate background checks would be conducted for any security personnel to ensure they have not been implicated in past abuses.

4.2.3 Workforce Screening and Induction Training

HKND would require that all Project workers (including subcontractors) receive induction training prior to initiating work in the following areas:

- Code of Conduct – compliance would be part of all employment contracts. This Code would establish policies such as required behaviors in camp, drug and alcohol use, required authorizations for leaving the camp, respect for and interactions with local communities, and prohibition on the possession of firearms and hunting.
- Health and safety – both general and job specific. HKND would impose a Competency Management Scheme to help ensure that no employees under take work for which they have not received the proper training. Health training would address communicable disease prevention.
- Driver Policy and Safety Trainings – these would be required for all employees and contractors driving vehicles on public roads.
- Human Rights Training for all security personnel.
- Environmental Sensitivity Training.
- Cultural Sensitivity Training.

HKND will introduce rigorous drug and alcohol testing for all employees.

HKND would require its subcontractors to meet these screening and induction training requirements through mandatory terms in their tenders. Frequent audits by HKND personnel would be conducted to ensure compliance.

4.2.4 Worker Camps

Assuming approximately 48,500 field-based workers, the nine proposed worker camps (see Section 3.3.6, Offices and Worker Camps) would need to accommodate about 5,400 workers each on average. Worker camps are intended for use strictly by construction workers; worker families would not be accommodated. All foreign workers would be expected to reside in the worker camps, although some management staff working from the Construction Management Office may be housed separately in Rivas and towns adjacent to the East Canal. Otherwise, only workers from nearby communities would be allowed to live outside the camps. There would be very limited number of rooms available for visitors.

The worker camps would be professionally managed by HKND or its contractors. HKND has committed that the worker camps would meet all applicable international and Nicaragua standards, such as the *Workers' Accommodation: Processes and Standards* (IFC and EBRD 2009). Rooms would be basic facilities, typically 12 meters by 3 meters portable units with five rooms per unit. Each room would be kitted with a single bed, chair, desk, and air-conditioner. Ablutions blocks would be installed for each group of accommodation units.

Each camp would be served with the following facilities:

- Power—either from the Nicaraguan electrical grid if nearby, or diesel generators.
- Water—from purpose built water treatment plant, with water supplied from a mix of rain water collection tanks and/or rivers/streams with appropriate water treatment.
- Food—central messing facilities would be constructed to provide all meals for construction workers.

- Wastewater Treatment—from package wastewater treatment plants located an appropriate distance from the camp. Treated effluent would meet international and Nicaragua standards and would be discharged in an environmentally acceptable manner.
- Waste Management—a sanitary landfill would be provided at each camp to allow for the proper disposal of all solid wastes. Any hazardous wastes would be disposed of in accordance with Nicaraguan law. Additional details will be provided in the ESIA.
- Recreation—recreation facilities would be provided for both indoor and outdoor recreational opportunities.
- Health Clinics—each camp would be served with full routine and, in some cases, emergency medical care. HKND would arrange agreements with local hospitals to provide additional trauma care for workers.
- Security—HKND would likely contract with the Government of Nicaragua (Government) or local firms to provide security for the worker camps.

HKND would require, via Government or subcontract, worker camp operators to abide by Camp Management Procedures that would prohibit informal trade, squatter camps, and prostitution within the worker camps and the temporary expropriation area. Compliance with these procedures would be audited by HKND. These procedures would also establish policies to secure any services locally wherever they could meet required standards and are competitively priced. For example, HKND is committed to securing food for the worker camps from local sources within Nicaragua.

The worker camps would be operated as “closed camps” – in that workers (other than local Nicaraguans who live nearby) would not be allowed to leave the camps unless part of an organized trip to buy personal items, entertainment or sightsee.

Construction works are currently planned to operate two 12-hour shifts per day, 7-days per week. Precise roster arrangements are yet to be determined, however, conceptual roster arrangements are as follows:

- Domestic/local workforce—2 weeks on, 1 week off; and
- Foreign/expatriate workforce—6 weeks on, 2 weeks off for management staff (to allow sufficient time for international travel home); and 22 weeks on, 4 weeks off for blue collar workers, with additional time off in camp.

Nicaraguan workers on leave would be transported on buses provided by HKND to Managua, Rivas, or Nueva Guinea; from these three locations, they would need to arrange their own transportation to their final destination. Chinese and other expatriate workers on leave would also be transported by HKND contracted buses to Managua so they could fly home.

4.3 EQUIPMENT

A summary of the main construction equipment is provided in Table 4.3-1. Most construction equipment would be diesel powered. HKND has committed to the use of low sulfur diesel for all land-based construction equipment to minimize impacts to air quality.

Table 4.3-1: Summary of Main Construction Equipment, Specification, and Quantity

Name	Specification	Quantity
Excavator	5～6 m^3	73
	14.5～16 m^3	66
	18～22 m^3	129
	28～36 m^3	6
Tub Grinder	45 t	648
	110 t	576
	180 t	1161
	240 t	54
Grader	205 kW	28
Bulldozer	235 kW	84
Sprinkler	110 m^3	28
Fuel tanker	30,000 L fuel	42
Fairway Drilling and Blasting		11
Amphibious excavator	120 t	20
Trailing suction hopper dredger	≥9000 m^3	6
Cutter suction dredger	4500 m^3/h	3
	3500 m^3/h	20
Sand barge	500 m^3	152
Self-propelled barge	2000 m^3	4
Self-propelled mud barge	2000 m^3	8
Cloth fabric machine	Maximum height of not less than 20m, horizontal transmission distance of not less than 25m, the minimum transmission capacity of not less than 120 m^3/h	30
Tower crane	Arm length is not less than 50 m, Minimum weight of not less than 10 t	58
Crawler cranes	Lifting capacity 10 t	3
Concrete pump	Productivity ≥ 60 m^3/h	21
Concrete mixer truck	Capacity ≥ 6 m^3	62
Dump truck	10 t	48
	20 t	140
Flatbed truck		21
Crane		33

kW = kilowatt; m = meter; m^3 = cubic meters; L = liter; h = hour; t = ton

4.4 MATERIALS AND SUPPLIES

Construction of the canal would require vast quantities of construction materials and supplies, which are listed in Table 4.4-1.

Table 4.4-1: Construction Materials and Supplies

Project	Unit	Ship lock	Channel	Crossing or water retaining construction	Bulwark	Diversion engineering	Summation
Earthwork	10,000 m^3	230.9	27,669.2	1,381.1		1,538.3	30,819.5
Stonework	10,000 m^3	5,553.3	270,474.7	3,300.5		1,203.7	280,532.2
Desilting	10,000 m^3		98,030.1				98,030.1
Hole digging	10,000 m^3					41.0	41.0
Filling	10,000 m^3	1,085.9	2,214.0	3,645.7	865.1	791.9	7,893.8
Concrete	10,000 m^3	1,485.1	58.9	27.4	42.5	14.3	1,595.6
Sprayed Concrete	10,000 m^3		117.4			5.9	123.3
Steel	10,000 t	44.2	3.9	0.4		1.2	49.6
Anchor Stock	10,000		740.5			46.9	787.4
Consolidation Grouting	10,000 m					5.0	5.0
Curtain Grouting	10,000 m	0.53		9.49		25.74	35.76
Concrete cut-off wall	10,000 m^2					8.3	8.3
Metal structures	t	223,048		2,268		286	225,602

m3 = cubic meters; m^2 = square meters; t = ton

For many of these materials, no Nicaraguan suppliers currently exist; therefore, most of these materials would need to be imported. There are two cement plants in the area that could supply sufficient cement to meet early stage work, after which it is likely that cement would need to be imported. Table 4.4-2 shows supply demand by construction year.

Table 4.4-2: Requisite Amount by year of Main Construction Building Materials

Time item	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year	Total
Cement (10,000 tons)	4.3	25.5	178.2	174.4	112.3	1.2	495.9
Coal ash (10,000 tons)	0.2	1.5	30.7	30.2	18.0	0.1	80.8
Explosive (10,000 tons)	4.2	25.5	35.8	36.2	34.0	2.5	138.2
Oil plants (10,000 tons)	34.9	184.3	219.0	199.4	182.8	15.0	835.2
Rebar and steel materials (10,000 tons)	10.4	6.4	22.2	27.0	27.6	1.9	95.4

4.5 INFRASTRUCTURE

4.5.1 Power

HKND estimates that construction of the canal would require an electricity peak load of approximately 190 MW. Construction power would primarily be diesel generators where main power is not available; and from the Nicaragua grid where there is sufficient power and transmission infrastructure available.

4.5.2 Fuel Storage and Machinery Refueling

Servicing of equipment (providing fuel and oil on a daily or twice daily basis) represents a major logistical challenge due to size of the equipment fleet. Sufficient onsite diesel storage (in bunded or self-bunded tanks) would be installed to provide for 3 weeks supply of diesel in case of supply interruptions due to the high rainfall in the area and possibility for access roads to be restricted for a period of time. Fuel would likely be trucked into site from Managua. The 3 week fuel storage level would include the fuel usage requirements for onsite diesel power generation.

Major storage facilities with adequate tank farm capacity would be located at the Brito and Aguila ports. There would also be temporary fuel storage along canal route, especially at locations such as the locks. The number of temporary storage facilities along the route would depend on the requirements in each area of the works and transport considerations.

In order to dispense fuel, 30,000-liter-fuel tankers equipped with hi-flow pumps would transport fuel from the central facility to the work area. These fuel tankers would park in a purpose designed area such that trucks approaching empty can drive up to tanker, allowing the tanker operator to refuel the truck. At this time, the truck operator would have a short meal break. The tanker should be designed to be able to refuel two trucks simultaneously (i.e., one truck either side). Once empty, the tanker returns to the central facility to refuel.

In addition to these tankers, purpose-built 15,000-liter service trucks (containing fuel and oil) would be employed to provide fuel and oil to less mobile tracked equipment (excavators, dozers, drills). These service trucks should be all-wheel drive vehicles where possible, as road conditions may be variable. Once empty, the service trucks return to the central facility to refuel/replenish oils. If dump trucks require oil, this would be provided by those service trucks also.

4.6 GENERAL CONSTRUCTION PRINCIPLES

Construction would need to occur simultaneously in three separate segments: West Canal, Lago de Nicaragua, and East Canal. The Camilo Lock and the East Canal earthworks are the largest challenge not just because the volume of earthwork, but because of the challenging access, logistics, and weather conditions. Early commencement of East Canal construction is a priority, and this requires early opening of access to the Camilo Lock in particular. The West Canal has significantly less earthwork as well as better access and weather conditions, but is located in a seismically active area and construction of the canal and especially the Brito Lock would require additional engineering measures to ensure safety. Similarly, the work in Lago de Nicaragua is a challenging operation because of the difficulty in getting large dredging equipment into the lake and because of environmental issues. In all likelihood, the actual critical path may run through each of three canal segments at different times, depending on specific events that affect them. These considerations demand that site infrastructure and facilities be established across the whole canal at the earliest possible time.

4.6.1 Mobilization

Mobilization would be a critical challenge for the Project. HKND would need to mobilize more than 2,000 pieces of major construction equipment, fuel, and lock materials, including more than 4 billion liters of diesel fuel for power generation and land-based construction equipment, about 1 billion liters of bunker fuel for the dredgers, 400,000 tons of explosives, and millions of tons of cement and steel.

Nearly all of these materials would have to be imported into Nicaragua as there are not sufficient local supplies to meet Project requirements. The local road system may be able to cope with road transport of smaller items, but cannot accommodate the larger trucks needed to transport large equipment and materials. Therefore, establishment of the temporary ports as part of the Early Works Phase (see Section 4.7.2) is critical for construction success. Construction of these temporary construction ports is required to start at the earliest possible time.

All major imported equipment and supplies will be delivered, at least initially, via the existing commercial ports of Corinto and El Bluff, where these equipment and supplies would be offloaded onto shallow draft landing barges or heavy lift ships for transport to the temporary ports and taken ashore to laydown areas for assembly. HKND would establish a logistics center at the main Project office in Rivas to manage the overall mobilization process.

HKND would source other materials locally within Nicaragua to the extent possible, including food, worker camp supplies, aggregate, and other materials needed for the construction of buildings and structures.

4.6.2 Earthworks

The Project would need to excavate nearly 5,000 Mm^3 of earthwork, much of which would be in an area that receives a large annual rainfall. Wet weather is one of the main earthworks challenges and would have a major impact on general excavation efficiencies. Scheduling around rainfall events and managing the sequence of excavation such that watercourse flows do not impact the work unnecessarily is absolutely critical. For the East Canal Segment, as much of the watercourse flows as possible need to be diverted westward over completed sections of the canal rather than be allowed to flow eastward over uncompleted works.

Dry excavation as possible be undertaken with a range of off-road mining equipment ranging from small all-terrain vehicles (40 to 60 tons) for "pioneering" to small (100 tons) and large (230 tons) off-highway vehicles serviced by 600-ton diggers for bulk excavations. Standard "strip-mining" techniques utilizing an "advancing face" would be appropriate for much of the work.

After vegetation clearing is generally completed as described in the Early Works Phase (see Section 4.7.2), dry excavation would be undertaken in the sequence as follows:

- Strip Topsoil;
- Free Dig;
- Drill and Blast;
- Load and Haul;
- Dump Placement; and
- Rehabilitation/ Landform Management.

Each of these sequential steps is discussed below.

4.6.2.1 Strip Topsoil

Topsoil would be stripped according to depth using 100-ton excavators and 40-ton, all-wheel drive trucks. This material would either be stockpiled separately for future rehabilitation activities or (preferably) direct-placed onto completed landforms. In all cases, care would be taken to minimize erosion of these stockpiles with preference given to topsoil stripping during the dry season (see Figure 4.6-1).

Source: MEC Mining 2014

Figure 4.6-1: Topsoil Stripping Example

4.6.2.2 Free Dig

"Free dig" is used to describe excavation activities that take place without first requiring drill and blast. Following topsoil removal, soft weathered material would be excavated down to approximately 20 meters below the original horizon. As this material is expected to provide difficult road conditions (soft, wet, boggy), it is proposed to utilize the small all-terrain vehicles (40-tons, all-wheel drive trucks) and 100-tons excavators on this material (see Figure 4.6-2).

Source: MEC Mining 2014

Figure 4.6-2: Free Dig Example

4.6.2.3 Drill and Blast

Standard drill and blast techniques would be employed where the material is no longer amenable to excavation without blasting. These techniques use a variety of hammer and rotary drilling methods, dependent on rock and ground type, to prepare blast holes ready for charging. Bulk explosives offer one of the cheapest blasting solutions. Due to the wet conditions expected, it is anticipated that 100 percent of the material blasted would require a wet blasting product such as an emulsion. Traditional Nonel (Non-Electric) detonators would be used for the majority of blasting scenarios (see Figure 4.6-3).

Source: MEC Mining 2014

Figure 4.6-3: Drill and Blast Examples

These explosives would be stored in secure storage magazines designed to meet Australian Standard 2187-1998 (Explosives Storage); additional details will be provided in the ESIA. These magazines would be located at least 4 kilometers away from residential communities, construction camps, and diesel storage facilities in an appropriately secured location (e.g., bounded, fenced, protected from lightning). The West and East canals would require two and six explosives storage magazines, respectively. Bulk explosives would be delivered to site in shipping containers via road, either from Managua or from a purpose-built port facility. Facilities for mixing bulk explosives would be constructed away from the main office site and maintenance workshops, such that it would only be mixed immediately prior to use in blast holes.

Drill and blast is a critical enabler to bulk excavation operations. Drill and blast design parameters for the material (top to canal base) at the West Canal and East Canal segments are illustrated in Table 4.6-1.

Table 4.6-1: Drill and Blast Design Parameters

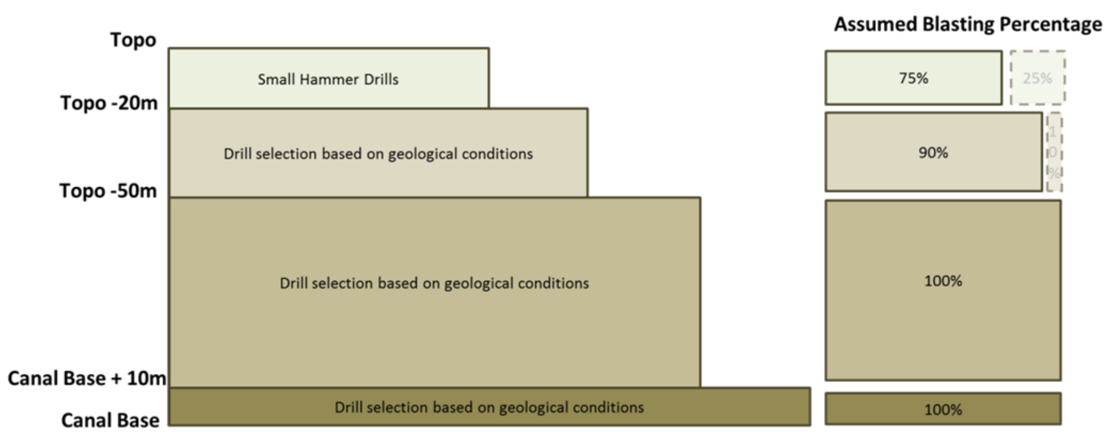
Canal Region	Pattern Size	Material – Top to Canal Base	Burden (m)	Spacing (m)	Bench Height (m)	Hole Diameter (mm)	Explosive Density (g/cc)	Powder Factor, PF (kg/m^3)
West	Sedimentary	Wet	6.3-9.8	7.3-11.3	10-15	152-254	1.2	0.39-0.41
East	Tertiary Volcanic	Wet	4.5-7.0	5.2-7.4	10-15	152-254	1.2	0.79-0.81

Source: MEC Mining 2014

m = meter; mm = millimeter; g/cc = grams per centimeter cubed; kg/m^3 = kilogram per cubic meters

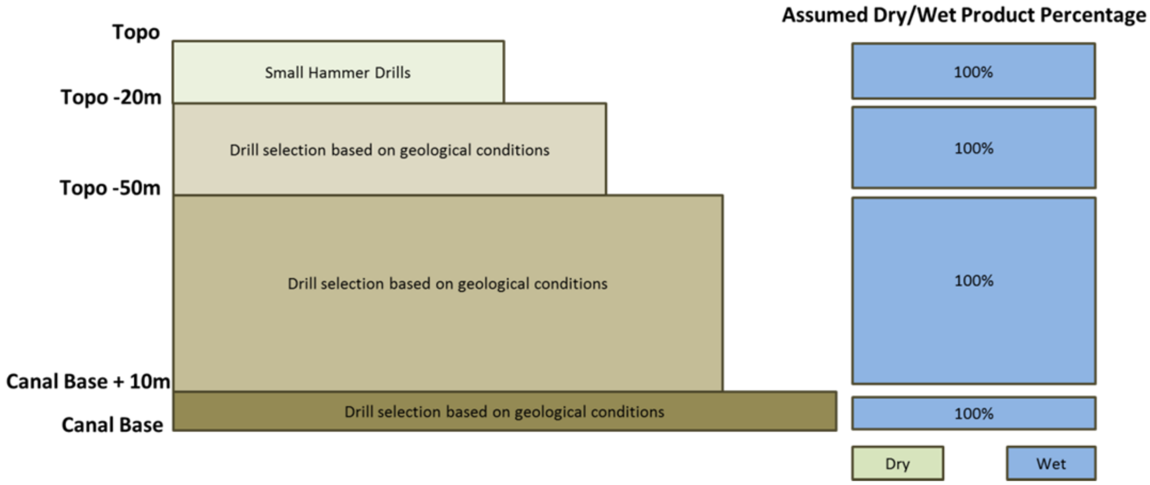
The application of each blasting pattern and subsequent explosive use is based on further assumptions on the requirements for blasting, broken down by horizon and associated pre-split requirements for final batters (i.e., for additional batter protection) (see Figures 4.6-4 and 4.6-5).

Presplitting is a technique used to create smooth and stable walls. Presplitting reduces the back break caused by production blasting (and the associated risk of rock falls), and increases productivity with reduced wall clean-up. Presplitting requires a row of closely-spaced blast holes drilled along the design excavation, which limits charged very lightly, and detonated simultaneously.



Source: MEC Mining 2014

Figure 4.6-4: Assumed Blasting Percentage by Horizon



Source: MEC Mining 2014

Figure 4.6-5: Wet and Dry Blasting Percentage by Horizon

4.6.2.4 Load and Haul

The 5-year excavation timeframe is suited to traditional load and haul practices commonly seen in large civil and mining excavations. Excavation would generally occur in benches of 10 meters high by 200 meters wide (see Figure 4.6-6).

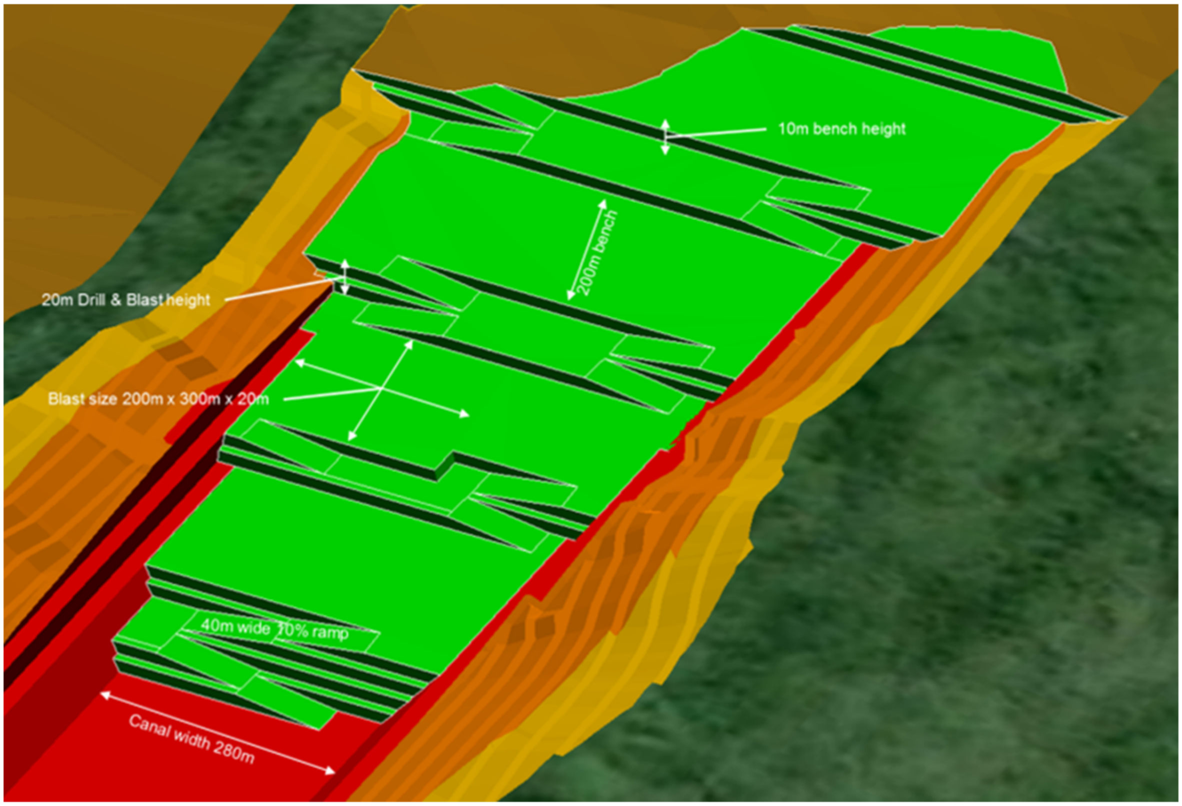
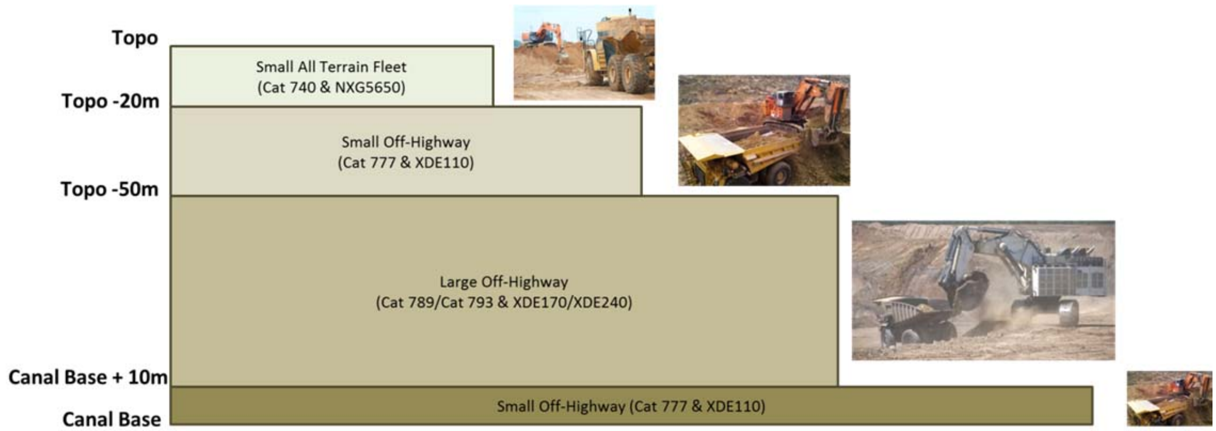


Figure 4.6-6: Graphic of Benched Excavation within Canal Footprint

Application of different operating fleets to the excavation horizons is important to ensure optimal productivity of equipment by matching equipment to material types, operating environments, working bench size, and haulage distance. Figure 4.6-7 shows the proposed equipment for each of four conceptual topographic horizons.



Source: MEC Mining 2014

Figure 4.6-7: Truck and Excavator Conceptual Configuration

A critical factor in any load and haul project is haulage distance, the effect on equipment numbers, and supporting personnel and equipment. Ultimately, cost can also be a significant factor. Optimization and limiting haul distance has been modelled using available simulation and optimization tools to reduce where possible the effective haulage distance. Haulage over large horizontal distances can create issues with overheating and destruction of tires. To compensate for this, trucks must either reduce speed or limit payload capacity both ultimately affecting the unit cost of material haulage. Effective placement of EMPAs is critical to managing this significant Project cost.

4.6.2.5 Excavated Material Placement

Excavated material would be segregated and placed in EMPAs and topsoil stockpiles (see Figure 4.6-8). EMPAs would generally be constructed within a maximum of about 3 kilometers haul distance from the canal and graded to be gently sloping so as not to pool water. The EMPAs would be constructed in lifts of no more than about 10 meters in height.

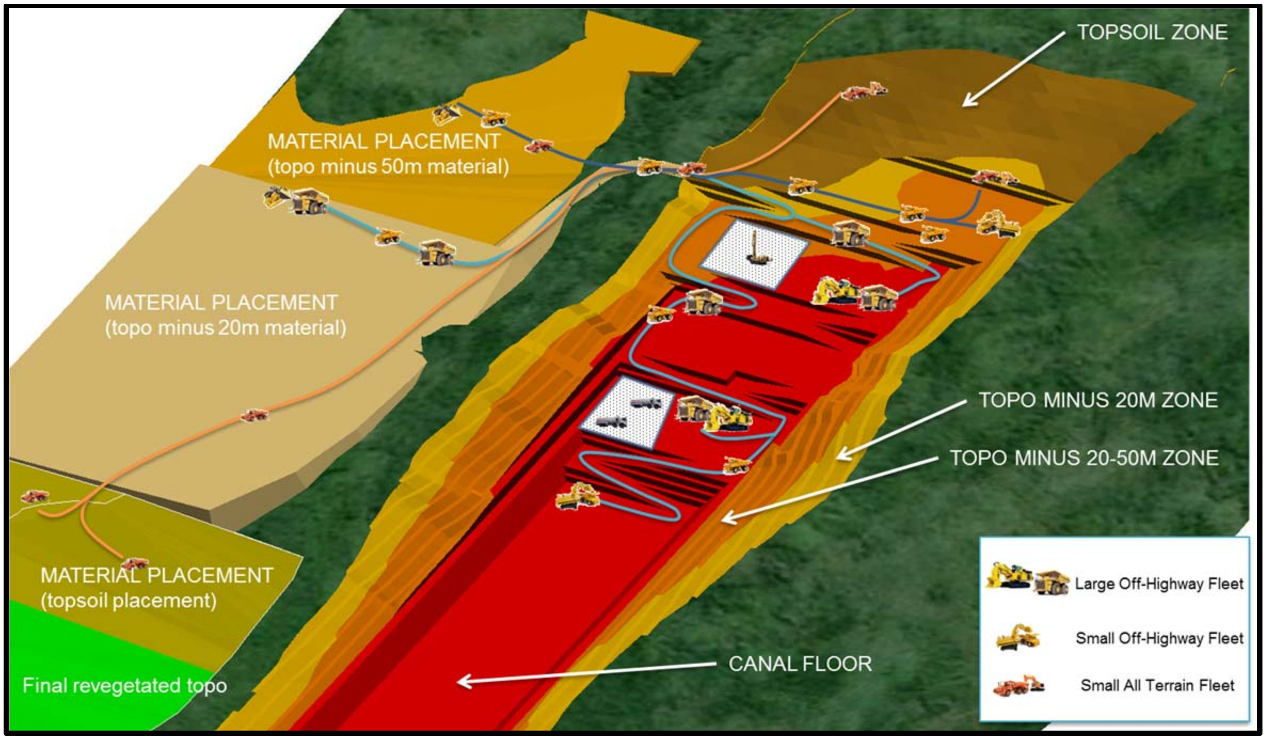


Figure 4.6-8: Excavated Material Placement

4.6.2.6 Rehabilitation/ Landform Management

The guiding principles for the management of excavated materials from the canal go far beyond the simple long-term storage of these materials. HKND's intent is for beneficial reuse of these EMPAs using landform management concepts to:

- Create usable agricultural and pasture land after restoration;
- Ensure long-term stability of the constructed surfaces;
- Minimize direct and indirect impact to environmentally sensitive areas and communities;
- Effectively manage rainfall, catchment, and overland water flows;
- Provide opportunities to re-form and restore areas affected by deforestation and other degradation; and
- Create long-term infrastructure usable by the local people post excavation.

As Figure 4.6-9 shows, HKND would strip topsoil, grade the EMPAs for slopes suitable for agricultural use, and then replace the topsoil with sufficient depth as is necessary to create productive farmland. HKND plans to coordinate closely with several universities (e.g., Universidad Nacional Agraria, Bluefields Indian and Caribbean University, and Universidad de las Regiones de las Costa Caribe de Nicaragua), as well as with the Unión Nacional de Agricultores y Ganaderos in developing protocols and procedures for rehabilitating the EMPAs for agricultural reuse.

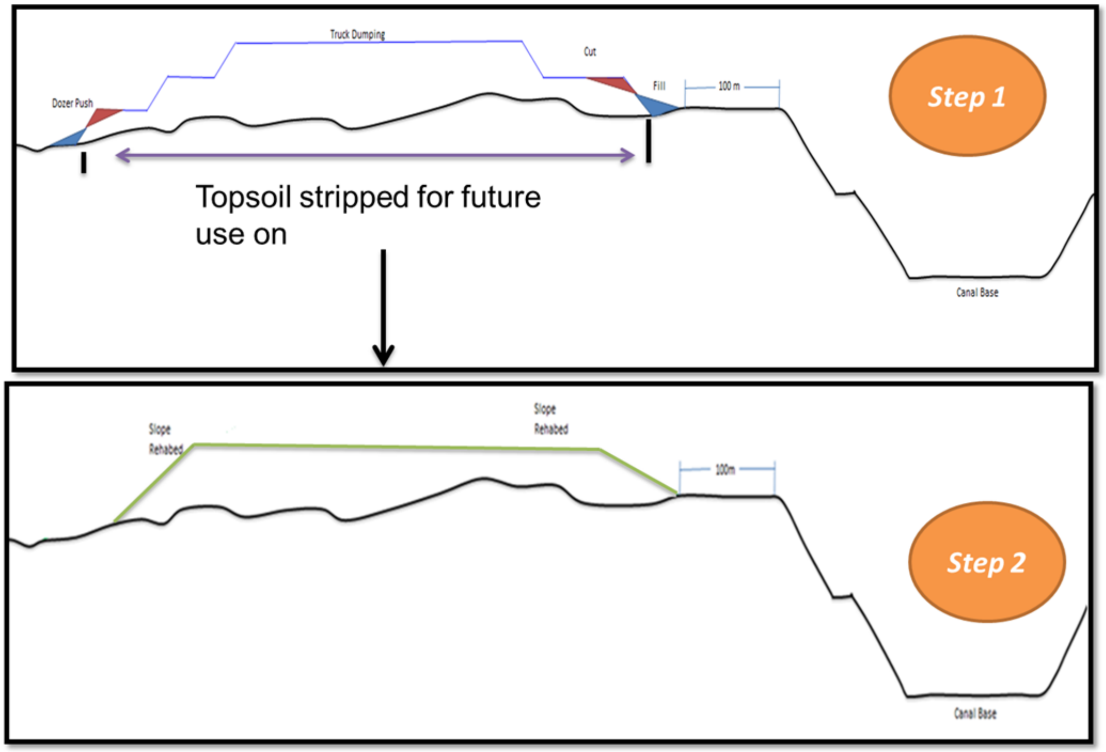


Figure 4.6-9: EMPA Reclamation Concept

4.6.3 Batters and Slope Protection

HKND would use a variety of different methods to protect the batters after excavation that are exposed to the elements after excavation. Batter protection has two primary purposes:

- Reduce erosion and sediment in runoff from reaching streams; and
- Prevent local structural failure where faulting or localized weakness occur.

The variability of the canal geology and terrain would ensure that a combination of methods would be used across the length of the canal. The protection applied to each location would be fit for purpose on a case-by-case basis. The suitability of each method is dependent on factors including rock strength, batter slope, height of batter, rock fracturing and fragmentation, and access to batter after excavation is completed.

Protection methods available include:

- Planting suitable vegetation;
- Shotcrete;
- Soil nails;
- Rock boltsmeshing;
- Rock sheeting;
- Latex membranes; and
- Grouting.

4.6.4 Water Management

The water management concept strategy is based around two key principals:

- Minimizing the impact of the existing watersheds during canal construction; and
- Providing long-term water management and storage during the operation of the canal for both use in the canal and by the proposed agricultural land created adjacent to the canal.

River and other watercourse diversions are a major part of the canal excavation operations because they effectively constitute a project on their own. The canal would intersect many watercourses over its length and would follow the valley of the Rio Punta Gorda for some 70 kilometers; therefore, management of the water flows is the most critical element of the earthmoving operation, particularly for East Canal. These works would be designed in detail in advance of the operations and constructed progressively ahead of or in conjunction with the works.

Water management associated with surface and sub-surface water requires careful integration into the canal design. A conceptual management approach has been developed based on the known watercourses, which intersect the Project. Water management facilities are proposed for known water bodies that intersect the excavation. The proposed water management facilities would provide water storage behind the material placement facilities and would be used to divert water around the excavation via a series of drainage channels and tunnels into other catchments or back into the canal at particular locations. Agua Zarca and Chiquito watercourse systems would be the main recipients of this diverted water, ensuring the water is maintained within the canal system for operation of the locks. The dams are expected to manage approximately 346 gigalitres of water annually (excluding evaporation). These dams are not solutions to long-term water storage requirements or freshwater capacity buffering for canal operation because they do not constitute in any way additional water availability. Additional freshwater sources would potentially be required; hence the provision of a reservoir at the Rio Agua Zarca.

Where watercourses cannot be diverted, drop structures are proposed so as to prevent erosion of the watercourse and the slope batters and to safely convey the stream flow to the canal, as illustrated in Figure 4.6-10 below. The drop structures would be used to dissipate energy, reduce flow velocity, and manage the change in height before the water enters the canal. Drop structures would be designed to accommodate five times the average annual flow rate of the watercourse and to reduce the velocity of the water to 0.25 meters per second.

Source: MEC Mining 2014

Figure 4.6-10: Drop Structures

4.7 CONSTRUCTION SEQUENCE

The general construction sequence would consist of the following phases, which are summarized here and discussed in more detail in the remainder of this section.

- Pre-Construction Phase (ongoing) – which includes securing all necessary permits and approvals, finalizing the engineering design and construction drawings, land acquisition and initial resettlement, issuing tenders and selecting contractors, purchasing construction machinery and equipment, materials, and other preparatory work.
- Early Works Construction Phase (through September 2015) – which includes provision of access to the construction sites, establishment of critical infrastructure (e.g., power, worker accommodations), and mobilization of the initial workforce.
- Construction Phase (September 2015 through March 2020) – which includes excavation and lock construction, with the Brito Lock construction completed and West Canal filled with water by around January 2020, and the Camilo Lock construction completed and the East Canal filled with water by around March 2020.
- Commissioning Phase (April 2020 through June 2020) – commissioning tests would begin as soon as the East Canal and West Canal segments were filled with water, and include testing of lock operations and training of lock and tug boat operators.

Each of these construction phases is described below.

4.7.1 Pre-Construction Phase

4.7.1.1 Permits and Approvals

The Project would need several permits and approvals, including:

- Environmental Permit from the Central Government (Ministerio del Ambiente y los Recursos Naturales [MARENA]);
- Permit from the Regional Government of the Región Autónoma del Caribe Sur (RAAS);
- Municipal Permits – several municipalities along the canal route;
- Clearance from the Nicaraguan Institute for Cultural Resources; and
- Explosives Management Use approval from the Nicaraguan Police.

HKND would not initiate construction until the appropriate permits have been obtained.

4.7.1.2 Finalizing Engineering Design

Based on comments received during the ESIA review process, HKND would finalize the engineering design for the Project and prepare appropriate construction drawings.

4.7.1.3 Land Expropriation and Resettlement

HKND and the Government would establish temporary and permanent land expropriation boundaries. They would also negotiate for temporary expropriation with owners of lands expected to be needed for canal construction, which may require temporary resident relocation. HKND would return these lands to the owners after construction is complete in similar or better condition than received, or provide compensation for damages. The Government and HKND would also negotiate for permanent land expropriation with owners of lands needed for canal operations (including lands for maintenance and security).

Land and cadastral surveys have recently been completed. HKND and the Government intend to prepare a Resettlement Action Plan (RAP) with the land expropriation process beginning as soon as possible in accordance with Nicaraguan law and consistent with the RAP

4.7.1.4 Procurement

Wherever possible, local suppliers would be utilized; however, because of the scale of the Project and Nicaragua's limited industrial capacity, it is expected that this would be predominantly in the services sector. The Project would utilize a wide range of international suppliers, and the tendering process would be transparent and rigorous.

HKND would not be an owner-builder; the intention is to utilize local and international contractors. Local contractors would be actively encouraged to participate in the Project, either directly or indirectly. Nevertheless the bulk of the work would be undertaken by international contractors; they would be encouraged to employ, and train, a local workforce to the maximum extent possible.

4.7.2 Early Works Phase

The focus of the Early Works Phase would be to provide/improve access to the canal alignment, but especially the port and lock locations; to conduct initial clearing; and to establish temporary ports at Brito and Aguila. This phase would extend from groundbreaking to about September 2015. Portions of this work are included in the First Stage Start Up Works ESIA that will be submitted separately to MARENA in December 2014 for limited clearing and some temporary access roads along the proposed West Canal route (ERM 2014).

4.7.2.1 Access Roads

A critical first step in canal construction is to provide/improve vehicular access to the ports and locks. HKND would initially provide simple 7-meter-wide gravel access roads. Sections of these road segments would ultimately be converted to permanent canal maintenance or public roads. These improvements would likely represent the initial construction activities.

Vehicular access to most parts of West Canal is available immediately using the existing road network, although new connecting roads would be required to connect the local road networks to the Project access roads.

Vehicular access to the East Canal is currently only available at its western end near San Miguelito. HKND would improve the existing "track" from Nueva Guinea to Punta Aguila (approximately 103 kilometers) such that it is useable year round. HKND would also construct a new road to access the Camilo Lock area.

4.7.2.2 Clearing

Once access is secured, HKND would initially clear the canal excavation footprint from top of batter plus 20 meters horizontally to top of batter plus 20 meters horizontally so as to provide general access to the site and to facilitate works such as surveying and site investigation borehole drilling. Environmentally sensitive areas would not be cleared initially (e.g., the Brito mangroves). Approximately 20-meter-wide buffers would be left along perennial streams and rivers for erosion and sediment control purposes.

HKND would log commercially-valuable timber, and then allow the public to remove any of the remaining timber for firewood.

4.7.3 Construction Phase

Construction of the major Project elements is expected to commence after September 2015 and continue through 2020, when the canal is completed. Following completion of the Early Works Phase, HKND would initiate excavation activities simultaneously at the Pacific, Caribbean, and Lago de Nicaragua work areas as well as initiating construction of both the Brito and Camilo locks.

4.7.3.1 Temporary Construction Ports

The Project would have a massive demand for power, fuel, explosives, cement, steel, and the numerous other materials and consumables. The only existing ports that can service the Project are at Corinto on the Pacific and Bluefields on the Caribbean. Initially these ports would be used, but their long-term use would not be effective because access between them and the Project by road is extremely limited and because neither of these ports has the capacity to handle the logistics needs of the Project.

Temporary Pacific Port

With the Inland Port protected location, a temporary landing barge port would initially be constructed 500 meters inland within the canal footprint. A combination of small earthmoving equipment (locally hired) and small marine cutterhead hydraulic dredges would be used to excavate an approximately 80-meter-wide by 5-meter-deep by 2-kilometer-long channel from the Pacific coastline to the inland port location, which would follow the alignment of the permanent canal. Most of the excavated material would be placed in EMPA W-01, although a small volume of the initial marine dredging would be placed in the marine disposal site P-1.

Once the temporary port site is accessed, HKND would construct an approximately 200 meter-long small vessel wharf, landing barge ramp, and temporary dock facilities comprising either flat-top barges, equipped with cranes for unloading of supplies, anchored against the wharf or a jack-up dock. HKND would also build a fuel wharf and tank farm to allow fueling of construction vessels.

This temporary construction port would service barges ferrying construction equipment and materials from Corinto, where they were offloaded from larger marine vessels.

As early as possible, construction would commence on the West Wharf of the permanent port, which would comprise the fuel jetty and berthing for shall ships and workboats. The West Port construction would be carried out “in the dry” and then subsequent excavation to finished port seabed level. Construction of the West Wharf and completion of sufficient dredging into the port would enable fuel, materials, and equipment to be delivered directly into the Project area.

Temporary Caribbean Port

Construction of the permanent port at the Caribbean end of the Project would take several years; therefore, a temporary landing barge port would be provided at Point Aguila, the proposed site of the permanent Caribbean port. Earth and rock from Punta Aguila would be pushed out to form a temporary breakwater. Initial small grab dredges and then trailer hopper suction dredges would establish a channel and docking facilities similar to those at the temporary Pacific port and would remove unstable silts from the Aguila Port reclamation area so that it would be prepared to accept sand and other coarse dredge material. This silty dredged spoil material would be hauled to the Caribbean placement site C-1 for disposal.

HKND would then construct a permanent fuel tank farm onshore near Punta Aguila, which would initially support refueling of primarily dredgers, and ultimately the fleet of construction equipment needed to excavate the East Canal.

Similar to the temporary Pacific port, construction equipment and supplies would be initially shipped to Bluefields Port, where it would be offloaded onto shallow draft service barges, lighters, and landing barges, which would ferry these supplies to Aguila Port.

As soon as possible at a point in the canal footprint about 9 kilometers inland at the end of a dredged channel, a temporary construction port would be developed to service the Camilo Lock construction works. This port would also service other construction works at the eastern end of the Project, although the temporary landing barge port at Aguila Port would also support construction once road access is available.

4.7.3.2 West Canal Construction

For the West Canal Segment, HKND would continue dredging inland from the Brito Port as far as possible (i.e., until hard rock is encountered, which is expected to be about 3 to 4 kilometers). From this point, upland excavation methods would be used to reach the Brito Lock location. Dredging would also be used for the West Canal coming from Lago de Nicaragua, but is expected to be limited because of shallow depth to rock in this area, and then upland excavation techniques would be used to reach the Brito Lock from the east. Construction of the West Canal would occur over a 5-year period, with the construction activities associated with each year described below. Figure 4.7-1 depicts the West Canal excavation strategy.

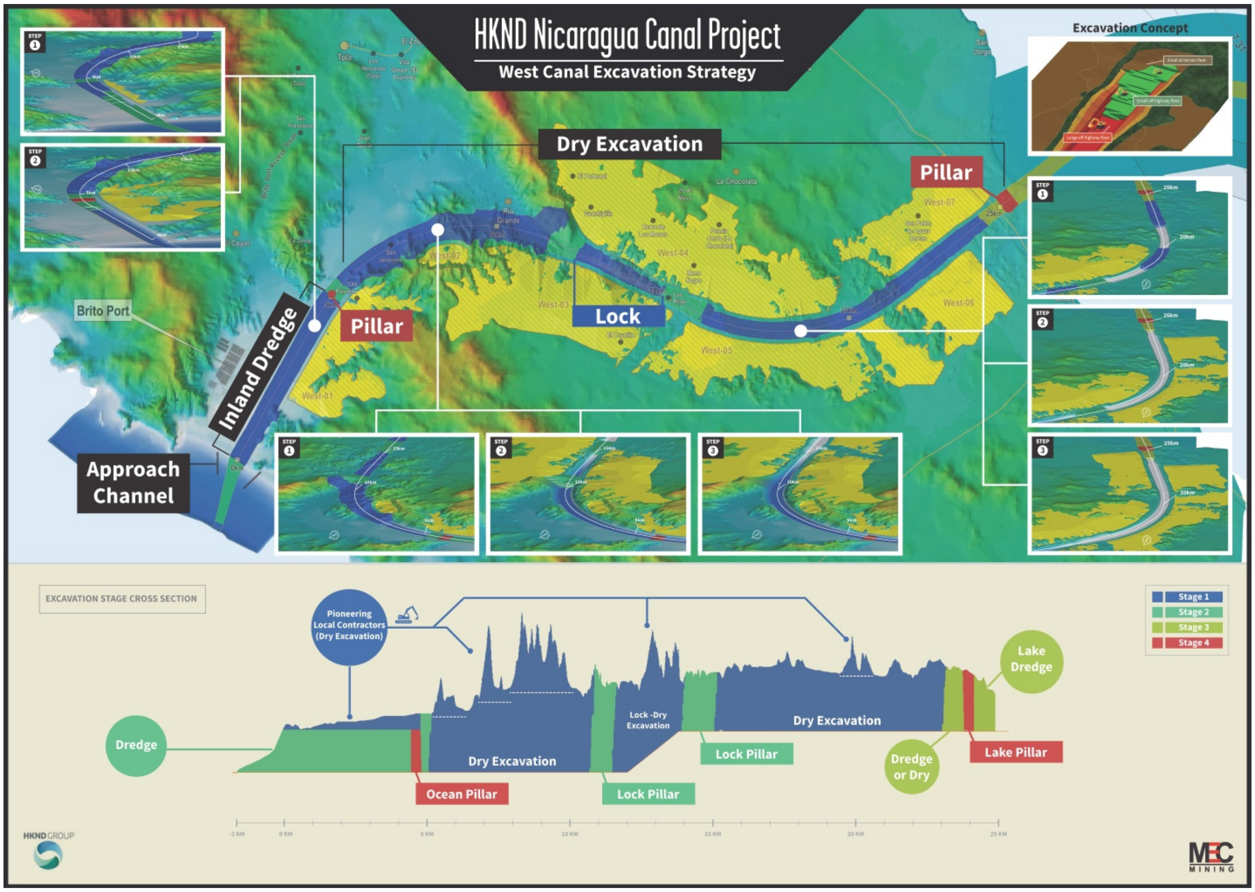


Figure 4.7-1: West Canal Excavation Strategy

Year 1

Year 1 construction includes both dredge and dry excavation. There are 12 activities in total: 6 for the dredge and 6 for the dry excavation. The inland dredge activities are described below and illustrated in Figure 4.7-2.

1. Establish the Brito connection road.
2. Establish the lock connection road on the northern side of the canal and a road over the ocean pillar to access the local contractor areas south of the Rio Grande.
3. Commence excavating dry material in the dredge section to RL-3 and place it on the southern side of the canal to form retention dams for dredge spoil.
4. The dredge commences by cutting an approach channel, then dredging a slot into the inland dredge section to a depth of 5 meters to establish a barge landing area.
5. Temporary fuel and freight unloading facilities are established inside the canal footprint in the initial dredge cut.
6. Subsequent dredge cuts increase the total canal width to full design and depth to 18 meters below sea level.

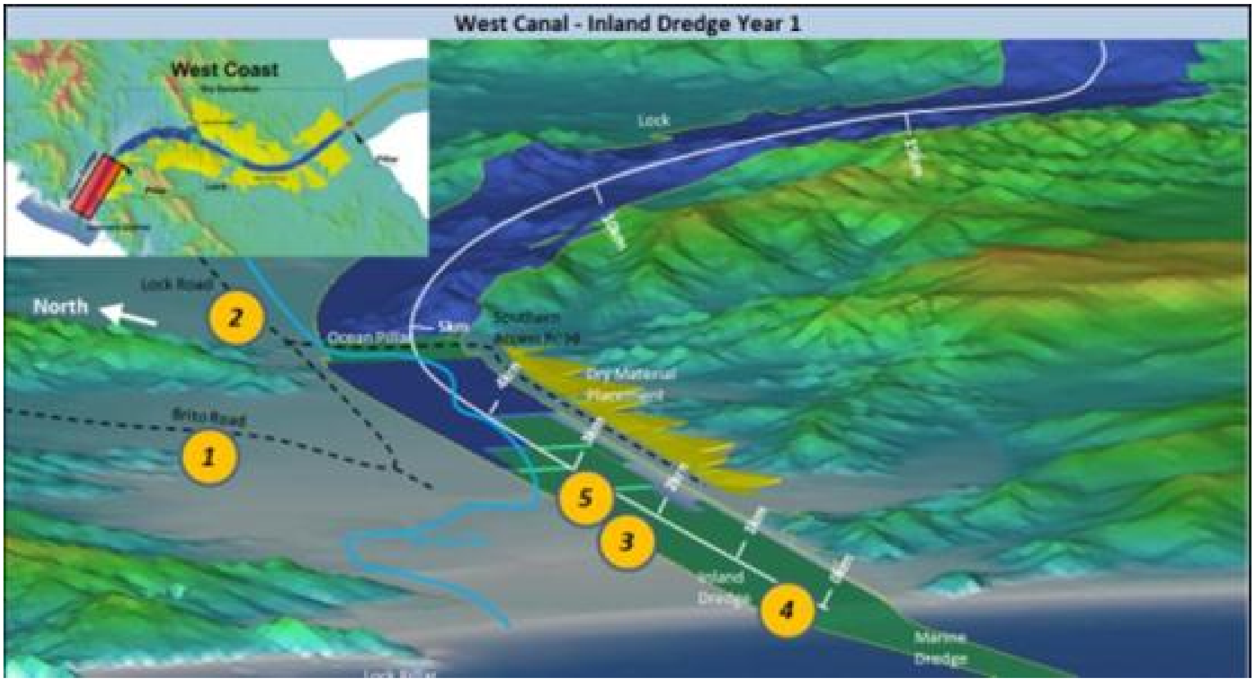


Figure 4.7-2: Year 1 West Canal Dredge Excavation

The dry excavation activities are described below and illustrated in Figure 4.7-3.

1. Establish the Brito Port connection road.
2. Establish bridges and access roads to the south of the canal over the ocean pillar including bridge, and a road to the lock along the north side of the canal.
3. Diversions for watercourses to allow access to excavation areas at 7 kilometers to open up the dry excavation area and a diversion at 11 kilometers to remove flows from the lock area.
4. Pioneering works to remove trees, topsoil, and material down to RL-3 in the western dredge section. Material placement would occur south of canal.
5. Small equipment would be used to level the topography within the canal in dry excavation areas to open up level work areas for the larger equipment.
6. Bulk dry Excavation commences using a terrace face. Material placement occurs to the south of the canal. The existing watercourses would continue to flow across the canal route in "pillar" locations, which would be excavated near the end of construction. Two bridges would need to be constructed along the new road.

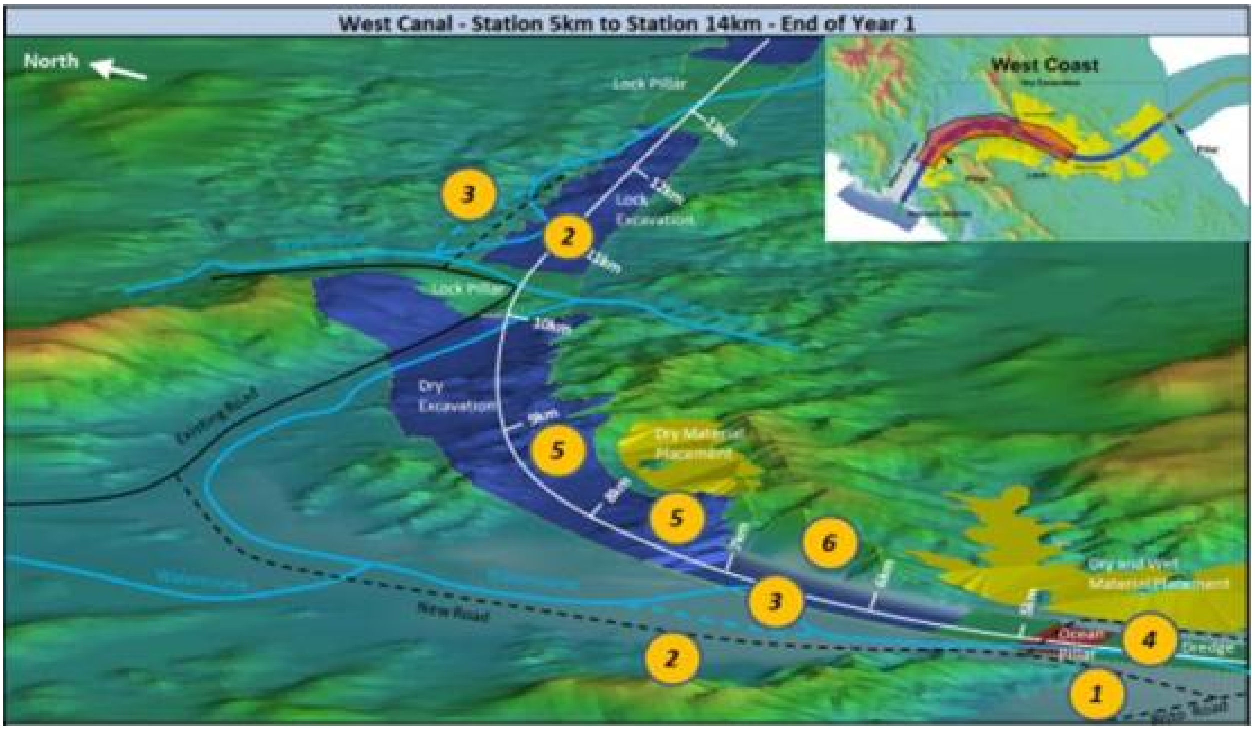


Figure 4.7-3: Year 1 West Canal Dry (Skim) Excavation

Year 2

Year 2 construction includes nine activities. There are five activities between Stations 5 to 14 kilometers and four activities between Stations 14 to 25 kilometers.

The activities in Stations 5 to 14 include the following and are illustrated in Figure 4.7-4:

1. Lock bulk excavation commences.
2. Dry excavation progresses to the east using a single terrace face to minimize haul lengths.
3. Dry excavated material from both the lock and adjacent areas would be placed on the southern side of the canal, reserving the northern side for material from the pillars.
4. Dredging continues in the inland dredge section.
5. Material from pioneering areas would be used to cap the material placement facility with a layer of weathered material placed on top of fresh rock, then covered with topsoil. The existing watercourses continue to flow across the canal route in "pillar" locations, which would be excavated near the end of construction. No water would be allowed to enter the canal

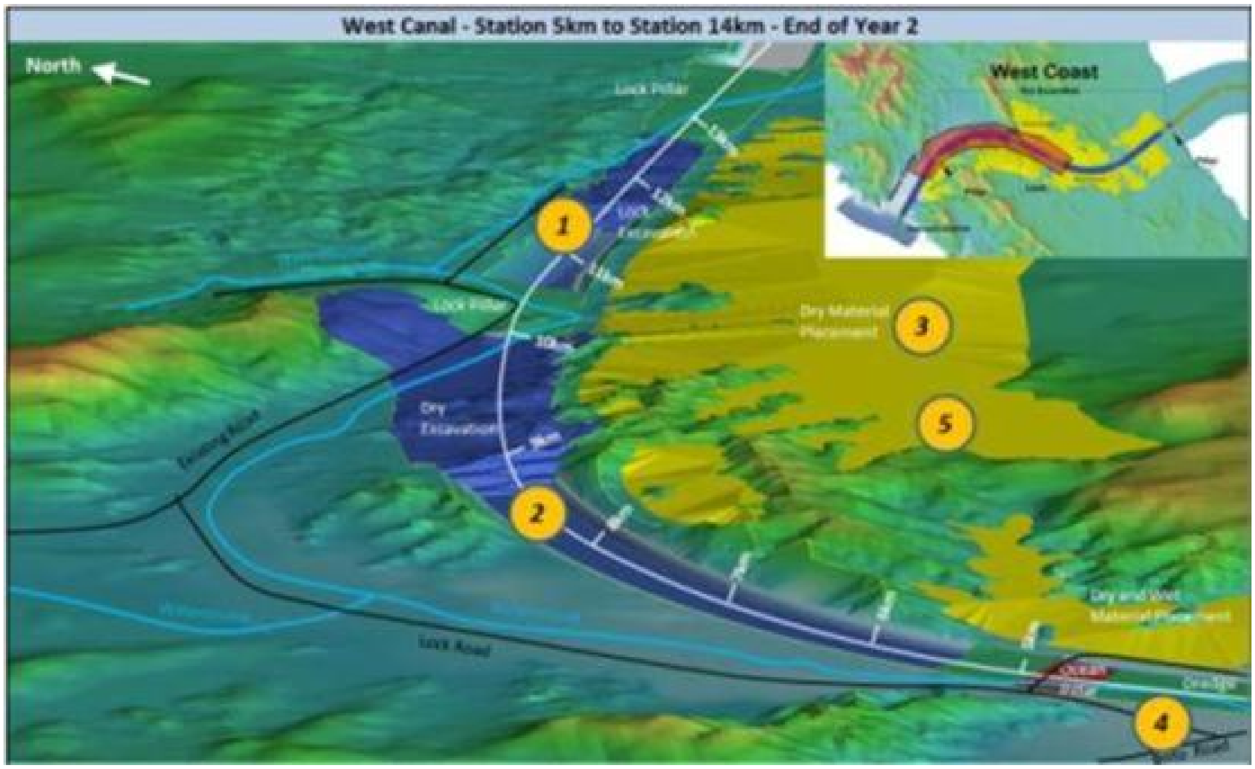


Figure 4.7-4: Year 2 West Canal Activities between Stations 5 and 14 Kilometers

The activities in Stations 14 to 25 include the following and are illustrated in Figure 4.7-5:

1. Create a road from the Pan-American Highway, along the northern side of the canal to the lock site.
2. Pioneer the excavation area including topsoil stripping and excavation down to a level surface to create work areas for the larger equipment.
3. Install dams on either side of the canal above the watershed at Station 19 to 20 kilometers using canal excavation material to prevent flows into canal.
4. Dry excavation commences at two face locations, using a terrace face to minimize haul lengths.

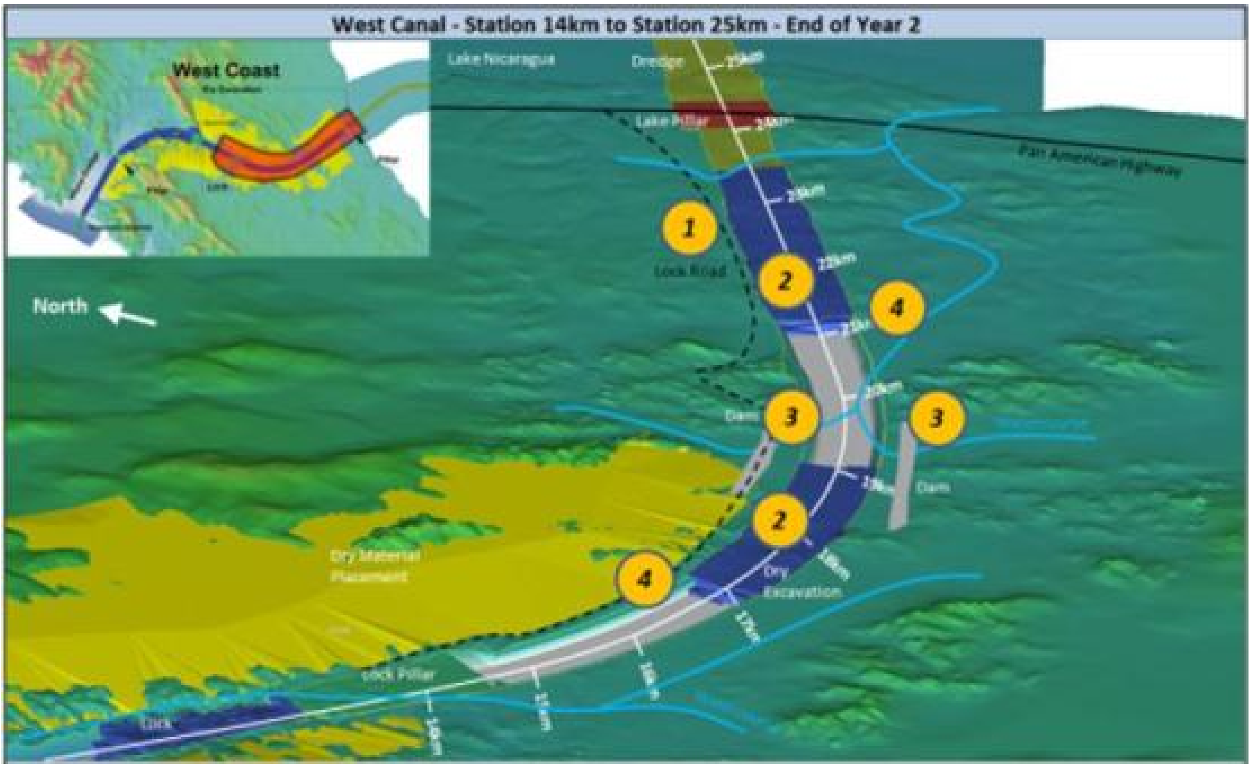


Figure 4.7-5: Year 2 West Canal Activities between Stations 14 and 25 Kilometers

Year 3

Year 3 construction includes six activities. There are four activities between Stations 5 to 14 kilometers and two activities between Stations 14 to 25 kilometers.

The activities in Stations 5 to 14 include the following and are illustrated in Figure 4.7-6:

1. Water flows from the canal and material placement catchment at 10km are diverted into the canal to allow the remaining dry excavation to take place.
2. Pumps are installed to move water over the ocean pillar to allow the lock pillars to be removed by dry excavation at a later date.
3. Dredging continues in the inland dredge section, leaving the ocean pillar in place.
4. The lock access road is diverted along the northern crest of the canal. The existing watercourses continue to flow across the canal route in "pillar" locations, which would be excavated near the end of construction. No water is allowed to enter the canal.

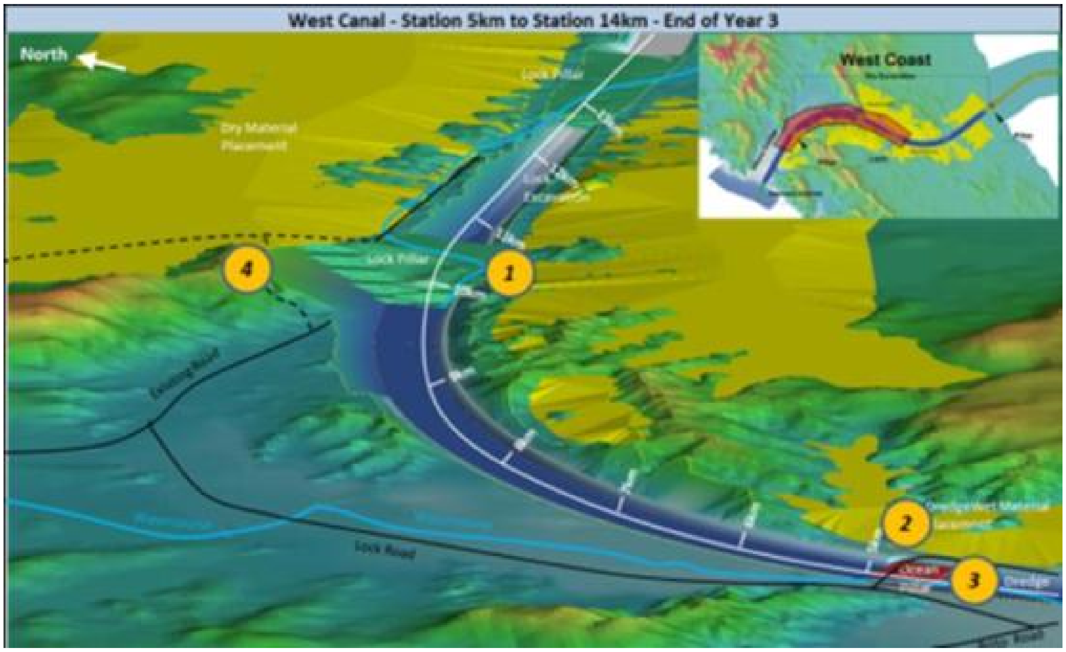


Figure 4.7-6: Year 3 West Canal Activities between Stations 5 and 14 Kilometers

The activities in Stations 5 to 14 include the following and are illustrated in Figure 4.7-7:

1. Complete the dry excavation areas leaving a lake pillar in place while a permanent bridge is built for the Pan-American Highway.
2. Install pumps to dewater the canal into the existing river at Station 23 kilometers.

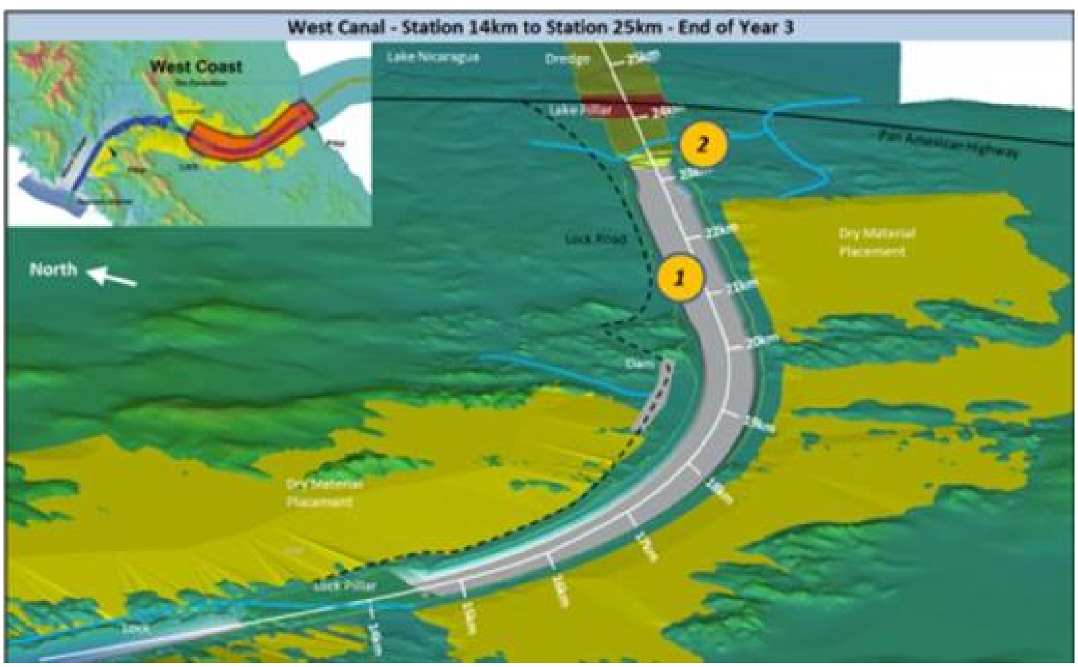


Figure 4.7-7: Year 3 West Canal Activities between Stations 14 and 25 Kilometers

Year 4

Year 4 construction includes four activities associated with dry excavation and three activities associated the inland dredge. These are described below and illustrated in Figures 4.7-8 and 4.7-9.

The activities in Stations 5 to 14 include the following and are illustrated in Figure 4.7-8:

1. Dry excavation commences on the lock pillars.
2. Pumps continue to move water over the ocean pillar to allow the lock pillars to be removed by dry excavation.
3. Dredging continues in the inland dredge section, leaving the ocean pillar in place.
4. A drain is installed along the length of the lock to take water flows past the lock pillar and into the completed canal to be pumped to the ocean.

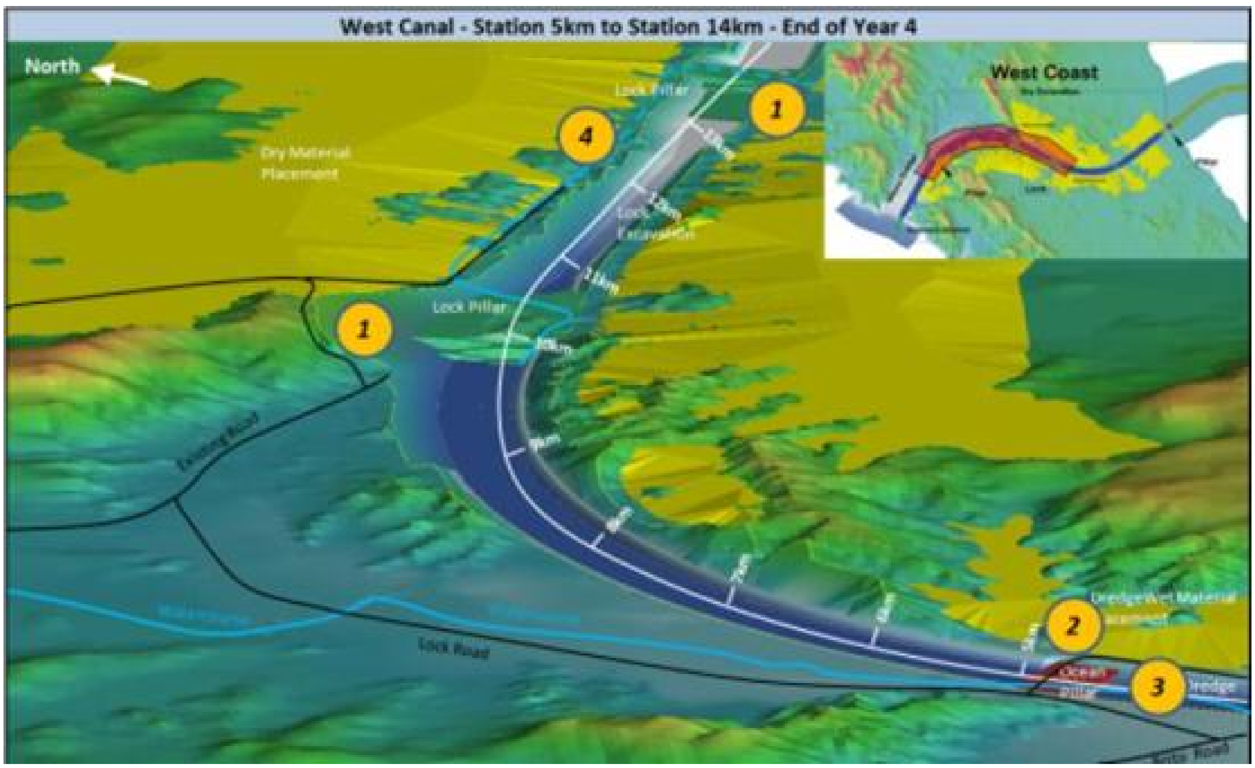


Figure 4.7-8: Year 4 West Canal Activities between Stations 5 and 14 Kilometers

The activities in Stations 14 to 25 include the following and are illustrated in Figure 4.7-9:

1. The dredge completes the channel and inland port to a depth of 18 meters below sea level. Dredge material would be deposited on land on the southern side of the canal.
2. Exposed excavation batter in the port and canal would be prone to liquefaction in the sand layers to an average depth of 8 meters. These would be lined with barrier rock for containment.
3. The remaining flows from the Rio Grande would be directed over the ocean pillar into the canal.

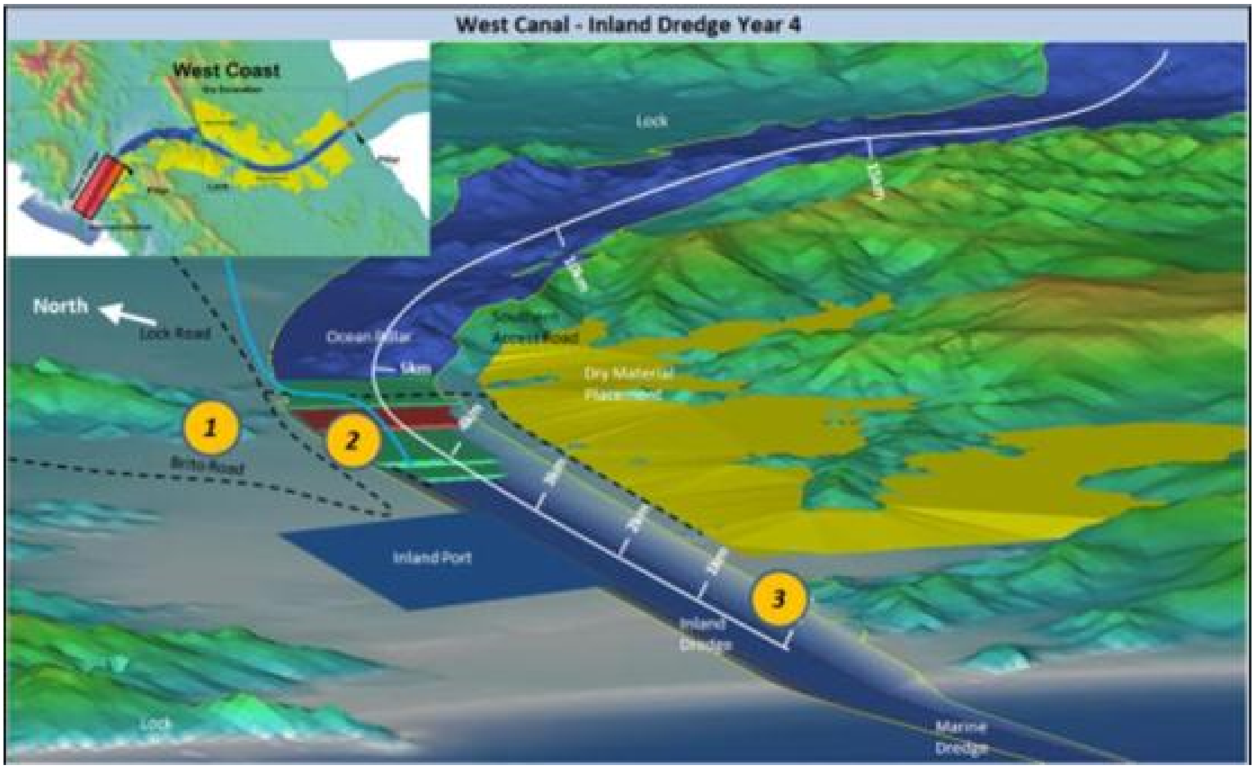


Figure 4.7-9: Year 4 Inland Dredging

Year 5

Year 5 construction includes three activities, which are described below and illustrated in Figure 4.7-10:

1. When the lock is complete and lock pillars are removed with dry excavation, then the remaining ocean pillar would be dredged to bring sea water into the canal.
2. A drop structure would be installed to allow remaining river flows from the Rio Grande to enter the canal.
3. Dredge the lake pillar to bring fresh water into the canal.

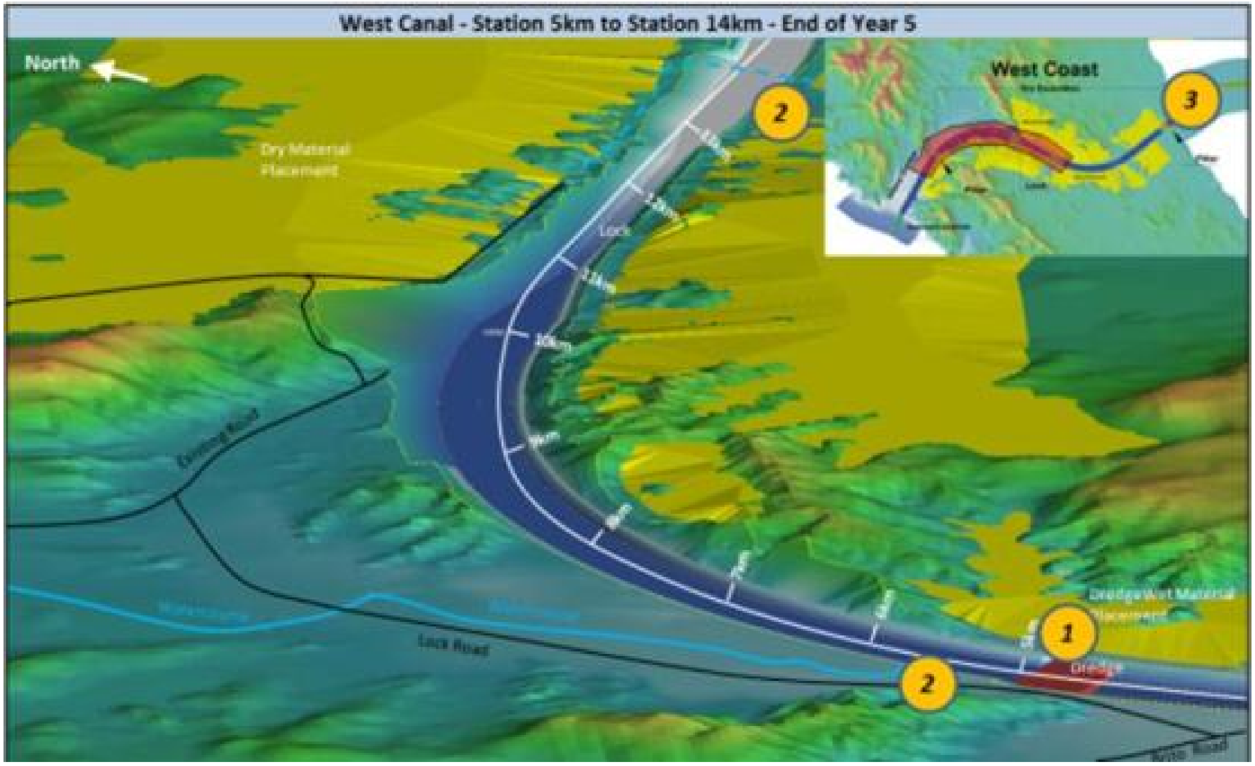


Figure 4.7-10: Year 5 West Canal Activities

4.7.3.3 Lago de Nicaragua Construction

The canal would require about 715 Mm^3 of dredging in Lago de Nicaragua. Borelog data indicates that the lake bottom is underlain by an average of about 4 meters of fine material (e.g., silts and clays), below which is a deep layer (greater than 20 meters) of coarse sands, with some rock found at about 26 to 30 meters below the lake bottom. These data suggest that all excavation across the lake could be accomplished with hydraulic marine dredges.

HKND would need to initially import and assemble small dredges near the shoreline of Lago de Nicaragua as there is no other way for large dredges to access the lake until the locks are operational. HKND would use hydraulic trailer dredges to remove the upper layer of fine silts in limited portions of the canal route through Lago de Nicaragua, with disposal in upland EMPAs adjacent to the lake. Once sand is reached (typically within about 4 meters based on lake boring data), cutter suction dredges would be used to excavate coarse sand material for transport to the CDFs, where it would be used for dike construction. Stone and armor rock needed for the exposed faces of the CDFs would be obtained from upland excavation from the West and East canals.

Once construction of the CDFs is completed, the hydraulic trailer dredges would continue dredging the channel removing the surficial fine sediments for disposal in the CDFs (estimated at approximately 150 Mm^3 of dredged material). The hydraulic cutterhead dredges would follow removing the underlying sand and placing it along (i.e., within about 1 kilometer) the south side of the dredged channel (i.e., LN-OW1). These smaller dredges would only excavate the channel to approximately 18 meters deep and about 150 to 200 meters wide at the base to allow for limited initial navigation. Once the locks are operational, larger cutterhead dredges would be floated to the lake and complete dredging of the channel to its design depth and width (i.e., 30 meters and 280 meters).

For cost planning purposes, a provision was made to excavate approximately 7 Mm^3 of what is characterized as weak weathered rock (approximately 1 percent of the total dredge volume for the lake). At this time, HKND does not believe use of explosives would be required as the cutterhead dredges can dredge soft rock, but additional geotechnical studies are needed to determine this conclusively.

4.7.3.4 East Canal Construction

At the Caribbean work area, HKND work from the Caribbean west to the Camilo Lock and from Lago de Nicaragua east to the Camilo Lock. Each of these construction fronts is described below. Figure 4.7-11 below, depicts the East Canal excavation strategy.

The segment from the Caribbean Sea to the Camilo Lock is only about 14 kilometers long, but represents the most biodiversity sensitive segment of the entire canal because of its proximity to the relatively pristine Indio Maiz Biological Reserve, the Palm Forest Biologically Important Area, and the Cerro Silva Nature Reserve, which collectively represent much of the remainder of the intact Meso-American Biological Corridor.

The environmental concerns together with the topography and climatic conditions constitute some serious engineering difficulties and dictate some significant operational restrictions, including how to minimize the construction footprint, where to dispose spoil material, and how to obtain and maintain access to the work site – all this in an area that receives over 3 meters of rainfall per year.

HKND proposes to use trailer hopper or cutterhead suction hydraulic dredges to excavate the canal through most of this segment, with excavated material transported by barge back to the Aguila Port reclamation area. Once the reclamation site is prepared, sand would be transported from the Caribbean Approach Channel excavation by large trailer suction dredges and hauled to the Aguila Port reclamation for placement as a "blanket" over the site to assist dewatering and compaction of material placed subsequently in the reclamation.

Land excavation work would progress from east to west using trailer suction dredges, commencing through the "Coastal Palm Section." It is expected that blasting of the central area of this section would be accomplished without difficulty, but the material on the inside and outside would be more problematic. Excavated material would be hauled by barge to the Aguila reclamation site. There would be no excavated material placement between the Caribbean coast and the Camilo Lock.

HKND would also be excavating material between Lago de Nicaragua and the Camilo Lock. The critical issue in this section is watercourse management; watercourses from small streams to the major Rio Punta Gorda intersect and potentially impact the construction works. The excavation strategy is directed at, to the maximum extent possible, sequencing the works such that stream flows are directed towards the west over completed works rather than to the east over work under construction. This dictates that completion of canal excavation progressively from west to east, which is difficult because the largest excavation volumes are in the center highlands. This excavation would be conducted in three stages, as described below.

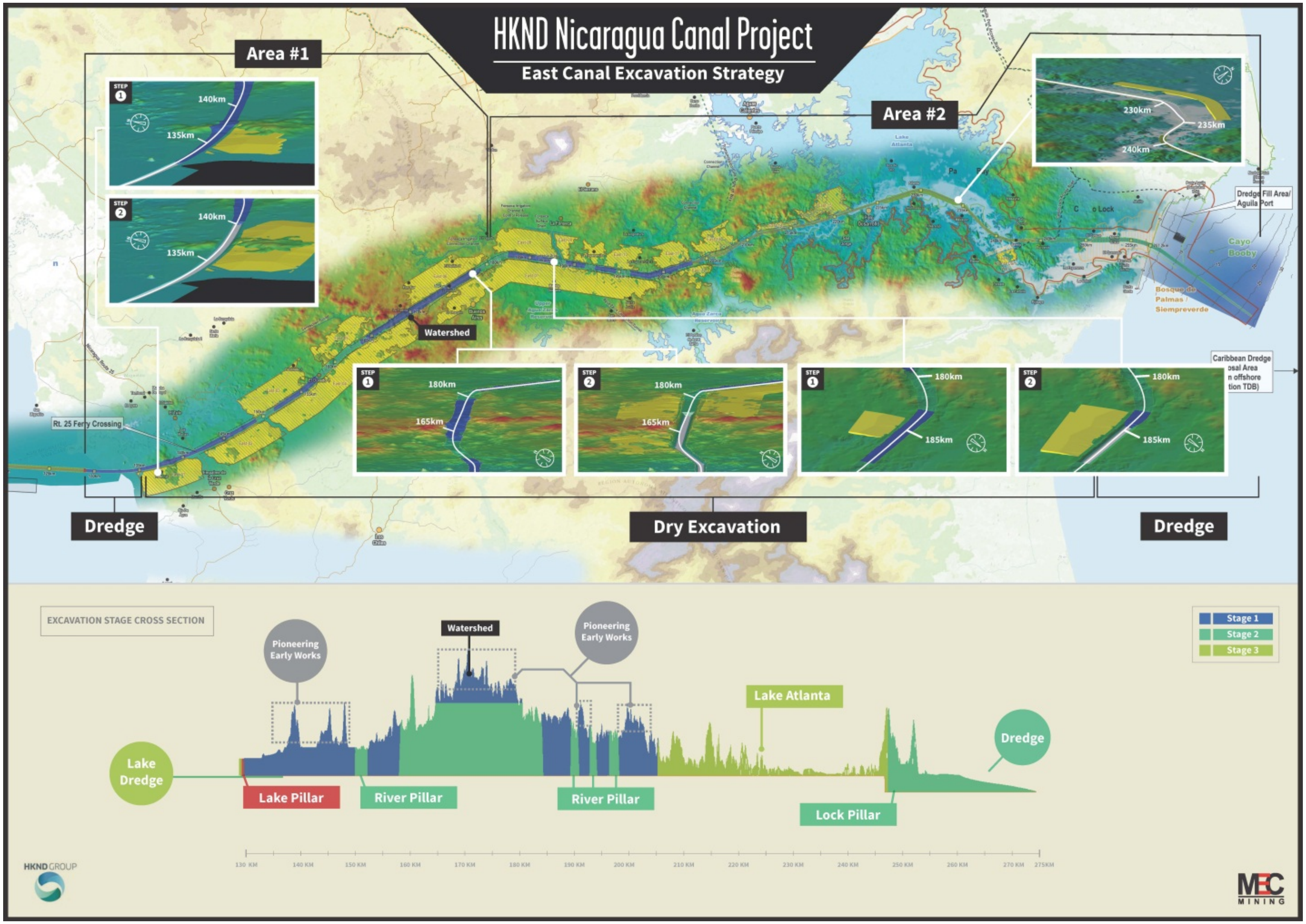


Figure 4.7-11: East Canal Excavation Strategy

Stage 1

HKND would focus initial excavations (approximately 1,500 Mm^3) in areas that do not intersect major streams/rivers. Rainfall that falls inside the cut would be pumped back to the main river system. Excavation on the Lake Slope would be from west (Lago de Nicaragua) to east (watershed divide), where HKND anticipates it can hydraulically dredge about the first 15 kilometers inland from the lake. Initial excavation in the upper portions of the Caribbean Slope would be from east to west.

From this point, upland excavation methods would be employed and construction would continue from west to east, ultimately reaching the Camilo Lock.

Stage 2

Figure 4.7.12 below shows the construction activities for the East Canal during Stage 2.

On a number of watercourses crossing the works, temporary or even permanent dams would be constructed to contain the water flows; calculations have been performed of the storage capacities available and the filling times in order to determine which watercourses can be "cut off" for the time required for excavation of the adjacent works.

Notwithstanding, the volume distribution along the alignment is such that there would be substantial volumes of water flow to be managed alongside actually canal excavation operations. Over substantial lengths of its course, the Rio Punta Gorda would have to be diverted at different stages as excavation proceeds. In some cases, complete diversion would be necessary; in others, the river would be able to be "switched" from side to side in its valley as excavation proceeds alongside. In some sections, the canal excavation would be stopped either side of the river course and the "bunds" removed subsequently.

Stage 3

Figure 4.7-13 below shows the construction activities for the East Canal during Stage 3.

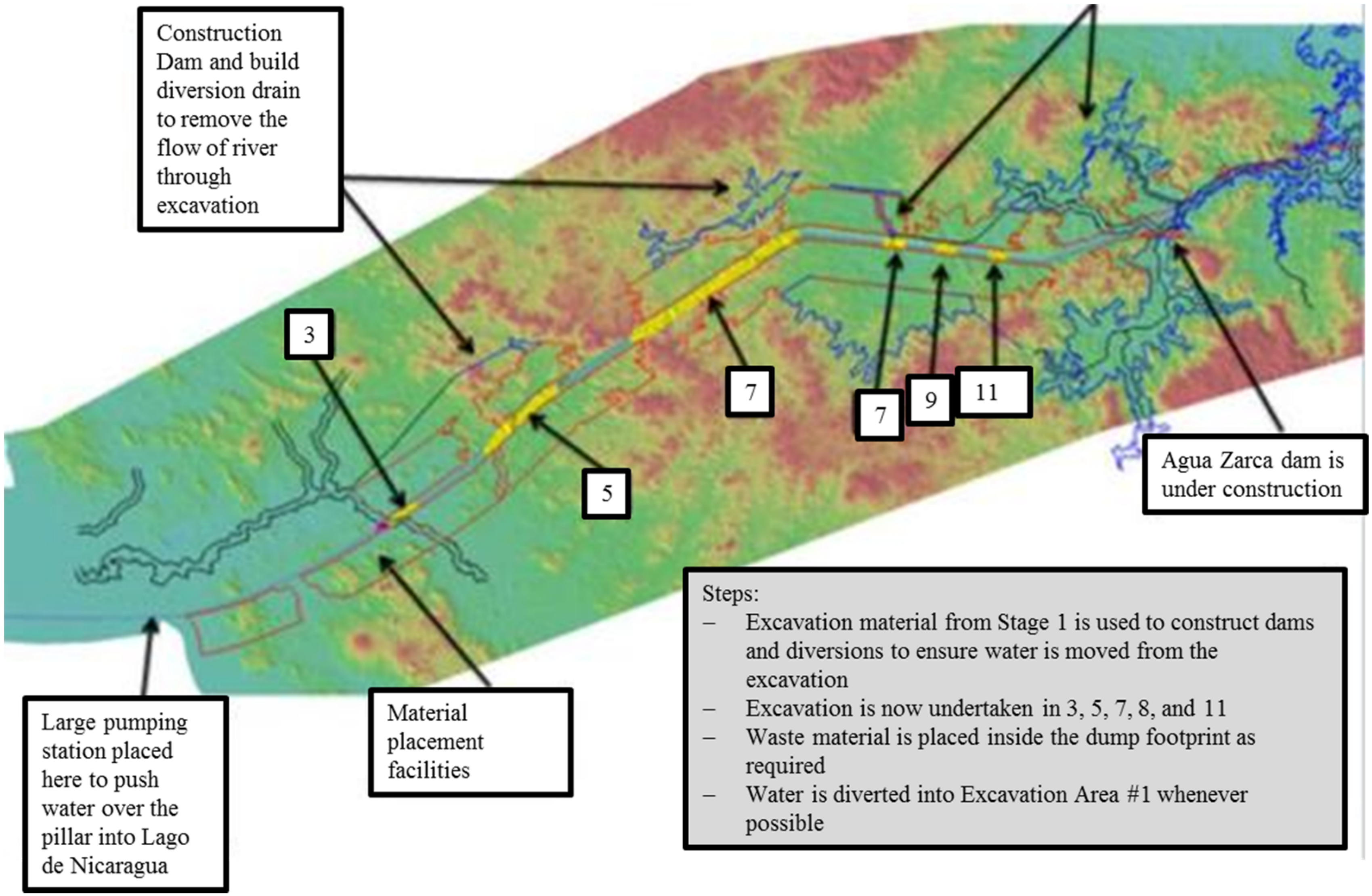


Figure 4.7-12: Stage 2

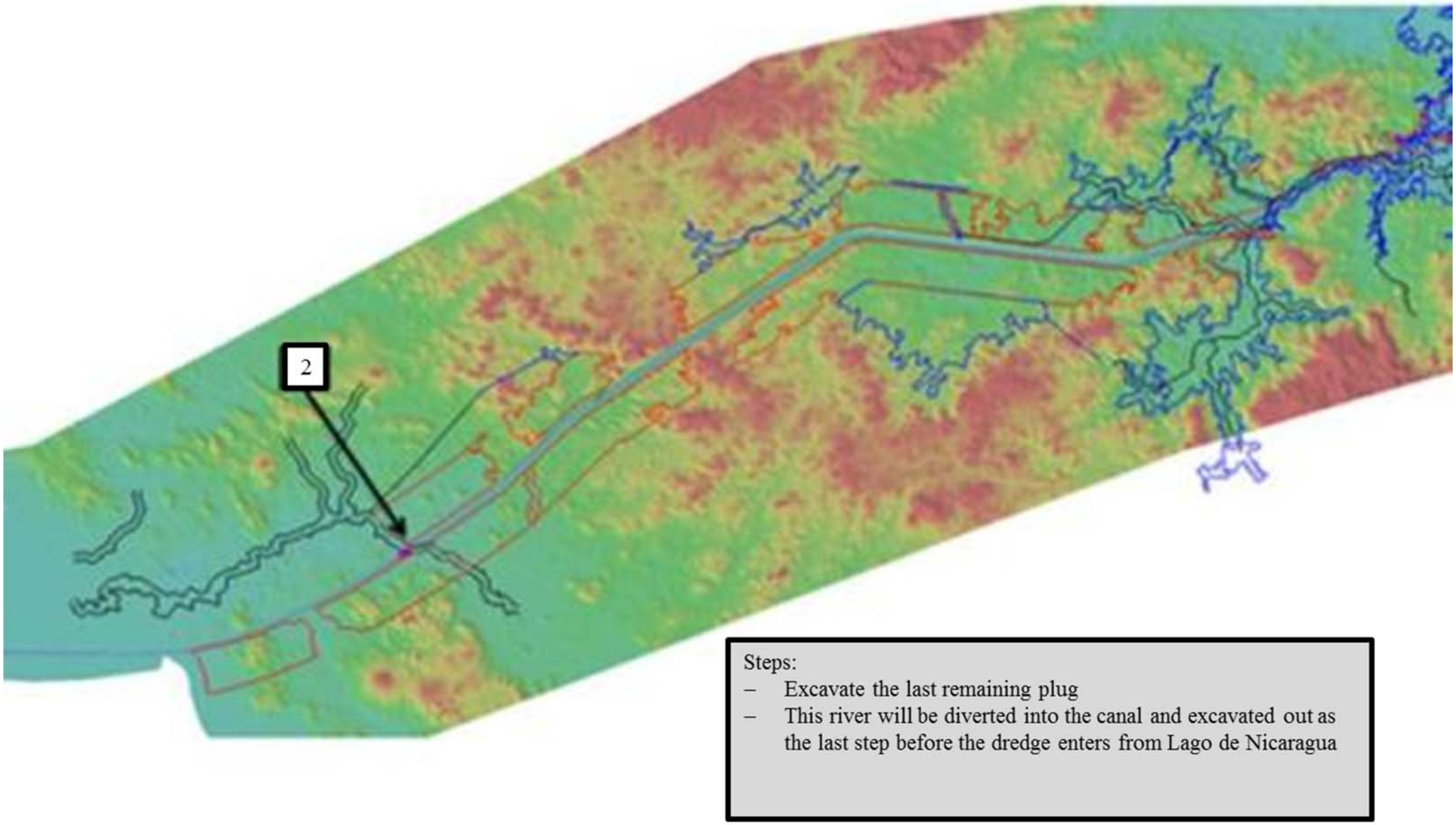


Figure 4.7-13: Stage 3

4.7.3.5 Brito Lock Construction

The Project locks would be the largest ever constructed. They would extend more than 1.5 kilometers in length and are more than 400 meters across. HKND would establish an approximately 1 km^2 construction center at the Brito Lock site, which would include an aggregate processing plant, concrete mixing plant, warehouses, assembly plant, machinery maintenance/repair shop, power substation, oil depot, with a worker camp and explosives magazine nearby.

Once general excavation of the lock area is completed, lock construction would begin. The initial work would be the excavation of the foundation pit, protected as needed by a coffer dam.

The concrete works would use established technology and processes. The locks are complex structures and require robust and attentive management. The primary challenges would be scheduling and interfacing all of the various disciplines, including civil excavation, concrete, electro-mechanical, and gate installation. The initial concrete works is pouring the foundation, followed by constructing the lock head and lock chambers.

The lock gates would be constructed in a large shipyard and transported to the site by a heavy lift ship. The delivery to the actual lock site would have to be along the canal, requiring that canal excavation between the Pacific and the Brito Lock be completed to allow for the heavy lift ship to reach the lock. The rolling lock gates and water conveyance systems are then installed.

The electrical and mechanical works are a critical element to the overall lock construction.

4.7.3.6 Camilo Lock

Construction of the Camilo Lock would be similar to that for the Brito Lock, except that construction of Camilo Lock would be more problematic because of the limited site access and logistics challenges that would undoubtedly cause problems throughout the whole construction period. Effective construction time available for Camilo Lock would probably be 6 month less than for Brito Lock because of initial access delays. Obtaining access to the lock site for delivery of the gates would be a significant challenge.

4.7.3.7 Dams

Dams are required in conjunction with the locks to hold back water in the lock pondages. Because of the Brito Lock location, these dams would actually comprise the backfill to each side of the lock.

At the Camilo Lock, the proposed location requires extended earth and rock fill dams structures adjoining the lock and running across the Rio Punta Gorda to the high ground on each side of the lock location. An alternative location would have backfill dams adjacent to the lock and a normal earth and rock fill dam separated from the lock across the Rio Punta Gorda.

The construction of the lock dams is a critical activity in terms of both schedule and safety. The dams are significant engineering structures and the foundations would be required to be taken down to impervious bedrock. Significant investigation drilling and other studies have to be undertaken as part of the detailed design of these structures.

The Agua Zarca Hydropower Project would be undertaken as a separate project. Additional information regarding the construction of the Agua Zarca Hydropower Project will be provided in the ESIA.

4.7.3.8 Bridges and Roads

The Project would not cross many existing public roads – on the East Canal it would only cross one asphalt road; however, the crossing of the Pan-American Highway on the Rivas Isthmus would require a large cable-stayed bridge. Its timely construction in advance of the canal excavation works would be a necessity.

A car ferry facility would be provided where the canal would interrupt Nicaragua Route 25 (Acoyapa-San Carlos road near San Miguelito).

4.7.4 Commissioning Phase

Commissioning the Project involves a number of different stages. As far as possible, pre-commissioning would be undertaken progressively as works are completed to a stage that allows it. In the construction schedule, 6 months has been allowed for canal and lock commissioning after effective completion of the works.

5. PROJECT OPERATIONS

Once commissioned, the canal and locks would operate 24 hours per day, year round, with the only exception being temporary closures because of hurricane warnings, gale force winds, heavy fog or rain (i.e., visibility less than 1000 meters), forecasts of earthquakes, other natural disasters or major overhaul in accordance with the canal's operating procedures. Additional details will be provided in the ESIA.

5.1 Ship Transit

The canal is estimated to accommodate a daily average of 14 transits per day by 2050, or approximately 5,100 ships a year. Ship transit projections by type of cargo by decade through 2070 are provided in Table 5.1-1. The maximum theoretical capacity of the canal is 9,153 transits per year.

Table 5.1-1: Canal de Nicaragua Freight Traffic Prediction by Year (number of transits)

Year	Container Vessel	Crude Oil Carrier	Product Carrier	Liquefied Natural Gas Carrier	Iron Ore Ship	Coal Hulk	Grain Carrier	Other	Total Number
2020	1,811	99	181	11	88	56	301	1,029	3,576
2030	1,752	392	186	11	123	80	348	1,246	4,138
2040	1,747	458	240	11	201	107	427	1,579	4,771
2050	1,403	495	282	12	279	151	531	1,944	5,097
2060	1,304	504	310	13	378	228	655	2,393	5,785
2070	1,236	496	324	13	513	295	775	2,945	6,598

A Navigation Control Centre would be established in the Brito canal approach. To the extent possible, the ships would be scheduled to transit the canal in a convoy, with generally up to four ships in each convoy; the possibility of larger convoys exists when traffic demand justifies it. The ships travel speed would be restricted to 12 knots (about 22 km/hr) in Lago de Nicaragua and the oceans and to 8 knots (about 15 km/hr) in the remainder of canal. Tugboats would help guide vessels from the breakwaters to the first lock and provide assistance as needed through the locks. The overall transit time through the canal for a ship would be approximately 30 hours.

East-to-West and West-to-East convoys could pass each other in the passing lanes provided, or one convoy could moor or marshal in Lago de Atlanta while the other convoy transits. Detailed management of the convoy system would facilitate the maximization of the number of ships able to be handled by the canal.

The vessels transiting the canal would be closely monitored through a Vessel Traffic Management System, which would assure ship navigation safety and efficiency. This system consists of an advanced computer management system. For example, the Lock Control Center at the Brito and Camilo locks should be equipped with the following systems:

- Lock computer supervisory control system;
- Lock electrical driving system;
- Navigable broadcast command system;
- Navigable command signal system;
- Video images monitoring system;
- Ship location detection system;
- Radio communication system; and
- Monitoring and control systems for water levels and major infrastructure.

The Operation Management System also provides ship tracking functions, including ship scheduling, ship login, information services, appointment of the pilot, port coordination, channel information, actual ship position display, navigation management, financial settlement, and cost accounting.

The Vessel Traffic Management System is primarily composed of:

- Radar Surveillance System, which uses radar techniques to track and monitor ships in the canal, monitor ship movements in real time, and helps manage traffic situations to ensure navigation safety;
- Ship-to-Shore Wireless Communication System, which enables voice communication between the canal navigation dispatching and passing ships using high frequency radiotelephone system; and
- Ship Automation identification System, which is a new digital navigation aid that broadcasts ship dynamic data (e.g., position, speed, rate of changing course, course), which in combination with ship static data (e.g., name, call sign, draft, cargo) allows ships and stations to share dynamic and static information on a real time basis and enhances ship safety.
- Lock Control System to safely operate the rolling gates, the water saving basins, valves for water management, and monitoring of water levels.

In areas along the canal where public boats (non-canal related) would be allowed, notwithstanding the laws of navigation at sea, these boats must respect a moving exclusion zone that travels with the vessel convoys as they transit the canal. This exclusion zone would be 3 kilometers ahead of the convoy, 1.5 kilometers astern, and 150 meters abeam similar to U.S. Coast Guard guidelines. The purpose of the exclusion zone is for both convoy security and the safety of the public boats. Changes to the maritime laws of Nicaragua may be required to enforce these exclusion zones.

5.2 Power Requirements

Canal operations would require about 18 MW of electricity, primarily for lock operations (approximately 9 MW for each lock). This power would be secured from the Agua Zarca Hydropower Facility, which would provide an annual average of about 10 MW, supplemented by power from the Nicaraguan grid via transmission lines connecting the Brito Lock to the existing Rivas electrical substation and the Camilo Lock to the existing Corocito electrical substation.

HKND would have backup diesel generators at each of the two locks to ensure reliable power in the event of a power outage.

5.3 Water Requirements

The Brito and Camilo locks would have a combined annual average daily water demand of 59.2 cubic meters per second, based on predicted vessel traffic in 2050 (14 transits per day), assuming the provision of three water saving basins per lock chamber (see Table 5.3-1). This does not include the release of flushing water for salinity management, which is one of several salinity management options described below.

Table 5.3-1: Project Operations Water Use

Water Use by Locking Process - Flow [m³/s]								
2030			2050			2070		
11 Transits/day			14 Transits/day			18 Transits/day		
PCF	CRB	TOT	PCF	CRB	TOT	PCF	CRB	TOT
19.9	26.6	46.5	25.4	33.8	59.2	32.6	43.5	76.1

Source: Image created by SBE.

m^3/s = cubic meters per second

Note: Water use for locking operations with three water saving basins: Pacific side (PCF) and Caribbean side (CRB) and Total (TOT)

Water balance modeling indicates that the Project design would have no net effect on water levels in Lago de Nicaragua (i.e., no lowering of water levels). Water level must remain between elevations 30.15 meters and 33.02 meters for the canal to operate.

The Agua Zarca Reservoir, in addition to hydropower generation, would also provide supplemental water storage in the event of an extreme or multi-year drought. In general, HKND would manage water levels in the reservoir such that the reservoir is full (maximum water level) at the end of the rainy season, in the same way that Madden Lake is managed at the Panama Canal.

5.4 Salinity Management

The Project's water demand could increase depending on the selected method to control salinity intrusion. There are several options available to control salinity intrusion through the locks, as described below in Table 5.4-1.

Table 5.4-1: Estimation of Effectiveness of Mitigating Project Measures including Indicative Uncertainty Ranges

Measure	Effectiveness of Prevention of Salt Intrusion	Range	Remarks
Lock operations management	Additional to structural measures	NA	Limiting the convoy length is very effective in reducing the salt intrusion
No further measures	NA	Salt intrusion = 80 – 90% of upper lock chamber content above the level of the upward step in the bottom (1008 kg/m3 brackish water) Freshwater loss – 80 – 90% of lock chamber content	
Flushing mixed brackish water	Low effectiveness	Salt intrusion – 70 – 85% of upper lock chamber content above the level of the upward step in the bottom (1008 kg/m3 brackish water) Freshwater loss = 160 – 200% of lock chamber content	No time loss
Pneumatic Barriers	Low effectiveness	Salt intrusion – 60 – 80% of upper lock chamber content above the level of the upward step in the bottom (1008 kg/m3 brackish water) Freshwater loss = 60 – 80% of lock chamber content	No time loss Effective in reducing forces
Flushing collected water, selective withdrawal	Good effectiveness	Salt intrusion – 20 – 30% of upper lock chamber content above the level of the upward step in the bottom (1008 kg/m3 brackish water) Freshwater loss = 180 – 220% of lock chamber content If combined with pneumatic barrier salt intrusion max 15 – 20%, about same freshwater loss	Probably no time loss Result very much depends on a well-designed and well operated flushing system
Retaining wall concept	High effectiveness	Salt intrusion 5 – 15% of (double head) lock chamber content (1024 kg/m3 saltwater) Freshwater loss = 10 – 20% of (double head) lock chamber content.	Probably no additional time loss for a single passing vessel, but the frequency of lockages of lower lock would be lower Forces on vessels need attention (pneumatic barriers are advised) Still requires significant efforts in development and for verification of feasibility

NA = not applicable

5.5 WORKFORCE REQUIREMENTS

HKND estimates its direct employment during operations would increase from approximately 3,700 employees in 2020 to about 12,700 employees in 2050 as the number of transits increases over time. It is anticipated that nearly all of these employees would be based in Nicaragua. A breakdown of skilled versus unskilled workers is not yet available.

5.6 SECURITY REQUIREMENTS

HKND would employ guards to provide security at the locks and other major infrastructure, to patrol the private maintenance roads along the canal, and to enforce the private boating exclusion zones for ships transiting the canal. HKND has committed to following the Voluntary Principles on Security and Human Rights (Foley Hoag, LLP 2014).

5.7 PUBLIC BOAT USE POLICY

HKND would not allow public (non-canal related) boating use of the West and East canals for safety and security reasons, with the following exceptions:

- Commercial boating would be allowed to use the canal between Lago de Nicaragua and Lake Atlanta in order to support a planned new town and port facility at Lake Atlanta, but only with a permit from HKND;
- Public boating would be allowed to cross the canal in Lago de Nicaragua, but would need to respect exclusion zones around canal-related vessels transiting the lake;
- Public boating would be allowed to cross the canal in Lake Atlanta at a single location designated and marked by HKND, but would again need to respect exclusion zones around canal-related vessels transiting the canal; and
- Public boating would be allowed within Lake Atlanta other than within the canal itself.

5.8 FERRY SERVICE

HKND would provide ferry service across the canal at the Acoyapa-San Carlos Road (Nicaragua Route 25) for vehicles, bicycles, and pedestrians. The ferries would be large enough to accommodate trucks and tractor trailers. The ferry service would be provided by HKND at no charge on a regular basis. This service would be provided indefinitely until alternative access across the canal was provided (e.g., a bridge).

5.9 MAINTENANCE DREDGING

The canal would require regular maintenance dredging, currently estimated by HKND at approximately 120,000 m^3/yr. Dredged material from the East Canal would primarily be disposed of at the Aguila Port/reclamation site, which has ample capacity to accept dredged material for a long time. Dredged material from the West Canal or Lago de Nicaragua would be placed in the CDFs, unless it is demonstrated that the material is sufficiently coarse to allow disposal in the open water disposal site along the canal (LN-OW1).

5.10 PORT OPERATIONS

HKND will provide a Ports Operations Management Plan at a future date. All port-related development (e.g., port facilities, associated residential/commercial/industrial development) would occur on the 14 km2 of reclaimed land (C-CDF1).

6. PROPOSED EMBEDDED CONTROLS

HKND has proposed the following embedded environmental controls that are considered to be part of the proposed Project:

Table 6-1: Embedded Controls Identified for Construction and Operation

Embedded Control Measure – Construction
Physical Resources • Provide excavation benching and sloping consistent with geotechnical stability guidelines • Provide slope reinforcement – e.g., shotcrete, cable tethering, • Provide engineered drainage of slopes (e.g., drop structures) • Provide soil erosion control • Salvage and replace topsoil • Stabilize and restore disturbed land • Provide salinity management measures at the locks • Use low sulfur diesel fuel (500 parts per million) for all land-based construction equipment and worker camp power generation. • Avoid use of underwater blasting in Lake Nicaragua • Avoid nighttime blasting near residential areas • Halt dredging during severe weather • Provide dust suppression in disturbed areas • Stage use of Tier 1 equipment will be staged on support vessels • Use riprap or other materials to protect shoreline areas from boat wake • Provide wastewater treatment plant at each worker camp • Beneficially reuse most excavated/dredged material for the creation of productive farmland and port development. • Dispose of fine surficial dredged material in Lake Nicaragua in confined disposal facilities • Monitor for and control any acid rock drainage • Rehabilitate EMPAs along the canal for agricultural and forestry purposes. • Provide secondary containment around all fuel storage facilities.
Biological Resources • Require vessel operators to use designated navigation channels and comply with required speed and wake restrictions
Human Resources • Build parallel East-West access roads on either side of the canal route and will allow non-vehicular public use of the roads • Establish a grievance mechanism • Implement an Active Archaeological Monitoring Program for Ground-disturbing Activities (Construction and Operations Phases) for Areas determined to Have Moderate or High Archaeological Potential • Avoid underwater Archaeological Targets Identified During an Analysis of Fit-for-Purpose Marine Geophysical Survey Data • Provide emergency transport to hospitals for any communities whose access is temporarily interrupted during construction

Embedded Control Measures - Operations
• Require all ships transiting the canal to comply with the International Convention for the Prevention of Pollution from Ships (International Convention for the Prevention of Pollution from Ships [MARPOL] 73/78); • Establish a Workers Code of Conduct • Develop and deliver a fit-for-purpose Cultural Heritage Training for Project Managers, Field Supervisors, and Construction Teams • Allow pedestrian crossing at the Camilo Lock • Construct a bridge at the point where the Pan-American Highway crosses the canal. • Provide ferry service at the point where the canal intersects the San Carlos-Acoyapa roadway

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