Department of Public Works and Highways

Infrastructure Preparation and Innovation Facility – Output 1 – Roads and Bridges

Samal Island – Davao City Connector (SIDC) Project – Environmental Impact Assessment Report

REP/265463/EIS004

Issue 4 31 July 2020

Contents

Abbreviation

AADT	Annual Average Daily Traffic
AAQM	Ambient Air Quality Monitoring
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
ALARP	As Low As Reasonably Practicable
APCD	Air Pollution Control Device
AQI	Air Quality Indices
ASP	Amnesic Shellfish Poisoning
BAWASA	Barangay Water System Association
BFAR	Bureau of Fisheries and Aquatic Resources
BFP	Bureau of Fire Protection
BHW	Barangay Health Workers
BMB	Biodiversity Management Bureau
BMS	Biodiversity Monitoring System
BOD	Biochemical Oxygen Demand
BSWM	Bureau of Soils and Water Management
CAAP	Civil Aviation Authority of the Philippines
CADT	Certificate of Ancestral Domain Title
CBR	Crude Birth Rate
CDD	Conservation and Development Division
CDR	Crude Death Rate
CENRO	City Environmental and Natural Resources Office
CER	Compliance Evaluation Report
CLUP	Comprehensive Land Use Plans
CMR	Compliance Monitoring Reports
CMVR	Compliance Monitoring and Validation Report
CNO	Certificate of Non-Overlap
CO	Central Office
COD	Chemical Oxygen Demand
CTD	Conductivity Temperature and Depth
DANECO	Davao del Norte Electric Cooperative
DAO	DENR Administrative Order
DBH	Diameter at Breast Height
DCWD	Davao City Water District
DLPC	Davao Light and Power Company
DCWD	Davao City Water District
DED	Detailed Engineering Design
DENR	Department of Environment and Natural Resources
DIC	Directly Impacted Community
DO	Dissolved Oxygen
DOLE	Department of Labor and Employment
DPWH	Department of Public Works and Highways
DRAM	DPWH ROW Acquisition Manual
DSP	Diarrhetic Shellfish Poisoning
DTI	Department of Trade and Industry
DVO	Davao City Office
EAT	Emergency Action Team

ECA	Environmental Critical Area
ECC	Environmental Compliance Certificate
ECP	Environmental Critical Project
EGF	Environmental Guarantee Fund
EGGAR	Engineering Geological and Geohazard Assessment Report
EIA	Environmental Impact Assessment
EIAMD	Environmental Impact Assessment Management Division
EIS	Environmental Impact Statement
EMB	Environmental Management Bureau
EMF	Environmental Monitoring Fund
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
ENIPAS	Expanded National Integrated Protected Areas System
ENRO	Environmental and Natural Resources Office
ERP	Emergency Response Plan
EQD	Environmental Quality Division
EQPL	Environmental Quality Performance Level
EU	Environmental Unit
FGD	Focus Group Discussions
FVC	Fish Visual Census
GEC	Galerio Environmental Consultancy
GPS	Global Positioning System
HAVS	Hand-Arm Vibration Syndrome
HC	Hard-coral Cover
IBAT	Integrated Biodiversity Assessment Tool
IEC	Information and Education Campaign
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IGaCoS	Island Garden City of Samal
IMP	Impact Management Plan
IR	Indicative Risk
IRR	Implementing Rules and Regulations
ISF	Informal Settler Families
ISPP	International Sewage Pollution Prevention
IUCN	International Union for Conservation of Nature
IV	Importance Value
LCC	Live Coral Cover
LGU	Local Government Unit
MARPOL	Marine Pollution
MENRO	Municipal Environmental and Natural Resources Office
MEPCOM	Marine Environmental Protection Command
METI	Ministry of Economy, Trade and Industry
MGB	Mines and Geosciences Bureau
MMT	Multipartite Monitoring Team
MOA	Memorandum of Agreement
MPA	Marine Protected Area
MPDO	Municipal Planning Development Officer
MRF	Materials Recovery Facility

NAAQGV	National Ambient Air Quality Guideline Values
NAMRIA	National Mapping and Resource Information Authority
NAPOCOR	National Power Corporation
NCIP	National Commission on Indigenous People
NEDA	National Economic Development Authority
NGO	Non-Government Office
NIPAS	National Integrated Protected Areas System
NWRB	National Water Resources Board
NO_2	Nitrogen Dioxide
O&G	Oil and Grease
O/TCT	Original or Transfer Certificates of Title
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAMB	Protected Area Management Bureau
PAR	Philippine Area of Responsibility
PCD	Pollution Control Division
PCCP	Portland Cement Concrete Pavement
PCG	Philippine Coast Guard
PCU	Passenger car units
PDS	Project Description Report for Scoping
PEISS	Philippine Environmental Impact Statement System
PG	Provincial Government
PH	Power of Hydrogen
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PM	Particulate Matter
PPA	Philippine Ports Authority
PPDO	Provincial Planning Development Officer
PPE	Personal Protective Equipment
PPP	Public-Private-Partnership
PO	People’s Organization
PSA	Philippine Statistics Authority
PSR	Public Scoping Report
PTT	Photo-Transect Technique
PW	Production Wells
RA	Republic Act
RAP	Resettlement Action Plan
RDC	Regional Development Council
RHU	Rural Health Unit
RMP	Rehabilitation Management Plan
ROW	Right-of-Way
ROWSAM	ROW Site Acquisition Manula
RPM	Revised Procedural Manual
SD	Social Development
SDP	Social Development Plan
SIDC	Samal Island - Davao City Connector
SMR	Self-Monitoring Reports
SO_2	Sulfur Dioxide
SWMP	Solid Waste Management Plan
TCSS	Traffic Control and Surveillance System

TDS	Total Dissolve Solids
TESDA	Technical Education and Skills Development Authority
TL	Total Length
TPDM	Transport Planning and Design Manual
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
UBIV	Under Bridge Inspection Vehicles
UPMO	Unified Project Management Office
WEF	World Economic Forum
WHO	World Health Organization
WQG	Water Quality Guidelines
WWF	World Wildlife Fund

Executive Summary

Project Fact Sheet

<table>
<tr><td>Name of Project</td><td colspan="2">Samal Island - Davao City Connector (SIDC) Project</td></tr>
<tr><td>Project Location</td><td colspan="2">Davao City: Barangays Vicente Hizon Sr., Angliongto and R. Castillo
Island Garden City of Samal (IGaCoS): Barangay Limao</td></tr>
<tr><td>Nature of the Project</td><td colspan="2">Bridge Construction</td></tr>
<tr><td>Project Size</td><td colspan="2">Length: 3.98km (total roadway, including 4 ramps); 2.85km (point to point length);
Width: 24m (Dual 2 lane carriageway with hard shoulder and walkway)</td></tr>
<tr><td>Summary of Major Components</td><td colspan="2"><table>
<tr><th>Project Component</th><th>Description / Specifications</th></tr>
<tr><td>Navigation bridge</td><td>Provide the necessary navigation clearance for ships</td></tr>
<tr><td>Marine viaducts</td><td>Viaduct structures constructed above sea water</td></tr>
<tr><td>Interchanges and viaducts on land</td><td>Viaduct structures constructed on land and provide connections to existing road networks</td></tr>
<tr><td>Approach ramps</td><td>Parts of the road that go up from existing ground level towards the approach bridge</td></tr>
</table></td></tr>
<tr><td>Project Cost</td><td colspan="2">Php. 16.606 Billion (Civil Works)
Php. 23.040 Billion (Total Project Cost)</td></tr>
<tr><td>Project Duration</td><td colspan="2">2019-2025</td></tr>
<tr><td>Operation Date</td><td colspan="2">2025</td></tr>
<tr><td>Proponent Name</td><td colspan="2">Department of Public Works and Highways (DPWH)</td></tr>
<tr><td>Proponent Authorized Representative</td><td colspan="2">Emil K. Sadain, CESO I
Undersecretary for UPMO Operations and Technical Services
Department of Public Works and Highways</td></tr>
<tr><td>Proponent Address and Contact Details</td><td colspan="2">Address: Bonifacio Drive Port Area, 652 Zone 068, Manila, 1018 Metro Manila, Philippines
Contact Number: +63 2 5304 3805 / +63 2 5304 3681</td></tr>
<tr><td>EIA Preparer (Consultant)</td><td colspan="2">Ove Arup & Partners Hong Kong Ltd and
Galerio Environmental Consultancy</td></tr>
<tr><td>Preparer Contact Person</td><td>David Rollinson
Ove Arup & Partners Hong Kong Ltd – Environmental and Social Team Leader</td><td>Leonila P. Galerio
GEC- EIA Team Leader</td></tr>
<tr><td>Preparer Address and Contact Details</td><td colspan="2">Ove Arup & Partners Hong Kong Ltd
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Galerio Environmental Consultancy
Door No. 1, Ground Floor, Matina IT Park, Building 2, McArthur Highway, Matina, Davao City, Philippines, 8000
Tel No.: + 63 2 2243 197</td></tr>
</table>

Process Documentation

- **Project Categorization**

As per the Revised Procedural Manual of the Department of Environment and Natural Resources (DENR) Administrative Order No. 30 Series of 2003 (DAO 2003-30), major roads and bridges are categorized as an Environmental Critical Project (ECP) under Category A, and within the scope of the EIS System based on Proclamation No. 2146 (1981) and Proclamation No. 803 (1996). Although based on the Environmental Management Bureau (EMB) Memorandum Circular 005 of 2014 (EMB MC 2014-005) or the Revised Gudelines for Coverage Screening and ad Standardized Requirments under the Philippine EIS System, the proposed Samal Island - Davao City Connector (SIDC) project with only approximately 3km, has been identified under Category B Non-ECP (>50 m but <5.0km), EMB Central Office has decided to have the Project categorized to Category A due to the following reasons (**Annex A**):

1. The Project will involve linking of two islands, which might have significant impacts on the oceanography and marine ecology; and
2. The Project impacts will not be comprehensively assessed through Initial Environmental Examination (IEE) Checklist that is being required for Non-ECP, but by undertaking an Environmental Impact Assessment (EIA) Study.

As the Project falls under Category A, hence this Environmental Impact Statement (EIS) Report is prepared to be submitted to EMB Central Office to identify the impacts of the project. This report will outline the current conditions of the project area and will demonstrate all potential impacts that may be found significant.

- **Definition of EIA**

As defined under the DAO 2003-30, an Environmental Impact Assessment (EIA) is a systematic process that involves the prediction and evaluation of significant impacts of a project, including cumulative impacts on the environment all throughout its life cycle (*construction, operation and abandonment phase*). In addition, it involves designing appropriate preventive, mitigating and enhancement measures addressing the consequences in attaining socio-economic and environmental balance.

- **Scope of the EIA Study**

Upon the submission of the Project Description Report for Scoping (PDS), advised the Project to proceed to the next stages, which is the Public Scoping and Technical Scoping (**Annex B**, **C** and **D**).The contents of this report are based on the agreed Technical Checklist (**Annex B**) during the Technical Scoping last 21 October 2019. Among the major and critical components of the EIS Report are the following:

1) Project Description
2) Key Environmental Impact and Management/ Monitoring Plan
3) Environmental/ Ecological Risks Assessment
4) Impact Management Plan (IMP)
5) Social Development Plan (SDP) and Information and Education Campaign (IEC) Framework
6) Environmental Compliance Monitoring
7) Emergency Preparedness and Response Policy and General Guidelines
8) Abandonment/ Rehabilitation Policy, and

9) Institutional Plan for Environmental Management Plan (EMP) Implementation

- **Public Participation Activities**

Consistent with the Guidelines on Public Participation under the Philippine Environmental Impact Statement System (PEISS) of DAO 2017-15, stakeholder's consultation has been continuously conducted for the SIDC Project. Information and Education Campaign (IEC) was completed in Barangay Caliclic and Limao, Island Garden City of Samal (IGaCoS) and Barangay Vicente Hizon, Davao City on 21 May and 24 May 2019.

In addition, a Public Scoping for the SIDC Project has been done and facilitated by EMB Region 11 (EMB-R11) under the current director RD Sophie T. Manuel, Ph.D, CESO V. The Public Scoping was held in Caliclic Gym, Barangay Caliclic, IGaCoS and Chateau del Mar, Barangay V. Hizon, Davao City last 20-21 September 2019. The activities were properly documented, and all issues and concerns raised were recorded and included in the EIS study of the project. Complete Public Participation Reports are provided in **Annex C**.

Furthermore, a position paper sent by Mr. Narciso L. Rodriguez., Paradise Island Park & Beach Resort has been received by the proponent, DENR-EMB Central Office, National Economic Development Authority (NEDA) and Asian Development Bank (ADB) last October 2019**.** Thus, discussions with Mr. Rodriguez has been continuously conducted by the proponent and its consultants, see **Annex E.**

- **EIA Team**

The Department of Public Works and Highways (DPWH), the main proponent of the project, is the lead engineering and construction agency of the government, tasked in ensuring and designing infrastructure developments such as national highways, bridges, flood control and other related public works.

DPWH has appointed Ove Arup and Partners Hong Kong Ltd., "Arup", as the lead consultant for the Feasibility Study of the SIDC Project. Arup is a multinational firm which provides engineering, design, planning, project management and consulting services for all aspects of the built environment (**Annex F**).

The Galerio Environmental Consultancy (GEC) was hired by Arup as its sub-consultant to collaborate in the preparation of the EIA for the project, including social aspects such as the conduct of public consultations, IECs, perception survey, among others. The EIA Team consists of the following members:

Table 1 EIA Team

Name	Role in the EIA Study	Qualification
David Rollinson	Environmental and Social Team Leader (Arup)	BSc (Hons) Environmental Biology MSc Environmental Management
Angel Salcedo	Environmental and Social Specialist (Arup)	EIA Registration No. IPCO 334 MSc Environmental Engineering B.S. Chemical Engineering
Maria Catherine Rontos	Environmental and Social Specialist (Arup)	EIA Registration No. IPCO 037 Diploma in Urban and Regional Planning B.S. Environmental Planning and Management

Name	Role in the EIA Study	Qualification
Geanella Belino	Environmental and Social Specialist (Arup)	M.A. Urban and Regional Planning B.S. Environmental Planning and Management
Leonila P. Galerio	Team Leader, Biologist (GEC)	EIA Registration No. IPCO 021 M.S. in Environmental Resource and Management B.S. in Biology
Abigail June L. Agus	Geologist, Hydrologist, GIS Specialist (GEC)	MSc in Geoinformation Science and Earth Observation B.S. in Geology
Ma. Luisa P. Martinez	Air Specialist (GEC)	EIA Registration No. IPCO 133 Ph.D. in Environmental Science M.S. in Chemical Engineering B.S. in Chemical Engineering
Melchor Retirado Deocadez	Marine Ecosystems Specialist (GEC)	Ph.D. in Environmental Science and Management MSc Environmental Science MSc Marine Biology BSc Fisheries, Major in Mariculture
Rhea Lou M. Rivera	Forester (GEC)	M.S. in Forest Resource Management B.S. in Forestry
Emelita T. Catalo-Guerzon	Water Quality Specialist (GEC)	EIA Registration No. IPCO 121 M.S. in Environment and Resource Management B.S. in Sanitary Engineering B.S. in Civil Engineering
Robert R. Pabiling	Marine Water Ecologist (GEC)	EIA Registration No. IPCO 107 M.S. in Marine Science (undergraduate) BSc in Biology, Major in Microbiology
Thelma D. Dela Cruz	Environmental Risk Assessment Specialist (GEC)	EIA Registration No. IPCO 387 Ph. D. Environmental Science (candidate) M.S. in Occupational Health M.S. in Environmental Science
Diana Kristina Velasco	Land Use Specialist (GEC)	Ph. D. Development Administration (candidate) M.A. in Urban and Regional Planning B.S. in Geology
Robeen John A. Gerodiaz	Project Coordinator (GEC)	B.S. in Forestry
Kirsten Marie T. Balaod	Researcher (GEC)	B.S. in Environmental Science

Name	Role in the EIA Study	Qualification
Marlon C. Suelto	Geologist/GIS Operator (GEC)	B.S. in Geology
Alliza Marie R. Lao	Researcher (GEC)	B.S. in Environmental Science
Maricel R. Dagooc	Forester / Researcher (GEC)	B.S. in Forestry
Julie Mae G. Mendoza	Forester / Researcher (GEC)	B.S. in Forestry
Jecar I. Dela Cerna	Researcher (GEC)	B.S. in Agro Forestry
Darvin Louis L. Cadungog	Researcher (GEC)	B.S. in Agro Forestry

- **EIA Study Schedule**

Table 2 presents the timeframe of activities set by the EIA consultant for the EIA study of the SIDC project.

Table 2 EIA Study Schedule

Year	2019																												2020																											
Month	June				July				August				September				October				November				December				January				February				March				April				June				July				August			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activities																																																									
Reconnaissance Survey																																																									
Coordination and Communication meeting																																																									
Initial Perception Survey																																																									
IEC and FGD																																																									
Davao City																																																									
IGaCoS																																																									
Report preparation for PDS Report																																																									
Submission of PDS/ EMB Office review																																																									
Public Scoping with EMB																																																									
Davao City																																																									
IGaCoS																																																									
Portion of Oceanographic Survey																																																									
Preparation of Public Scoping Report (PSR)																																																									
Submission of PSR to EMB Office																																																									
Technical Scoping with EMB																																																									
Fauna Assessment																																																									
Flora Assessment																																																									
Corals Assessment																																																									
Seagrass Assessment																																																									
Fish Assessment																																																									
Land-Use Assessment																																																									
Geohazard Assessment																																																									
Air & Noise Sampling																																																									
Water sampling and analysis																																																									
Sediment sampling and analysis																																																									
EIS report writing																																																									
EMB Procedural Screening* and EIS Draft Report Acceptamce for substantive Review of REVCOM																										*						*									*														

Year	**2019**																												**2020**																											
Month	**June**				**July**				**August**				**September**				**October**				**November**				**December**				**January**				**February**				**March**				**April**				**June**				**July**				**August**			
Week	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Awaiting new EMB DMO																																																								
ERSF and processing fee																																																								
Public Hearing																																																								
Davao City																																																								
IGaCoS																																																								

- **EIA Study Area**

The bridge will be constructed in two provinces, Davao del Sur (Davao City) and Davao del Norte (Samal Island). The landing points of the bridge are specifically located in Davao City and IGaCoS. In Davao City, the barangays that will be affected are Vicente Hizon, Sr., A. Angliongto and R. Castillo, while Barangay Limao will be affected on the IGaCoS side.

- **EIA Methodologies**

Secondary data and information on baseline environmental conditions for land, water, air and people components were collected from the following sources: (1) Local Government Units Comprehensive Land Use Plans (CLUP); (2) National Mapping and Resource Information Authority (NAMRIA) Topographic Map; (3) Bureau of Soils and Water Management (BSWM); (4) Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA); (5) Philippine Institute of Volcanology and Seismology (PHIVOLCS); (6) Mines and Geosciences Bureau (MGB); (7) DENR and (8) National Commission on Indigenous People (NCIP).

Other secondary information was obtained from published documents and literature, from the internet such as Google Earth images and the Philippine Statistics Authority (PSA).

The methods employed for primary data collection on the four components (Land, Water, Air and People) of the EIS study are summarized in **Table 3**.

Table 3 Summary of EIA Methodologies

EIA Key Components	Methods
Land	
Land Use and Classification	Baseline environmental conditions of the project area were studied by reviewing all available secondary information, including comprehensive land use plans, comprehensive development plans, zoning ordinances, socio-economic profile, and other sources; and conducting reconnaissance survey, detailed field investigations, rock sampling and identification, and transect sampling and analysis.
Geology/Geomorphology	Review of secondary data includes flood maps, landslide susceptibility maps and other geology-related resources from DENR-MGB, PHIVOLCS and NAMRIA, among others, which were validated through field investigations.

EIA Key Components	**Methods**
Geohazard Assessment	The following activities were undertaken during the conduct of the geological investigation of the proposed bridge: • Research – prior to detailed mapping, technical reports regarding the geologic conditions of the region were collected. • Satellite Interpretation – accessing satellite images. • Field geologic and geohazard mapping – Actual field inspection of the area where information such as local site geology is obtained. Topography and other terrain properties, including the drainage characteristics of the area, were also observed and noted. Geologic mapping was conducted on a scale of 1:10,000 while geohazard mapping was done on a 1:5,000 scale. Mapping activities covered a total approximate area of about 400 hectares. Data analysis and report preparation – this final stage is concerned with scrutinizing all data gathered, including those from the field inspection.
Pedology	In-situ soil samples were taken and >2mm fractions (such as gravel, roots and organic material) were removed by hand. Soil was moistened with a little water and kneaded into a bolus, until sample did not exhibit any apparent change in plasticity. Boluses were further kneaded into ribbons and rods, and textures were compared to the field texture grade, adapted from the methodology described in McDonald et al. Field sampling confirmed the predominance of Bolinao Clay in the area.
Terrestrial Ecology: Flora Assessment	Flora surveys were undertaken to assess species composition and importance. The methodology employed was anchored on the Terrestrial Ecosystems Biodiversity and Assessment Monitoring Manual (DENR-EMB, 2017). Species found inside the quadrats were recorded and measured. Analysis and identification of tree species were based on the standard taxonomic classification. For ecological and conservation status, the International Union for Conservation of Nature (IUCN) Red List and DAO 2007 were used as references.
Terrestrial Ecology: Fauna Assessment	The assessment was based on the Terrestrial Ecosystems Biodiversity and Assessment Monitoring Manual (DENR-BMB, 2017). Integrated Biodiversity Assessment Tool (IBAT) was used as an initial screening tool and supplemented by passive and active methods. Passive methods included mist netting, live-trapping and key informant interviews. Active methods employed include transect walk and point counts and purposive search and opportunistic catching.
Water	
Hydrology/ Hydrogeology	Secondary data review and hydrogeologic map from MGB were used for the discussion of drainages and catchment within the Project area.
Oceanography	The assessment was based on the study of environmental conditions of Pakiputan Strait in Davao City, its physical parameters and water column structure, general flow patterns and the grain size and distribution patterns of bottom sediments prior to bridge construction.

EIA Key Components	Methods
	Conductivity Temperature and Depth (CTD) and Acoustic Doppler Current Profiler (ADCP) Surveys. The CTD and ADCP surveys were done in July 2019 from 13 sampling stations in order to obtain vertical temperature and salinity profiles and tidal circulation patterns. The area was surveyed twice, once each during the flood cycle and ebb cycle of the tides. *Sediment sampling and grain size analysis*. Bottom sediments along the Pakiputan Strait were collected on July 2019 from 15 sampling sites that were selected to cover ~1 km upstream and ~1 km downstream of the proposed bridge site. Sediments were collected using a ponar grab sampler. *Hydrodynamic modelling.* Hydrodynamic model was done using DELF3D modelling software to determine the general flow characteristics and potential changes due to the construction and operation of the bridge, particularly simulate the effects of bridge pier on water flow in Pakiputan Strait. The proposed piers were accounted for by incorporating the calculated friction term of each bridge pier and its associated ship impact protection piles into the hydrodynamic model.
Water Quality	*Surface and Groundwater sampling.* In Davao City, one river was sampled for surface water and one source closest to the alignment of the bridge sampled for groundwater. In Samal Island, there was no nearby surface water, while two (2) sites were sampled for groundwater. In-situ parameters tested include conductivity, pH, total dissolved solids (TDS), salinity and temperature. *Marine water quality*. The tracking and mapping of water quality parameters off the coast of the Pakiputan Strait was carried out using a Hanna HI9828 Water Quality Meter with built-in GPS for in-situ measurements. Aside from in-situ sampling, grab sampling was carried out at ten (10) sampling stations and were submitted to the laboratory for analysis of chemical oxygen demand (COD), total suspended solids (TSS), oil and grease (O&G) and total and fecal coliform levels.
Marine Ecology	*Seagrass Assessment.* Surveys were conducted on 28-29 June and 6-7 December 2019 at 3 stations with 9 points at the Davao side and 3 stations with 9 points at the Samal side. A 50-m transect method, where a 0.5m x 0.5m quadrat was placed every 5 meters to asses and identify the seagrass and seaweed communities. *Corals Assessment.* Coral reefs and reef-associated marine fauna were assessed in areas that may potentially be affected by the proposed project. The baseline assessment was carried out in seven sampling stations, four at Davao and three at IGaCoS, on 28-29 June and 6-7 December 2019. *Marine Assessment.* Benthic ecosystem surveys were conducted using photo-transect for corals, transect-quadrat method for seagrasses and fish visual census (FVC) technique for reef fishes. Seven stations were established. Plankton abundance, diversity and richness were also assessed in 15-16 June 2019. Vertical samples were taken at each station by hauling 25-cm mouth diameter conical plankton, with 20 microns mesh size for phytoplankton samples and 60 microns mesh size for zooplankton samples.
Air	

EIA Key Components	Methods
Climate and Meteorology	The assessment discussed on the review of available secondary data on regional climate, temperature, rainfall, relative humidity, wind speed and direction, cloud cover and climatological conditions.
Ambient Air Quality	24-hour ambient air sampling was undertaken at the proposed impact areas of the bridge project. A total of six (6) stations were set up for the ambient air sampling. Concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulate (TSP) and particulate matter with aerodynamic diameter less than 10 (PM10) and PM2.5 were analyzed by an accredited laboratory; BGI/MESA LABS. PQ 200 TSP/PM10/PM2.5 High Volume Sampler was used to obtain TSP, PM2.5 and PM10; 3-Gas Sampler SO_2 and NO_2.
Noise Levels	A total of six (6) monitoring points were designated for baseline noise measurements; these points are proximal to the air sampling stations. The noise levels were recorded using the CASELLA Sound Level Meter. This was done for 24 hours per station.
People	
Seceondary Data Gathering	Secondary data gathered were acquired from the most recent data of Philippine Statistics Authority (PSA), Comprehensive Land Use Plans of Davao City (2013-2022), Comprehensive Development Plan (CDP) of IGaCoS (2018 - 2023) and Barangay Profiles of Caliclic, Hizon, Limao and R. Castillo. In addition, as-built drawings of existing utilities from concerned utility companies were also used to locate aerial and underground utilities and verify the data gathered from the survey. Data were assessed for demographic, basic services, health and safety and income and employment baseline study.
Scoping and Public Participation	Activities conducted includes initial perception surveys, IECs and FGDs, complemented by public and technical scoping sessions. A total of 3 barangays and 344 households were covered in the perception survey, while about 485 stakeholders from 5 barangays participated in public events related to the project, see **Annex C**.
Traffic Impact Assessment	Data on ferry facilities and annual average daily traffic provided by DPWH were reviewed and supplemented with 24-hour traffic counts in 21 key junctions in Davao and Samal to determine baseline demand and road network performance. Traffic demand was forecasted to determine infrastructure requirements for the bridge crossing, approach roads, and local roads.
Environmental Risk Assessment	Hazards were identified, analyzed, and assessed in terms of environmental risks. Analysis focused on potential safety (i.e. fire, explosion, toxicity) and physical hazards characterized by low probability, high consequence, accidental nature and acute effects.

EIA Summary

- **Siting**

There are six (6) options for the road links structural form proposed for the SIDC project. Based on initial studies and a rigorous option selection process, it was determined that an extradosed bridge (Option 4a-2) along the Southern Corridor was the most preferable option for the SIDC project. **Table 4** shows the various structural forms considered.

Table 4 Summary of Bridge Options

Option	Structural Form
1d	Immersed Tube Tunnel
2b	Low Level Bridge
3	Bridge
4a-1	Box Girder Bridge
4a-2	Extradosed Bridge
4b	Immersed Tube Tunnel

- **Technology Selection**

Given the nature of a bridge project, there will be no alternative/ special technologies, operation processes and measures to minimize waste generation. The updated designs will be determined as the study progresses whilst good site practices and standard waste collection process will be implemented in the construction and operational phases, respectively.

Integrated Summary of Impacts and Efficiency of Measures after Mitigation

Generally, positive impacts are anticipated due to the implementation of the Project, particularly with the increase in Davao and IGaCoS' economy and property values. **Table 5** summarizes the findings and observations regarding the impacts and residual effects of the proposed project with respect to the four components of the EIA.

Table 5 Integrated Summary of Impacts and Efficiency of Measures

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
CONSTRUCTION PHASE			
General			
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	• Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs; • Compliance with RA 6685; • Contractors to provide trainings for hired workers.	Providence on equal employment for qualified workers and livelihood will 80-100% be ensured by the proponent.
Hiring of local workers	Health and Safety of construction workers.	• Use of Personal Protective Equipment to all construction workers; • DPWH and Contractor to provide emergency and health and safety program for workers; • Provide Medical Kit and first aid; • Provide potable water and temporary sanitation facilities; • Provide trash bins in strategic locations and coordinate with LGUs and host barangays for regular waste collection and disposal; • Conduct frequent safety, hygiene, and construction sanitation training for workers; • Training of personnel and staff during emergencies.	Impacts on health and safety will be 80-100% mitigated, considering proponent's aim of zero accident.
General Construction works	Potential threat to health and safety of people / communities	• Ensure site is well-lit, secured and guarded; • Formulate security procedures with local police and LGUs for provision of needed facilities, guard posts. • Provision of Grievance Redress Mechanism for any issues and complaints;	100% efficiency of GRM for complaints and concerns.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
		• Coordinate with concerned agencies to ensure safety and reduced negative impacts to the community and environment.	
Preparation and Construction of Temporary Facilities			
Site preparation, clearing, and/ or tree cutting activities	Impact in terms of compatibility with existing land use	• Reclassification of direct impact areas for infrastructure use and integration of the project in LGU land use and development plans • Reclassification of appropriate land use development and rezoning, particularly on Samal Island Master Plan	Due to the permanent construction effect, the proponent and the contractor will ensure that design of the structures will be in accordance with the Design Standard guidelines of DPWH and other specifications of the project, where necessary
Site preparation, clearing, and/ or tree cutting activities	Displacement and loss of livelihood of residents and business owners during ROW land acquisition.	• Preparation of Resettlement Action Plan, Utilities Relocation Plan, Securing ROW, Land Acquisition, Socio-Economic Profiling, and conduct consultations guided by processes and directives under the Philippine Government, DPWH, DOTr, and ADB (i.e. RA 10752 – ROW Act; DPWH ROW Acquisition Manual; or DOTR ROW Site Acquisition Manual; and resettlement policy). • Proper compensation and/or relocation of affected residents and landowners.	Provide 100% compensation based on the agreement between the proponent and the Project Affected Persons (PAPs).
Site preparation, clearing, and/ or tree cutting activities	Temporary disruption of public services, such as water and electric supply	• Relocation and replacement of affected utilities will be paid by the proponent and will be carried out by the relevant utility companies; • Inform affected stakeholders ahead of any temporary disruption during utility relocation • Attention will be made on utilities that will be relocated and will be closely monitored during implementation of utility relocation	Ensure 100% efficiency through proper coordination of affected communities and businesses.
Site preparation, clearing, and/	Loss of topsoil due to vegetation clearing may trigger soil erosion and may	• Prepare and implement a materials handling program or a site protection and rehabilitation program;	Ensure 100% efficiency in compaction and materials handling plan.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
or tree cutting activities	induce landslides in some areas.	• Immediate compaction of the all-weather road by means of a road roller to prevent any splash and soil erosion.	
Site preparation, clearing, and/ or tree cutting activities	Loss of vegetation during clearing operation (i.e. fruit bearing trees, and forest trees); Possible change in floral community structure	• Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; • Secure applicable and relevant permits, including tree cutting permit should be secured prior to tree cutting activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02. Earth balling of big trees native trees and vegetation will be planted to compensate for any loss or replacement seedlings will be provided by the proponent; • Compensation to owners of non-timber species that will be cut; • Native flora species shall be at least conserved in selected areas to serve as refuge and forage for wildlife species; • Creation of dedicated habitat areas to achieve no net loss habitat or rehabilitate native species in Samal and Davao, as necessary; • A competent, experienced ecologist will oversee the clearance of native flora. • Coordination with LGUs.	DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary;
Site preparation, clearing, and/ or tree cutting activities	Disturbance or loss of habitat and will affect existing wildlife	• Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; • Secure applicable and relevant permits, including tree cutting permit should be secured prior to tree cutting activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02. Earth balling of big trees or replacement seedlings will be provided by the proponent; • Gradual conversion of the area to provide sufficient time for wildlife movement; • A biodiversity protection plan, restoration plans, and a stand-alone monitoring plan will be created to detail the restoration and habitat creation of native flora, as necessary; • Creation of dedicated habitat areas to achieve no net loss habitat or rehabilitate native species in Samal and Davao, as necessary; • Coordination with LGUs.	DPWH will ensure 80-100% efficient on gradual conservation of land use; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Site preparation, clearing, and/ or tree cutting activities	Accumulation of solid wastes; Devaluation of land value as a result of improper solid waste management	• Implement an organized waste storage, collection, and proper waste management system; • Housekeeping measures can also prevent possible contamination in soil and water; • Non-recyclable waste will be collected daily by a licensed 3rd party contractor to ensure cleanliness in the workplace; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices; • Prepare Solid Waste Management Plan in accordance with RA 9003; • Ensure compliance to national and local waste regulations	Waste management will be 90-100% implemented, unless there will be incidents which are uncontrolled.
Site preparation, clearing, and/ or tree cutting activities	May trigger siltation	• Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods; • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to the adjacent water bodies to ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase; • Silt traps will be installed for all nearby water bodies; • The waste soil and other debris will be properly handled and disposed on a regular basis.	Although use of silt curtains will be 40% efficient, impacts on degradation of water will be 80-100% mitigated, hence the proponent will ensure compliant with standards.
Site preparation, clearing, and/ or tree cutting activities	Alteration of air quality from fugitive dust and equipment use.	• Regular and adequate sprinkling of water should be done in the premises to minimize the dust particles generated; • Preventive maintenance of heavy equipment and vehicle; • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQGV.	Impacts on alteration of ambient air will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
		• Workers will be provided with the appropriate personal protective equipment (PPE) and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards; • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
Site preparation, clearing, and/ or tree cutting activities	Disturbance in nearby communities due to generation of noise.	• Use equipment which generates less noise, and/or will be fitted with muffler or silencers; • The host communities will be kept informed of the duration and timing of any noisy construction; • Limit the construction time to a given standard hours or limit night work to avoid distraction of nearby establishments like residential areas; • Periodic monitoring and evaluation of noise levels; • Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment; • The project can use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be used to control noise impacts	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Accumulation of solid wastes; Devaluation of land value as a result of improper solid waste management	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Domestic waste disposal will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices; • Prepare Solid Waste Management Plan in accordance with RA 9003; • Ensure compliance to national and local waste regulations	Waste management will be 90-100% implemented, unless there will be incidents which are uncontrolled.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility.	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Used oil, spillages and other hazardous waste should be collected, contained and disposed by a 3rd party accredited hauler and treater; • Maintenance and proper use of construction materials and heavy vehicles; • Disposal of non-recyclable wastes by a licensed contractor; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	Impacts on generation of hazardous materials will be 90-100% mitigated depending on DENR accredited hauler collection.
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Degradation of water quality due to generation of domestic wastewater	• Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods; • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment • Soil debris and other excavated materials should be hauled out from the site • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • Locate motor-pool area at least 500 meters away from any body of water; • Set up of portable sanitary facilities and collect wastewater to be disposed accordingly; • The contractor will be required to comply with the Civil Works Guidelines; • Project shall be equipped with an oil-water separator to remove oil from effluents prior to discharge to water bodies; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil;	Impacts on generation of domestic wastewater will be 80-100% mitigated, depending on DENR accredited hauler collection, but the proponent will ensure 100% compliant with standards.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
		• Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place).	
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Alteration of air quality from fugitive dust and equipment use.	• Regular and adequate sprinkling of water should be done in the premises to minimize the dust particles generated; • Preventive maintenance of heavy equipment and vehicle; • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQGV. • Workers will be provided with the appropriate personal protective equipment (PPE) and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards; • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	Impacts on alteration of ambient air will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards
Construction and installation of site facilities – Temporary Facilities (field offices and barracks)	Disturbance in nearby communities due to generation of noise.	• Use equipment which generates less noise, and/or will be fitted with muffler or silencers; • The host communities will be kept informed of the duration and timing of any noisy construction; • Limit the construction time to a given standard hours or limit night work to avoid distraction of nearby establishments like residential areas; • Periodic monitoring and evaluation of noise levels; • Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment; • The project can use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be used to control noise impacts.	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Construction, bore piling and installation of piers and columns on land – Permanent Structure			
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	May trigger soil erosion and induce landslides in some areas.	• Prepare and implement site protection plan; • Immediate compaction of the all-weather road by means of a road roller to prevent any splash and soil erosion.	Ensure 100% efficiency in compaction and materials handling plan.
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Change in sub-surface geology and underground conditions due to project inducement of subsidence, karst subsidence, liquefaction, and mass movements	• Consider ground acceleration values in the final project design, particularly pile and pylon foundations; • Conduct detailed geotechnical and subsurface investigations during DED leading to the design of ground improvement activities to be implemented during construction • Design structures and facilities to withstand ground subsidence where suspected to occur • Investigate underlying soils and rocks during DED	Due to the permanent construction effect, the proponent and the contractor will ensure that design of the structures will be in accordance with the Design Standard guidelines of DPWH and other specifications of the project, where necessary.

Activity	**Impact**	**Enhancement/ Mitigating Measure**	**Efficiency of Measures**
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Soil contamination from leaks of lubricants agents and used oil.	• Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place).	Impacts on soil contamination will be 80-100% mitigated, depending on DENR accredited hauler collection, but the proponent will ensure 100% compliant with emergency plans and standards.
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Accumulation of solid wastes	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	Waste management will be 90-100% implemented, unless there will be incidents which are uncontrolled.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility.	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Used oil, spillages and other hazardous waste should be collected, contained and disposed by a 3rd party accredited hauler and treater; • Maintenance and proper use of construction materials and heavy vehicles; • Disposal of non-recyclable wastes by a licensed contractor; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	Impacts on generation of hazardous materials will be 90-100% mitigated depending on DENR accredited hauler collection.
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Impairment of visual aesthetics	• Final project design to consider aesthetic impacts • Harmonize with existing surroundings considering engineering, safety, environmental, and its aesthetic impacts • Ensure that iconic and elegant bridge be maintained and visually appealing during construction phase.	Due to the permanent construction effect, the proponent will ensure that the site is clean and visually appealing during construction phase.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	May trigger siltation	• Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods; • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to the adjacent water bodies to ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase; • Silt traps will be installed for all nearby water bodies; • The waste soil and other debris will be properly handled and disposed on a regular basis.	Although use of silt curtains will be 40% efficient, impacts on degradation of water will be 80-100% mitigated, hence the proponent will ensure compliant with standards.
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Increase in flooding susceptibility	• Provide proper drainage canals that consider surface water flows and existing structures in the area; • Control water inflow by placing water-shut panels, intercept drainages and pump stations in strategically selected areas; • Provide overflows to avoid water build-up on bridges when drainage infrastructure is blocked	Waterways and drainage will be 90-100% managed to ensure control of water flow and contamination.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Degradation of water quality due to oil, fuel or other lubricant agents leaks	• Project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies; • Locate motor-pool area at least 500 meters away from any body of water; • Set-up portable sanitary facilities and collect wastewater to be disposed of accordingly; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place).	Impacts on water contamination will be 80-100% mitigated, depending on DENR accredited hauler collection, but the proponent will ensure 100% compliant with emergency plans and standards.
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure.	Traffic congestion	• Follow the Traffic Management Plan to aid in avoiding traffic congestion; • Contractors to provide traffic enforcers in areas where construction is on-going; • Coordinate with LGUs to provide alternative routes	Impacts on traffic congestion will be 85-95% mitigated.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges and bridge structure; Transport of materials.	Alteration of air quality from fugitive dust and equipment use.	• Regular and adequate sprinkling of water should be done in the premises to minimize the dust particles generated; • Preventive maintenance of heavy equipment and vehicle; • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQGV. • Workers will be provided with the appropriate personal protective equipment (PPE) and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards; • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	Impacts on alteration of ambient air will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards
Excavation on land; Earthmoving through use of heavy equipment; Installation of columns/ foundations and construction of interchanges	Disturbance in nearby communities due to generation of noise.	• Use equipment which generates less noise, and/or will be fitted with muffler or silencers; • The host communities will be kept informed of the duration and timing of any noisy construction; • Limit the construction time to a given standard hours or limit night work to avoid distraction of nearby establishments like residential areas; • Periodic monitoring and evaluation of noise levels; • Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment;	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
and bridge structure; Transport of materials.		• The project can use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be used to control noise impacts.	
Construction, bore piling and installation of piers and columns on marine – Permanent Structure			
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Accumulation of solid wastes and impact on sediments	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Storage or disposal sites of the excavated or dredged sediments should be properly secured to prevent leakage of sediments, contaminants or pollutants through surface runoff; • Slope protection on the bridge landing site, particularly on IGaCoS side, to minimize surface runoff and sedimentation; • Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices; • Compliance to MARPOL 73/78 -Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14; and • Prepare Solid Waste Management Plan in accordance with RA 9003.	Although use of silt curtains will be 40% efficient, waste management will be 90-100% implemented, unless there will be accidents and incidents which are uncontrolled.
Dredging on water;	Water contamination due to fuel, oil and other hazardous materials leakages	• Implement an organized waste collection and storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment;	Impacts on generation of hazardous materials will be 90-100% mitigated,

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Operation of Vessels; Installation of columns/ foundations and construction of bridge structure		• Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in water; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place); • Maintenance and proper use of construction materials and heavy vehicles; and • Ensure compliance to PCG Memorandum # 07-14.	unless there will be incidents which are uncontrolled. This will also depend on DENR accredited hauler collection.
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Impairment of visual aesthetics	• Final project design to consider aesthetic impacts; • Harmonize with existing surroundings considering engineering, safety, environmental, and its aesthetic impacts; and • Ensure that iconic and elegant bridge be maintained and visually appealing during construction phase.	Due to the permanent construction effect, the proponent will ensure that the site is clean and visually appealing during construction phase.
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Degradation of water quality due to construction	• Apply appropriate siltation control measures such as well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase; • The contractor will be required to comply with the Civil Works Guidelines; and	Although use of silt curtains will be 40% efficient, impacts on water quality will be 80-100% mitigated, hence the proponent will ensure compliant with standards.

Activity	**Impact**	**Enhancement/ Mitigating Measure**	**Efficiency of Measures**
		• Compliance in of MARPOL 73/78 -Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14.	
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Seagrass in IGaCoS side are still abundant and thriving and may decline when buried by sediment.	• Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Biodiversity protection plan to be drawn up to detail methods to minimize impacts on seagrass beds and detail seagrass habitat creation and subsequent monitoring; • Surveys to be undertaken to explore opportunities for suitable translocation and habitat creation sites for seagrass beds, should be necessary; and • Dredging must be confined at the immediate area so that only a small part of the meadow will be affected.	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.
Dredging, and bore pilling activities on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Local loss and disturbance of natural sedimentary habitats due to introduction of hard substrates and increase in sediment loads from construction materials Deterioration, destruction and disruption of fish habitats in IGaCoS side.	• Engineering modifications to provide greater surface complexity and encourage marine growth; • Engineering design does not hinder longshore currents and ensures free circulation of water; • Well-designed silt control scheme; and • Proper disposal of debris. • Any debris or concrete waste must be removed as quickly as possible; • Monitoring and evaluation of benthic habitats to be conducted quarterly or bi-annually to capture changes; • Secure storage or disposal sites of excavated or dredged sediments to prevent leakage of sediments, contaminants or pollutants through surface run-off; • Provide slope protection on bridge landing site, particularly on the IGaCoS side, to minimize surface runoff and sedimentation.	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient, but the proponent will ensure 100% compliant with plans and standards especially with proper disposal practices.
Dredging on water;	Changes in channel beds and impacts on fish and aquatic life	• Strict observance and implementation of Site Protection and Rehabilitation Program and materials handling which provide for soil erosion control measures;	Due to the permanent construction effect, the proponent will ensure to

Activity	**Impact**	**Enhancement/ Mitigating Measure**	**Efficiency of Measures**
Operation of Vessels; Installation of columns/ foundations and construction of bridge structure		• Observe best practices in proper construction procedures that promote care and minimal disturbance to the existing environment; • Monitoring and evaluation of benthic habitats, including habitat created/ translocated and remedial actions taken, if required; • Should there be any affected corals and seagrasses, coral translocations/ seagrass mitigation / translocation of any benthic species should be undertaken by a suitably qualified marine ecologist; and • Biodiversity protection plan to be drawn up to detail methods to minimize impacts.	limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient, but the proponent will ensure 100% compliant with plans and standards especially with proper disposal practices. Impacts on biodiversity will be appropriately mitigated through species translocation, habitat creation and the application of pollution prevention and control technologies and practices consistent with international good practices.
Dredging on water; Operation of Vessels; Installation of columns/	Alteration of air quality from fugitive dust and equipment use.	• Regular and adequate sprinkling of water should be done in the premises to minimize the dust particles generated; • Preventive maintenance of heavy equipment and vehicle; • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQGV.	Impacts on alteration of ambient air will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
foundations and construction of bridge structure		• Workers will be provided with the appropriate personal protective equipment (PPE) and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards; and • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Disturbance in nearby communities due to generation of noise.	• Use equipment which generates less noise, and/or will be fitted with muffler or silencers; • The host communities will be kept informed of the duration and timing of any noisy construction; • Limit the construction time to a given standard hours or limit night work to avoid distraction of nearby establishments like residential areas; • Periodic monitoring and evaluation of noise levels; • Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment; and • Construction vessels that will be used will have on-board noise reduction to protect construction workers from excessive noise exposure, in accordance with the International Convention for the Safety of Life at Seas (SOLAS).	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
Dredging on water; Operation of Vessels; Installation of columns/ foundations and construction of	Disruption of marine navigation route along Pakiputan Strait	• Coordinate with Marina, PPA and Coastguard for the rerouting of sea vessels; • Vessels will observe speed restriction and follow routing clearance to avoid sensitive marine areas.	There will be permanent disruption of navigational route.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
bridge structure; Transport of construction materials and demolition debris to and from the construction site during works at marine			
OPERATION PHASE			
Hiring of local workers	Increase in employment opportunities and livelihood	• Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs; • Compliance to RA 6685; and • Contractors to provide trainings for hired workers.	Providence on equal employment for qualified workers and livelihood will 80-100% be ensured by the proponent.
Hiring of local workers	Health and Safety of personnel	• Use of Personal Protective Equipment to all site workers; • DPWH and Contractor to provide emergency and health and safety program for workers; • Provide Medical Kit and first aid; • Provide trash bins in strategic locations and coordinate with LGUs and host barangays for regular waste collection and disposal; • Conduct frequent safety, hygiene, and sanitation training for staff; and • Training of personnel and staff during emergencies.	Impacts on health and safety will be 80-100% mitigated, considering proponent's aim of zero accident.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Operation of the bridge	Potential threat to health and safety of people / communities	• Deploy security personnel and incorporate a control center with CCTV and other monitoring systems; • Ensure site is well-lit, secured and guarded; • Formulate security procedures with local police and LGUs for provision of needed facilities, guard posts; and • Implementation of Emergency Response Team for accidents and other emergency cases.	The proponent will ensure 100% safe use of the bridge and efficiency of Emergency Response Team.
Operation of the bridge	Health and Safety of drivers bridge end-users (e.g. drivers and passengers)	• Regular inspection of bridge; • Good signage and clear direction of traffic and bridge users; and • Training of personnel and staff during emergencies.	
Operation of the bridge	Boost economic development of Samal Island by improving tourism competitiveness		
Operation of the bridge	Accelerate infrastructure development that would enhance internal circulation, mobility and external linkages to support the growth potential of Davao Region		
Operation of bridge	Disruption of natural water flows and currents	• Monitor sediment transport loads; • Samal landfall pier positioning to avoid ephemeral stream locations; • Provide silt removal facilities; and • Site formation design to re-direct surface runoff to appropriate discharge points at each landfall location.	Permanent impact due to the project.

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
Operation of bridge	Disruption of marine navigation route along Pakiputan Strait	• Coordinate with Marina, Philippine Ports Authority (PPA) and Philippine Coast Guard for the rerouting of sea vessels.	Permanent impact due to the project, as some large vessels need to be rerouted
Movement of passengers	Increase in solid waste generation from passengers and operational works	• Provision of waste bins that will allow proper waste segregation at both ends of the bridge; • Regular waste audits and collection of wastes for recycling or disposal; • Samal LGU to highly consider Solid Waste Management for the likely huge increase in development; and • Local authorities to control littering and entry to the island.	Waste management will be 90-100% implemented.
Movement of vehicles along the bridge	Noise from vehicles may exceed national standards for noise in general areas	• Portions of existing viaduct deck high above the sensitive receivers; • Alert signage to reduce noise placed on the bridge; and • Install noise barriers such as insulating walls.	Permanent impact due to the project.
ABANDONEMENT PHASE			
Abandonment on Bridge	Land	• Complete soil/land evaluation to determine residual impacts and appropriate corrective actions, if applicable.	
Abandonment on Bridge	Water	• Assess groundwater capacity and monitoring of surface water quality to evaluate impacts during operation of project and provide possible mitigation measures.	
Abandonment on Bridge	Unlikely air impacts due to dispersion of mobile source emissions	• Assess temporary impacts during demolition; and • Assess unlikely impacts due to dispersion or mobile source emissions to the atmosphere and dilution of pollutants released when bridge was in operation	
Abandonment on Bridge	Loss of economic benefits and livelihood and employment	• Assess loss of economic benefits; • Assess Loss of livelihood and employment;	

Activity	Impact	Enhancement/ Mitigating Measure	Efficiency of Measures
		• Implement a Labor Retrenchment and support package and labor support programs	

Risks and uncertainties relating to the findings and implications for decision making

Risks and uncertainties anticipated regarding the construction and operation of the bridge are shown in the **Table 6** below.

Table 6 Risk and Uncertainties of the Project

EIA Module	Risks and Uncertainties	Control Measures
Project Design	Structural failure	Use of good competent designer and contractor and supervised to ensure high quality finish Use of high-quality materials and scaffoldings during construction Regular maintenance and monitoring of the structure particularly during operations phase
Land	Change in sub-surface geology and underground conditions due to the project, inducement of subsidence, karst subsidence, liquefaction and mass movements	Conduct of detailed geotechnical and subsurface investigations during the DED phase, leading to the design of ground improvement activities to be implemented during construction
	Degradation of direct and indirect impact areas due to improper solid waste management and pollution	Implementation of proper management practices and mitigating and enhancing measures with the local LGU’s
	Increase in solid waste generation from passengers and operational works	Provide waste bins to allow proper waste segregation at both ends of the bridge Regularly conduct waste audits and waste collection for recycling or disposal Samal LGU to highly consider Solid Waste Management for the likely huge increase in development. Local authorities to control littering and entry to the island.
	Vegetation removal during clearing operation; Possible change in floral community structure	Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; Secure applicable and relevant permits, includiMng tree cutting permit should be secured prior to tree cutting activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02.

EIA Module	Risks and Uncertainties	Control Measures
		Earth balling of big trees native trees and vegetation will be planted to compensate for any loss or replacement seedlings will be provided by the proponent; Compensation to owners of non-timber species that will be cut; Native flora species shall be at least conserved in selected areas to serve as refuge and forage for wildlife species; Creation of dedicated habitat areas to achieve no net loss habitat or rehabilitate native species in Samal and Davao; A competent, experienced ecologist will oversee the clearance of native flora. Coordination with LGUs.
	Clearing of vegetation will affect existing wildlife	Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; Secure applicable and relevant permits, including tree cutting permit should be secured prior to tree cutting activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02. Earth balling of big trees or replacement seedlings will be provided by the proponent; Gradual conversion of the area to provide sufficient time for wildlife movement; A biodiversity protection plan, restoration plans, and a stand-alone monitoring plan will be created to detail the restoration and habitat creation of native flora, as necessary; Coordination with LGUs.
Water	Damage or collapse due to tsunami, seiches and storm surge	Final design of mitigating measures such as breakwaters or wave dissipating blocks based on more detailed studies
	Increase in flooding susceptibility	Proper drainage channels that take into consideration surface water flows and existing structures in the area Ground disturbance and removal of vegetation minimized to preserve watershed characteristics Provision of overflows to avoid water build-up on bridges when drainage infrastructure is blocked Design of structures to have a clearance above established flood levels

EIA Module	Risks and Uncertainties	Control Measures
	Degradation of water quality	Application of appropriate erosion control measures such as addition of pavements, concrete sea walls, sediment traps and barriers during heavy rain periods Hauling of soil debris and other excavated materials from the site Locate motor-pool area at least 500 meters away from any body of water Set up of portable sanitary facilities and collect wastewater to be disposed accordingly The contractor will be required to comply with the Civil Works Guidelines Project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies
	Scouring and sedimentation near the piers	Regular seabed monitoring to determine sites of scouring
	Possible contamination of nearby water body due to improper effluent handling/ management/ disposal which leads to deterioration, destruction and disruption of fish habitats in IGaCoS side.	Removal of any debris or concrete waste as quickly as possible. Monitoring and evaluation of benthic habitats to be conducted quarterly or bi-annually to capture changes Samal landfall pier positioning to avoid ephemeral stream locations. Site formation design to re-direct surface runoff to appropriate discharge points at each landfall location.
	Seagrass in IGaCoS side are still abundant and thriving and may decline when buried by sediment	Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; Biodiversity protection plan to be drawn up to detail methods to minimize impacts on seagrass beds and detail seagrass habitat creation and subsequent monitoring. Surveys to be undertaken to explore opportunities for suitable translocation and habitat creation sites for seagrass beds, should be necessary. Dredging must be confined at the immediate area so that only a small part of the meadow will be affected.
	Changes in channel beds and impacts on fish and aquatic life resulting from	Strict observance and implementation of Site Protection and Rehabilitation Program and materials handling which provide for soil erosion control measures;

EIA Module	Risks and Uncertainties	Control Measures
	demolition, excavation, pile driving and bridge structure construction.	Observe best practices in proper construction procedures that promote care and minimal disturbance to the existing environment; Monitoring and evaluation of benthic habitats, including habitat created/ translocated and remedial actions taken, if required; Should there be any affected corals and seagrasses, coral translocations/ seagrass mitigation / translocation of any benthic species should be undertaken by a suitably qualified marine ecologist. Biodiversity protection plan to be drawn up to detail methods to minimize impacts.
Air	Alteration of air quality from vehicles, fugitive dust and from equipment use	Regular and adequate sprinkling of water in the premises to minimize the dust particles generated. Preventive maintenance of heavy equipment and vehicle Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the DAO 2000-81
	Noise Generation – Disturbs people and areas	Use of equipment which generates less noise Limit construction time to given standard hours or limit night work to avoid distraction of nearby residential areas Periodic monitoring and evaluation of noise levels, among other parameters included in the ECC for future references
	Excessive noise and vibration from construction equipment and vehicles may exceed national standards for noise in general areas	Installation of noise barricade may be considered
People	Accidents and injuries on the project site	Orientation of workers/personnel on occupational safety, development of strong safety culture with the contractor and the proponent. Use of Personal Protective Equipment by all construction workers Provision of medical kit and first aid

EIA Module	Risks and Uncertainties	Control Measures
	Health and Safety of drivers and people crossing the bridge	Inspection of bridge before operations Training of personnel and staff during emergencies

1 Project Description

1.1 Project Location and Area

1.1.1 Description of Project Area

The proposed SIDC Project will be linking two cities, particularly the northeastern section of Davao City and the northwestern side of Samal Island. Davao City is approximately 970 km south-southeast of the Philippine capital Manila. The site is accessible by 1.5-hour plane trip or by 48-hour private vehicle or commuter buses trip, traversing the Pan-Philippine National Highway and through roll on-roll off (RORO) ferries that interconnect the eastern islands of the country from Luzon to Mindanao.

The SIDC Project will be roughly located within the geographic coordinates indicated in **Table 1.1** (WGS 1984 datum) at the Davao City side and along the western coast of the Island Garden City of Samal (IGaCoS) (**Annex G**). **Figure 1.1** shows the vicinity map of the Project.

The Davao landing point is located within Barangay Hizon and is approximately 8.2km (road distance) and 5km (aerial distance) northeast of the City Hall of Davao. From the city center, the landing point may be accessed by taking various routes along R. Castillo Street (via Quezon Boulevard or Elpidio Quirino Highway) or J.P. Laurel Avenue (via C.M. Recto Street) through various private or public conveyances including non-motorized transport and cars, motorcycles, tricycles, jeepneys or buses.

The Samal landing point, on the other hand, is located within Barangay Limao and is approximately 10.2 km (road distance) and 5.5 km (aerial distance) from the IGaCoS City Hall. From the City Hall, the landing point may be accessed by taking the Samal Island Circumferential Road via private vehicles or buses, multicabs or modified commuter motorcycles locally referred to as habal-habal.

Table 1.1 Geographic Coordinates (WGS 1984)

Point	Latitude	Longitude
1	7° 5' 57.315" N	125° 40' 4.535" E
2	7° 5' 57.315" N	125° 40' 4.430" E
3	7° 5' 57.297" N	125° 40' 4.279" E
4	7° 5' 57.239" N	125° 40' 4.098" E
5	7° 5' 57.192" N	125° 40' 3.999" E
6	7° 5' 57.071" N	125° 40' 3.841" E
7	7° 5' 56.793" N	125° 40' 3.637" E
8	7° 5' 56.650" N	125° 40' 3.584" E
9	7° 5' 56.412" N	125° 40' 3.550" E
10	7° 5' 56.268" N	125° 40' 3.561" E

Point	Latitude	Longitude
11	7° 5' 56.058" N	125° 40' 3.618" E
12	7° 5' 55.891" N	125° 40' 3.708" E
13	7° 5' 55.784" N	125° 40' 3.791" E
14	7° 5' 55.581" N	125° 40' 4.045" E
15	7° 5' 55.529" N	125° 40' 4.207" E
16	7° 5' 55.507" N	125° 40' 4.303" E
17	7° 5' 55.505" N	125° 40' 4.607" E
18	7° 5' 55.617" N	125° 40' 4.921" E
19	7° 5' 55.774" N	125° 40' 5.122" E
20	7° 5' 55.967" N	125° 40' 5.263" E
21	7° 5' 56.229" N	125° 40' 5.357" E
22	7° 5' 56.507" N	125° 40' 5.369" E
23	7° 5' 56.739" N	125° 40' 5.311" E
24	7° 5' 56.948" N	125° 40' 5.194" E
25	7° 5' 57.119" N	125° 40' 5.028" E
26	7° 5' 57.292" N	125° 40' 4.692" E
27	7° 5' 52.896" N	125° 40' 4.223" E
28	7° 5' 53.453" N	125° 40' 4.166" E
29	7° 5' 54.010" N	125° 40' 4.111" E
30	7° 5' 54.569" N	125° 40' 4.100" E
31	7° 5' 55.124" N	125° 40' 4.170" E
32	7° 5' 58.056" N	125° 40' 4.494" E
33	7° 5' 58.610" N	125° 40' 4.424" E
34	7° 5' 59.143" N	125° 40' 4.260" E
35	7° 5' 59.643" N	125° 40' 4.010" E
36	7° 6' 0.117" N	125° 40' 3.713" E
37	7° 6' 0.590" N	125° 40' 3.412" E
38	7° 6' 1.063" N	125° 40' 3.112" E
39	7° 6' 1.536" N	125° 40' 2.812" E
40	7° 6' 2.008" N	125° 40' 2.512" E
41	7° 5' 55.317" N	125° 40' 4.197" E
42	7° 5' 55.511" N	125° 40' 4.186" E
43	7° 5' 57.337" N	125° 40' 4.414" E
44	7° 5' 57.591" N	125° 40' 4.485" E
45	7° 5' 57.840" N	125° 40' 4.501" E
46	7° 6' 12.311" N	125° 38' 29.814" E
47	7° 6' 12.777" N	125° 38' 32.817" E

Point	Latitude	Longitude
48	7° 6' 13.244" N	125° 38' 35.820" E
49	7° 6' 12.077" N	125° 38' 28.313" E
50	7° 6' 13.477" N	125° 38' 37.322" E
51	7° 6' 5.402" N	125° 38' 29.299" E
52	7° 6' 4.711" N	125° 38' 30.384" E
53	7° 6' 3.713" N	125° 38' 31.955" E
54	7° 6' 26.808" N	125° 38' 46.401" E
55	7° 6' 25.892" N	125° 38' 47.471" E
56	7° 6' 24.656" N	125° 38' 48.945" E
57	7° 6' 4.451" N	125° 38' 30.173" E
58	7° 6' 7.095" N	125° 38' 32.264" E
59	7° 6' 9.778" N	125° 38' 34.298" E
60	7° 6' 12.390" N	125° 38' 36.433" E
61	7° 6' 15.002" N	125° 38' 38.568" E
62	7° 6' 17.615" N	125° 38' 40.703" E
63	7° 6' 20.227" N	125° 38' 42.838" E
64	7° 6' 22.839" N	125° 38' 44.973" E
65	7° 6' 25.451" N	125° 38' 47.109" E
66	7° 6' 28.063" N	125° 38' 49.243" E
67	7° 6' 30.676" N	125° 38' 51.378" E
68	7° 6' 3.141" N	125° 38' 29.110" E
69	7° 6' 31.982" N	125° 38' 52.446" E
70	7° 6' 14.729" N	125° 38' 48.835" E
71	7° 6' 15.352" N	125° 38' 45.628" E
72	7° 6' 13.975" N	125° 38' 52.024" E
73	7° 6' 13.123" N	125° 38' 55.189" E
74	7° 6' 12.236" N	125° 38' 58.344" E
75	7° 6' 11.349" N	125° 39' 1.499" E
76	7° 6' 10.461" N	125° 39' 4.654" E
77	7° 6' 9.574" N	125° 39' 7.810" E
78	7° 6' 8.687" N	125° 39' 10.965" E
79	7° 6' 7.800" N	125° 39' 14.120" E
80	7° 6' 6.913" N	125° 39' 17.275" E
81	7° 6' 6.025" N	125° 39' 20.431" E
82	7° 6' 5.138" N	125° 39' 23.586" E
83	7° 6' 4.251" N	125° 39' 26.741" E
84	7° 6' 3.364" N	125° 39' 29.896" E

Point	Latitude	Longitude
85	7° 6' 2.477" N	125° 39' 33.052" E
86	7° 6' 1.589" N	125° 39' 36.207" E
87	7° 6' 0.704" N	125° 39' 39.362" E
88	7° 5' 59.869" N	125° 39' 42.532" E
89	7° 5' 59.138" N	125° 39' 45.726" E
90	7° 5' 58.533" N	125° 39' 48.946" E
91	7° 5' 58.041" N	125° 39' 52.187" E
92	7° 5' 57.605" N	125° 39' 55.435" E
93	7° 5' 57.172" N	125° 39' 58.684" E
94	7° 5' 56.741" N	125° 40' 1.934" E
95	7° 6' 15.628" N	125° 38' 44.023" E
96	7° 5' 56.531" N	125° 40' 3.559" E
97	7° 6' 16.098" N	125° 38' 42.608" E
98	7° 6' 16.660" N	125° 38' 42.000" E
99	7° 6' 17.089" N	125° 38' 41.770" E
100	7° 6' 17.562" N	125° 38' 41.655" E
101	7° 6' 18.104" N	125° 38' 41.673" E
102	7° 6' 18.673" N	125° 38' 41.856" E
103	7° 6' 19.185" N	125° 38' 42.149" E
104	7° 6' 15.905" N	125° 38' 42.392" E
105	7° 6' 16.038" N	125° 38' 41.254" E
106	7° 6' 16.030" N	125° 38' 40.580" E
107	7° 6' 15.921" N	125° 38' 40.030" E
108	7° 6' 15.581" N	125° 38' 39.330" E
109	7° 6' 15.987" N	125° 38' 41.803" E

The directly impacted communities (DIC) along the proposed bridge are barangays Vicente Hizon, R. Castillo and Angliongto in Davao City and Barangay Limao in IGaCoS, sourced from Department of Environment and Natural Resources (DENR) Region XI **(**Figure 1.3).

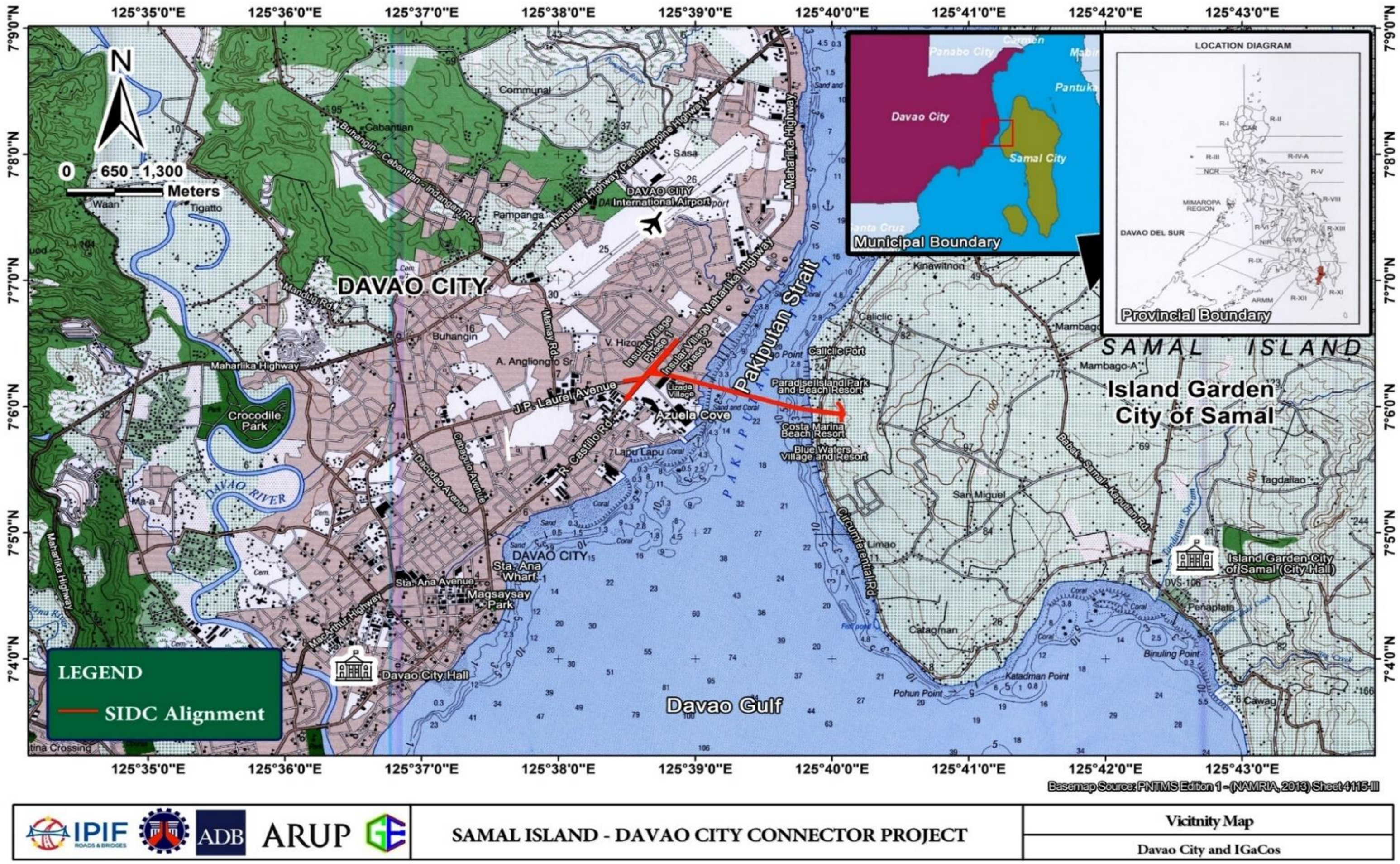
The Davao City inland portion of the bridge will fall within the political jurisdiction of the three above mentioned barangays, which contain a mix of different land uses, including residential, commercial and industrial, with commercial establishments encountered near the main road of the National Highway which leads to the proposed connector project. Public utility vehicles, tricycles and private vehicles are the main means of transportation in the area. To cross between IGaCoS and Davao, barges are currently being used to transport passengers and vehicles.

1.1.2 Impact Areas

The proposed roundabout on the IGaCoS side will be connected to the circumferential road of the island. The IGaCoS inland section of the SIDC lies within developed resort areas in the southern section of Barangay Caliclic and close to the border of the adjoining Barangay Limao. The direct impact area is the Paradise Island Park and Beach Resort owned by the Rodriguez clan, while the indirect impact area includes the Costa Marina Beach Resort. The complete list of affected areas is summarized and shown in **Table 1.2** and Figure 1.4.

Table 1.2 Direct and Indirect Impact Areas

Impact Areas	Davao City	Samal
Direct Impact Areas (DIA)	Lanang Beach Club, particularly Aplaya Beach Resort, Residence 1234 (apartment), Modern Times Enterprises, Merco bakeshop and other commercial establishments in the same building owned by Damosa Land, Caltex gasoline station, Petron gasul outlet, Mindanao Trucking Corporation, Daruma Industries, Staff house of Acacia Hotel employees, Commercial space and guard house along the West Insular Village main road Pidok's restaurant parking space West Empire Chinese restaurant parking space, Security Bank parking space R Gem Auto Trade Repair and Servicing Center parking space Fellowship Vineyard parking space Bayantel office parking space TW Gas parking space Sunscor Realty parking space, Pakiputan Strait	Lucas and Rodriguez Land
Indirect Impact Areas	Azuela Cove South Bay Lumber	Paradise Island Blue Waters



Source: PNTMS Edition 1 - (NAMRIA,2013) Sheet No. 4115-III

Figure 1.1 Vicinity Map

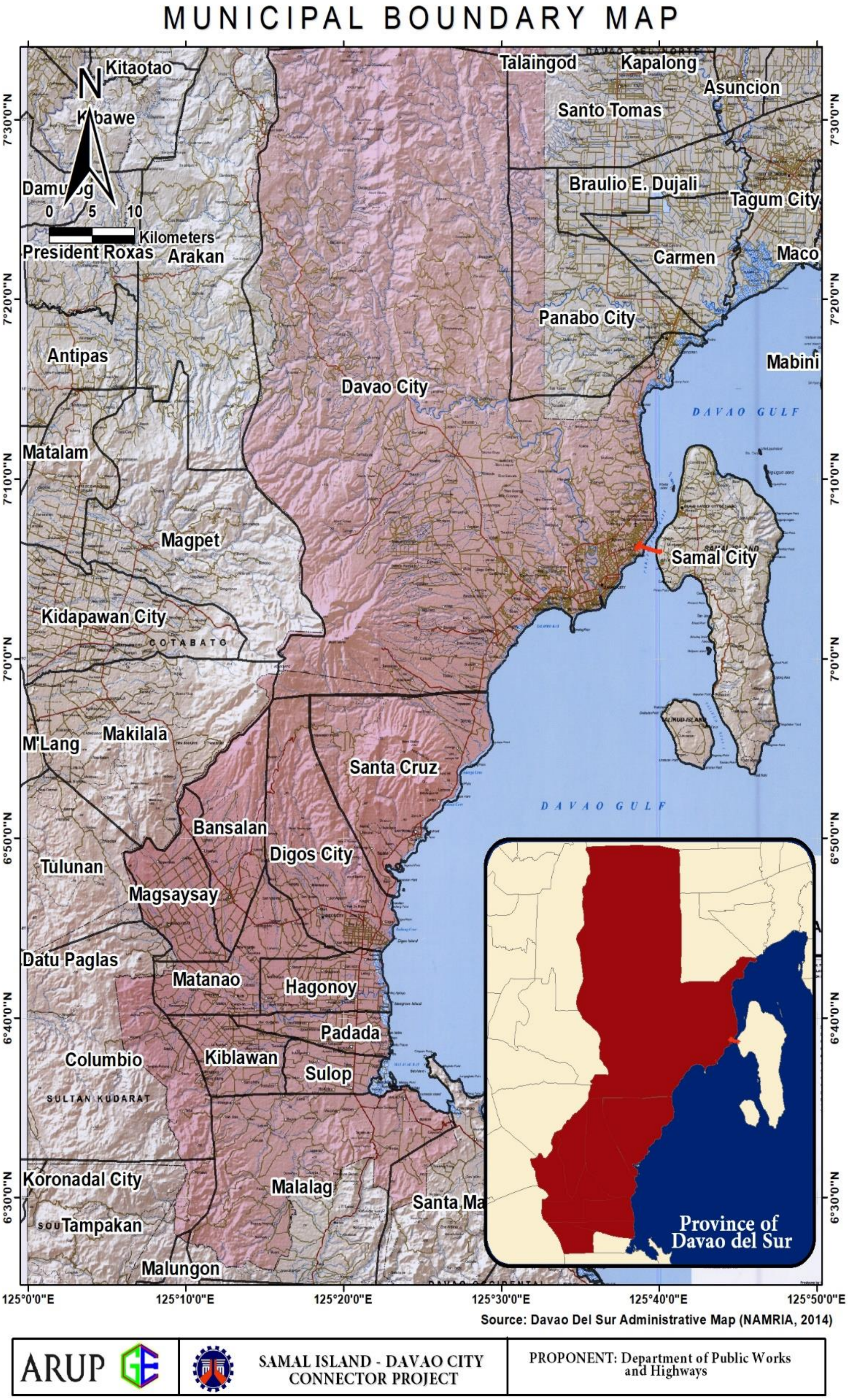
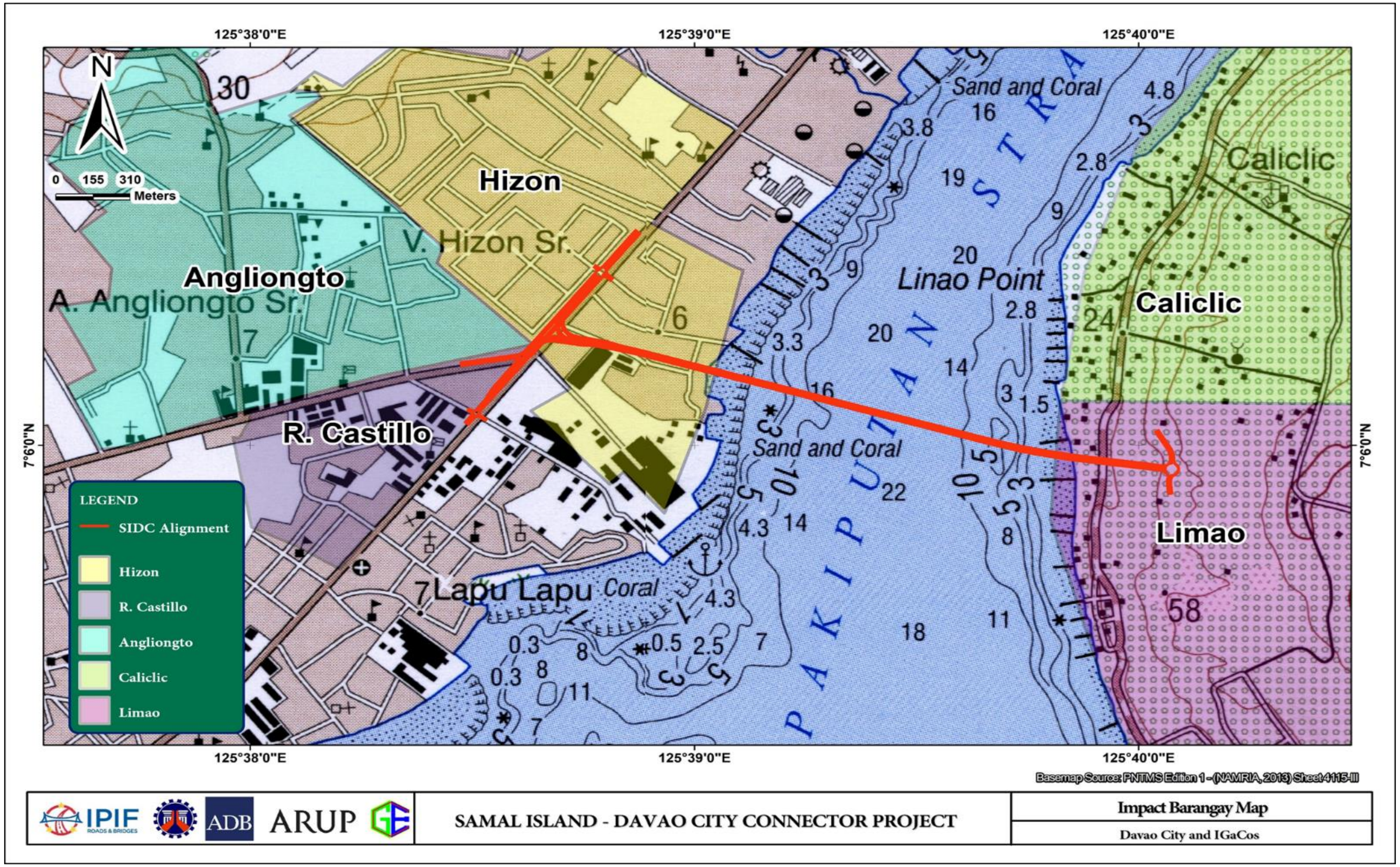
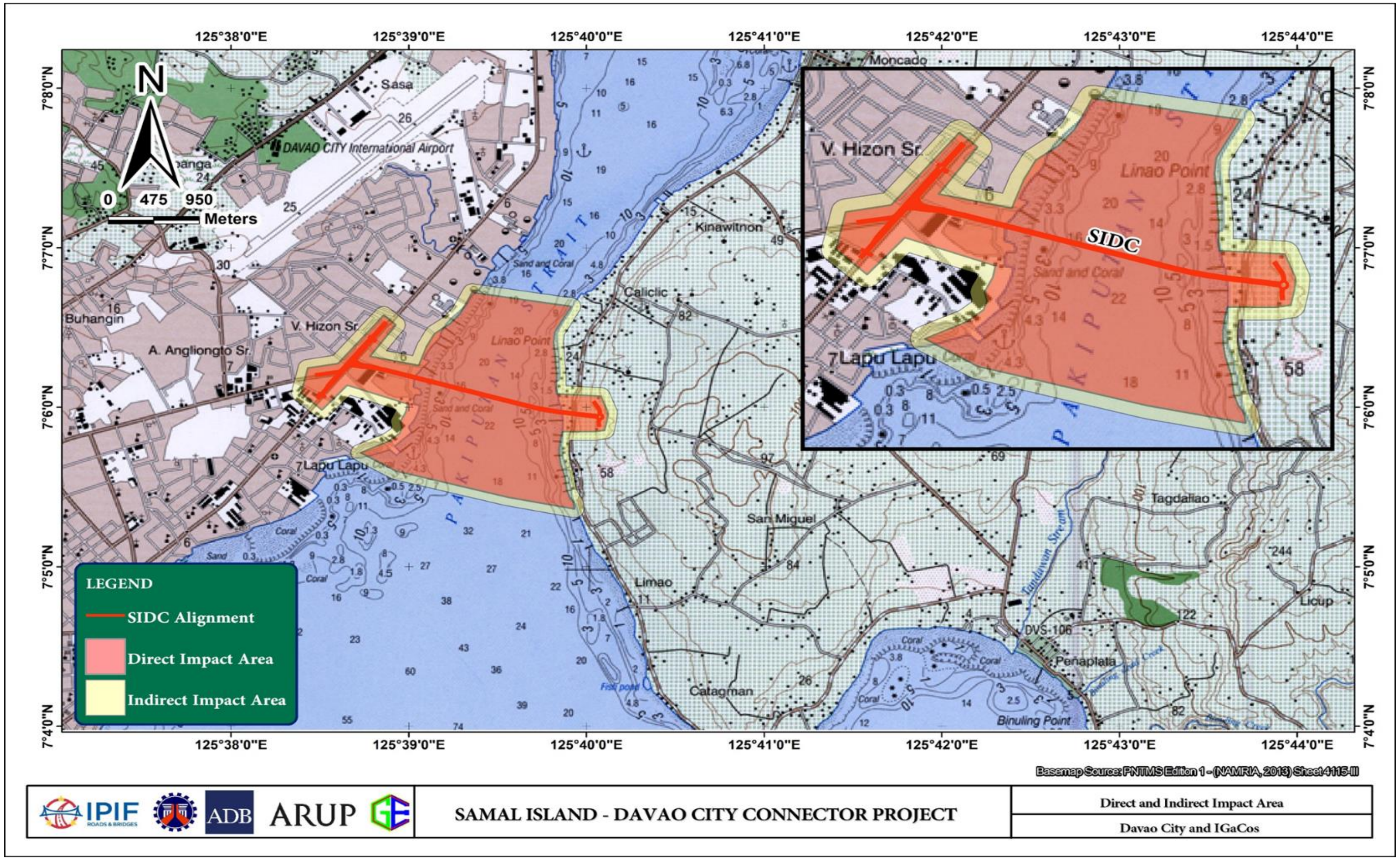


Figure 1.2 Municipal Boundary Map



Sources: PNTMS Edition 1 - (NAMRIA,2013) Sheet No. 4115-III; DENR XI. Barangay Boundaries Shapefile

Figure 1.3 NAMRIA map Showing the Impact Barangays and its boundaries



Basemap Source: PNTMS Edition 1 - (NAMRIA,2013) Sheet No. 4115-III WGS84

Figure 1.4 NAMRIA map showing the direct and indirect impact areas of the project.

1.2 Project Rationale

During the World Economic Forum (WEF) on the Association of Southeast Asian Nations held in Cambodia, Philippine President Rodrigo Roa Duterte presented the administration's ten-point socio-economic agenda. The fourth agenda aims to accelerate the annual infrastructure spending to account for 5% of the gross domestic product, with Public-Private-Partnership (PPP) playing the key role. In line with this, the administration intends to spend 8 to 9 trillion pesos from 2017-2022 solely for infrastructure. These infrastructure projects will allow the recipient communities to have easy access to work, businesses, markets, education, health and other services. According to the project administration manual of the ADB for the infrastructure preparation and innovation facility (IPIF), the impact of underdeveloped public infrastructure in the Republic of the Philippines will impede the potential of businesses and economic opportunities in the country.

The SIDC Project is one of the 75 big-ticket flagship projects (now increased to 100 based on the 2019 revised list of priority projects) under the "Build, Build, Build" program. This was first conceptualized in the year 1970, or about 40 years ago. The project team from the DPWH and Ove Arup & Partners Hong Kong Ltd. presented the results of the Feasibility Study Stage I to the Regional Development Council (RDC) XI during its first quarter meeting on 26 March 2019. The presentation included four possible alignment corridors for the SIDC, which are detailed in **Section 1.3**. After the said meeting, RDC endorsed Option 4 from among the four alignment corridors, which is the subject of this EIS Report.

The proposed project will link the existing road networks of Davao City and IGaCoS to enhance the economic activity in both cities. This is expected to reduce travel time and address reliability constraints due to the current conditions of the ferry services in the region. The benefits of the project include a resilient and solid transportation network and improved access to education, employment and business opportunities, as well as other services the two cities can and will offer. Furthermore, utilities such as telecommunications, water and power will become more accessible to the island. Through this proposed bridge, IGaCoS may even become one of the world-class tourist destinations in the long run. In general, the proposed project will support the growth of Davao Region through enhanced internal circulation, mobility and external linkages.

Moreover, providing a road link offers the best opportunity to integrate IGaCoS into Davao's expanding economy, which allows Samal to share in the rapid economic growth of Davao City, and to drive economic growth through better access to labour and capital. Infrastructure will be critical to raising the competitiveness of local industries and realising the growth opportunities.

1.3 Project Alternatives

1.3.1 Alternative Options

In providing a permanent roadway between Davao City and IGaCoS, four potential alignment corridors were initially considered for the Feasibility Stage Stage I of the project as illustrated in **Figure 1.5**, while a summary of options is presented in **Table 1.3**.

Table 1.3 Summary of Alignment Options

Alignment Option	Type	Key Points
Northern Corridor	Tunnel	Near Malagamot Road towards Arboles Island
North of Sasa Port	Low level Bridge	Nearest to Sasa Port
Central Corridor	METI Bridge	Subject of previous Ministry of Economy, Trade and Industry (METI) Feasibility Study
Southern Corridor	Bridge or Tunnel	Possible connection to Davao Coastal Road

Options and sub-option alignments were then identified within each of these corridors during the project's limited duration of Stage I of Feasibility Stage. Alignment options were studied and recorded in the A3 Highways Bridges Tunnel and Civil Engineering Report including the proposal of JICA (METI alignment) in the previous study for Samal Island – Davao City Bridge.

Option 1: (options 1a to 1d) were immersed tube tunnels in the Northern Corridor connecting between landing point D1 in Davao near Malagamot Road and different landing points at the Samal Circumferential Road, over a length of approximately 4.5 km**.**

Option 2: (options 2a to 2c) were low level bridges approximately 2.5 km long in the additional corridor, connecting point D2 on the Davao City – Panabo City Road to different points on the Samal Circumferential Road.

Option 3: was a bridge considered in the Central Corridor at the shortest crossing point, based on a scheme previous developed in a Feasibility Study by the Japanese Ministry of Economy, Trade and Industry (METI) in 2016.

Option 4: (options 4a and 4b) were developed in the Southern Corridor, crossing approximately 2.8 km between landing point D4 near the junction of J.P. Laurel Avenue and R. Castillo Street in Davao over to landing point S8 on the Samal Circumferential Road, either by bridge or tunnel.

From the ten alignment options, these were narrowed down to five options. **Table 1.4** shows a summary of the options that were taken forward to Options Selection and Scoring Workshop.

Table 1.4 Alignment Options

Alignment Options	Landing Point		Structure Type	Option Description
	Davao City	Samal Island		
Option 1d: Tunnel in Northern Corridor	D1	S9	Tunnel	Immersed Tube Tunnel (IMT) that connects Davao City-Panabo City Road (in Tambo), including reclamation south of Arboles Island, and viaduct or embankment joining to Samal Island. No restrictions to navigation. Limitations for dangerous goods vehicles. The total length of this option is 3,850m. Expensive.
Option 2b: Low Level bridge just north of Sasa port	D2	S5	Low level bridge	Viaduct connecting between Davao City-Panabo City Road (just north of Sasa Port) and Samal Circumferential Road (in Kinawitnon). Ships would have unrestricted access to Sasa port from the south. Large vessels wishing to travel further north would need to go around the eastern side of

Alignment Options	Landing Point		Structure Type	Option Description
	Davao City	Samal Island		
				Samal Island. The total length of this option is 2,500m.
Option 3: Bridge in Central Corridor	D3	S7	Bridge	Bridge between Davao City - Panabo City Road (south of Sasa Port) and Samal Circumferential Road (in Caliclic), with a 300m span. Very large vessels going to Sasa port would need to divert to the eastern side of Samal Island and approach the port from the north. The total length of this option is 2,650m.
Option 4a: Bridge in Southern Corridor	D4	S8	4a-1 - Box girder bridge 4a- 2 - Extradosed bridge	Bridge between R. Castillo – Daang Maharlika junction and Samal Circumferential Road, with large navigation span (dependent on airport height restriction). Very large vessels going to Sasa port would need to divert to the eastern side of Samal Island and approach the port from the north. The total length of this option is 2,850m.
Option 4b: Tunnel in Southern Corridor	D4	S8	Tunnel	IMT between R.Castillo – Daang Maharlika junction and Samal Circumferential Rd (near Caliclic / Limao), with large navigation span (dependent on airport height restriction). Very large vessels going to Sasa port would need to divert to the eastern side of Samal Island and approach the port from the north. The total length of this option is 2,850m. No restrictions to navigation. Limitations for dangerous goods vehicles. Expensive.

1.3.2 Options Selection and Scoring

An option selection workshop was held on 19 February 2019 to compare the advantages and disadvantages of the shortlisted options and in order to select which option will proceed to Stage II of the Feasibility Study.

These options were assessed using the Option Selection Methodology, whereby a score is given to various criteria that had been identified as key to the success of the project in the categories, Technical, Financial, Economic, Environmental, and Social.

Each category was divided into several definable criteria, which each alignment option can be scored against. A ranking and weighting system was determined upon establishment of the criteria. The weighting system for the criteria was agreed during the option selection workshop at ADB and confirmed by DPWH.The criteria for the evaluation were grouped and assigned with corresponding weights under the following criteria categories:

Table 1.5 Weighting Criteria

Criteria	Weightings
Technical	30%
Financial	25%
Economics	25%

Criteria	**Weightings**
Environmental	10%
Social	10%
Total	**100%**

For each of the criteria the order of preference will be identified along with a scaling of base score, which can be a maximum of 10 but is subject to agreement by relevant stakeholders such as concerned government offices.

For base score of scale of 10, score of 8 to 10 – Excellent; score 6 to 8 – Good; score 4 to 6 – Fair; score 2 to 4 – Poor and 1 to 2 – very poor. Or in general a score of 5 and above is considered to be relatively satisfactory and a score below 5 is less than satisfactory. A score of 1 can be considered to be highly undesirable and approaching an insurmountable problem. When 0 is scored for a particular discipline, the entire option is insurmountable and is considered as a nonstarter. This score is required as in some cases, an option cannot be found infeasible for a particular discipline until a very late stage.

Table 1.6 Performance Scoring Criteria

Performance	**Score**
Excellent	9 to 10
Good	7 to 8
Acceptable	5 to 6
Poor	3 to 4
Very poor	1 to 2

In the Option Selection and Scoring Workshop, the alignment options and concept design, associated implementation duration and approximate cost estimate, were presented. Sensititivity tests were undertaken on the findings to compare against 'what-if' scenarios to ensure accuracy. The weighted scores were then calculated and the summary of results was presented. The stakeholders in the workshop were then given the opportunity to comment and discuss the scores and any other pertinent issues. The scores of all the criteria and the preferred alignment option were then agreed and concluded in the workshop.

The key challenges faced in appraising each alignment option include:

- The impact of height restrictions on bridge options located in proximity to flight paths at the Francisco Bangoy International Airport. Height restrictions on these sub-options will impact vessel navigation in the strait. A series of port facilities such as Sasa and Tefasco operate in the strait and they may see their operations affected to some degree, as large vessels would be unable to pass under these bridge structures.

- Land availability for construction at landing points, and the potential for resettlement requirements associated with acquiring the Right of Way.

- Integration with the existing road network and potential requirements for less desirable turning radii on slip lanes at interchanges.

- Existing road network congestion at the landing points for some sub-options, and the impact that differing alignments may have in exacerbating these issues.

- A lack of pedestrian and cyclist accessibility via tunnels as opposed to bridges, and the impact of a tunnel option in meeting wider initiatives to enhance walking and cycling facilities.

1.3.3 Assessment of Alternative Options

The project options were carefully assessed based on a set of criteria both measurable (i.e. cost) and other more subjective non-quantifiable items such as some of the potential environmental impacts. The evaluation procedure involves the comparison of each option against baseline criteria. The final alignment selected was determined through Option Selection and Scoring Workshop conducted last 19 February 2019. The findings and assessment for each criteria per alternative option are discussed in detail in **Table 1.7**.

Table 1.7 Assessment of Alternative Options for SIDC

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
TECHNICAL					
Efficiency of Road Traffic Movement	Option serves desired travel patterns (from previous JICA Study on Davao–Samal Island Linkage) Able to connect to Davao City Bypass to minimize freight impact on local roads. Does not have good access to Coastal Road	Option lands near Sasa Port. Traffic and freight must use Daang Maharlika Highway (although less congested as it is further from the CBD) Not located close to strategic Coastal Road or Davao City Bypass linkages, thus will increase traffic and freight volumes on local roads.	Can accommodate desired travel patterns (from JICA Study on Davao–Samal Island Linkage) even though traffic still must travel on congested Daang Maharlika Highway to reach market in CBD Located several kilometres away from Coastal Road or the Davao Bypass Road, which would mean higher freight and vehicle movements on local road network There is limited space available, and a sub–standard directional T junction is proposed.	Option serves desired travel patterns (from JICA Study on Davao–Samal Island Linkage) Able to connect with the planned Coastal Road to minimize freight impacts on local roads. Poor access to JICA Bypass Road.	Option serves desired travel patterns (from JICA Study on Davao–Samal Island Linkage). Able to connect with the planned Coastal Road to minimize freight impacts on local roads. Poor access to JICA Bypass Road
Impact on Marine Traffic	Tunnel across the northern portion of the Pakiputan Strait towards Arboles Island, and then a low-level bridge east of Arboles island towards Samal.	Low level bridge, with the narrowest navigation channel. Allows access to Sasa Port, but all northbound vessels (towards Panabo) using the strait will need	Bridge with small and restrictive one-way traffic navigation channel. Does not allow access to Sasa Port or northbound for post Panamax vessels.	Bridge with medium navigation channel. Allows access for 90% of the vessels currently using the Strait.	Tunnel crossing the southern portion of the Pakiputan Strait, providing un–restricted access for vessels using the Strait.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
	Provides un–restricted access for vessels using the Strait.	to re–route around Samal Island.	Larger vessels will need to re–route around Samal Island. Additionally, the structure is highly susceptible to ship impact.	Lager vessels travelling northbound, would need to re–route around Samal Island.	
Pedestrian/ Cyclist Friendliness	Tunnel cannot accommodate a shared use path for active transportation use.	Shared use path incorporated in functional cross section and separated from traffic.	Shared use path incorporated in functional cross section and separated from traffic.	Shared use path incorporated in functional cross section and separated from traffic. It is possible that the shared use path could connect to the shared use path of the Davao City Coastal Road Project. Thus, creating an attractive active transportation route.	Tunnel cannot accommodate a shared use path for active transportation use.
Implementation Schedule	~63 months (critical path – IMT)	~54 months (critical path – navigation bridge)	~72 months (critical path – navigation bridge)	~66 months (critical path – navigation bridge)	~63 months (critical path – IMT)
Constraints and Risks to Implementation	Tunnel and artificial island have higher construction risks.	Navigation channel requirements are a significant constraint. Not successfully resolving the clearance requirements is a risk to project implementation. There is potentially re–settlement and ROW issues associated with the	The airport height limits and navigation channel requirements are significant constraints. The airport height limits and navigation channel requirements are significant constraints. Not successfully resolving these	The airport height limits and navigation channel requirements are significant constraints. Not successfully resolving these constraints with stakeholders is a risk to project implementation.	Tunnel has higher construction risks. Significant land resumption required.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
		landing point on the Davao side.	constraints with stakeholders is a risk to project implementation Significant high density / high value land resumption including schools and petrochemical companies is required.	Significant land resumption required.	
Operations & Maintenance Considerations	Tunnel requires more onerous O&M arrangement and special arrangement for hazardous vehicles.	Typical O&M procedures for concrete bridges	Typical O&M procedures for concrete and steel bridges (navigation span)	Typical O&M procedures for concrete and cable supported bridges	Tunnel requires more onerous O&M arrangement and special arrangement for hazardous vehicles
FINANCIAL					
Construction Cost	Construction cost = PHP62.5 bn	Construction cost = PHP19 bn	Construction cost = PHP14 bn. • Note, the design life of the structure is only 30 years.	Construction cost = PHP22 / 25 bn	Construction cost = PHP54 bn
Clearance, Compensation and Resettlement Cost	Total land acquisition is approximately 150 hectares. The estimated cost for acquiring the land is estimated to be PHP475m	Total land acquisition is approximately 125 hectares. The estimated cost for acquiring the land is estimated to be PHP455m	The estimated cost for acquiring the land is estimated to be PHP155m. This is based on a substandard road design. If the road geometry was updated to desirable minimum gradients and radii, then it is anticipated	Total land acquisition is approximately 175 hectares. The estimated cost for acquiring the land is estimated to be PHP420m.	Total land acquisition is approximately 190 hectares. The estimated cost for acquiring the land is estimated to be PHP456m.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
			that the costs would increases significantly for this option.		
Risk and Uncertainty to Cost	IMT has not been constructed in the Philippines before, and therefore poses a higher risk and uncertainty.	Land resumption at the landing point of Sasa port may be complex due to the current land use in the area. But this is offset by the simplicity of the proposed bridge structure.	There is extensive land resumption required on the Davao City landing point, including schools, petrochemical storage areas etc.	There is extensive land resumption required on the Davao City landing point. Most of this land appears to be uninhabited.	IMT has not been constructed in the Philippines before, and therefore pose a higher risk and uncertainty.
Operations & Maintenance Cost	Maintenance cost per year = PHP900m	Maintenance cost per year = PHP120m	Maintenance cost per year = PHP350m.	Maintenance cost per year = PHP255m	Maintenance cost per year = PHP815m
ECONOMIC					
Ability to Improve Existing Transport Networks	Provides a longer 4.5km route to Samal to the less–developed north–western side of the island.	Provides a direct, 2.5km route to the south of Babak, preventing some congestion.	Provides the shortest, most direct route (1km).	Provides the closest (most southern) connection to central/ southern Davao City to the south of the study area, where employment in Davao is concentrated.	Provides the closest (most southern) connection to central / southern Davao City to the south of the study area.
	Causes longer trips for those travelling between the south of Samal Island and Davao City.	Provides the closest link to Sasa Wharf which may enhance efficiency in freight transportation.	Connects to the highly developed Daang Maharlika Hwy in the Davao City.	Provides a short and direct route (1.6km).	Provides a short and direct route (1.6km).
	Panacan and Tambo are less urbanized, reducing employment benefits due to higher travel times for users travelling between Central or South Samal Island and Davao City.	Offers convenient airport access, reducing congestion to the south to access ferry services.	This may increase congestion on the already heavily congested local road network in Davao City, as all users to/from Samal Island must use the Maharlika Hwy.	The landing at South Caliclic is less developed and would put less pressure on the road network.	The landing at South Caliclic is less developed and would put less pressure on the road network.
	-	Travel times may be longer as tourists from the	Connects in the less–developed Caliclic region	Provides the closest link to the Davao City Coastal	Provides the closest link to the Davao City

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
		airport may travel to urbanized areas to the south.	in Samal, which has low existing levels of congestion.	Road Project, which is under construction.	Coastal Road Project, which is under construction.
	-	Also, as employment concentrates at the south of Davao City, economic benefit still lower in general as this option will cause longer trip for the users travel to the south of Davao City.	Furthest away from the on–going bypass projects (Davao City Bypass and Davao City Coastal Road Projects).	Provision for shared use path and connectivity to Davao City Coastal Road, creates an attractive active transportation route.	A tunnel does not allow for active transportation between Samal and Davao.
	-	-	-	Users who travel to the airport and north of Davao need to travel on the congested Daang Maharlika Hwy and it is far away from the Davao City Bypass Road.	Users who travel to the airport and north of Davao need to travel on the congested Daang Maharlika Hwy and it is far away from the Davao City Bypass Road.
Growth Opportunities of the Surrounding Area and its Supply Chains	Connecting via Tambo may impact growth in centres such as Babak and Caliclic, where ferry services currently connect.	Provides greater accessibility between urbanised Babak, the Sasa Wharf, and the airport.	Provides greater accessibility to the less urbanised Caliclic.	Connects to southern Caliclic, which is less developed.	Connects to southern Caliclic, which is less developed.
	Sasa Wharf is in close proximity which may promote industry in both Sasa and the Tambo area through agglomeration effects.	This may provide agglomeration benefits to industry in Samal (especially Babak) due to lower transportation costs.	May present opportunities for industrial expansion and economic diversification.	May present opportunities for industrial expansion and economic diversification.	May present opportunities for industrial expansion and economic diversification.
	In Davao, freight and industry enterprises may shift somewhat from the	More direct connectivity between Samal Island and	Enhanced access to Samal for industry to/from the airport.	Provides the most direct route for freight transported from Davao	Provides the most direct route for freight transported from Davao

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
	highly urbanized and congested Lanang area to the comparatively less developed Panacan area to the north.	the airport may support tourism growth.		City and the Gulf to the south.	City and the Gulf to the south.
	The tunnel cannot accommodate active transportation.	-	Agglomeration benefits to industry may arise due to lower freight transportation costs.	Provides the closest link to Santa Ana Wharf to the south of the study area.	Provides the closest link to Santa Ana Wharf to the south of the study area – potentially via the Davao City Coastal Road Project, which is currently under construction.
	-	-	More direct connectivity between Samal Island and the airport may support tourism growth.	-	-
Accessibility Impacts on Labour Market, Employment and Productivity	The landing points are in the least–developed areas out of all options.	Provides greater accessibility for workers to the more urbanised Babak in Samal.	Provides a ‘centralised’ connection between activity centres in Samal and Davao City.	Provides a ‘centralised’ connection between activity centres in Samal and Davao City.	Provides a ‘centralised’ connection between activity centres in Samal and Davao City.
	Increased accessibility may encourage development and employment growth.	Provides direct access to Sasa Wharf in Davao and the northern side of the airport.	Caliclic is less developed than Babak further north.	Southern Caliclic is less developed than Caliclic and Babak further north.	Southern Caliclic is less developed than Caliclic and Babak further north.
	The northern location may result in longer distances travelled between Davao and the centre or south of the Samal Island, reducing productivity/access to employment.	Less direct access to employment zones within the Davao City centre to the south of the study area.	Provides direct access to industry nearby the Davao landing point and to the airport.	More direct access to employment zones within the Davao City centre to the south of the study area.	More direct access to employment zones within the Davao City centre to the south of the study area. The tunnel cannot accommodate active transportation and

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
					commuters' transport demand.
	Less direct access to employment zones within the Davao City centre to the south of the study area.	Provides greater access to the Special Economic Zone in the North of Samal Island, which is identified on the future comprehensive land use plan for Samal Island.	More direct access to employment zones within the Davao City centre to the south of the study area.	-	-
	Provides greater access to the Special Economic Zone in the North of Samal Island, which is identified on the future comprehensive land use plan for Samal Island.	-	-	-	-
Impact on Land Use Capacity and Development	May promote development around Tambo, which is less developed.	More available land at the Samal side connection, which may support diversified growth.	Supports development in Caliclic and provides the most direct access to Davao City.	Would make the land more attractive for hotel developers/increase land value of existing resorts in Samal.	Would make the land more attractive for hotel developers/increase land value of existing resorts in Samal.
	Agglomeration effects are likely to occur with industry in Panacan.	Connects Samal Island to the Sasa Wharf, and the airport which provides accessibility to industrial areas and direct access to Samal Island from the Wharf.	The Samal landing at Caliclic provides greater accessibility to the resorts and tourist attractions in this area.	Available land would provide opportunity for more diversified growth in this less developed area.	Available land would provide opportunity for more diversified growth in this less developed area.
	May promote growth in freight and industry outside of the central Davao City area to the North near Malagamot Road.	This may in turn promote industrial development in proximity to the Samal side connection.	Connects to a developed industrial area in Davao, providing better accessibility for freight.	Connects to a highly developed industrial area in Davao, providing better accessibility for freight.	Connects to a highly developed industrial area in Davao, providing better accessibility for freight.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
	Growth would occur from a 'lower base'.	-	-	-	-
ENVIRONMENTAL					
Encroachment in Environmental Critical Areas (ECAs)	The alignment would encroach on Arboles Island and associated corals.	Alignment traverse a dense port area and over an existing busy waterway.	Alignment traverse a dense urban area and over an existing busy waterway.	Alignment traverse a dense urban area and over an existing busy waterway.	Alignment traverse a dense urban area and over an existing busy waterway.
	Proclamation 2152 S. 1981 (See **Annex H**)	Proclamation 2152 S. 1981 (See **Annex H**)	Proclamation 2152 S. 1981 (See **Annex H**)	Proclamation 2152 S. 1981 (See **Annex H**)	No known ECAs within the alignment corridor. (See **Annex H**)
Impacts on Cultural Heritage	The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.	The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.	The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.	The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.	The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.
Vegetation Removal	Relatively limited vegetation on the Davao City side however significant mangrove and agricultural areas are found in Samal side. These areas may require vegetation removal for construction.	Minor vegetation on Davao City side, whilst on the Samal Island side, mangrove coverage appears sparse towards Babak.	Vegetation removal on Davao Side is expected to be minimal due to dense urban area.	Vegetation removal on the Davao side is expected to be minimal.	Vegetation removal on the Davao side is expected to be minimal.
	-	Should the alignment cover the Kinawiton area, mangroves and inland terrestrial vegetation is expected to be cleared.	Vegetation on Samal side is fairly minimal due to existing development at the anticipated landing point.	On the Samal side there appears to be existing terrestrial vegetation, both natural and agricultural that may need to be cleared.	On the Samal side there appears to be existing terrestrial vegetation, both natural and agricultural that may need to be cleared.
	-	-	-	Mangroves may also be impacted.	Mangroves may also be impacted.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
Loss of Habitat, Threat to Species, and Hindrance to Biological Access	Extensive impacts on the ecological resources associated with Arboles Island are anticipated.	Marine ecological impacts in both the water column and on the seabed are anticipated, however these are expected to be temporary and mitigable in the construction phase.	Marine ecological impacts in both the water column and on the seabed are anticipated, however these are expected to be temporary and mitigable in the construction phase.	Marine ecological impacts in both the water column and on the seabed are anticipated, however these are expected to be temporary and mitigable in the construction phase.	Marine ecological impacts in both the water column and on the seabed are anticipated, however these are expected to be temporary and mitigable in the construction phase.
	There appears to be extensive mangrove colonies on the Samal Island coastline.	On Samal Island there appears to be existing natural terrain and mangroves that may be impacted.	On the Davao side, due to the current land use, ecological impacts are considered to be minimal, if any, whilst on Samal side, there appears to be existing development at the landing point which again would limit any ecological impacts.	On the Davao side, due to the current land use, ecological impacts are considered to be minimal.	On the Davao side, due to the current land use, ecological impacts are considered to be minimal.
	-	-	-	On the Samal side, there appears to be existing mangroves and terrestrial vegetation that would require further ecological study.	On the Samal side, there appears to be existing mangroves and terrestrial vegetation that would require further ecological study.
Impact on Marine and Freshwater	In the construction phase, a tunnel option would have a much larger footprint, with extensive dredging and groundworks.	In the construction phase, there would be intensive marine works associated with the construction of foundations, however these occupy a much lower marine footprint than that of a tunnel.	In the construction phase, there would be intensive marine works associated with the construction of foundations, however these occupy a much lower marine footprint than that of a tunnel.	In the construction phase, there would be intensive marine works associated with the construction of foundations, however these occupy a much lower marine footprint than that of a tunnel.	In the construction phase, a tunnel option would have a much larger footprint, with extensive dredging and groundworks.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
	This option is much closer to sensitive marine ecology and has the longest alignment.	The foundation is a permanent fixture within the water column.	The foundation is a permanent fixture within the water column.	The foundation is a permanent fixture within the water column.	This option scores higher than 1D as it has a shorter alignment.
Air Pollution and Increase in Noise Levels	The Davao side, of all the alignment options, appears to be the least affected noise and air sensitive receivers, whilst the Samal side is relatively unpopulated.	The Davao landing point is in a densely populated area, where it is inevitable that construction would bring about noise and air impacts on surrounding communities.	The Davao landing point is in a densely populated area, where it is inevitable that construction would bring about noise and air impacts on surrounding communities.	The Davao landing point is in a densely populated area, where it is inevitable that construction would bring about noise and air impacts on surrounding communities.	The Davao landing point is in a densely populated area, where it is inevitable that construction would bring about noise and air impacts on surrounding communities.
	-	-	Especially sensitive land uses such as schools.	The Samal side is relatively unpopulated, and significant impacts to sensitive receivers are not anticipated with robust mitigation measures in place.	The Samal side is relatively unpopulated, and significant impacts to sensitive receivers are not anticipated with robust mitigation measures in place.
	-	-	The Samal side is relatively unpopulated, and significant impacts to sensitive receivers are not anticipated with robust mitigation measures in place.	-	Unlike Option 4A, the operational phase for the tunnel option would have impacts associated with ventilation buildings.
Existing Soil Contamination	Whilst a portion of the area is greenfield, there are also potentially contaminating activities such as industrial activities.	Bridge construction is likely to have a lower footprint than that of a tunnel and would involve less excavation and exposure to contaminated soil.	Whilst there is less excavation for this option in comparison to a tunnel option, it is considered that the likelihood of contamination in this area is high, given the	Bridge construction is likely to have a lower footprint than that of a tunnel and would involve less excavation and exposure to contaminated soil.	There are some minor industrial facilities located within the Davao portion of the landing points, which are considered to have

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
			industrial land uses present.		the potential to contaminate the land.
	As construction of a tunnel would involve large scale excavation, it is considered that encountering contaminated land is likely.	The landing point on the Davao side primarily consists of port activities and storage and therefore the soil may not be extensively contaminated.	-	The landing point on the Davao side primarily consists of port activities and storage and therefore the soil may not be extensively contaminated.	• As construction of a tunnel would involve large scale excavation, it is considered that encountering contaminated land is likely.
Waste Generation	Considerable amounts of construction waste, such a C&D materials and excavated soils are anticipated to be generated from the construction phase of the tunnel option.	Construction of the alignment would result in the generation of construction waste, especially during the construction of foundations.	Construction of the alignment would result in the generation of construction waste, especially during the construction of foundations.	Construction of the alignment would result in the generation of construction waste, especially during the construction of foundations.	Considerable amounts of construction waste, such a C&D materials and excavated soils are anticipated to be generated from the construction phase of the tunnel option.
	•Such waste would require disposal or reuse. Furthermore, this alignment is longest.	The work is anticipated to be significantly less intensive than tunnel construction.	The work is anticipated to be significantly less intensive than tunnel construction.	The work is anticipated to be significantly less intensive than tunnel construction.	Such waste would require disposal or reuse. This alignment scores better as it is shorter than Option 1D.
	-	-	This option scores slightly higher than other bridge options due to its shorter alignment.	-	-
Quality of Visual Experience	The alignment has the potential to interact with Arboles Island, which is significant feature of the landscape.	There may be some landscape impacts depending on the aesthetic design of the bridge.	There may be some landscape impacts depending on the aesthetic design of the bridge.	There may be some landscape impacts depending on the aesthetic design of the bridge.	This tunnel option may allow for the existing landscape to be largely preserved.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
SOCIAL					
Displacement of Informal Settlers	The landing point on the Davao side is on an area that is currently unoccupied.	The area surrounding Sasa port appears to have a significant concentration of informal settlers, especially along the coast to the immediate north which may directly or indirectly impacted.	The Davao side landing point appears to largely consist of industrial land uses with no informal settlers currently present, whilst there is expected to be minimal impact on the sparsely populated Samal side.	The Davao side landing point appears to largely consist of industrial land uses with no informal settlers currently present, whilst there is expected to be minimal impact on the sparsely populated Samal side.	The Davao side landing point appears to largely consist of industrial land uses with no informal settlers currently present, whilst there is expected to be minimal impact on the sparsely populated Samal side.
	There are potentially informal settlers in the vicinity that may require to be resettled for the construction phase (indirect impacts).	-	-	-	-
	The Samal side is relatively sparsely populated and thus impacts are anticipated to be relatively minor.	-	-	-	-
Indigenous People	On the Davao side there are no know records of Indigenous Peoples. On the Samal Side, in the vicinity of the landing points, there are no known ancestral domains, however Indigenous Peoples are known to be present on Samal Island, thus further study would be required to verify.				
Right of Way Conflict	Predominantly green field site with low residential and commercial / industrial land uses within the area of the landing point on the Davao side.	Dense industrial area with a number of private companies on the Davao side.	Dense industrial area with a number of private companies on the Davao side.	Medium density industrial area with a small number of private companies on the Davao side.	Medium density industrial area with a small number of private companies on the Davao side.
	The Samal side is similarly relatively unpopulated.	ROW negotiations may require lengthy	ROW negotiations may require lengthy	ROW negotiations may require lengthy	ROW negotiations may require lengthy

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
		negotiations with private entities.	negotiations with private entities.	negotiations with private entities.	negotiations with private entities.
	-	On the Samal side, the landing point is south of Babak in predominantly green field area.	On the Samal side major impacts on ROW negotiations are not anticipated.	On the Samal side major impacts on ROW negotiations are not anticipated.	On the Samal side major impacts on ROW negotiations are not anticipated.
	-	-	There are also a school and petrochemical companies located in the area. Major impacts to ROW could be anticipated.	-	-
Security Risks	Predominantly green field site with low residential and commercial / industrial land uses within the area of the landing point on the Davao side. The Samal side is similarly relatively unpopulated.	Dense industrial area with a number of private companies on the Davao side. ROW negotiations may require lengthy discussions with private entities. Security issues may arise due to ROW conflicts. On the Samal side, the landing point is south of Babak in predominantly green field area	Dense industrial area with a number of private companies on the Davao side. ROW negotiations may require lengthy discussions with private entities. Security issues may arise due to ROW conflicts. On the Samal side major impacts on ROW negotiations are not anticipated. There is also a school and petrochemical companies located in the	Medium density industrial area with a small number of private companies on the Davao side and some resorts in Samal. ROW negotiations may require lengthy discussions with private entities. Security issues may arise due to ROW conflicts. On the Samal side major impacts on ROW negotiations are not anticipated.	Medium density industrial area with a small number of private companies on the Davao side and some resorts in Samal. ROW negotiations may require lengthy discussions with private entities. Security issues may arise due to ROW conflicts. On the Samal side major impacts on ROW negotiations are not anticipated.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
			area. Major impacts to ROW could be anticipated.		
Traffic Congestion During Construction	The land area is out with the existing CBD and therefore the area will be more capable of handling an increase in traffic during the construction and operational phases.	This option, on the Davao side, is within an extremely dense area with a lot of traffic, but not to the same extent as Option 3.	This option, on the Davao side, is also within an extremely dense area with a lot of traffic.	This option is within a dense area prone to moderate traffic; however, it is slightly out with the CBD.	This option scores slightly lower than Option 4A as tunnel construction is a lot more intensive and therefore during the construction phase there will be more vehicles entering the site for a longer period of time.
	The baseline traffic congestion is moderate and therefore there would be impacts.	An increase in traffic in the area is likely to cause significant impacts.	An increase in traffic in the area is likely to cause significant impacts.	-	-
Resettlement Impact	On the Davao side, the current landing point occupies a green field site and therefore resettlement is unlikely to be required in terms of direct impacts.	On the Davao side, the current landing points occupy primarily industrial land uses and therefore resettlement is unlikely to be required in terms of direct impacts. However, residential establishments are still located in close proximity to the west of the proposed landing point, and resettlement may be required if these areas are encroached upon. The Samal side is relatively unpopulated and significant resettlement impacts are not anticipated.			
	The Samal side is relatively unpopulated and significant resettlement impacts are not anticipated.	-	-	-	-
Economic Displacement	Appears to be relatively little commercial activity on site and no fisherfolk are evident on the Davao side.	Potential loss of livelihood on Davao side due to industrial land uses making way for the alignment.	Potential loss of livelihood on Davao side due to industrial land uses making way for the alignment.	Potential loss of livelihood on Davao side due to industrial land uses making way for the alignment.	Potential loss of livelihood on Davao side due to industrial land uses making way for the alignment.

Criteria	Option 1D	Option 2B	Option 3	Option 4A	Option 4B
	There may be some economic displacement from impacts on agricultural activities on the Samal side.	-	-	Resorts in Samal island may temporarily be affected during construction	Resorts in Samal island may temporarily be affected during construction
Final Rank:	**5**	**2**	**3**	**1**	**4**

Table 1.8 Summary of Results of Options Selection Workshop

Structural Form	Option					
	Option 1: Northern Corridor	**Option 2: North of Sasa Port**	**Option 3: Central Corridor**	**Option 4: Southern Corridor**		
	1d	**2b**	**3**	**4a-1**	**4a-2**	**4b**
	Immersed Tube Tunnel	**Low Level Bridge**	**Bridge**	**Box Girder Bridge**	**Extradosed Bridge**	**Immersed Tube Tunnel**
Length	3845 m	245 m	2620 m	2830 m		
Construction Cost	PhP 62.4 B	18.8 B	15.6 B	25.2 B	22.4 B	54.4 B
Implementation Schedule	87 months	54-60 mos.	75 mos.	60 mos.	60 mos.	87 mos.
Technical	Good	Good	Non-compliant road geometry	Good	Best	Good
Financial	Most Expensive	2nd cheapest	Cheapest	Moderate	Moderate	Expensive
Economics	Good	Good	Good	Good	Best	Good
Environmental and Social	Slightly Worse	Good	Ok	Good	Least Impact	Slightly Worse

As a result of subsequent studies, it was determined that an extradosed bridge along the Southern Corridor was the most feasible option for the SIDC – Option 4a-2. This determination was made during the Options Selection Workshop held last 19 February 2019, which considered the parameters presented in **Table 1.5**.

The selected option takes into consideration key site constraints, including the imposed Civil Aviation Authority of the Philippines (CAAP) maximum allowable height of 73 meters (owing to the proximity of the project to the Francisco Bangoy International Airport, as well as the vessel navigation clearance needed within the Pakiputan Strait to ensure continued access of vessels to the ports in Davao and Panabo Cities.

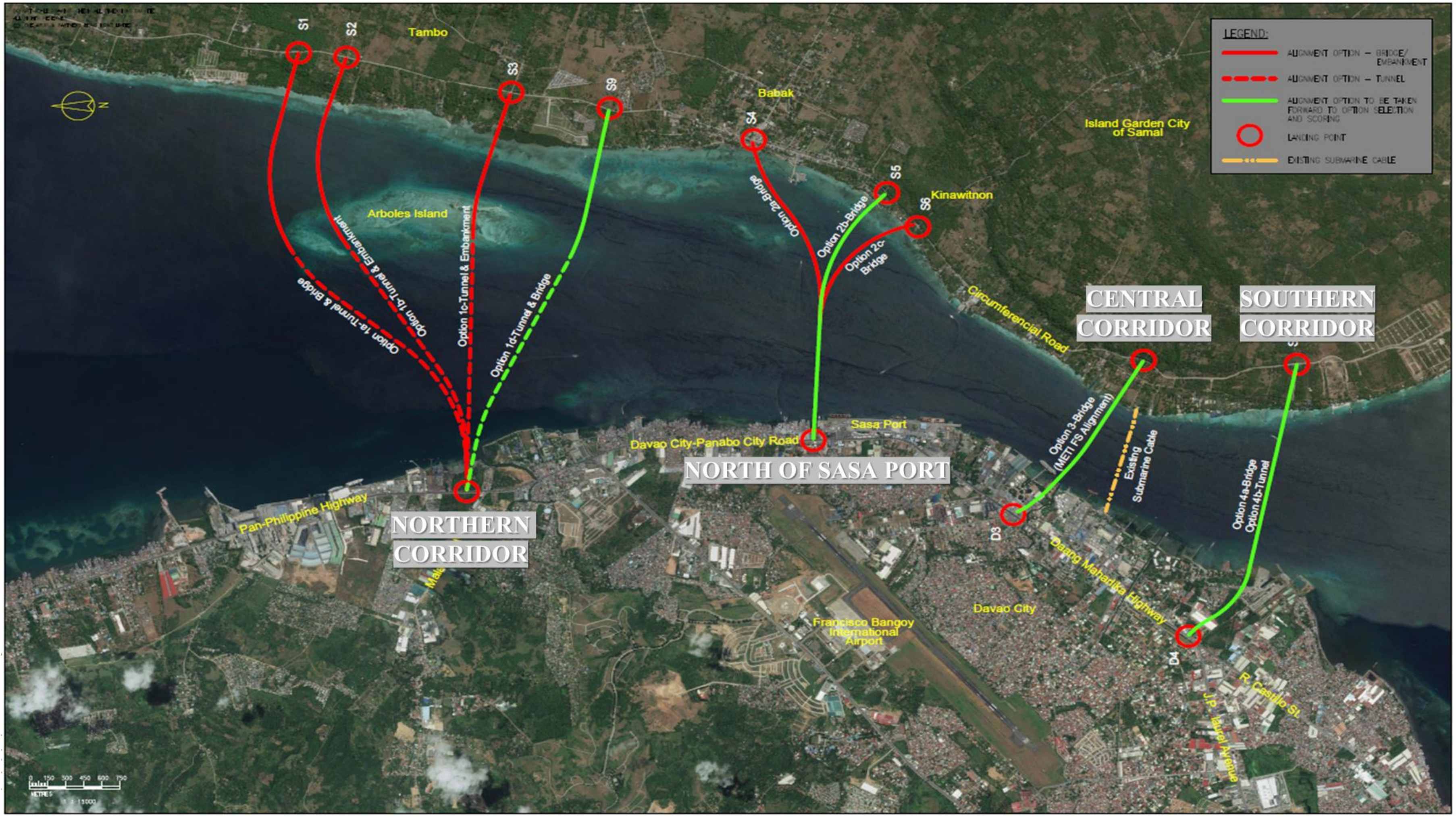


Figure 1.5 Illustration of SIDC Alignment Options

Alignment Option 4A has been further studied to come up with improved variations. The reason for this change was due primarily to the ROW issues. DPWH proposed to adjust the alignment to have the most economical option with the least impact in the area and to conform with the existing road network. Options to move the connection point slightly further north east were investigated.

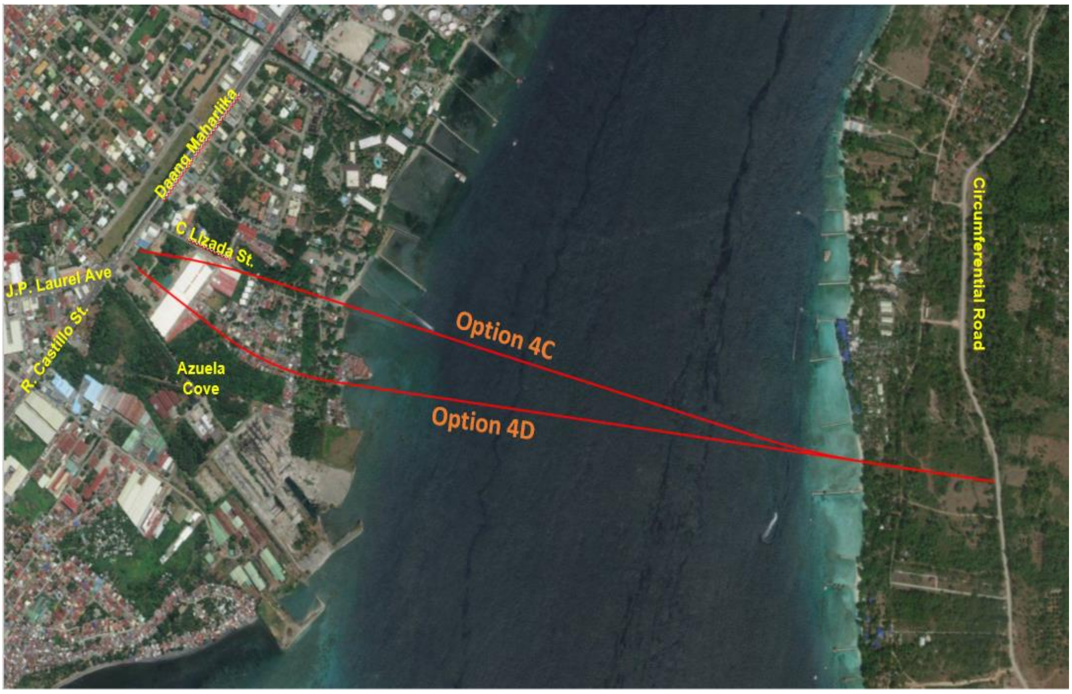


Figure 1.6 Refined Alignment Options

Two refined alignment options were developed, namely Option 4C that runs above Lizada Street and crosses Dominic and Sons property to join with Daang Maharlika Highway and Option 4D also crossing Dominic and Sons property near the Davao coast towards various residential lot owners and warehouse fertilizer owned by So Peng Kee.

Based on the Traffic Study, Alignment Development and Preliminary Engineering Workshop conducted on 21 June 2019, Option 4C is the most desired option with the best overall balance of positive outcomes, cost, ease of implementation, and minimum negative impact.

1.3.4 Technology Option

No alternative technologies, operation processes and measures to minimize wastes have been identified at this stage. The process technology that will be used in preventing adverse impacts to the environment is discussed in **Section 1.7**. The design selection for storage is not applicable for the infrastructure project.

1.3.5 Resources

The majority of the materials that will be required for the construction of the project will be sourced locally to minimize the amount of imported materials and machinery required. For viaducts on land, considering that most of the bridge structures in the Philippines are concrete bridges, it is recommended that concrete bridges should be considered, wherever possible. It is noted that the interchanges, due to their complex geometry, could be composite bridges (steel-concrete). As for the electricity needed for the bridge, there should be an independent back-up power supply source either from an independent power plant and network or from diesel generator sets, in case of failure of the primary supply. A UPS system will cover the power demand of the vital functions during the period it takes before switch over to the back-up source.

1.3.6 Environmental Impacts of Alternatives

Five alignments were compared using defined criteria in order to identify the preferred layout. The criteria identified for assessment under Environmental and Social category are described in sub-sections below. Each criteria category has been assigned a “weighting proportion” which denotes the relative percentages of the items as a fraction of the weighting value as a whole. The environmental criteria that will be used in the evaluation of the options are:

- Encroachment in Environmental Critical Areas (ECAs)
- Induced Soil Erosion
- Vegetation removal, Loss of habitat, Threat to species
- Impact on marine and freshwater
- Air pollution and increase in noise levels
- Hindrance to biological access
- Waste Generation from Construction
- Quality of Visual Experience

The social criteria that will be used in the evaluation of the options are:

- Displacement of Informal Settlers
- Indigenous People
- Right of Way Conflict
- Traffic Congestion during Construction
- Resettlement impact
- Economic Displacement

The previous Ministry of Economy, Trade and Industry (METI) Feasibility Study Project for Construction of Davao-Samal Bridge in 2016 (Option 3: Central Corridor) was equally considered in the evaluation of project options for the environmental and social constraints assessment.

According to the study, at its time of writing, Samal Island is listed as a Marine Protected area, declared by the LGU. However, in 2013, a resolution was made to delist Samal Island Protected Landscape/ Seascape as a permanent component under the National Integrated Protected Areas System (NIPAS) Act, provided that the mangrove areas not within MPAs shall be managed through a Memorandum of Agreement between the land/resort owner in close coordination with LGU and DENR. Until 2015, the decision for delisting has not been determined yet.

The study also confirmed that there was no objection from DENR and an "Area Status and Clearance" was issued on 04 Decemebr 2015 by DENR, certifying clearance of the one thousand eighty meters (1,080 m.) stretch of the proposed bridge (Option 3) only for the Feasibility Study.

The environmental impacts from the options available were avoided such as impacts to the Arboles Island of the Northern Corridor. Furthermore, the immersed tunnel design was also avoided as this could potentially increase environmental impacts of the project since the construction will affect more of the marine habitat and species. As for resources and technology options, this will be identified and consulted with the contractor of the project during the detailed engineering design stage.

Based on the evaluation of the options, the proposed land development under this option is in Barangay Vicente Hizon Sr., Davao City and Barangay Limao, Samal.

1.3.7 Summarized Comparison of Environmental Impacts of Each Alternatives

Listed below are the summarized environmental and social constraints for each alignment option in Samal Island and Davao City.

Table 1.9 Summarized Environmental and Social Constraints at Samal Island and Davao City

Key Aspect	Option 1: Northern Corridor	Option 2: North of Sasa Port	Option 3: Central Corridor	Option 4: Southern Corridor
Land	D: Situated in industrial, residential and green area with few coconut trees and bird species as sighted.	D: Situated in commercial and residential area. In an established port area and boat terminal for fisher folks.	D: Located in CBD, in an industrial zone and within sensitive receptor area (school, church etc.) Near the F. Bangoy International Airport, where there should be height restrictions	D: Located in CBD and in residential and industrial zone. Near the F. Bangoy International Airport, where there should be height restrictions
	S: Situated in commercial areas, sensitive receptors (i.e. schools, residences and	S: Area is rich in seagrass and mangroves. S4 is a commercial area	S: Area is situated in coastal tourism zone. Its land mass is	S: Area is situated in coastal tourism zone. Its land mass is composed of limestone

Key Aspect	Option 1: Northern Corridor	Option 2: North of Sasa Port	Option 3: Central Corridor	Option 4: Southern Corridor
	memorial gardens) and MPA/NIPAS/ECA (i.e. Sanipaan Marine Park and Monfort Bat Sanctuary)	(including the port/wharf- Samal Ferry terminal), while S6 is situated in coastal tourism zone.	composed of limestone deposits that may be critical for selection of construction materials. Since it also lies in an agricultural area, that there may be flora and fauna species to get affected.	deposits that may be critical for selection of construction materials. Since it also lies in an agricultural area, that there may be flora and fauna species to get affected.
Water	D: The residents use the area for recreation (i.e swimming, picnic etc.)	D: Source of livelihood for fisherfolks	Effect in marine species of Davao Gulf	Effect in marine species of Davao Gulf
	S: Effect in marine ecology: Sanipaan Marine Park is a MPA, which is rich in mangroves, marshes, corals and seagrass. Tidal flat - located offshore of Arboles Shoal; rich in marine species (ie fish landing areas with presence of shells, starfish, sea urchin etc)	S: Area is rich in seagrass and mangroves, which is a protected area.		
Air	D: Downwind area of the existing Davao Oil Mill Plant. *For tunnel option:* Proper ventilation will be needed during tunnel construction. Air and noise pollution is expected to increase during construction phase.	Air and noise pollution is expected to increase during construction phase.	Air and noise pollution is expected to increase during construction phase.	*For tunnel option:* Proper ventilation will be needed during tunnel construction. Air and noise pollution is expected to increase during construction phase.

Key Aspect	**Option 1: Northern Corridor**	**Option 2: North of Sasa Port**	**Option 3: Central Corridor**	**Option 4: Southern Corridor**
People	D: Traffic congestion due to nearby public market	D: Presence of informal settlers and possible existence of migrant *Badjao*. Land acquisition issues. Area is near their source of livelihood. Traffic congestion due to Sasa Wharf.	D: Land acquisition will be critical due to presence of informal settlers, sensitive receptors and private businesses. Located in a central urban area thus will increase heavy traffic. Minor effect in livelihood, since this option is located in Lansa boat terminal going to Paradise Island.	D: Critical land acquisition on private businesses (Alcantara and Ayala). Located in CBD area thus will increase existing heavy traffic.
	S: Lies in an agricultural area and marine protected area. Land acquisition will have an effect in livelihood and tourism.	S: Land acquisition will be critical due to presence of private resorts and restaurants.	S: Land acquisition will be critical due to presence of private resorts and restaurants. Its effect will mainly in their livelihood and settlement.	S: Land acquisition will be critical due to presence of private resorts and restaurants. Its effect will mainly in their livelihood and settlement.

Notes: S: Samal Island; D: Davao City

1.3.8 No Project Option

The following are the potential effects of a no-project option:

1. The barge will remain to be the mode of transportation between Davao and IGaCoS, which means long travel times, limited accessibility, congestion, circulation and mobility and escalating traffic conditions due to a dearth of resilient and reliable transportation links.
2. There will be limited opportunities for economic development of IGaCoS due to lack of linkage to industry, commerce, trade and tourism.
3. There will be limited access to employment and social services for IGaCoS residents.

1.4 Project Components

The proposed bridge comprises of land and marine bridges, with a 250 m span main navigation bridge in the form of an extradosed bridge. The scheme is developed to comply with the airport height limits imposed by the Francisco Bangoy International Airport, whilst providing a navigable channel for 98% of the current merchant shipping using the Pakiputan Strait. The scheme consists of various components, including interchanges with the existing road network, viaducts over sections of land, and a different form of viaduct over the marine area, and the main navigation span bridge.

The total roadway length of the bridge including the four (4) ramps on Davao side is 3.98 km. The point to point crossing is around 2.85 km long with a marine section approximately 1.6 km long where the seabed along the alignment can be up to 40 m deep towards the middle of the channel. The bridge will provide a dual carriageway with two lanes in each direction plus shoulder. Sidewalks with cycleways (for the expected low volumes of pedestrians and cyclists) will also be provided.

1.4.1 Bridge Characteristics

An extradosed bridge is frequently adopted in situations where there are height restrictions. This type of bridge is considered as "in-between" girder bridges and cable-stayed bridges. In a cable-stayed bridge, the loads (permanent as well as live loads) are globally carried predominantly by the stay cables. In a girder bridge, loads are carried by shear and flexure of the girder and internal pre-stressed or post-tensioned cables which produce permanent stresses that act opposite to those produced by self-weight and moving loads.

An extradosed bridge is generally composed of pylon, girder and pier. For a seismic region like the Philippines, the longitudinal displacement of the deck is minimized by using a rigid connection. Moreover, this connection does not require a temporary support or fixing during balanced cantilever erection, which is most commonly used for extradosed bridges.

1.4.2 Main Components

The proposed SIDC has a total alignment length of approximately 3.98 km, which is composed of land viaducts and ramps, marine viaducts and extradosed bridge, as presented in

Figure **1.7** below. The direct crossing length from Daang Maharlika Highway in Davao City to the Samal Circumferential Road is approximately 3 km.

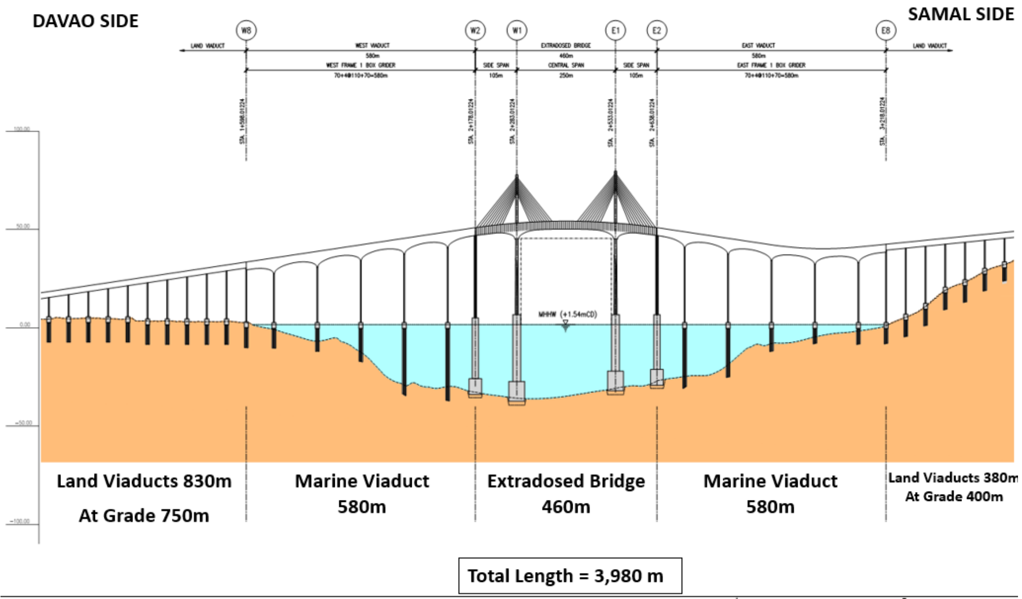


Figure 1.7 Illustration of SIDC Components

Navigation bridges (extradosed bridge) – The main structure that provides the necessary navigation clearance for safe operation of shipping at the project site.

Marine viaducts – The typical viaduct structures which will be constructed above sea water. To minimize the impact to the waterway and reduce costs longer spans are provided in the marine section.

Interchanges and viaducts on land – These are the viaduct structures which can be constructed on land and provide the connection to the existing road network.

Approach ramps – The parts of the road that go up from existing ground level towards to approach bridge.

1.4.2.1 Bridge Form

The form of the proposed bridge at the navigation span is a 250 m span extradosed bridge (**Figure 1.8**), with short towers above the deck, with shallow cables to support the concrete box girder superstructure. Marine and land approach viaducts either side of this would connect to the navigation span bridge. Various options exist for the form of the lower level approach spans, and the connections to the existing road network at either side.

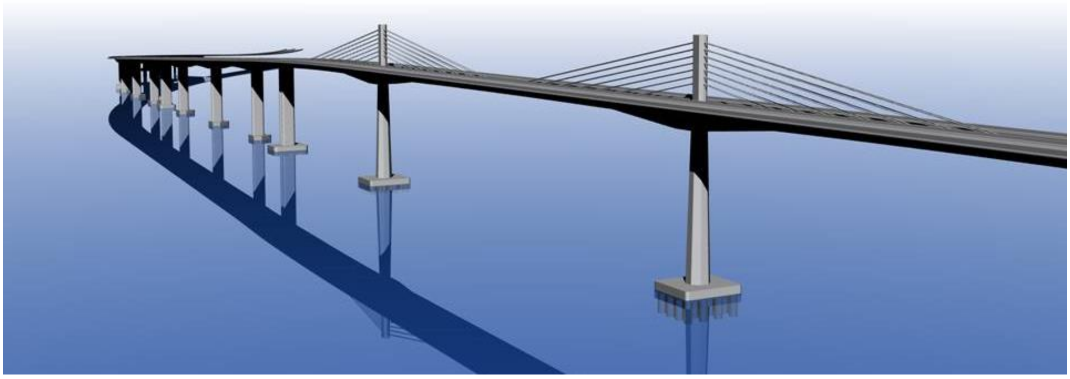


Figure 1.8 Initial Structural Concept for the Extradosed Bridge

1.4.2.2 Interchanges

An initial assessment of the land use and right of way (ROW) was made. For the purposes of preliminary assessment of the ROW reference has been made to the Detailed Urban Zoning Map of Davao City, 2013-2022 to identify the land use in Davao City and the existing IGaCoS Comprehensive Land Use Plan 2008-2017, Prepared by the City Planning and Development Office of IGaCoS.

Davao Side

An elevated junction on the Davao side has the advantage of reducing the required gradient of the main line as it climbs up from Davao and over the navigation channel, as shown in **Figure 1.9**.

Of the options developed, a directional T-interchange with 3-level ramps provides the best overall solution. Although the ramps connect along the centreline of R. Castillo Street and Daang Maharlika Highway, i.e. merging with the fast lanes, this option has least impact on the existing land use and road junctions and allows for future expansion of the at-grade roads.

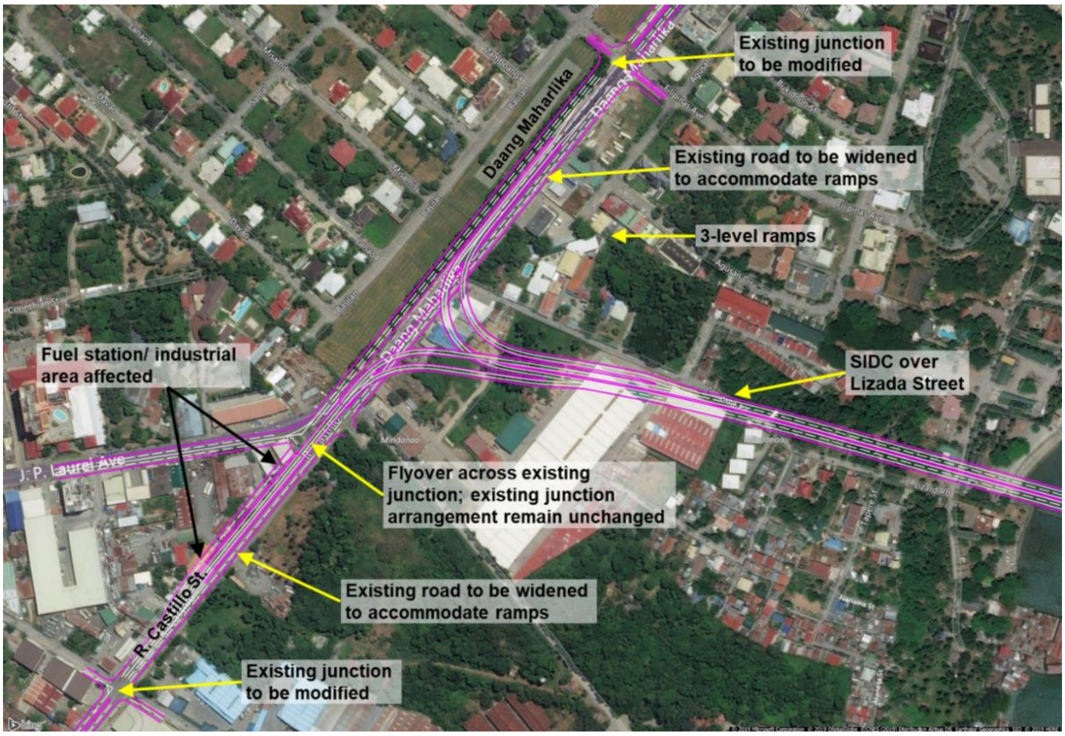
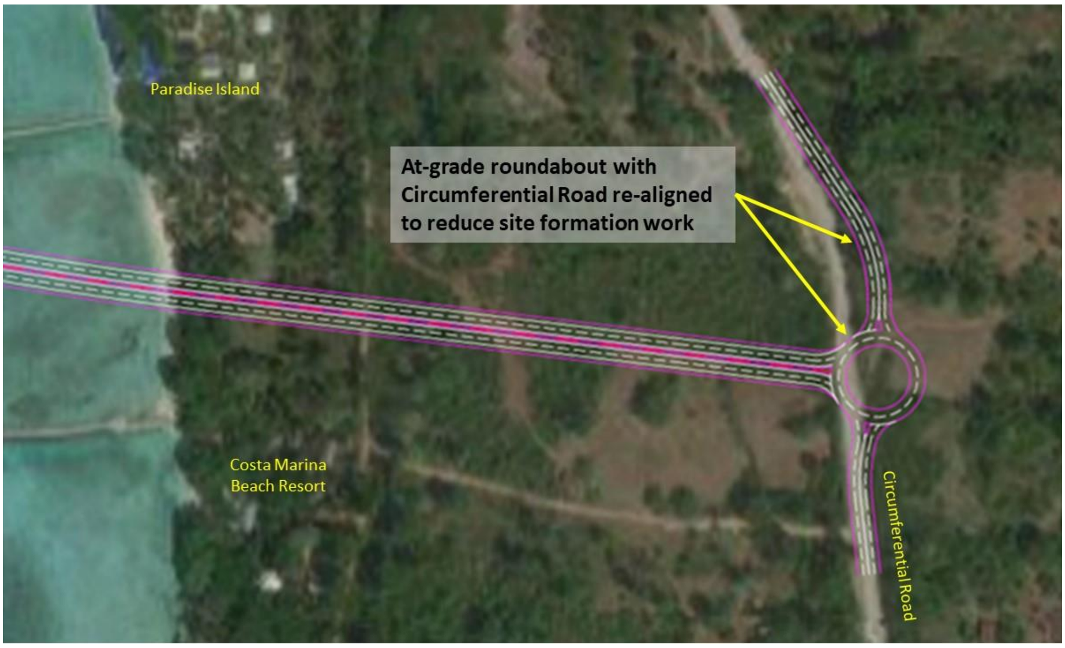


Figure 1.9 Directional T-Interchange at R. Castillo Street and Daang Maharlika Highway (Google Earth, June 2019)

Samal Side

On the Samal side, the existing lane falls away steeply to the west of the Circumferential Road and rises to the east. A junction type with the minimum footprint is therefore desirable, to limit the amount of site formation works required to achieve a level area for the junction.

A roundabout option is considered to provide the best solution, as shown in **Figure 1.10**.



Source: Google Earth, June 2019

Figure 1.10 Roundabout Junction at the Samal Circumferential Road

1.4.3 Support Facilities

There is a separate preliminary Basis of Design Report for the plans and designs of support facilities such as drainage design. This Basis of Design Report will be updated along with the Feasibility Study and Preliminary Design as the design and studies progress to subsequent stages.

1.4.3.1 Associated infrastructure facilities and buildings

Apart from the main bridge described above, the project will also need to include the associated infrastructure facilities/ buildings for operation and maintenance purpose.

1.4.3.2 Administration building

An administration building is often required for bridge link of such scale. The building will include facilities for inspection and maintenance staff, storage of records of maintenance activities and control room for the traffic control and surveillance system (TCSS) equipment if required

1.4.3.3 Maintenance Depot

Maintenance of the bridge is important and it will be necessary to procure appropriate machines such as Under Bridge Inspection Vehicles (UBIV). This is likely to require a centralised depot where there will be parking spaces for maintenance vehicles, space for storage of spare parts, workshops as well as staff amenities and facilities.

1.4.3.4 Electricity Substation

Electricity substation may be required to provide electricity for the highway lighting and Traffic Control and Surveillance Systems (TCSS) as well as other electrical facilities. The substation may require a heavy transformer and an access road will be required.

Substations along the link bridge may also be required in order to reduce the power loss of transmitting electricity for the highway lighting on the bridge.

1.4.3.5 Source of construction material

The construction of the long sea crossing will require a large amount of concrete for construction. The source of the raw materials (i.e. aggregates and sand) for the concrete mix will need to be studied further at Detailed Engineering Design (DED) stage.

1.4.3.6 General works areas

It is essential that land is made available to the contractor(s) for use as a works area. As a minimum, this is required for Contractor’s offices, resident site staff offices, equipment storage yard, machine storage and repair workshop etc. The size and location of works areas must be considered carefully. It is anticipated that there will be several works areas considering the geographical extent of the project. The works areas must be as close as possible to the work fronts as possible in order to make the construction logistics feasible.

It is possible that non-critical areas of the permanent works sites can double up as works areas. For instance, the location of the administration building could be used and this could be taken into account when determining the amount of land that needs to be made available.

1.4.3.7 Dumping area

There will be many excavation activities such as bored piling and/or pile cap construction for both land and marine viaducts. It is necessary to identify dumping/ storage areas for material which is either suitable or unsuitable for re-use. If dredged from the bored piles it is likely to be unsuitable material and cannot be used for site formation works. Excavated material might need to be dumped at identified area such as landfill site. This has to be controlled in a suitable manner with minimum impact to the environment. The dumping site would ideally be as close to the project location as possible reduce the cost of transportation.

1.4.3.8 Barging points

In order to transport construction material to the site as well as to take away excavated material barging points may be required. For example, the dumping site could be offshore. The location and requirement of barging points depends on the quantities of the material that needs to be transported as well as any identified works areas.

1.4.3.9 Haul road

Haul road(s) to and from the construction sites and in particular the works area(s), barging point(s) and/or precasting yard will be required. The capacity of existing roads should be checked and upgraded if necessary, to suit the construction activities. This may need to be carried out as advanced works.

1.4.3.10 Power and Water Supply

During the construction phase, power and water supply will be required by the project. Initially, these requirements may be sourced from current providers and supplemented by auxiliary sources. However, this will need to be studied and determined further during the DED stage

1.4.4 Pollution Control Devices and Waste Management System

Pollution control devices and waste management system is a significant component of the project.

Air Pollution Control

Emission of air contaminants/pollutants due to construction activities such as earthworks on site, use of heavy equipment and machineries, and other possible sources shall be minimized and if possible, avoided. The proposed use of the following air pollution correction methods to reduce emissions or limit to a manageable range include:

- Use of well-maintained equipment, machineries, and vehicles
- Use of low sulfur fuel and ensuring fuel efficiency of equipment and vehicles
- Air pollutant concentrations will be monitored via regular sampling to ensure conformity with the National Ambient Air Quality Guideline Values (NAAQGV)

Noise Pollution Control

Temporary noise barriers will be installed accompanied with monitoring of ambient noise level within the perimeter of the project and near the sensitive receptors. The management of noise pollution will be integrated with strategic scheduling of construction working hours to limit and control noise. Other proposed noise pollution control methods are:

- Use of hydraulic oscillator piling equipment to reduce noise and vibration
- Oscillator rigs will be specified to reduce vibrations
- Use of movable noise barriers in areas where exceeding noise levels are expected to be generated by machineries/ equipment

Figure 1.11 shows examples of noise barriers typically during construction.

Source: Environmental Protection Department Website, retrieved February 2020
https://www.epd.gov.hk/epd/misc/construction_noise/contents/index.php/en/home2/mitigation-measures/item/157-construction-noise-barrier.html

Figure 1.11 Movable noise barrier next to an excavator

Water Pollution and Wastewater Management

Anticipating the water pollution and wastewater that may be generated from varying project activities and in consideration with the project site's proximity to the water body and the marine area, the following water pollution and wastewater management system will include:

- Treatement and collection of wastewater from construction activities by a third-party contractor accredited by the Department of Environment and Natural Resources Environmental Management Bureau (DENR-EMB).
- Installation of a drainage system to collect rainwater
- To prevent water pollution, the drainage area will contain a filter to separate water contaminants such as oil and grease, which will be drained and collected in sump
- Installation of a well-designed silt curtain control scheme
- Separation of oil and water mixtures into separate components using oil water separator (OWS)

Waste Management System

Waste Materials (domestic, toxic, hazardous, non-toxic and non-hazardous waste, and other types of waste) will be managed thru the development of a Solid Waste Management Plan. The plan shall follow the protocols stipulated in Republic Act No. 9003 or the Ecological Solid Waste Management Act of 2000 and in line with the local government's solid waste management plan. Waste that will be generated during the construction phase will be managed in coordination with the local government units as the LGUs may have a specific contractor/waste hauler that handles construction waste. Treatment and disposal of toxic and hazardous waste shall be done by a DENR-EMB accredited contractor.

Garbage bins shall be placed in strategic locations and regular maintenance of the area shall be done. The assigned pollution control officer (PCO) shall monitor the activities upholding the social safeguard and environmental policies concerning the project.

Prefabrication and optimized construction practices will be employed to minimize overall waste generated during construction.

CCTV cameras and monitoring on the bridge will be used with signage warnings to record and fine polluters.

Figure 1.12 Preliminary Project Components Layout (ArcMap Imagery, February 2020)

1.5 Process/ Technology

1.5.1 Construction Method

Provided below is a brief discussion of construction methods that the project may employ.

1. Navigation Span Bridge

For the span length required for the navigation span bridge, balanced cantilever is the only practical construction method for superstructure erection of a box girder. Typically, it would be efficient to use precast segments, but for very long spans requiring very deep sections at the piers, these would pose major challenges to be precast and lift into place. Therefore in-situ construction would be preferable. For a more modest span length, pre-casting would be favored.

Balanced cantilever construction involves casting or erecting precast segments sequentially from the piers outwards in a balanced manner – i.e. a pair of segments, one on each side. Prestress is then applied to hold these segments in place so that construction can move onto the next pair. The segments under construction/ erection would be supported by travelling formwork for in-situ construction, or by lifting frames which pick up the precast segments from barges. A span is completed by stitching the ends of two cantilevers together. Typically, the deck and piers are monolithic except at the end spans.

Figure 1.13 Typical In-situ balanced cantilever construction of the Skye Bridge, Scotland

2. Extradosed Bridge

The structural system of an extradosed bridge has the combined characteristics of an externally prestressed structure and a cable-stayed structure, which leads to efficient structural dimensions for the span length of 250m, which is proposed for the SIDC project.

Figure 1.14 Construction of Himi Bridge in Japan

3. Balanced Cantilevers

Launching girders could be used to lift segments into place instead of lifting frames. The main advantages of this erection method are:

- The segment size can be tailored for ease of transportation such that existing road networks may be used.
- The small size of segment also allows the use of smaller barges in the shallow waters.
- The segments can also be transported on the already constructed deck.
- Compared to span-by-span and full span launching methods, longer spans can be achieved.

The main drawbacks are the end spans are typically shorter than internal spans. For long viaduct, the spans would look uneven and not as aesthetically pleasing.

Balanced cantilever construction allows a greater span length to be achieved. An example of this is the Tuen Mun - Chek Lap Kok Link in Hong Kong with typical spans of 75 m, and main spans of up to 200 m, see **Figure 1.15** below.

Figure 1.15 Tuen Mun - Chek Lap Kok Link, Hong Kong

4. Span-by-span Erection by Launching Gantry

In this method, each box girder comprises several precast concrete segments. A launching gantry is used to erect the girder on a span-by-span basis. Precast segments can be transported on either barges or on the already constructed deck. All segments in a span are hung from the gantry, posttensioned and locked together and the whole span then lowered onto temporary bearings. The gantry can then be launched to erect the next span. To make the individual spans continuous, a concrete stitch can then be cast between the ends of two spans after the gantry has left. The decks will be jacked up such that temporary bearings can be replaced by permanent bearings with the desired articulation. Typically, a 50 m span can be erected every 4 days.

A typical span length for this would be about 40 – 50 m. While gantries are more widely available for the shorter spans of around 40 m, gantries for longer spans are becoming available. A recent example is Penang Second Bridge in Malaysia, which has typical spans of 55 m, as shown in **Figure 1.16**.

The same construction method has been used in many bridge projects in urban areas in Hong Kong, as shown in **Figure 1.17**.

Figure 1.16 Gantry Construction of Penang Second Bridge, Malaysia

Figure 1.17 Gantry Construction of Viaduct, Hong Kong

1.5.2 Pollution Control and Waste Management

Proper solid waste management practices will be adopted to ensure pollution control especially during construction stage. Domestic wastes from construction workers will be managed through a portable toilet, which will be set-up by the contractor.

Regular domestic waste disposal will be collected daily by a third-party contractor to ensure cleanliness in the workplace and avoid possible water quality impacts to drainages and waterbodies.

All construction materials and chemicals will be properly stored and managed in secured storage area with provision of secondary containment. Silt traps will be installed for all nearby water bodies. The waste soil and other debris will be properly handled and disposed on a regular basis. Trainings will be provided to site workers to improve their awareness on proper solid waste management practices.

In addition, construction vessels that will be used will have on-board noise reduction to protect construction workers from excessive noise exposure. This will be in accordance with the International Convention for the Safety of Life at Seas (SOLAS), which would limit ambient noise from on-board machineries and other noise generating equipment. Furthermore, propeller of vessels will be cleaned or polished regularly. Vessels that will be used will observe speed restriction and follow routing clearance to avoid sensitive marine areas.

The project will employ well-designed marine silt curtain scheme installed within the buffer of construction activities to prevent any pollution and silt disturbance due to construction activities at sea. This will also be regularly checked and monitored to avoid any significant environmental incidents.

Source: MakMax Taiko Kogyo Corporation Website, retrieved February 2020, http://www.taiyokogyo.com/siltprotector/index.html (above); Tuen Mun – Chek Lap Kok Link Investigation Draft EIA Report, retrieved February 2020, https://www.epd.gov.hk/eia/register/report/eiareport/eia_1722009/pdf/Section%209%20(Water%20Quality)/Appendix%209D6.pdf (below).

Figure 1.18 Illustration of Silt Curtains

Furthermore, the proponent will ensure that the contractor will abide the Marine Pollution (MARPOL) 73/78[1] and Philippine Coast Guard (PCG)[2] marine vessel operations guidelines particularly, but not limited to:

1. Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL)
    - No synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ashes from plastic products which may contain toxic or heavy metal residues will be disposed into the sea.
2. Regulations for the Prevention of Pollution by Sewage from Ships (MARPOL)
    - To enable pipes of reception facilities to be connected with the ship's discharge pipeline, both lines shall be fitted with a standard discharge connection in accordance to the standard dimensions of flanges for discharge connections table.[3]
    - The vessel that shall be used during construction phase will be equipped to discharge sewerage in accordance with the requirements of regulation 11 -Annex IV of the MARPOL.
3. Prevention of Pollution from Garbage (PCG Memorandum # 07-14)
    - The vessel operator will minimize the generation of garbage by limiting the taking on board ship of potential garbage
    - The vessel that will be used will have Garbage Record Book, duly registered at Marine Environmental Protection Command (MEPCOM)
4. Prevention of Pollution from Sewage (PCG Memorandum # 10-14)
    - If the vessel that will be used is within the scope of the Memorandum # 10-14, the operator will be required to secure International Sewage Pollution Prevention (ISPP) Certificate on board at all times or a waiver that certifies its exceptions.
    - If the vessel that will be used is within the scope of the Memorandum # 10-14, the ship will discharge comminuted and disinfected/treated sewage at a distance of more than four (4) nautical miles from the shoreline.

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[1] Source: http://www.marpoltraining.com/MMSKOREAN/MARPOL/intro/index.htm. Accessed on April 2020

[2] Source: http://www.coastguard.gov.ph/index.php/memorandums/12-mc. Accessed on April 2020

[3] Source: http://www.marpoltraining.com/MMSKOREAN/MARPOL/Annex_IV/r11.htm. Accessed on April 2020

5. Rules on Prevention, Containment, Abatement of Oil Marine Pollution (PCG)

    - The vessel that will be used will have a minimum of three (3) kilos of rags of other sorbent materials and appropriate number of open-ended drums with cover for clean-up in cases of oil spills on decks and pump rooms.

In case of pollution incidents or spill of oil or noxious substances, the masters of vessels/ persons-in-charge of vessels will immediately notify PCG. The notification will include the name of vessel, location, weather condition, type of spill and quantity or any other information necessary for immediate recovery and clean-up operations.

On the other hand, for in-land construction works, the project may use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be recommended to control noise impacts.

Source: Architectural Services Department Website, retrieved February 2020, https://www.archsd.gov.hk/archsd/html/report2011/en/supply-chain-management.html (left); Arup Project: South Island Line Independent Environmental Checker (right)

Figure 1.19 Illustration of Piling Rig and Breaker with Acoustic Mat

During operations phase, local noise barriers can be installed to reduce or deflect the noise. The design and type of noise barrier that will be installed will be carefully assessed to identify what will be suitable, if necessary. Screens can be made on the edge of the bridge to provide privacy, indeed it is likely that some noise barrier will be required and this can be designed to be dual purpose to screen any private properties from unwanted viewing and reduce noise. **Figure 1.20** shows an example of a typical noise barrier used in Tsing Tsuen Bridge in Hong Kong.

Figure 1.20 Illustration of Noise Barrier Installed in Tsing Tsuen Bridge, Hong Kong

1.5.3 Operation and Maintenance

The design of the structures will be in accordance with the Design Standard guidelines of DPWH and other specifications of the project, where necessary. These design standards contain principles and requirements for safety, serviceability and durability. It assumes that maintenance activities are performed during the working life of the bridge structures in order to enable them to fulfil the requirements for reliability.

In order to preserve the intended reliability of the structures there is an absolute requirement for ongoing inspection and maintenance. Replacement or repair of certain components shall be carried out as necessary to ensure that the reliability of the structures is not reduced during the intended service life.

1.6 Project Size

The project is a 24-meter wide bridge deck with dual two lane and shoulder. An exit / entry ramp for pedestrian and bicycles will be part of the interchange proposed arrangement. The total roadway length of the bridge including the 4 ramps on Davao side is 3.98 km (point to point length 2.85 km, with 1.6 km marine crossing). The proposed navigation channel is 150 meters wide and 47 meters high, to facilitate one-way ship traffic. It is noted that two-way traffic could be permitted for smaller vessels. The in-land portion of the bridge will require a total area of 63,380 m^2. Davao City will need 42,328 m^2 or 67%, while IGaCoS requires 21,052 m^2 or 33% of the total. In-land components include land viaduct, Davao's ramp, and IGaCoS' roundabout junction.

The height is within the 73-meter maximum allowable limit as set by the CAAP. There are also two approach ramps that will form a directional t-interchange connecting to the land viaduct, one is along R. Castillo and the other along Daang

Maharlika. Each approach ramp is about 9.7m in width with one lane per direction. While there will be a 2-lane roundabout in circumferential roads in IGaCoS.

1.7 Development Plan, Description of Project Phases and Corresponding Timeframes

The project components will be implemented according to the Department of Public Works and Highways (DPWH) Standard Specifications, Volume II: Highways, Bridges and Airport (the Blue Book) 2004 edition. This will be supplemented with additional project-specific specifications, where necessary.

1.7.1 Project Phases

Major activities that will be carried out in the pre-construction and operation phase are summarized in **Table 1.10**. A brief description of specific activities and the potential environmental impacts associated with the works are also in the table below.

Table 1.10 Summary of Major Project Activities

Major Activities	Description	Potential Environmental Impact
Pre-construction		
Site Preparation	This includes site preparatory activities such as land clearing and/or tree cutting activities.	Generation of waste and hazardous materials, may lead to spillages; Loss of vegetation, disturbance to biodiversity, may trigger soil erosion, and induce landslides
Ground Preparation and Earthworks	Activities may include excavation for foundations; cut and fill; levelling and compaction, and other engineering works	Generation of noise and air pollutants, ground shaking
Land and ROW Acquisition for Project-Affected-Persons (PAPs)	Land acquisition activities include stakeholder engagements and corresponding social activities to acquire necessary permits/documents pertaining to land ownership.	Displacement of people and loss of livelihood
Construction		
Transport of Materials	This involves mobilization of construction vehicles (i.e. trucks and vessels) and heavy equipment for hauling and transport of materials.	Noise and air pollutant generation, traffic congestion
Construction of Temporary Facilities	These are facilities in the construction site that are built temporarily such as housing	Noise and air pollutant generation, ground shaking, domestic solid wastes and

Major Activities	Description	Potential Environmental Impact
	for workers, construction offices, storage facilities, etc.	wastewater accumulation, disturbance to sensitive receptors
Dredging and Excavation	Dredging and excavation involve removal of silt, sediments, and other materials. Soil will be removed to a required depth in which the foundation of the structure will be placed	Noise and air pollutant generation, change in channel beds, disturbance to marine and terrestrial habitats
Operation of Heavy Machineries	Operation of these heavy machineries are for civil works such as the construction of casting yard, foundations, bridge and interchanges, and bridge structure	Noise and air pollutant generation, ground shaking, disturbance to marine and terrestrial habitats, domestic solid wastes and wastewater accumulation, disturbance to sensitive receptors

1.7.1.1 Pre-construction/Pre-operational Phase

The pre-construction phase involves planning and conduct of the detailed engineering design for the bridge components, obtaining ROW and necessary clearances and local permits, pre-qualification of contractors and awarding of contracts, and mobilization for construction.

During the pre-constructional phase, the contractor(s) will mobilize equipment and supplies to the project site, erect temporary facilities for workers and field office, storage sheds and workshops required for the management and supervision of the project. Construction management staff and workers, including local labor, which will include women. Casting yard, which will also serve as a dry dock, will be set up where steel segments and precast concrete elements such as girders, beams and caissons will be cast.

The Road Right-of-Way (ROW) and compensation process will be completed before the start of construction. Affected land and property must be cleared before the start of construction, including properties that should be demolished for the construction of land viaduct, ramps and roundabout junctions. Trees and vegetation areas on the site will be removed at site clearing phase.

Detailed geotechnical and subsurface investigations will be conducted. Ground preparation and earthworks will commence at the pre-construction phase. As the layout of the structure should be already set accurately at this stage, excavation work will begin, where the soil will be removed to a required depth in which the foundation of the structure will be placed. Heavy machineries like boulders, backhoe, shovels, and scooper will be used for earthworks i.e. removing of excessive soil and other material from construction site.

A health and safety management plan will be prepared and implemented to establish protocols and procedures in addressing potential health and safety emergencies (e.g. oil spills).

Construction of temporary facilities will also be built during this stage depending on the number of workers that will be hired and the actual civil works. The acquired land will be utilized for construction of these.

There may be minimal disruption to road users in the vicinity of the project site during the construction phase. Access roads may need to be opened prior to the commencement of construction-related activities. Any required road closures or detours will be clearly marked to ensure that there are no safety risks for road users, and any possible distribution will be minimized.

During bridge construction, a navigable channel will be maintained, as required, to ensure safe and convenient passage of vessels in the vicinity of the project area. The design plans will integrate required clearances for unobstructed passage of vessels under the bridges.

Following are the clearances, permits and documentations needed:

Table 1.11 Clearances, Permits, and Documentation Requirements

Permits / Clearances	Authorities Involved
Pre-Construction	
Authority over the land/Waiver of Rights	Lot owner(s)
Municipal endorsement for the project / Certificate of no objection	City/ Municipal LGU
Dumping Permit	City/ Municipal LGU
Building & Ancillary Permits (Mechanical, Electrical, Sanitary/ Plumbing)	LGU/ City/ Municipal Office of the Building Official/ Bureau of Fire Protection (BFP)/ DPWH
Fire safety evaluation clearance	BFP, City/ Municipal LGU
Occupancy permit	LGU/ City/ Municipal Office of the Building Official
Electrical connection agreement	City/Municipal LGU
Barangay endorsement to the project/ Certificate of no objection	All concerned barangays
Zoning/ Locational clearance (Certificate of zoning compliance	Zoning division, City/ Municipality LGU
Proof of Ownership of Land	Registry of Deeds, or depends
Road-right-of way	Department of Public Works and Highways (DPWH)/ Private lot owner
Environmental Compliance Certificate	EMB - DENR
Sampling (PAMB) Clearance/ resolution (only if needed)	Conservation and Development Division (CDD) – Biodiversity Management Bureau (BMB) – DENR
Special Agreement for Protected Areas (SAPA)	BMB - DENR
Tree cutting permit	BMB - DENR
Land use conversion or Land use reclassification (as needed)	LGU/Municipal Planning/Zoning Office

Permits / Clearances	**Authorities Involved**
Water Permit	National Water Resources Board (NWRB)
Area Status and Clearance	CENRO*
Navigational Clearance	Philippine Coast Guard
Coastguard Clearance	Philippine Coast Guard
Certificate of Non-Overlap	NCIP
Certificate of No Objection	LGUs/Barangays
Construction/ Building Permit	LGUs
CAAP Clearance	Civil Aviation Authority of the Philippines
BFAR Clearance	Bureau of Fisheries and Aquatic Resources
Construction	
Registration of Safety Officer	Department of Labor and Employment (DOLE)
Environmental registration for managing heads	EMB
Registration for Pollution Control Officer	EMB
Hazardous waste generator ID	EMB
Permit to Transport	DENR
Wastewater discharge permit	EMB
Permit to Operate Generator Sets	EMB

Note: DENR-CENRO Panabo cleared that the project is not within the NIPAS, hence secured the NIPAS Certificate (**Annex H**).

1.7.1.2 Construction/ Development Phase

Bridge construction will involve the following activities:

- **Casting Yard Preparation**

The casting yard is where all the precast concrete and steel segments will be fabricated. The yard will have its own delivery and storage areas, concrete batching plant, and assembly area. It will also have a dry dock to have access to the shores of Davao City. This will need a separate ECC application, therefore, casting yard preparation is not considered as one of the project components. However, it is a significant activity in the early construction phase of the project.

  - Transport of Materials

    All materials needed for the concrete structures will be transported and stored in casting yard. Materials will be transported through freight or vessel. Specific procedure will be prepared as part of the project management and traffic management plan during DED.

After the segments are completed, it will be transported to the construction site via land and sea.

- **Foundation**

For the structures on land such as abutments, retaining walls and bridge structure, the site will be excavated for the footing foundations and the completed structures will be backfilled. All excavated materials will be disposed of properly or reused for backfilling, if applicable. Work will also include the furnishing and placing of approved foundation fill material to replace unsuitable material if encountered below the foundations of structures.

For the marine viaducts, large diameter concrete bored piles will be adopted. These require steel casing to be first driven into the seabed. The material will then be excavated from withing the casing. Steel reinforcement cages, and finally concrete will be poured into the excavation to form the final foundation structure.

For the navigation bridge, prefabricated caissons will be immersed until it rests on the seabed. Before placing the caisson, the seabed will be prepared to prevent undue settlements. The soil layer or pad underneath the caisson may be created by soil improvement (jet grouting / deep soil mixing) or with inclusion piles.

- **Bridge Approach and Interchanges Construction**

The construction work will involve embankment fill and sub-grade preparation before placing the aggregate sub-base material. The sub-base materials will be spread and compacted to the required thickness. Aggregate base course material will be placed and compacted on the prepared sub-base, and a Portland Cement Concrete Pavement (PCCP), as required per the design will be constructed on the prepared base according to specifications. Road shoulders of the bridge approaches will be protected from erosion by installing grouted riprap for slope protection, as required.

- **Bridge Structures**

The construction of the land and marine viaducts and navigation bridge will involve the following activities:

- Erection of Columns and Girders
- Cast in place approach slab, deck slab and road curb/barriers
- Installation of storm drain system
- Apply bitumen wearing coarse
- Installation of lighting/signal system
- Marking of roads and traffic signage

1.7.1.3 Operational Phase

The bridges and roads are part of a National Highway system and will be maintained by the DPWH-Central in coordination with the DPWH Region XI District Engineering Office in Davao. Road Traffic Management will be coordinated with the concerned local government units. Solid Waste Management will be coordinated with the concerned local government office and the DENR.

1.7.1.4 Demobilization Phase

The demobilization activities will proceed after the construction phase. This will include demobilization of temporary accommodation for works and other temporary facilities structures, and removal of all equipment. Construction areas will be cleared and cleaned of any construction waste or debris. Demobilization and restoration work will comply with the accepted procedures and standards prescribed in the approved civil works contract, per DPWH standards.

1.7.2 Project Schedule

The project schedule is shown in **Figure 1.21** below. Project preparation and identification started last 2018 while the civil works construction will begin in 2021. The construction is expected to end by the year 2024.

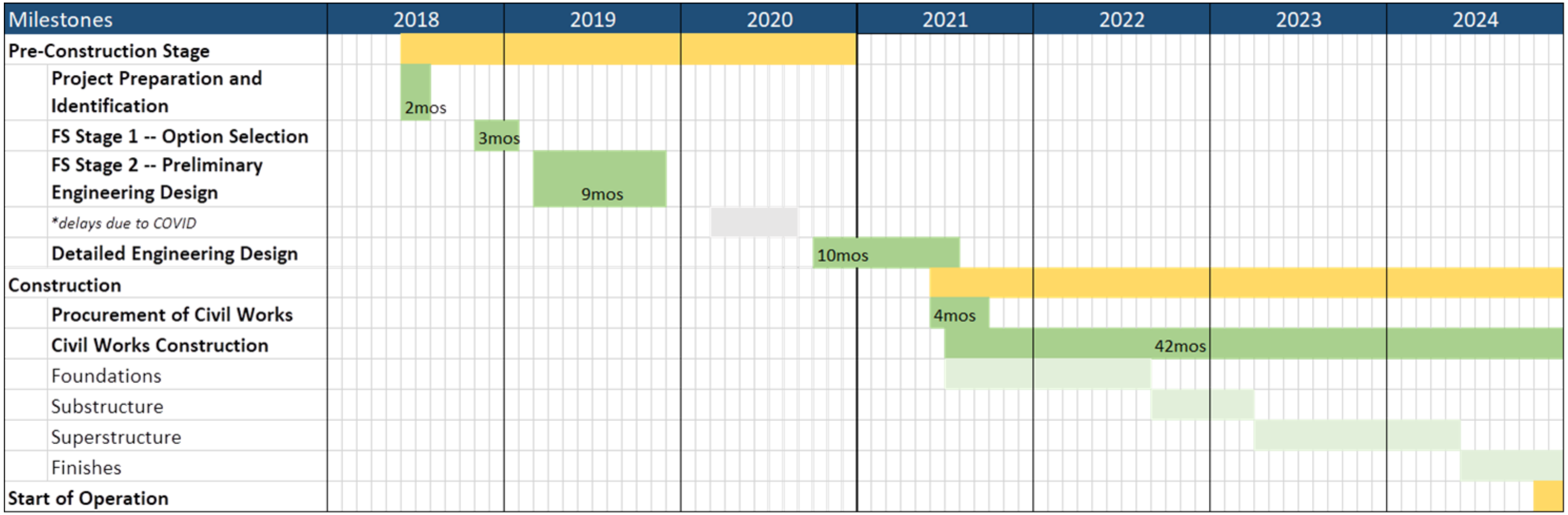


Figure 1.21 SIDC Project Schedule

1.8 Manpower

1.8.1 Preconstruction Phase

The manpower necessary during pre-construction phase are the project proponents,consultants and sub-consultants of the project. The total estimated manpower for this phase is listed in **Table 1.12**.

1.8.2 Construction Phase

During construction, the work force will consist mainly of skilled workers, which include masons. The project will need about 500-1300 skilled and unskilled workers for the construction of the bridge, where hiring of qualified locals is recommended.

A percentage of the construction manpower will be provided by the contractor; hence DPWH will require the contractor to adopt strict policy requiring to source workforce from qualified locals and to develop scheme of prioritization in local hiring.

Furthermore, DPWH will strictly enforce RA 6685 in the project. This act requires private contractors to whom the project have been undertaken to hire at least 50% of the qualified unskilled and at least 30% of the qualified skilled workers from the host city or municipality of the project.

Moreover, the contractor is required to apply labor standards and equal pay for work of equal value for both men and women. Equal opportunities will be provided for men and women. A target percentage of female workers will be set on the DED stage of the project.

Lastly, it will be part of the policy of DPWH to hire qualified applicants including persons with disability (PWD), members of indigenous communities, senior citizens and those any sexual orientation and gender identities (SOGI). These all will be part of the Terms of References (TOR) of the contractor during construction and operations phase.

1.8.3 Operation Phase

For the bridge operations, there will be lesser people hired as compared to the construction phase of the project. The operation phase will need people who will handle the security and passage of vehicles, as well as the maintenance and repair works of the bridge. DPWH commits to the implementation of an employment protocol, prioritizing locals as a hiring policy.

Table 1.12 Summary of Manpower Requirements for the Project

Project Phase	Expertise/Skills Required	No.
Pre-Construction Phase		**100 -150**
Construction Phase		**500 - 1300**
Skilled		*190-500*
Construction Engineer	Monitoring of construction activities, provide technical support and prepare physical construction plans	
Human Resources	Hiring and screening of qualified applicants, Responsible in giving trainings for employees (if needed)	
Community Relations	Excellent interpersonal skills, management of Social Development Plan of the project	
Audit and Finance	Meticulous in financial documentation and process	
Admininstration Staff	Must have organizational and planning skills	
Vessel Operators	Experienced and competent in vessel or navigational operations	
Construction Manpower and General Workers *Construction Workers* *Laborers* *Other Contractors*	Knowledge and experience in construction operations and/or maintenance	*310-800*
Operation Phase		**10 - 25**

Note: Subject to further refinement during DED stage.

1.9 Indicative Project Investment Cost

The civil works of the project will cost approximately PhP 16.606 Billion, while the estimated total cost of the proposed SIDC project is PhP 23.040 Billion. Given that the SIDC is in the early stages of study, a factor of +50% and -20% may be applied to the total project cost.

2 Assessment of Environmental Impacts

This chapter contains the assessment of environmental impacts to land, air, water, and people of the proposed SIDC Project. For each subsection, methodologies on how the study was conducted will be discussed, key findings on the baseline environmental conditions will be presented, followed by the perceived significant impacts identified for each component with corresponding mitigation measures.

2.1 The Land

Davao City is a first class highly urbanized city in the southeastern part of Mindanao, with an area of 244,000 ha, which is one of the largest administrative areas in the world (Davao City Comprehensive Land Use Plan, 2013-2022). IGaCoS is a fourth-class city in the province of Davao del Norte, located in Davao Gulf, with a total land area of 30,130 ha. (IGaCoS Comprehensive Development Plan 2018-2023).

The project is expected to cover varying land areas based on the proposed alignment of the bridge. With this, it is highly important to study the conditions of the land in the project area in order to assess potential impacts that may emanate from the project. This section provides impacts, mitigation, and enhancement plans for the following land components divided into the following subsections:

- Land Use and Classification
- Geology/Geomorpholgy and Geohazard Assessment
- Pedology
- Terrestrial Ecology

Methodology

Varying methodologies were employed to study and determine baseline environmental conditions of the land in the project area. These methods include:

a. Review of all available secondary information
b. Reconnaissance survey
c. Detailed field investigations
d. Rock sampling and identification
e. Transect sampling and analysis

The application of these methodologies is described in more detail in the subsequent sections for this module.

2.1.1 Land Use and Classification

Land use assessments for Davao City and IGaCoS were based on a review of relevant secondary data, including comprehensive land use plans, comprehensive development plans, zoning ordinances, socio-economic profile, and other sources.

Different components of the SIDC bridge will intersect varying types of land uses and plans, which need to be identified in order to integrate the project with the planned developments for both Davao City and IGaCoS.

Baseline Environmental Conditions

Land Classification

Davao Region has a total land area of 19,721.09 sq. km. or 1,972,109 ha. (DENR Cadastral Survey, 2015) which covers 4 provinces: Compostela Valley, Davao del Norte, Davao Oriental, and Davao del Sur. Davao City and Samal are among the six cities in the region. The Davao Regional Physical Framework Plan 2015-2045 indicates that 40% of the region's total land area is classified as alienable and disposable (A&D), while 60% are forestlands.

Figure 2.1 presents Davao Region's Land Classification Map.

Land Use

Davao City was developed as a regional trade center for Southern Mindanao and the Southern Pacific, serving as a southern gateway to nearby countries. The city is divided into 3 districts and subdivided into 182 barangays with varying land uses. Only 5.37% of land is for urban use, while forest, grassland, and pasture lands account for 65% and agricultural lands represent 30% of the city area (**Table 2.1**).

Table 2.1 Existing Land Use, Davao City, 2011

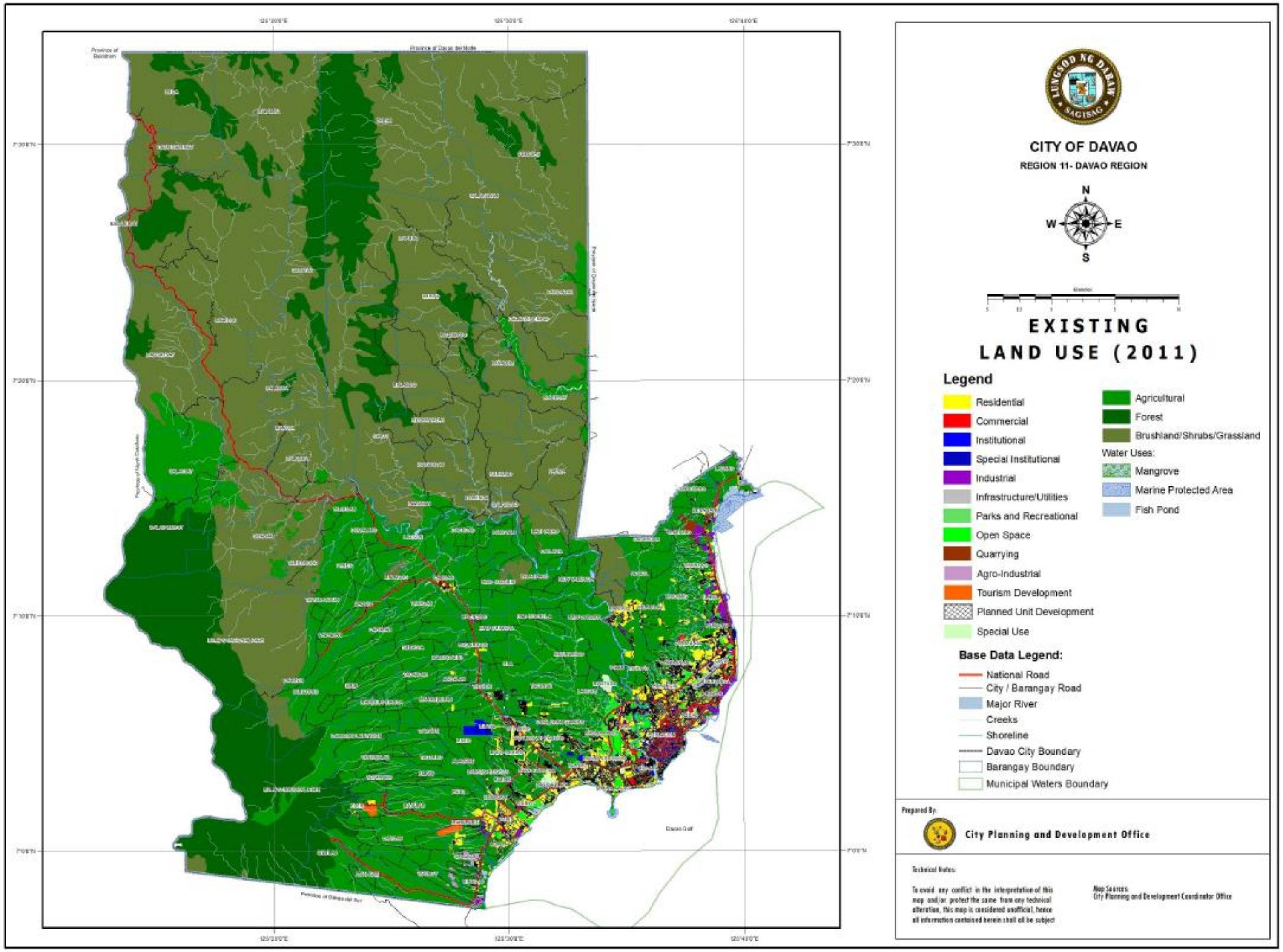
Land Use Categories	Area (in hectares)	Percent to Total
Urban Use Areas		
Residential	8,382.38	3.44%
Commercial	1,583.32	0.65%
Infrastructure/Utilities	208.62	0.09%
Institutional	629.03	0.26%
Parks/Playgrounds and other recreational spaces	61.73	0.03%
Industrial	853.02	0.35%
Planned Unit Development	76.86	0.03%
Open Space	1,258.80	0.52%
Agriculture	73,086.05	29.95%
Forest and forest use categories	39,916.94	16.36%
Mining/Quarrying	157.14	0.06%
Grassland/Pasture	116,832.08	47.88%
Agro-industrial	168.36	0.07%
Tourism	200.08	0.08%
Special Use	342.09	0.14%
Water Uses (Fishponds / Mangroves)		
Fishpond (Inland water use)	209.98	0.09%

Land Use Categories	**Area (in hectares)**	**Percent to Total**
Mangrove forests	33.91	0.01%
TOTAL	244,000.00	100.00%
Water Use (Marine Protected Area)	415.00	

Source: Davao City Comprehensive Land Use plan, 2013-2022

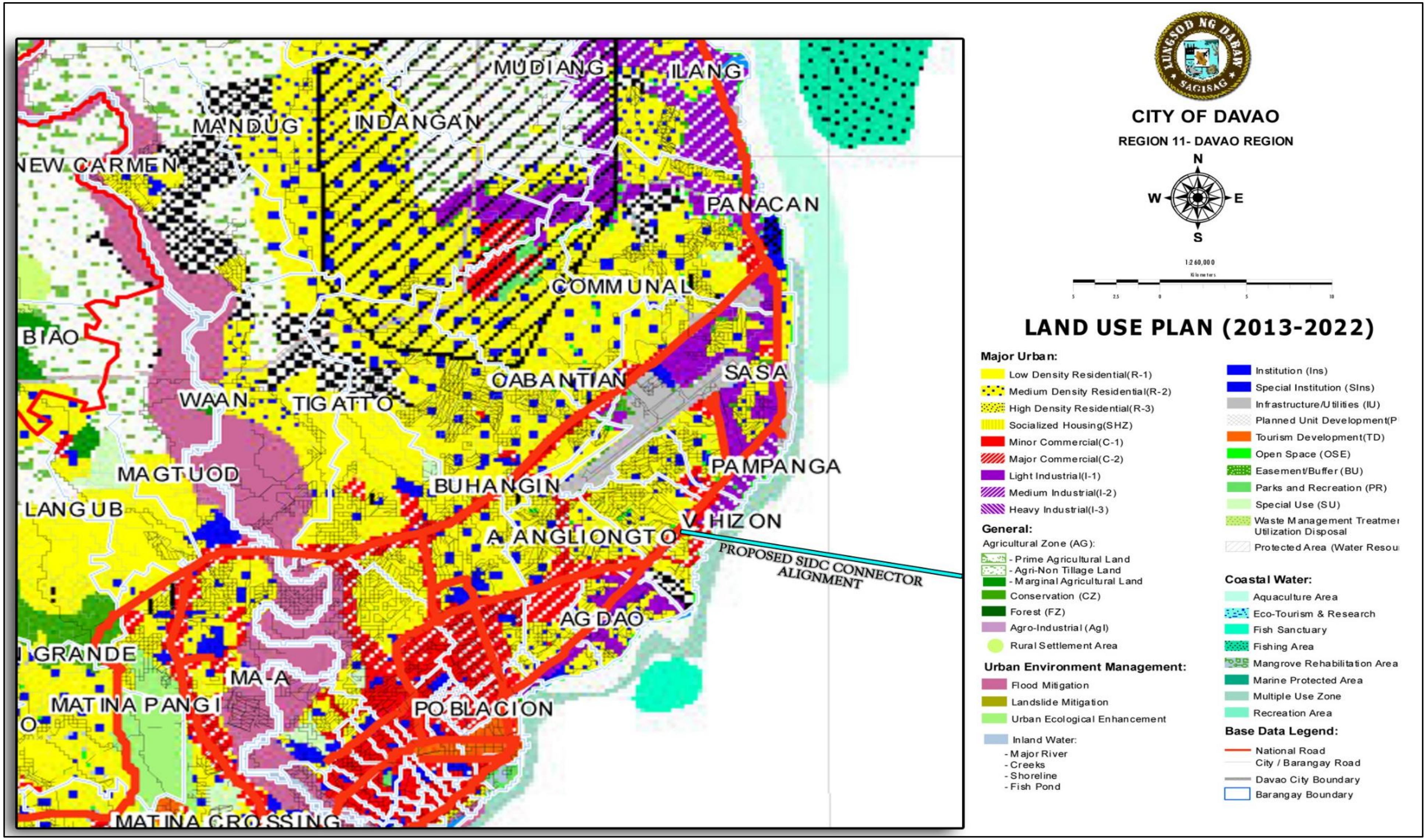
Source: Davao Region Physical Framework Plan, 2015-2045

Figure 2.1 Davao Region Land Classification Map, 2015



Source: Davao City Comprehensive Land Use plan, 2013-2022

Figure 2.2 Davao City Existing Land Use Map, 2011



Source: Davao City Comprehensive Land Use plan, 2013-2022

Figure 2.3 Land Use Plan of Davao City showing the proposed SIDC Alignment

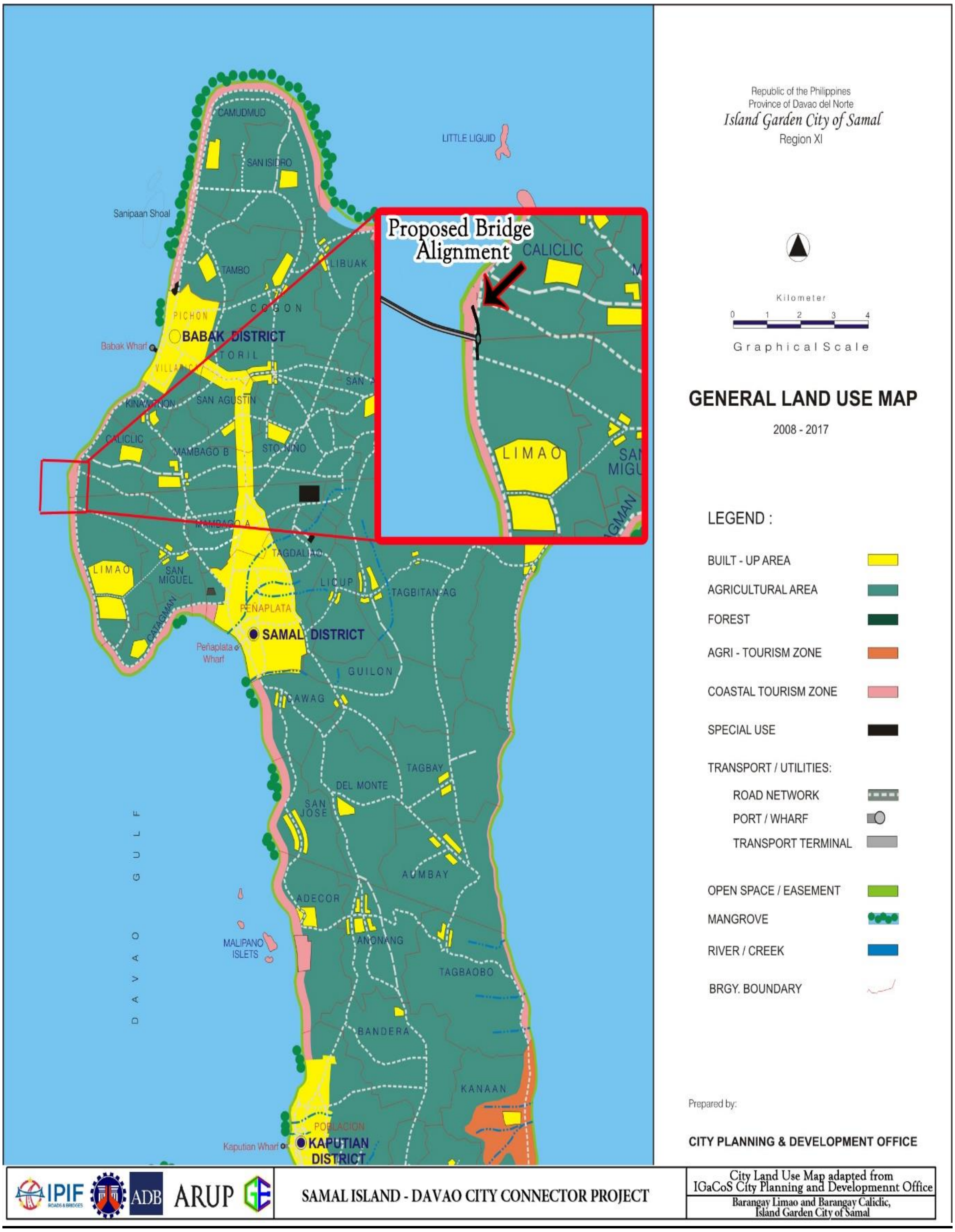
IGaCoS consists mainly of Samal Island and Talicud Island and is part of Davao del Norte Province. Its land area is divided in 3 districts, which are subdivided into 46 barangays. Built up areas only occupy 1.75% of total land area. Though beach resorts are mostly located along the coast, majority of the land area, about 90%, is for agricultural use. Main crops cultivated are corn, banana, mango, and coconut. **Table 2.2** shows existing land use categories and their corresponding land area.

Table 2.2 Existing Land Use, IGaCoS, 2007

Land Use Categories	**Area (in hectares)**	**Percent to Total**
Built-up	526.42	1.75
Agricultural	26,961.01	89.48
Forest	1,099.60	3.65
Open Space/Grasslands	258.13	0.86
Special Use	14.84	0.05
Agri-Tourism/Tourism	568.39	1.89
Infra/Utilities	461.87	1.53
River/Creeks	31.05	0.1
Swamps and Marshes/Fishponds	144.12	0.48
Mangroves	64.08	0.21
TOTAL	**30,130**	**100**

Source: Comprehensive Land Use Plan 2008-2017, IGaCoS Comprehensive Development Plan 2018-2023

Samal Island is predominantly a coconut plantation. While about 30% of the island specializes on mangoes. Agricultural activities have expanded in the island from lowland areas to upland areas. The IGaCoS Comprehensive Development Plan 2018-2023 further indicates that some forestland areas have been converted to settlement areas. **Figure 2.4** shows the existing general land use map of IGaCoS, with the proposed alignment.



Comprehensive Development Plan of IGaCoS, 2008-2017

Figure 2.4 General Land Use Map of IGaCoS showing the proposed SIDC Alignment

Environmentally Critical Area (ECA)

Under Proclamation No. 2146, series of 1981, guided by the DAO 2003-30, there are 12 categories of Environmentally Critical Areas (ECAs). These include the following:

1. All areas declared by law as national parks, watershed reserves, wildlife preserves and sanctuaries;

2. Areas set aside as aesthetic potential tourist spots;
3. Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine Wildlife (flora and fauna);
4. Areas of unique historic, archaeological, or scientific interests;
5. Areas which are traditionally occupied by cultural communities or tribes;
6. Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.);
7. Areas with critical slopes;
8. Areas classified as prime agricultural lands;
9. Recharged areas of aquifers;
10. Water bodies characterized by one or any combination of the following conditions;
    a. tapped for domestic purposes
    b. within the controlled and/or protected areas declared by appropriate authorities
    c. which support wildlife and fishery activities
11. Mangrove areas characterized by one or any combination of the following conditions:
    a. with primary pristine and dense young growth;
    b. adjoining mouth of major river systems;
    c. near or adjacent to traditional productive fry or fishing grounds;
    d. which act as natural buffers against shore erosion, strong winds and storm floods;
    e. on which people are dependent for their livelihood.
12. Coral reefs characterized by one or any combinations of the following conditions:
    a. With 50% and above live coralline cover;
    b. Spawning and nursery grounds for fish
    c. which act as natural breakwater of coastlines.

Table 2.4 summarizes the identified ECAs and their significance, where the project is located or those that are near the project area.

Proclamation 2152 s 1981 declares portions of Samal Island as a protected area. It was mentioned that Samal Island is known "Mangrove Swamp Forest Reserve" and "Samal Island Protected Landscape and Seascape". However, based on the data gathered from NAMRIA in December 2018, the Biodiversity Management Bureau (BMB) dataset indicates that the identified mangrove forest swamp reserve in Samal Island is approximately 5km from the nearest point of the SIDC alignment. Data gathered from DENR Region 11 also indicates that the Samal Island Protected Landscape and Seascape is approximately 200 meters from the nearest point of the SIDC alignment (**Annex H**).

A review of the RA 7586 on NIPAS and RA 11038 on Expanded NIPAS Act of 2018 was undertaken. These laws confirm that the two (2) protected areas per Proclamation 2152 s 1981 are considered as initial components protected area. Should these initial components be recommended to be established as protected areas, NIPAS requires DENR to undertake the following activities (i) maps and technical descriptions (ii) conduct suitability assessment of the areas and (iii) public consultations.

The recommendations of DENR can either declare the protected area as part of the System or disestablishment. If the endorsement of DENR is to declare the protected area as part of the system, the President shall issue a proclamation establishing the proposed protected areas until Congress enacts a law and declares integration into the System. If DENR suggests disestablishment, the protected area should be withdrawn, or its boundaries modified.

Nevertheless, DPWH has coordinated with the DENR Region 11 to ensure that the project follows RA 11038. An Area Status and Area Clearance and NIPAS map with DENR logo overlaying the project alignment were requested to DENR Region 11 last 25 March 2020. The request was then forwarded to City Environment and Natural Resources Office (CENRO) Panabo. DENR CENRO Panabo gave clearance that the project area is not within the NIPAS, through the NIPAS Certificate released on 13 May 2020. Accordingly, DPWH complied with the recommendations of CENRO Panabo, which means application of PAMB Clearance or SAPA will no longer be needed. The protected areas map, letter requests, and NIPAS Certificate are provided in **Annex H**.

Land Tenure

The project covers low to medium residential areas, interspersed with minor commercial lands in Davao City. Primary impact areas in IGaCoS are used for commercial coastal tourism purposes, which are surrounded by agricultural areas. No records or indication that these agricultural lands are classified as high yield or prime agricultural areas were found. However, potential project impacts to agricultural lands will still be assessed and considered. Surveys conducted found that informal settler families may be affected. Affected lots with and without structures at respective barangays are listed in **Table 2.5**.

Visual Aesthetics

Davao Region has numerous significant landscapes including Mount Apo, a popular tourist destination in the country. Monfort Bat Cave in Samal is known for its bat colony that is certified by the Guinness Book of World Records as the largest colony of fruit bats in the world. In Davao Oriental, the 'Sleeping Dinosaur' is a land formation along Pudaja Bay, Mati City that forms a landscape of rice fields and coconuts. The project site will not affect any of these visually significant landforms. Visual aesthetics of areas only traversed by the alignment may be affected mostly during construction phase.

Solid Waste Management

It is clearly defined in the Local Government Code and RA 9003 or the Ecological Solid Waste Management Act that LGUs must have a 10-year Solid Waste Management Plan (SWMP) to ensure efficient waste collection, transfer, disposal and its overall management. Davao City prepares a SWMP; however, the LGU CENRO claims that proper waste disposal and implementation of 'no segregation, no collection' policy must be strengthened in communities and establishments in the city. The projected Municipal Solid Waste in Davao City is presented in **Table 2.3**.

Table 2.3 Projected Municipal Solid Waste Amount (in kg/day), Davao City

	2022	2030	2045
Total waste amount	1,023,310	1,274,976	1,601,736
Biodegradable	550,581	638,381	801,989
Non-Biodegradable			
Recyclable	202,441	234,723	294,880
Residual	324,939	376,755	473,313
Special Waste	21,663	25,117	31,554

Source: 10-year Integrated Solid Waste Management Plan (2018-2027)

The IGaCoS SWMP 2013-2023 was approved in 2015 and aims to develop alternative source of energy out of solid waste materials. Selected barangays in the city have a Materials Recovery Facility (MRF) that promotes reuse and recycling of solid waste.

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Potential Impacts on Land Use and Classification

The infrastructure is expected to traverse varying zones and land uses for both Davao City and IGaCoS as seen in **Figure 2.3** and **Figure 2.4**. The project was designed in a way that existing structures are avoided, and that the alignment chosen would have less impact on existing properties.

In Davao City, direct impact areas affected by the project include primarily low to medium residential areas, interspersed with minor commercial lands along shoreline and existing roads which include the Maharlika Highway (a national road that is also part of the Asia Highway 26 – AH26) and barangay access roads (including Lizada and Tanere Roads), among others. The land use plan of Davao City showing the proposed SIDC Alignment can be seen in **Figure 2.3**.

The proposed bridge alignment that will be in IGaCoS will be under agricultural, commercial, residential, and coastal tourism areas. Most of the properties within the proposed project location in Samal are undeveloped land with resorts along its shoreline. The existing land use of primary impact areas are used for commercial coastal tourism purposes, surrounded by areas that are mostly agriculture in nature, as well as the Samal Island Circumferential Road. As reported in the official website of Samal City, its total land area is generally classified as alienable and disposable (A&D) and forestlands. Considerations for agricultural area should be given high importance since the city mostly depend on crop production (as officially reported in Samal City Government website).

Potential Impacts on Environmentally Critical Areas (ECA)

In accordance with Presidential Proclamation No. 2146, series of 1981, **Table 2.4** summarizes the identified ECAs and their significance to the project, in addition to traversing barangay-level declared marine protected area (MPA) in Barangay Vicente Hizon, Sr. (**Figure 2.5**).

The MPA has not yet been confirmed to be part of the local government's enlisted protected areas and is not part of the protected areas as defined by the ENIPAS. However, the MPA of Barangay Hizon is currently proposed to be included in the next Comprehensive Land-Use Plan (CLUP) of Davao City. Succeeding an intensive environmental assessment and consultations with community stakeholders, the said MPA may and will be relocated to other new area that is not susceptible to possible degradation and disturbance. This was confirmed through the Sangguniang Barangay Resolution Interposing No Objection that the Project has secured after consultations (**Annex I**). Thus, the land to be occupied is suggested to be compatible with and effectively capable of accommodating the project.

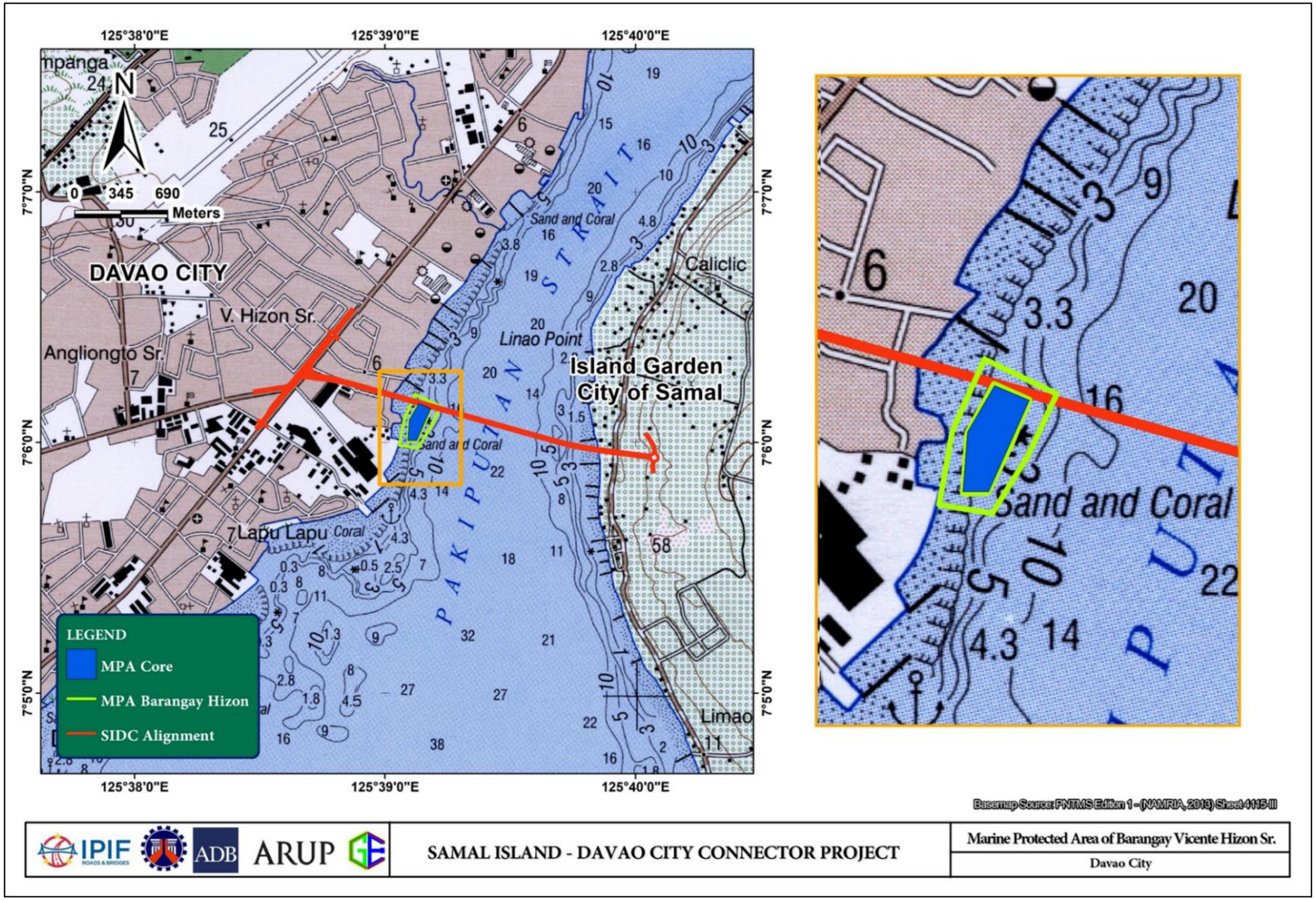
Moreover, the project does not transect any declared protected areas based on the NIPAS (**Figure 2.6**). This has already been decided by DENR CENRO Panabo through the NIPAS Certificate released on 13 May 2020 (**Annex H**).

Table 2.4 Summary of Environmentally Critical Areas (ECA) in Davao City and IGaCoS

Technical Description of ECA Categories	Relevance to the Project Site
Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	There are no declared national parks, watershed reserves nor wildlife preserves and sanctuaries within and in the vicinity of the project site. The nearest such areas include the Samal Island Protected Landscape and Seascape (<1 km north, covering Barangays Caliclic, Kinawitnon, Tambo, Pichon, Villarica, Tagpopongan, Balet, San Isidro, Libuak and Camudmud in the Babak District), Malagos Watershed Reservation (28 km northwest), Mount Apo Natural Park (30 km west-southwest) and Mabini Protected Landscape and Seascape (30 km northeast) aerial distance from the project (**Figure 2.5**).
Areas set aside as aesthetic, potential tourist spots	The IGaCoS is a local tourist spot, whose beaches and other natural features, are frequented by residents of Davao City as well as domestic and international tourists.
Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	**Flora:** Based on the IUCN Status Red List 2020, few vulnerable species, including the *Pterocarpus indicus forma indicus* (Smooth Narra), *Swietenia macrophylla* (Big-Leaf Mahogany) and *Artocarpus blancoi* (Antipolo), were identified in the project vicinity in Samal. In Davao, vulnerable species, including the Big-Leaf Mahogany, Antipolo, and the *Eucalyptus deglupta* (Bagras) were also identified. Their removal during construction will not compromise the ecological integrity of the surrounding areas. Even so, in order to achieve no net loss in natural habitats, replacement trees/ lora will be provided for all affected areas. **Fauna:** While faunal species were noted around the project site, their known habitats are 31km to 38km from Area of Influence (AOI) and thus would not be severely impacted by the project. Moreover, no endangered or vulnerable faunal species were noted within and in the immediate vicinity of the project site. As fauna are motile, it is their instinct to take flight at the first sign of disturbance, save for nesting species which may tend to ward off intruders in their niche. This instinct can be exploited in preventing loss of fauna species, especially during construction. From the surveys conducted, species that may be affected along the trace of the SIDC include cane toads and common green frogs. For mammals, those that will be predominantly affected are bats, as well as house shrews and house rats. The largest percentage comprise Avifauna, which include glossy swiftlets, Eurasian tree sparrows, chestnut munia, yellow-vented bulbul, white-eared dove, barn swallow, Philippine pied fantail, eastern spotted dove, red-turtle dove, and Brahminy kite. Those species that will be affected will either be translocated to other natural habitats or appropriate habitats will be created to accommodate them.
Areas of unique historic, archeological, geological, or scientific interests	There are no areas of unique historic, archeological, geological or scientific interests within the project site.
Areas which are traditionally occupied by cultural communities or tribe	The proposed project will not affect any cultural communities. Portions of Samal Island and its surrounding waters at the east and south are the domain of the Sama tribe, as indicated by Certificate of Ancestral Domain Title No. R11-SAM-0415-177 issued by the National Commission on Indigenous Peoples. The said CADT area is approximately 5km from the proposed project site.

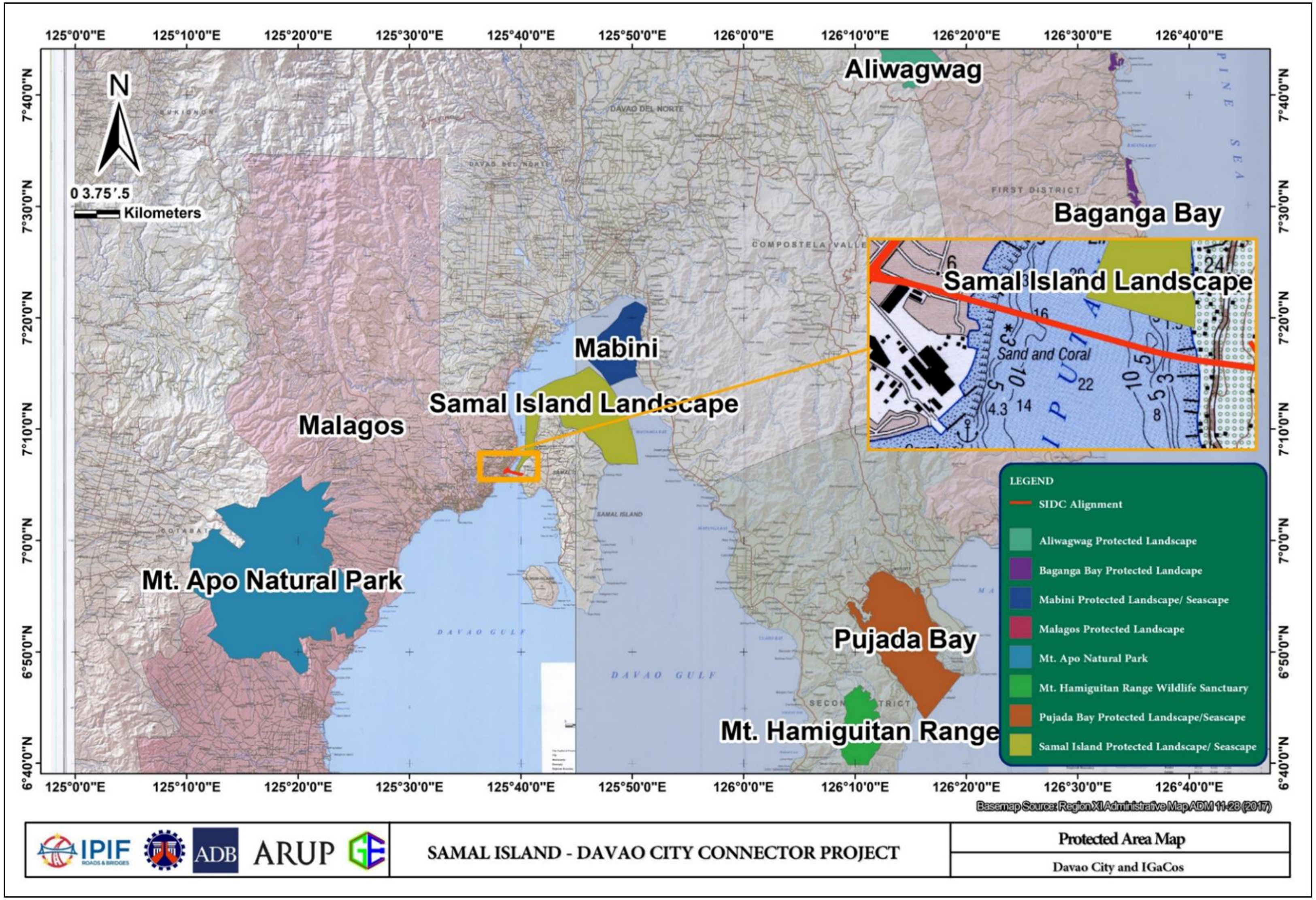
Technical Description of ECA Categories	**Relevance to the Project Site**
	Furthermore, the issuance of Certificate of Non-Overlap by NCIP confirms that the Proposed project site is not within any ancestral domain inhabited by indigenous peoples or cultural communities (**Annex J**).
Areas frequently visited and or hard-hit by natural calamities Geological hazard areas Flood-prone areas Areas frequently visited or hard-hit by typhoons Areas prone to volcanic activities / earthquakes	The vicinity of the project may be susceptible to various natural hazards. Also, and as with majority of the Philippines, the project is also susceptible to seismic and volcanic hazards. Their characterization and corresponding recommended mitigation measures are discussed in detail in **Section 2.1.2** of this EIS Report. Detailed, site-specific engineering mitigating measures will be identified during the DED phase of the project to address the following potential hazards: subsidence, karst subsidence, liquefaction, mass movements, flooding, erosion, ground shaking, ground rupture, ashfall, scouring and sedimentation. Notable events in recent times affecting Central and Southern Mindanao include various typhoons beginning with Pablo/ Bopha in 2012 and the 2019 M6.3 to 6.9 earthquake series.
Areas with critical slope	The project is not situated in areas with slopes >50% or forestlands, including unclassified forests. All areas within and in the immediate vicinity of the project are classified and used as alienable and disposable land. Thus, the slope in nearly all areas of the project is <18%, with the exception of a 30-meter strip of land with a slope of 30% representing a modified cliff face within a resort in the Samal side. The topography near the Davao side of the project is exemplified by flat coastal areas that grade into moderate slopes moving inland – however, the project itself will be situated within the extensive coastal flats of the city and, as such, will cross shores that are relatively gently in slope. The topography near the Samal side of the project is composed of horizontal to gently sloping uplifted marine terraces. The eastern and southern portions of the island – beyond the geographic scope of the project – are mostly composed higher terrain which includes knobby hills and peaks with moderate to steep slopes and with the peak of Puting Bato (the highest elevation in Samal) at 410 meters above sea level.
Areas classified as prime agricultural lands	While there are agricultural lands abutting the project, these are not classified as prime agricultural lands based on Network of Protected Areas for Agricultural and Agro-industrial Development (NPAAD) of the Department of Agriculture (DA). The NPAAD covers all irrigated areas, all irrigable lands already covered by irrigation projects with firm funding commitments; all alluvial plain land highly suitable for agriculture whether irrigated or not; Agro-industrial crop lands or lands presently planted to industrial crops that support the viability of existing agricultural infrastructure and agro-based enterprises, highlands, areas located at an elevation of five hundred (500) meters or above and have the potential for growing semi temperate and high-value crops; all agricultural lands that are ecological fragile, the conversion of which will result in serious environmental degradation, and mangrove areas and fish sanctuaries.
Recharge areas of aquifer	The project is not within or in the vicinity of aquifer recharge areas.

Technical Description of ECA Categories	Relevance to the Project Site
Water bodies: Water bodies shall refer to waters that are tapped for domestic purposes or those which support wildlife and fishery activities within declared protected areas, including the buffer zones	The project will traverse the Pakiputan Strait. Other closest water bodies or river to the alignment is the Mamay and Sasa Creeks, which are about 500 m and 1.45km north of the Davao side, respectively. However, this is not used for domestic or fishery purposes and does not support wildlife.
Mangrove areas characterised by one or any combination of the following conditions: • With primary pristine and dense young growth • Adjoining mouth or major river system • Near or adjacent to traditional productive fry or fishing grounds • Which act as natural buffers against shore erosion, strong winds and storm flood • On which people are dependent for their livelihood, pursuant to and taking into consideration Republic Act No.7161 which prohibits the cutting of mangrove species	There are mangrove swamps along Samal Island but the project site itself does not traverse any ecologically valuable mangrove forests based on actual floristic survey. Project implementation will not affect Samal mangroves due to their distance and location vis-à-vis the SIDC.
Coral Reefs: characterised by one or any combination of the following conditions: • With 50% and above live coralline cover • Spawning and nursery grounds for fish • Which act as a natural breakwater of coastline	Of the seven coral reef survey stations for the SIDC, actual observed hard coral cover ranged from 6.8% to 14.7% – all characterized as being in poor condition. While live coral cover ranged from 20.2% - 60.1% (poor to good) in Davao and 15.7%-25.5% (poor to fair) in Samal Island. There is a strong mutual dependency between coral and reef inhabiting fishes. Corals rely on the fish for reproductive success. whereas the fish depend on the corals for food and habitat. Inasmuch as the seven areas surveyed were all characterized by poor coral, fish spawning in these areas were insignificant. There were no endangered fish species encountered during the reef fish community assessment of the project.



Basemap Source: PNTMS Edition 1 - (NAMRIA,2013) Sheet No. 4115-III WGS 84 and Local Government Bureau of Fisheries and Aquatic Resources

Figure 2.5 Planned Marine Protected Area at Barangay Vicente Hizon Sr., Davao City



Source: DENR XI One Control Map, 2019 (WGS 84)

Figure 2.6 Protected Area Map of Region XI

Potential Impacts on Existing Land Tenure

The initial assessment of affected land acquisition requirement is shown in **Table 2.5**. SIDC project involves the construction of a 2.85-km bridge that will require a total area of 63,380m^2. Davao City needs 42,328m^2 or 67%, while IGaCoS requires 21,052m^2 or 33% of the total. The land area required for the project is subject to compensation.

Table 2.5 Number of affected lots, per barangay

Project Components	Location (m^2)		Total Affected Land Area (m^2)
	Davao City	IGaCoS	
Land viaduct	13,231	9,564	22,795
Ramp + road widening	29,097	0	29,097
Road widening + roundabout	0	11,488	11,488
TOTAL	**42,328**	**21,052**	**63,380**

At this point, there are no perceived large impacts to land tenure. However, issues may emanate during land acquisition phase including negotiations on compensation to landowners.

In order to address such issues, the proponent must secure landowner acquiescence to government acquisition of the required ROW for the project, in a manner that is guided by pertinent processes and directives as issued by the Philippine government and the DPWH.

Impairment of Visual Aesthetics

The excavation of land during the construction phase will impact on the visual aesthetics only of and within the project area. However, no significant impairment to the visual aesthetics of landscapes will be greatly affected.

It is expected that some steep slope hills and mounds will be excavated and developed, altering the original morphology of the project site. During earthworks activities, large masses of rocks and soil will be immediately moved to the designated dumping site to prevent accidents and the transportation of sediments to nearby water bodies.

Devaluation of land value as a result of improper solid waste management and other related impacts

The generation of solid wastes will be limited to construction debris and other civil works during the construction phase. If these will be improperly handled, it may lead to devaluation of land value. Furthermore, irresponsible discharge of wastewater may affect soil quality in the project site and its vicinity. Through practice of a proper waste management system, spills, and soil pollution may be avoided.

This concern can be addressed through an effective solid waste management plan, as part of the contractor's commitment, which adheres to Ecological Solid Waste Management Act of 2003 (RA 9003) and local regulations. This plan may include the provision of trash bins, designation of disposal sites and regular hauling and disposal of wastes in both sides of Davao and IGaCoS.

Options for Prevention, Mitigation and Enhancement

Options or measures for prevention, mitigation, and enhancement for the identified impacts in land use and classification are discussed in this subsection.

Compatibility with the Land Use

Given that the project is not aligned with the proposed land use plans of both Davao City and IGaCoS, it is necessary to reclassify the project footprint areas as infrastructure and support zones succeeding the completion of right-of-way acquisition activities to reflect its intended use, as defined by the project. Integration of the project in the future land use plans of both cities will enable each LGU to harmonize the plans intended for their development. In case of reclassification, appropriate permits and other necessary steps that entail this should be complied with to conform with the appropriate land use for the project.

Environmentally Critical Area (ECA)

The identified potential impacts on the barangay-level declared Marine Protected Area in Barangay Vicente Hizon in Davao City, including the impacts that may emanate from the construction activities due to proximity to Samal Island Protected Landscape and Seascape in the northern part of the project alignment can be addressed by collaboratively working with the governing bodies and respective local government units of both Davao City and IGaCoS. Understanding that the project covers varying land areas, appropriate engineering and design measures will be applied. In support to this, an environmental management plan will be prepared and implemented to ensure appropriate management, monitoring, and mitigation measures are applied to the implementation of the proposed project activities that may affect these critical areas. To be included in the environmental management plan will be the creation of marine habitats for those areas that will be impacted by the project. Such habitats will be devised based on results of consultations with participants and consequently implemented in collaboration with relevant stakeholders.

Tenurial Instruments

There is a need to acknowledge that the project will have an impact on existing tenurial instruments that cover its direct impact areas, which are classified as alienable and disposable (A&D) lands covered by corresponding Original or Transfer Certificates of Title (O/TCTs) and other instrumentalities.

The acquisition of rights of way from current land and property owners will enable the proponent – in this case, the Government of the Philippines through the DPWH – to implement its intended best use in affected parcels to benefit the greater majority of the population and in adherence to the Regalian Doctrine. Acquisition will cover project right of way currently utilized for commercial, residential and light industrial purposes on the Davao side, and tourism and agricultural land on the IGaCoS side.

Visual Aesthetics

In terms of impairment of visual aesthetics, SIDC may be perceived by the occupants and users of existing and future land uses in the areas surrounding the project as either (1) enhancing existing vistas or (2) disrupting the ambience of the natural surroundings. The latter may be more applicable to IGaCoS side of the project, as its footprint is situated in the middle of two operating commercial resorts that depend on the natural amenities of the area (i.e. clear waters, seclusion, unhampered view of Davao) to attract clientele.

Either option, on the other hand, which may also be applied to the Davao side, particularly on the planned high-end, mixed-use Azuela Cove development which will be in the immediate vicinity of the project. Thus, the final design of the project must not only emphasize engineering, safety and environmental considerations but also consider the aesthetic impacts of implementation. When done creatively and properly within the limits of available resources, the bridge may end up being an iconic landmark in the region, as is the case of other similar inter-island bridges in the country.

Devaluation of Land Value

During the construction and operation phases of the project, improper solid waste management and other sources of pollution may lead to the devaluation of direct and indirect impact areas. However, the implementation of proper management practices and mitigating and enhancing measures will address these potential issues and eradicate the risk of the lowering of property values in the immediate vicinity of the SIDC, especially at the Davao side.

In IGaCoS side, it needs to be acknowledged that the perceived worth of a commercial tourism property may be directly affected by its natural surroundings, although that is not the only factor that determines its actual value – other factors include accessibility, services and man-made amenities. The implementation of the current alignment of the SIDC may still actually increase property values of directly impacted parcels of land, and this increase may be brought about by its transition as a fully commercial space with eco-tourism features. In this case, we may perceive the project to contribute in the possible increase of zonal value rather than devaluation of land.

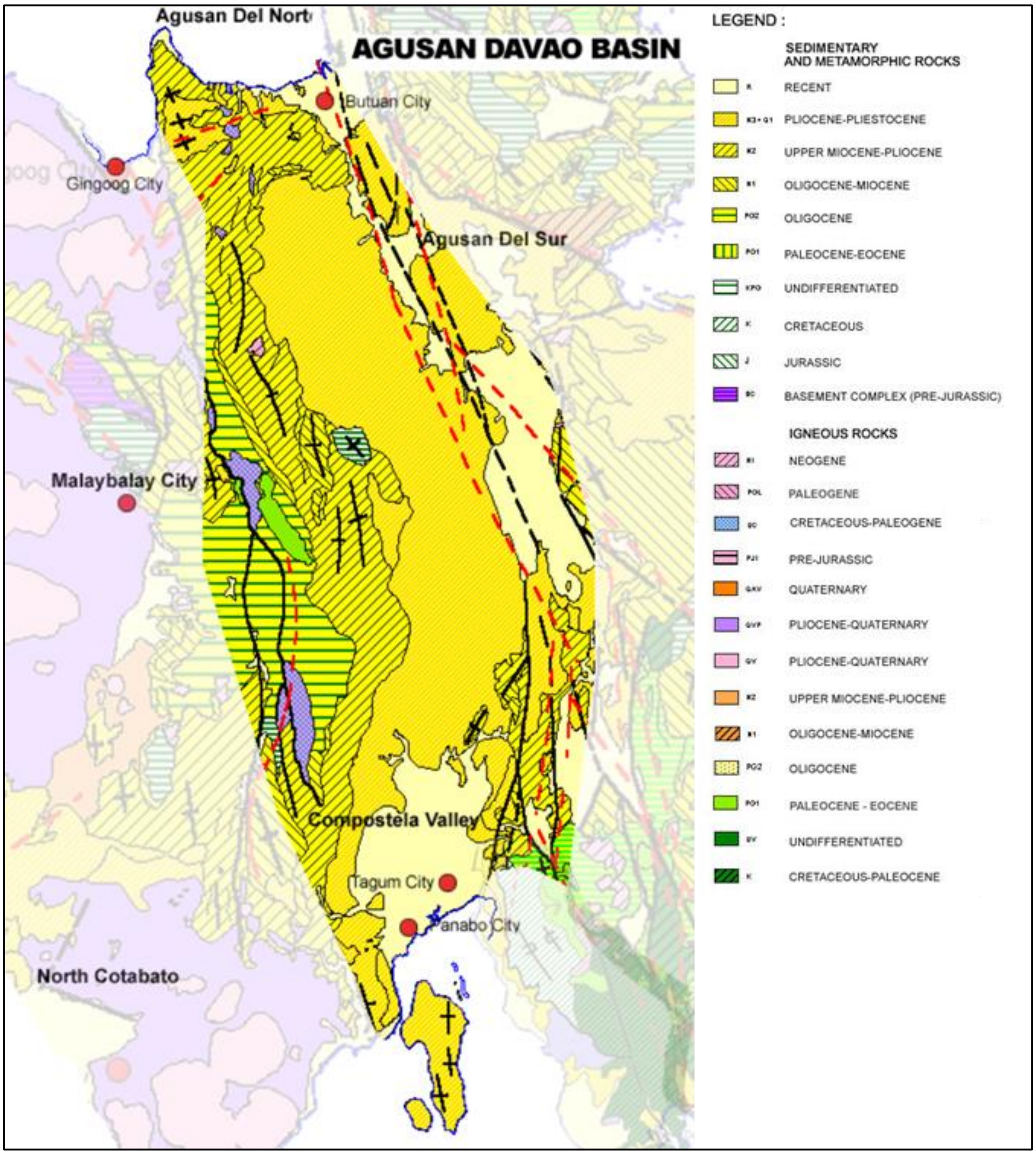
2.1.2 Geology/ Geomorphology

Baseline Environmental Conditions

Regional Geologic Setting

The SIDC project lies within the Agusan Davao Basin, a stratigraphic unit that covers the central section of Mindanao and extends from the northern coast of Agusan del Norte to the southern shores of Samal. The unit is elongated, oriented north-northwest and south-southeast, and is composed of rock units with varying ages.

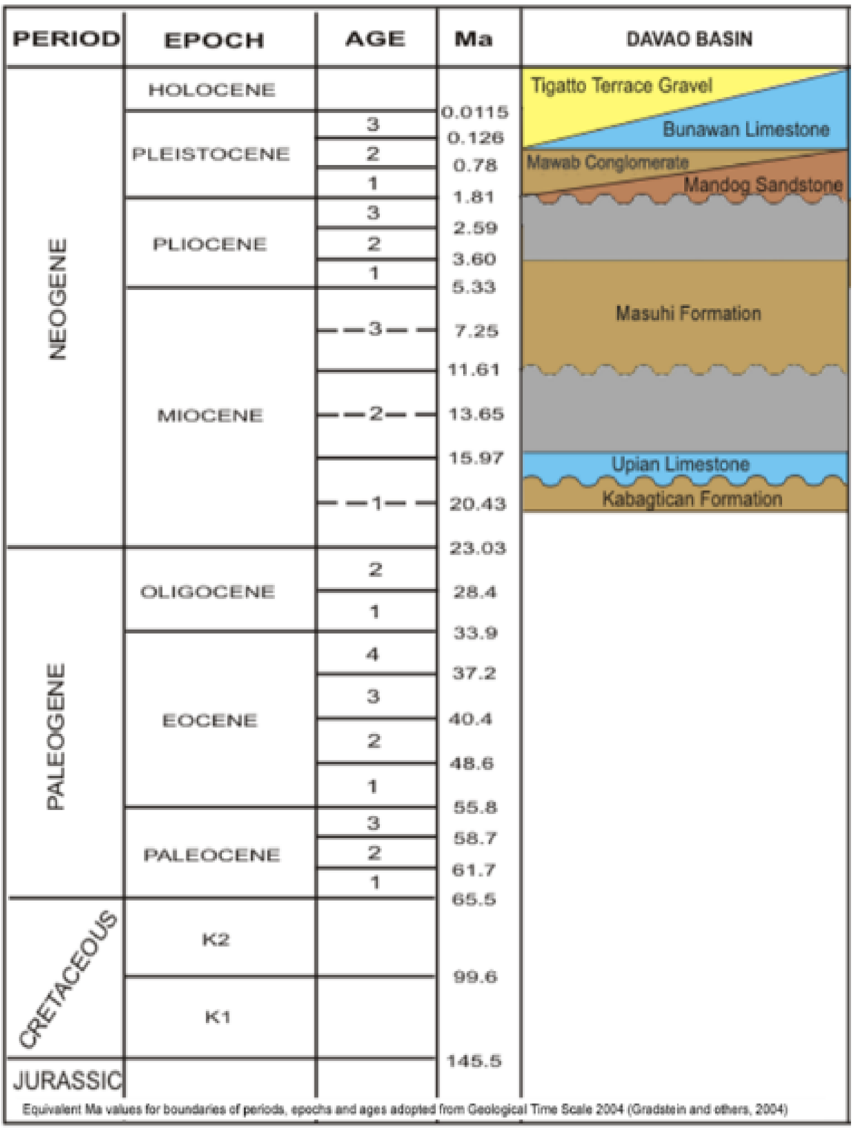
Underlying lithologies include: igneous, sedimentary and metamorphic rock types. The upper levels of the basin are primarily covered with sedimentary facies as attributed to its sedimentary basin configuration, which allows detrital sediments to collect in its valley floor.



Source: MGB, 2010

Figure 2.7 Regional Geologic Map of Agusan Davao Basin

Based on the MGB Geology of the Philippines 2010, the basin is considered to have the thickest sedimentary fill compared with all other sedimentary basins in the Philippines. The estimated fill thickness reaches up to 12 km in some areas and covers basement rocks that include a mix of ophiolites and metamorphic rocks and arc-related rocks and limestone.

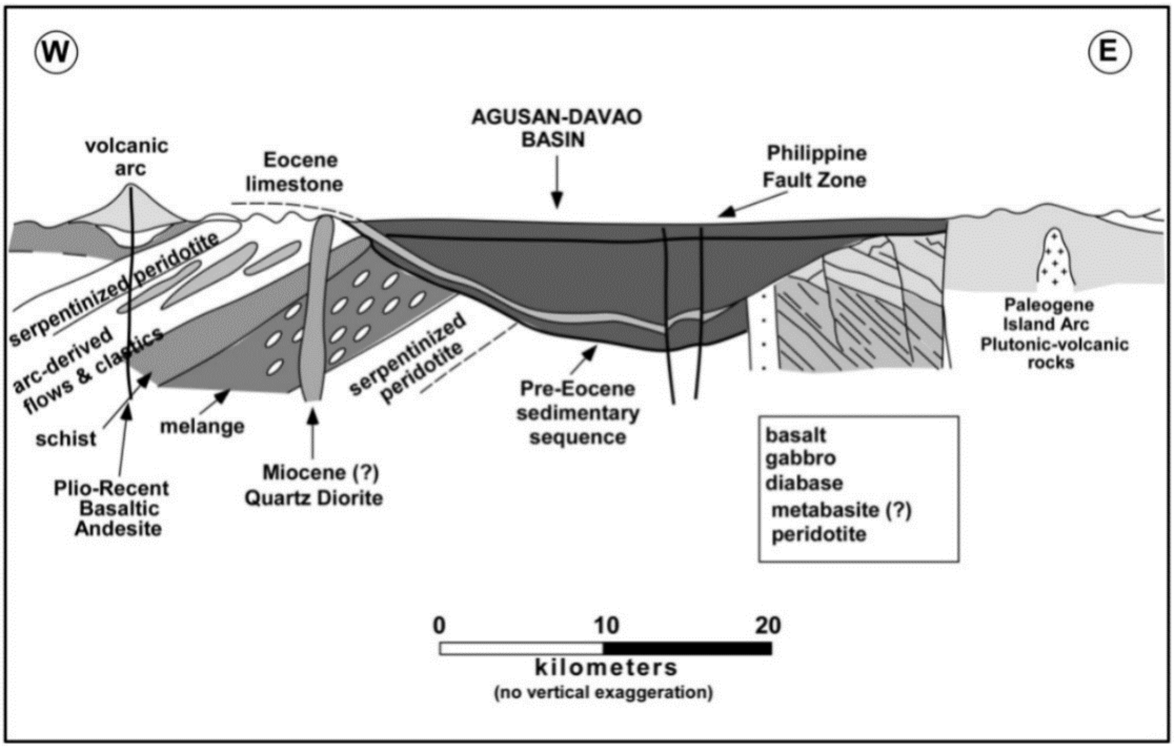


Source: MGB, 2010

Figure 2.8 Regional Stratigraphic column of Davao Basin

Overlying the basement rocks is a sedimentary suite that ranges in age from Miocene, consisting of clastic sandstones, siltstones, shale, and limestone with other carbonaceous layers. Overlying these are the younger sedimentary cover that was deposited during the Pliocene until Quaternary period, which is dominated by marine deposits and some fluviatile facies.

Geologic structures within the basin are predominantly striking north-northwest south-southeast, approximately parallel to the overall axis of the basin. Several anticlinal and synclinal structures are found along the western side of the basin, while major fault lines traverse the whole basin. Most notable fault is the strike-slip Philippine Fault that runs longitudinally close to the east of the centre of the basin.



Source: MGB, 2010

Figure 2.9 Schematic section across Davao Basin according to Hawkins and others

Stratigraphy/Geology

The project straddles two land masses which is underlain by different lithologic basements. The SIDC alignment will be largely underlain by two geological units, namely limestone and quaternary alluvial deposits.

Samal Island is underlain by different sedimentary lithologies including limestone, sandstone, and conglomerate. The most predominant lithologic unit is limestone, identified as the Samal Reefal Limestone, and is composed of porous and poorly compacted limestones that contain identifiable fossils of corals and mollusks, and abundant algae and foraminifera. These are mostly exposed along the western side of the island. This is the main geological unit underlying the SIDC alignment and is believed to be early Holocene in age.

Soil profiles were observed to be relatively thin throughout the area. Underlying limestone rocks are typically exposed on the surface, appearing as white to dirty white rubbly eroded surfaces. Other exposures appear to contain some tints of light pink due to weathering and erosion by-products/staining. Road cuts along the newly constructed Circumferential Road (**Figure 2.11**) providing useful exposures of both the underlying rock types, showing evidence of the four uplifted terrace levels in this area of Samal. Maeda and Siringan (2004) hypothesise that these terraces have been uplifted due to seismic and tectonic events coupled with glacio-eustatic adjustment.

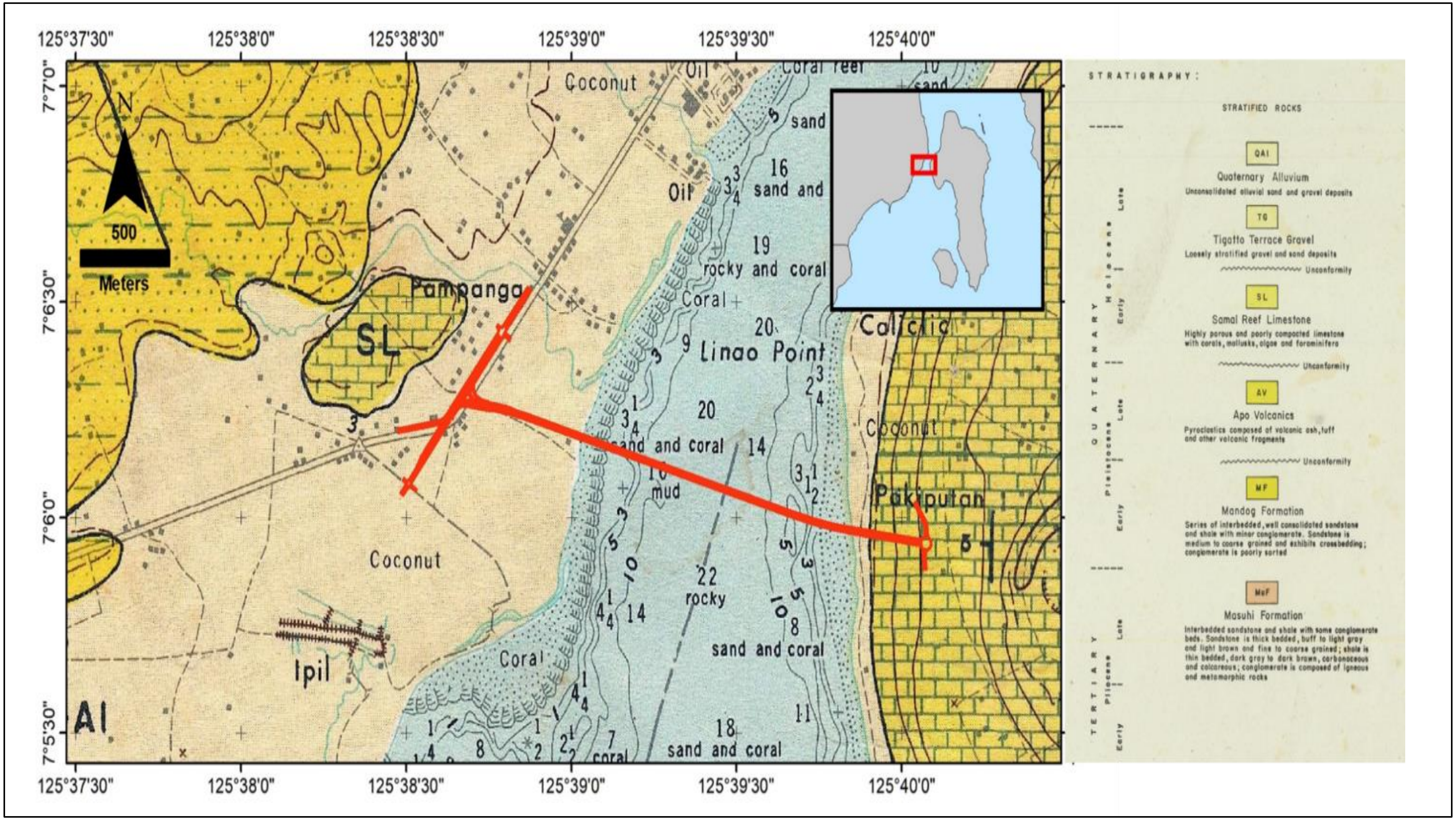
Figure 2.10 Limestone exposure along the Barangay Road in IGaCoS

Figure 2.11 Weathered limestone exposed in road cut faces along the Circumferential Highway in IGaCoS

The western portion of SIDC will traverse the shores of Davao City. This region is within the gently sloping coastal plains of Davao. The alignment will traverse an area covered by relatively thick quaternary alluvial deposits that blanket majority of the city's coastal areas. These materials are poorly consolidated and indurated and are products of erosion, transportation, and deposition of surrounding in-situ rocks.

Field inspection in the area shows that it is predominantly covered by sandy materials and is flat from the waterline until the point where the alignment merges with the existing highway. Some beach resorts have undergone beach nourishment resulting in the enrichment of coralline sands unlike the naturally occurring darker sands that have relatively higher lithic content. Subsurface investigations of other projects along this region of the coastal flats of Davao have shown that underlying the sandy quaternary alluvial deposits at depths are coralline limestone materials. This may be correlated to exposures of Samal Reefal Limestone units north of the SIDC alignment.

Figure 2.12 Coralline Sand and Rubble in Davao City Beach



Source: MGB, 2010

Figure 2.13 Geologic map of the project area

Geologic Structures

The eastern Mindanao region is strongly influenced by several tectonic structures, including the Philippine Trench, the Philippine Fault Zone, and the Central Davao Fault System (**Figure 2.1**). Samal Island is also characterized by several longitudinal anticlinal and synclinal features. The eastern side of Davao City is also an anticline, which is proximal to the western termination of the SIDC alignment. The western termination is within the general area of the anticline but not straddling the axis of the anticline.

Philippine Trench

This is a major structural feature in the Philippine Mobile Belt that resulted from the subduction of the Philippine Sea Plate beneath the eastern Philippine Arc (Mines and Geosciences Bureau, 2010). It is a morphological landform that extends from the mid-northern offshore of the Philippines until the eastern side of Mindanao. It has a length of 1,320 km, a width of 30 kilometers, and its deepest point is 10,540 m. The predicted trace of the trench is approximately 185 km east of the Samal portion of SIDC.

Philippine Fault Zone

This is the primary earthquake generator of the archipelago and runs from the northern tip of Luzon Island until the southern side of Mindanao. Within Mindanao, the fault system splits into several splays; namely, the West and Central Compostela Segment, the Caraga River Segment, and the Mati Segment. The project is closest to the Mati Segment, which is approximately 56 km aerial distance from the Samal end of the SIDC. The Philippine Fault is relatively active, with seismic studies showing records of 7.8 magnitude earthquakes (Mines and Geosciences Bureau, 2010).

Central Davao Fault System

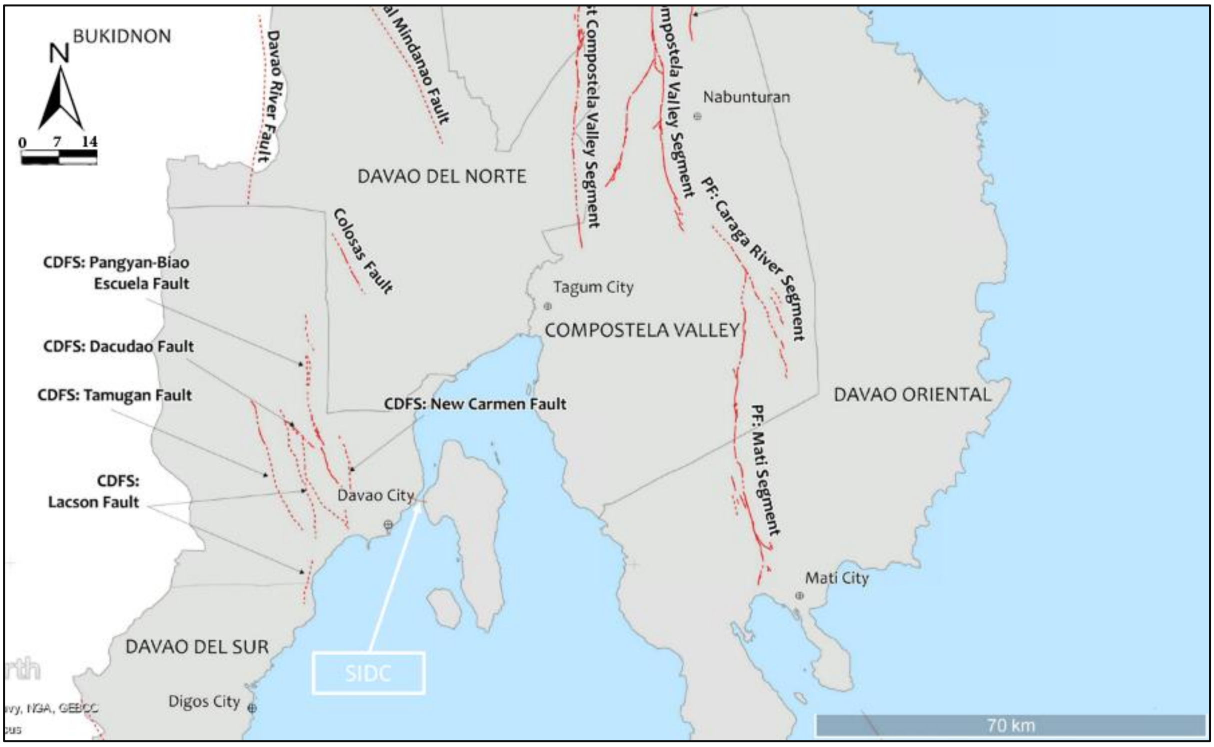
The Central Davao Fault System is a collection of fault traces that have been mapped by the PHIVOLCS within Davao City. It mainly traverses the middle portion of the city and is composed of several segments. At this time, there are limited studies on the seismicity of the Central Davao Fault System. From west to east these are the Tamugan Fault, the Lacson Fault, the Dacudao Fault, the Pangyan-Biao-Escuela Fault, and the New Carmen Fault. The nearest fault trace to the proposed SIDC alignment is the New Carmen Fault. This segment is found about 10.1 km west-northwest of the western extremes of the SIDC alignment. The New Carmen Segment is oriented approximately north-south and runs roughly parallel to the main river valley of Matina River.

Anticline and Syncline Structures

Within Samal Island, several anticlines and anticlinal structures have been identified by previous workers (MGB) that are oriented approximately north-south, parallel to the elongated axis of the island. These landform features represent the small hills and elevated portions of the island. Proximal to the SIDC alignment is the axis of an anticline that is oriented north-south. This anticline represents the rise going into Brgy. Limao and Brgy. San Miguel. The SIDC alignment essentially traverses the western limb of the anticline.

Further inland, the western limb of this anticline connects to a syncline which represents the depressed lower elevations of the island found within the northwest region. This area includes Brgys. Mambago A, Mambago B, Penaplata and San Agustin.

Beneath the western portions of the SIDC alignment (Davao City) another anticline can be found northwest of the project. This area is represented by the undulating hills of Barangay Communal. The axis is oriented north-northwest and extends from the coastal plains of Davao City to the northern highlands of Davao City.



Source: PHIVOLCS, 2017

Figure 2.14 Active fault map in Region XI showing the SIDC alignment

Geomorphology

In general, Samal Island is characterized by variable terrain, with the north-western portion exhibiting flat to gently sloping terraces punctuated by steeply sloping terrace steps. The eastern and southern portions of the island are mostly composed of elevated terrains, which includes knobby hills and peaks with moderate to steep slopes. The highest elevation on the island is represented by the peak of Puting Bato (white rock) at approximately 410 m above sea level.

Within the section traversed by the SIDC, the topography of the area is composed of horizontal to gently sloping uplifted marine terraces. The alignment crosses at least four levels of marine terraces, which are generally narrower towards the shoreline compared to the inland terraces. The first terrace level represents the gentle slopes closest to the water where most of the resort establishments are situated. This platform is terminated by sea cliffs along the waterline, which range from less than a meter to three meters in height. Most of the cliff faces have been modified as a consequence of the construction of beach resorts in the area. The base of the cliff face is reached by seawater during high tides while low tides expose a narrow sandy beach terrace which connects to a rubblier surface composed of eroded coral heads towards the sea. Most of the sandy materials are observed to have been preserved due to the construction of groynes in the area.

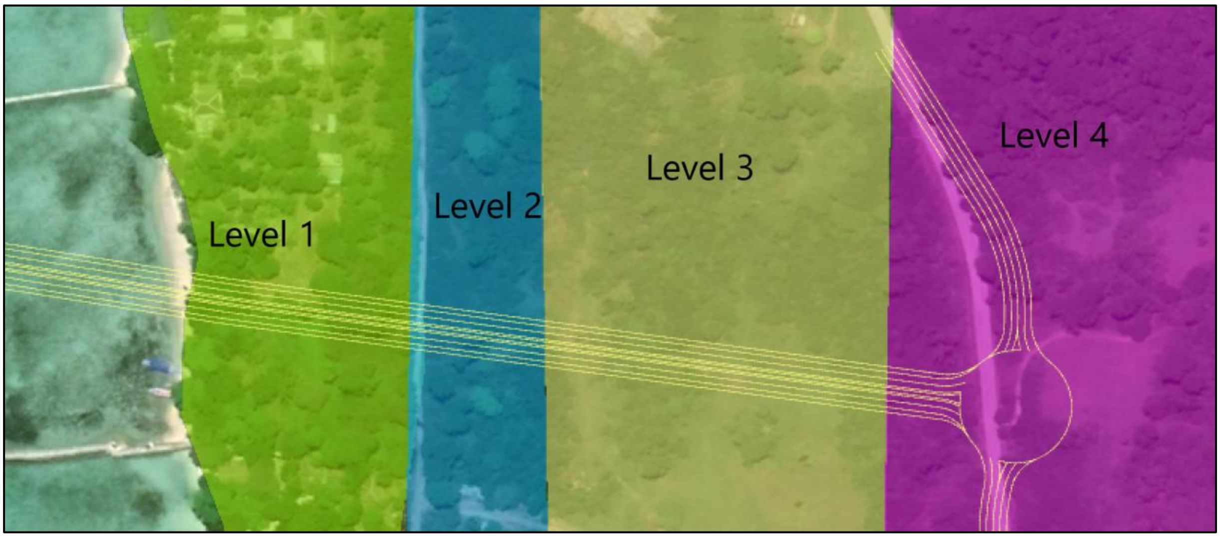


Figure 2.15 Different Terraces Traversed by the SIDC alignment

The second-level terrace consists of flat to nearly flat areas found at the back of most resorts. It is approximately 60 meters in width and, like all other terrace levels, is fairly continuous and traceable along the northwestern shores of Samal. Generally, terrace risers within this area are not very distinct and the transition to the third-level terrace is not easily discernable. The third level is about 190 meters wide and is composed of a flat terrace platform. This level is bounded by a steely sloping terrace face as it connects to the fourth level terrace. The fourth-level terrace platform exhibits a flat to gently sloping terrain and is wider than the previous terraces. It is the area where the current circumferential highway is located and where the SIDC alignment will terminate.

Figure 2.16 shows the 3D rendition of the digital elevation model of areas traversed by the SIDC (blue is water, black line is the marine segment of the bridge and elevation increases from green to white).

The portion of Samal Island that SIDC traverses is not heavily dissected, with only a few gullies and one defined intermittent drainage body encountered during the field inspection. Most of the gullies are shallow and not interconnected. An intermittent creek is found on the southern side of the proposed alignment, and it is deeper and wider in the inland section close to the national highway and progressively shallows downstream. Within the portion close to the barangay road in terrace level 2, this natural drainage has appreciably diminished into a small canal.

Generally, the topography of Davao City is exemplified by flat coastal areas that grades to moderate slopes moving inland and eventually composed of rugged terrain into the mountainous regions. The SIDC alignment is located within the extensive coastal flats of the city and, as such, will cross shores that are relatively gentle in slope. The alignment will connect to the existing national highway running ñllel to the shoreline, which is on gentle to levelled ground.

Drainage within the Davao City side is mostly composed of modified and man-made canals as it is within a combined residential and industrial zone within the city. A canal runs perpendicular to the coast approximately 230 m south of the alignment in this area, and another canal is located 465 m northeast of the alignment.

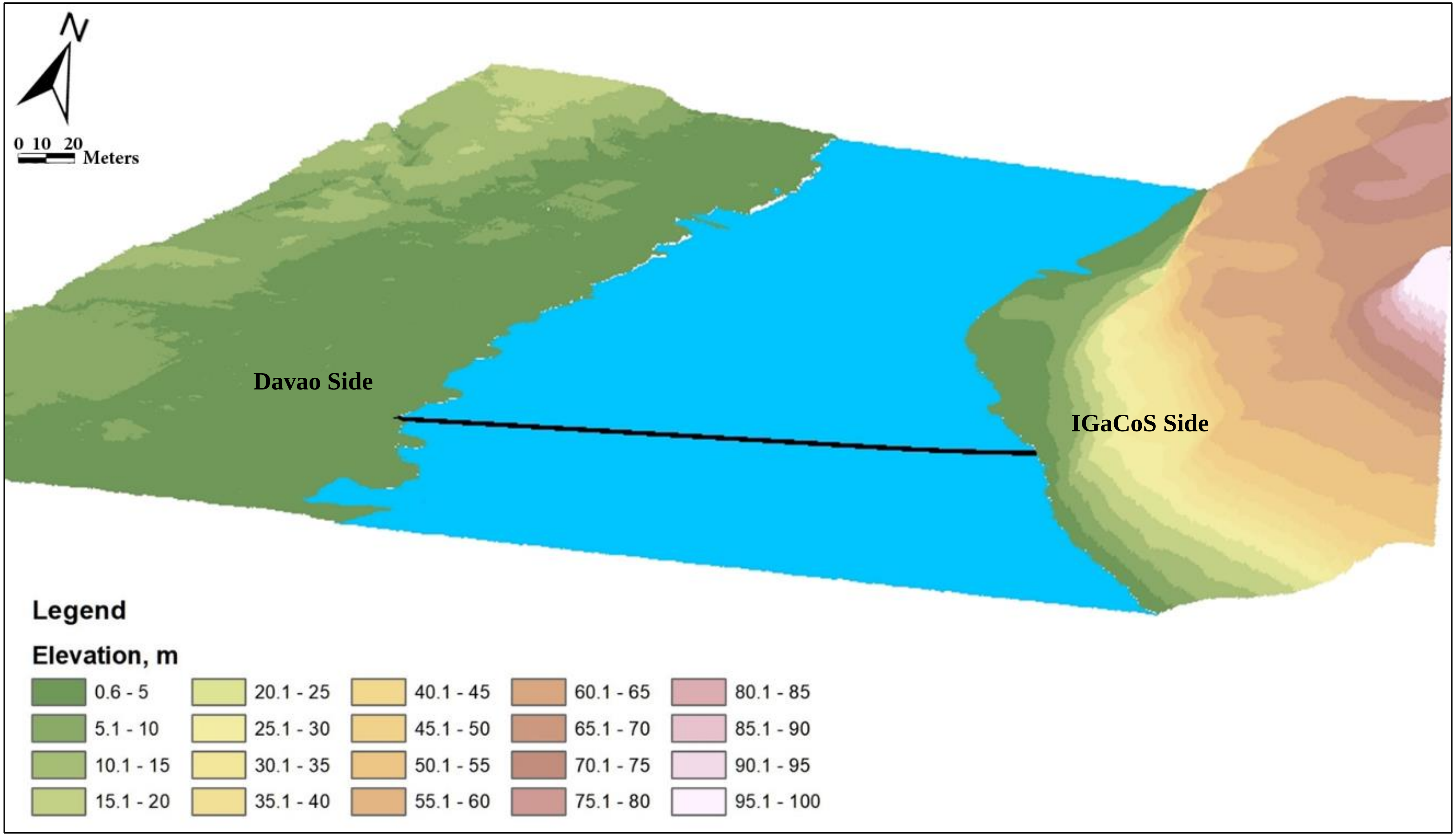


Figure 2.16 Topographic map of the SIDC alignment

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Change in Surface Landform, Geomorphology, Topography, Terrain, and Slope

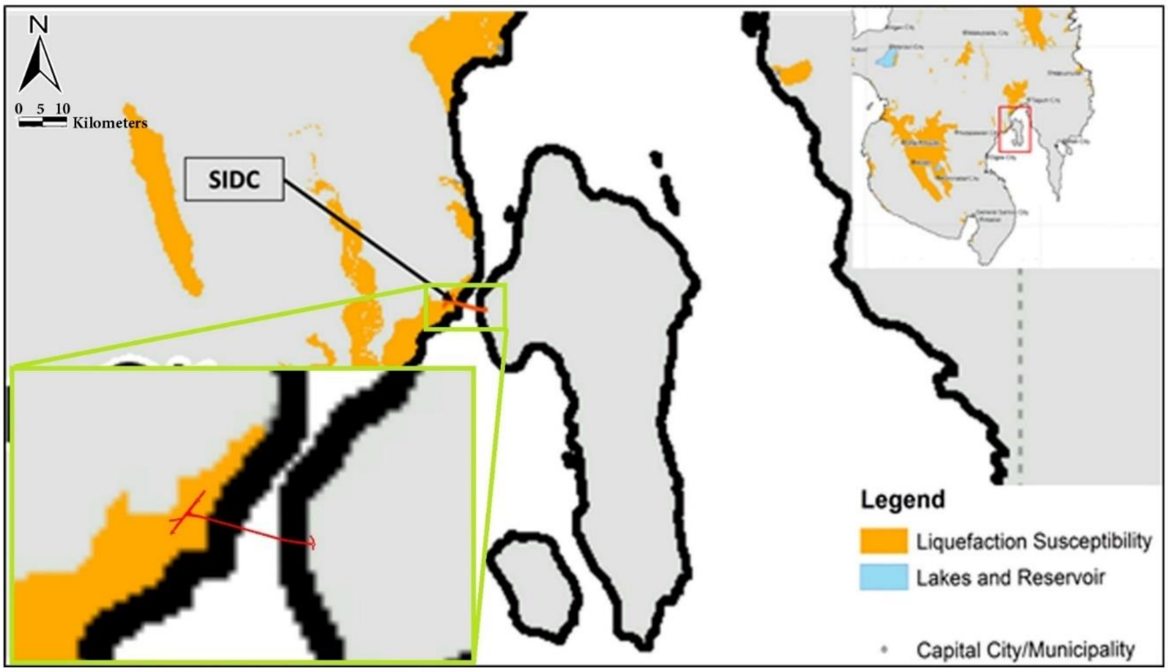
There will be no change in the surface landform, geomorphology, topography, terrain or slope associated with SIDC since the region where the alignment will be located within Samal Island is not heavily dissected, with just a few gullies and one defined intermittent drainage encountered during field inspection. In addition, the project is to be located within the extensive coastal flats of both cities and will cross shores that have relatively gentle slopes.

Change in Sub-Surface Geology/Underground Conditions

A detailed subsurface investigation will be conducted during the DED phase to provide a clear picture of the underground conditions and determine possible impacts of the project to the sub-surface geology prior to construction. Other than the installation of piled foundations, no changes to sub-surface geology are considered likely.

Inducement of Subsidence, Liquefaction, Landslides, Mud/Debris Flow, etc.

The Liquefaction Potential Map of the Philippines published by PHIVOLCS (**Figure 2.18**) shows that the Davao end of the SIDC is within a zone that is prone to liquefaction. Thus, ground improvement may need to be undertaken in certain areas to increase stability – however, as most of the proposed SIDC is supported on pile foundations, any impacts are expected to be negligible. Results from geotechnical investigations, which will be done during the DED, will provide important characteristics of the underlying subsurface materials to aide in the final design of the mitigation measures as well as the sub-structure of SIDC.



Source: PHIVOLCS, 2018

Figure 2.17 Liquefaction Susceptibility Map

The carbonate geology underlying SIDC does result in the potential development of karstic terrain features. Karst is a distinctive terrain developed on soluble rock with landforms related to the dissolution of the calcium carbonate within the limestone and the presence of a complex underground drainage network. These dissolution processes are slow and wall retreat within fissures and caves are typically no more than a few millimetres per 100 years. This means that the bedrock features formed within a karst terrain are themselves typically quite stable under natural loading conditions. The geotechnical hazards arising as a result of karst features therefore more commonly relate to works that change the loading condition above a cavity/ fissure, or as a result of the downward washing of soil into voids within the underlying rock mass. For at-grade portions of the alignment, the primary ground risk is from sinkholes and differential settlement. For the elevated portions, uneven rockhead and cavities can lead to challenges for piled foundations.

Detailed subsurface investigations will be conducted during the DED to investigate these issues. This information will be critical in the final design of the foundations and will serve to confirm the presence of any karstic features Subsurface assessments may include, but are not limited to drilling, electrical resistivity and GPR surveys. The results of these investigations will also provide clear details should there be other subsurface dissolution features that are not manifested on the ground surface. Mitigation measures may include void filling with grout or other flowable fill materials but for very large cavities, other methods may be used to span the cavity entirely, and thus maintaining water flow patterns.

Geohazard Assessment

A geohazard assessment was conducted along the alignment of the proposed SIDC project to determine the present geological conditions and the different geological hazards that will likely affect or ensue due to the development.

Methodology

The primary objective of geohazard mapping is to delineate areas prone to ground-related natural and man-made hazards and recommend mitigating measures to lessen the impact of such hazards to the environment. The following activities were undertaken during the geological site visit of the proposed bridge. Each phase was conducted in a progressive sequence leading to the preparation of the final geological and geohazard report.

Research – prior to detailed mapping, desktop study of technical reports regarding the geologic conditions of the region – which include tectonic setting, seismicity and maps - were collected to provide a background on the study area.

Satellite Interpretation – this phase consists of accessing satellite images of the study area. Interpretation and analysis of satellite information and data were then undertaken.

Field geologic and geohazard mapping – this stage is primarily concerned with actual field inspection of the area where information such as local site geology is obtained. During the field inspection, areas where different infrastructure will be built were meticulously examined for possible occurrences of geohazards that may affect the proposed project. Also, the rock layers within the project site, as well as those of adjacent areas, were characterized. Furthermore, topography and other terrain properties, including the drainage characteristics of the area, were observed and noted.

Data analysis and report preparation – this final stage is concerned with scrutinizing all data gathered, including those from the field inspection. These data are interpreted in view of the suitability and stability of the project site for the proposed development.

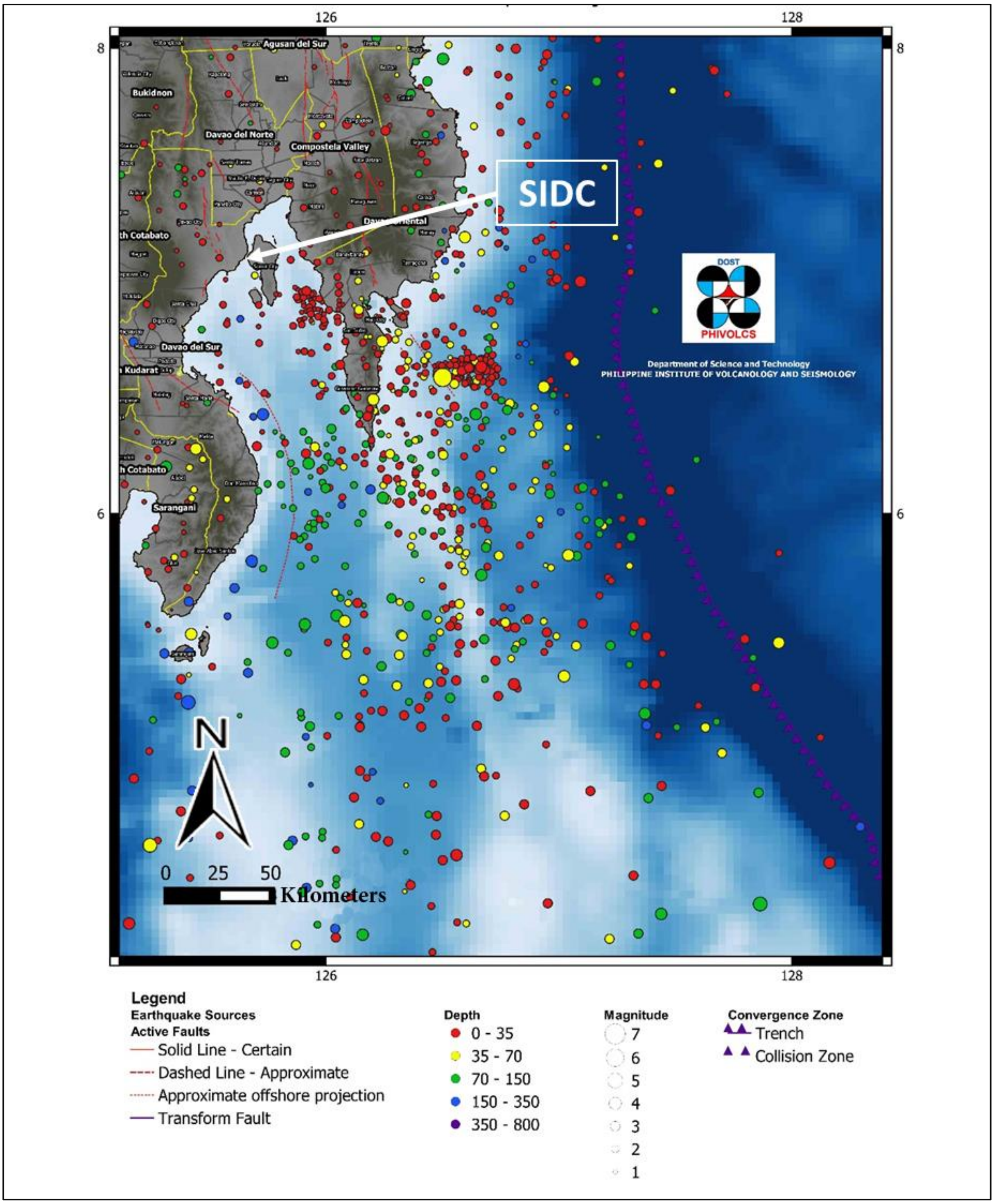
Seismic-Related Hazards

One of the most predominant hazards in the Philippines is earthquake-related, also known as seismic hazards. Owing to the geological setting of the country, numerous faults and other geologic structures crisscross the archipelago. These structures, especially faults and fault zones, are loci of points that might produce ground tremors of large enough magnitude that may endanger surrounding communities. Some of the effects of these earthquake events include ground rupture, liquefaction, ground shaking or acceleration and subsidence, among others. This section tackles the different impacts on the proposed project given the present seismic conditions of the area.

Seismicity

The Philippines archipelago is dissected by several major faults. Review of various active fault traces (provided by PHIVOLCS) shows that the nearest fault lines to the proposed SIDC are the Davao Central Fault System, Mati and Compostela Segments of the Philippine Fault Zone and the Philippine Trench. All of these have the potential to generate large magnitude earthquakes that may have adverse consequences in the Davao and Samal areas. Recently, a M6.3 earthquake struck near Tulunan, Cotabato on 16 October 2019, that resulted in an Intensity V or strong ground shaking, affecting Davao City area and its vicinities. This event has been attributed to a local strike-slip fault which is associated with the Cotabato-Sindangan Segment of the Mindanao Fault (PHIVOLCS, 2016). This incident has resulted in several casualties, as well as damage to buildings in several areas in southern Mindanao exemplifying the serious effects of earthquakes.

The latest compilation of seismic events by PHIVOLCS shows that large magnitude earthquakes (≥M6.0) have been recorded along the offshore extension of the Philippine Fault Zone as well as the Philippine Trench. Most of the inland epicenters recorded are of relatively shallow depth, ranging from less than one to 35 km, with most being between magnitudes 3 and 5. There is also a marked clustering of epicenters offshore Mati City that may be attributed to subduction along the Philippine Trench.



Source: PHIVOLCS, 2016

Figure 2.18 Seismicity Compilation Map of Region XI, 2016

Ground Rupture and Fault Creep

One of the dangers presented by faults to civil structures and communities is active ground deformation attributed to ground rupture or fissuring. This type of ground displacement may occur should the fault trace intersect the earth's surface and manifests as large breaks or cracks on the ground. Should this phenomenon occur in areas with significant above-ground civil structures such as buildings and other construction projects, the effects will significantly undermine the stability of the structures, if not result to complete failure or collapse.

Along the proposed alignment of the SIDC, ground traces of local faults were not observed both on the Samal and Davao sides of the project. Moreover, the active faults map of PHIVOLCS indicates that the closest identified active fault in their region is found a few kilometers west of the site, represented by the New Carmen Segment of the Davao Fault System.

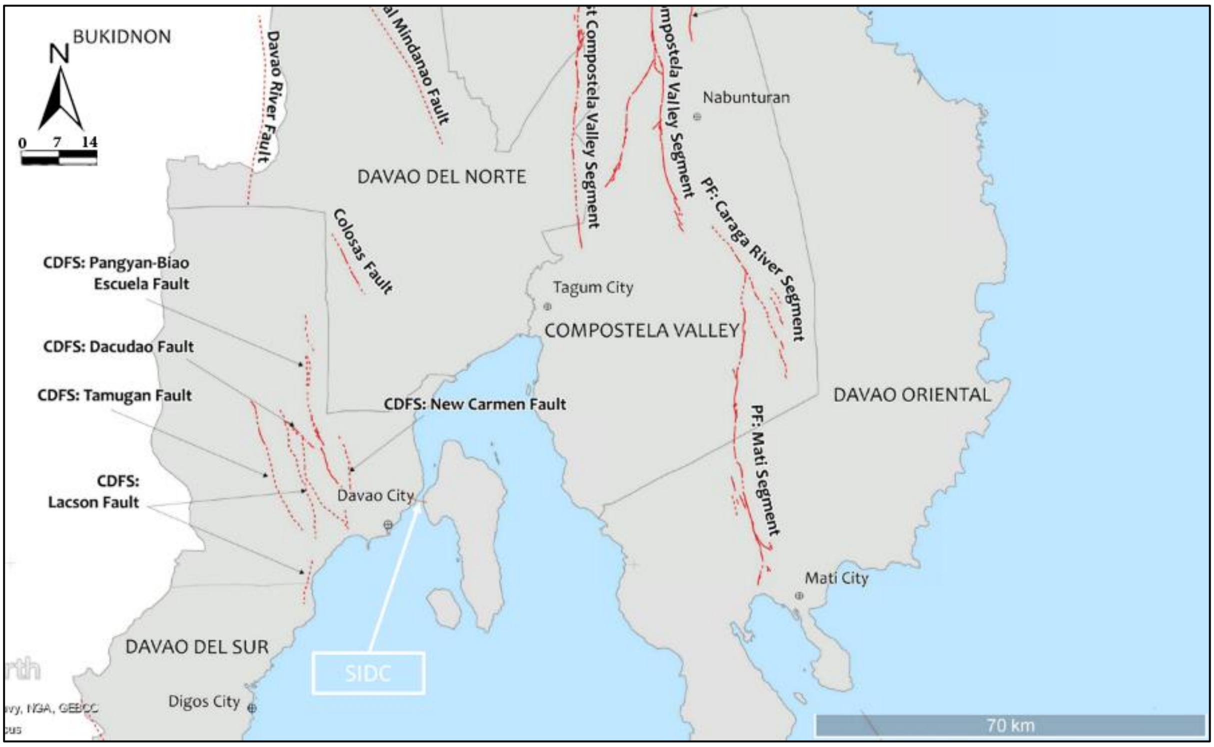


Figure 2.19 Active Faults Map of Region 11 from PHIVOLCS showing the location of SIDC (2017)

Ground Acceleration

Ground shaking is the most noticeable effect of earthquakes and it is also one of the most destructive to rigid civil projects. Vibrations transmitted by seismic waves in vertical and horizontal directions cause significant stresses within concrete and steel structures that are inherently stiff materials. Ground movements that exceed the allowable thresholds of dynamic movement of these structures result in instability and damage, which may ultimately lead to collapse and destruction. One of the most active earthquake generators in the country is the Philippine Fault Zone which has a history of producing large magnitude earthquakes of ≥M7.0.

Ground motion, as it relates to movement that will be affected on objects above ground, can be measured through the peak ground acceleration that is expected of any given earthquake event at a certain magnitude generated from a fault system. The PHIVOLCS has generated an earthquake model for the Davao City area given events that may be generated from the Philippine Fault Zone with M7.3. From this, it can be seen that the location of the SIDC is expected to experience around PEIS 7 intensity based on the Philippine Earthquake Intensity Scale. This means that the proposed project site with likely experience destructive ground shaking in the event of a M7.3 earthquake along the Philippine Fault.

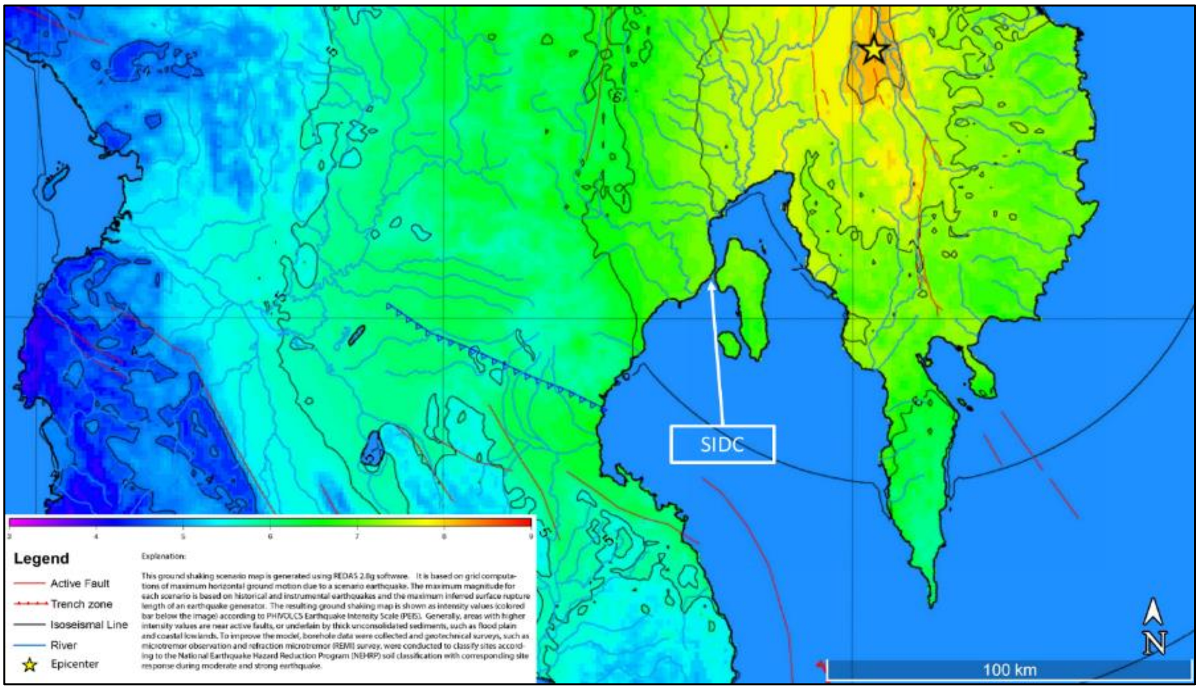


Figure 2.20 Extract from M7.3 earthquake scenario along the Philippine Fault by PHIVOLCS in 2017

Another major earthquake generator within the region is the Philippine Trench. This is a subduction zone that runs along the eastern offshore area of Mindanao Island and may generate earthquakes of greater than M7. A scenario ran by PHIVOLCS shows that the area in the vicinity of the SIDC will experience intensity 6 based on the PEIS scale. This means that the area will experience very strong ground shaking in the event of a M7.9 earthquake with the epicenter located within the Philippine Trench.

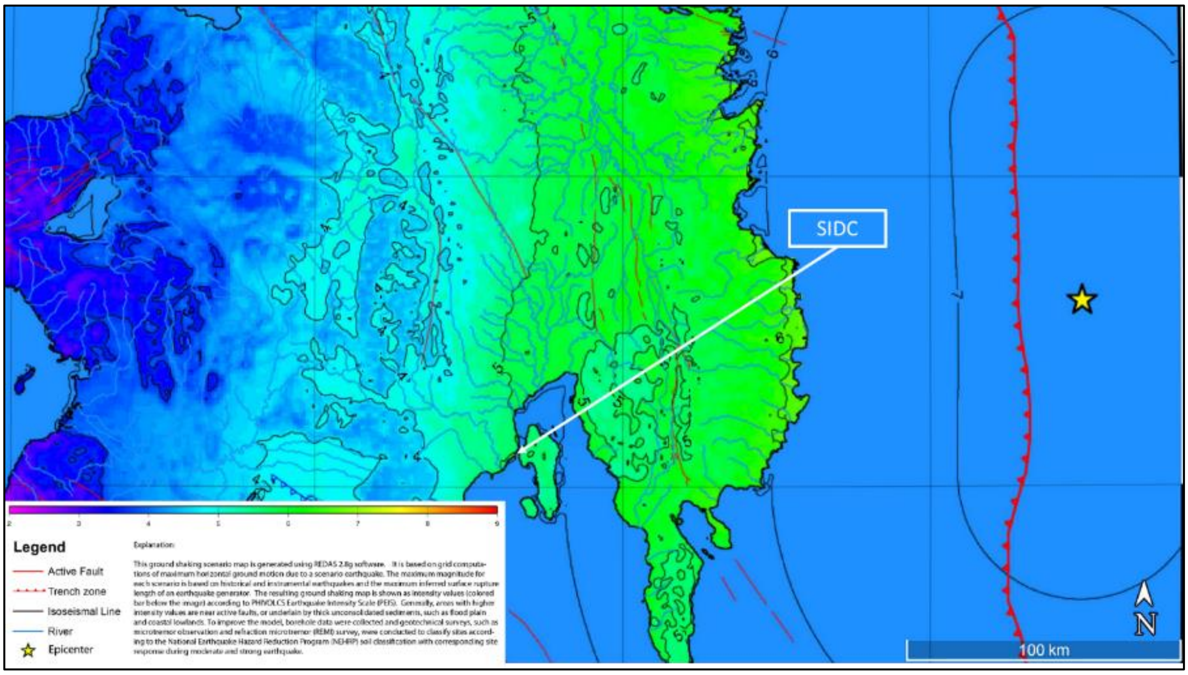
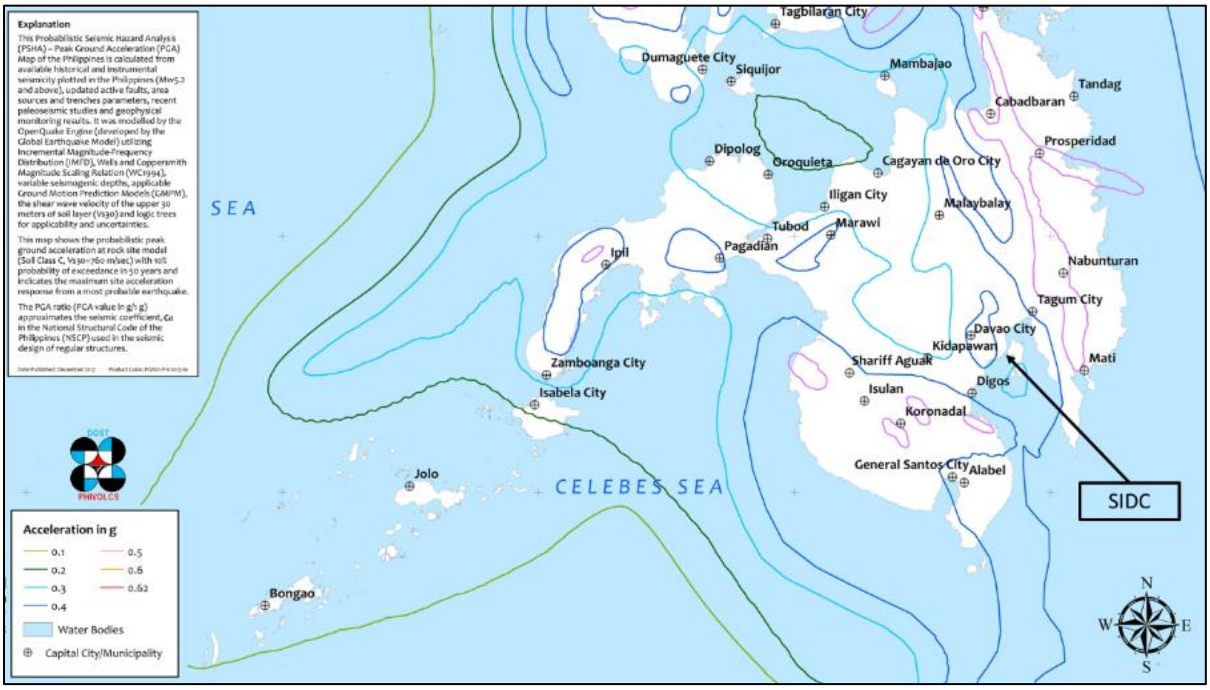


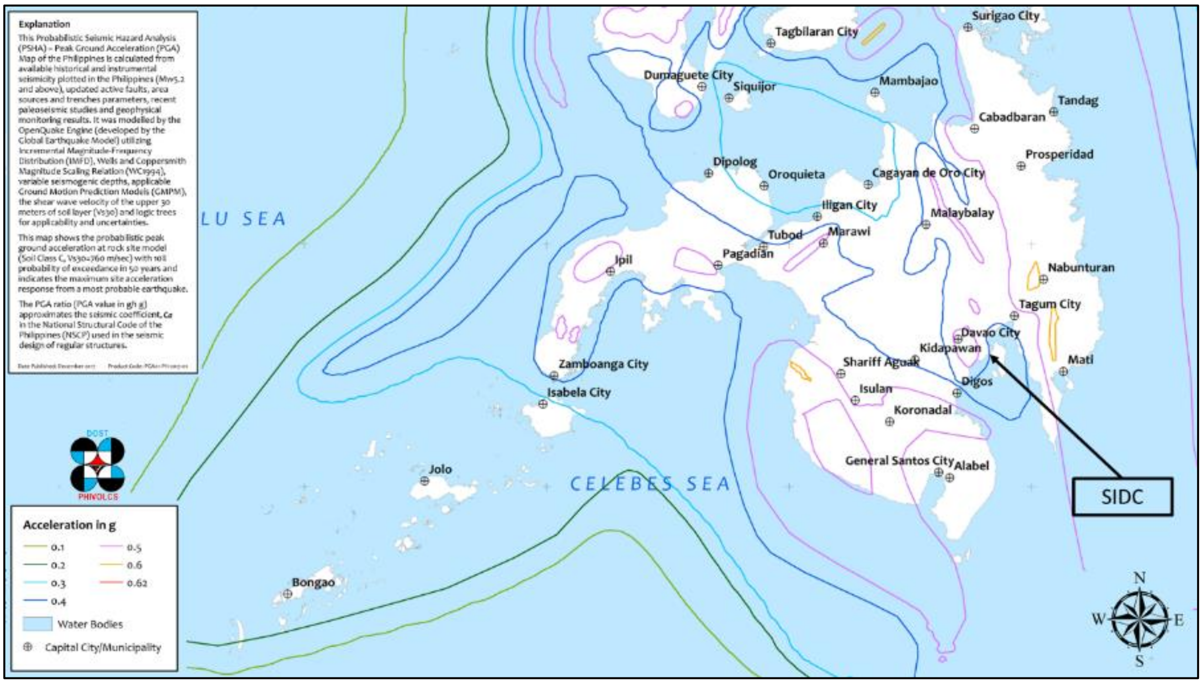
Figure 2.21 Extract from M7.9 earthquake scenario along the Philippine Trench by PHIVOLCS in 2017

Another earthquake parameter that is especially important in projects within seismically active areas is peak ground acceleration or PGA. PGA values indicate the expected maximum ground shaking that can be experienced in a given location from an earthquake event. The mandated agency, PHIVOLCS, has published PGA maps for given ground conditions for the most probabilistic earthquakes for the whole country. Based on these maps, the location of the SIDC will likely experience 0.3g-0.4g, 0.4g, and 0.5g for rock site areas at return periods of 500, 1000 and 2500 years, respectively. For areas with stiff soils, it is modelled that the SIDC location will have an expected PGA of less than 0.4g in 500-year return period events.



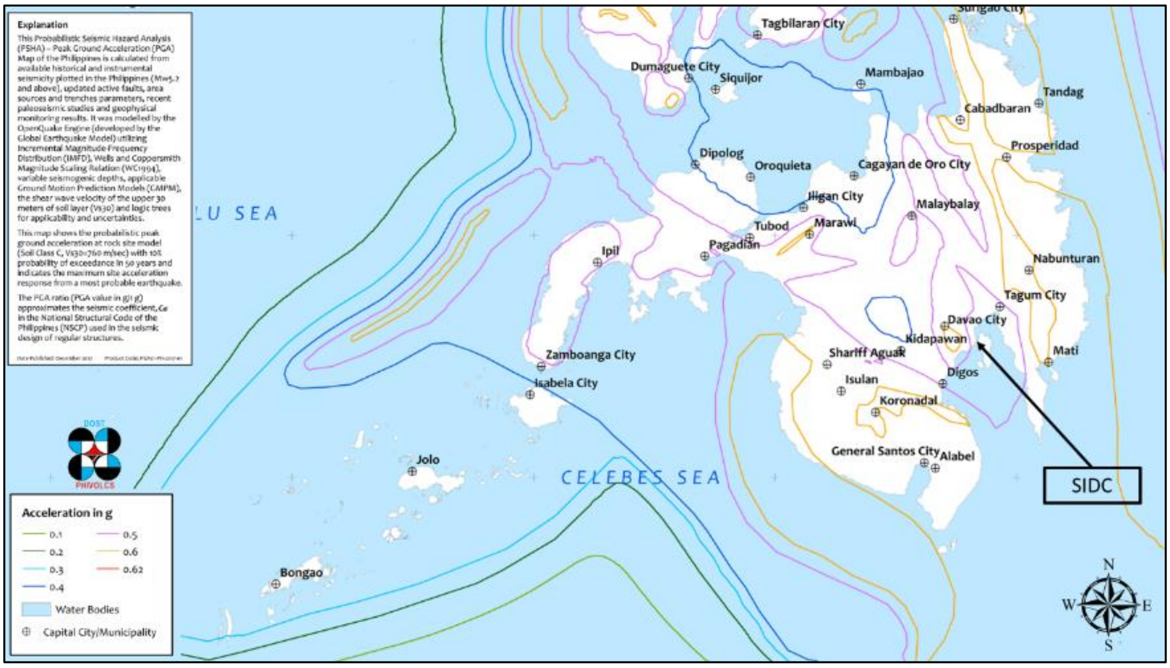
Source: PHIVOLCS, 2017

Figure 2.22 Extract of the peak ground acceleration map of the Philippines for rock sites at 500-year return period



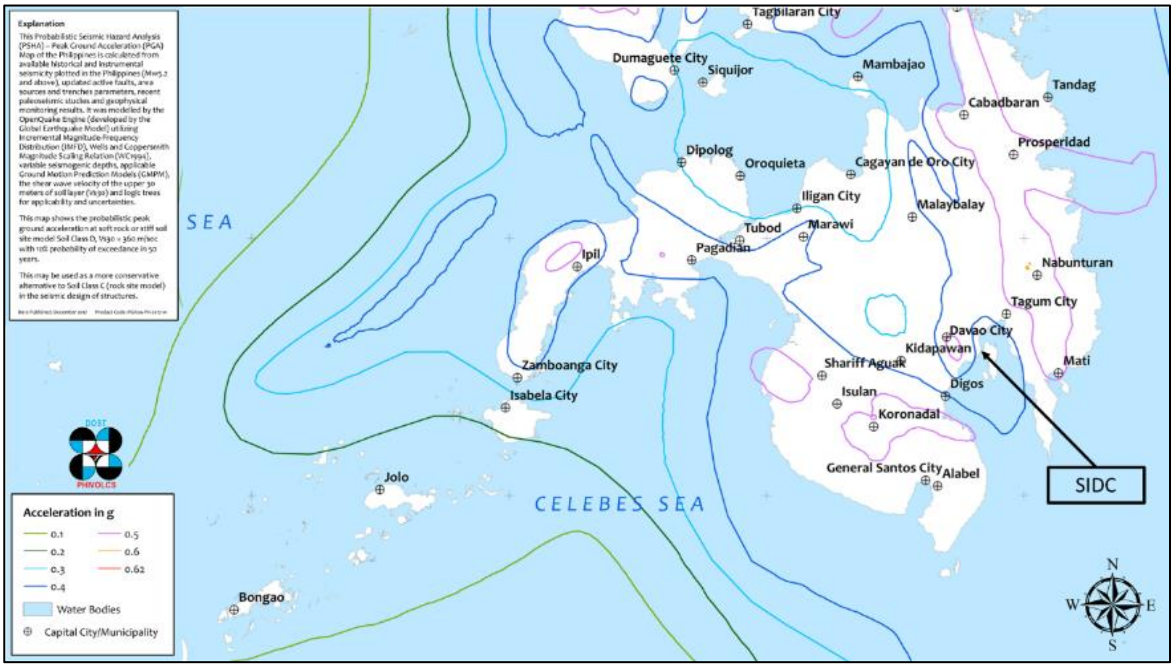
Source: PHIVOLCS, 2017

Figure 2.23 Extract of the peak ground acceleration map of the Philippines for rock sites at 1000-year return period



Source: PHIVOLCS, 2017

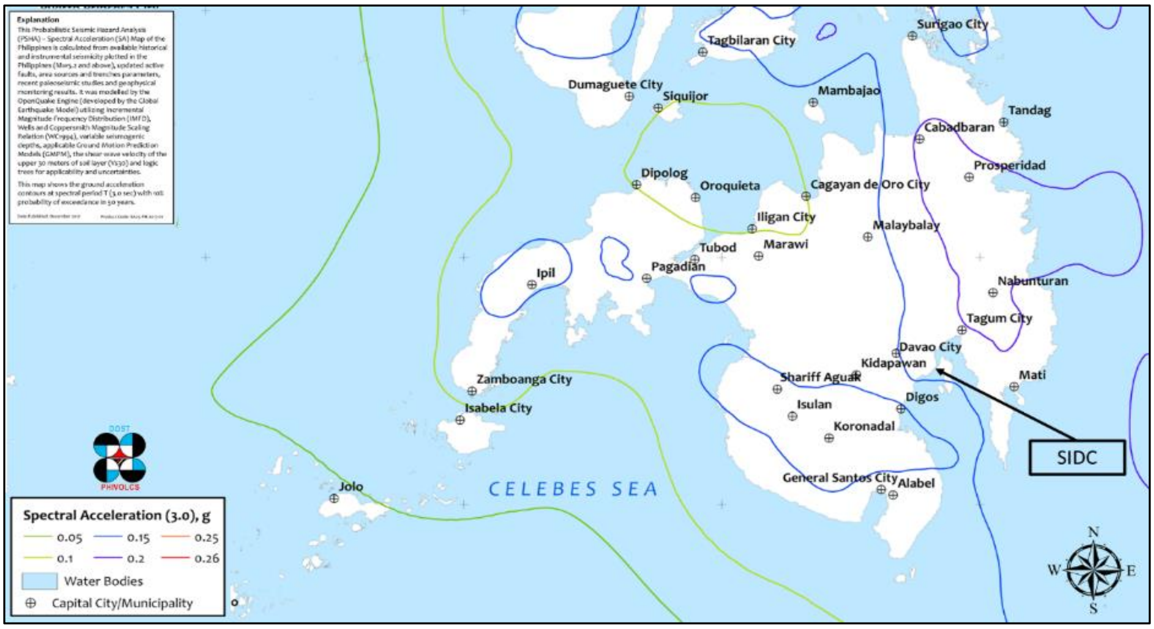
Figure 2.24 Extract of the peak ground acceleration map of the Philippines for rock sites at 2500-year return period



Source: PHIVOLCS, 2017

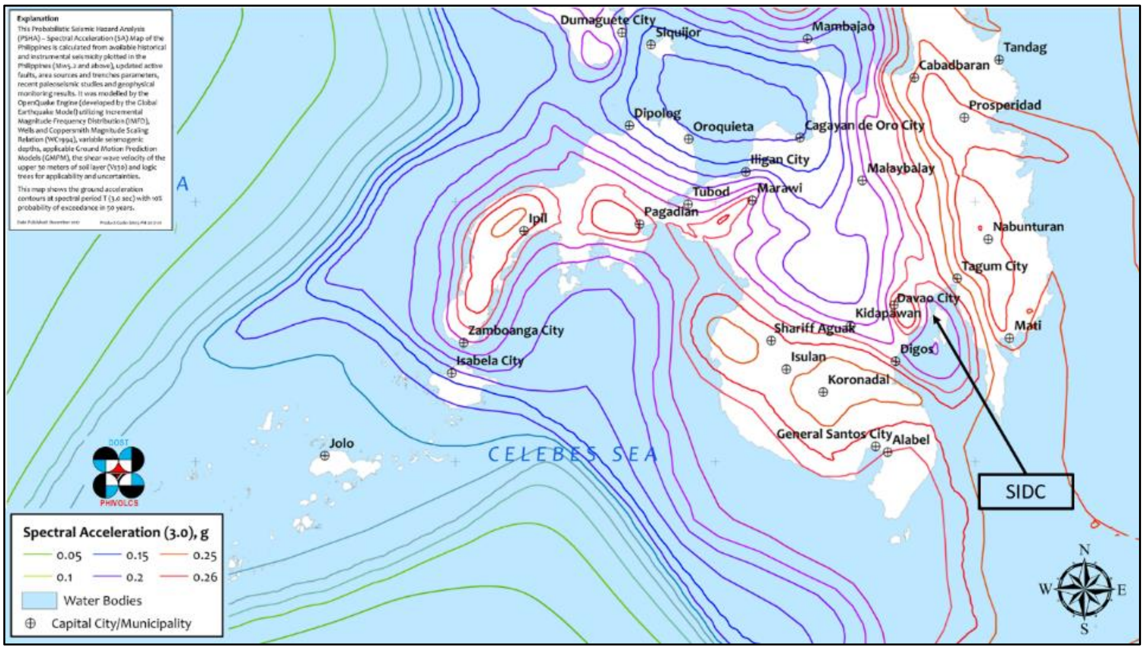
Figure 2.25 Extract of the peak ground acceleration map of the Philippines for stiff soils at 500-year return period

PGA values represent the expected ground shaking for objects on the ground surface. However, objects that are elevated above ground will have different movements as a function of the oscillation of different structures. It has been proposed that the better measure for ground motion in the demand/design for construction, especially for high structures, is the spectral acceleration or response spectral acceleration (SA). Modelled values for spectral acceleration at different periods have been published by PHIVOLCS, showing that the area of SIDC will likely experience between 0.15g-0.2g spectral acceleration for earthquakes with magnitude 5.2 and above at periods of 0.3s, 0.5s, 0.8s, 1.0s, and 3.0s. These values were calculated at 10% probability of exceedance in 50 years.



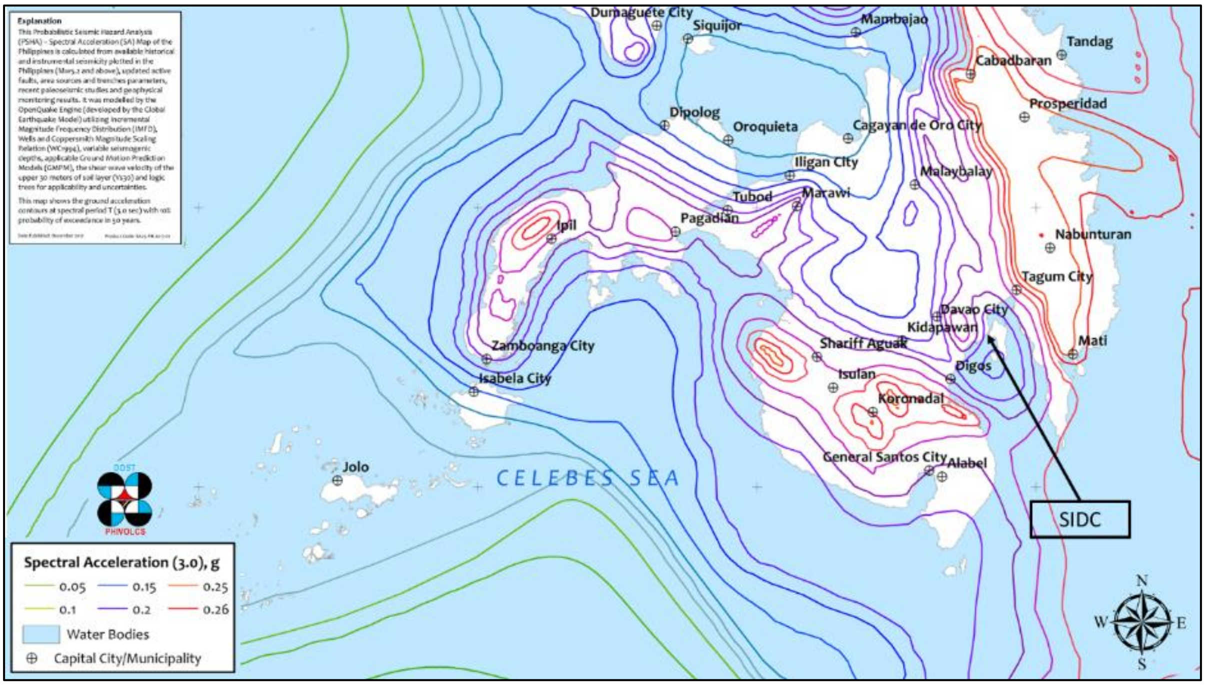
Source: PHIVOLCS, 2017

Figure 2.26 Extract of the spectral acceleration map of the Philippine in 2017 by PHIVOLCS SA (0.3 seconds) at 500-year return period on stiff soil



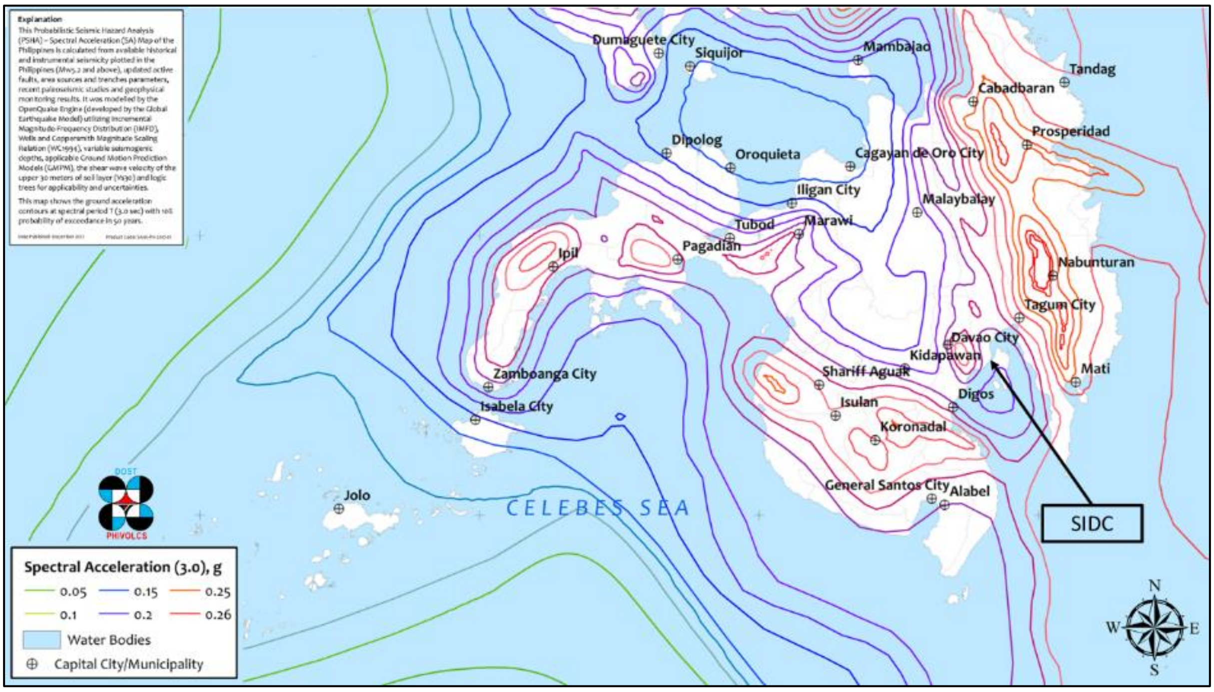
Source: PHIVOLCS, 2017

Figure 2.27 Extract of the spectral acceleration map of the Philippine in 2017 by PHIVOLCS SA (0.5 seconds) at 500-year return period on stiff soil



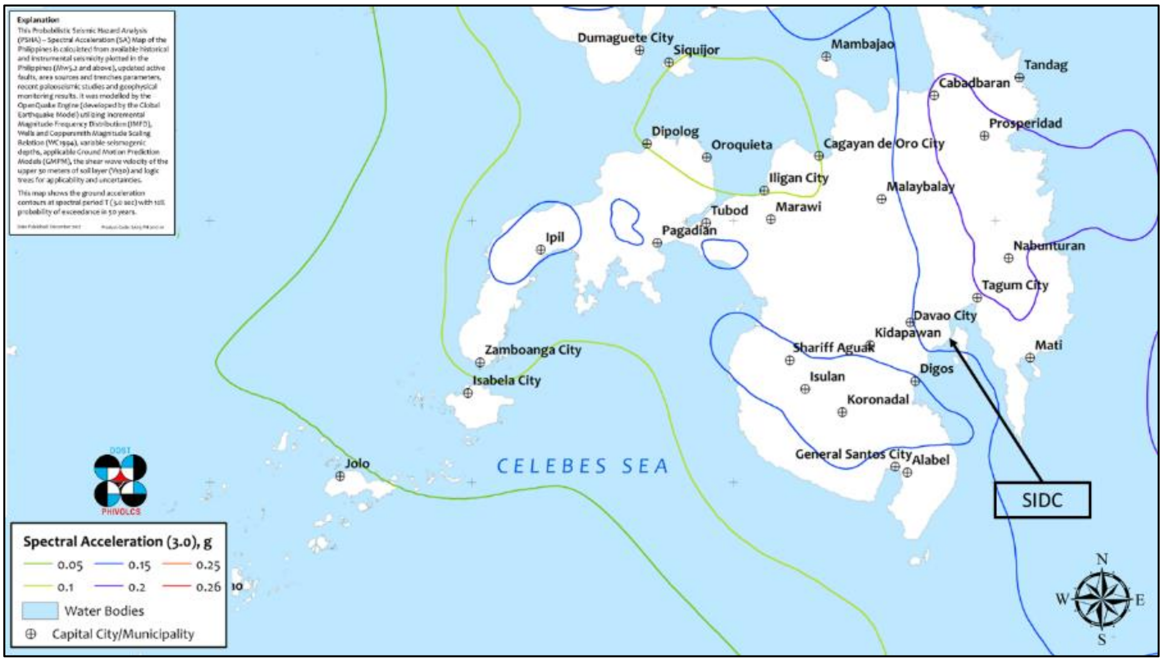
Source: PHIVOLCS, 2017

Figure 2.28 Extract of the spectral acceleration map of the Philippine in 2017 by PHIVOLCS SA (0.8 seconds) at 500-year return period on stiff soil



Source: PHIVOLCS, 2017

Figure 2.29 Extract of the spectral acceleration map of the Philippine in 2017 by PHIVOLCS SA (1.0 seconds) at 500-year return period on stiff soil



Source: PHIVOLCS, 2017

Figure 2.30 Extract of the spectral acceleration map of the Philippine in 2017 by PHIVOLCS SA (3.0 seconds) at 500-year return period on stiff soil

Taking into consideration the susceptibility of the proposed project to strong ground shaking, it is critically important to consider ground acceleration values in the final design of the structures, especially the foundation of each pile and pylons. More detailed design parameters will be determined during the DED phase, wherein detailed geotechnical investigations of the area will be undertaken to provide specific geotechnical parameters that will constrain the engineering plans.

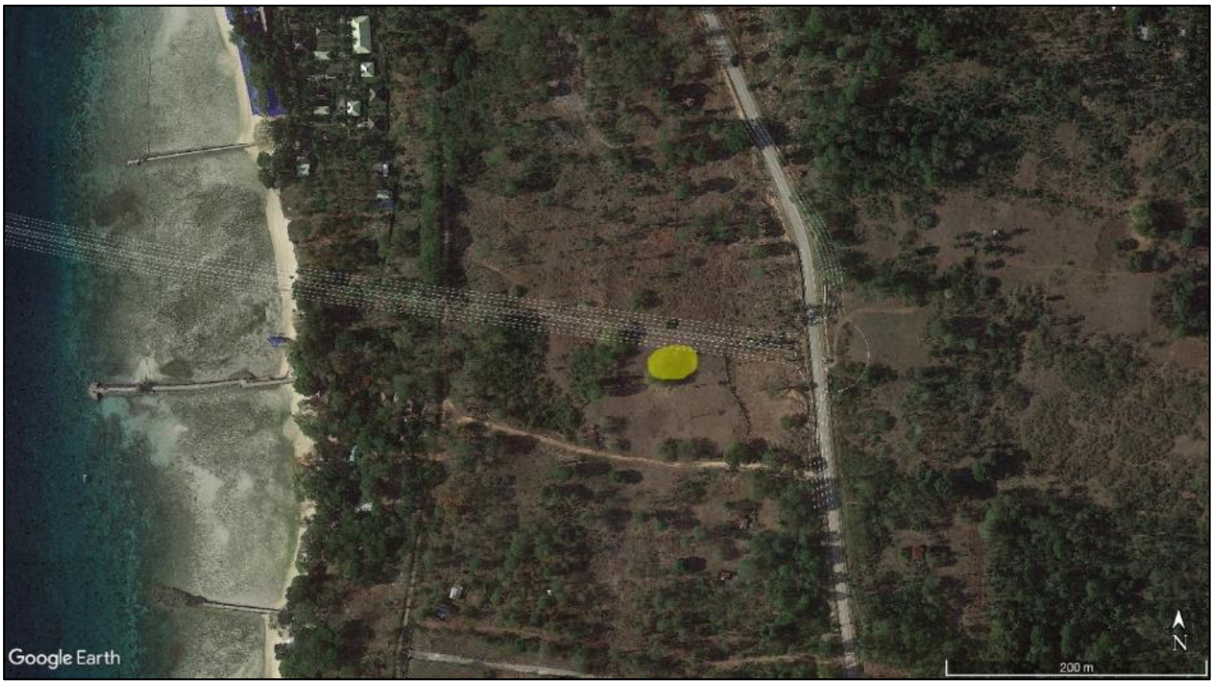
Ground Settlement and Lateral Spread

Lateral spread results from horizontal movement of soil layers due to the movement induced by earthquake events. This type of phenomenon usually occurs in thick soil profiles in areas that are bounded by slopes. In the SIDC project, the terrace platforms within Samal Island are terminated along nearly vertical terrace risers; however, the soil layer in the area is not well developed. Thus, the thin soil profile encountered will not result in any significant lateral spreads during earthquake events. On the other hand, the slopes within the Davao City side of the SIDC are relatively gentle, which does not promote lateral spread. However, the submarine areas within the Pakiputan Strait exhibits a relatively steeper slope based on bathymetry data of the area. Depending on the thickness of sediment cover within this submarine transect, which will be determined through detailed geotechnical investigations during the DED, these areas may be susceptible to horizontal movement downslope.

Ground settlement as a consequence of earthquake events usually results from the consolidation of underlying sediments or via the collapse of subsurface cavities. This phenomenon will not likely affect areas along the Davao end of the SIDC. In contrast, the Samal area is underlain by limestone or carbonate rocks that are highly susceptible to dissolution. This process often results in the formation of caves and subsurface solution cavities, or otherwise known as karstic terrain or karst topography.

One sinkhole was identified adjacent to the location of the alignment. This is based on surface manifestations of a rounded depressed section presently occupied by abundant bamboo grasses. Also, areas along the coastline exhibit clear indications of limestone dissolution features – in Bluewaters Village Resort, a cave system was encountered. Other similar features were also determined within Costa Marina, towards the north. Exposures of the limestone basement rocks also exhibit abundant dissolution cavities and cracks.

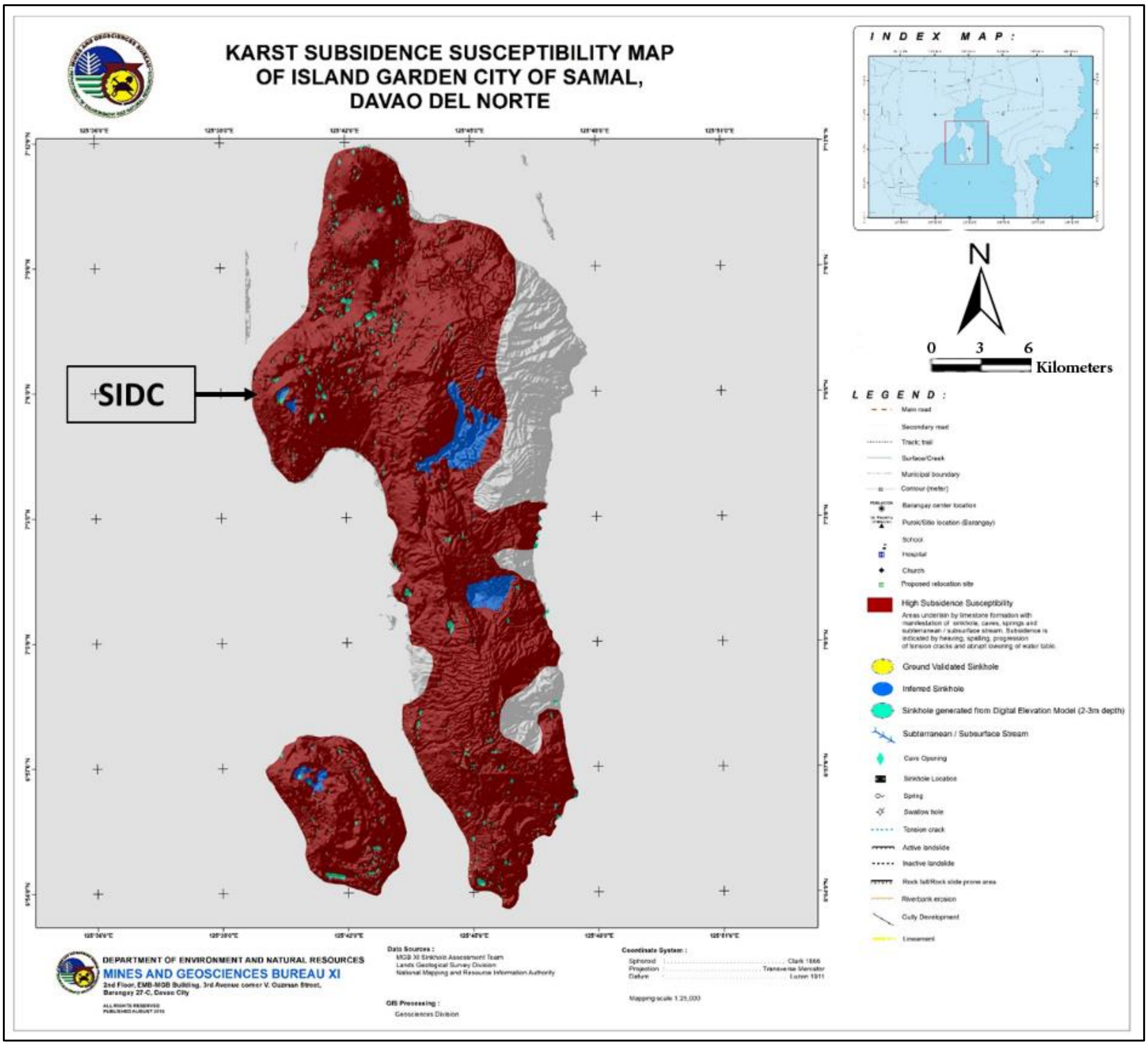
In addition, based on the Karst Subsidence Mapping undertaken by the Mines and Geosciences Bureau Regional Office 11, majority of the areas within Samal Island is highly susceptible to karst subsidence. This is ground settlement due to the collapse of roofs of subsurface voids formed through the extensive dissolution of the underlying limestone materials.



Base map source: Google Earth, 18 October 2019

Figure 2.31 Location of sinkhole in relation to the proposed SIDC alignment

Figure 2.32 Photo of sinkhole along the alignment of SIDC



Source: MGB, 2016

Figure 2.33 Karst subsidence hazard map of IGaCoS showing the location of SIDC

Subsurface investigations will be conducted during the DED to provide information for the design of foundations and the characteristics of the identified sinkhole. Potential mitigation measures are discussed above.

Liquefaction

In areas with high water saturation and mostly clean sands, earthquake events may cause the ground to behave like a fluid because of increased pore pressure brought about by the dynamic movement. This phenomenon is referred to as liquefaction and is one of the destructive occurrences associated with earthquakes. Structures that are supported by ground that liquifies will be prone to damage and collapse.

The Liquefaction Potential Map of the Philippines which was published by PHIVOLCS shows that the Davao end of the SIDC is within a zone that is prone to liquefaction. Thus, ground improvement may need to be undertaken in these areas to increase stability.

Tsunami and Seiches

The Philippines is an archipelago with extensive coastlines and transected by numerous faults and trenches. These conditions make it susceptible to tsunamis and seiches. Tsunami events are characterized by large waves generated by the displacement of large volumes of water due to submarine seismic events, volcanic eruptions or landslides. Seiches are similar events that occur in large inland bodies of water.

The transect of the SIDC crosses the Pakiputan Strait and is prone to local and distant tsunami events. Thus, mitigation measures such as breakwaters or wave dissipating blocks and coastal structures will be considered. Final designs will be based on the results of a more detailed study of the area.

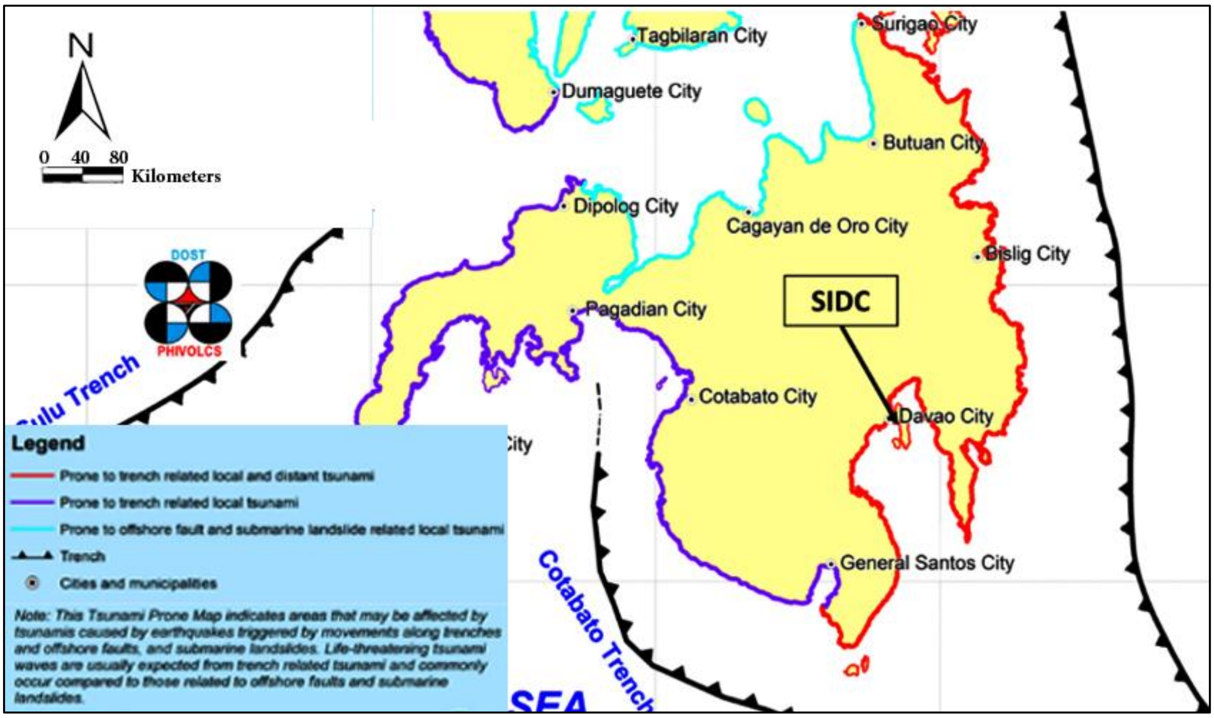


Figure 2.34 Extract of Tsunami prone areas in the Philippines map by PHIVOLCS in 2017

Volcanic Hazards

The Philippine Mobile Belt, which comprises most of the landmass in the Philippine Archipelago, is a geological amalgamation of ancient and young volcanic island arcs brought together by the tectonic movement of adjacent crustal plates. Adding to this, the country is situated along the major plate boundary between the Philippine Sea Plate and Eurasian Plate which constitute a segment of the Pacific Ring of Fire. This geologic setting resulted to the formation of numerous volcanic centers within the country, both active and inactive. Thus, the country is also very susceptible to volcanic hazards such as lava flows, pyroclastic flows, debris flow and avalanches, lahar, ashfall, tsunami, volcanic projectiles, volcanic gases and volcanic earthquakes.

The map of active volcanoes in the Philippines published by PHIVOLCS shows that the nearest active volcanic center to the SIDC project is the Leonard Kniaseff, which is located approximately 56.2 km to the northwest. The potentially active Mt. Apo in western Davao is about 43.7 km from the western terminus of SIDC. The closest inactive volcanic center is Mt. Sibulan, which is around 34.4 kilometers to the southwest. Considering the distance of Leonard Kniaseff to the project site, it is expected that the only volcanic hazard that could impact the development is ashfall. These fine materials are carried by the wind and the distances traveled by these are strongly influenced by wind and climate patterns, as well as the nature of the volcanic eruption. Taking this into account, the final design of the SIDC will ensure that structures will not easily accumulate ash fall on roofs and other civil works.

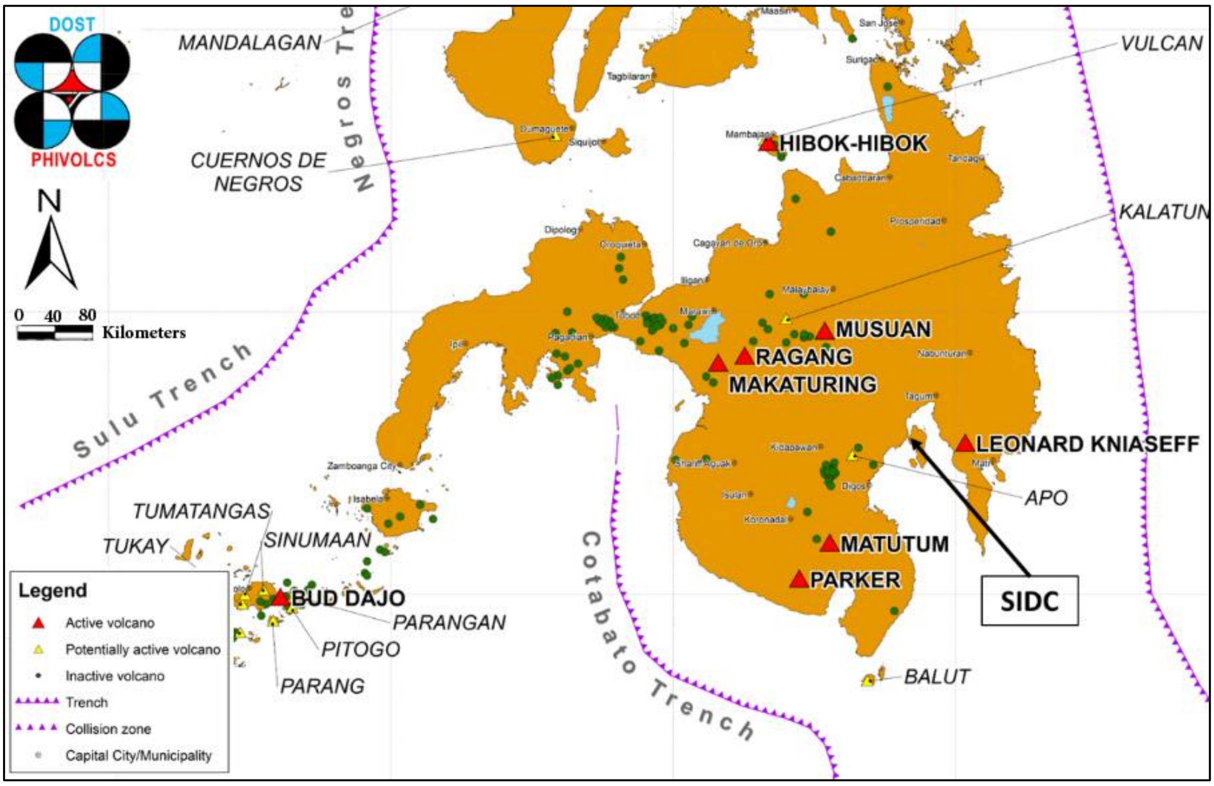


Figure 2.35 Extract from the map of active volcanoes in the Philippines published by PHIVOLCS in 2016 showing the location of the project

Mass Movement

One of the most ubiquitous geologic hazards in the country are landslides or, technically, mass movements. This is mainly due to the variable topography with large areas of moderate to steep slopes, the lack of vegetative cover, thick weathering mantle and soils and the prevalence of geologic structures that contribute to the general weakness of rock and soil.

However, within the area of the proposed SIDC and in particular, the Davao end of the project, the structures will be running through a gentle to flat coastal area where the possibility of slope failure is minimal. Conversely, the Samal side of the project is underlain by relatively competent limestone materials with very little soil cover accumulation such that mass movement may not likely affect the area. Also, the terrace platforms where the bridge will be traversing are relatively level or with gentle slopes that are not prone to failure. The only other section that may likely experience failure is along the cliffy terrace riser in between platforms, and road cuts where dissolution may have weakened the rocks although generally, limestone can be relatively stable at higher angles. Other areas that may likely experience slope instabilities will be the submarine section of the project, because of the moderate to steep slopes revealed by bathymetric data.

Given the limited sections that may be susceptible to landslides, construction design will take into consideration in situ and site-specific geotechnical parameters that will be obtained during the detailed geotechnical investigation to be conducted during the DED phase. Ground preparation at the pre- and construction phase will also take into account the landslide susceptibility of these areas and ensure the slope stability.

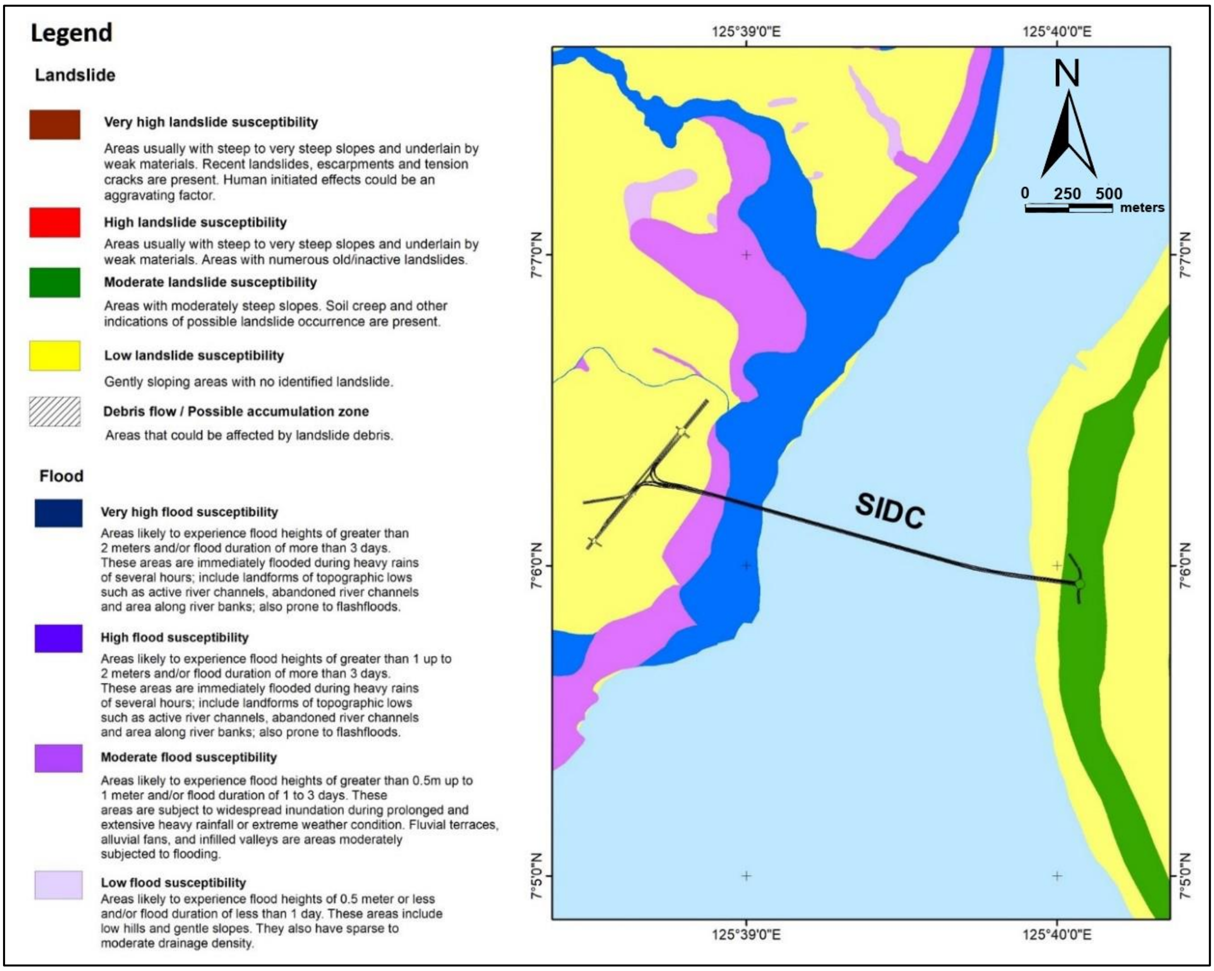


Figure 2.36 Extract of the consolidated landslide and flood susceptibility map of Davao City and IGaCoS from MGB 1:10,000 scale Geohazard Mapping Program (2014)

Fluvial Hazards

Flooding is a widespread hazard that is especially frequent in highly urbanized areas. In Davao City, several low-lying regions are also susceptible to flooding, including where the proposed SIDC will be located.

Based on the combined flood and landslide susceptibility map of Davao City by the MGB, the alignment will cross sections that are moderately to highly susceptible to flooding. Field inspection also confirmed flooding occurrences in the area. They are primarily caused by the lack of drainage canals that efficiently remove storm waters, further aggravated by the fact that the area is very close to the water line and forms a depressed low elevation catchment of rainwater coming from the slightly elevated highway area and surrounding residential lots.

Large canals that are found several tens of meters north and south also overflow during heavy rains; however, based on interviews, water flows do not reach the alignment portion. There was also no natural surface drainage that will be intersected by the alignment.

Figure 2.37 Granular and free draining area at the back of the residential lot where the alignment will cross

Considering the susceptibility of the area to flooding, the final design for the approach of the SIDC project will ensure that there is efficient flow and removal of surface water by establishing appropriate drainage canals. The elevation of the area and the proximity to the sea will also be considered in design and planning.

In IGaCoS side of the project, gullies were observed to have formed along the sloping regions of the limestone. Dissolution is the dominant process in these areas. Although this region is not extensively dissected by surface drainage, an intermittent creek was encountered south of the SIDC alignment. This creek is relatively wider upslope and crosses the main highway, but significantly narrows as it reaches the lower terraces. Flood modelling of the expected discharge shows that this will not cause significant flooding in the area during storm events. However, it is still necessary to establish a well-designed drainage system to ensure that effective storm water flow is maintained in the area.

Figure 2.38 Main channel of an intermittent creek south of the alignment with culvert installed at highway crossing

Figure 2.39 Shallow gully which is the extension of the intermittent creek found upslope

Coastal Hazards

The proposed project will be located along the shores of Samal Island and Davao City; as such, it will be susceptible to coastal hazards. Chief of these is locally generated tsunamis associated with seismic events, which were discussed in the seismic hazards section of this chapter. Both sides of the project are within areas that may be vulnerable to trench and locally generated tsunamis.

The other hazard that may likely affect the site and very similar to the above-mentioned phenomenon is storm surge. These are abnormally high sea waves driven by extreme weather conditions such as strong typhoons. As the site is within the coast, it may be affected by abnormal disturbances of sea level. With the current design of the SIDC, the viaduct is relatively elevated as it approaches the shoreline and may not be affected by high water levels associated with storm surges. However, these conditions will be incorporated into the design of the piers and foundations. Flooding in the Davao coastal area is primarily due to water inundation from inland sources and not from marine waters. On the other hand, the Samal coastal region is composed of cliffy rock faces that are of relatively higher elevations.

Within the submarine section of the project, increased loading due to the construction of the pylons may ensue. These conditions will be taken into account during construction and in the design of the final engineering plans. Moreover, detailed geotechnical characteristics of the area will be collected during the subsurface investigations in the DED phase and will be used as inputs during the planning stage.

Figure 2.40 Approximate alignment of the SIDC along the coast of IGaCoS

The Engineering Geological and Geohazard Report (EGGAR) is found in **Annex K.**

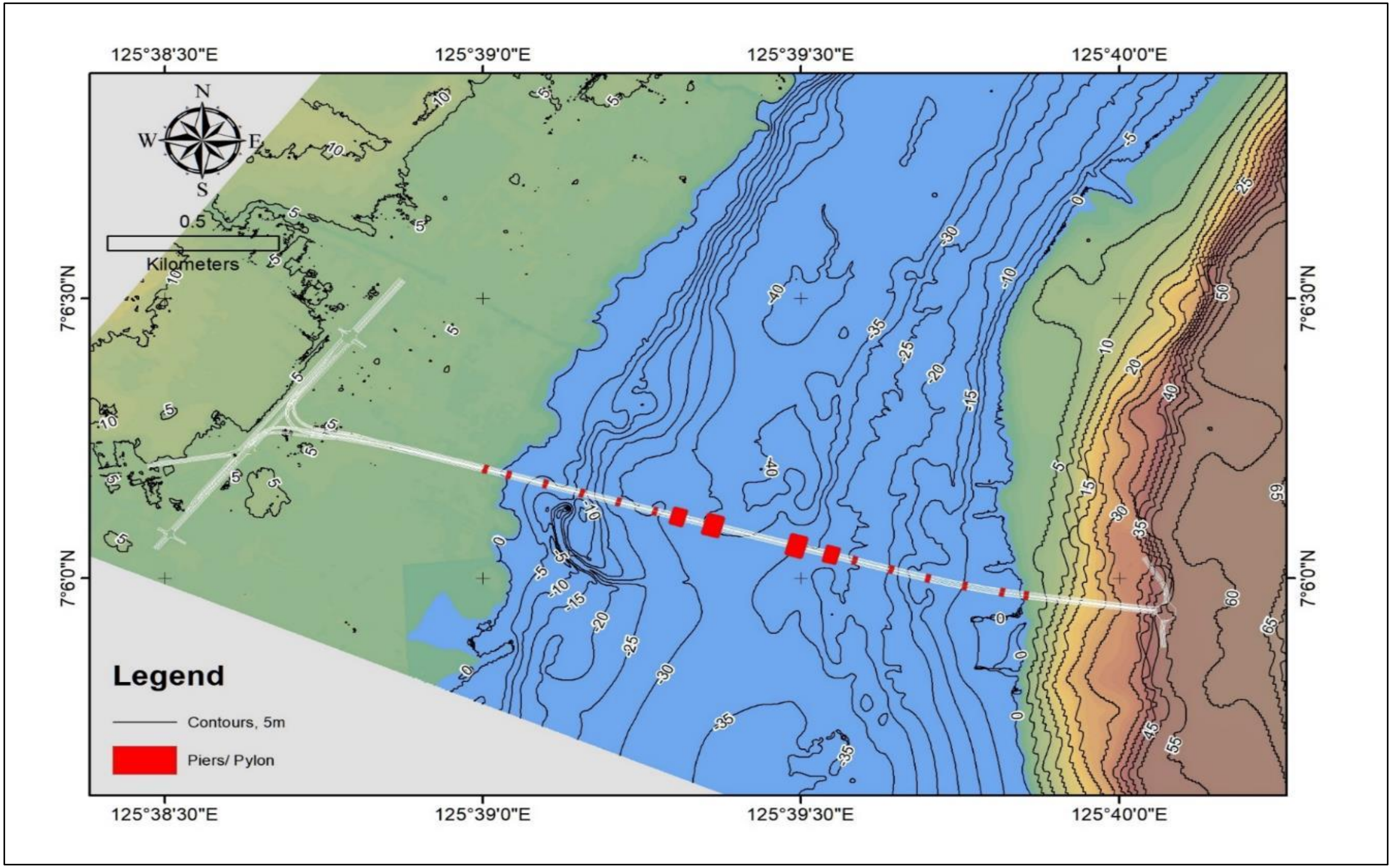


Figure 2.41 Topographic and bathymetric map of SIDC alignment

2.1.3 Pedology

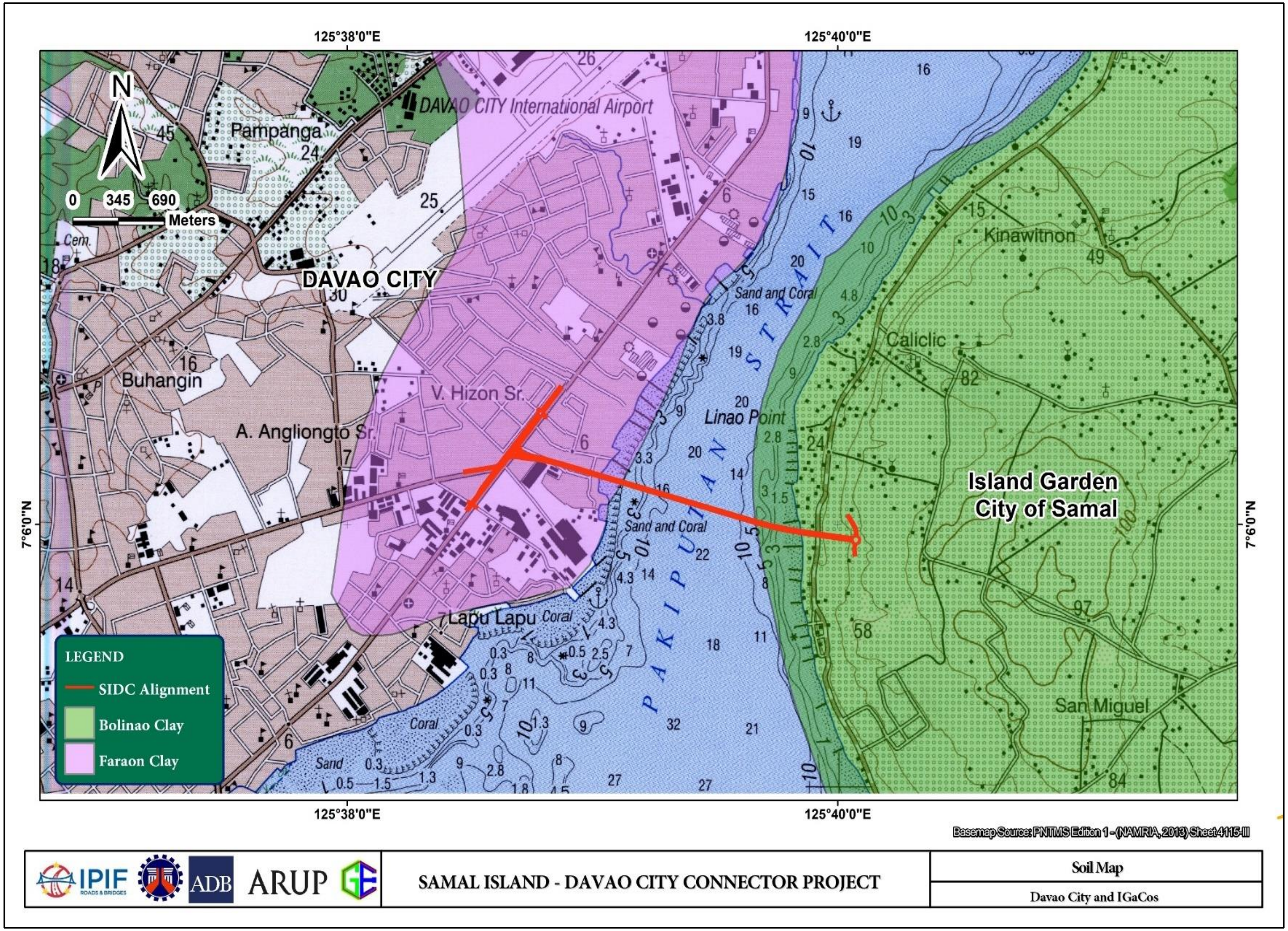
Methodology

In-situ soil samples were taken and >2mm fractions (such as gravel, roots and organic material) were removed by hand. Soil was moistened with a little water and kneaded into a bolus, until sample did not exhibit any apparent change in plasticity. Bolus were further kneaded into ribbons and rods, and textures were compared to the field texture grade adapted from McDonald et al. Field sampling confirmed the predominance of Bolinao Clay in the area.

Baseline Environmental Conditions

The SIDC project connects Davao City and IGaCoS and cuts through the Pakiputan Strait, located within the foreshore and backshore areas of its respective barangays. Its area coverage contains two different soil types of the same origin (coralline limestone). Both soil types are the product of weathering and deposition of the host material, which formed the topmost layer of the soil horizon. Incidentally, coralline limestone is a type of sedimentary rock formed from the deposition and diagenesis of calcium carbonate originating from sea corals and soft and hard-shelled organisms from oceans and seas.

In Davao City, the composition of the soil along foreshore and shoreline areas are clays. Based on data gathered from Bureau of Soils and Water Management (BSWM), the SIDC alignment along Davao City is part of the Faraon Clay. The soil of the Faraon Series was derived from decomposed coralline limestone and generally with superficial color of black to brown. Faraon Clay tends to get sticky when wet and friable when moist (Demetrio, 1961).



Sources: DOST-UP Training Center for Applied Geodesy and Photogrammetry, 2015; PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III, WGS 84

Figure 2.42 Soil Map

Figure 2.43 Shows the exposure of Faraon Clay at Barangay Vicente Hizon Sr., Davao City

In IGaCoS area, the soil type along the alignment is part of the Bolinao Clay. Bolinao Clay is heavy clay that is usually encountered at depths between 10 to 24 centimeters. This soil type has a distinct color of red to reddish brown and sticky and plastic when wet. Compared to Faraon Clay, it is more eroded and malleable when moist.

Figure 2.44 Shows the exposure of Bolinao Clay at Barangay Limao, IGaCoS

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Soil Erosion/ Loss of topsoil/ Overburden

The proposed project will incur minor impacts to the soil profile. There will be no soil erosion but minor loss of topsoil would be possible along the bridge's major structures. Major foundations and towers will be located onshore; therefore, removal of deep and massive soil profile will not happen along the offshore alignment. The project only covers minor displacement due to the construction of connection foundations from onshore to offshore areas.

2.1.4 Terrestrial Ecology

Terrestrial assessment measures the biological diversity at the proposed alignment for the SIDC Project. The assessment was conducted in order to determine the status of the vegetative cover, faunal population, location and other existing and potential factors that may influence their stability, especially during the project construction and operation phases.

The assessment was also used as basis in determining mitigating measures to anticipated impacts on biodiversity. The assessment was carried out to provide baseline information on the population, structure and composition of the flora and fauna thriving within the proposed alignment of the project and its vicinity and to make recommendations for the management and planning of the area based on existing environmental laws, rules and regulations.

Methodology

The methodology employed was based on the DENR-EMB Terrestrial Ecosystems Biodiversity and Assessment Monitoring Manual 2017. Although the manual was designed for protected areas, it may be applied to any terrestrial biological assessment, having been modified from the Biodiversity Monitoring System (BMS).

A review of all available secondary data relative to the area was also undertaken to determine the flora and fauna species of concern that may be present in the area. Secondary data sources, including DAO 2007-01 and the IUCN Red List, can be found in the references section of this report. Key informant interviews were also conducted to supplement data gathered in the field.

Survey Design

Flora Assessment

Nested quadrats were placed along transects in vegetated areas to determine the flora in the area. The nested quadrats were not enclosed and staked, partly to respect agreement with owners and occupants. Instead, the central point of the established quadrat was marked using GPS.

To stratify the object of study, i.e. the secondary-growth forest and plantations, three dimensions of the nested quadrats were made:

- 10m x 10m – for sampling of trees with more than 10 centimeters diameter at breast height (dbh) and more than 4 meters in height (Canopy Layer)
- 5m x 5m – for sampling of small to medium size trees, large herbs (e.g. banana), and large grasses (bamboo). Small to medium size trees include those having less than 10 centimeters dbh and less than 4 meters in height. (Under Canopy Layer)
- 1m x 1m – for sampling of wildlings (< 1 meter height), grasses, herbs, ferns and other plant forms that grow close to the ground (Ground Layer/ Undergrowth)

Figure 2.45 Establishing the transect line (left - Davao City; right – IGaCoS)

All plant species were assessed based on their form and habitat, ecological status, conservation status and economic value and uses based on available references and existing local and international policies.

The sampling sites were photographed using Android application Geocam Pro to complement observations in the identified areas (**Annex L**). The geographical location of the four (4) sampling plots – (2) in Davao City and (2) in IGaCoS, can be found in **Table 2.6**. Sampling site maps for both cities are in **Figure 2.46** and **Figure 2.47**.

Table 2.6 Geographical Data of Sampling Plots

Plot No.	Sampling Location (WGS, 1984)		Description / Remarks
	Latitude	Longitude	
Davao City Side			
1	7.10055556º N	125.64916667ºE	Private land, near community/shore
2	7.10138889 ° N	125.64666667 °E	Private land / Secondary growth
IGaCoS Side			
3	125.64666667 ° N	125.66638889 ° E	Grassland
4	125.66638889 ° N	125.66638889 5° E	Grassland

Fauna Assessment

a. Passive Methods

Mist Netting

Ten (10) mist nets were hoisted along identified flyways, feeding trees and roosting areas in the study area. The mist nets were used to capture avian (birds) species and volant mammals (fruit bats, insect bats) for identification and population estimation.

Mist nets are nylon nets with 35mm-sized mesh, set in 3-4 rungs with loose pockets to allow capture (**Figure 2.48**). The nets are set in projected flyways (e.g. gaps in canopy, fruiting trees). Height ranges from 6-12m above the ground. These nets were placed in locations where there are irregular human presence in order to avoid tampering with the nets or trapped wildlife. The nets were checked every 2 hours between 0600H to 2200H. The nets were opened for 24 hours for 3 days and nights.

Nets were checked regularly to minimize the ecological impact of the survey. All species caught were properly documented before release. No voucher specimens were collected during the conduct of the activity.

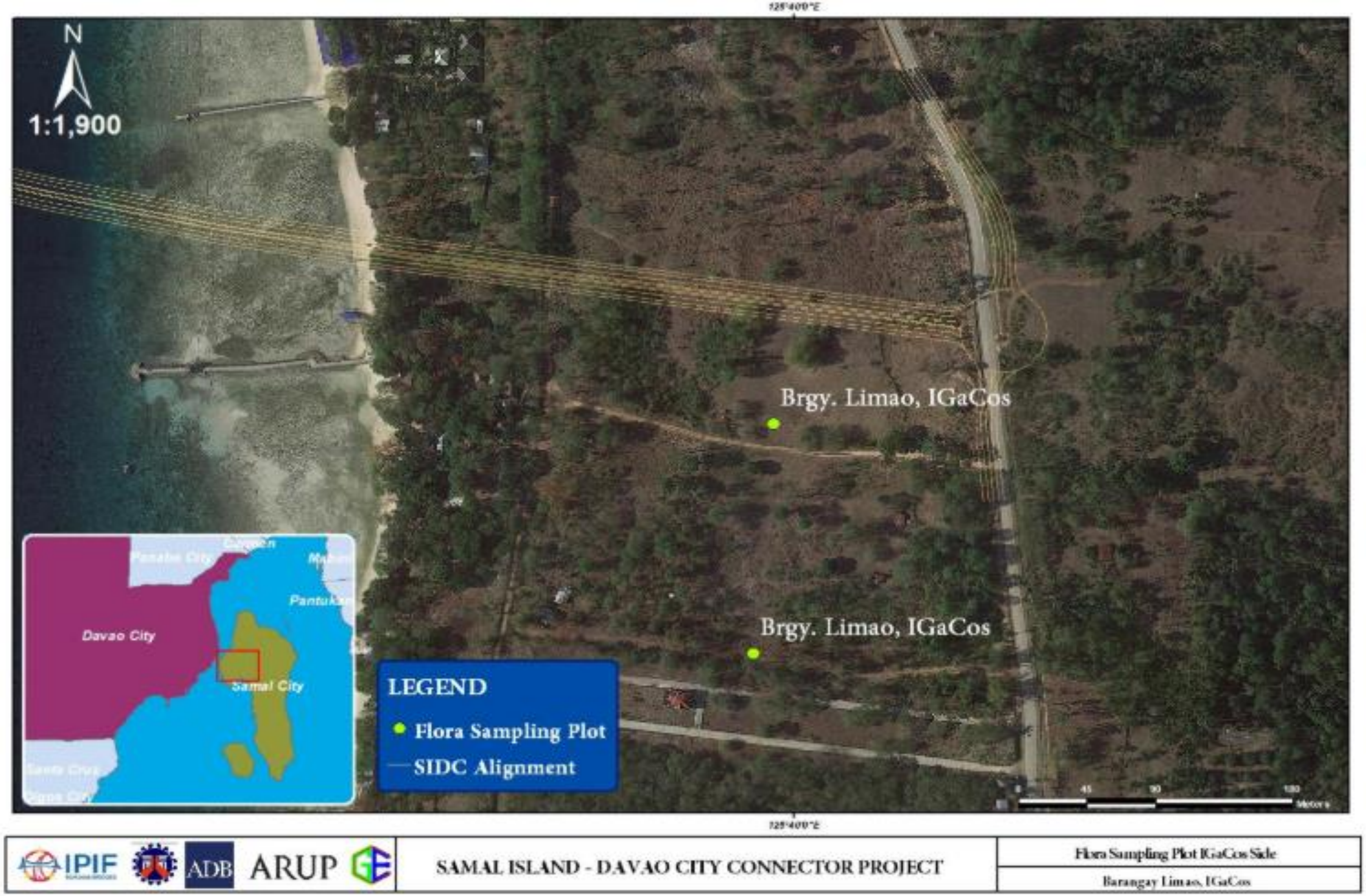
Live-trapping

Five (5) spring-loaded live traps were used during the assessment (**Figure 2.49**) The traps used were first smoked to remove the odor of metal and other scents.These were then baited using roasted coconut meat smeared with peanut butter. The traps were set near the vicinity of the mist nets, foot trails, under fallen trees, rocks and in sheltered crevices along the transect line. These traps were checked for any capture early in the morning of the next day and re-baited, especially if ants had run over the bait.

Live traps were installed on locations where there are tell-tale signs and probable hideaways (e.g. burrows, fallen logs) and were open 24 hours for three days. The traps were checked around 7am-8am, rebaited and re-set when necessary.

Google Earth, June 2019

Figure 2.46 Map of Sampling Sites in Davao City



Google Earth, June 2019

Figure 2.47 Map of Sampling Sites in IGaCoS

Figure 2.48 Mist Nets

Figure 2.49 Baited Live Traps

Key Informant Interviews

Key informant interviews were also conducted to supplement key findings and determine if other flora and fauna species may have been recorded through other methods. Information on their presence and how they are used were solicited though field guides and similar references. The informants are the actual occupants and people that frequently wander in the area.

KIIs were conducted with randomly selected respondents in an informal setting, which usually yields more information as opposed to formal, questionnaire-guided interviews. Talking points focused on observed wildlife and complemented by the use of illustrated field guides.

b. Active Methods

Transect walk and Point counts

The transect line established was walked twice a day, at around 6:00 to 8:00 AM and 4:00 to 6:00 PM, to observe birds and other fauna that may be active during these times. The transect walk was conducted twice a day for 3 days, at 6-8am and 4-6pm. The said times are when birds and other diurnal wildlife are most active.

Point counts were employed in strategic areas where bird activity was common. Information gathered included bird species seen and heard calling, and ecological notes for habits, habitat type, association with other species and participation in mixed-species flocks.

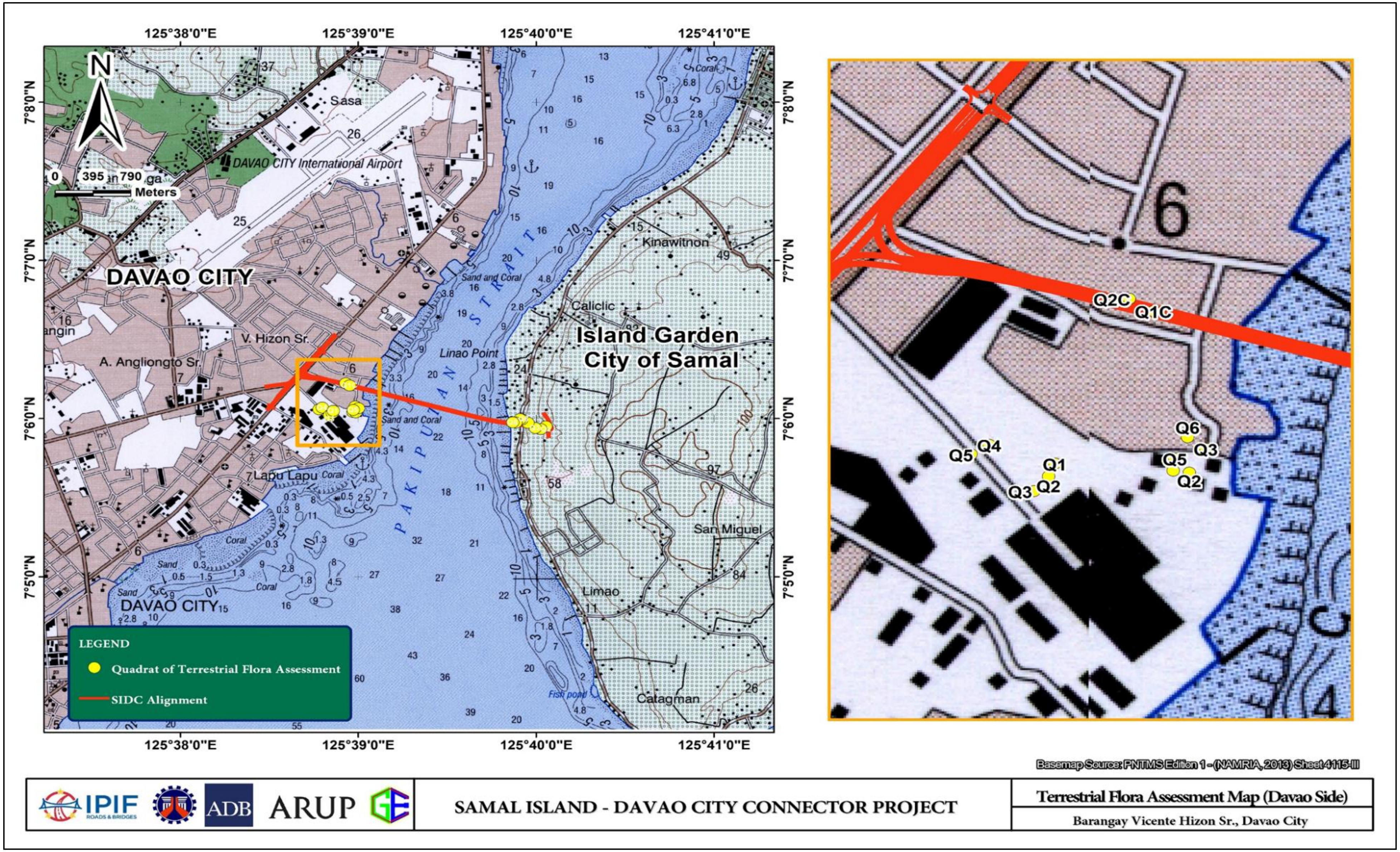
The same transect was used for the herpeto-fauna and volant mammal Visual Encounter Study. Direct sightings and evidences like tracks and sign identification (e.g. molted skins, feathers, droppings and dens) were used to augment the survey.

Purposive Search and Opportunistic Catching

Purposive search and opportunistic catching was also employed to record species for the terrestrial and arboreal (non-volant) fauna species. Suspected and specific microhabitats were purposively and intensively searched from at least 5 and up to 30 minutes for any possible faunal inhabitants. Microhabitats that were sampled include tree hole, barks, tree buttresses, forest floor, palm and aroid leaf axils, epiphytes, tree ferns, aerial ferns, puddles, lotic and lentic bodies of water.

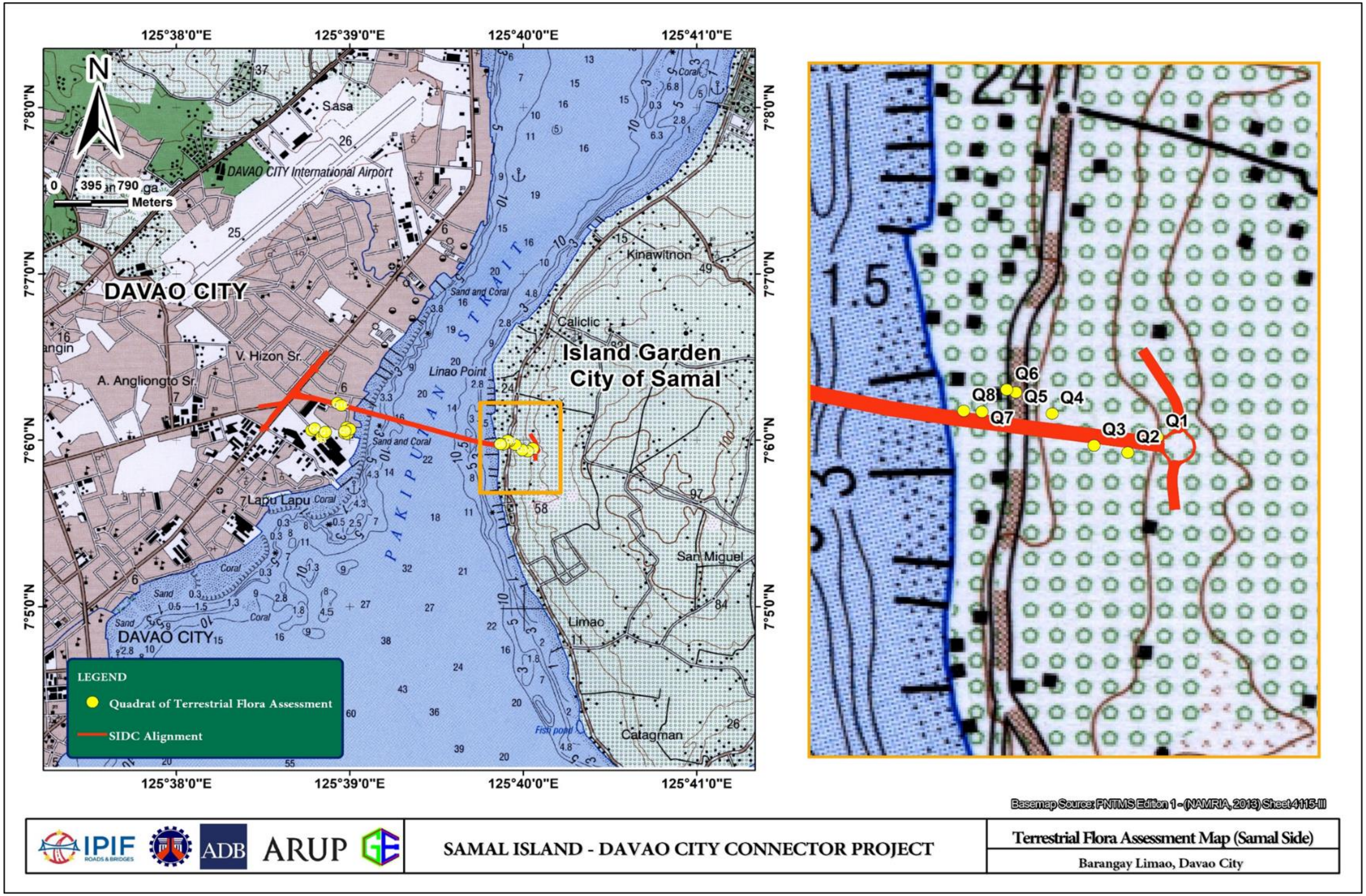
Field identification was conducted at the site and was further verified during data processing and analysis using available references (print or web-based). Each flora and fauna has its own means of identification, like phyllotaxy for flora and body parts for fauna.

The parameters used in the assessment include the relative values for Density, Frequency and Dominance. Also included are the computed Importance Values, which determine the ranks of the species within the sampled area. Importance Value determines the measure of how dominant a species is in a sampled area, thereby indicating the ecological importance of a species in a given ecosystem. As such, it gives a view of prioritizing a selected range of species for conservation, which in turn, would greatly influence its ecosystem in terms of nutrient cycling, energy transfer and micro-climatic effects.



Source: NAMRIA, 2013; Sheet No. 4115-III (WGS84)

Figure 2.50 Quadrat for Terrestrial Flora Sampling Site in Davao City. Basemap Source: PNTMS Edition 1



Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS84

Figure 2.51 Quadrat for Terrestrial Flora Sampling Site in Samal Island.

Figure 2.52 Sampling Site in IGaCoS

The parameters mentioned and corresponding formulae are as follows:

a. *Abundance (Abun)* - the number of individuals of a species regardless of area size

b. *Relative Abundance (RAbun)* - percent composition of an organism of a particular kind relative to the total number of organisms in the area

$$\frac{\text{Abun}}{\text{Total Abun}} \quad \text{X } 100$$

c. *Density (Den)* – the number of individuals of a species in a given area

d. *Relative Density* - Proportion of the number of individuals of one species relative to the total number of individuals of all species

$$\frac{\text{Den}}{\text{Total Den}} \quad \text{X } 100$$

e. *Frequency (Freq)* - Number of nested quadrats or subplots in which a species is found

$$\frac{\text{No. of times a species occurred in all plots}}{\text{Total number of plots}}$$

Figure 2.53 Measuring dbh of trees within the quadrats

f. *Relative Frequency (RFreq)*- the proportion of the frequency of a species relative to all frequencies of all species in the transect

$$\frac{\text{Freq}}{\text{Total Freq}} \quad \text{X 100}$$

g. *Basal Area* - circumference at breast height occupied by each species
h. *Dominance (Dom)*– the average basal area of all individuals of a species

$$\frac{\text{Basal Area in a species}}{\text{Total Basal Area}}$$

i. *Relative Dominance (RDom)* - Proportion of the average basal area of one species relative to the total basal area of all species

$$\frac{\text{Dom}}{\text{RDom}} \quad \text{X 100}$$

j. *Importance Value (IV)* - total of all relative values per species, the species with the highest value indicating the dominant species that would exert influence on the ecosystem.

$$\frac{\text{Sum of Relative Values}}{\text{No. of Relative Values Used}}$$

The indices of Density, Frequency and Dominance were used to compute the Importance Value for plant diversity, while fauna diversity utilized relative values of Abundance and Frequency.

Biodiversity measurements were computed and analysed using the Shannon-Weiner Diversity and Pielou’s Evenness Indexes.

Shannon Diversity Index = $H' = -[\sum(p_i)(\ln p_i)]$

Where:

"H'"- represents the symbol for the amount of diversity in ecosystem (species diversity)

"p_i"- represents the proportion or relative abundance of each individual species to the total (measured from 0 to 1)

"ln p_i" - represents the natural logarithm of p_i

Pielou's Evenness Index = $J = H/Hmax = -[\sum(p_i)(\ln p_i)]/\ln S$,

Where:

"J" – represents the symbol for the species richness

"H'" – species diversity

"Hmax" – species maximum diversity

"S" – number of species in the community

The interpretation of the values obtained using the above formulas were based on the Fernando Biodiversity Scale, 1998 shown in **Table 2.7**.

Table 2.7 The Fernando Biodiversity Scale (1998)

Relative Values	Shannon-Weiner Index (H')	Pielou's Evenness Index (J')
Very High	3.5 and above	0.75-1.00
High	3.0-3.49	0.50-0.74
Moderate	2.5-2.99	0.25-0.49
Low	2.0-2.49	0.15-0.24
Very Low	1.9 & below	0.05-0.14

Baseline Environmental Conditions

Integrated Biodiversity Assessment Tool

The Integrated Biodiversity Assessment Tool (IBAT) screening is undertaken to check the possible presence of protected sites and to identify possible critical (CR) and endangered (EN) species in project area.

Two IBAT reports were generated on 3 September 2019. These are IBAT Proximity Report and IBAT World Bank Group Diversity Risk Screen. The IBAT Proximity Report uses a buffer of 1 km and 3 km but identifies potential species of conservation status within the 50 km area of interest. As expected, no protected nor key biodiversity sites were found within 1 - 3km, though potential presence of CR and EN species was identified in the area (**Figure 2.54**). The IBAT Proximity

Report identified 228 species in the IUCN Red List that are potentially found within 50 km of the area of interest. The World Bank Group Diversity Screen using buffers of 10 km and 50 km indicates that there are 27 species listed as endangered (EN) and eight species listed as critically endangered (CR). Out of the 228 species, 27 species are EN and eight are CR.

IBAT results also show that there are 35 IUCN Red List of Threatened Species – CR and EN, 2 Key Biodiversity Areas (i.e. Mt. Apo Natural Park and Mt. Kampalili-Puting Bato) and 2 Protected Areas (i.e. Mt. Apo Natural Park and PNOC Geothermal Site) that may be found within 50 km of the proposed alignment (**Figure 2.55**)

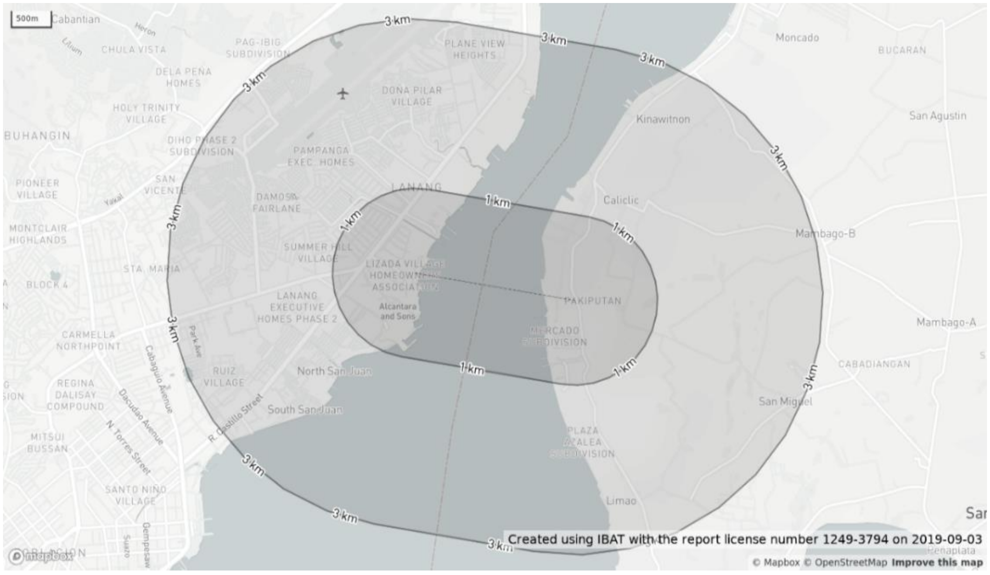


Figure 2.54IBAT result– within 1 and 3 km buffers

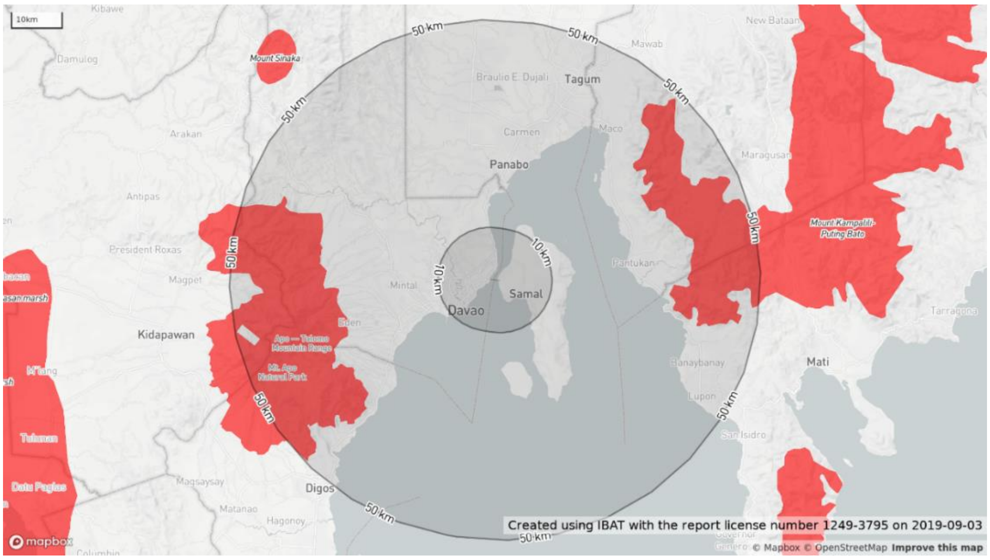


Figure 2.55IBAT result – within 10 and 50km buffers

In summary, threatened species are only found in 50 km buffer, hence the project is expected to insignificantly impact the area.

Flora Assessment

Plant Diversity Assessment

Results of the assessment identified 100 species, represented by 24 families of flora in the study area. This includes species found in the sampling plots along the transect line. A total of 100 individuals were observed in the four established sampling plots. The flora present in each sampling plot gives character to the habitat type. The values indicate that the species found along the transect lines have relatively the same species in the sampling plots. Diversity indices of the proposed project site are relatively low in all sampling plots which means that the affected species of the proposed project is of least concern to the IUCN Red List. Only the 5x5 sampling plot has a value of 1 in evenness index, indicating that all taxa are equally present in all sampling plots. It is noted that the Gmelina (*Gmelina arborea*) and Big-Leaf Mahogany (*Sweitenia macrophylla*) are the least species found on the proposed project site.

Table 2.8 Summary Results for Plant Diversity Assessment

Parameters	1x1	5x5	10x10	Overall
Density	44	5	51	100
Species Richness	10	5	9	81
# of Families	10	5	9	24
Diversity Index	1.86	1.61	1.75	2.42
Evenness Index	0.81	1.00	0.80	0.82

Diversity and Evenness

Diversity and Evenness measures the importance of plant community. Species diversity is the number of different species in a particular area weighted by some measure of abundance (e.g. number of individuals or biomass). Evenness measures how close the number of species are in the area.

Results showed that the highest diversity indices in all plots were calculated in DC2 with a low plant diversity of H’ =2.187, but with very high evenness at J’ = 0.95. According to the Shannon index, an ecosystem with H’ value of 2.0 – 2.49 has been regarded as low diverse in terms of species composition. The results imply that tree diversity of the proposed project is low. It is indicated that priority for vegetation in the area is low due to the presence of community and some highly disturbed areas. In addition, the location of the sampling plot can be characterized as a secondary growth forest, with closed canopy and a fair number of regenerants. The least calculated diversity values are observed in SI1 with a Very Low H’ = 0.899 and J’ = 0.864. SI plots are grassland areas utilized for grazing animals, hence the low values

Figure **2.56** shows the graph of flora diversity and evenness from the sampling plots in Davao and IGaCoS:

- DC1 – Davao City Sampling Plot 1

- DC2 – Davao City Sampling Plot 2
- SI1 – Samal Island Plot 1
- SI2 – Samal Island Plot 2

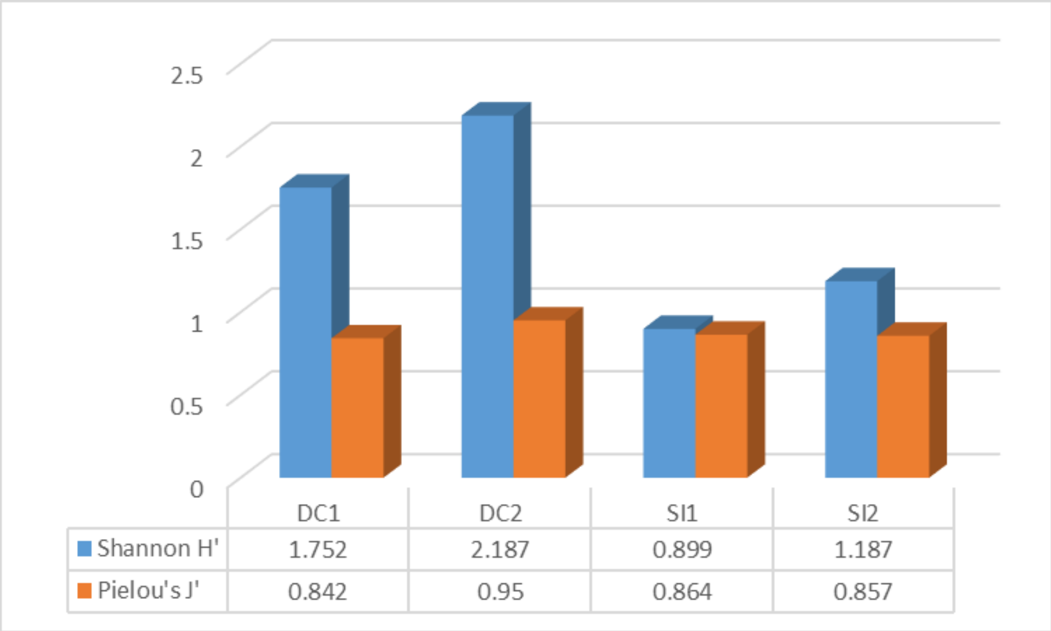


Figure 2.56 Graph of Flora Diversity and Evenness

Density and Species Richness

Density is computed by dividing the number of individuals from the area sampled in a forest stand. However, species richness is the number of species that have been recorded for a specific group of organisms during a specific time period. Density and species richness measures the quantity of individuals of plants species in a sampled area or the abundance species in the sampled area. The highest abundance and species richness was observed at Sampling Plot No. 4 compared to other plots, as shown in **Figure 2.47**. This is attributed to the area being a helipad, which has been rarely used in the recent years and located at top of a ridgeline. This provides canopy full exposure to sunlight to penetrate the forest floor and promote increase in regenerants.

The graph of flora diversity and species richness is shown in **Figure 2.57** with corresponding legend:

- DC1 – Davao City Sampling Plot 1
- DC2 – Davao City Sampling Plot 2
- SI1 – Samal Island Plot 1
- SI2 – Samal Island Plot 2

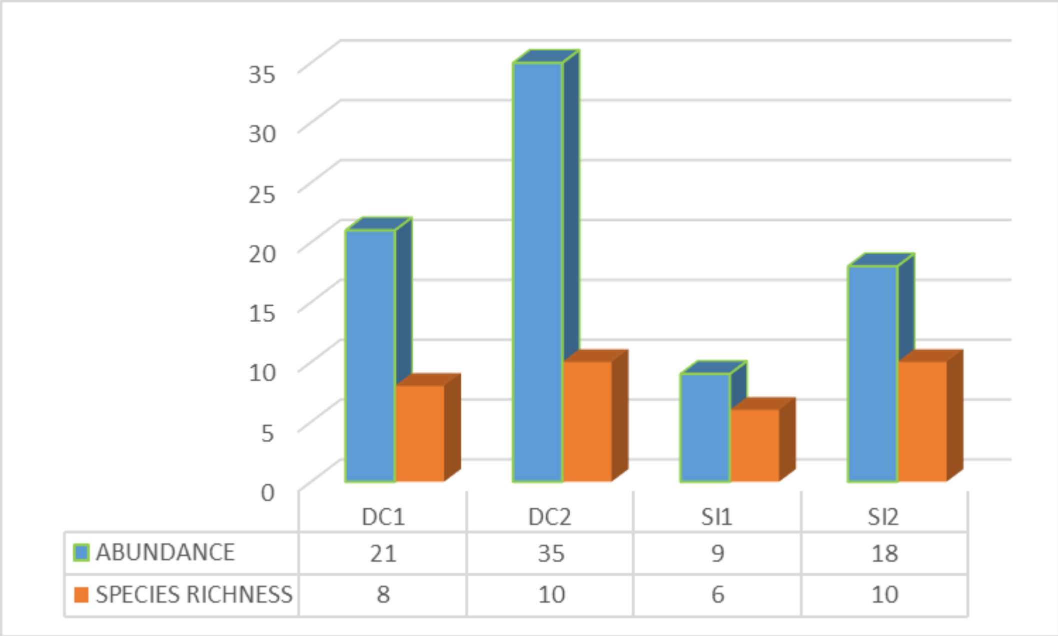


Figure 2.57 Graph of Flora Diversity and Species Richness

In terms of species, *Imperata cylindrica* obtained the highest calculated values. It was expected as the SI1 was predominantly grassland. *Swietenia mahagoni* and *Gmelina arborea* were the top-ranking trees, confirming that these species are the usual choice for reforestation activities, due to its availability and economic value (e.g. timber and pulp). Other species were pioneer species which may have been brought by pollinators like birds, bats and civet cats.

Table 2.9 Top Ranked Flora Species Based on Important Values (IV)

Rank	Family Name	Scientific Name	Common Name	Dens	Rel Dens	Freq	Rel Freq	Dom	Rel Dom	IV
1	POACEAE	*Imperata cylindrica*	Cogon	22	22	1	17.86			33.99
2	POACEAE	*Saccharum spontaneum*	Talahib	15	15	0.6	10.71	0.222	14.288	13.33
3	MELIACEAE	*Swietenia macrophylla*	Mahogany	5	5	0.4	7.14	0.125	8.062	6.73
4	VERBENACEAE	*Stachytarpheta jamaicensis*	Kandi-kadilaan	9	9	0.6	10.71			6.57
5	LYTHRACEAE	*Duabanga moluccana*	Loktob	14	14	0.2	3.57	0.967	62.124	5.86
6	LAMIACEAE	*Gmelina arborea*	Gmelina	6	6	0.2	3.57	0.102	6.553	5.37
7	MORACEAE	*Artocarpus altilis*	Rimas	6	6	0.2	3.57	0.076	4.913	4.83
8	FABACEAE	*Leucaena leucocephala*	Ipil-ipil	8	8	0.2	3.57			3.86
9	LAMIACEAE	*Vitex parviflora*	Molave/Tug-as	3	3	0.2	3.57	0.032	2.028	2.87
10	FABACEAE	*Pithecellobium dulce*	Kamatsile	3	3	0.2	3.57			2.19

Plant Form

Assessment of the plant forms within an area helps identify the structure of the overall floral community. Plant forms were classified into the following groups: Trees, Shrubs, Herbs, Vines, Grass and Bamboo. Overall, the highest number of species identified were grass accounting for 26%, followed by herbs (22%), and trees (21%). Shrubs and other plant forms represented the remainder.

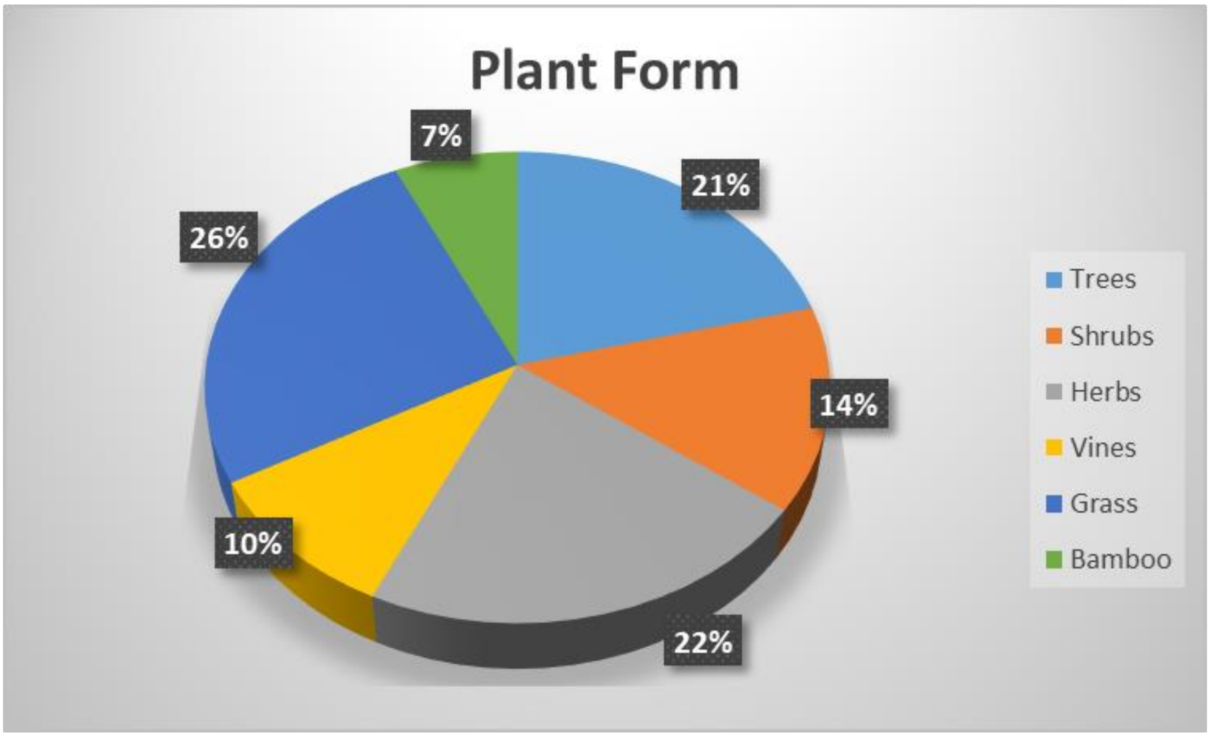
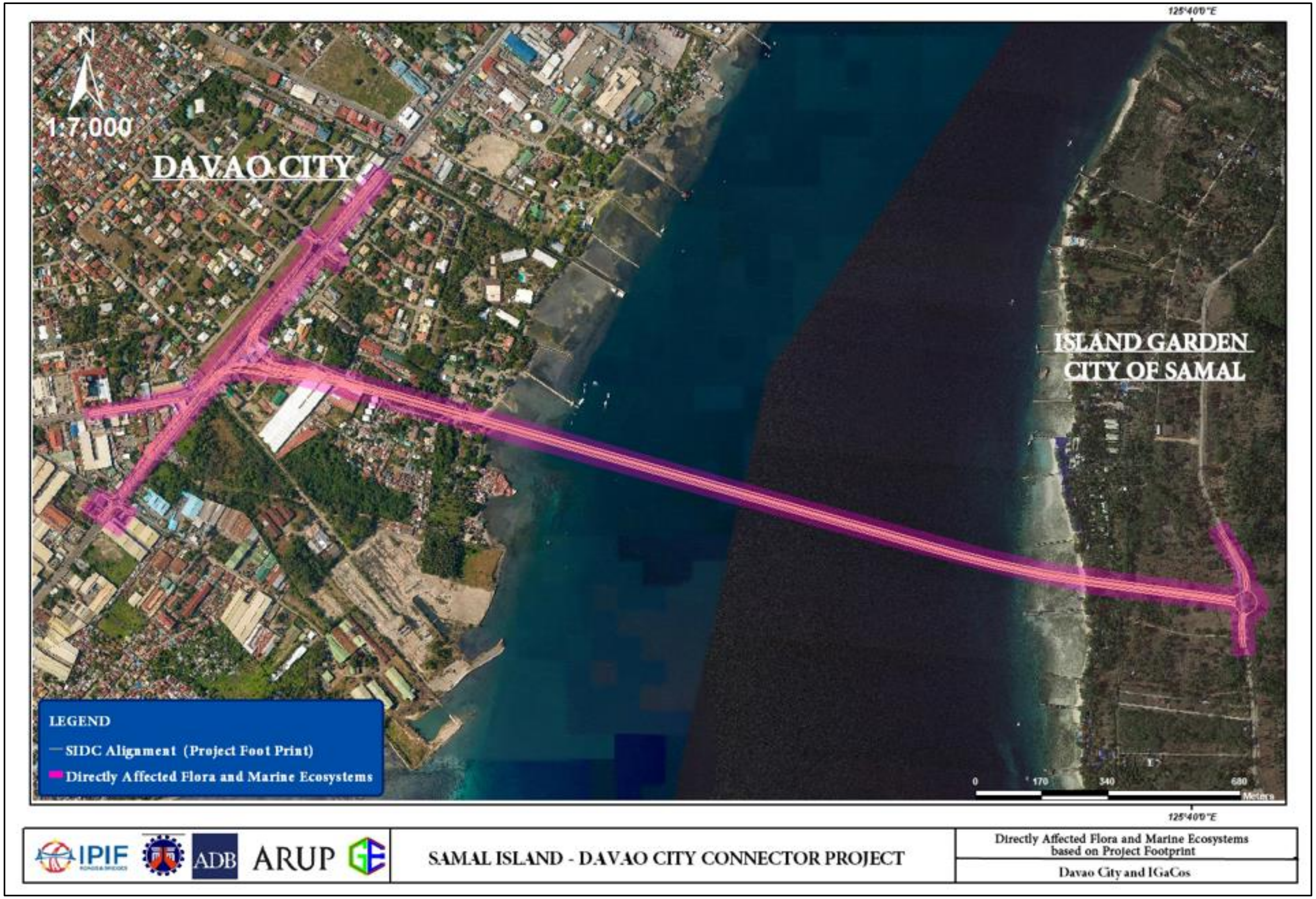


Figure 2.58 Chart of Plant Form

Threatened Species

Critically endangered and vulnerable tree species were found and are considered as native species to the Philippines. Based on the floristic surveys, only Narra (*Pterocarpus indicus*) was identified as a critically endangered species in the project area based on the DAO 2007 – 01. This species provides excellent timber in southern Asia and is listed among the most valuable for construction, musical instruments, making furniture, cabinets, cartwheels, carving, and other novelty items. Directly affected flora and marine ecosystems based on project footprint are shown in **Figure 2.59**.



Google Earth, February 2020

Figure 2.59 Directly Affected Flora and Marine Ecosystems based on Project Footprint

Fauna Assessment

Using passive and active methods, the assessment was able to round up a total of 298 individuals for all faunal groups. Avifauna (Birds) garnered the highest number of individuals at 211 represented by 38 species belonging to 25 families. Computations of indices show that diversity was Moderate at H' = 2.73 with Very High evenness at J' = 0.78. This indicates that bird species are very highly distributed within the area with moderate diversity.

For mammals, 41 individuals representing 9 species and 6 families were identified. Diversity was Very Low and evenness Very High with values of H' = 1.85 and J' = 0.84, respectively.

Herps were recorded at 46 individuals represented by 14 species and 10 families. Similarly, Diversity was moderate, and Evenness was very high at H' = 2.26 and J' = 0.86, respectively. **Table 2.10** shows the summary of species richness, diversity and evenness for all faunal groups at both sites.

Table 2.10 Species Richness, Diversity, & Evenness of Fauna Groups

Fauna	Abundance	No. of Species	No. of Families	Diversity Index (H')	Evenness (J')
Birds	211	38	25	3.16	0.85
Mammals	41	9	6	1.85	0.84
Herps	46	14	10	2.26	0.86

Table 2.11 summarizes the species encountered in the course of the survey with highest important values. All are categorized as species of least concern based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

Table 2.11 Summary Results of Fauna Assessment based on IUCN Red List of Threatened Species

Species	Common Name	IUCN Category
Avifauna		
Collocalia esculenta	Glossy swiftlet	Stable – Least Concern
Passer montanus	Eurasian tree sparrow	Decreasing – Least Concern
Lonchura atricapilla	Chestnut munia	Stable – Least Concern
Pycnonotus goiavier	Yellow-vented bulbul	Increasing – Least Concern
Phapitreron leucotis	White-eared brown dove	Stable – Least Concern
Hirundo rustica	Barn swallow	Decreasing – Least Concern
Rhipidura nigritorquis	Philippine pied fantail	Stable – Least Concern
Spilopelia chinensis	Eastern spotted dove	Increasing – Least Concern
Streptopelia tranquebarica	Red turtle-dove	Decreasing – Least Concern
Haliastur indus	Brahminy kite	Decreasing – Least Concern
Mammals		
Cynopterus brachyotis	Lesser dog-faced fruit bat	Unknown – Least Concern
Hipposideros diadema	Diadem leaf-nosed bat	Unknown – Least Concern
Eonycteris spelaea	Dawn bat	Unknown – Least Concern
Ptenochirus jagori	Greater musky fruit bat	Stable – Least Concern

Species	Common Name	IUCN Category
Rousettus amplexicaudatus	Geoffroy's rousette	Unknown – Least Concern
Rhinolophus arcuatus	Arcuate horseshoe bat	Stable – Least Concern
Suncus murinus	House shrew	Stable – Least Concern
Rattus tanezumi	Oriental house rat	Increasing – Least Concern
Herpeto-Fauna		
Rhinella marina	Cane toad	Increasing – Least Concern
Hylarana erythraea	Common Green Frog	Stable – Least Concern
Heremites septemtaeniatus	Grass skink	Stable – Least Concern
No data	Brown Mabouya	No data
Gekko gecko	Tokay Gecko/ Tuko	Unknown – Least Concern
No data	Common House Lizard	No data

Birds

The top-ranking avian species based on IV is the Glossy swiftlet (*Collocalia troglodytes*), owing to the number of observed individuals. These birds feed mainly on insects and usually flock together. The swiftlets are followed by the Eurasian Tree Sparrow (*Passer montanus*), doves, sparrows, bulbul, and shrike. It was noted that there were less birds in Davao sampling sites, possibly due to its more urbanized nature. Water birds like egrets and heron were observed near shorelines.

Table 2.12 Ranking of Avi-fauna Based on Important Values (IV)

Species	Abundance	Relative Abundance	Frequency	Relative Frequency	IV
Collocalia esculenta	30	14.22	0.4	4.76	9.49
Passer montanus	27	12.80	0.2	2.38	7.59
Lonchura atricapilla	14	6.64	0.4	4.76	5.70
Pycnonotus goiavier	14	6.64	0.3	3.57	5.10
Phapitreron leucotis	6	2.84	0.4	4.76	3.80
Hirundo rustica	11	5.21	0.2	2.38	3.80
Rhipidura nigritorquis	9	4.27	0.2	2.38	3.32
Spilopelia chinensis	8	3.79	0.2	2.38	3.09
Streptopelia tranquebarica	5	2.37	0.3	3.57	2.97
Haliastur indus	2	1.17	0.4	4.94	3.06

Figure 2.60 Chestnut Munia (*Lonchura atricapilla*)

Mammals

This fauna is mostly represented by bats. The species *Cynopterus brachyotis* (Lesser dog-faced fruit bat) was the most common volant mammal recorded. However, it should be noted that the bats utilize the area as a hunting and feeding ground and not as a roosting area. The presence of the *Rattus tanezumi* (Oriental house rat) and *Tarsius syrichta* (Philippine tarsier) was based on droppings observed along the transects and confirmed through key informant interviews.

Figure 2.61 Lesser short-nosed bat (*Cynopterus brachyotis*)

The few species observed may be related to the limited food source in the area. As most of the bats are fruit eaters, these volant mammals could be competing with birds for the limited fruit-bearing plants in the area.

Table 2.13 Ranking of Mammals Based on Important Values (IV)

Species	Abundance	Relative Abundance	Frequency	Relative Frequency	IV
Cynopterus brachyotis	13	31.71	0.75	17.05	24.38
Hipposideros diadema	5	12.20	0.75	17.05	14.62
Eonycteris spelaea	5	12.20	0.75	17.05	14.62
Ptenochirus jagori	9	21.95	0.30	6.82	14.38
Rousettus amplexicaudatus	4	9.76	0.75	17.05	13.40
Rhinolophus arcuatus	1	2.44	0.50	11.36	6.90
Suncus murinus	1	2.44	0.25	5.68	4.06
Rattus tanezumi	2	4.88	0.10	2.27	3.58

Herps

The least observations found among the observed fauna are the herps, mostly represented by the Cane Toad (*Rhinella marina*), which was followed by the Common green frog and skinks. Other species identified were based on informant accounts frequently in the area. They report the presence of pythons, monitor lizards and Philippine cobra although none were encountered during the assessment.

Figure 2.62 Cane toad (*Rhinella marina*)

Table 2.14 Ranking of Herpeto-fauna Based on Important Values (IV)

Name	Abundance	Relative Abundance	Frequency	Relative Frequency	IV
Cane Toad	39	51.32	0.50	18.52	34.92
Common Green Frog	9	11.84	0.50	18.52	15.18
Grass skink	6	7.89	0.50	18.52	13.21
Brown Mabouya	6	7.89	0.50	18.52	13.21
Tokay Gecko/ Tuko	6	7.89	0.20	7.41	7.65
Common House Lizard	7	9.21	0.20	7.41	8.31

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Vegetation Removal and Loss of Habitat

Project implementation may result to the disturbance and loss of local, limited, site-specific habitats used by fauna as feeding grounds. Loss of habitat may be mitigated by creation of new habitats or the rehabilitation of the area after the construction. As such, the native flora species should be used to rehabilitate the area, since the same will attract resident fauna back in the area. Centennial species/century old trees should be left instead of replacing them after planting.

The implementation of the project will require clearing of vegetation only in those areas that will be utilized for construction activities. The construction of facilities during construction phase may very well affect fruit bearing trees, and forest trees, including the existing wildlife in the project area.

For those areas with natural vegetation that would be required to be cleared, a competent ecologist will inspect such areas weeks in advance. The competent ecologist will likewise be on site during clearing operations so as to be able to translocate to nearby natural habitats any and all species that may be affected

It is recommended to earth ball big trees or provide replacement seedlings provided by the proponent as required by DENR, and provide compensation to owners of non-timber species that will be cut. It is also suggested that native flora species within the project area be allowed to remain standing in selected sites in order to serve as refuge and forage sites for wildlife species that can thrive in disturbed areas. If possible, rehabilitate native species that will be inevitably affected. Loss of natural habitats stemming from construction activities will be mitigated through habitat creation with the planting of native fauna.

Threat to Existence and/or Loss of Important Local Species

The project area is characterized as a disturbed wildlife habitat, which was confirmed with the results of the surveys undertaken. It also has very low endemicity which signified the area's state of being distressed. Nevertheless, the implementation of the project which will require clearing of vegetation and construction of facilities will affect not only the residents in the area but also the wildlife existing therein.

Naturally, wildlife will relocate themselves once they are disturbed. During the project implementation in which noises will be brought by heavy equipment, the wildlife are assumed to transfer to nearby areas where they can establish their new habitat. Thus, gradual conversion of the area into a road/bridge is recommended to provide sufficient time for wildlife movement.

A competent, experienced ecologist will be employed to oversee vegetation removal and wildlife translocations prior to construction activities. Species will be translocated to existing and newly created habitat.

Furthermore, it is also suggested that native flora species within the project area shall at least remain standing (maybe in selected sites) in order to serve as refuge and forage for wildlife species that can thrive disturbed areas. Also, lost habitat will be replaced with created habitat to achieve no net loss habitats.

2.2 The Water

Methodology

For this module, variety of methodologies were employed to determine baseline environmental conditions. These include:

a. Review of all available secondary information

b. Detailed field investigations

c. Conductivity Temperature and Depth (CTD) and Acoustic Doppler Current Profiler (ADCP) surveys

d. Sediment sampling and analysis

e. Flood mapping

f. Water sampling

g. Marine assessment

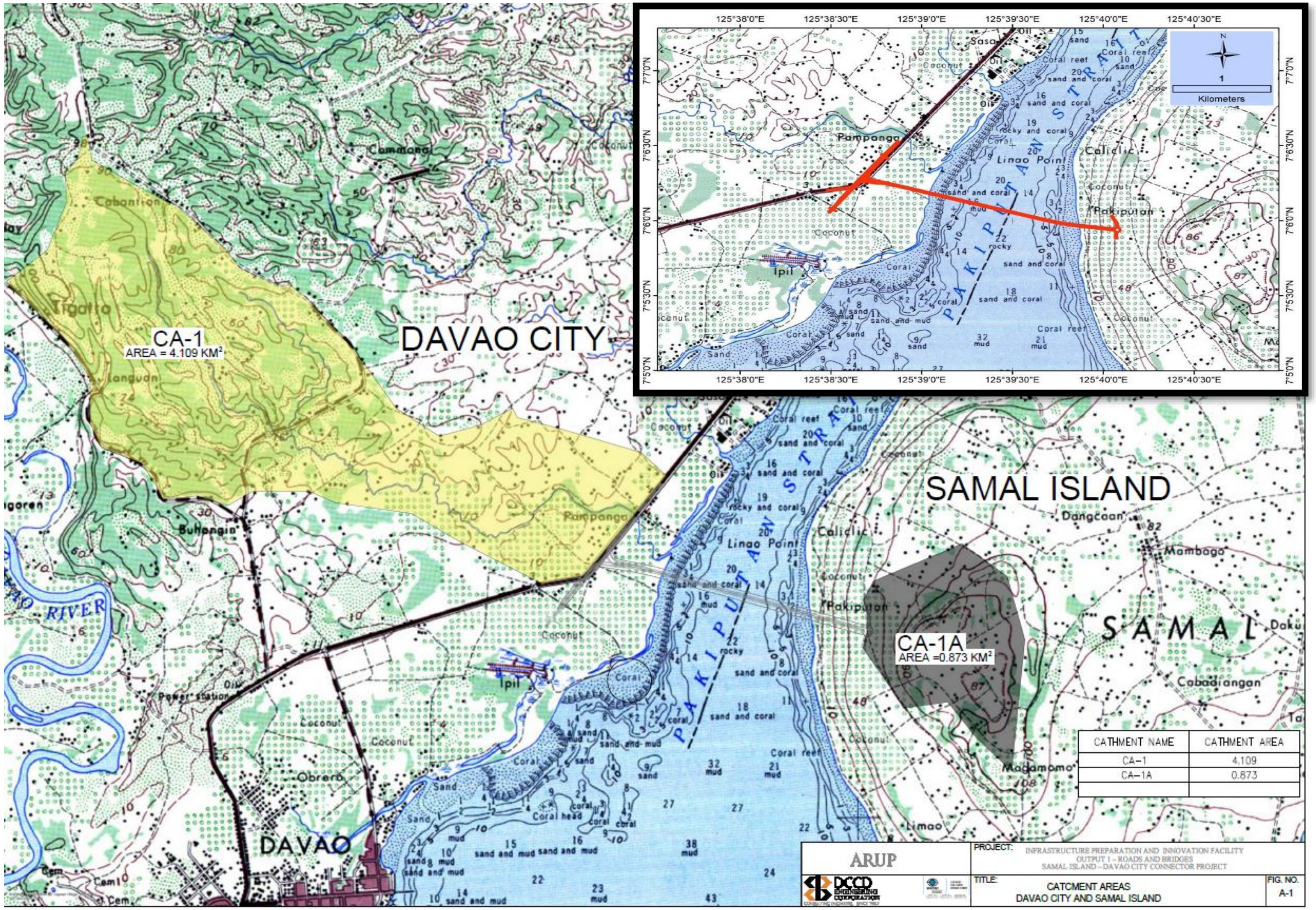
The application of these methodologies is described in more detail in the subsequent sections for this module.

2.2.1 Hydrology/ Hydrogeology

In general, Samal Island does not contain extensive surface drainages owing to the nature of its basement rocks. Limestone usually develops underground drainages, which partly explains its development on subsurface cavities or voids. The only surface drainage that was observable within the project area was the intermittent creek that runs roughly west-east perpendicular to the shoreline. This drainage is relatively short as its upstream area is terminated along the edge of a large depression approximately 500 meters east of the national highway.

The determination of catchment areas for various waterways at the SIDC sites were delineated on the consolidated 1:50,000 scale NAMRIA maps. The corresponding stream lengths and centroidal lengths were likewise taken from this map. Figure 2.63 shows the catchment area determined for Davao City and Samal Island side. The parameters of each catchment area are shown in **Table 2.15**.

Based on the results of the groundwater resource assessment and mapping conducted by MGB XI, the water-bearing rocks within the island include an upper aquifer, which is composed of fractured limestone and a lower aquifer made up of calcareous sandstone. Additionally, shallow wells surveyed during the same assessment did not show indications of saltwater intrusion. Based on the hydrogeological map of Davao del Norte from MGB, the location of the alignment is within a zone of fairly extensive aquifers with high potential for recharge (**Figure 2.64**).



Source: Bureau of Coast and Geodetic Survey, US Army Map Series 711. Compiled in 1956 from 1947-1953 Photographs, Department of Public Works and Highways and others

Figure 2.63 NAMRIA topographic map of the proposed project site showing perennial surface water drainages

Table 2.15 Catchment Area Parameters for Davao City and IGaCoS

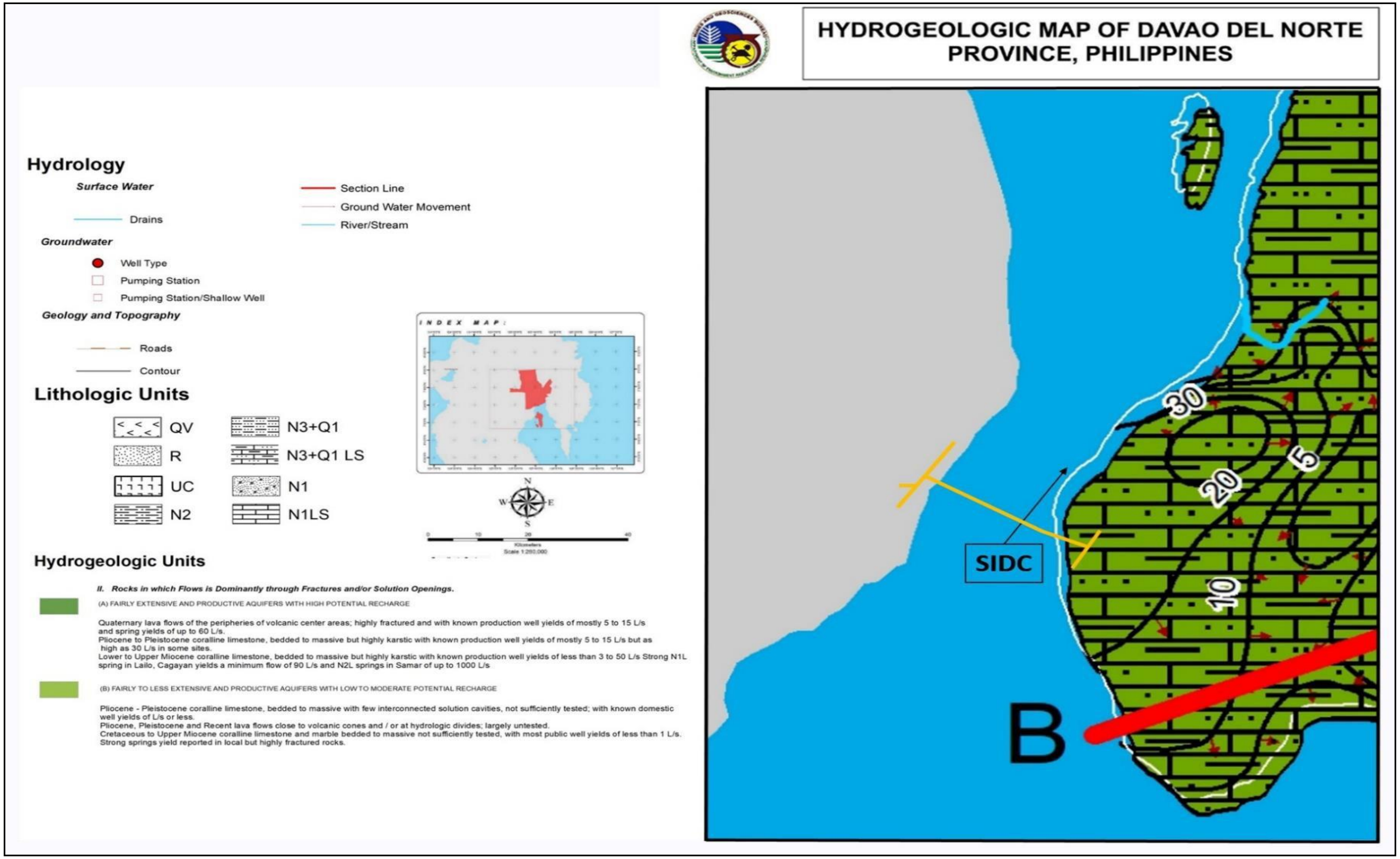
	Davao City	Samal Island
Catchment Area	4.11 sq. km.	0.873 sq. km.
Length of Watercourse	5790 m	1713 m
Top Elevation of Catchment	98 m	108 m
Bottom Elevation of Catchment	5 m	62 m
Average Catchment Slope	1.606 %	2.685 %

The Davao City extension of the SIDC will cross coastal areas of the mainland but will not cut any defined surface drainage. The closest waterbody to the alignment is the Mamay Creek, which flows approximately 500m north of the alignment, followed by Sasa Creek, which is about 1.45km from the alignment (**Figure 2.65**). This river system flows northwest-southeast and drains the hills of Tigatto. However, at this time, because of dense development in the area, this drainage has been considerably modified to accommodate different drainage canals of adjacent subdivisions and buildings.

Currently, the length of the river close to the mouth is comprised of a man-made open concrete canal. Based on the hydrogeological map of the province of Davao del Sur, this section of the city is within fairly extensive and productive aquifers with several known wells in the vicinity (**Figure 2.66**).

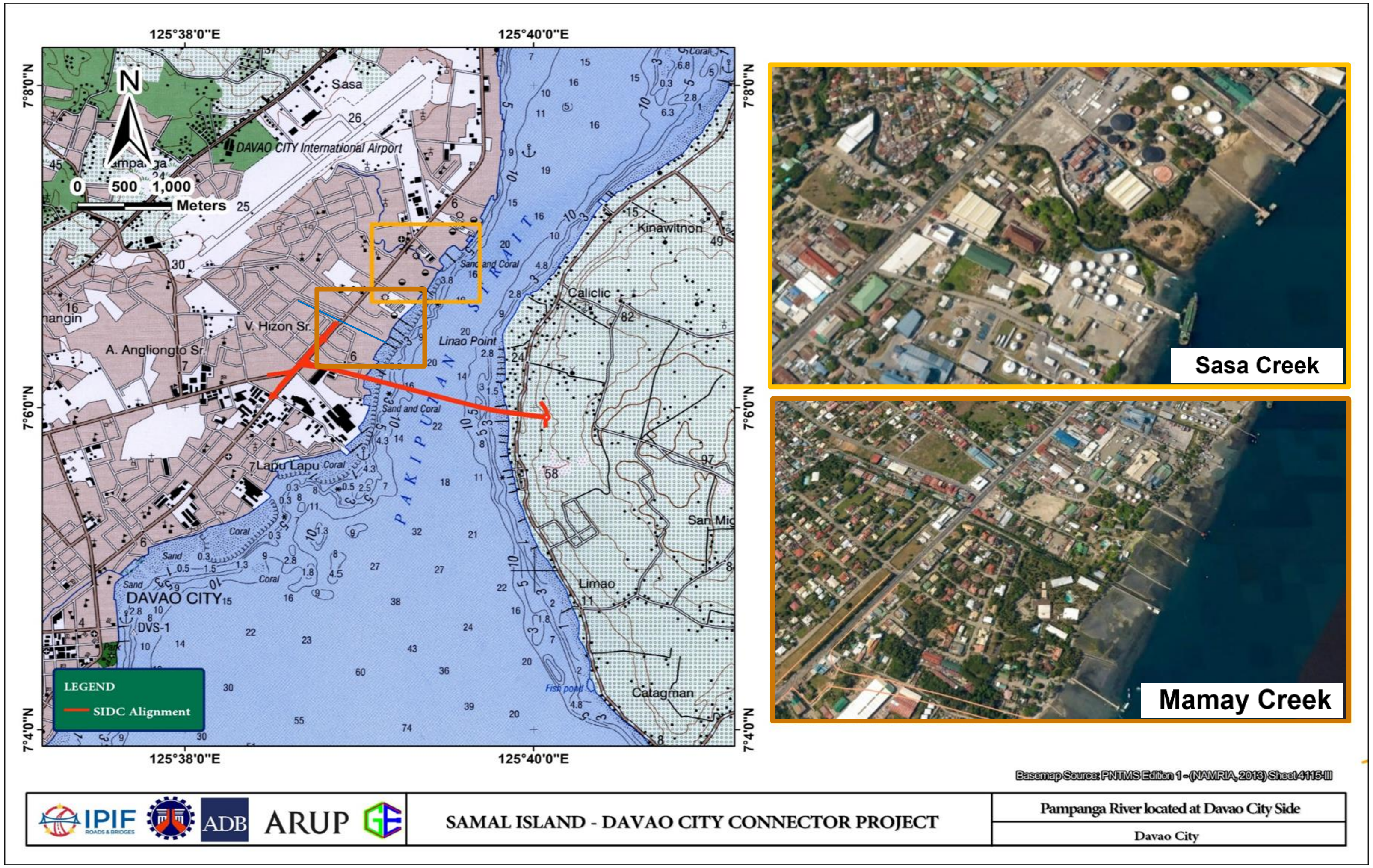
The proposed project will not likely affect the surface drainages within the Davao coastal areas; however, the section where the alignment will be located currently experience some flooding. Based on the flood susceptibility map of Davao City by the MGB, the alignment will cross sections that are moderately to highly susceptible to flooding (**Figure 2.36**). This is primarily caused by the lack of drainage canals that efficiently remove storm waters, further aggravated by the fact that the area is very close to the water line and forms a depressed low elevation catchment of rainwater coming from the slightly elevated highway area and surrounding residential lots. This will therefore be aggravated during the construction phase. Thus, to minimize flooding in the project site, proper drainage canals must be established to consider the surface water flows and existing structures in the area.

Considering the design and purpose of the proposed SIDC project, it will not significantly alter the surface water flow pattern at Samal and Davao, as well as affect the groundwater flow in the area. Water requirements during the construction phase will be identified on the design of the project and may only be available during the DED stage.



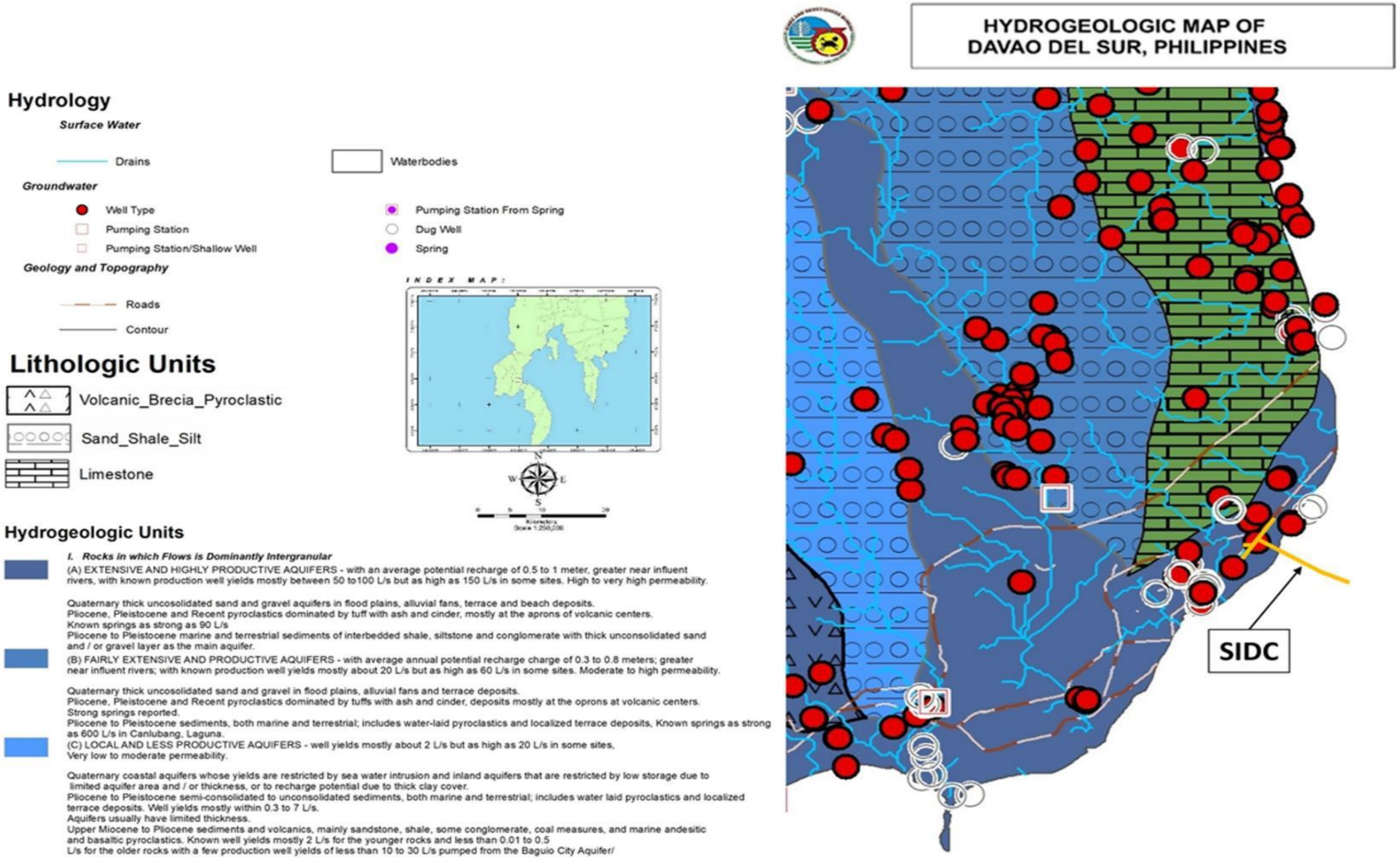
Source: MGB, 2018

Figure 2.64. Hydrogeologic map of Davao del Norte



Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS84; Google Earth, 2020

Figure 2.65 Google Earth image of the SIDC showing the location of the modified Sasa and Mamay Creeks



Source: MGB, 2016

Figure 2.66 Hydrogeologic map of Davao del Sur

2.2.2 Oceanography

This study describes the environmental conditions of Pakiputan Strait in Davao City, its physical parameters and water column structure, general flow patterns and the grain size and distribution patterns of bottom sediments prior to bridge construction.

Site Location

The project site is located in the narrow channel (**Figure 2.67**) between Davao City (Barangay Vicente Hizon, Sr., R. Castillo and Angliongto) and IGaCoS (Barangay Limao). The northern part of the channel proceeds to the head of Davao Gulf, while the southern part heading to the mouth of the said gulf.

Methodology

Conductivity Temperature and Depth and Acoustic Doppler Current Profiler Surveys

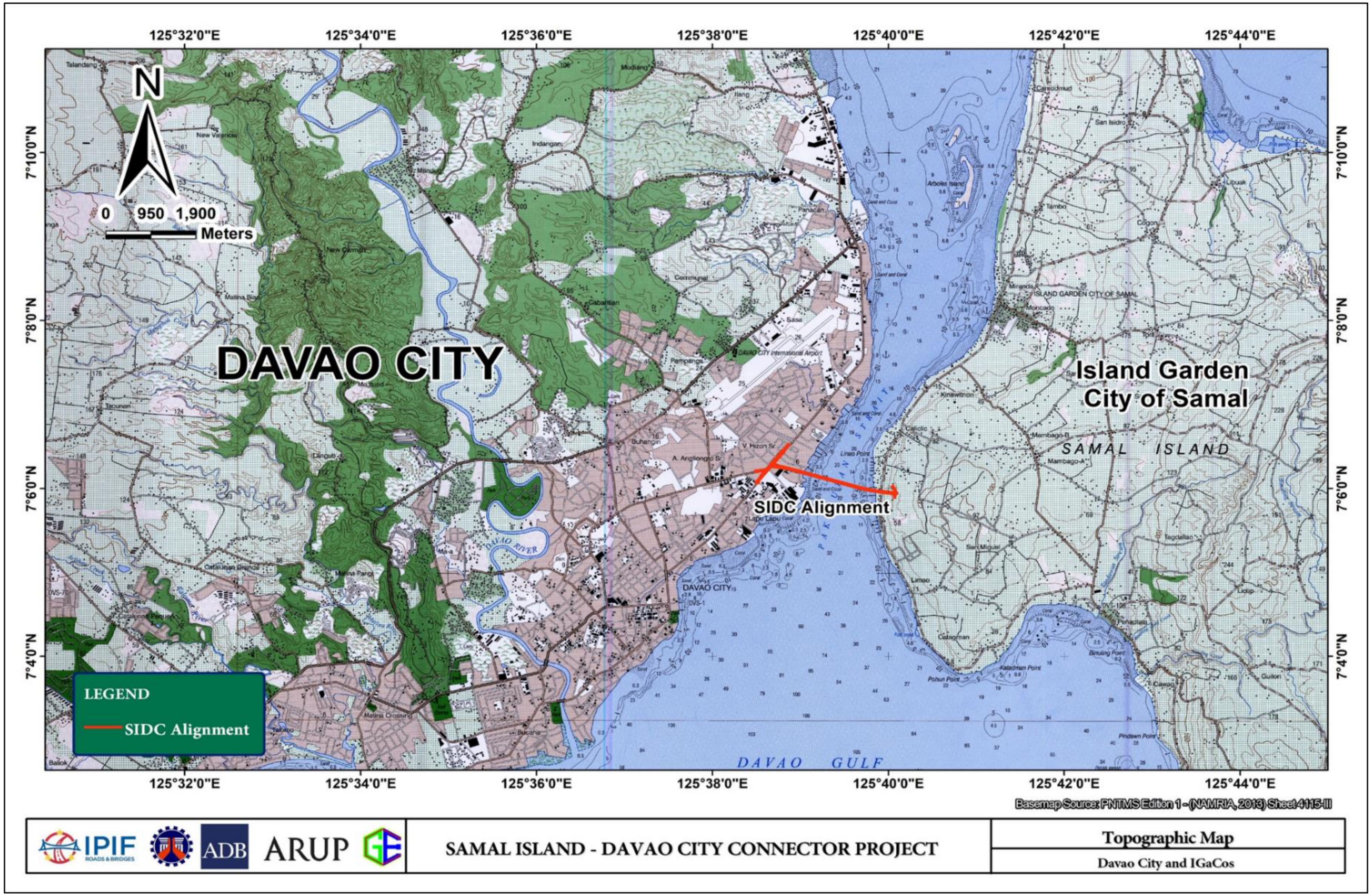
The Conductivity Temperature and Depth (CTD) and Acoustic Doppler Current Profiler (ADCP) surveys were done on 10-11 July 2019 to obtain vertical temperature and salinity profiles and current measurements, respectively. The area was surveyed twice, once each during the flood cycle and ebb cycle of the tides.

Figure 2.68 shows the locations of CTD deployment to record temperature and salinity distributions in the water column. The stations were strategically assigned to capture possible variabilities in temperature and salinity as influenced by freshwater input, tidal cycle and subsurface circulation.

A total of 13 CTD stations were sampled using a CastAway - CTD profiler (**Table 2.16**). This instrument obtains measurements of temperature and salinity in the water column. Deployment was done at a maximum depth of 45 meters.

Table 2.16 Coordinates of CTD sampling location (WGS84)

Station	Longitude	Latitude
1	125.65707	7.10973
2	125.65447	7.10455
3	125.65199	7.09827
4	125.65000	7.09300
5	125.65976	7.10916
6	125.65812	7.10380
7	125.65714	7.09772
8	125.65600	7.09200
9	125.65900	7.09200
10	125.66200	7.09200
11	125.66100	7.09700
12	125.66100	7.10400
13	125.66300	7.10900



Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III, WGS84

Figure 2.67 Topographic map showing location of Project site

Source: Google Earth, March 2020

Figure 2.68 CTD stations within the Project site

Tidal circulation patterns, on the other hand, were determined using a TRDI 600 Hz Workhorse Sentinel ADCP. The ADCP was mounted on the side of a boat and towed across the area of interest, while logging the position of the boat using the Garmin Global Positioning System (GPS) (**Figure 2.69**). The ADCP measured and recorded current magnitudes and directions at 1-minute intervals every 2 meter depth bins.

Photo taken at Pakiputan Strait on 10 July 10 2019

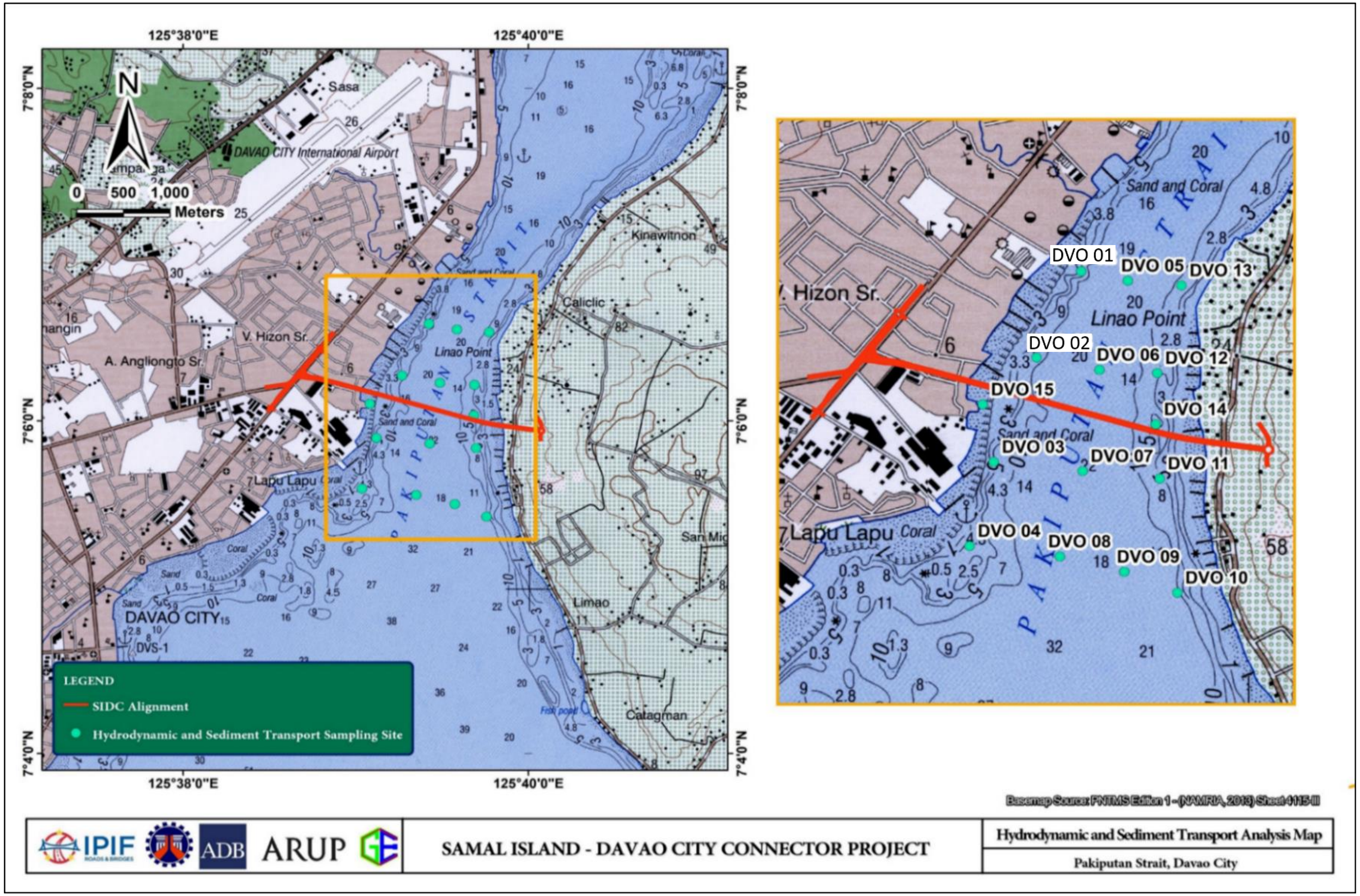
Figure 2.69 Horizontal towing of ADCP

Sediment sampling and grain size analysis

Bottom sediments along the Pakiputan Strait were collected on 10-11 July 2019 from 15 sampling sites that were selected to cover ~1 km upstream and ~1 km downstream of the proposed bridge site (**Figure 2.70**). To collect the sediments, a ponar grab sampler was lowered to the ocean bottom from a side platform on an outrigger boat (**Figure 2.71**).

The ponar grab sampler works best with soft sandy to muddy bottom – that is neither too hard or nor too soft. The seabed surface on the Pakiputan Strait, however, is gravelly and hard. In some cases, the ponar grab sampler is not fully closed during retrieval as some gravel particles are trapped in between the opposing jaws of the grab sampler. As such, the fine particles may have been washed away during retrieval and may be underrepresented in the grainsize analysis. Nevertheless, the clear waters on Pakiputan Strait during our sampling indicate that there is very low turbidity and the amount of fine sediments (i.e. mud) may not be significant. No sample was retrieved in site DVO 05 either because the bottom surface was too hard or the sediments too coarse.

The coordinates for each sediment sampling stations are listed in **Table 2.17**.



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS84

Figure 2.70 Location of bottom sediment samples at the Pakiputan Strait

Table 2.17 Coordinates and water depth for the sediment sampling sites (WGS 1984)

Sample ID	Longitude	Latitude	Water depth (m)
DVO 01	125.6571	7.10973	37.4
DVO 02	125.6545	7.10455	18.8
DVO 03	125.6520	7.09827	20
DVO 04	125.6509	7.09211	9.1
DVO 05	125.6598	7.10916	43
DVO 06	125.6581	7.10380	35.5
DVO 07	125.6571	7.09772	45.7
DVO 08	125.6545	7.09162	35.8
DVO 09	125.6584	7.09067	32.5
DVO 10	125.6624	7.08971	18.3
DVO 11	125.6616	7.09727	19.5
DVO 12	125.6615	7.10361	17.8
DVO 13	125.6629	7.10888	13.4
DVO 14	125.6619	7.09986	2.0
DVO 15	125.6514	7.10209	37.4

Figure 2.71 Retrieval of ponar grab sampler that contains bottom sediments

Each sediment sample was described and subjected to grain size analysis. Prior to description and analysis, the sediments were washed with distilled water to remove salts and oven dried at 60°C for 24 hours. The dried sediments were weighed on a top loading balance. Dry sieve analysis of the sediments was done following a method outlined by Lewis and McConchie (1994) with minor modifications. The gravel component of each sample was separated from the sand component using a 2mm (0 Φ) sieve mesh, to avoid the weight bias towards the gravel component. Depending on the largest particle size of the sand component, a subsample between 30 g to 100 g was obtained for each sample using the coning technique. Subsamples were then dry sieved using a sieve shaker with six (6) sieves at 1φ interval size class. The grainsize data, including percentage weight for each size class, were then run through the open-source program GRADISTAT version 8.0 (Blott, 2001) to generate statistical grainsize distributions.

Bottom sand transport estimates

The logarithmic mean, sorting and skewness of each sample (Folk and Ward, 1957) were used as grain size input parameters to determine the bottom sand transport directions following Gao and Collins (1992), previously applied for coastal and inner shelf environments. Gao and Collins (1992) adopted the hypothesis of McLaren and Bowles (1985) stating that sediment transport follows one of the following situations:

[1] sediments at a downstream site are better sorted, finer and more negatively skewed than at an upstream site; and

[2] sediments at a downstream site are better sorted, coarser and more positively skewed than at an upstream site.

To determine sediment transport trend vectors, each sample was compared with its neighbor. Neighboring site(s) are defined by a characteristic distance, which represents the space-scale sampling distance. Two sites are neighboring if the distance between them is smaller than the characteristic distance. The grainsize parameters of the neighboring sites were then compared to generate the transport vectors. In this study, we tested three (3) values for critical distance – 500 meters, 1000 meters and 1500 meters. The resultant transport vectors were subjected to averaging and significance test analyses to remove noise and assess high level of confidence. Since there was good grain size resolution only for the sand and mud components, the method was only applicable for bottom transport of sand and may not necessarily correspond to gravel transport. It was not also applicable for determining suspended sediment dispersal.

Baseline Environmental Conditions

Temperature and Salinity

Water properties inside the Pakiputan Strait showed strong temperature and salinity gradients (**Figure 2.72**). A 10-meter thick surface mixed layer can be distinctly observed for stations situated at the alongshore middle section to eastern side of the channel. Overall surface temperature in the channel ranged from 28.15 – 29.09 °C. The highest temperatures (~29°C) were recorded at the mouthward stations during flood tide when oceanic waters are coming into the gulf. Water temperature inside the channel, however, notably appeared to be slightly cooler during ebb. The wide temperature gradients within the water column (surface to bottom) provided characteristic wider temperature range of 2.6°C (from 26.49 – 29.09 °C).

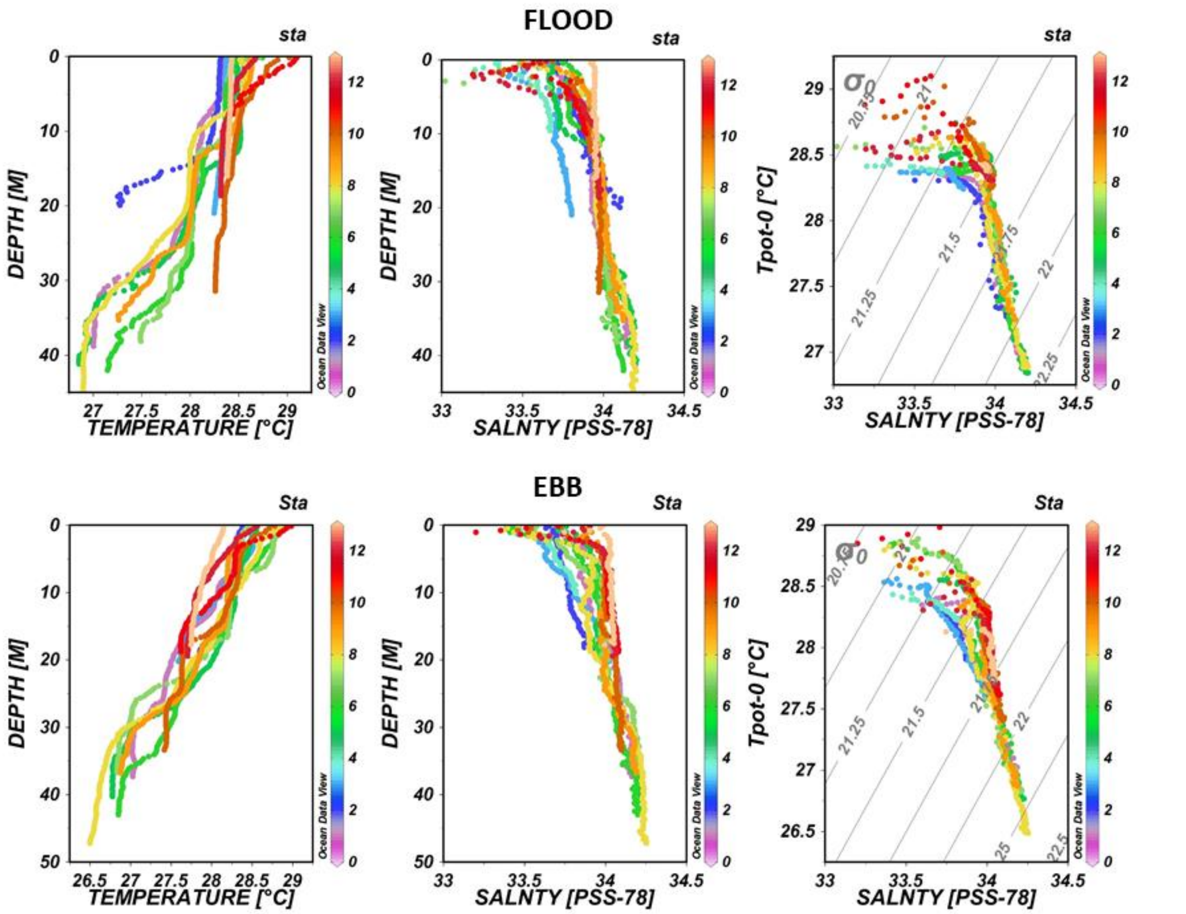


Figure 2.72 Profiles of temperature (T) and salinity (S) and TS- diagram for all CTD stations during flood and ebb periods

Similarly, fairly broad salinity range is indicated at 1.2 ppt. Fresher salinity profiles were noted on stations 1, 2, 3 and 4, which were situated in the western side (Davao side) of the channel. South of these stations are Davao River and a small tributary that appears to be the major contributor (along with Sasa Creek) for the observed lower salinity values. Although a very light and intermittent rain showers occurred that coincided with CTD-ebb sampling, freshwater input from these events can be accounted at the sea surface. The fresher and colder water column in stations 1-4 can be distinctly delineated from the fresher and warmer surface waters in stations 7, 8, 9, 10, 11 and 12 as shown in temperature-salinity diagrams for flood and ebb (**Figure 2.72**). The noticeable waters of higher density are characteristic of subsurface layers from stations located at the center towards the eastern side of the channel.

The density of water also plays a major role in the movement of water in the channel. Density of seawater increases with increasing salinity and decreasing temperature. In the case of Pakiputan strait, the lighter fresh water originating from the rivers mixes with the heavier salt water from coastal waters and creates a gradient in water density in the channel (**Figure 2.73** and **Figure 2.74**). The movement of lighter, lower-salinity water is along the surface while higher-salinity water flows is along the bottom. Such movements may have implication on the distribution/ redistribution of suspended particles such as sediments and bottom sand transport.

Surface salinity distribution

Salinity distribution on the surface ranged from 33.2 to 33.98 psu. Low salinity signatures observed on the southern part and across the middle of the channel are likely coming from Sasa

Creek and tributaries in the south, including the Davao River (**Figure 2.72**). Looking at subsurface layers, at 5 meter and 10 meter depths, the freshwater signal dissipated at depth (**Figure 2.73** and **Figure 2.74**). The stronger freshwater signal came from the western (Davao City) side, as it remained persistent to depth, compared to the eastern signal, which appeared only at the surface. Between ebb and flood tides, the freshwater signal was weaker at flood than during ebb, possibly due to dilution by oceanic waters.

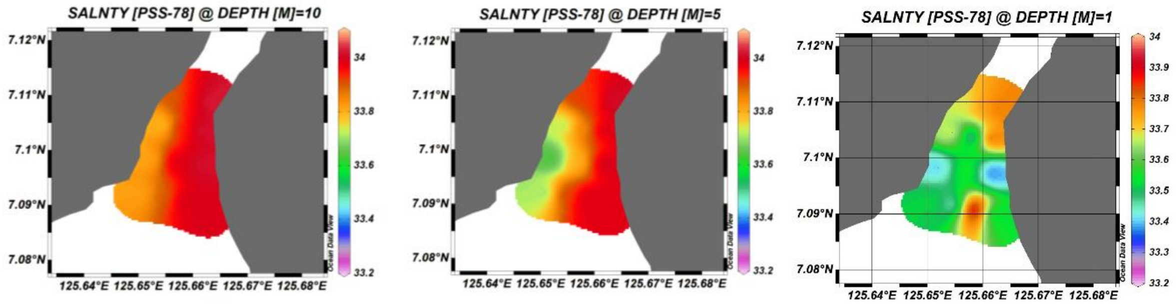


Figure 2.73 Surface salinity distribution showing riverine discharge at ebb tide

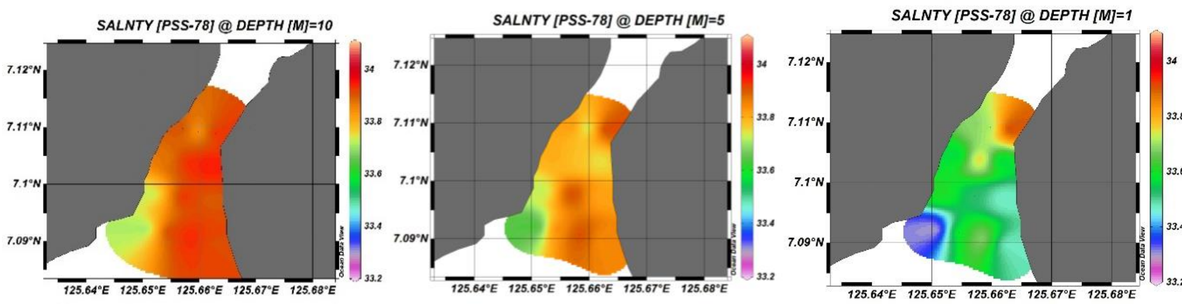


Figure 2.74 Surface salinity distribution showing riverine discharge at flood tide

Water Current

Shown in **Figure 2.75** are the typical current distributions along Pakiputan channel during flood and ebb periods. Flow of water during flood tide was consistently northward, following the contour of the channel. Similarly, flow at ebb tide was generally southward, with some diversions near the opening to Davao Gulf. Current flow is relatively stronger at flood as compared to ebb. Irrespective of tidal period, the particularly stronger flow is notable on the eastern side of the channel (**Figure 2.75**). Current movements do not vary significantly with depth. But bottom currents touching the bottom depth causes the direction of some current flows to deviate from its typical movement. Influence of this current distribution was demonstrated on the observed bottom sand transport in **Figure 2.75**.

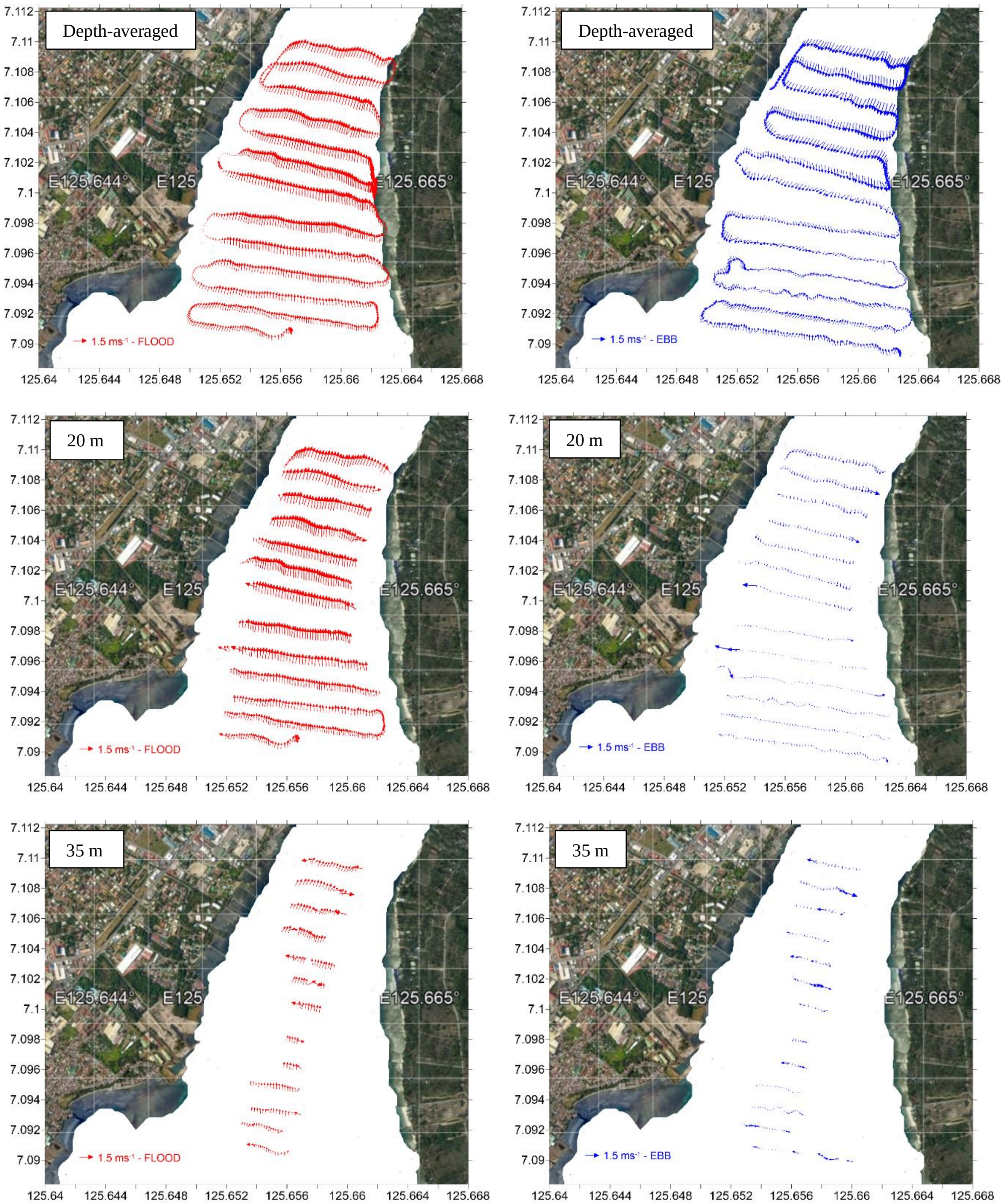


Figure 2.75 Current flows during flood (left, in red arrows) and ebb (right, in blue arrows)

Sediments

Sediment composition

The bottom sediments are mostly reef-derived carbonates consisting of coral rubbles, shell fragments, forams and spicules (**Figure 2.76**). Only the sediment in DVO 15 is non-carbonate. It is instead composed of river-derived dark gray siliciclastic sediments from volcanic terrain inland. The siliciclastic sand contains grains of the black heavy mineral called magnetite and are commonly present near river mouth.

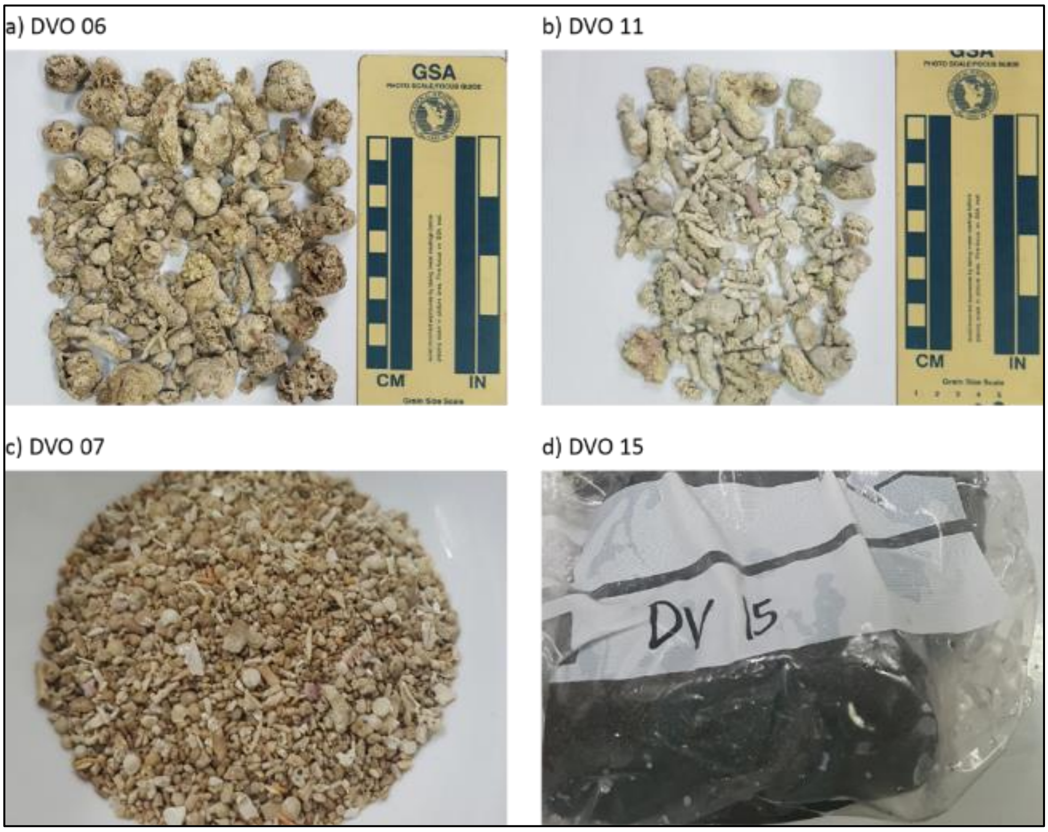


Figure 2.76 Bottom surface sediments on the Pakiputan Strait are dominantly reef-derived carbonate.

Sediment grain size distribution

The bottom surface sediments on the Pakiputan Strait near the vicinity of the proposed SIDC are mostly gravel size, grains that are >2 mm diameter (**Figure 2.77**). Sediments taken adjacent to the proposed bridge (e.g. DVO 15, DVO 07) contain significant amounts of sand to mud (<2 mm diameter) (**Table 2.18**). Most of the sand are predominantly coarse grained, except for samples in DVO 13 and DVO 15 that yielded mostly medium to fine sand grains (**Figure 2.78**).

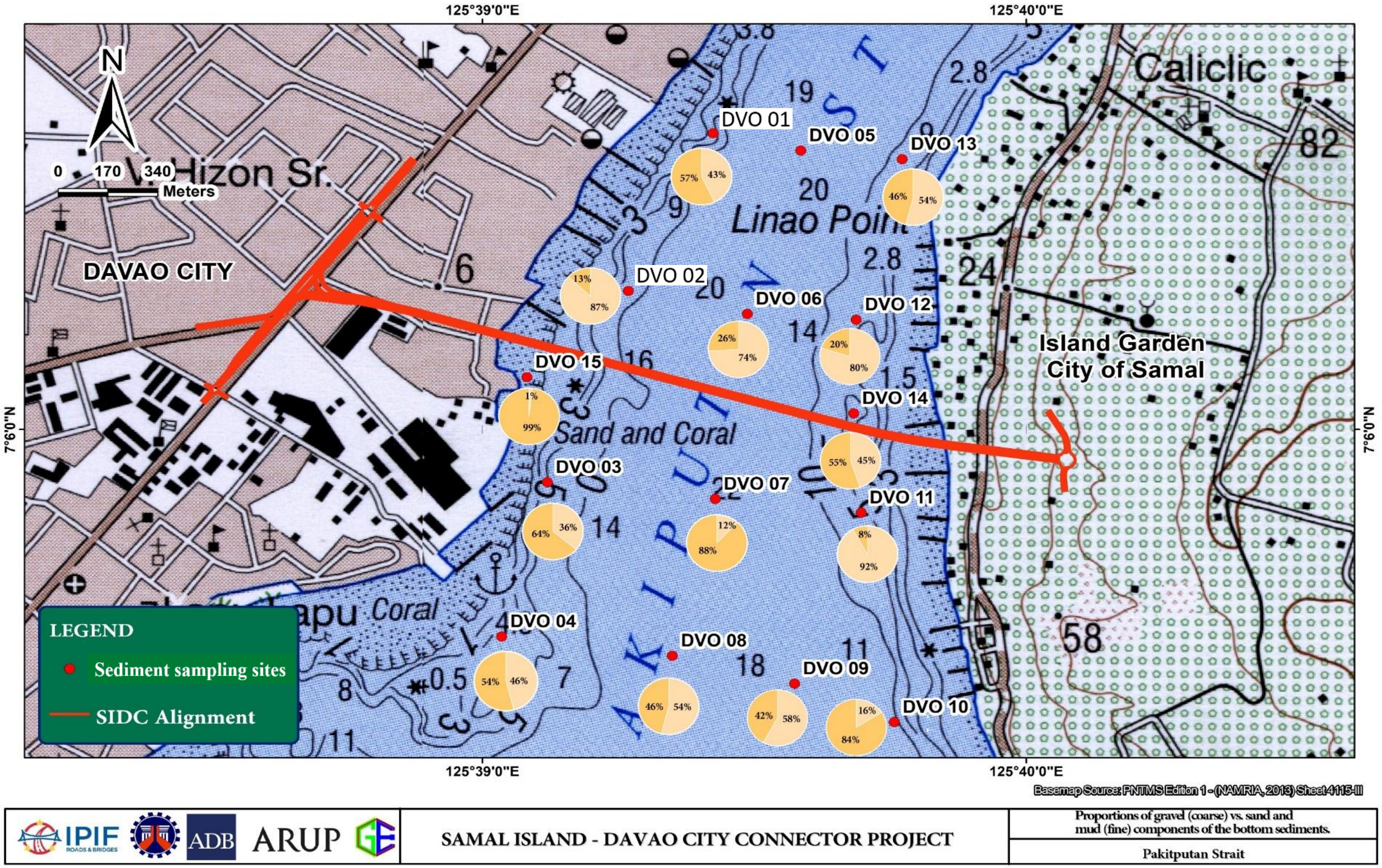


Figure 2.77 Proportions of gravel (coarse) vs. sand and mud (fine) components of the bottom sediments.

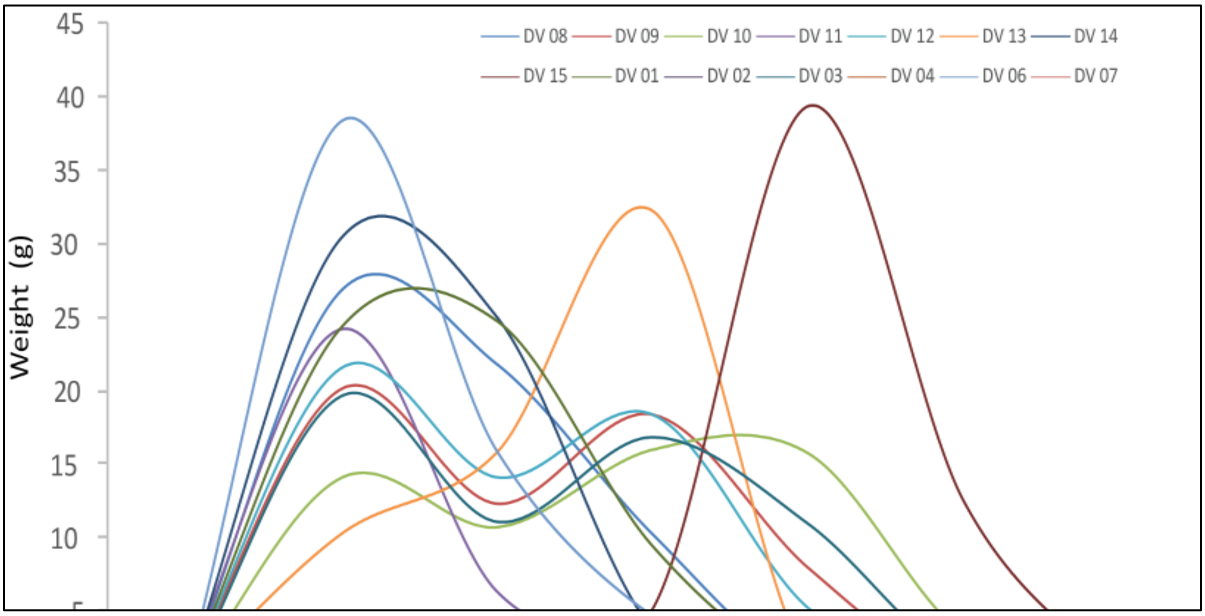


Figure 2.78 Proportions of the sand and mud component. The sand grains are predominantly coarse (1Φ) to very coarse (0Φ) except for samples DVO 13 (medium, 2Φ) and DVO 15 (fine, 3Φ).

Table 2.18 Proportion of particle size class and grainsize statistics of the sand component.

Sample ID	% Gravel	% Sand & mud	Sand component grainsize statistics		
			Mean	Sorting	Skewness
DVO 01	42.7	57.4	0.23	0.84	0.10
DVO 02	87.2	12.8	0.37	1.06	0.25
DVO 03	36.2	63.8	0.89	1.26	0.00
DVO 04	45.9	54.1	0.46	1.08	0.20
DVO 05	-	-	-	-	-
DVO 06	74.3	25.7	-0.09	0.74	0.35
DVO 07	11.5	88.5	-0.08	0.63	0.17
DVO 08	53.7	46.3	0.21	0.86	0.18
DVO 09	58.0	42.0	0.71	1.16	0.02
DVO 10	15.7	84.3	1.21	1.34	-0.10
DVO 11	92.0	8.0	-0.09	0.89	0.47
DVO 12	79.5	20.5	0.60	1.11	0.09
DVO 13	54.3	45.7	0.93	0.87	-0.34
DVO 14	44.8	55.2	0.02	0.71	0.15
DVO 15	0.6	99.4	2.61	0.72	0.00

Bottom sand transport

The grainsize statistics including logarithmic mean, sorting and skewness of each sample (**Table 2.18**) were used as grain size input parameters to determine the bottom sand transport directions (Gao and Collins, 1992). The analysis using 1500 meter critical distance yielded the optimum sediment transport vectors, generating vector trends from 11 sites out of the 14 sampling sites (**Figure 2.79**). The bottom sand particles on the upstream and downstream area are transported on opposite directions. Sand particles on the upstream area are predominantly transported northwards, while on the downstream side sands are transported southwards into the Davao Gulf. The sand particles on areas adjacent to the proposed bridge are either transported towards the shore (on the east bank) or transported into the middle of Pakiputan Strait (on the west bank). The sand on the deep part of Pakiputan Strait (> 40 m depth) yielded an upstream-directed (north/northwest) bottom sand transport (e.g. DVO 06).

The bottom sediment transport patterns reflect strong influences of bottom tidal currents and bathymetry. The upstream-directed sand transport (north) may be influenced by flood tidal currents, while the downstream-directed (south) may be influenced by ebb tidal currents. On the west bank near the proposed bridge, the steep bathymetry overcomes tidal influences to cause the dominant downslope sand transport into the middle of Pakiputan Strait. On the other hand, the shore-directed sand transport on the east bank is consistent with the shore-directed bottom current flows at depths between 15 to 20 meters. The strong influence of tidal currents and bathymetry on the bottom sand transport in Pakiputan Strait is consistent with previously observed bottom sediment transport on narrow straits (e.g. Carter and Heath, 1975; Grochowski et al., 1993).

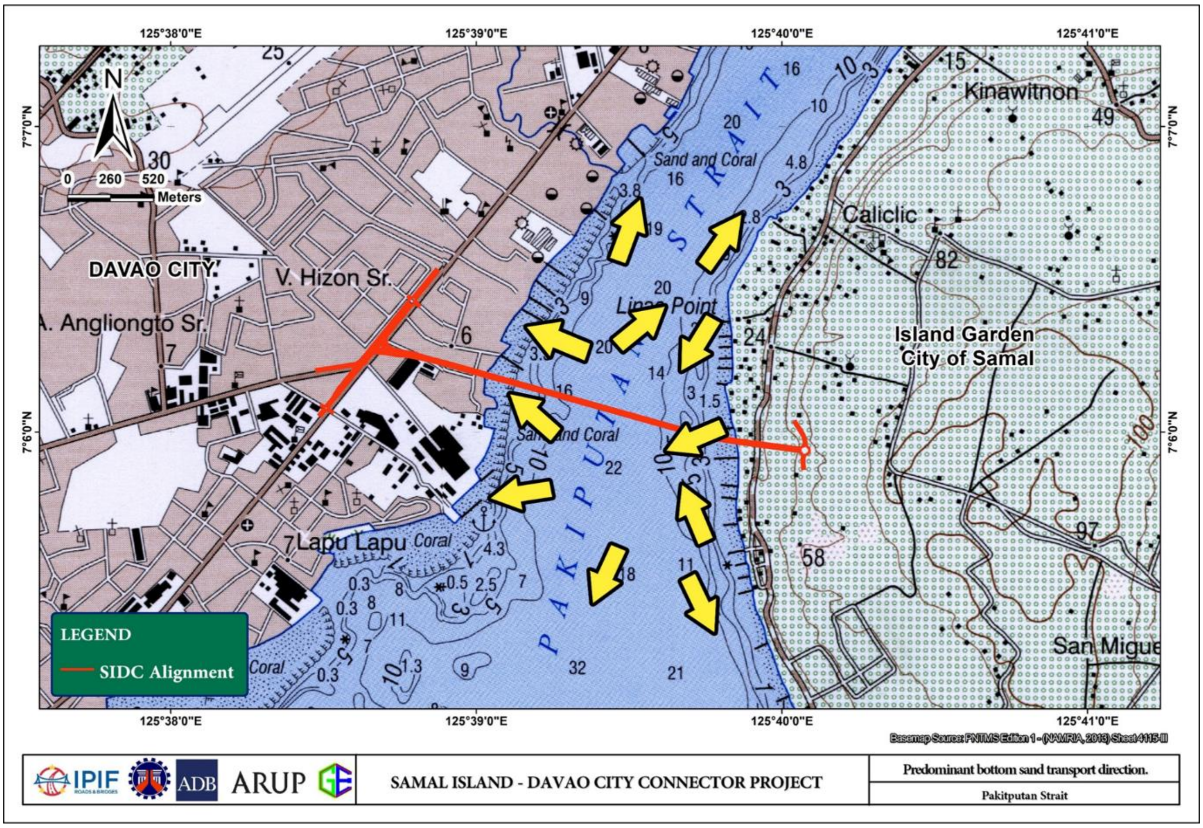


Figure 2.79 Predominant bottom sand transport direction using a critical distance of 1500 m.

2.2.2.1 Hydrodynamic Modelling

Methodology

This section presents the results from the initial overly conservative hydrodynamic model that has been run for the SIDC project. The hydrodynamic model will continue to be refined and update in line with the most recent engineering parameters.

A 7-layer sigma coordinate hydrographic model was developed using DELFT3D to simulate the effects of bridge pier on water flow in Pakiputan Strait. The model used a curvilinear grid that has a minimum grid size of 28 x 65 m^2 to a maximum of 330 x 350 m^2. Bathymetry used was a composite of field measurements obtained from a survey conducted by NAMRIA Hydrographic Division in 2007 and depths digitized from bathymetric map (**Figure 2.80**).

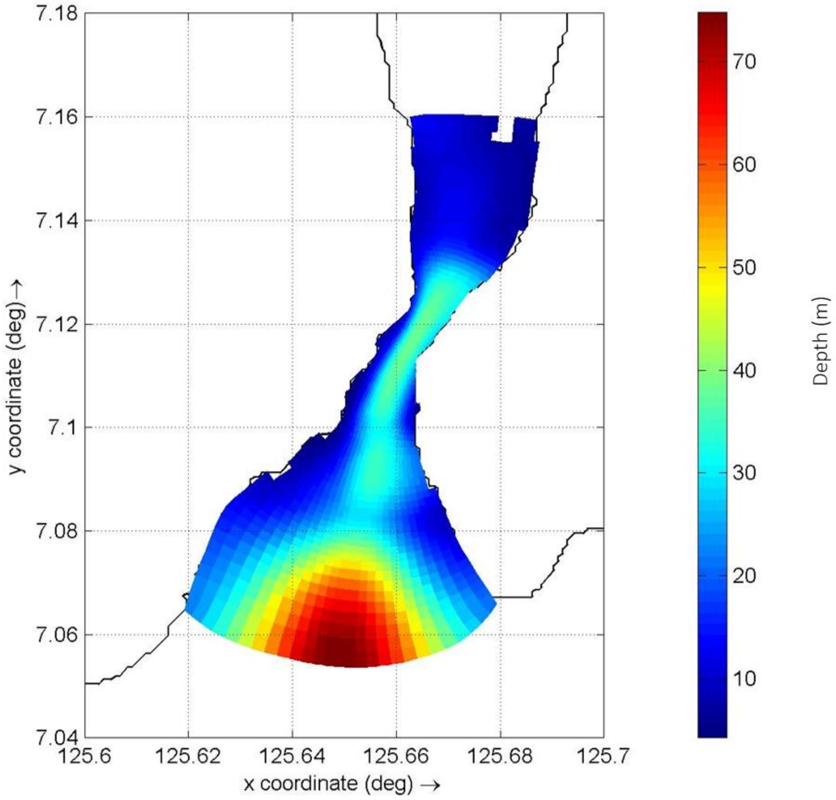


Figure 2.80 Bathymetric data of the Pakiputan Strait

The model domain's open boundary is forced with global TPXO Tide models (Topex Poseidon) obtained with OSU Tidal Inversion Software (OTIS) derived through the Delft Dashboard and surface boundary with wind.

Four model runs were conducted, two each ('with and without project') for NE and SW monsoon seasons. The 'with project' scenarios simulated hydrodynamic flow that demonstrates the effects of bridge pier addition on water flow. The 'without project' scenarios, on the other hand, simulate the area's natural water flow (i.e. absence of bridge piers). The project proposes several piers to support the bridge in the Pakiputan Strait (**Figure 2.81**). These were accounted for by incorporating the calculated friction term of each of bridge pier and its associated ship impact protection piles into the hydrodynamic model (**Figure 2.82**). The layout and locations of these bridge structures are shown in **Table 2.19** and **Figure 2.82**. A summary of the different scenarios implemented in the hydrodynamic model are also presented in **Table 2.20**.

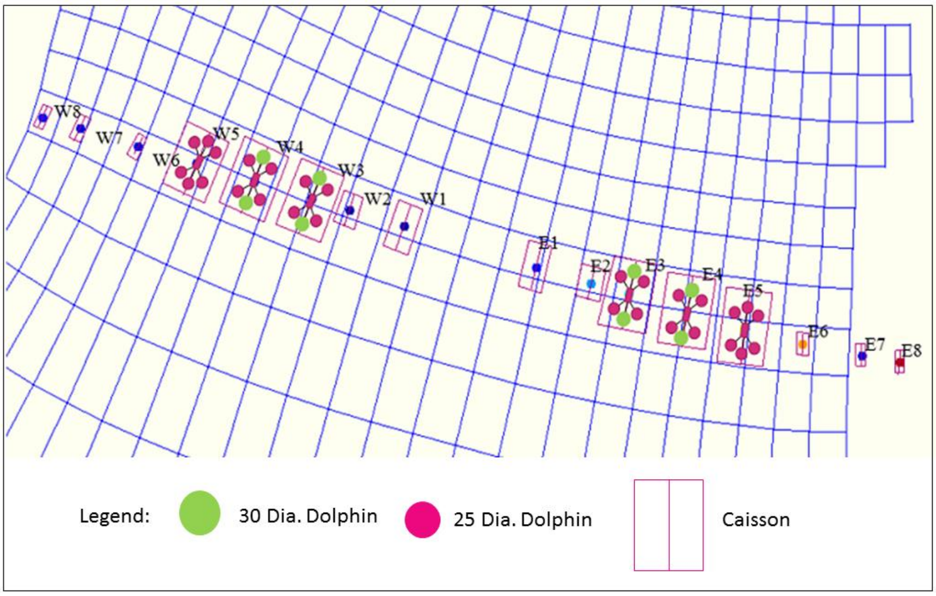


Figure 2.81 Location of piers and dolphins on the model grid

Table 2.19 Bridge piers coordinates

Pier	Latitude	Longitude
W1	7.101572	125.656037
W2	7.101829	125.655122
W3	7.102001	125.654512
W4	7.10227	125.653554
W5	7.10254	125.652595
W6	7.102809	125.651637
W7	7.103079	125.650678
W8	7.10325	125.650069
E1	7.100959	125.658215
E2	7.100702	125.65913
E3	7.100531	125.65974
E4	7.100261	125.660699
E5	7.100003	125.66166
E6	7.099775	125.662629
E7	7.09959	125.663607
E8	7.099492	125.664233

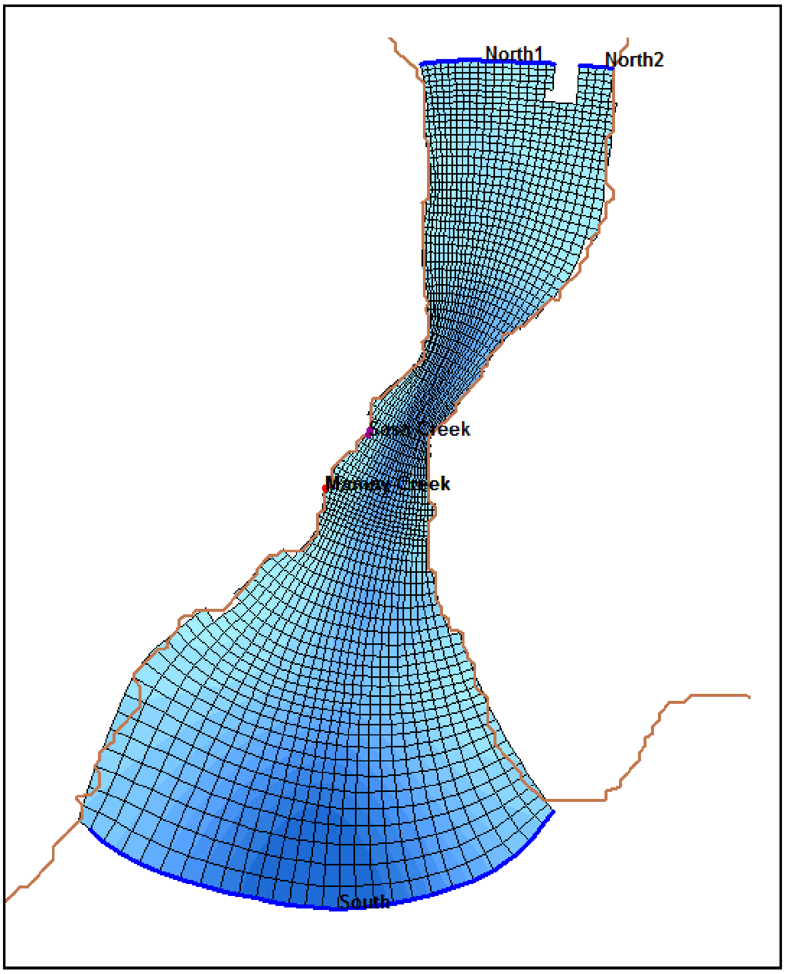


Figure 2.82 Computational grid of the model domain showing the location of Mamay (lower) and Sasa (upper) Creeks as well as the open boundaries labelled as North1, North2 and South

Table 2.20 Hydrodynamic model scenarios for the construction of the Project in Pakiputan Strait

Scenario	Northeast Monsoon	Southwest Monsoon	With Project	No Project	With Sediment
1	x		x		
2	x			x	
3		x	x		x
4		x		x	x

Sediment Transport Model

DELFT 3D was used to simulate tide-induced fine sediment transport in order to visualize the sediment dynamics in the area. The computational domain has accounted for only two creeks that served as the sources of sediments. The creeks, located in the northwest portion of the piers, are identified as Mamay Creek and Sasa Creek with hypothetical discharge rates of 10.04 m^3/s and 11.25 m^3/s, respectively. Due to the unavailability of data on these creeks, the values were determined by ratio and proportion from the nearest river with an available discharge rate. It was found that Davao River is the closest river for the two creeks. JICA (2015) shows that during SW monsoon season, Davao River has a high discharge rate of 134 m^3/s with a mouth width of 160.09m. With this information, the discharge rates of Mamay and Sasa Creeks were calculated given the following widths of 12 and 13.44 meters respectively. To illustrate,

$$\text{discharge rate of Mamay} = 134*12/160.09 = 10.04\ \ m^3/s$$

These runoff values were used throughout the timeframe of the model carrying sediment load for sand, silt, and clay. During simulation, sand, silt, and clay were plugged into the creeks and released at the surface. An assumption made was that the creeks are shallow. Summarized in **Table 2.21** are the parameters that were used for the sediment study.

Table 2.21 Sediment specific densities and creek discharge rates

	Specific Density (kg/m^3)	**Dry Bed Density (kg/m^3)**
Sand-Quartz	2650	1600
Silt	1330	1280
Clay	2115	1200
	Discharge Rate (m^3/s)	Concentration of sediments (kg/m^3)
Mamay Creek	10.04	4.87E-05
Sasa Creek	11.25	4.89E-08

Baseline Environmental Conditions

Water Level

Variability in sea elevation is forced by a variety of mechanisms. Wind, river discharge, seawater density, and reversing tides are among the contributing factors that can locally affect water elevation in the Pakiputan Strait.

Color maps (**Figure 2.83** and **Figure 2.84**) illustrate highest and lowest water elevations signifying high and low phases of the tide within the Pakiputan Strait. At low tide (**Figure 2.83A**), water level height within the deeper region is slightly higher as compared to water level height within the shallower region. Water levels reach a maximum of more than -1.1075 and -1.125 meters below the mean water level during NE and SW monsoons, respectively. In contrast, high tide water levels can reach a maximum water elevation of 0.971 meters during NE monsoon and 1.023 meters during SW monsoon (**Figure 2.84A**).

A color map of the ebb and flood tide 'with project' scenario is shown in **Figure 2.83** and **Figure 2.84**. The presence of piers along the bridge alignment during the flood period shows an increase in water level and change in flow of water. The proposed bridge piers in the area are obstructing the flow and are causing an increase in water levels south of the bridge (**Figure 2.87**). A slight increase in water level is also noticeable north of the bridge piers during ebb. This increase is just barely noticeable in the narrow portion of the channel.

Freshwater input from creeks and rivers draining towards the coast generate parcels of seawater with less salinity and less dense water properties. These lighter, less saline waters tend to exhibit higher water level heights with respect to surrounding seawater. This phenomenon is demonstrated in areas influenced by water discharged from Mamay Creek and Sasa Creek. For 'with project' scenario during ebb, the lighter, less saline waters are noted as triangular, elevated parcels near the two creeks and likewise down at the corner on the western side of the alignment. In addition, streaks of elevated water alongshore contribute to relative low water level during flood.

In the presence of wind, however, these high water elevations in the south and north of the bridge piers can become more pronounced as demonstrated by the complimenting effects of southwesterly winds and northward flowing water during high tide (right-lower panel of **Figure 2.84**). This is also true with southward moving water and northeast winds during low tide as shown below (right-lower panel of **Figure 2.83**).

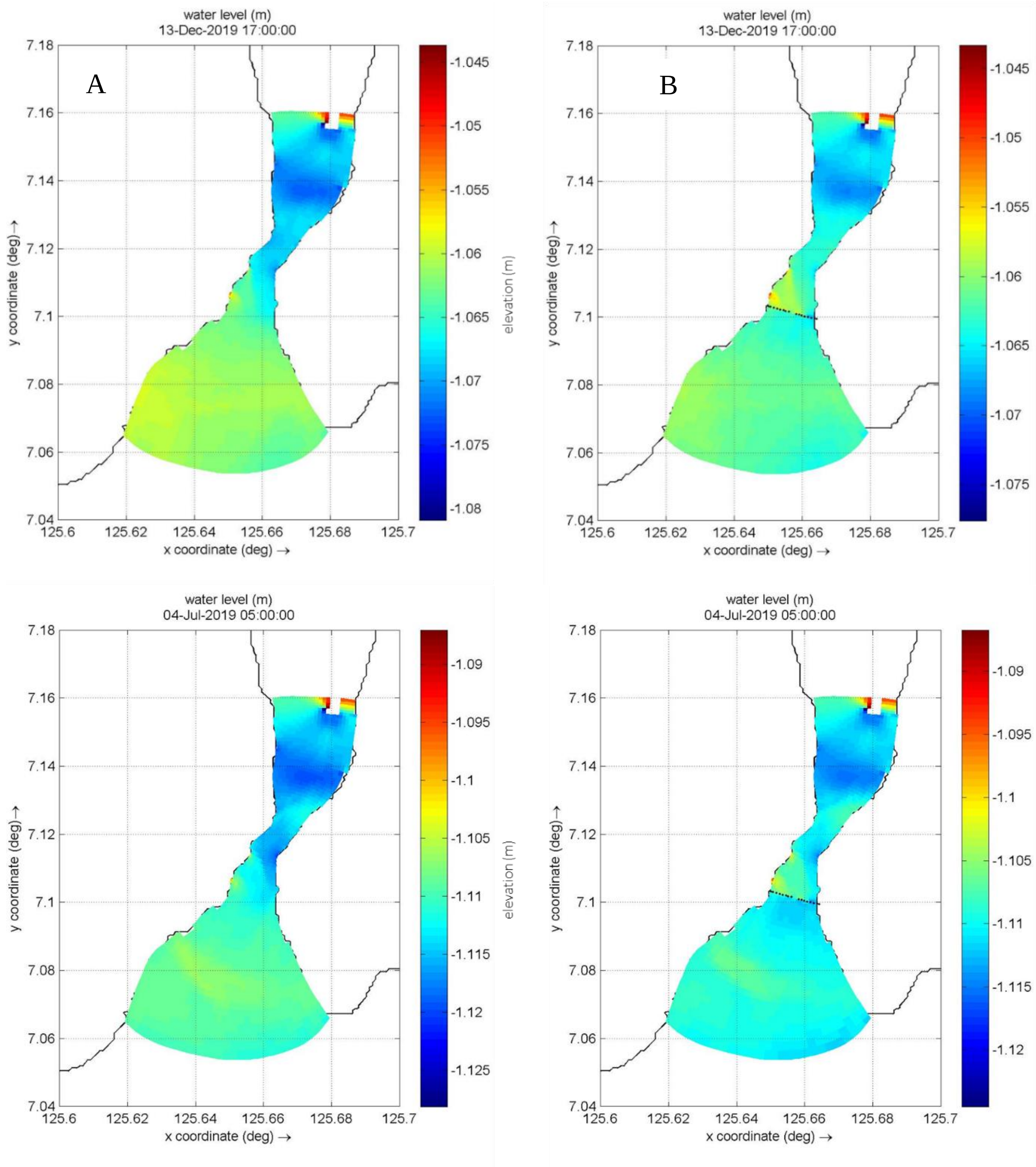


Figure 2.83 Water level plot during low tide of a) 'without project' and b) 'with project' for the NE (December 2019) and SW (July 2019) monsoon periods

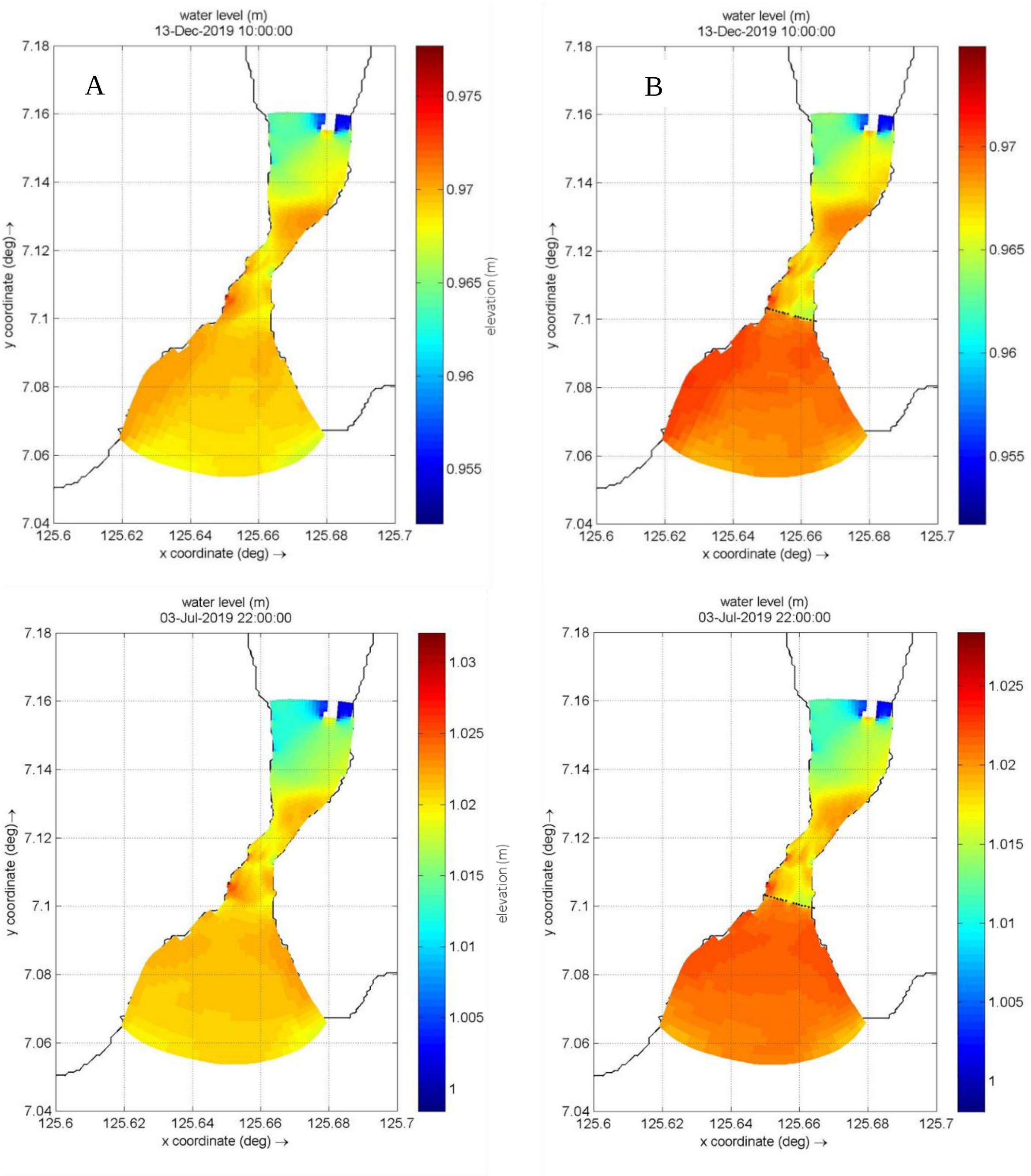


Figure 2.84 Water level plot during high tide of a) 'without project' and b) with project' for the NE (December 2019) and SW (July 2019) monsoon periods

Water circulation

The general water movement in Pakiputan Strait during flood and ebb are shown in **Figure 2.85** and **Figure 2.86**. Current flow during flood tide was consistently northward. Similarly, flow at ebb tide was stronger and generally southward. Water currents are generally faster within narrower and shallower areas along the strait irrespective of tidal period. This can be attributed to the volume of water across a large cross-section of the area to the south that is flowing into a constrained shallower area to the north.

With the presence of bridge piers, changes can be seen to the south and north of the proposed bridge alignment (right panel of **Figure 2.85** and **Figure 2.86**). During flood, water flow is reduced north of the bridge piers. However, it should be noted that there are strong northward currents that continuously move through the waterway at the center of the bridge alignment (W1 and E1 piers) (**Figure 2.81**). During ebb, flow reversals occur albeit with reduced flows in the upstream area. Constricted water in between W1 and E2 piers is exhibited as a strong flowing current towards the south (right–lower panel of **Figure 2.85** and **Figure 2.86**).

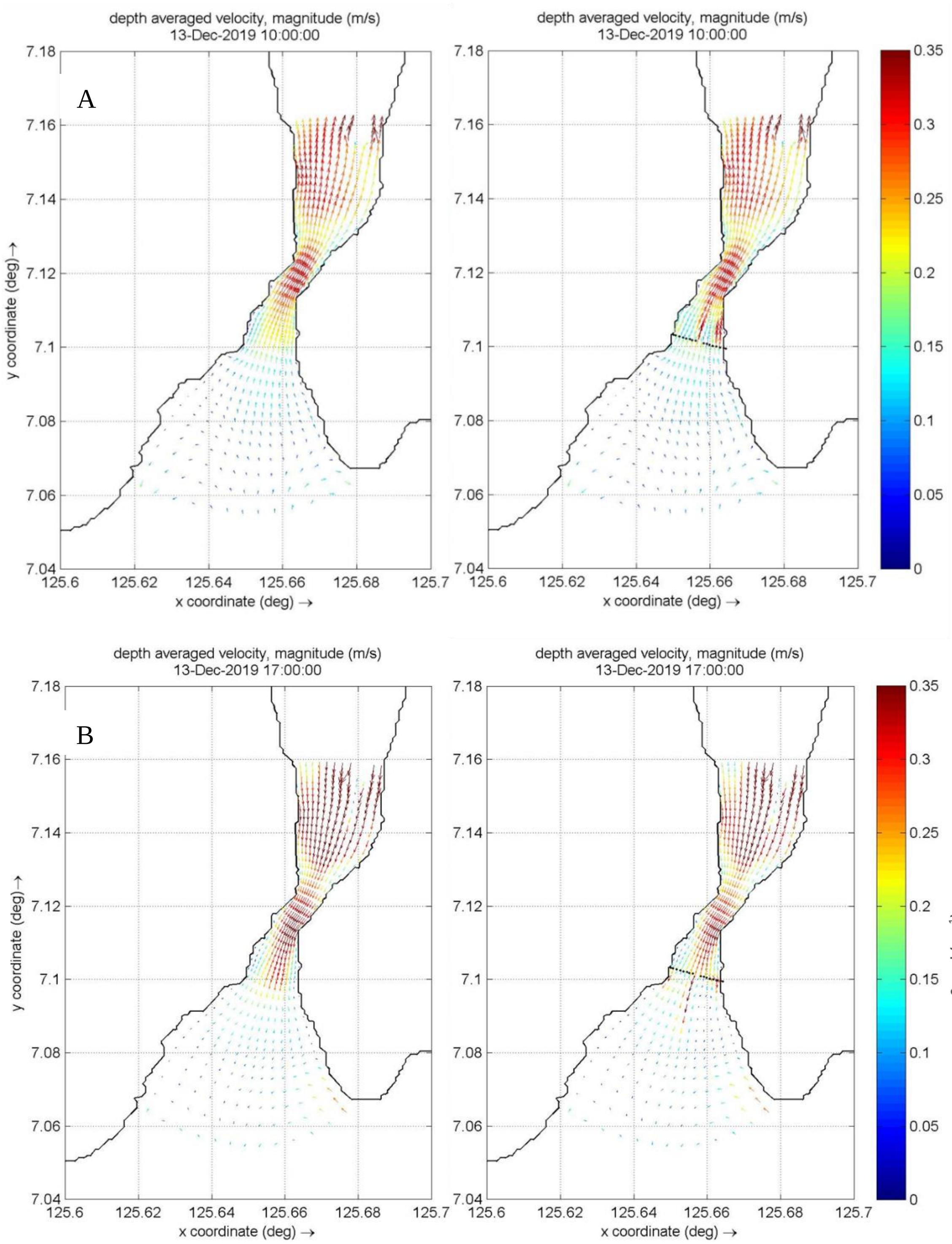


Figure 2.85 Depth average velocity plot during peak a) flood and b) ebb of Scenario 2 'without project' and Scenario 1 'with project' for the SW monsoon

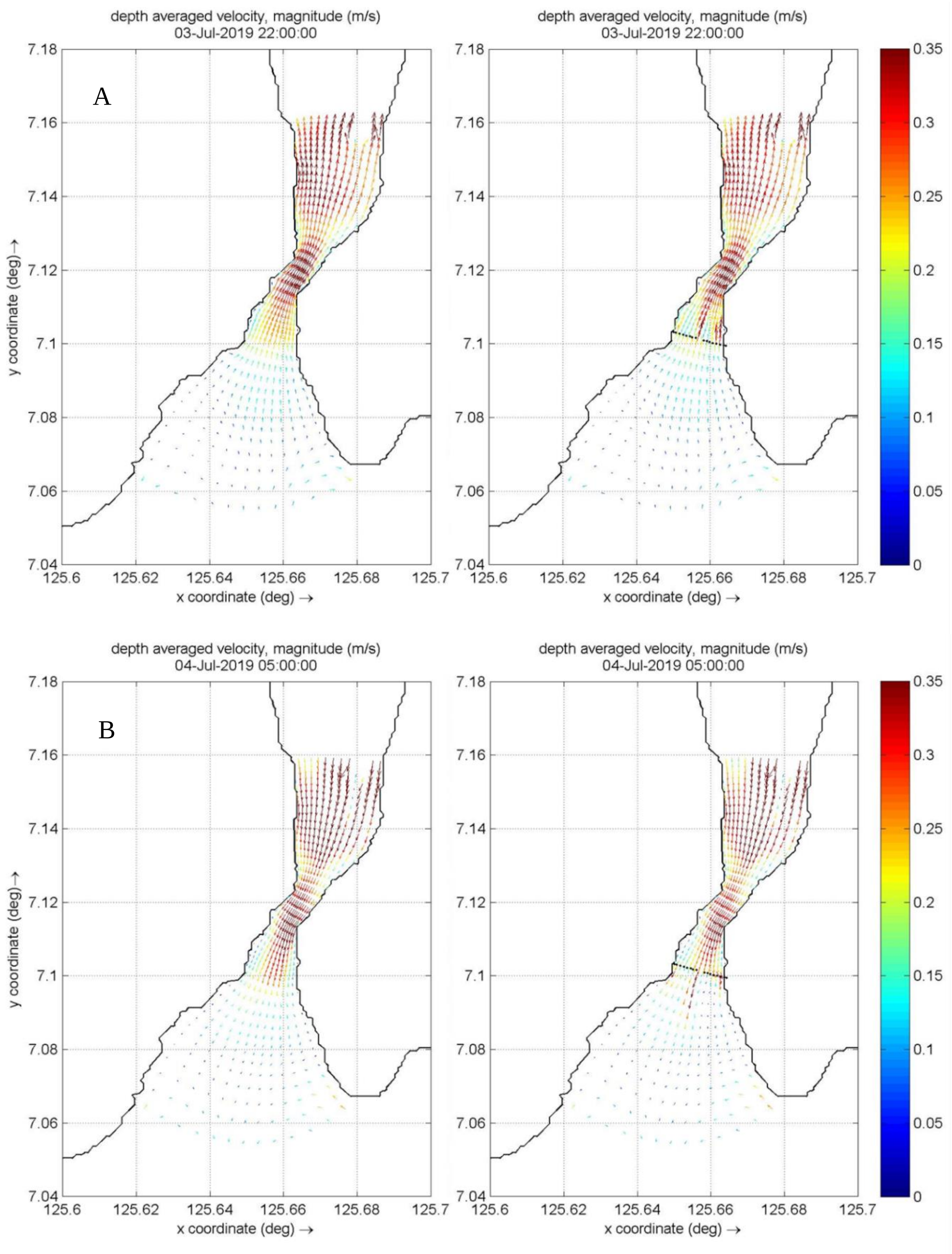


Figure 2.86 Depth average velocity plot during peak a) flood and b) ebb of Scenario 2 'without project' and Scenario 1 'with project' for the SW monsoon

Effects of Bridge Piers on Flow Rate

Model-derived accumulated flow data were extracted and analysed to determine the effects of bridge piers placement on water flow in the Pakiputan Strait. Transects M55 and M68 were selected to represent the northern and southern portions of the proposed bridge to demonstrate its effect on flow across the channel (**Figure 2.87**).

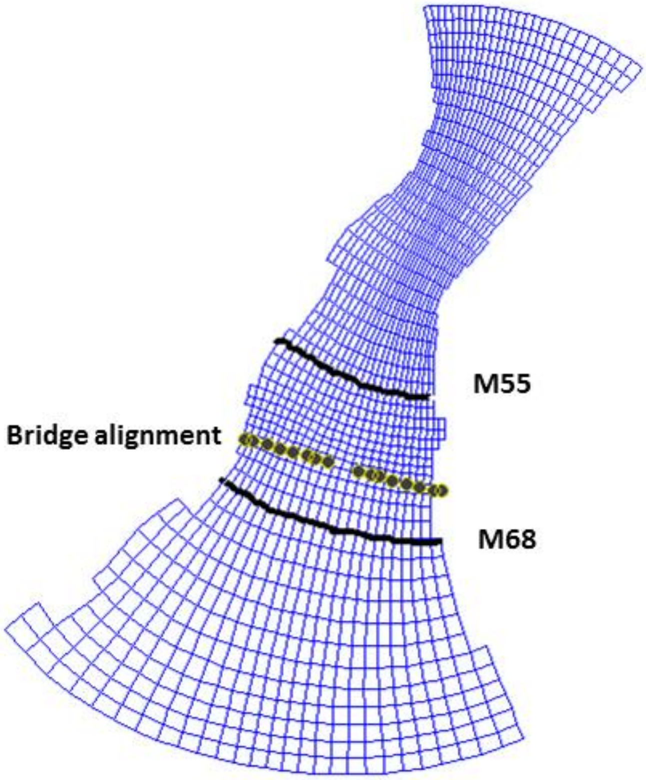


Figure 2.87 Model domain showing transects M55 and M68 extraction

Hourly and accumulated flows of the two transects based on 'with project' and 'without project' scenarios over a 24-hr spring tidal cycle (for both SW and NE monsoon season) are shown in **Figure 2.88**. Although a general decrease in the hourly flow and accumulated flow rates of 'with project' cross sections are apparent, observed flow changes do not vary significantly from that of 'without project'.

Both the unchanged and changed flows as depicted by 'without project' and 'with project' scenarios, respectively, show similar flow patterns/characteristics. Current flows progressed at the beginning of flood/ebb, reached the flow maximum at mid-flood/mid-ebb, and regressed back towards the end of flood/ebb period. The flow that added up and peaked over a complete ebb and flood cycle period represents the accumulated flow.

Notable results are the more reduced flows at transect M68 that coincided to mid-flood and flood and the increased flow reduction at transect M55 that coincide to mid-ebb and ebb events (**Table 2.22, Table 2.23** and **Figure 2.88**). These results highlight the effects of bridge piers obstruction on water flow upstream/ positive side of the bridge. It should be noted that water movement along the strait is tide dominated. As such, the upstream and downstream orientation with respect to bridge location would therefore depend on the direction of tidal flow.

Table 2.22 and **Table 2.23** summarize the change in flow characteristics between model scenarios of 'with project' and 'without project'. Values shown are flow rate differences between Scenarios 1 and 2 (for Northeast monsoon) and Scenarios 3 and 4 (for Southwest monsoon).

Table 2.22 Effects of bridge piers on hourly flow across sections M55 and M68

Southwest (3-4 July 2019)		**M55**		**M68**	
Tide period	**Time**	**Flow change between w/ and without project (m^3/hr)**	**% flow change**	**Flow change between w/ and without project (m^3/hr)**	**% flow change**
Mid-flood	16:00	-203,000	-2%	-373,000	-4%
Mid-ebb	22:00	-1,182,000	-4%	-577,000	-2%
Mid-flood	5:00	-1,347,000	-5%	-2,077,000	-8%
Northeast (13 Dec 2019)					
Mid-flood	4:00	-750,800	-6%	-934,800	-9%
Mid-ebb	10:00	-860,000	-3%	-340,300	-2%
Mid-flood	17:00	-1,629,300	-6%	-2,603,800	-11%

Table 2.23 Effects of bridge piers on accumulated flow across sections M55 and M68

Southwest (3-4 July 2019)		**M55**		**M68**	
Tide period	**Time**	**Accumulated Flow change between w/ and without project (m^3/hr)**	**% change of Accumulated flow**	**Accumulated Flow change between w/ and without project (m^3/hr)**	**% change of Accumulated flow**
Flood	13:00 - 18:00	-1,162,000	-3%	-1,308,000	-4%
Ebb	18:00 - 01:00	5,737,000	-5%	3,560,000	-3%
Flood	01:00 -08:00	-6,659,000	-6%	-15,123,000	-14%
Northeast (13 Dec 2019)					
Flood	01:00 - 06:00	-3,610,500	-9%	-3,943,220	-11%
Ebb	06:00 - 13:00	3,215,500	-3%	645,220	-1%
Flood	13:00 - 20:00	-8,587,600	-7%	-18,656,500	-16%

Vertical Velocity

To provide insights on the vertical distribution of velocity as influenced by bridge piers, cross sections of transects M55 and M68 were plotted. Vertical sections of current velocity fields describing the typical (without project) flow of water with south to north flow during flood (right to left - upper panel of **Figure 2.89**) and north to south flow during ebb (right to left - upper panel of **Figure 2.90**) are shown. Comparatively slower, northward moving currents that originate from a wider area in the south characterize the vertical distribution of the current velocity field at transect M68. As these enter the narrow channel, increased current velocities become apparent (transect M55). When flow reverses during ebb, however, relatively stronger southward currents can be observed at transect M55. The water continues to flow and starts to slow down (transect M68) as it exits toward a wider cross section in the south.

With regard to transect M55 ‘with project’ during flood, the change is more prominent (lower-left panel of **Figure 2.89**). The higher velocities at the cross section, which normally occur between the banks, are observed to be markedly reduced. Narrower, stronger currents in between (as well as in the shallow area on the right bank) are emphasized. During ebb at transect M68, the same dominant feature was observed. But here, it reverses with the tidal flow. The conspicuously stronger southward currents can be seen at midway and these are enclosed by relatively weaker current velocities along the shallower east bank and deeper west bank. Note, however, that this strong velocity feature at midway, which represents its vertical extent, corresponds to strong northward horizontal flow at transect M55 during flood and strong southward horizontal flow at M68 during ebb (**Figure 2.85** and **Figure 2.86**).

Figure 2.88 Hourly flow and accumulated flow rates at cross sections M55 and M68 during a) 3-4 July 2019 spring tide and b)13 Dec 2019 spring tide

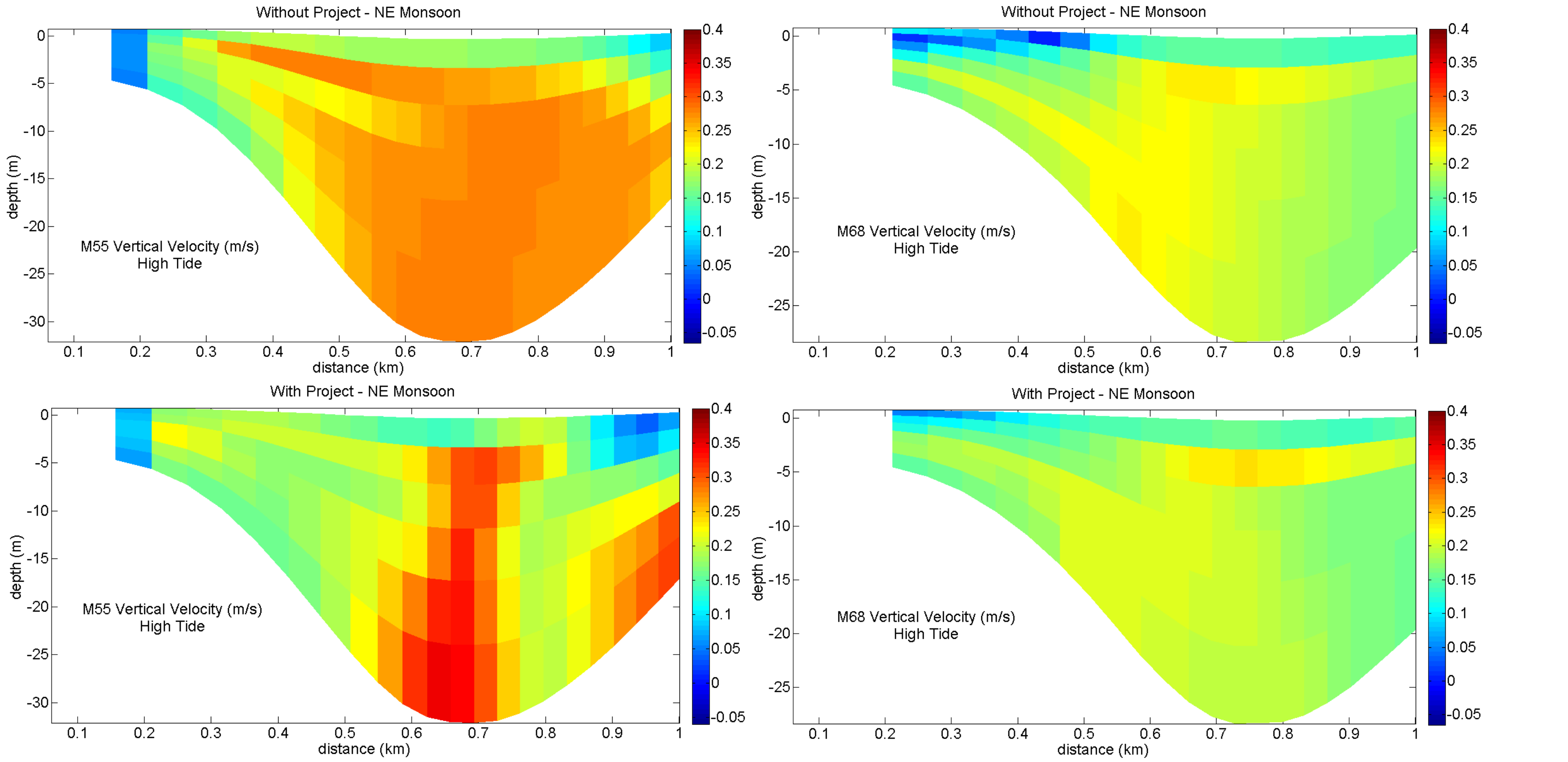


Figure 2.89 Effects of bridge piers on vertical velocity of M55 and M68. Plots illustrate changes during high tide of NE monsoon

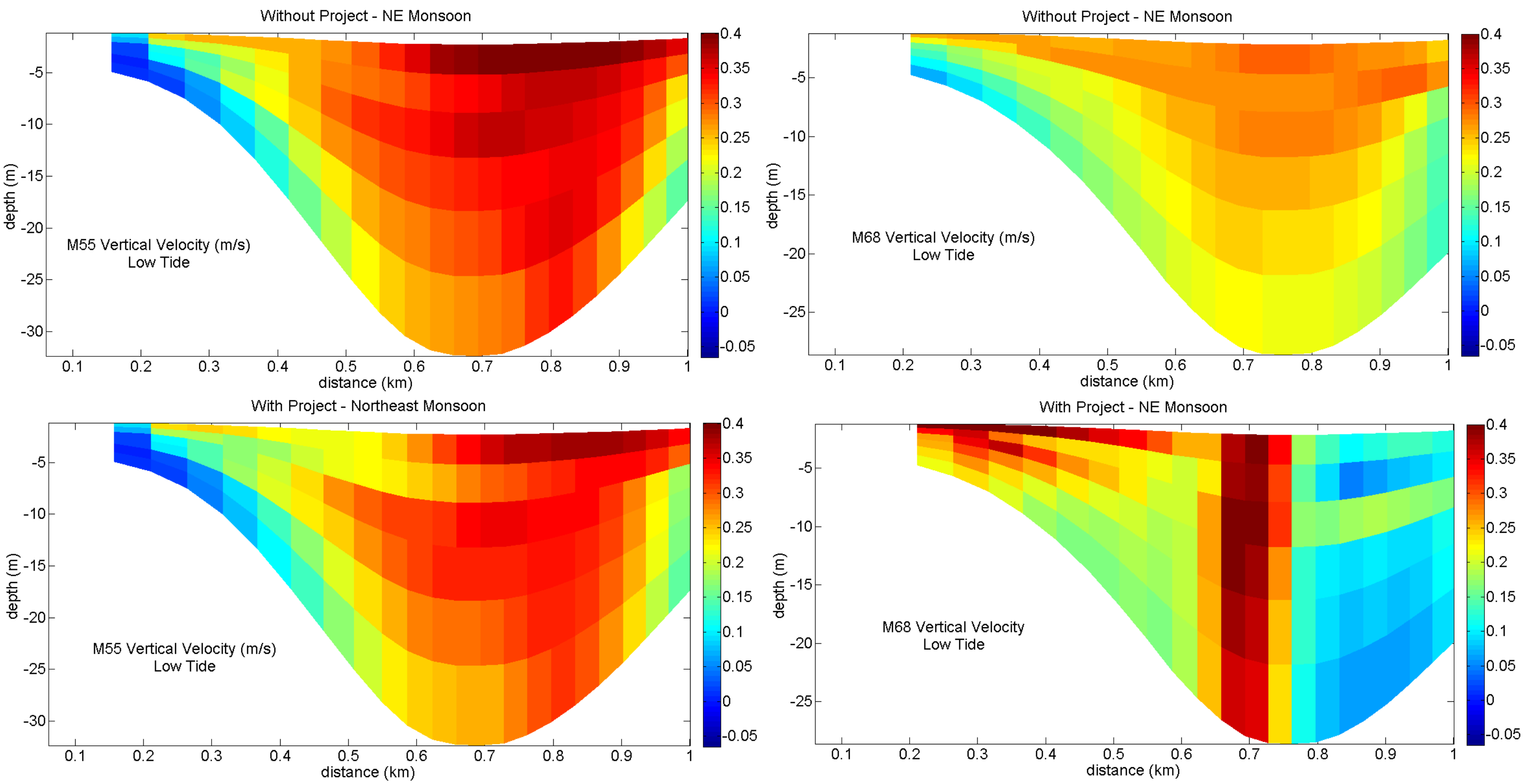


Figure 2.90 Effects of bridge piers on vertical velocity of M55 and M68. Plots illustrate changes during low tide of NE monsoon

Sediment Dispersal

Sediment distribution along the Pakiputan Strait is rather negligible. Even so, distribution is shown to be influenced by the movement of tidal currents. Sediments derived from Mamay Creek are transported northeastward and southwestward during flood and ebb, respectively (**Figure 2.91** and **Figure 2.92**). With the added action of winds, suspended silt and clay particles can extend from the source to a distance of up to 3.5 km northward during flood and 2 km southward during ebb. Clay and silt particles transported from Sasa Creek are not very visible due to the faster discharge rate of this creek, which hastens sediment distribution resulting to lower sediment concentration.

Sand, silt, and clay particles follow the tidal movement. Sand distribution is mainly observed near the source (**Figure 2.93**). Higher sand concentration is notable in Mamay Creek due to a slower discharge rate as compared to Sasa Creek.

A relatively high concentration of sediment was observed on the northern part of the domain during ebb and this is attributed to high velocity currents flowing from the area. However, fewer data points were registered in this area (as opposed to higher bathy resolution provided for the target area such as at bridge piers and the whole length of narrow channel). This is due to relatively shallow bathymetry and requirements relative to perturbed sediments and prescribed sediment thickness.

With respect to bridge piers, the same observations were noted except for the relative increase in sediment deposition especially for a 'without project' scenario. The influence of reduced flow/current velocities along the northern area of the bridge piers during flood is marked by accumulation silt and clay particles near the source, which decreases in volume northwards. During ebb, the southward currents appear to be moving the sediments towards and across the pier.

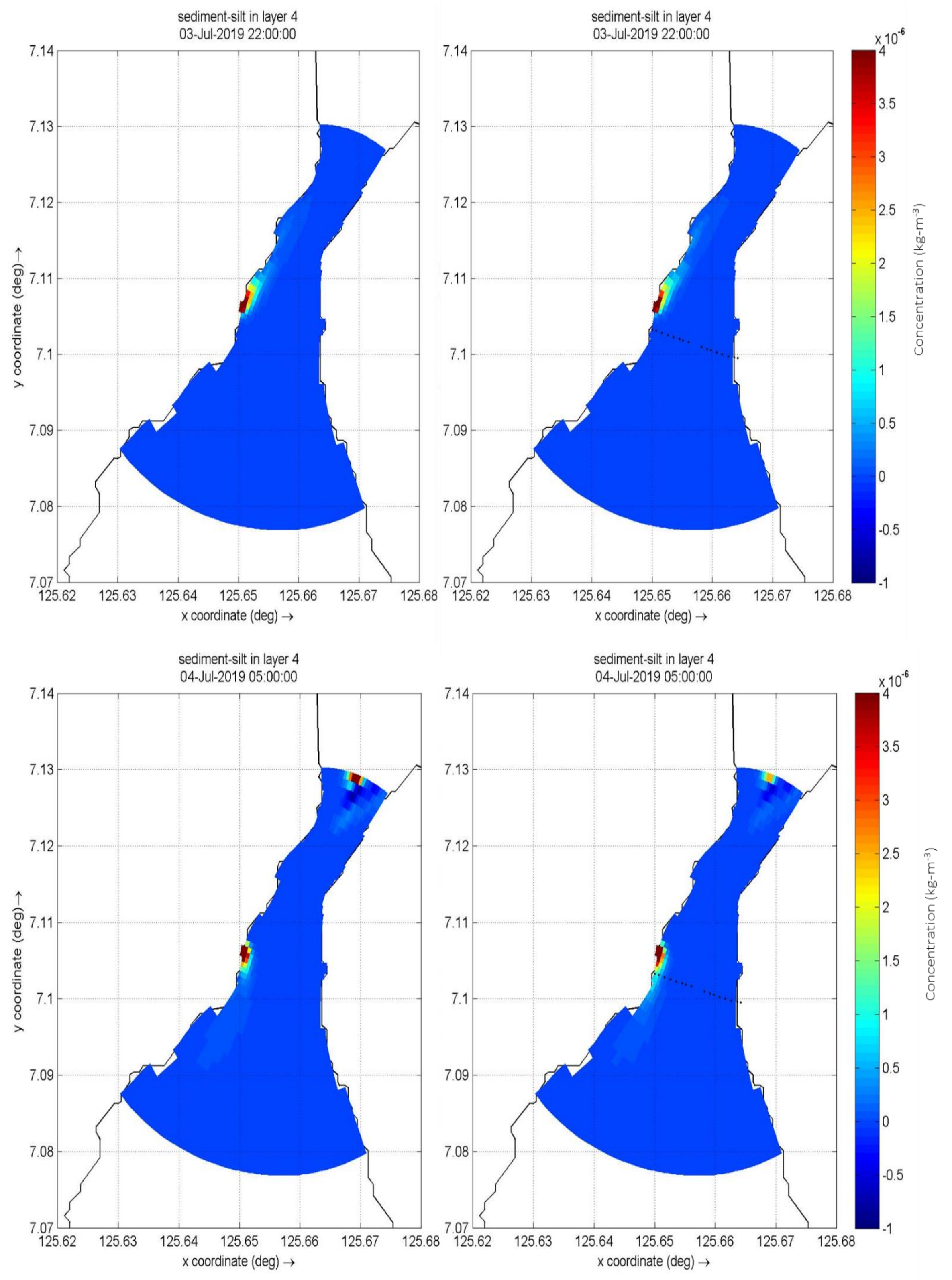


Figure 2.91 Silt scattering plot during a) peak flood and b) peak ebb for without and with project

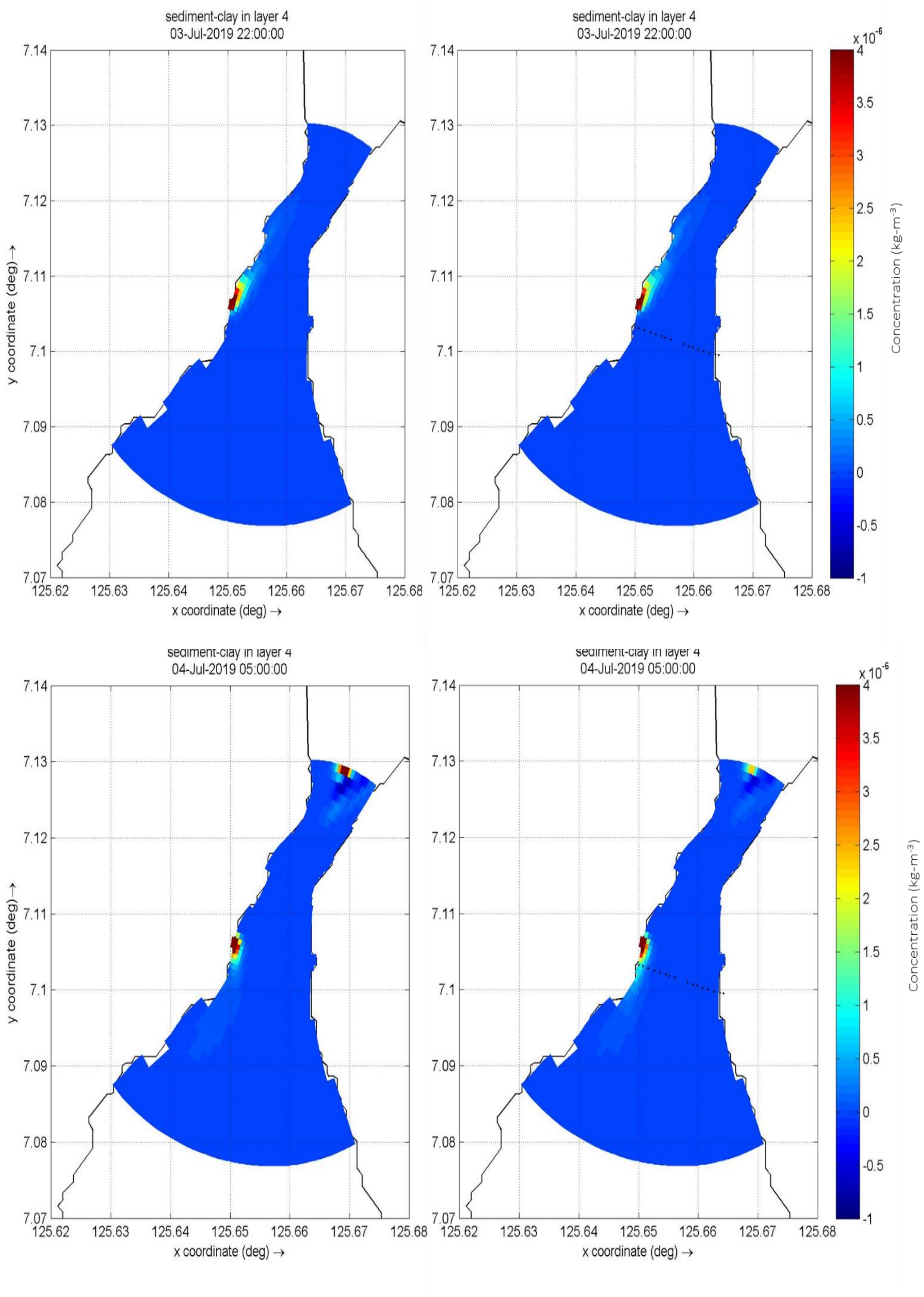


Figure 2.92 Clay scattering plot during a) peak flood and b) peak ebb for without and with project

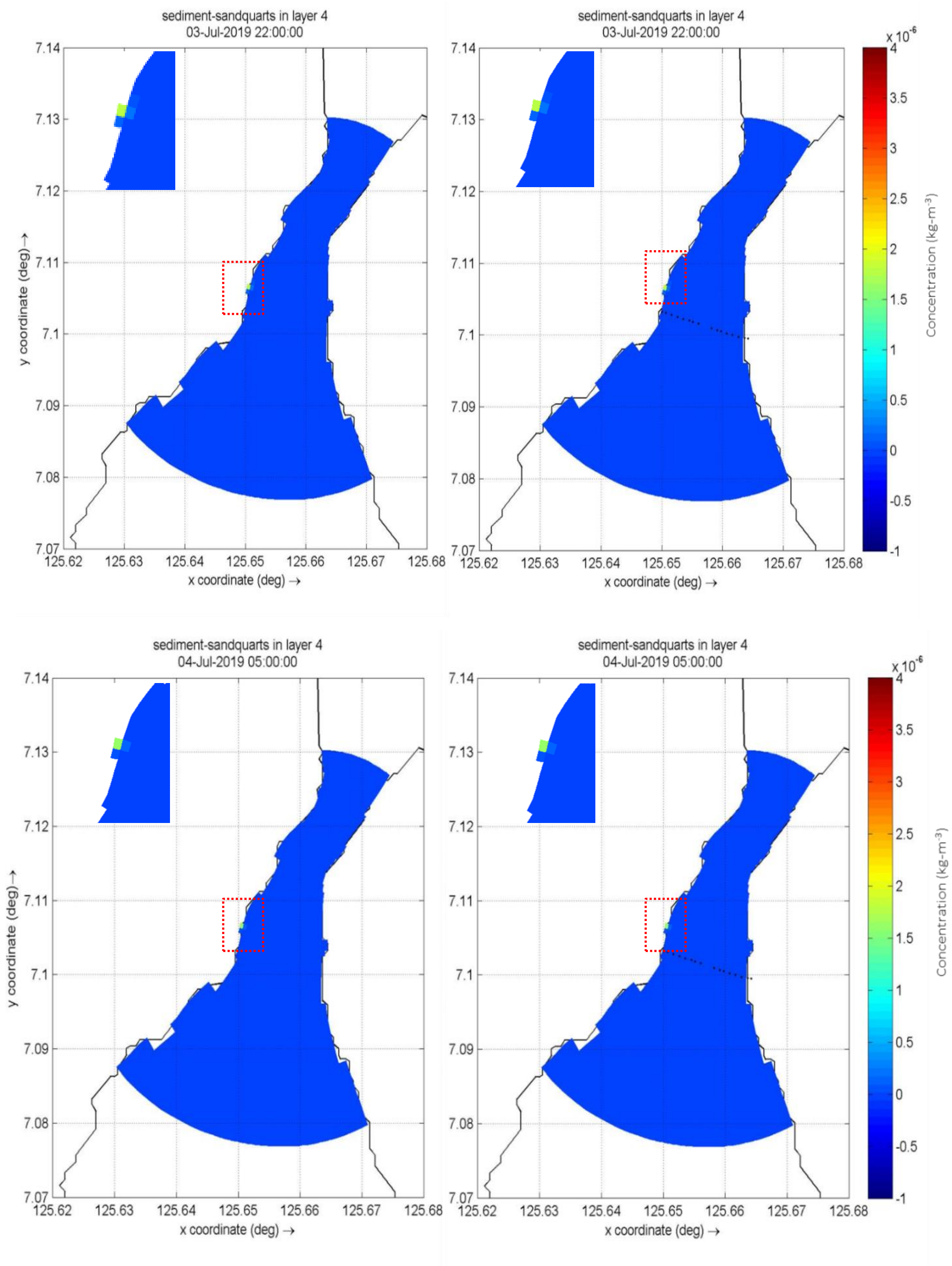


Figure 2.93 Sand scattering plot during peak flood and peak ebb for without and with project

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Sediment and Siltation

Based on the physical parameters, the largest potential impact foreseen would be during construction.

Sedimentation and siltation would be a crucial source of risk and impact. Considering the strength of current at flood tide compared to ebb, the resultant flow would be northward through the narrow segment of the channel. This would gradually trap resuspended sediments from dredging operations towards the head of the gulf, which is a cul de sac in orientation.

Marine habitats and organisms are at potential risk as resuspended sediments can settle and literally 'suffocate' the ecosystem. One particular island, Arboles (formerly Sanipahan) Island, however approximately 8 km away from the proposed alignment, is located right in the direction of the resultant flow and closer to the head part of the gulf. Surrounding the island and along the coast of ICaGoS are coral and seagrass beds that are important ecosystems. Resuspension can attenuate or impede light from reaching organisms both in the water column and substrate. Depending on the extent of sediment transport, sedimentation can also reach other islands in the south, as in Malipano and Talikud Islands (around 12 and 16 km, respectively).

During post-construction, there could be potential impediment in water flow, with the bridge being located in a narrow channel and with accumulation of sediments from construction. Each step to the completion of the bridge could leave a mark on the surrounding ecosystems. But based on the hydrodynamic modelling result, the construction and operation of the bridge may not cause a significant impact on the sediment deposition and changes in water discharge/ flow.

As such, during the design stage, ample consideration should be accorded to the possibility of sediment deposition on the leeward side of subsea structures and of scouring around the opposite side of the same structure. Of utmost importance is to preserve the integrity of subsea structures.

Potential impacts of the bridge to sediment distribution and transport patterns

Localized disturbances of bottom sediments, such as erosion and deposition, are expected during the construction of the bridge's piers. Although the bottom surface sediments do not contain a significant amount of mud, muddy sediments might be present at depths. The muddy sediments may be exposed and resuspended both during the excavation and disposal. Elevation of suspended sediment concentrations will increase turbidity in the Pakiputan Strait.

The settling rate and dispersal pattern of the resuspended sediments depend on the tide, surface currents and the type of resuspended sediments. Whether permanent or temporary, the storage or disposal sites of the excavated or dredged sediments should be properly secured to prevent leakage of sediments, contaminants or pollutants, if any, through surface runoff. Slope protection should also be placed on the bridge landing site, particularly on the Samal side, to minimize surface runoff and sedimentation.

For as long as the piers do not disrupt the alongshore transport of sediments, the bridge will not contribute to beach erosion. Seawalls and solid-based piers of most beach resorts may have strongly altered sediment transport such that localized erosion are already observed in several segments of the beach.

After construction, localized changes on bottom current velocity and direction may also occur around the piers. Scouring will occur on the updrift side, while deposition will occur on the downdrift (leeward) side. Regular seabed monitoring is needed to determine sites of scouring and sedimentation near the piers.

Hydrodynamic Modelling

Hydrodynamic model was done using DELF3D modelling software to determine the general flow characteristics and potential changes due to the construction and operation of the bridge. The proposed piers were accounted for by incorporating the calculated friction term of each bridge pier and its associated ship impact protection piles into the hydrodynamic model.

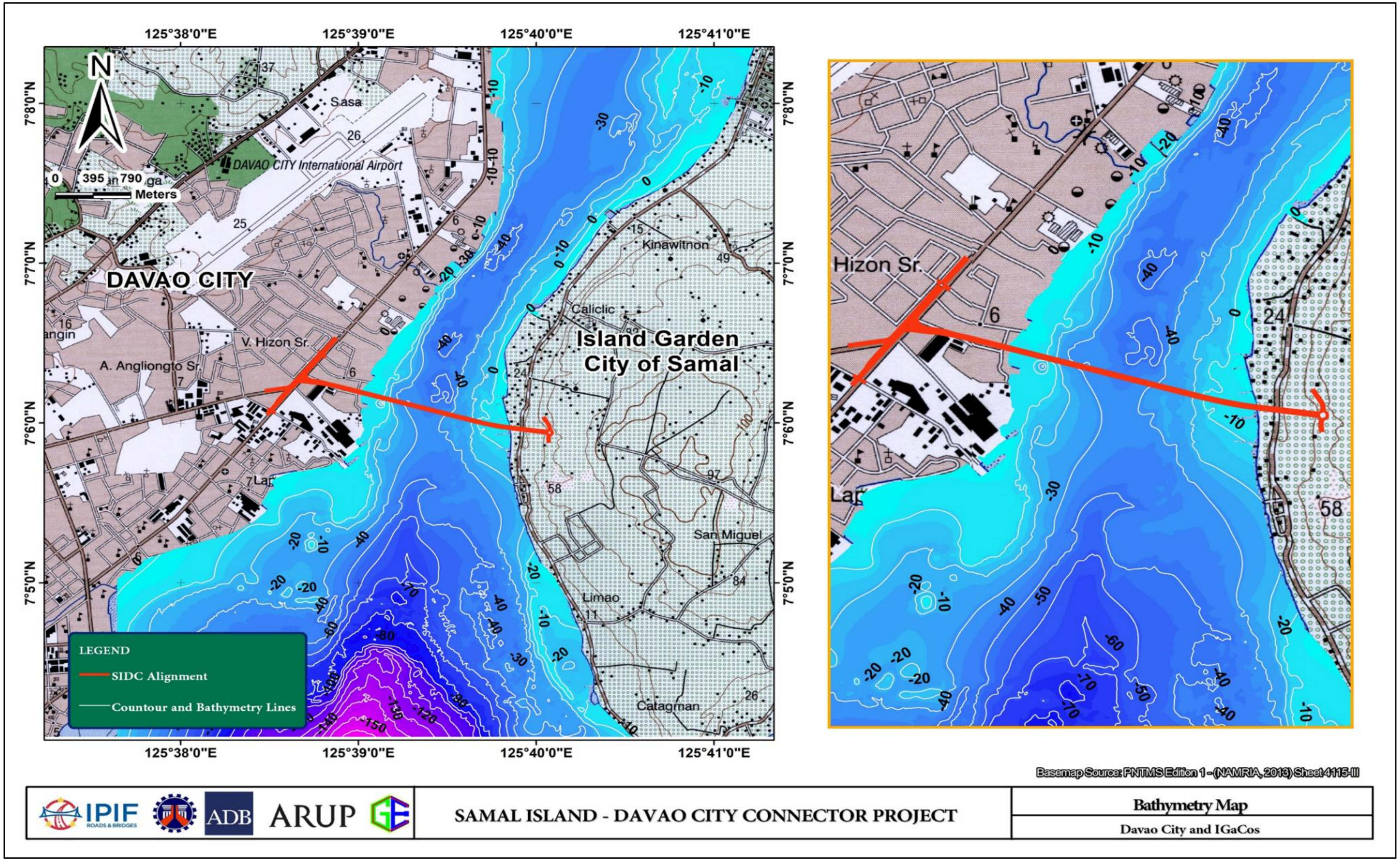
With the current modelling results, it was shown that percentage changes in water discharge/ flow between unobstructed and ‘with bridge’ piers were low and exhibited no significant differences. Therefore, the construction of the bridge across the channel may not contribute significant effects to the Pakiputan Strait during the typical meteorological condition.

With a proportional estimation of the discharge flow rate and typical sediment concentration of the two creeks, DELFT 3D was used to simulate tide-induced fine sediment transport in order to visualize the sediment dynamics in the area. Similar observations were noted for the cases of “without Project” and “with Project” that indicate that the construction and operation of the bridge may not cause a significant impact on the sediment deposition.

Caution should be taken that the hydrodynamic condition during adverse weather is not considered. Besides, the lack of actual discharge flow rate and sedimentation concentration may also bring uncertainty to the sedimentation deposition assessment.

Bathymetry

As presented in **Figure 2.94**, the bathymetry along the SIDC alignment and its immediate environs is slightly variable, with the gentlest slopes being found between the largest, center pylons of the structure. Maximum depth along the alignment is estimated at 35 meters. The seaward, eastern dipping slopes at the Davao side are relatively steeper compared to the western dipping slopes of Samal. While being relatively steeper, the slopes from Davao towards the Pakiputan Strait may be described as consistent, displaying no abrupt changes or massive drop-offs along the alignment as one goes from west to east. Similar observations are also noted as one goes east to west from Samal towards the Pakiputan Strait, with depth changes tending to run longer and gentler. Overall, the bathymetry lends itself well to the project, and the alignment corresponds to the most prudent configuration based on the underwater topography of the site (also in **Figure 2.94**).



Source: PNTMS Edition 1-(NAMRIA, 2013) Sheet 4115-III

Figure 2.94 Bathymetric map

2.2.3 Water Quality

Baseline Environmental Conditions

2.2.3.1 Groundwater Quality

Davao City Side

Potable water of Davao City is sourced from both groundwater and surface water. Drinking water at Barangay Vicente Hizon Sr in Buhangin District, where the landing area of the SIDC connector would be, is supplied by the Davao City Water District (DCWD).

The DCWD extracts groundwater in the Talomo-Lipadas Watershed which uses the following 51 production wells (PWs):

a. Dumoy System – 38 PWs, 150,000 water service connections

b. Tugbok System – 6 PWs, 25,000 water service connections

c. Riverside System – 1 PW, 2,000 water service connections

d. Toril System – 2 PWs, 8,000 water service connections

e. Lubogan System – 2 PWs, 8,000 water service connections

f. Calinan System – 2 PWs, 3,500 water service connections

High-quality water however, comes only from production wells in Talomo-Lipadas Watershed. Other water sources from Cabantian to Tibungco do not have the same quality, though DCWD claims that these water sources are potable based on a series of water monitoring and testing activities.

The Bunawan Watershed located at the Davao-side landing of the project is not among DCWD's groundwater sources. Any existing groundwater within and in the vicinity of the project is not being used as a potable water source. The baseline study however, includes in-situ groundwater quality measurements to characterize the shallow aquifer in Brgy. Vicente Hizon in order to provide supplementary information in the overall baseline water quality characterization of the project.

IGaCoS Side

The Samal Water District supplies the domestic water for Barangay Limao, the host barangay of SIDC Project in IGaCoS.

A review of secondary data indicates that one of the major water resources in IGaCoS is through the development of scattered springs at abrasion cliffs in the western coast. The littoral deposits and neritic sediments in the area could be potential groundwater-bearing aquifers. Wells in the coastal area of Babak to Samal with depths of less than 30 meters and at shallow water levels are producing groundwater for Level I (point source) and Level II (communal system) services.

In plateaus with elevations between 50 – 250 meters above sea level, potential aquifers for deep wells are seen mainly in various sedimentary rock units, specifically major reef limestone bodies. Deep wells with depths of 40 – 120 meters constructed in this plateau area have moderate production capacities, with static water levels ranging from 30 mBGS to 90 mBGS.

The Samal side of the project is currently not being used as a potable water source. While some private properties in the project vicinity operate deep wells for non-drinking purposes (e.g. handwashing and toilets), in-situ measurement results negate their viability as a groundwater resource and reinforces the non-applicability of PNSDW to all three (3) sampling stations.

Groundwater baseline condition

Groundwater quality was assessed against common in-situ parameters, i.e. temperature, salinity, dissolved oxygen (DO), pH, and total dissolved solids (TDS). In-situ water quality measurements of groundwater sources in Barangay Vicente Hizon Sr. in Davao City and Barangay Limao and Caliclic in Samal were made on 22-23 September 2019. One station was selected in Davao City, while two groundwater sampling stations were selected for Samal (**Figure 2.95** to **Figure 2.98**). **Table 2.24** and **Annex M** present the results of groundwater in-situ water quality measurements.

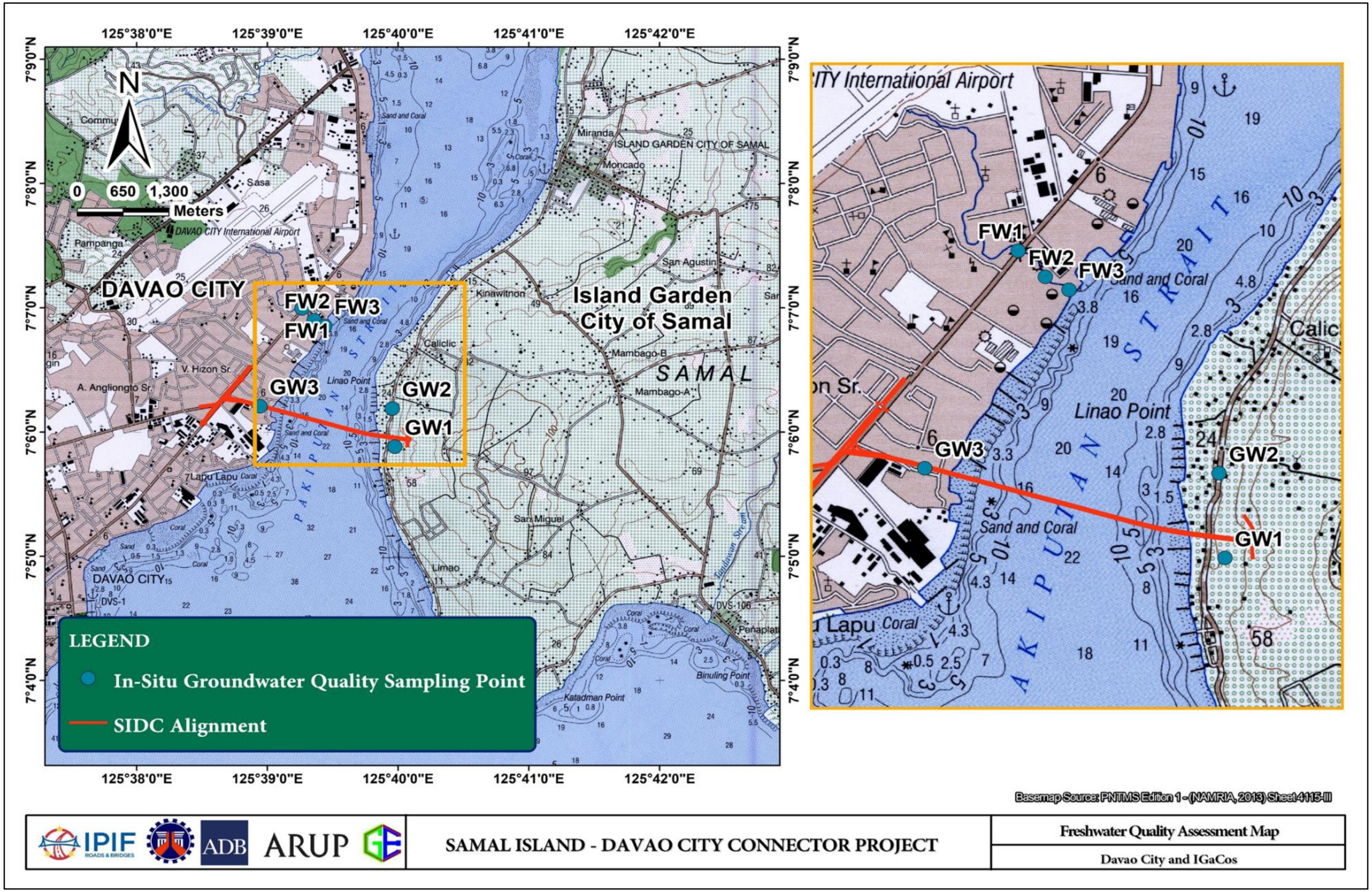
Table 2.24 Results of In-Situ Water Quality Measurements for Groundwater Sources

Parameters	**GW1**	**GW2**	**GW3**	**DENR Criteria Class A DAO 2016-08**
Date and Time of Measurement	23 September 2019			
	12:00 pm	12:16 pm	2:36 pm	
Temperature, °C	29.64	31.8	30.84	26 – 30
Salinity, ppt	1.2	0.5	0.1	--
Conductivity, µS/cm	2	1	0	--
Dissolved Oxygen (DO), mg/L	5.5	5.1	5.2	5 (min)
pH	8.16	8.45	8.20	6.5 – 8.5
Total Dissolved Solids (TDS), mg/L	1,128	480	136	--

Table 2.25 Geographical coordinates of groundwater sampling points (WGS 84)

Sampling stations		**Latitude**	**Longitude**
GW1	Barangay Limao, IGaCoS	7.098	125.666
GW2	Barangay Caliclic, IGaCoS	7.103	125.666
GW3	Barangay Vicente Hizon Sr., Davao City	7.104	125.649

Traces of salt are evident in the sampled groundwater in Davao City and Samal sampling sites. This may indicate saltwater intrusion in both aquifers. The high concentration of TDS due to inorganic salts and organic matter are also reflected by the sampling conducted in Barangay Limao, which may be due to its water hardness. On the other hand, temperature, DO and pH are all within the limits set for Class A water by DAO 2016-08. Given that these aquifers are not used as sources of potable water, the parameters covered by in-situ measurements are more than sufficient to supplement the required baseline water quality information for the project..



Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS84

Figure 2.95 Location of In-Situ Groundwater and Freshwater Quality Measurements.

Figure 2.96 Groundwater source in Barangay Limao (GW1), at the staff house of Costa Marina Beach Resort

Figure 2.97 Groundwater source in Purok 4-B, Barangay Caliclic (GW2), IGaCoS

Figure 2.98 Groundwater source in Barangay Vicente Hizon Sr. (GW3), Davao City

2.2.3.2 Freshwater Quality

Freshwater baseline condition

Table 2.26 and **Annex M** present freshwater quality measurements taken from Sasa Creek in Davao City. The mouth of Sasa Creek is located near the port, where boat services to and from the Paradise Island Resort is located.

The creek is situated more than 500 meters north of the project site. No significant effects are therefore expected during the construction and operation phases. In-situ measurements of limited parameters in three sampling points within this creek were conducted to serve as supplementary information and additional reference for environmental monitoring activities should they extend beyond the sphere of influence of the project.

Freshwater quality parameters were assessed against the DENR DAO 2016-08 standards for Class C water bodies.

Table 2.26 Results of In-Situ Water Quality Measurements for Freshwater Sources

Parameters	**FW1**	**FW2**	**FW3**	**DENR Criteria Class C DAO 2016-08**
Date and Time of Measurement	22-23 September 2019			
	12:49 pm	12:51 pm	2:34 pm	
Temperature, °C	31.50	31.02	30.84	25-31

Parameters	FW1	FW2	FW3	DENR Criteria Class C DAO 2016-08
Date and Time of Measurement	22-23 September 2019			
	12:49 pm	12:51 pm	2:34 pm	
Salinity, ppt	28.1	31.9	0.1	--
Conductivity, mS/cm	44	49	0	--
Dissolved Oxygen (DO), mg/L	5.07	5.11	5.5	2 (min)
pH	8.69	8.76	12.14	6.5 – 9.0
Total Dissolved Solids (TDS), mg/L	21,930	24,560	136	--

Table 2.27 Geographical coordinates of freshwater sampling points (WGS 84)

Sampling stations	Latitude	Longitude
FW1	7.117	125.654
FW2	7.115	125.656
FW3	7.114	125.657

Results show that although temperature, DO, and pH values are within prescribed DAO 2018-06 Water Quality Guidelines (WQG) for Class C waters, there are, nonetheless, elevated salinity, conductivity, and TDS values are evident due probably to the inorganic salts and effect of water hardness from the intrusion of marine waters to the creek.

It should be noted, however, that this river is situated more than 500 meters north of the proposed project and is not expected to be affected during the construction and operation phases. Nevertheless, in-situ measurements of limited parameters in three sampling points within this river were conducted as part of this baseline study, to serve as supplementary information and additional reference for environmental monitoring activities should they extend beyond the sphere of influence of the project.

IGaCoS Side

There is no freshwater source near the Samal landing site of the SIDC. The nearest potential source, Hagimit River, is located at about 7.7 km southeast of the alignment.

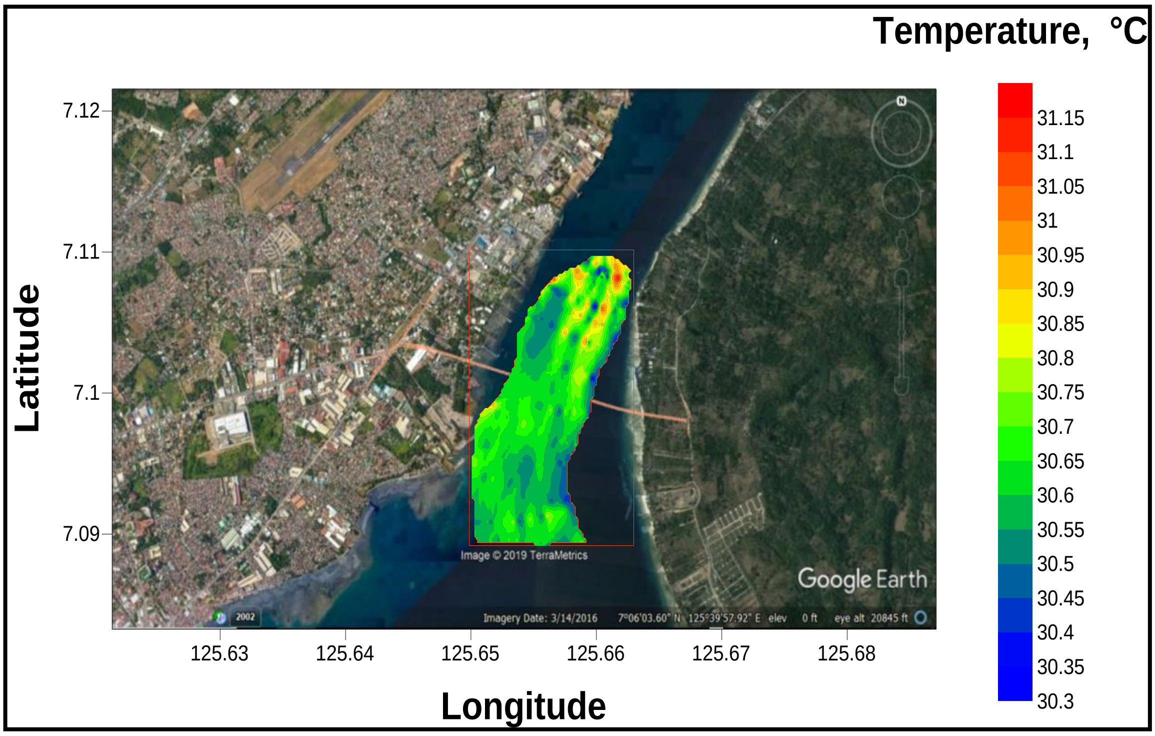
2.2.3.3 Marine Water Quality

Sampling measurements were conducted on 22 September 2019. Pakiputan Strait serves multiple functions, though mostly serves as a navigable waterway. Numerous ports at Davao and Samal side service water vessels crossing the Pakiputan Strait. Recommended shipping movements due to project implementation are discussed in **Section 2.4**. Other uses include small scale fishing and tourism.

The tracking and mapping of water quality parameters off the coast of Pakiputan Strait was carried out using a Hanna HI9828 Water Quality Meter with built-in GPS. Using a boat with controlled speed and a water quality meter with predefined modes, temperature tracking was conducted.

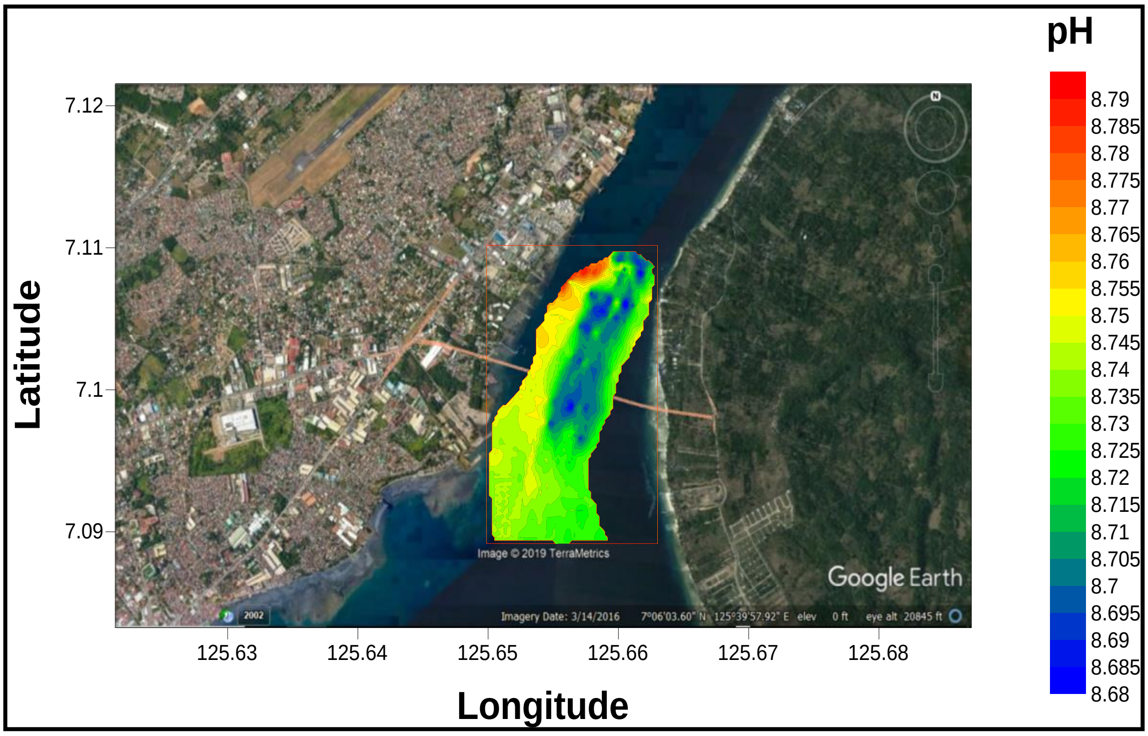
Figure 2.99 to **Figure 2.104** show the measured profile of temperature, pH, DO, salinity, conductivity and TDS conducted along the Pakiputan Strait near the alignment.

Results indicate that profile values along the alignment are all normal, where: temperature ranges from 30.55-30.8°C, pH from 8.7 to 8.755, DO from 5.6 to 5.75m. g/L, salinity from 32.6 to 34 ppt, conductivity from 500000-52000 µS/cm, and TDS from 25000 to 26000mg/L. The surveyed portions of Pakiputan Strait meet DAO 2016-08 WQG for Class SC waters.



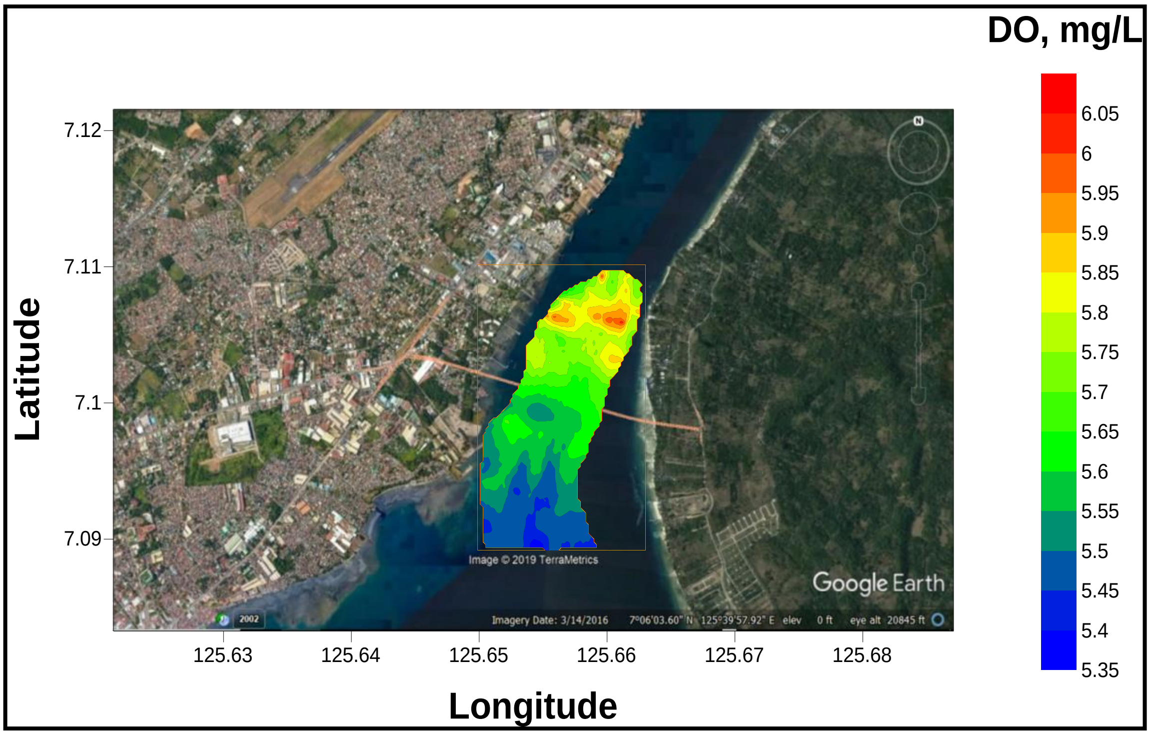
Basemap used: Google Earth Image (2019)

Figure 2.99 Temperature profile along the Pakiputan Strait.



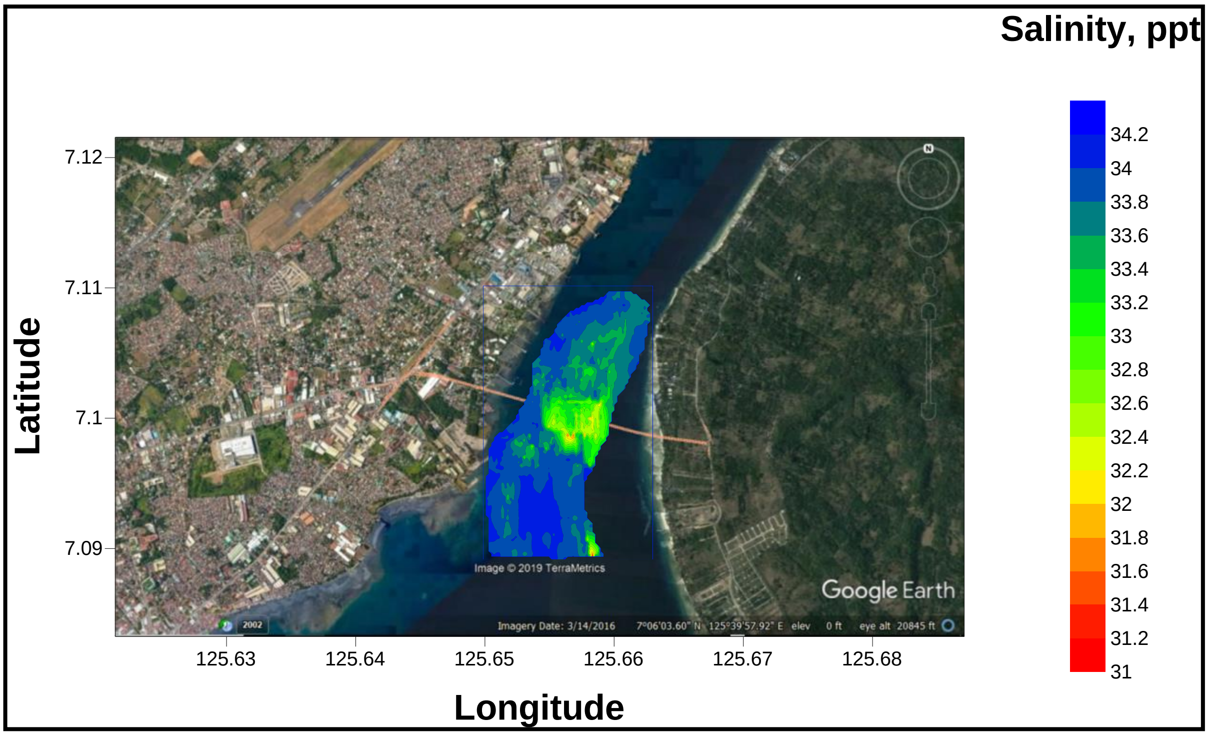
Basemap used: Google Earth Image (2019)

Figure 2.100 pH profile along the Pakiputan Strait)



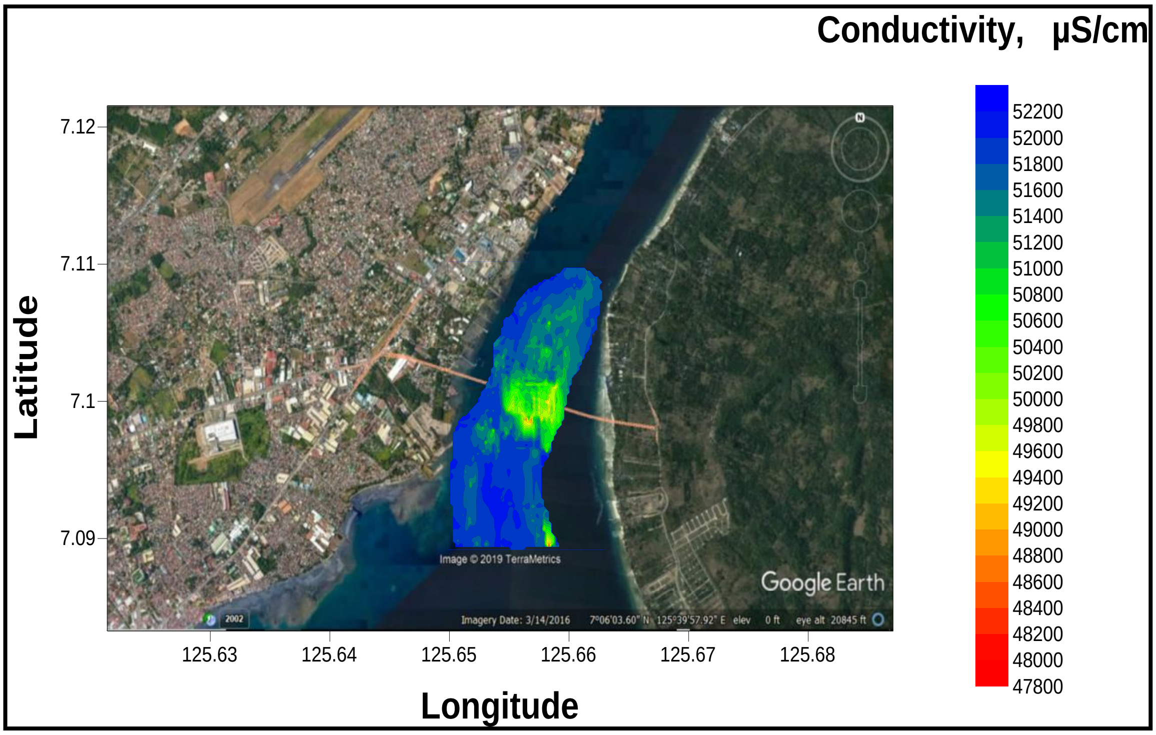
Basemap used: Google Earth Image (2019)

Figure 2.101 DO profile along the Pakiputan Strait



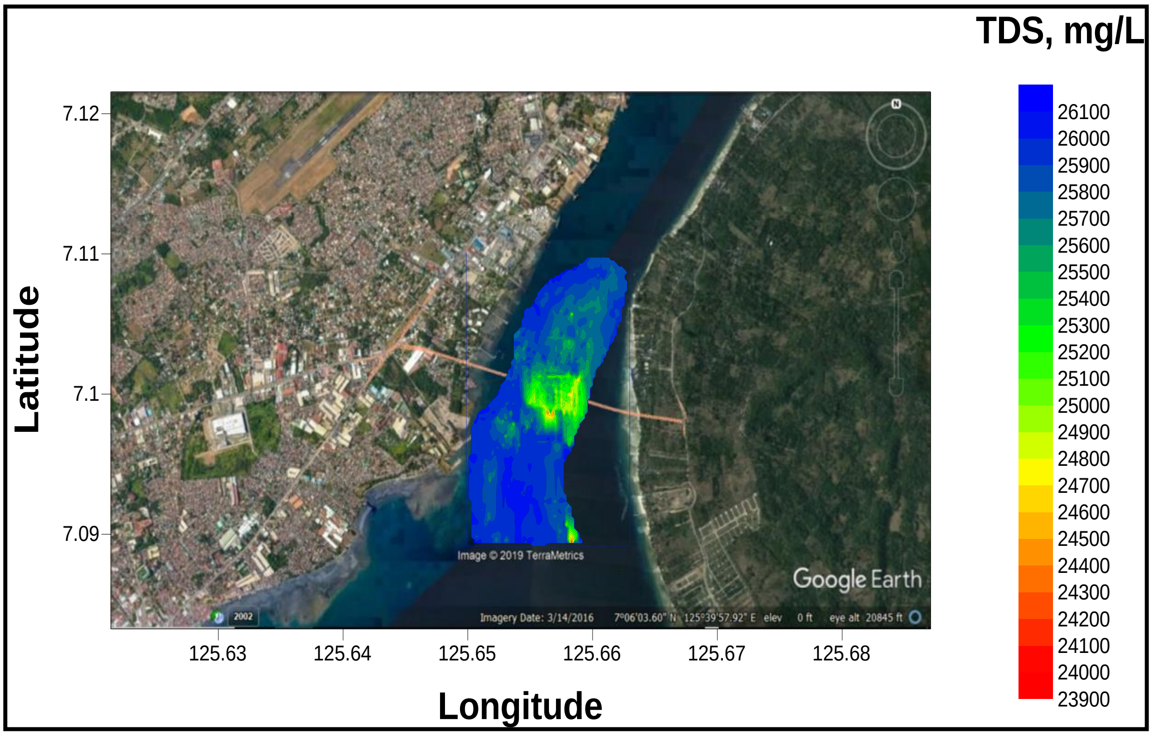
Basemap used: Google Earth Image (2019)

Figure 2.102 Salinity profile along the Pakiputan Strait



Basemap used: Google Earth Image (2019)

Figure 2.103 Conductivity profile along the Pakiputan Strait



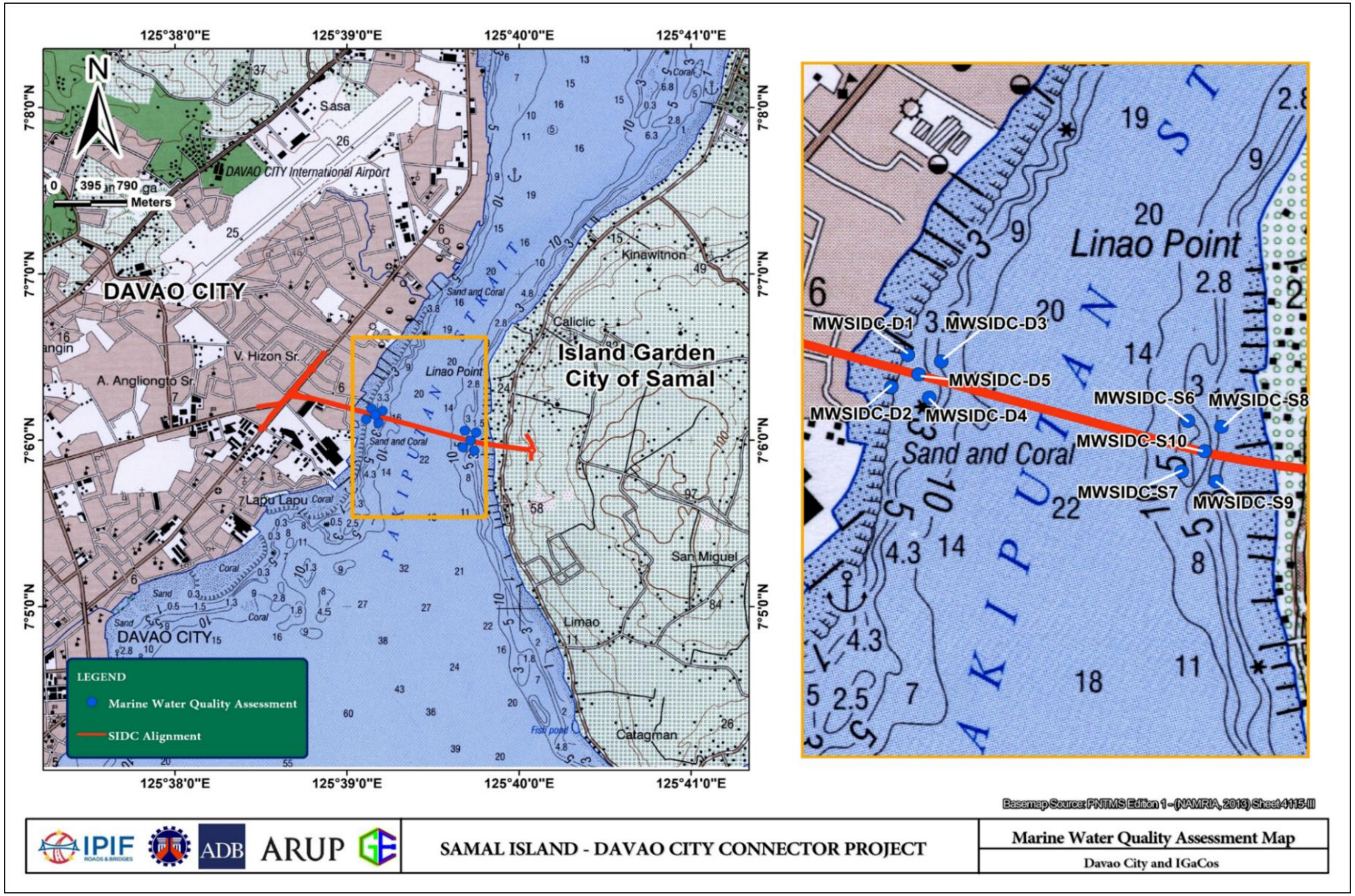
Basemap used: Google Earth Image (2019)

Figure 2.104 TDS profile along the Pakiputan Strait

Marine water sampling was conducted at ten (10) stations. The parameters used were derived from the agreed laboratory parameters during the technical scoping, following the standards set for Class SC WQG of DAO 2016-08. The sampling station distribution is presented in **Figure 2.105**, while the result of the conducted sampling is summarized in **Table 2.28** and **Annex M**.

The results of the marine water quality sampling is summarized in **Table 2.28**. Physico-chemical parameters, as temperature, DO, pH, total suspended solids (TSS) and oil and grease, are all within the prescribed limit set by DAO 2016-08 for Class SC waters.

Fecal coliform in the area ranges from 280 to 9200 MPN/100ml in contrast to the standard value for Class SC of 200 MPN/100ml. Fecal coliform refers to a group of total coliforms found in feces of warm-blooded animals. This bacteriological test conveys whether the water is free from disease-causing bacteria. The high level of fecal coliform can be attributed to animal wastes and domestic water discharges from nearby communities. Water with values exceeding the standard is considered unsafe. Total coliform, on the other hand, is a large collection of different kinds of bacteria. This is common in the environment and may be found in soil or vegetation and are largely harmless.



Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS84

Figure 2.105 Sampling stations in marine water quality

Table 2.28 Results of Water Quality Measurement for Marine Waters

Parameters	**Units**	**Water Matrix**	**MWSI DC-D1**	**MWSI DC-D2**	**MWSI DC-D3**	**MWSI DC-D4**	**MWSI DC-D5**	**MWSI DC-S6**	**MWSI DC-S7**	**MWSI DC-S8**	**MWSI DC-S9`**	**MWSI DC-S10**	**DENR Criteriar Class SC DAO 2016-08**
In-Situ Water Quality Measurements													
Date and Time	22 September 2019, 10:25 AM – 12:30 PM												
Temperature	°C	Surface	30.75	30.70	30.72	30.75	30.75	30.75	30.70	30.71	30.70	30.71	26-30
Salinity	ppt	Surface	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	---
Conductivity	mS/cm	Surface	51,660	51,630	51,630	51,620	51,610	51,620	51,630	51,660	51,650	51,600	---
Dissolved Oxygen (DO)	mg/L	Surface	5.65	5.60	5.60	5.65	5.45	5.56	5.60	5.65	5.45	5.60	5
pH	*unitless*	Surface	8.75	8.70	8.76	8.74	8.75	8.76	8.74	8.73	8.70	8.75	6.5 – 8.5
Total Dissolved Solids (TDS)	mg/L	Composite	26,100	26,110	26,100	25,900	25,900	25,900	26,100	25,900	25,990	26,100	---
Laboratory Analyses													
10 October 2019, Time:			10:26 AM	10:34 AM	10:39 AM	10:22 AM	10:17 AM	9:37 AM	9:26 AM	9:42 AM	9:32 AM	9:18 AM	
Chemical Oxygen Demand (COD)	Mg O_2/L	Composite	1,226	534	157	346	503	346	1,635	236	1,022	534	---
Total Suspended Solids (TSS)	mg/L	Composite	62	43	55	38	29	47	52	47	42	34	80
Oil and Grease	mg/L	Composite	<0.50	1.2	1.0	<0.50	0.88	<0.50	1.8	<0.50	1.2	0.81	3
Total Coliform,	MPN/100 mL	Composite	9,200	540	16,000	1,600	1,600	350	5,400	920	350	920	---
Fecal Coliform	MPN/100 mL	Composite	1,700	540	9,200	1,600	1,600	350	5,400	280	350	920	200

Table 2.29 Geographical coordinates of marine water sampling points (WGS 84)

Sampling station ID	Latitude	Longitude
MWSIDC-D1	7.103°	125.652°
MWSIDC-D2	7.102°	125.652°
MWSIDC-D3	7.103°	125.653°
MWSIDC-D4	7.102°	125.653°
MWSIDC-D5	7.103°	125.653°
MWSIDC-S6	7.101°	125.661°
MWSIDC-S7	7.101°	125.663°
MWSIDC-S8	7.099	125.662°
MWSIDC-S9	7.1°	125.662°
MWSIDC-S10	7.099°	125.661°

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Degradation of groundwater quality

It is possible that accumulated oil and dust on road and ground surfaces could permeate towards shallow aquifers and affect groundwater quality during the construction phase of the project. Nevertheless, the influence of surface runoff is negligible and mostly limited during construction phase.

Construction activities may also have significant impacts on groundwater hydrology and quality. The site may need to be drained to provide suitable conditions for engineering works, which may result to temporary changes to ground water flow. In addition, soil contaminated from a previous land use may be disturbed during construction, causing pollutants such as heavy metals to enter ground and surface waters.

Degradation of surface water quality

During construction, it is possible that soil runoff from adjacent bare lands resulting from earthmoving activities, such as cutting and filling, will cause water quality degradation downstream of the construction area.

Destabilized soil from cut and fill areas may be protected by reinforced soil walls, retaining walls and sodding, to reduce the possibility of soil runoff and water quality degradation downstream. Due consideration must be given to construction methods and terms of work, since temporary water quality degradation is assumed only during the foundation work for bridge piers.

Construction activities may encourage soil erosion and increase the sediment loads of nearby streams, while accidental leaks and spills of oil and fuel from storage tanks, and construction, maintenance and decommissioning vehicles can also pollute surface waters. In addition to this, improper sanitation during construction will lead to increased levels of total and fecal coliform.

It is expected that there are no to minimal impacts anticipated on surface water quality during the operations phase of the project.

2.2.4 Freshwater Ecology

There will be no impact on the freshwater ecology due to the project. There are no permanent water bodies or active rivers or streams nearby.

2.2.5 Marine Ecology

Following the Presidential Proclamation No. 2146, series of 1981, the Project will traverse areas considered as ECA as discussed in **Section 2.1.1** and **Table 2.4**, however not under NIPAS as cleared by CENRO Panabo (**Annex H**).

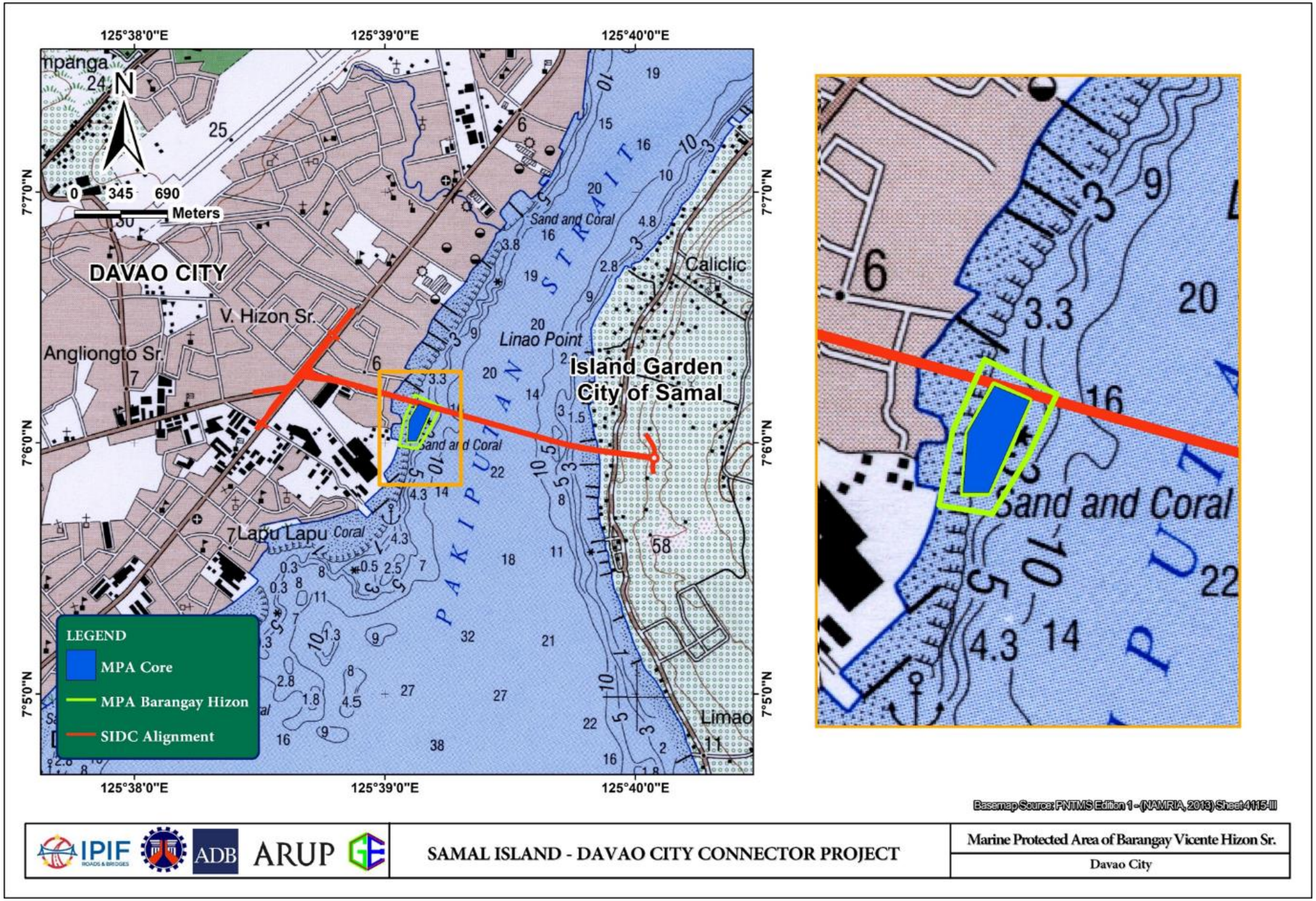
According to the assessment, the alignment runs at the side of a barangay-level declared Marine Fish Sanctuary Area. This 2.7 hectares area was declared through Barangay Ordinance No. 06 series of 2013, among the seven proposed MPA's in Davao City, however found the smallest area (**Figure 2.106**).

The MPA is on a barangay level and is not declared under any City Ordinances. As consulted with a representative from World Wildlife Fund (WWF), he mentioned that the MPA in Barangay Hizon only has soft corals that are anchored on a man-made reef consisting of car tyres and that there are no fishes around the MPA found with economic value. The representative also advised the team to consult the barangay and the people about this concern. A letter to Barangay Hizon's Captain was submitted on October 2019 requesting for the Barangay Resolution, interposing no objection/ Endorsement Resolution of the Project. The Barangay Resolution of Interposing no Objection of the Project was granted on 21 November 2019 (**Annex I**).

A preliminary coordination with DENR coastal was also conducted and found that building a pier in that area can be managed since the current direction is going towards south of Davao Gulf, thus will still not greatly affect the MPA. In addition, based on aerial map provided in **Figure 2.107**, the barangay level declared marine fish sanctuary is surrounded by industrial and commercial areas (i.e. beach resorts), which validates that recreational and industrial activities near the marine fish sanctuary is present in the area. Hence, if the said area is an MPA, the area should not be used for recreational activities, including fishing.

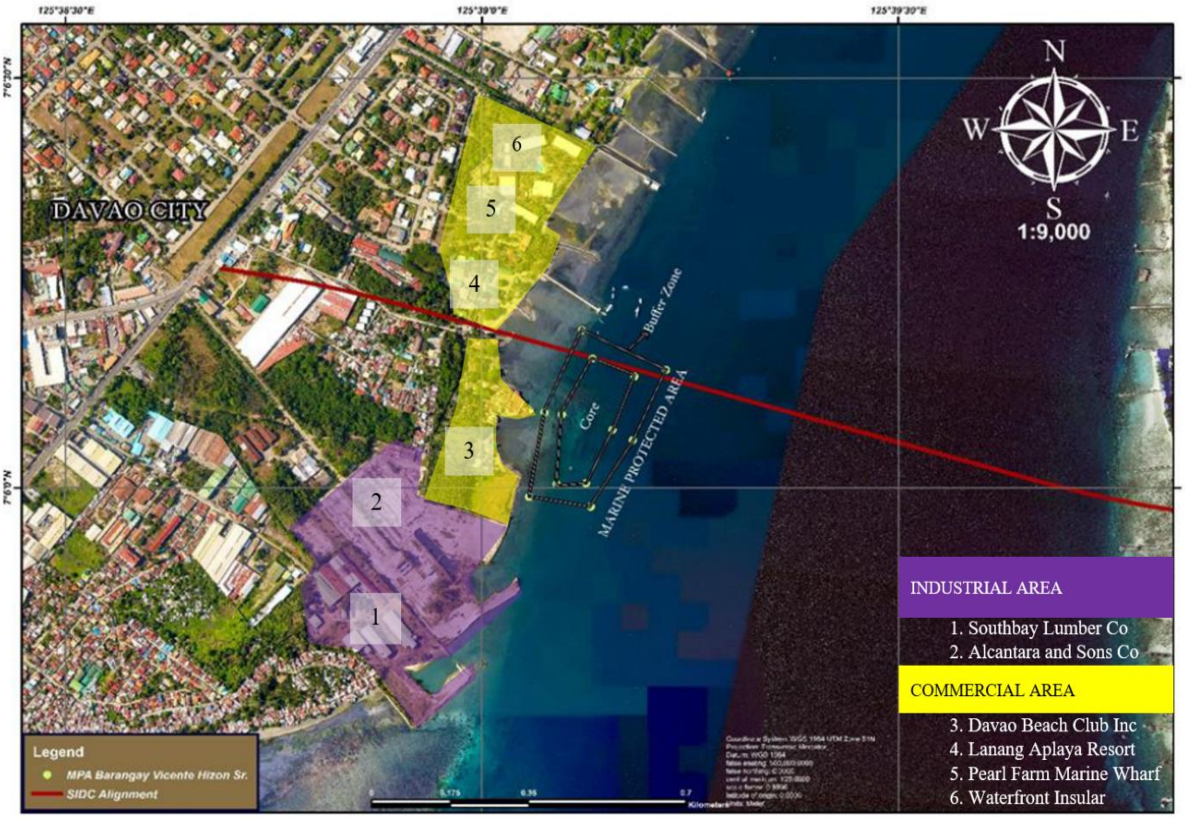
The MPA has not yet been confirmed to be part of the local government's enlisted protected areas and is not part of the protected areas as defined by the expanded National Integrated Protected Areas System (ENIPAS). However, the MPA of Barangay Hizon is currently proposed to be included in the next Comprehensive Land-Use Plan (CLUP) of Davao City. Nevertheless, and after an intensive environmental assessment and consultations with community stakeholders, the said MPA will be relocated to another new area that is not susceptible to possible degradation and disturbance. Thus, the land to be occupied may be said to be compatible with and effectively capable of accommodating the project.

To validate the existing condition of the area, a marine baseline assessment was carried out on 25-29 June 2019 and 6-7 December 2019. Submerged coastal habitats, such as coral reefs including the reef-associated fishes, were assessed in areas that may potentially be affected by the proposed project. These benthic ecosystem were surveyed using photo-transect for corals, transect-quadrat method for seagrasses and fish visual census (FVC) technique for reef fishes.Standard assessment methodologies were utilized and discussed in succeeding sections.



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS 84; Source: Local Government Bureau of Fisheries and Aquatic Resources

Figure 2.106 Marine Fish Sanctuary



Source: Google Earth, January 2019

Figure 2.107 Vicinity map of barangay level marine fish sanctuary

2.2.5.1 Seagrass Assessment

This marine assessment for seagrass aims to gather information on the seagrass species composition, cover, and density at the vicinity of the proposed sites and to provide recommendations to mitigate any adverse changes that may occur. Surveys were initially conducted on 28-29 June 2019, followed by additional surveys on 6-7 December 2019 to extend sampling area.

Methodology

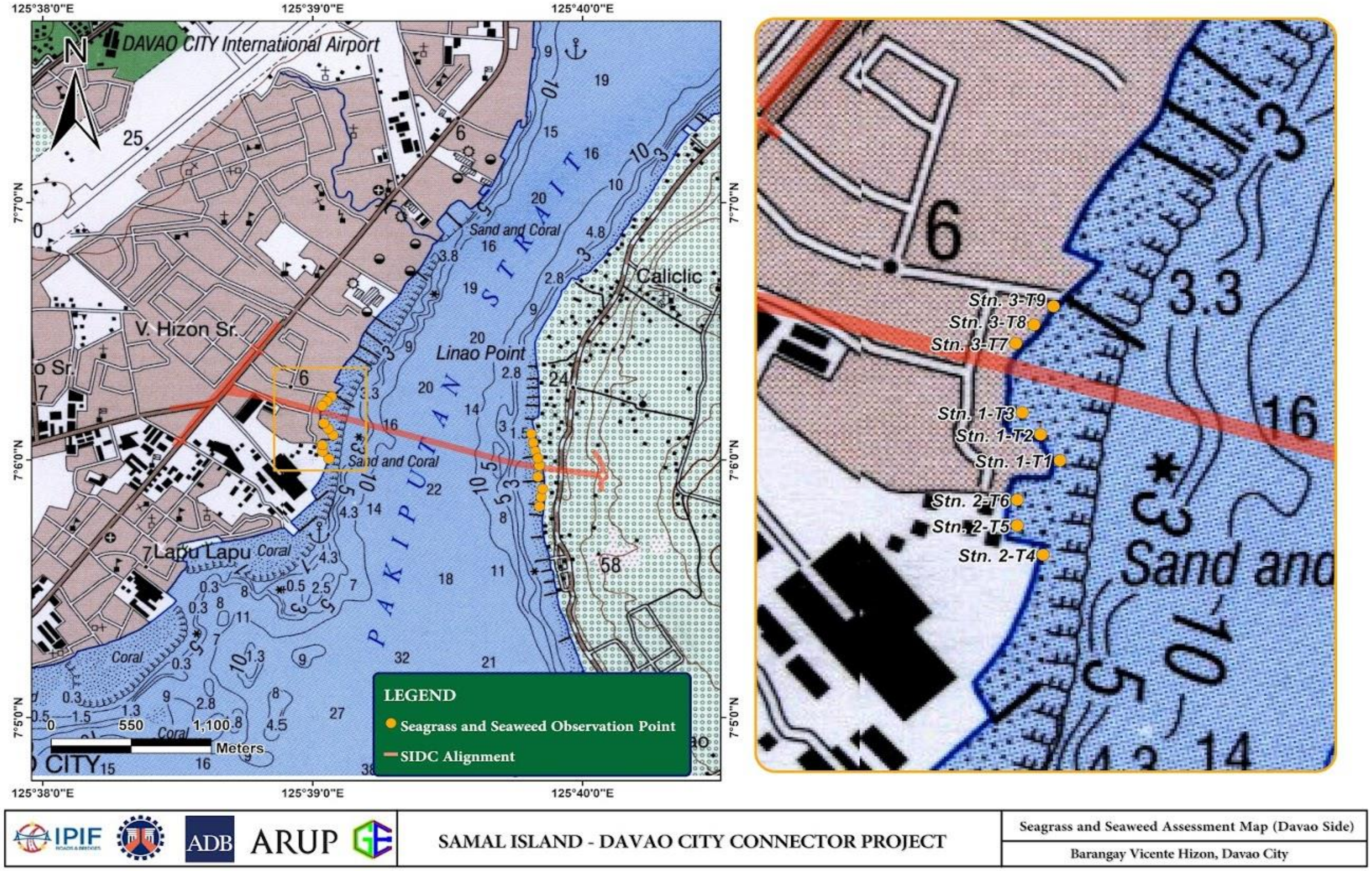
The seagrass and seaweeds assessment covered 3 stations with 9 points at the Davao side and 3 stations with 9 points at the Samal side, along the general location of sites for the proposed bridge (**Table 2.30**).

A 50 meter transect was laid perpendicular to the shore starting at the point near the beach, where seagrass was first seen (Duarte and Kirkman 2001, Short et al. 2006). Each quadrat of 0.5m x 0.5m, or 0.25 m^2, was stationed every 10-meter intervals. The data collected includes the type of substrate, seagrass species composition, seagrass canopy cover, percent total cover and per species, estimated according to photo guides (Seagrass Net Manual, Short et al., 2002), shoot densities of each species as well as the genus-level identification of seaweeds. Proper documentation was observed during sampling, ensuring depth and invertebrates were also recorded (Koch & Verduin 2001).

All data were transcribed and later encoded and added to the database. **Table 2.30** summarizes the seagrass cover, species composition and habitat features extracted from each site and average of shoot density per species (shoots/m^2) were calculated (Duarte & Kirkman 2001).

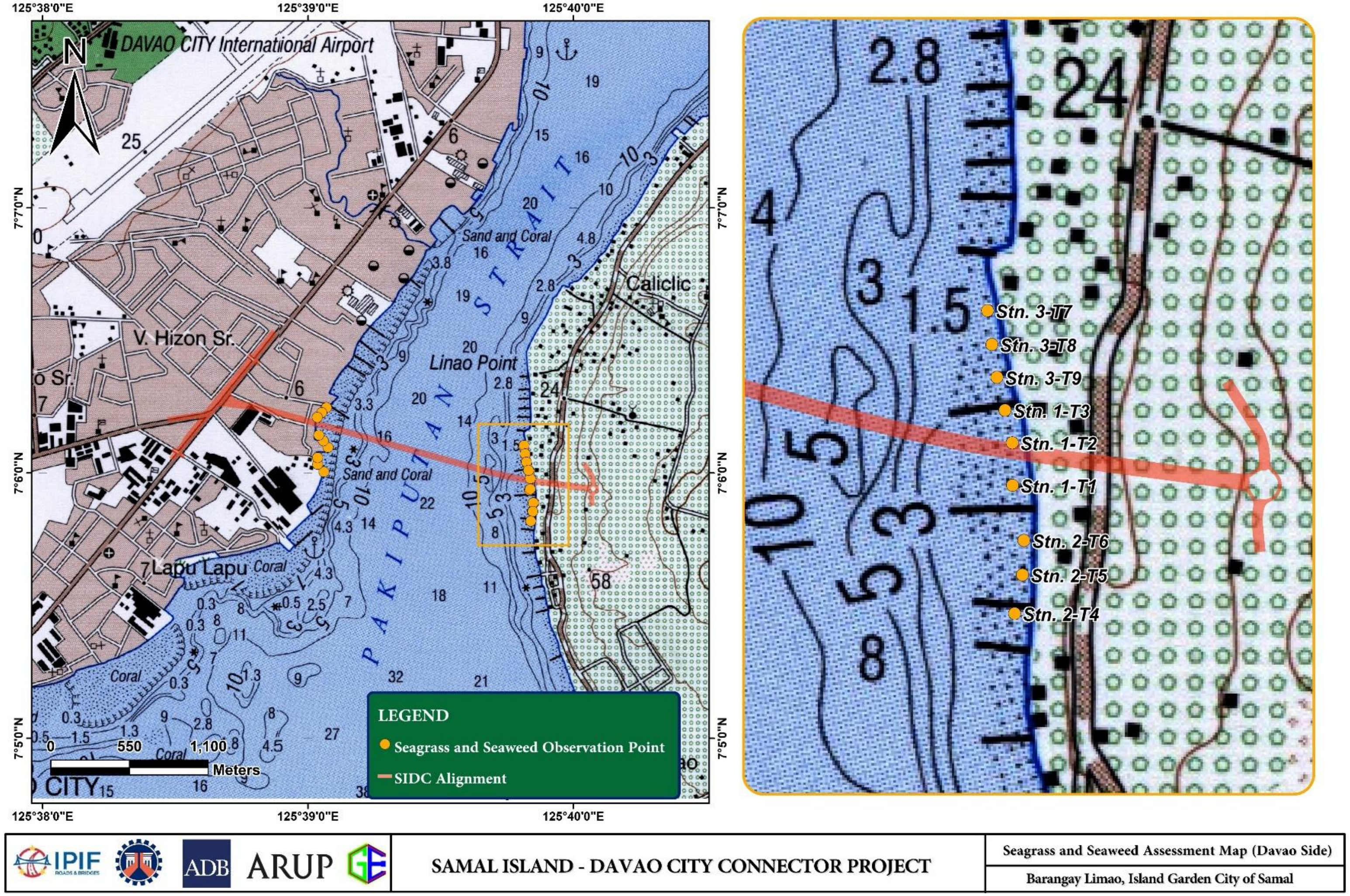
Table 2.30 Coordinates of seagrass areas surveys (WGS 84)

Location	Date	Station	Point	Coordinates	
Barangay Hizon, Davao City	June 28, 2019	1	1	7.10171	125.65100
			2	7.10219	125.65037
			3	7.10249	125.65034
		2	4	7.10008	125.65097
			5	7.10056	125.65058
			6	7.10097	125.65057
	Dec. 7, 2019	3	7	7.10278	125.65069
			8	7.10351	125.65098
			9	7.10382	125.65132
Barangay Limao, IGaCoS	June 29, 2019	1	1	7.09892	125.66388
			2	7.09964	125.66403
			3	7.10012	125.66390
		2	4	7.09699	125.66395
			5	7.09760	125.66406
			6	7.09814	125.66415
	Dec. 6, 2019	3	7	7.10319	125.66361
			8	7.10260	125.66326
			9	7.10224	125.6630



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III

Figure 2.108 Spots checked for seagrass in Barangay Hizon, Davao City



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III

Figure 2.109 Starting point of transect laid along Paradise Beach Resort and Costa Marina, Brgy. Caliclic, Babak District, Samal

Baseline Environmental Conditions

Davao City side

The survey carried out on 28 June 2019 was not productive due to water depth and turbidity. Underwater visibility at Stations 1 and 2 was very poor and only spot checks were conducted in Barangay Hizon. Another survey was conducted on 7 December 2019 at Station 3, where water was clearer and visibility was observed better.

Seagrass distribution was sparse and patchy at Stations 1 and 2, but at transect point 9 of Station 3, seagrass cover and density were higher. The water was quite deep at high tide condition over 1.5 meters deep and has poor underwater visibility at Stations 1 and 2, hence seagrass species were identified by collecting samples from the substrate. For the Davao site, a total of five seagrass species were observed, namely *Enhalus acoroides, Cymodocea rotundata, Halodule uninervis, Halodule pinifolia* and *Halophila ovalis*. Site attributes and observations are summarized in **Table 2.31**.

Station 1: Point 1 is near a compound, within an enclosed walls, with houses and videoke bar/resort. Some section of the wall however had already collapsed into the sea and was being repaired during the survey (**Figure 2.110**). Three seagrass species were seen: *Enhalus acoroides, Cymodocea rotundata* and *Halodule uninervis*. Points 2 and 3, however have no presence of seagrass (**Figure 2.111**). The substrate in these areas was predominantly composed of sand and silt with occasional rocks and some dead coral.

Figure 2.110 Point 1 near a videoke bar/ resort with poor water visibility, 28 June 2019

Figure 2.111 Point 2-3 near resort with very turbid water, 28 June 2019

Station 2: Points 4, 5 and 6 were located near Azuela Cove (**Figure 2.112** and **Figure 2.113**). Point 4 was not allowed to be surveyed, since the survey team was asked to move 50 meters away from the survey point, yet observed with poor water visibility. Points 5 and 6 are adjacent to houses and boats were observed docked on the beach. Seagrass distribution was also sparse and patchy, with a total of four seagrass species noted, namely *Cymodocea rotundata, Halodule uninervis, Halodule pinifolia* and *Halophila ovalis*. Rhizomes of the seagrass, a horizontal stems that help bind the plant to the bottom, were observed exposed, possibly caused by the wave action on the loose sand in the area.

Figure 2.112 Point 4 near the construction site of Azuela Cove with very turbid water

Figure 2.113 Point 5-6 near houses and docking area with turbid water

Station 3: During the site assessment on December 2019, it was observed that water visibility was much better than the first visit. The mean total seagrass cover in Station 3 was 24% this was comprised of *Cymodocea rotundata*, *Halodule uninervis*, and *Halophila ovalis* (**Figure 2.114**).

Figure 2.114 At Station 3, showing Point 8 (*top*) and Point 9 (*bottom*), near resorts and residential houses, and with clearer water, 7 December 2019

Table 2.31 Summary of attributes at Barangay Hizon Davao site

Station	Point	Substrate	Depth (m)	Underwater Visibility	Seagrass	IUCN Status 2020	Observations/ remarks
1*	1	sand, silt, rock	1-1.5	Poor (visibility 1 ft)	*Enhalus acoroides*	Decreasing -Least Concern	Near seawall, patchy distribution
					Cymodocea rotundata	Stable- Least Concern	
					Halodule uninervis	Stable- Least Concern	
	2	sand, silt with dead coral	0.5-1		none	---	~50m from Davao 1 point
	3	fine sand, silt	1-1.5		none	---	Near fenced residence
2*	4	sand, rock	1.5-2	Poor (visibility 1 ft)	not examined	---	No site access
	5	gray sand, silt	0.5-1		*Halodule uninervis*	Stable- Least Concern	Beside wall boundary of Azuela and houses & docking area of boats
					Halodule pinifolia	Decreasing -Least Concern	
	6	sand, silt, rock, dead coral	0.5-1		*Halodule uninervis*	Stable- Least Concern	Sparse and patchy; rhizomes are exposed
					Halodule pinifolia	Decreasing -Least Concern	
					Cymodocea rotundata	Stable- Least Concern	
					Halophila ovalis	Stable- Least Concern	
3	7	sand, silt, rock	0.5-1	Good	none	---	Near resorts and residential houses
	8	sand, silt, rock, coral rubble	0.5-1	Good	*C. rotundata*	*H. ovalis*	Near resorts and residential houses
	9	sand, silt, rock, coral rubble	0.5-1	Good	*C. rotundata*	Stable- Least Concern	Near resorts and residential houses
					H. uninervis		
					H. ovalis		

*Note: High tide at time of survey

Table 2.32 Estimated percent seagrass cover in a 0.25m^2 quadrat at Station 3 for Davao site, 7 December 2019

Station	Transect Point	*Cymodocea rotundata*	*Halophila ovalis*	*Halodule uninervis*	Total seagrass cover (%)
3	7	0	0	0	0
	8	14	0	0	14
	9	32	3	22	57
	Mean	**15**	**1**	**7**	**24**

IGaCoS side

Underwater visibility was better on the IGaCoS side. The areas assessed cover popular tourist spots hence many tourists were swimming, doing water sports and having picnics at the beach during the time of survey (**Figure 2.115** and **Figure 2.116**). The survey carried out on 29 June 2019 at Stations 2 and 3 in Barangay Limao, while at Station 1 survey was conducted on 6 December 2019.

Figure 2.115 Jet skis and banana boats seen at the Paradise Beach Resort, 29 June 2019

Figure 2.116 Picnic tables and people at the Costa Marina beach resort, 29 June 2019

Based on this assessment, it was noted that the seagrass beds were located in the intertidal area, exposed at low tide and submerged at high tide to a depth of over one meter. Three transects were laid at Station 1(Points 1 to 3) and at the beach front of two resorts, Costa Marina (Points 4 to 6, **Figure 2.118**) and Paradise Beach Resort (Points 7 to 9, **Figure 2.119** to **Figure 2.120**), for a total of nine transect points. For the IGaCoS site, a total of four seagrass species were observed, namely *Cymodocea rotundata*, *Thalassia hemprichii*, *Halodule uninervis* and *Halophila ovalis*. Seagrass cover and density per species and other attributes are summarized in **Table 2.33** and **Table 2.34**.

Station 1: At transects points 1 to 3, the mean seagrass cover was quite low at only 10% with mean shoot density at 262 shoots/m^2 (**Figure 2.117**).

Figure 2.117 At Station 1 – no seagrass at Transect 1 (*left*); Cymodocea rotundata inside a 0.25 sqm quadrat (*right*)

Station 2: Transect points 4 to 6 were observed to have a mean seagrass cover lower than in Transect points 1 to 3 with only 25% and shoot density at 196 shoots/m^2. In this area, seagrass grew mostly on a substrate of white sand with some rock and coral rubble (**Figure 2.118**).

Figure 2.118 At Costa Marina Beach Resort, where water is much deeper at high tide (waist-deep) (*top left*) and underwater seagrass being examined within a quadrat (*top right*); wider view of seagrass underwater and the deep end (*bottom*)

Station 3: At transect points 1 to 3, it was observed that seagrass grew on a substrate of white sand, rock, coral rubble and in some areas with silt and mud. Mean seagrass cover at this area was 50% with mean density of 378 shoots/m^2. Sea cucumbers or *balat* and *Synapta sp.* and peanut worm were some of the invertebrates observed (**Figure 2.120**).

Figure 2.119 Transects at Paradise Beach Resort, 29 June 2019

Figure 2.120 Seagrass being examined inside a quadrat (*top left*), and invertebrates seen include *Synapta sp*. (*top right*), sea cucumber or balat (*bottom left*) and peanut worm (*bottom right*) at Paradise Beach Resort, 29 June 2019

Table 2.33 Estimated percent seagrass cover in a 0.25m^2 quadrat for IGaCoS site

Station	Transect point	Substrate	Depth* (m)	*Cymodocea rotundata (%)*	*Thalassia hemprichii (%)*	*Halodule uninervis (%)*	*Halophila ovalis (%)*	Total seagrass cover (%)
1: Samal	1	Sand, silt, rock, coral rubble	0.5	0	0	0	0	0
	2		0.6	4	0	9	6	19
	3	Sand, silt, mud	0.8	2	0	4	4	10
	Mean		**0.6**	**2**	**0**	**4**	**3**	**10**
2: Costa Marina, Samal	4	Sand, rock, coral rubble	0.6	23	5	0	3	30
	5		1.0	26	6	0	0	32
	6	Sand, rock, coral rubble, silt	1.5	5	9	0	0	14
	Mean		**1.0**	**18**	**6**	**0**	**1**	**25**
3: Paradise Beach Resort, Samal	7	Sand, silt, rock	0.1	26	9	0	1	36
	8	Sand, rock, coral rubble	0.4	38	24	0	1	63
	9		0.4	39	11	0	1	51
	Mean		**0.3**	**34**	**15**	**0**	**1**	**50**

*Survey conducted on 29 June 2019 in the morning was at low tide (T7-T9); high tide in the afternoon (T4-T6)

Table 2.34 Seagrass density (number of shoots/m^2) at IGaCoS

Station	Transect points	*Cymodocea rotundata*	*Thalassia hemprichii*	*Halodule uninervis*	*Halophila ovalis*	Total number shoots/sqm	Observations/ remarks
1: Samal	1	0	0	0	0	0	*Some seaweeds (Padina sp.)*
	2	97	0	359	58	515	
	3	22	0	215	33	271	
	Mean	**40**	**0**	**192**	**31**	**262**	
2: Costa Marina, Samal	4	244	22	0	28	68	
	5	202	24	0	0	226	
	6	35	33	0	0	294	*Synapta*; some seaweeds (*Padina*)
	Mean	**160**	**26**	**0**	**9**	**196**	
3: Paradise Beach Resort, Samal	7	259	51	0	5	315	Invertebrates: Sea cucumber, *Synapta*, peanut worm
	8	282	151	0	4	437	Brown algal mat on seagrass; seaweeds (*Galaxaura sp.*, *Actinotrychia sp.*)
	9	307	61	0	13	381	Thick algal mat on seagrass; seaweed (*Padina sp.*)
	Mean	**283**	**88**	**0**	**8**	**378**	

Seagrasses were seen along the vicinity of the proposed of the SIDC project. Sampling done in Barangay Hizon, Davao City has encountered with five species (*Enhalus acoroides*, *Cymodocea rotundata*, *Halodule uninervis*, *Halodule pinifolia* and *Halophila ovalis*), however distribution was very patchy and sparse. In Barangay Limao, IGaCoS, there were four species seen (*Thalassia hemprichii*, *C. rotundata*, *H. uninervis* and *H. ovalis*) but seagrass cover was denser and covered a larger area compared to that seen in the Davao side.

A total of six (6) seagrass species from two (2) families were recorded in Davao and Samal stations. All of these species are of Least Concern based on IUCN Red List of Threatened species (**Table 2.35**). The seagrass population trend of all species is stable, with the exception of *Enhalus acoroides* which shows a decreasing population (Short et al., 2011).

Table 2.35 Seagrass Red List category of Davao and Samal station (Short et al., 2011).

Species	Common Name	Family	Red List category	Pop. Trend
Enhalus acoroides	Eel grass	Hydrocharitaceae	Least Concern	Decreasing
Cymodocea rotundata	Ribbon seagrass	Cymodoceaceae	Least Concern	Stable
Halodule uninervis	Narrowleaf seagrass	Cymodoceaceae	Least Concern	Stable
Halodule pinifolia	Needle seagrass	Cymodoceaceae	Least Concern	Stable
Halophila ovalis	Spoon seagrass	Hydrocharitaceae	Least Concern	Stable
Thalassia hemprichii	Sickle seagrass	Hydrocharitaceae	Least Concern	Stable

Seagrass habitat will be heavily affected particularly in those areas wherein the marine viaducts will be constructed. In terms of area that will be affected, the likely loss of seagrass habitat in the IGaCoS side is estimated to be at around 7,484 square meters whereas in Davao City, there is no seagrass directly affected in AOI.

Conditions for seagrass growth seem to be better in the Samal area as compared to Davao, where there were numerous houses and establishments along the coast that most probably emit sewage, waste and other pollutants into the surrounding sea. Water was observed quite turbid, and garbage and trash were found floating in the area during survey in the Davao side. The area is a busy navigation area, where boats and ships were observed passing back and forth, hence may be the reason for lesser seagrass growth in the area. Sedimentation and eutrophication are the two main causes of seagrass loss and decline.

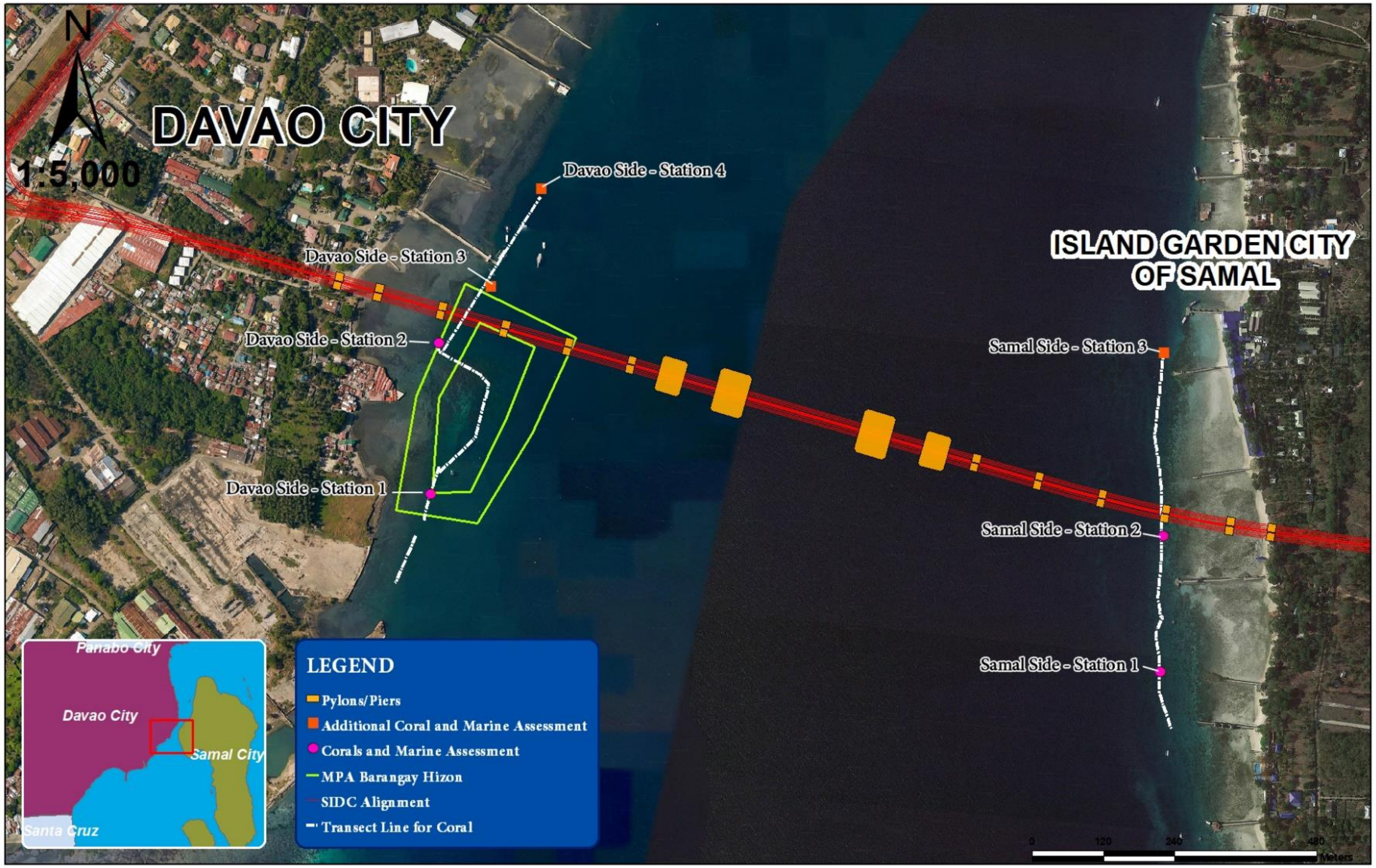
In comparison, the area in IGaCoS is cleaner. This has been evident as IGaCoS is presently popular for tourism, hence the area has been properly maintained. With few houses along the coast, the water is clearer and numerous invertebrates, especially sea cucumbers, were obseerved in the seagrass bed.

2.2.5.2 Corals and Marine Assessment

Methodology

Sampling station

Benthic ecosystem surveys were conducted using photo-transect for corals and fish visual census (FVC) technique for reef fishes. Seven (7) stations were established as shown in **Table 2.36** and **Figure 2.121**.



IPIF ADB ARUP	SAMAL ISLAND - DAVAO CITY CONNECTOR PROJECT	Coral and Marine Assessment Sites for SIDC
		Davao City and IGaCos

Source: Google Earth, February 2020

Figure 2.121 Map showing the transect location in Barangay Vicente Hizon, Davao City and Barangay Limao, Samal City

Table 2.36 Location and depth of the survey stations in Barangay Vicente Hizon, Davao City and Barangay Limao, Samal City.

Station	Coordinates (WGS 84)		Transect depth (in)	Transect length (m)	No. of Transect	Method
	Latitude	Longitude				
DAVAO						
Station 1	7.100059	125.651475	4	50	3	FVC/PIT
Station 2	7.102327	125.651595	4	50	3	FVC/PIT
Station 3	7.103050	125.652074	4	50	3	FVC/PIT
Station 4	7.104570	125.652650	4	50	3	FVC/PIT
IGaCoS						
Station 1	7.097391	125.662960	6	50	3	FVC/PIT
Station 2	7.099942	125.662593	7	50	3	FVC/PIT
Station 3	7.102725	125.662772	7	50	3	FVC/PIT

Note: FVC=Fish Visual census, PTT=Photo-transect Technique

Benthic Coral Community

Detailed coral reef assessment was conducted using the Photo-transect technique (PTT) method (Vergara and Licuanan, 2007). Aside from facilitating the conduct of the survey and providing a permanent record of benthic cover, the PTT was accurately used in detecting changes on the reef through time as this method is ideal for long term monitoring of coral reefs (Leujak and Ormond, 2007). The advantages of using the PTT method in coral reef assessment have been extensively discussed in the works of Vergara and Licuanan (2007) and Leujak and Ormond (2007).

In the survey, transects were deployed depending on the morphology and depth of the reef. Usually, transects are laid at the reef slope or reef edge. For each transect, digital photographs were taken at 1-meter intervals and using a camera to substrate distance of about 1-meter. The consistency of the camera distance to the substrate was ensured using a stainless distance bar with a camera mounting provision. The camera is set at full wide angle to capture the largest possible area of the substrate. Photographs were refined using the ADOBE Photoshop software. Ten points were superimposed in the image using the same program (**Figure 2.122**). In each of these points, life forms and hard coral genus intercepted were recorded and scored. For the life form identification, the standard 28 benthic lifeform categories of English et al. 1997 was used.

Percent cover was computed using the following equation:

$$\textbf{\textit{Percent cover (\%)}} = \frac{\text{Total number of points per life form}}{\text{Total number of points per transect}} \times 100\%$$

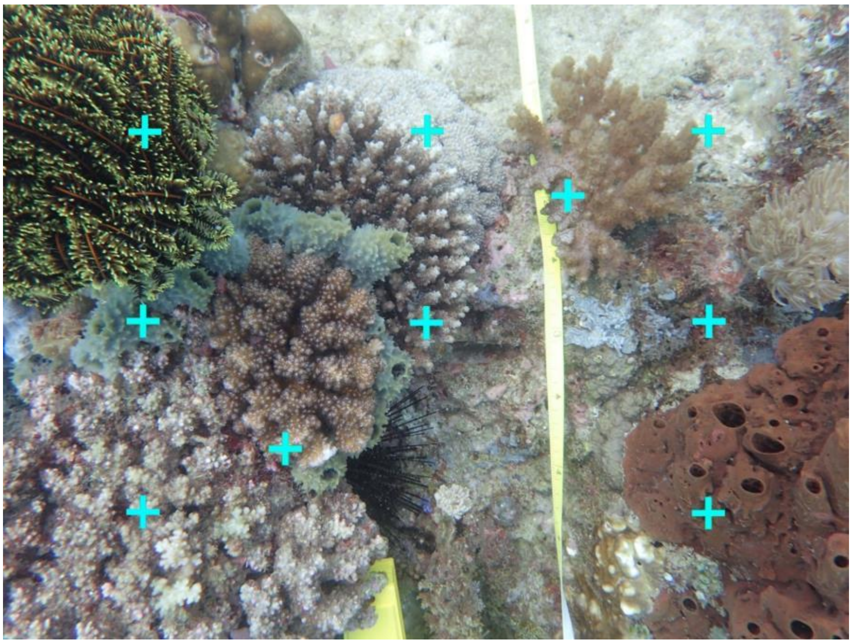


Figure 2.122 A sample photo-transect frame superimposed with ten (10) points for benthic identification and scoring.

Curently, there are two coral indices established for reef health classification in the Philippines. The quartile index established by Licuanan et.al, 2017 looks into the proportion of living hard corals was compared relative to other benthic components (e.g., dead coral, soft coral, algae, rubble, etc.). Gomez et al., 1981 on the other hand, compares the proportion of living corals (hard coral + soft coral) relative to other benthic components (e.g., dead coral, soft coral, algae, rubble, etc.). Both are adopted in this report. however Licuanan et.al, 2017 is widely used by the DENR for the EIA and coral reef assessment. Coral reef health classification is summarized in **Table 2.37**.

Table 2.37 Coral reef classification

Source	Poor	Fair	Good	Excellent
Live Coral Cover (LCC) from Gomez and Alcala (1979) and Gomez et al. (1981)	0-24.9%	25-49.9%	50-74.9%	75-100%
Hard Coral (HC) from Licuanan et al (2017)	0-22%	23-33%	34-44%	>44% cover

Reef fish Community

Fish Visual Census (FVC) technique was used to determine the species diversity, abundance and biomass in the different sites surveyed (English et al., 1997). This procedure was done on the same transect laid for the coral survey. After the line had been laid, observers waited for about 5 to 10 minutes before the actual census to allow for the disturbed fish community to return to their normal behavior. Starting at one end of the line, all fishes within a 5m x 10m imaginary quadrat were identified up to species level whenever possible and their numbers and estimated sizes were recorded. Observers swam to and briefly stopped at every 5-meter mark along the line until the transect line was completed. The faster moving fishes were counted first before the slower ones. Each transect covers an area of 500m^2 (50m length x 10m width). All fish sizes were estimated to the nearest centimeter using the total length (TL). All fishes observed were grouped into three (3), i.e. (1) target, (2) coral indicator and (3) major species. *Target* species is the commercially important species, coral indicator species is coral-associated, and major species are those that belong to non-commercially important species. Fish density and biomass were then computed using *ReefSum* formula (Uychuaoco, 2000).

Fish biomass is based from the relationship,

$$\mathbf{W=}\boldsymbol{a}\mathbf{L^b},$$

where, *W* is the weight in grams, *b* are growth coefficient values taken from published length-weight data and *L* is the length of the fish in cm (English et al., 1997).

Fish abundance will be expressed in terms of individuals per 500m^2, while biomass is extrapolated to MT/km^2, which is also equivalent to g/m^2.

Table 2.38 Species richness categories adapted from Hilomen et al. (2000).

Category	**No. of species per 1,000m^2**
Very poor	0 – 26
Poor	27 – 47
Moderate	48 – 74
High	75 – 100
Very high	>100

Table 2.39 Fish abundance categories as adapted from Hilomen et al. (2000).

Category	**No. of individuals per 1,000m^2**
Very poor	0 – 201
Poor	202 – 676
Moderate	667 – 2267
High	2268 – 7582
Very high	>7592

Table 2.40 Fish biomass categories adapted from Nañola et al. (2006).

Category	**Biomass (MT/ km^2)**
Very low	<5
Low	6-10
Medium	11-20
High	21-40
Very high	>41

Plankton and Marine Macroinvertebrates

The sampling program is based on the areas covered by the map presented in **Figure 2.123**. The geographic coordinates of each of the stations were taken using Garmin Venture HC etrex with the position format of hours-minutes-seconds (hdddºmm'ss.s). **Table 2.41** shows the coordinates and descriptions of the Plankton and Macroinvertebrates sampling stations.

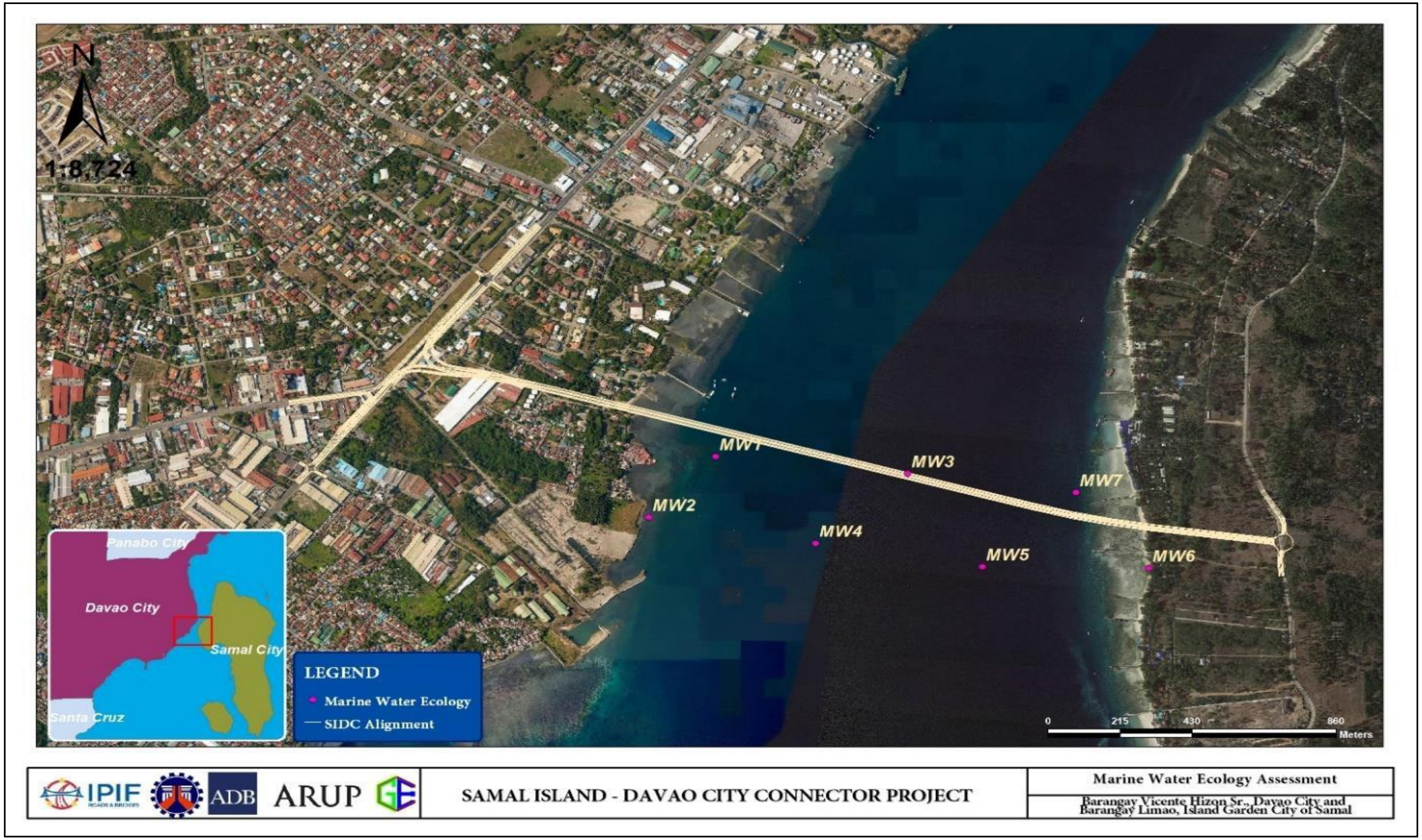
A total of seven (7) sampling stations were conducted to assess the plankton abundance, diversity and richness last 15-16 June 2019. Vertical samples were taken at each station by hauling 25-cm mouth diameter conical plankton with 20 microns mesh size for phytoplankton. For zooplankton samples, a 60 micron mesh net was utilized. Collection was done by pulling the mesh net through the water starting near the bottom and then through the water up to the surface. This was done so as to minimize the effect of variations brought about by diurnal migration of plankton (Jillett, 1971; Estudillo, 1979). In this manner, all levels of the water column were sampled. The sampling depth per station was recorded to be used to estimate the volume of water filtered by the net during each haul. For phytoplankton samples, Lugol's solution was used as preservative and allowed to settle in the laboratory. After settling, phytoplankton samples were decanted and placed in a Sedgewick-Rafter counting chamber. Samples were identified and enumerated using the inverted microscope. Organisms are identified down to the lowest taxonomic level. Species counts are expressed as cells per cubic meter (cells/L).

Zooplankton samples, on the other hand, were preserved with 10% neutral formalin. Dye was added to facilitate sorting and identification. The preserved samples were identified, enumerated, and counted in the laboratory using a stereomicroscope. Identification was done down to the lowest practical taxonomic level. Results were expressed in number per cubic meter (no./m^3).

Diversity, species richness and evenness were computed using a Primer E software. Photomicrographs of the most dominant organisms were also done for documentation purposes. **Figure 2.124** shows the conventional plankton net used during the sampling.

Table 2.41 Plankton and Macroinvertebrates sampling stations

Station	Location	GPS Coordinates (WGS 84)
MW1	Front of Lanang Aplaya Beach Club, Brgy. Vicente Hizon Sr., Davao City	7° 6'6.02"N 125°39'9.57"E
MW2	Near Azuela Cove, Brgy. Vicente Hizon Sr., Davao City	7° 5'59.25"N 125°39'3.11"E
MW3	Deep Station, Pakiputan Strait, Davao City	7° 6'4.11"N 125°39'28.13"E
MW4	Deep Station, Pakiputan Strait, Davao City	7° 5'56.32"N 125°39'19.22"E
MW5	Deep Station, Pakiputan Strait, Brgy. Limao, Samal Island	7° 5'53.69"N 125°39'35.36"E
MW6	Costa Marina Resort, Brgy. Limao, Samal Island	7° 5'51.74"N 125°39'45.19"E
MW7	Paradise Island Resort, Brgy. Caliclic, Samal Island	7° 6' 2.0"N 125°39'44.4"E



Source: Google Earth, March 2020

Figure 2.123 Sampling Stations for Plankton and Marine Macroinvertebrates


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Figure 2.124 Conventional plankton net used in the collection of plankton samples

Marcoinvertebrates survey, on the other hand, was intended to evaluate the benthic community in the area with respect to its composition, density and relative abundance. Replicate samples were obtained from locations consistent with the stations of plankton survey stations using a portable grab sampler covering an area of 0.0225 m^2 aboard a motorized boat. The benthic samples were taken with a portable gravity grab sampler deployed over the side of the boat. The grab sampler was lowered through the water column with the jaws open and locked. The motorized boat was anchored at each sample location, and sample positions were recorded using a Global Positioning System (GPS) unit.

Benthic samples were then placed in a pre-labeled plastic bag. The grab samples for faunal analysis were fixed immediately with 10% formalin, stained with Rose Bengal and brought to the laboratory for analysis. In the laboratory, the samples were wet sieved using different openings. The collected samples were further sorted and identified in the laboratory using a dissecting microscope and readily available taxonomic keys. Benthic macroinvertebrates in each sample were identified down to the lowest practicable taxonomic level and enumerated as much as possible. Quantities are expressed as numbers of individuals per square meter (individuals/m^2). **Figure 2.125** shows the portable ponar grab sampler used in the collection of benthic macroinvertebrates samples.

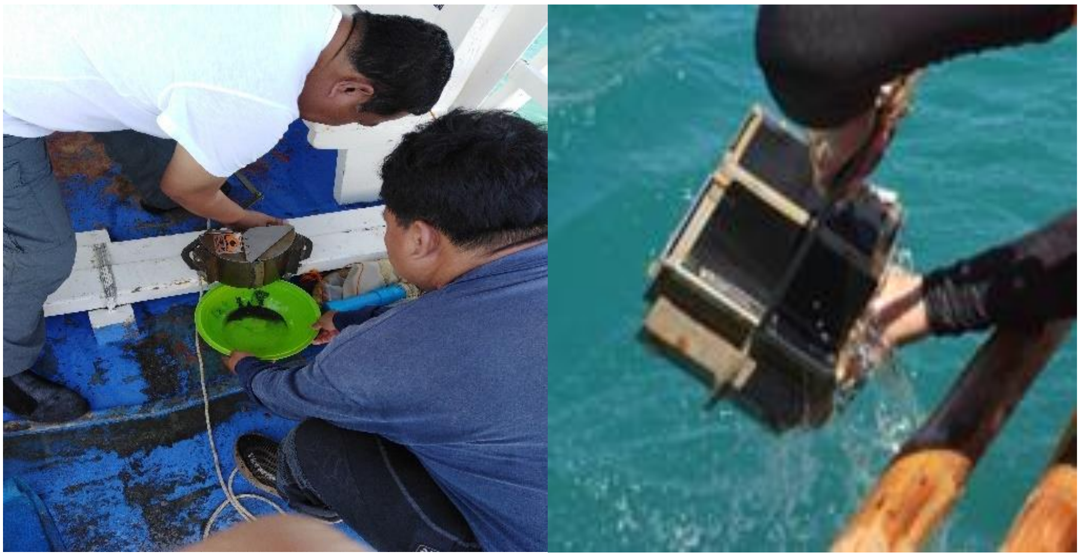


Figure 2.125 A portable ponar grab sampler used in the collection of benthic macroinvertebrates samples.

Plankton and Macroinvertebrates Data Processing and Analyses

Ecological condition indicators were computed for each sampling station using the formulas below.

Dominance

The dominant species for each site were determined based on the importance value (IV). IV is the sum of the relative density, relative frequency, and relative dominance. These were computed using the following formula:

Density = $\frac{\text{Total number of individuals counted for a given species}}{\text{Total area sampled}}$

Relative density = $\frac{\text{Total number of individuals of a given species}}{\text{Total number of individuals of all species}} \times 100$

Dominance = $\frac{\text{Total area covered by a given species}}{\text{Total area sampled}}$

Relative dominance = $\frac{\text{Total coverage of a species}}{\text{Total coverage of all species}} \times 100$

Frequency = $\frac{\text{Number of plots where a given species occurs}}{\text{Total number of plots in the site}} \times 100$

Relative frequency = $\frac{\text{Frequency of a given species}}{\text{Total frequency of all species}} \times 100$

Importance Value = Relative density + Relative dominance + Relative frequency

Species Diversity and Abundance

On the other hand, species diversity indices were computed using the following formula:

Shannon-Weiner diversity index (H’)

$$\mathbf{H' = -\Sigma p_i \ln p_i}$$

where: p_i, the proportional abundance of the *i*th species = (n_i/N)

Evenness (J) of the species was calculated using the formula:

$$J = H'/\ln S$$

where: S, number of species in a stand

Pielou's Evenness

$$J = H/H_{max} = -[\sum(pi)(\ln pi)]/\ln S$$

where: J – represents the symbol for the species richness

H – species diversity

H_{max} – species maximum diversity

S – number of species in the community

The interpretation of the values obtained using the above formulas were based on the Fernando Biodiversity Scale, 1998 shown in **Table 2.42**.

Table 2.42 The Fernando Biodiversity Scale, 1998

Relative Values	Shannon Biodiversity (H') Index	Pielou (J') Evenness Index
Very High	3.5 and above	0.75-1.00
High	3.0 – 3.49	0.50-0.74
Moderate	2.5 – 2.99	0.25-0.49
Low	2.0 – 2.49	0.15-0.24
Very Low	1.9 and below	0.05-0.14

Baseline Environmental Conditions

2.2.5.2.1 Benthic Coral Community Assessment

Barangay Vicente Hizon, Davao (Station 1)

Station 1 is located at narrow and shallow reefs. The area has poor visibility, due to its proximity to populated areas. Based on the survey, the average hard cover is in poor condition (HC = 7.5%, Licuanan et al., 2017). Soft corals still comprise a higher proportion (12.7%) compared to hard coral cover. Among the hard coral, Acroporidae (i.e. *Acropora* sp.) dominated the reefs. Other conspicuous non-acroporids coral life form genera were *Euphyllia*, *Fungia*, *Porite*s, & *Pocillopora*. Other noticeable fauna species were sponges (Barrel sponge), sea anemone and ascidians. Algal assemblages (i.e. AA) and loose abiotic components (e.g. rubble and silt) contributed more than half of the benthic cover.

Barangay Vicente Hizon, Davao (Station 2)

The hard-coral cover (HC) at Station 2 is 10.3%, which is considered as *poor* condition based on the category of Licuanan et al., 2017. However, a higher proportion of soft corals (49.8%) were recorded indicating a *good* condition based on Gomez et al. About eight percent (7.5%) of hard coral belong to Acroporidae family (*Acropora* & *Montipora* genera) and less of non-acroporids (2.8%, i.e. *Goniopora*, *Fungia* and other faviids). Some life forms genera observed were massive *Lobophyllia*, *Symphyllia* and sub-massive *Pocillopora*. Other fauna recorded was low cover (2%) include sponges, feather stars and sea stars. Abiotic components include silt and rubble was apparent in this station (27.8%). Seagrass species was also recorded i.e. *Halophila ovalis* & *Enhalus acoroides* species.

Barangay Vicente Hizon, Davao (Station 3)

The reef is narrow and shallow fringing type. Mean hard coral cover is classified as *poor* condition (7.4%) which is dominated by the *Acropora* corals (4.6%) and live coral cover (LCC) is under *fair* condition. Other conspicuous hard corals were massive *Porites*, *Goniopora*, foliose *Pectinia* and encrusting *Montipora*. Other conspicuous coral were *Favites*, *Leptastrea* and *Favia*. Sponges are among dominant other fauna recorded in the survey (**Table 2.43**, **Figure 2.126**).

Barangay Vicente Hizon, Davao (Station 4)

This station is generally sandy-silt fringing reef to about 20m seaward. The reef is shallow with steady sloping up 6m depth. The reef is generally sheltered with low reef complexity. Based on the results, the average hard coral cover is low (6.8%) which considered as poor condition. Whereas the LCC is considered fair when the soft coral is also assessed. Branching *Acropora*, *Pocillopora* and massive *Porites* were the dominant coral life forms genera. Some life forms observed were mostly foliose *Montipora*, massive *Favites* and *Favia*. Other benthic attributes are other fauna, such as sponges and gorgonian were recorded. Abiotic component such as rubble and silt were apparent in this station (**Table 2.43**, **Figure 2.126**).

Generally coral reefs in Davao side are relatively silted, narrow and shallow, extending from shore to about 20 to 150 meters seaward at its widest extent. The reef crest is about 2 to 4 meters deep and slightly sloping. The site is usually protected from both the northeast monsoon (*Amihan*) and southwest monsoon (*Habagat*). The area is usually has poor visibility. Based on the results, hard coral cover of four (4) in Barangay Vicente Hizon is classified as poor (Licuanan et al., 2017), while live coral cover is classified as poor to good (Gomez et al, 1981)

(**Table 2.43**, **Figure 2.126**). The average hard coral cover generally poor (8.0%) with highest cover in Station 2. Mean algal cover is also low but mostly *Padina* and *Dichyota* were found to on dead corals. Soft coral was apparent in all stations and much higher cover compared to hard coral. Sponges among other organisms were abundant in Stations 4 and 1. Most of stations were high abiotic component (i.e. silt, sand & rubble) and highest in Station 1 and 3. Based on this status, we can deduce that most of the dead coral was translated into algal cover and abiotic components, suggesting that coral mortality was followed by colonization by algae, and this exacerbated by costal development and boat anchoring. It is of note, though, that most of the delicate lifeforms (e.g. branching) became rubble.

Barangay Limao, Samal (Station 1)

Station 1 is narrow reefs, extending from seagrass beds to about 50 meters seaward. The reef is shallow (6 meters) but slightly sloping up 10 meters and beyond is sandy area. This station is usually sheltered, with low reef complexity. The average hard coral cover is at 14.7%, which is considered as poor condition, but considered fair for the LCC. Hard coral (14.7%) is slightly higher than soft coral (10.8%). Massive *Porites* was the dominant hard coral life form genera, followed by foliose *Echinopora* and sub-massive *Pocillopora, Millepora* and *Euphyllia*. Some coral genera observed were mostly branching *Acropora*, massive *Favites* and *Favia*. Other fauna such as sponges (Barrel sponge), sea anemone and ascidians were recorded. Abiotic component (51.1%, i.e. rubble and sand) and algal assemblages (19.2 %, i.e., AA) covered almost one-third of the total benthic cover**.**

Barangay Limao, Samal (Station 2)

Transects were laid in shallow reefs, extending along the reef crest. The average hard coral (7.3%) and living coral (19.5%) are both in *poor* category (Licuanan et al., 2017; Gomez et al, 1981). Soft coral has higher benthic proportion compared to hard coral. Due to strong current, low profile but with massive *Porites, Diploastrea* and *Lobophyllia* are abundant. Other conspicuous corals are sub-massive *Pocillopora*, encrusting *Galaxea* and other massive faviids genera. Algae and abiotic component dominated the reefs at 28.3% and 48.6% respectively. Moreover, dead coral with algae is low at 0.4%.

Barangay Limao, Samal (Station 3)

Transects in Station 3 were laid beside the small pier. Part of the reef was covered with rubble and consolidated rocks. This condition may be damaged due to the construction of the pier and boat anchorage during the tourist transport. The average hard coral (9.2%) and living coral (15.7%) are both in poor category (Licuanan et al., 2017; Gomez et al, 1981). Low relief corals observed in patch reef with dominant massive *Porites*, branching *Acropora* and *Pocillopora*. Other conspicuous corals are fire coral *Mellipora*, and other massive faviids genera. Algae (17.7%) and abiotic component (64.3%) dominated the reefs, which covered more than half of benthic cover. Moreover, dead coral with algae (0.5%) and soft coral were recorded low (6.5%).

Overall, the average living coral (20.2%) and the hard-coral cover (10.4%) in Brgy. Limao is in poor condition based on the quartile index of reef health (Licuanan et al., 2017; Gomez et al, 1981). Soft coral condition is 23.4%, mean algal cover is 15.4% and mostly dead coral is covered with filamentous algae. Other fauna such as sponges, sea anemone and ascidians were apparent. Based on this result, we can infer that most of the dead coral was translated into algal cover and abiotic components, suggesting that coral mortality was followed by colonization of alga and further damage by pier construction and boat anchoring.

Table 2.43 Mean Benthic Cover

Benthic Life Form / Station	Benthic code	Davao Stations 1	2	3	4	Mean	IGaCoS Stations 1	2	3	Mean
Coral Diversity										
Genera		19	18	17	20	19	19	17	20	18.7
Family		11	9	10	12	10	11	10	11	11
Hard Coral Status *(Licuana et al, 2017)*		**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**
Live Coral Status *(Gomez et al, 1981)*		**Poor**	**Good**	**Fair**	**Fair**	**Fair**	**Fair**	**Poor**	**Poor**	**Poor**
Living Coral (HC+SC)	LC	20.2	60.1	39.8	45.4	41.4	25.5	19.5	15.7	20.2
Hard Coral (ACR+Nos-ACR)	HC	7.5	10.3	7.4	6.8	8.0	14.7	7.3	9.2	10.4
Acroporids	ACR	2.8	7.5	4.6	4.2	4.8	1.3	0.2	2.2	1.2
Non-acroporids	Non-ACR	4.7	2.8	2.8	2.6	3.2	13.5	7.1	7.0	9.2
Soft coral	SC	12.7	49.8	32.4	38.6	33.4	10.8	12.2	6.5	9.9
Dead coral/with algae	DC/ DCA	2.3	5.0	1.5	2.5	2.8	1.4	0.4	0.5	0.8
Algae	AL	15.7	4.0	2.9	7.8	7.6	19.2	28.3	17.7	21.7
Other fauna	OT	1.5	2.0	0.7	2.0	1.6	2.7	1.7	1.5	2.0
Abiotic component	AB	57.5	27.8	54.3	41.2	45.2	51.1	48.6	64.3	54.7
Seagrass	SG	2.7	1.1	0.7	1.1	1.4	0	1.5	0.2	0.6
Total		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

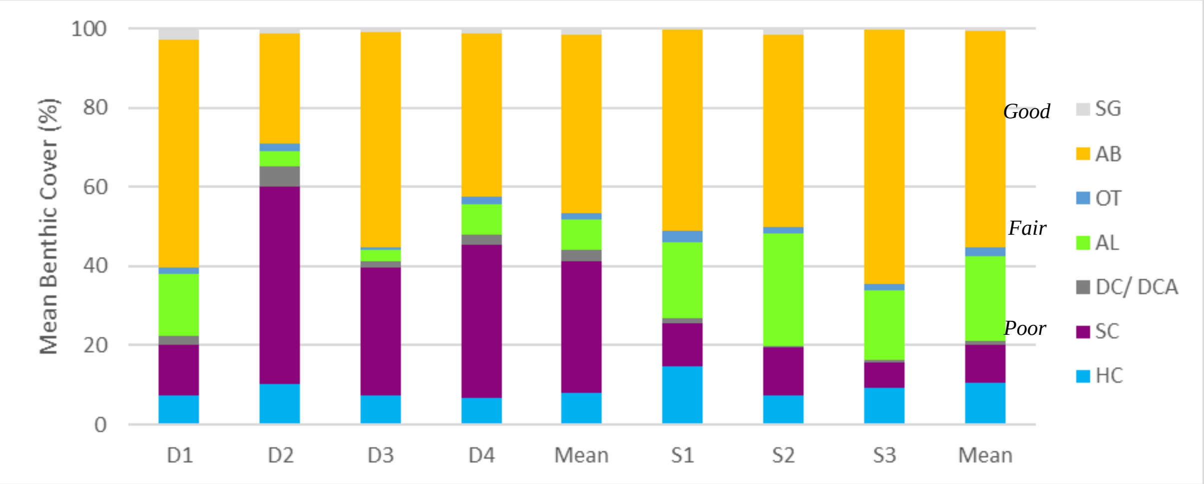


Figure 2.126 Mean benthic cover in each sampling sites

2.2.5.2.2 Reef Fish Community Assessment

Davao City

There were 12 50-m transects laid in Davao City, distributed evenly between Stations 1, 2, 3 and 4, with each station having 3 deployed transects. Species richness was highest in Station 3 with 73 species recorded that belong to 22 families. As with other stations, the most common species is *Pomacentrus moluccensis* (lemon's damsel). This was followed by *Acanthochromis polyacanthus* (spiny Chromis damsel), *Cirrhilabrus cyanopleura* (blueside wrasse), *Pomacentrus opisthostigma* (brown damsel) and *Pomacentrus brachialis* (charcoal damsel). Among the target species, the most frequently observed was *Acanthurus mata* (elongate surgeonfish). This was followed by the soldierfish *Myripristis murdjan* (pinecone soldierfish) and *Sargocentron caudimaculatum* (silverspot squirrelfish).

Fish abundance is also highest at Station 3 (958 individuals/500m^2), while the lowest abundance was at Station 1 (195 individuals/500m^2). Target species abundance follow the same pattern but the difference in target species numbers across the four stations are very minimal to be considered significant. Similarly, the fish biomass values are highest in Station 3 (24.9 metric tons/km^2) followed by Station 4 (19.8 metric tons/km^2). Remarkably, the biomass values of the four stations straddle the low to high category (Average = Medium) relative to national standards.

IGaCoS

A total of 9 50-m transects from three (3) stations were deployed in Barangay Limao, Samal at about 1 km stretch of reef crest. Species richness was highest in Station 1 with 97 species. The most common species found were *Pomacentrus brachialis* (charcoal damsel), *Pomacentrus amboinensis* (ambon damsel), *Acanthochromis polyacanthus* (spiny *Chromis* damsel), *Cirrhilabrus cyanopleura* (blueside wrasse), and *Amblyglyphidodon curacao* (staghorn damsel). While the most common target species were *Ctenochaetus cyanocheilus* (short-tail bristle tooth surgeonfish), *Scarus rivulatus* (rivulated parrotfish), *Scolopsis lineatus* (stripe monocle bream) and *Scolopsis ciliatus* (saw-jawed monocle bream). The fringing reef in Barangay Limao is characterized by shallow and strong currents. These features bring much food and nutrients and especially favor plankton feeding species.

Fish abundance was highest in Station 1 (930 individuals/250m^2) followed by Station 2 (918 individuals/500m^2) and lowest in Station 3 (775 individuals/250m^2, **Table 2.44**). Biomass values are still highest in Station 1 (28.3 metric tons/km^2), followed closely by Station 2 (25.3 metric tons/km^2) and by Station 3 (20.9 metric tons/km^2). These values are considered to be in the high biomass category relative to national standards. Target species biomass are highest in Station 1 (8.8 metric tons/km^2) followed by Station 2 (7.3 metric tons/km^2, **Table 2.44** and **Figure 2.128**). The target species biomasses of the aforementioned stations are within the high category (Nañola et al., 2006).

Overall, the community structure of reef fishes for the stations in Davao City and IGaCoS are summarized in **Table 2.44**. Across the board, the reef fish community structure in IGaCoS showed higher values for species richness, adult abundance and biomass. This is because the stations in Davao City have relatively poor water quality and less than ideal habitat conditions. Water visibility is very low, often less than 1 meter, due to silt and other suspended solids. Thus, there is no large coral reef structure. There were few scattered coral patches, composed mostly of soft corals that support damselfishes and cardinalfishes. Even Davao City Station 2, which is considered a fish sanctuary, is also in a poor state. While, there is an existing artificial reef structure in the area, there is very little commercially important species aside from very few surgeon fishes, goatfishes, and wrasses. The site is predominantly turbid and sandy.

Moreover, adult fish abundance was approximately four times higher in IGaCoS stations than in Davao City. Due to strong water currents, there is improved water clarity in IGaCoS stations. Though there are still large sandy areas, the coral reef extent is larger than on the opposite side. Abundance values in IGaCoS are moderate, while biomass values are in the high category relative to national standards (Hilomen et al., 2000 & Nañola et al., 2006). Damselfishes are still the predominant group as in most reef sites found in the country. However, diverse representative fishes from other families were observed, including butterflyfishes, coral breams, parrotfishes, rabbitfishes, surgeon fishes and wrasses. All the fishes observed were quite common and widespread. No recorded species is protected or known to be rare or endangered locally or regionally.

Table 2.44 Fish Species Richness, Abundance and Biomass (Hilomen et al 2000 * & ** and Nañola et al., 2006 ***).

	Davao Stations					IGaCoS Stations			
Indicator	**1**	**2**	**3**	**4**	**Mean**	**1**	**2**	**3**	**Mean**
Species diversity (1500m^2)*	**Poor**	**Poor**	**Poor**	**Poor**	**Poor**	**High**	**High**	**High**	**High**
Species richness	32	46	73	68	55	97	94	100	96
No. of families	11	15	22	20	17	24	26	28	25
Adult abundance (individ./500m^2)*	**Poor**	**Poor**	**Mode rate**	**Mode rate**	**Poor**	**Mode rate**	**Mode rate**	**Mode rate**	**Modera te**
Target species	3	5	33	28	17	59	49	40	54
Coral indicator species	2	6	4	10	5	10	10	8	10
Major species	190	234	921	819	541	861	860	728	860
Total	**195**	**245**	**958**	**856**	**564**	**930**	**918**	**775**	**924**
Juvenile abundance ((individ./100m^2)									
Target species	0	0	no data	no data	0	0	0	no data	0
Coral indicator species	0	0	no data	no data	0	0	0	no data	0
Major species	10	4	no data	no data	7	49	108	no data	78
Total	**10**	**4**	**no data**	**no data**	**7**	**49**	**108**	**no data**	**79**
Adult biomass (MT/km^2)**	**very low**	**Low**	**High**	**Medi um**	**Mediu m**	**High**	**High**	**High**	**High**
Target species	0.4	0.7	5.2	3.8	2.5	8.8	7.3	5.4	8.1
Coral indicator species	0.0	0.3	0.2	0.3	0.2	0.5	0.4	0.4	0.4
Major species	3.8	5.7	19.6	15.8	11.2	19.0	17.6	15.1	18.3
Total	**4.2**	**6.6**	**24.9**	**19.8**	**13.9**	**28.3**	**25.3**	**20.9**	**26.8**

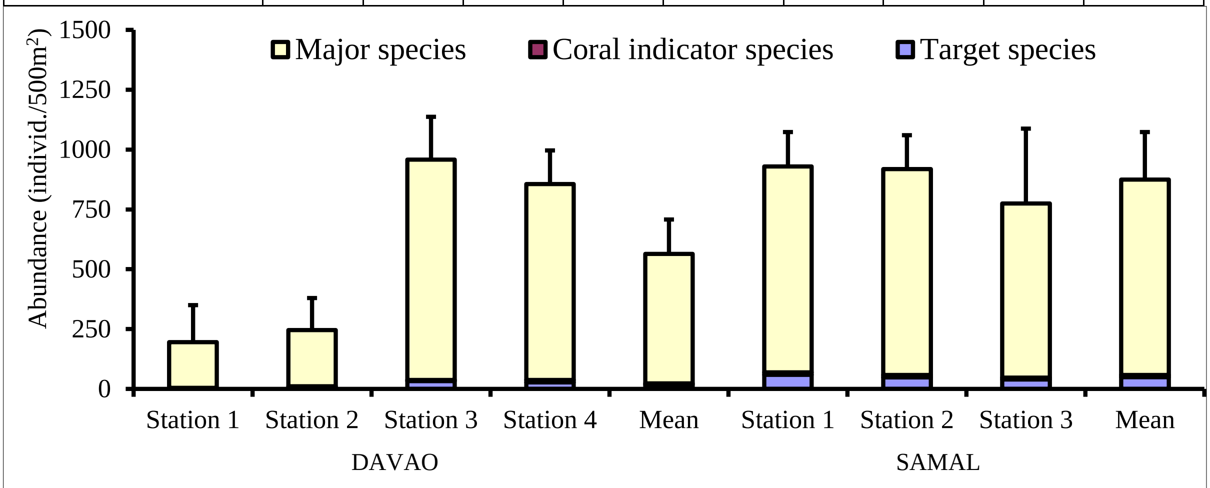


Figure 2.127 Mean fish abundance results

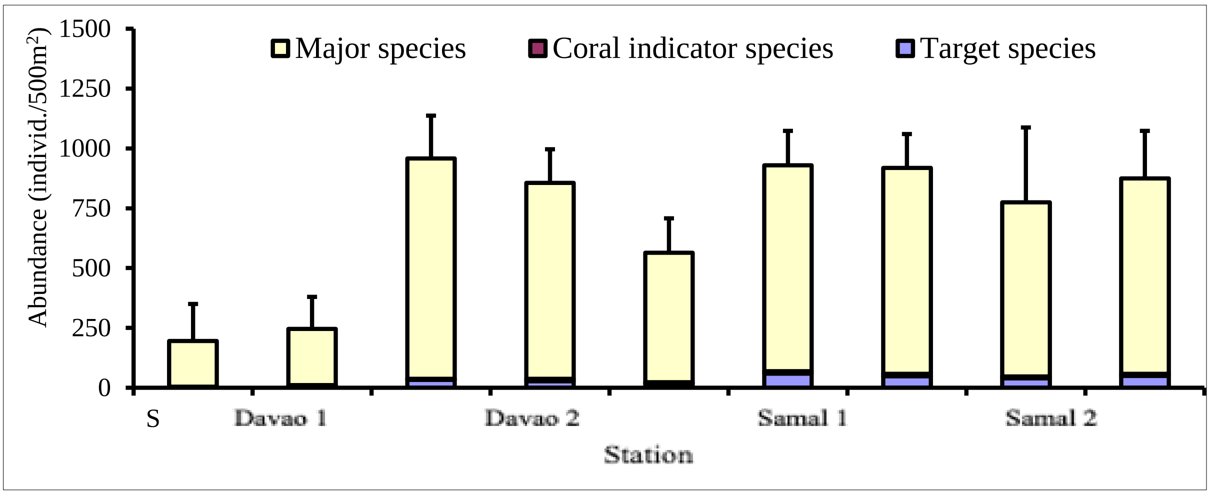


Figure 2.128 Mean fish biomass results

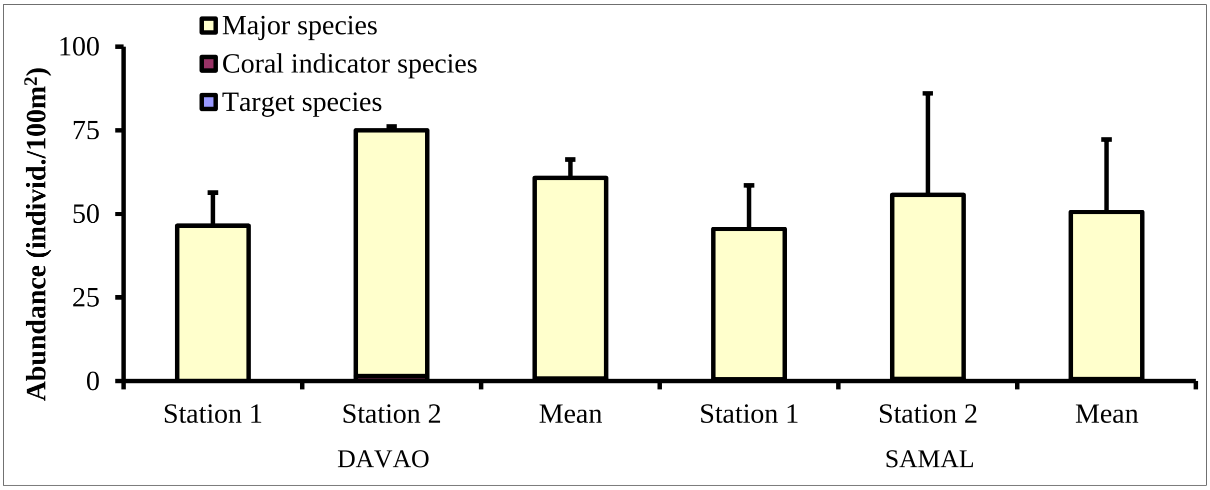


Figure 2.129 Juvenile fish abundance results

Panoramic shot (Davao Station 1)


Branching (*Acropora*)


Branching (*Acropora*)


Branching (*Hydnophora*)


Soft coral (*Lobophyton*)


Mushroom coral (*Fungia*)

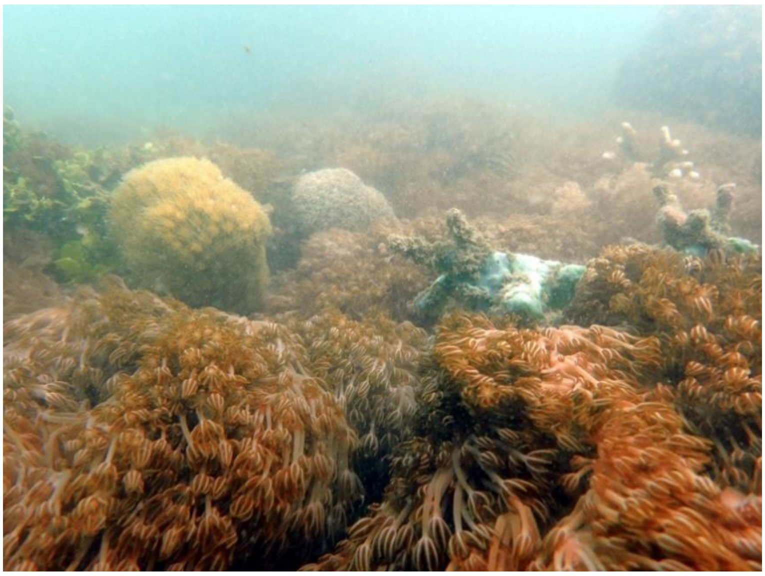

Massive coral (*Platygyra*)


Massive coral (*Lobophyllia*)


Macro-invertebrate Crown of Thorn Starfish (COT)


Concrete ARs covered with soft corals and sponges

Figure 2.130 Photo-documentation during the survey in Barangay Vicente Hizon, Station 1


Panoramic shot (Davao Station 2)

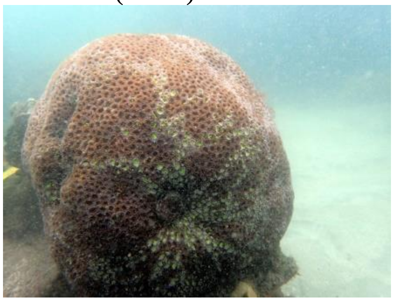
Branching (*Acropora*)

Branching (*Acropora*)

Soft coral (*Xenia*)

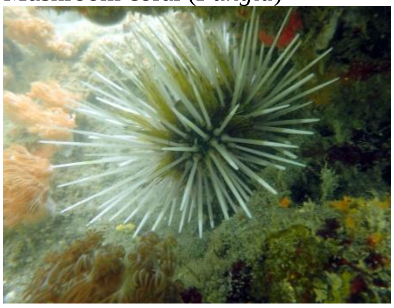
Soft coral *Lobophyton*

Mushroom coral (*Fungia*)



Massive coral (*Favia*)

Macro-invertebrate (Sea star)



Macro-invertebrate (Sea urchin)

Garbage entangled in corals

Figure 2.131 Photo-documentation during the survey in Barangay Vicente Hizon, Station 2

Panoramic scene of the reef (Davao Station 3)

Branching *Acropora*

Massive *Platygyra*

Soft coral

Anemone fish
Amphiprion perideraion

Stripe puffer *Arothron manilensis*

Razorfish *Aeoliscus strigatus*

Cardinal fishes *Apogon* spp.

Sea urchin

Garbage

Figure 2.132 Photo-documentation during the survey in Barangay Vicente Hizon, Station 3

Panoramic scene of the reef (Davao Station 4)

Branching *Acropora* & soft coral

Massive *Favia*

Foliose *Pectinia*

Massive Porites & soft coral

Soft coral (*Xenia*)

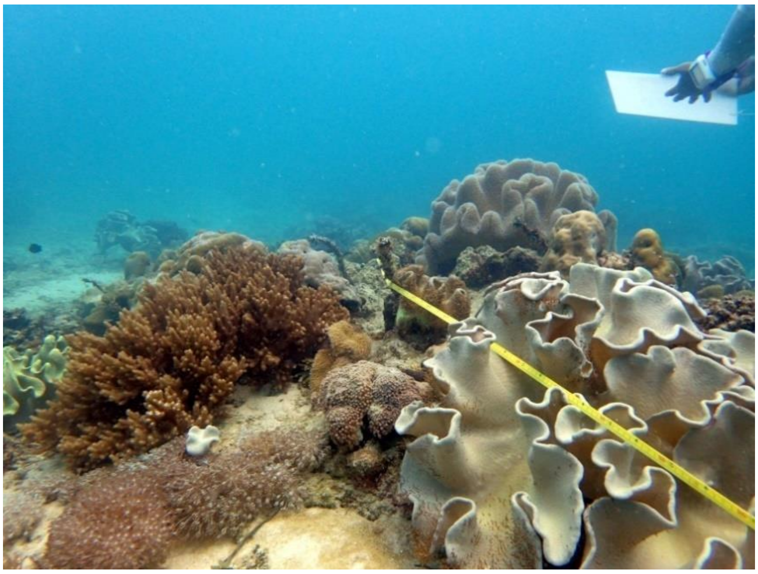
Blackspot Cardinalfish *Archamia melasma*

Porcupinefish *Diodon liturosus*

Sea snakes

Garbage

Figure 2.133 Photo-documentation during the survey in Barangay Vicente Hizon, Station 4



Panoramic scene of the reef (Samal Station 1)

Branching (*Acropora*)

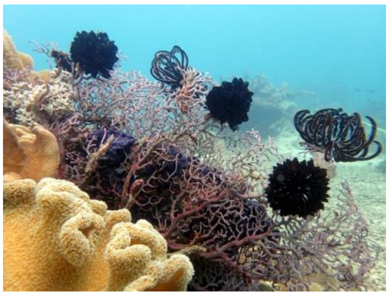
Massive coral (*Platygyra*)

Massive coral (*Physogyra*) with soft corals

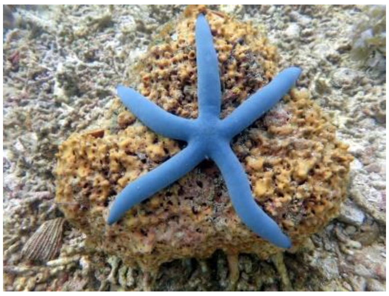
Foliose coral (*Turbinaria*)

Sandy-rubble below reef crest (10-m)

Fairy basslets (*Pseudanthias huchti*



Soft coral with Feather stars



Macro-invertebrate, Sea stars (*Linckia laevigata*)

Fish trap (Bobo)

Figure 2.134 Photo-documentation during the survey in Barangay. Limao, Samal City, Station 1

Diver doing an FVC technique (Samal Station 2)

Branching (*Acropora*)

Massive coral (*Porites*)

Massive coral (*Diploastrea*)

Soft corals

Soft coral & Feather stars

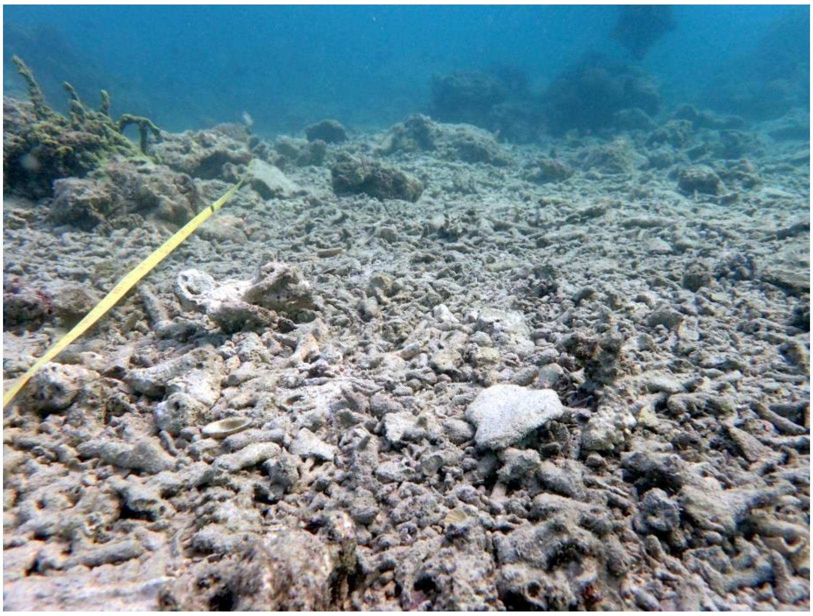
Damselfishes over soft corals

Puffer fish (*Arothron manilensis*)

Macro-invertebrate (Sea star)

Garbage entangled in corals

Figure 2.135 Photo-documentation during the survey in Barangay Limao, Station 2



Panoramic scene of the reef (Samal Station 3)

Rocks boulders beside small pier

Foliose *Montipora*

Branching *Acropora* with damselfishes

Massive *Platygyra*

Bargill Cardinalfish *Apogon sealei*

Spinecheek Anemonefish *Premnas biaculeatus*

Cardinalfishes *Apogon* spp. on dead branching coral

Barrel sponge

Mantis shrimp

Figure 2.136 Photo-documentation during the survey in Barangay. Limao, Samal City, Station 3

Table 2.45 List of Target Species with IUCN Conservation Status 2020

Family Name	Species	Common name	IUCN Conservation Status
Target species			
Acanthuridae	*Acanthurus mata*	Elongate Surgeonfish	Least concern
	Acanthurus pyroferus	Mimic Surgeonfish	Least concern
	Ctenochaetus binotatus	Two-spot Bristletooth	Least concern
	Ctenochaetus cyanocheilus	Short-tail bristle-tooth	Least concern
	Ctenochaetus striatus	Striped Bristletooth	Least concern
	Naso unicornis	Bluespine Unicornfish	Least concern
Balistidae	*Balistapus undulatus*	Orange-lined Triggerfish	--
	Rhinecanthus verrucosus	Blackbelly Triggerfish	--
Diodontidae	*Diodon hystrix*	Spot-fin Porcupinefish	Least concern
Haemulidae	*Plectorhinchus chaetodonoides*	Many-spotted sweetlips	Not evaluated
Holocentridae	*Myripristis murdjan*	Pinecone Soldierfish	Least concern
	Sargocentron caudimaculatum	Silverspot Squirrelfish	Least concern
	Sargocentron cornutum	Threespot Squirrelfish	Least concern
LabCheilininae	*Cheilinus chlorourus*	Floral Wrasse	Least concern
	Cheilinus fasciatus	Red-breasted Wrasse	Least concern
	Cheilinus trilobatus	Tripletail Wrasse	Least concern
LabCorinae	*Cheilio inermis*	Cigar Wrasse	Least concern
	Hemigymnus melapterus	Blackeye Thicklip	Least concern
	Hologymnosus doliatus	Pastel Slender Wrasse	Least concern
Mullidae	*Parupeneus barberinus*	Dash-and-dot goatfish	Least concern
	Parupeneus pleurostigma	Sidespot goatfish	Least concern
	Upeneus tragula	Freckled goatfish	Least concern
Nemipteridae	*Scolopsis bilineatus*	Two-lined Monocle Bream	--
	Scolopsis ciliatus	Saw-jawed Monocle Bream	--
	Scolopsis lineatus	Striped Monocle Bream	Least concern
	Scolopsis margaritifer	Pearly Monocle Bream	Least concern
Scaridae	*Calotomus carolinus*	Carolines Parrotfish	Least concern
	Chlorurus sordidus	Daisy Parrotfish	Least concern
	Scarus chameleon	Chameleon Parrotfish	Least concern
	Scarus dimidiatus	Yellowbarred Parrotfish	Least concern
	Scarus ghobban	Blue-barred Parrotfish	Least concern
	Scarus hypselopterus	Yellow-tail Parrotfish	Near threatened

Family Name	Species	Common name	IUCN Conservation Status
	Scarus psittacus	Common Parrotfish	Least concern
	Scarus quoyi	Quoy's Parrotfish	Least concern
	Scarus rivulatus	Rivulated Parrotfish	Least concern
	Scarus sp. (gray)	--	--
Siganidae	*Siganus fuscescens*	Mottled Spinefoot	Least concern
	Siganus guttatus	Golden Rabbitfish	Least concern
	Siganus spinus	Scribbled Rabbitfish	Least concern
Synodontidae	*Synodus variegatus*	Variegated Lizardfish	Least concern
Coral indicator species			
Chaetodontidae	*Chaetodon auriga*	Threadfin Butterflyfish	Least concern
	Chaetodon baronessa	Eastern Triangle Butterflyfish	Least concern
	Chaetodon citrinellus	Speckled Butterflyfish	Least concern
	Chaetodon kleinii	Sunburst Butterflyfish	Least concern
	Chaetodon octofasciatus	Eightband Butterflyfish	Least concern
	Chaetodon speculum	Mirror Butterflyfish	Least concern
	Chaetodon unimaculatus	Teardrop Butterflyfish	Least concern
	Chaetodon vagabundus	Vagabond Butterflyfish	Least concern
	Chaetodon xanthurus	Pearlscale Butterflyfish	Least concern
LabLabrichthyinae	*Diproctacanthus xanthurus*	Yellowtail Tubelip	Least concern
	Labrichthys unilineatus	Tubelip Wrasse	Least concern
Zanclidae	*Zanclus cornutus*	Moorish Idol	Least concern
Major species			
Apogonidae	*Apogon apogonides*	Plain Cardinalfish	--
	Apogon bandanensis	Bigeye Cardinalfish	--
	Apogon chrysopomus	Spotted-gill Cardinalfish	--
	Apogon compressus	Ochre-striped Cardinalfish	Least concern
	Apogon harzfeldii	--	--
	Apogon wassinki	Kupang Cardinalfish	Least concern
	Archamia bleekeri	Gon-s Cardinalfish	--
	Archamia fucata	Orangelined Cardinalfish	Least concern
	Archamia sp.	--	--
	Cheilodipterus macrodon	Large Toothed Cardinalfish	Least concern
	Cheilodipterus quinquelineatus	Five-lined Cardinalfish	--
	Sphaeramia nematoptera	Pajama Cradinalfish	--

Family Name	Species	Common name	IUCN Conservation Status
Blenniidae	*Meiacanthus grammistes*	Striped Poison-fang Blenny	Least concern
Centriscidae	*Aeoliscus strigatus*	Coral Shrimpfish	Data deficient
Cirrhitidae	*Cirrhitichthys falco*	Dwarf Hawkfish	Least concern
Gobiidae	*Amblygobius phalaena*	Whitebarred Goby	--
	Amblygobius sp.	--	--
	Exyrias bellisimus	Mudreef Goby	--
	Valenciennea strigata	Bluestreak Goby	Least concern
LabBodianinae	*Bodianus mesothorax*	Split-level Hogfish	Least concern
LabCheilininae	*Cirrhilabrus cyanopleura*	Blueside Wrasse	Data deficient
	Cirrhilabrus temminckii	Threadfin Wrasse	Data deficient
	Epibulus insidiator	Sling-jaw Wrasse	Least concern
	Novaculichthys taeniourus	Rockmover Wrasse	Least concern
	Oxycheilinus celebicus	Celebes Wrasse	Least concern
	Oxycheilinus digrammus	Violetline Maori Wrasse	Least concern
	Paracheilinus hexataenia	Six line Wrasse	--
	Pseudocheilinus evanidus	Striated Wrasse	Least concern
LabCorinae	*Coris batuensis*	Batu Coris	Least concern
	Coris gaimard	Yellowtail Coris	Least concern
	Halichoeres chloropterus	Pastel-green Wrasse	Least concern
	Halichoeres hortulanus	Checkerboard Wrasse	Least concern
	Halichoeres leucurus	Grayhead Wrasse	Least concern
	Halichoeres melanurus	Tail-spot Wrasse	Least concern
	Halichoeres nebulosus	Nebulous Wrasse	Least concern
	Halichoeres nigrescens	Bubblefin Wrasse	Least concern
	Halichoeres scapularis	Zigzag Wrasse	Least concern
	Halichoeres trimaculatus	Threespot Wrasse	Least concern
	Macropharyngodon meleagris	Blackspotted Wrasse	Least concern
	Macropharyngodon negrosensis	Yellow-spotted Wrasse	Least concern
LabCorinae	*Stethojulis bandanensis*	Red-shoulder Wrasse	Least concern
	Stethojulis interrupta	Cutribbon Wrasse	Least concern
	Stethojulis strigiventer	Three-ribbon Wrasse	Least concern
	Stethojulis trilineata	Blue-ribbon Wrasse	Least concern
	Thalassoma hardwicke	Sixbar Wrasse	Least concern

Family Name	Species	Common name	IUCN Conservation Status
	Thalassoma lunare	Moon Wrasse	Least concern
LabLabrichthyinae	*Labroides dimidiatus*	Bluestreak Cleaner Wrasse	Least concern
Microdesmidae	*Ptereleotris evides*	Blackfin Dartfish	Least concern
Monacanthidae	*Aluterus scriptus*	Scribbled Leatherjacket Filefish	Least concern
	Cantherhines pardalis	Honeycomb Filefish	Least concern
	Pervagor janthinosoma	Blackbar Filefish	Least concern
	Pseudomonocanthus macrurus	Strap-weed Filefish	--
Nemipteridae	*Pentapodus trivittatus*	Three-striped Whiptail	Least concern
Pempheridae	*Pempheris vanicolensis*	Vanikoro Sweeper	--
Pinguipedidae	*Parapercis clathrata*	Latticed Sandperch	--
	Parapercis hexopthalmus	Speckled Sandperch	--
	Parapercis sp.	--	--
Pomacanthidae	*Centropyge bicolor*	Bicolor Angelfish	Least concern
	Centropyge vroliki	Pearlscale Angelfish	Least concern
Pomacentridae	*Abudefduf sexfasciatus*	Scissortail Sergeant	Least concern
	Acanthochromis polyacanthus	Spiny Chromis Damsel	Least concern
	Amblyglyphidodon curacao	Staghorn Damselfish	Least concern
	Amphiprion clarkii	Clark’s Anemonefish	Endangered
	Amphiprion ocellaris	Ocellaris Clownfish	--
	Amphiprion perideraion	Pink Skunk Clownfish	Least concern
	Amphiprion sandaracinos	Orange Anemonefish	Least concern
	Cheiloprion labiatus	Big-lip Damselfish	--
	Chromis ternatensis	Ternate Chromis	--
	Chrysiptera rollandi	Rolland’s Demoiselle	--
	Dascyllus aruanus	Whitetail Dascyllus	--
	Dascyllus reticulatus	Reticulated Damselfish	--
	Dascyllus trimaculatus	Domino Damsel	Vulnerable
	Dischistodus perspicillatus	White Damsel	--
	Dischistodus prosopotaenia	Honey-head Damsel	--
	Hemiglyphidodon plagiometopon	Lagoon Damselfish	--
	Neopomacentrus nemurus	Coral Demoiselle	--

Family Name	Species	Common name	IUCN Conservation Status
	Plectroglyphidodon lacrymatus	Whitespotted Devil	--
	Pomacentrus alexanderae	Alexander's Damsel	--
	Pomacentrus amboinensis	Ambon Damsel	--
	Pomacentrus auriventris	Goldbelly Damsel	--
	Pomacentrus bankanensis	Speckled Damselfish	--
	Pomacentrus brachialis	Charcoal Damsel	--
	Pomacentrus burroughi	Burrough's Damsel	--
	Pomacentrus chrysurus	Whitetail Damsel	--
	Pomacentrus coelestis	Neon Damselfish	--
	Pomacentrus moluccensis	Lemon Damsel	--
	Pomacentrus nagasakiensis	Nagasaki Damsel	--
Pomacentridae	*Pomacentrus ophistostigma*	Brown Damsel	--
	Pomacentrus simsiang	Blueback Damsel	--
	Stegastes obreptus	Western Gregory	--
Santhiinae	*Pseudanthias huchti*	Red-cheeked Fairy Basslet	Least concern
Sepinephelinae	*Cephalopholis boenak*	Brown-banded Seabass	Least concern
Tetraodontidae	*Arothron hispidus*	White-spotted Puffer	Least concern
	Arothron manilensis	Narrow-lined Puffer	Least concern
	Arothron nigropunctatus	Blackspotted Puffer	Least concern
	Canthigaster compressa	Compressed Toby	Least concern
	Canthigaster dumerili	--	--
	Canthigaster papua	Papuan Toby	Least concern
	Canthigaster solandri	Spotted Sharpnose	Least concern
	Canthigaster valentini	Valentin's Sharpnose Puffer	Least concern

Fish migration

The result of the fish census surveys did not observe fish migration patterns. This is since the Pakiputan Channel is a busy navigational route for small tourist boats and large vessels. Generally, Davao Gulf is a major fishery area of commercially important, small pelagic species such as *Decapterus macrosoma*, *Selar crumenopthalmus* & *Auxis rochei* and large pelagic species such as big eye tuna. Davao Gulf encompasses multiple fishing activities, composed of commercial and municipal fisheries (Villanueva 2017). Fishing operations are usually done in the offshore areas fronting Sta. Cruz, Malita and Gov. Generoso municipalities, as well as in scattered sites in the middle portion of the gulf (Romena and Villanueva 2002). Nevertheless, the impact of the project on fish migration patterns is anticipated to be minimal, at most.

2.2.5.2.3 Cetaceans and marine mammals

As earlier stated, the waters surrounding Samal is a busy navigational route. Tourist island-hopping boats usually circumnavigate the entirety of the island. Nevertheless, sightings of cetacean species is common in the eastern section of Davao Gulf (**Figure 2.137**). Previous surveys conducted in the Davao Gulf have determined that this 650,000-hectare marine area is one of the country's top diversity sites for whales and dolphins. Aside from this, dugong (*Dugong dugon*) – the only species of the family Dugongidae, is also observed in the area. The latest sightings in the 2018 survey updated the total number of cetacean species in the Gulf to 15 from the previous record of 14 based on past surveys and stranding reports. This proves that Davao Gulf is indeed a marine key biodiversity area as shown by the diverse number of cetacean species whose presence indicate the health of the area as shown in figure 4.92. (WWF, 2004, 2018). An area is commonly considered as a hotspot due to the high number of stranding of marine mammalian species. Sometimes, due to unusual stranding events, a site is also considered as hotspot (Aragones, et al 2010). This was the case of Davao City, as in 2004, a Longman's beaked whale (*Indopacetus pacificus*), one of the rarest cetacean species, was stranded. However, the said species is classified as Data Deficient by the IUCN Red List, due to its rather uncommon nature. The said species is covered by the Memorandum of Understanding for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (Pacific Cetaceans MOU). In 2011, a four-meter female Blainville's beaked whale (*Mesoplodon densirostris*) that beached alive in Davao Gulf died after an hour from stranding and upon examining its body after it died, 0.25 kilos of plastic garbage was found in its stomach. A dead sperm whale washed ashore on Samal Island and a pygmy sperm whalegot stranded in the Sasa area and eventually died in 2017 and 2018 respectively.

Marine mammals can strand for a variety of reasons. Some identified causes have included diseases, parasites, boat or ship strikes, entanglement in fishing gear, pollution exposure, starvation, and harmful algal blooms, such as red tide. In addition, strandings often occur after unusual weather or oceanographic events. In many cases, the cause of stranding remains unknown (OBX MMSN).

Foregoing mentioned, most cetacean species observed are stranded and pod sightings are mostly in the vicinity of Talikud Island, which is some 17km away from the project site. The location of sightings may be attributed to the presence of food and away from the usual boat traffic. Although one cannot prevent nor predict the direction of travel of cetacean species when chasing their prey in open waters, it may be safe to say that the project will have little impact on cetacean species.

As it is, the perceived effects of the SIDC on marine mammals can be alleviated by strictly implementing the mitigation measures identified by the project management. Evidently, most of the cases of stranding in Davao Gulf, involved the ingestion of plastic and similar pollutants by marine mammals. As such, a sound waste management plan for the project should be in place as one of the mitigation measures of the project. Once the SIDC becomes operational, increased plastic pollution as well as all the generation of other manner of refuse should be anticipated and measures for mitigation be should instigated. An effective means for mitigation will involve a pro-active approach. Personnel should be trained and made aware of workplace housekeeping with emphasis on strict, regular implementation.

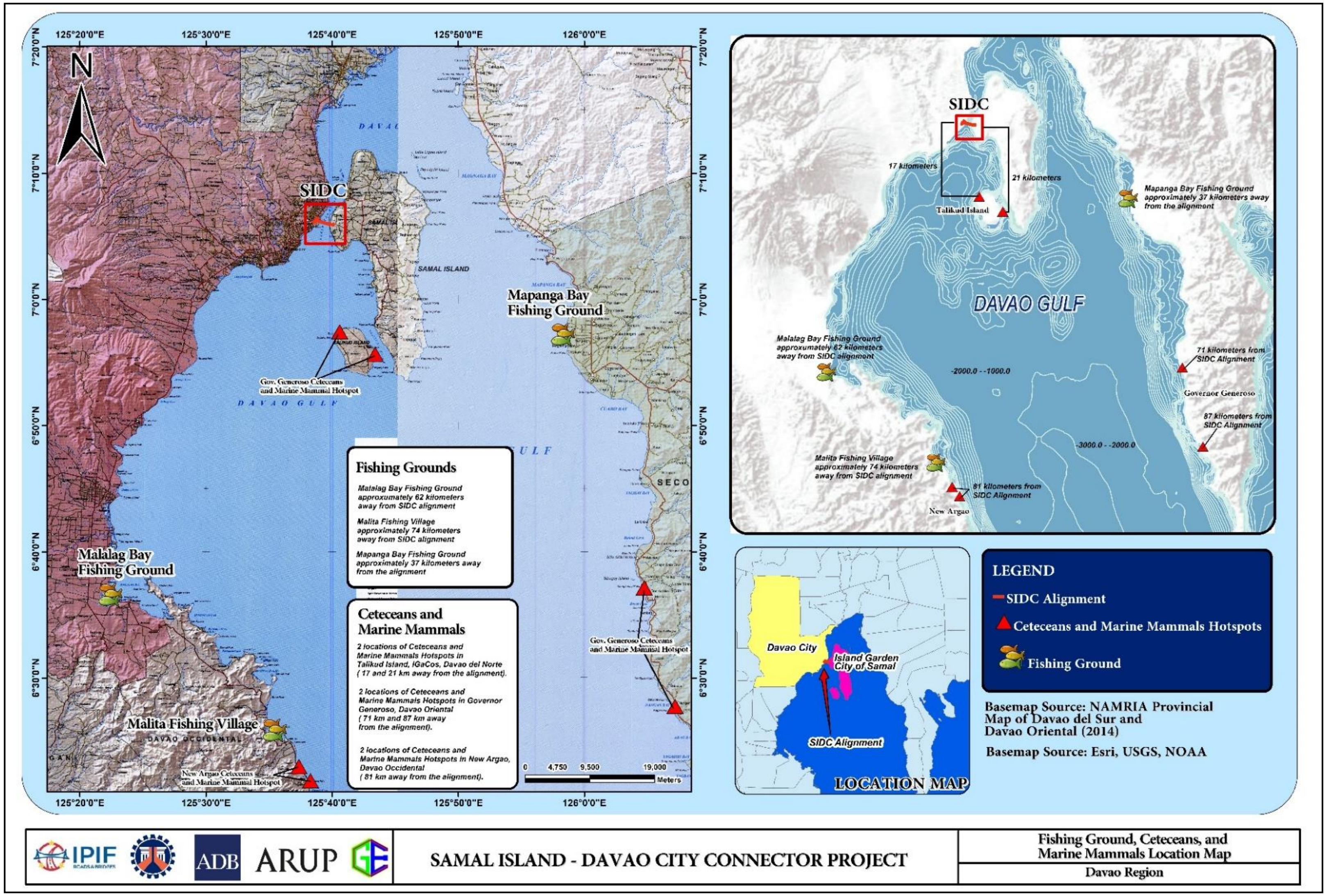


Figure 2.137 Fishing Ground, Cetaceans and Marine Mammals Location Map

2.2.5.2.4 Phytoplankton

As part of the study to determine the baseline biotic community, water sampling was conducted to assess plankton abundance, diversity and richness in coastal waters in the vicinity of the project area last 15 June 2019.

A total of 48 phytoplankton species was identified across seven stations (**Table 2.46**). The phytoplankton community was comprised of two major groups i.e. diatoms and dinoflagellates. The community was totally dominated by diatoms constituting 97%, while dinoflagellates accounted for the remaining 3%. In addition, diatoms were the most dominant groups in all sampling stations.

The top ten taxa (

Figure **2.138**) in terms of relative abundance were C*haetoceros* spp (20%), *Rhizosolenia* spp (16%), *Bacteriastrum* spp (12%), *Thalassionema* sp. (8%), *Stephanopyxis* sp. (7%), *Skeletonema* sp. (6%), *Thalassiosira* sp. (5%), *Lauderia* sp. (4%), *Pseudonitzschia* sp. (2%), *Lioloma* sp. (2%) All the remaining phytoplankton genera accounted for roughly 18% of the total density. These species contribute significantly to the overall productivity of the marine ecosystem in this area.

The potentially harmful species identified during the survey were *Pseudonitzschia* sp. and *Dinophysis* sp. Some species of *Pseudonitzschia* are known to produce toxins associated with Amnesic Shellfish Poisoning (ASP). On the other hand, toxins produced by some species of *Dinophysis* are associated with Diarrhetic Shellfish Poisoning (DSP). However, negative health impacts could only be caused by the blooms of these species when accumulated by filter feeders like shellfish. Cell densities observed in this sampling were not high enough to be considered as blooms and there is no extensive shellfish farming in the area. Thus, negative health impacts are less likely but continued monitoring of harmful species is highly recommended.

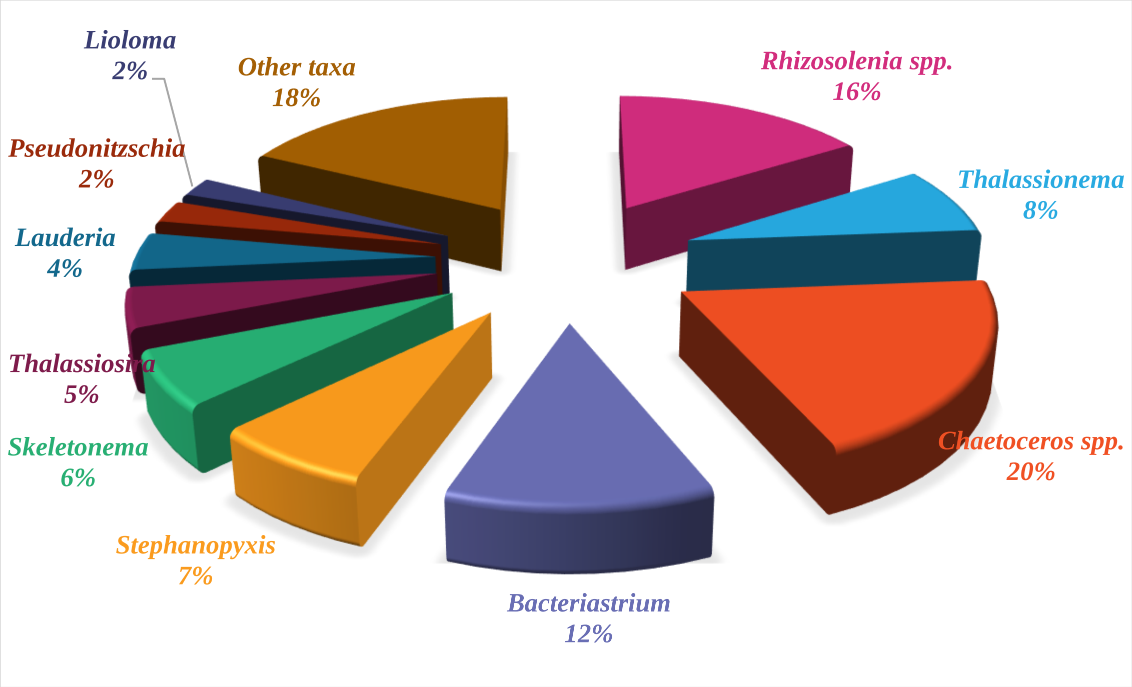


Figure 2.138 Percentage composition of top 10 major phytoplankton taxa identified in seven coastal stations near the project area, 15 June 2019

Table 2.46 Phytoplankton composition, distribution, diversity and abundance (cells/L)

Phytoplankton cells/m^3	STATIONS							Grand Total	Percentage
	MW1	MW2	MW3	MW4	MW5	MW6	MW7		
Bacillariophyta	**1,702,618**	**1,557,345**	**2,942,236**	**639,567**	**172,683**	**619,238**	**169,942**	**7,803,629**	**97.358**
Asterionellopsis		9,594	15,076					24,669	0.308
Asteromphalus			21,471					21,471	0.268
Bacteriastrum elongatum	42,257	74,235	119,462	25,811	7,538	33,577	4,112	306,992	3.830
Bacteriastrum furcatum	55,048	99,818	141,390	19,187	10,507	16,218	7,081	349,249	4.357
Bacteriastrum hyalinum	37,232	54,135	106,899	53,906	6,396	37,460	8,223	304,251	3.796
Biddulphia	8,680	2,284	8,680					19,644	0.245
Chaetoceros sp.1	82,687	142,532	306,078	22,385	10,050	9,594	13,477	586,803	7.321
Chaetoceros sp.2	223,848	91,824	132,939	49,110	11,649	35,633	14,390	559,393	6.979
Chaetoceros sp.3	65,099	117,178	163,546	33,120	6,624	46,597	9,822	441,986	5.514
Climacodium			17,817					17,817	0.222
Coscinodiscus	6,853	3,426	8,223					18,502	0.231
Cylindrotheca		6,624	8,908					15,532	0.194
Ditylum	8,223	9,594	14,619	2,969		5,025		40,430	0.504
Ephemera	63,957		68,982					132,939	1.659
Eucampia	14,162	10,507	50,023	15,761	6,167	16,218		112,838	1.408
Fragilariopsis	67,155	41,572	24,212					132,939	1.659
Guinardia		8,680	13,477					22,156	0.276
Hemiaulus		12,106	41,800					53,906	0.673
Lampriscus	26,953	5,254	10,736					42,942	0.536
Lauderia	129,741	79,261	94,108	12,791	6,853	13,248	4,340	340,341	4.246

Phytoplankton cells/m^3	STATIONS							Grand Total	Percentage
	MW1	MW2	MW3	MW4	MW5	MW6	MW7		
Leptocylindrus	9,365	2,969	8,680					21,014	0.262
Lioloma	18,959	37,460	41,800	30,608	9,594	31,978	2,969	173,368	2.163
Melosira		41,572	30,151					71,723	0.895
Navicula	4,340							4,340	0.054
Nitzschia	12,106	2,741	5,710	3,426	7,538		11,192	42,714	0.533
Odontella	5,939	2,513	5,939	2,056		4,340		20,786	0.259
Pleurosigma	4,112	8,680	18,502	14,619	7,309	12,791	6,396	72,408	0.903
Probosciaalata	6,624	8,223	10,736	5,939	1,371	8,908	4,112	45,912	0.573
Pseudonitzschia	60,074	26,953	54,820	16,218	5,254	21,014	15,304	199,636	2.491
Pseudosolenia	14,619	21,014	36,547	5,254		8,223		85,656	1.069
Rhizosolenia pungens	49,110	51,165	143,903	44,313	14,390	29,237	11,878	343,996	4.292
Rhizosolenia setigera	191,870	226,133	374,603	71,723	6,624	65,556	8,223	944,732	11.786
Skeletonema	96,849	65,327	193,012	49,566	11,649	58,703	18,730	493,837	6.161
Stephanopyxis	202,149	121,746	141,847	52,079	18,959	41,115	8,223	586,117	7.312
Thalassionema	86,570	95,021	287,805	53,906	9,365	77,890	5,025	615,583	7.680
Thalassiosira	86,798	49,110	142,075	36,090	6,167	29,237	10,507	359,985	4.491
Thalassiothrix	12,563	16,446	54,363	18,730	8,680	16,674	5,939	133,395	1.664
Trichotoxon	8,680	11,649	23,299					43,628	0.544
Dinophyta	**68,982**	**51,851**	**62,586**	**10,964**	**2,741**	**11,192**	**3,426**	**211,742**	**2.642**
Ceratium furca	3,655	10,050	6,396	2,741	2,056	5,482	914	31,293	0.390
Ceratium fusus	14,162	6,396	10,279	4,797	685	5,710	2,513	44,541	0.556
Ceratium gibberum	7,081							7,081	0.088
Ceratium horridum	5,939							5,939	0.074

Phytoplankton cells/m^3	**STATIONS**							**Grand Total**	**Percentage**
	MW1	**MW2**	**MW3**	**MW4**	**MW5**	**MW6**	**MW7**		
Ceratium trichoceros	6,624			2,741				9,365	0.117
Dinophysis		3,655	10,050					13,705	0.171
Noctiluca	5,025	685	4,112					9,822	0.123
Peridinium	9,365	5,254	4,340	685				19,644	0.245
Phalacroma	17,131	21,014	16,446					54,592	0.681
Protoperidinium		4,797	10,964					15,761	0.197
Grand Total	**1,771,600**	**1,609,196**	**3,004,822**	**650,531**	**175,424**	**630,430**	**173,368**	**8,015,372**	**100**
Richness	**39**	**41**	**44**	**27**	**22**	**24**	**21**		
Evenness (J')	**0.54**	**0.53**	**0.53**	**0.69**	**0.87**	**0.76**	**0.85**		
Diversity (H')	**3.05**	**3.09**	**3.14**	**2.93**	**2.95**	**2.90**	**2.89**		

The mean phytoplankton abundance in the sampling sites is 1,145,053 cells/m^3. In terms of spatial distribution, MW3 recorded the highest phytoplankton abundance and richness, with 3,004,822cells/m^3 and 44 taxa (**Figure 2.139**). The lowest phytoplankton abundance was observed in MW7 at 173,368 cells/m^3, while the most depauperate station was also recorded in this station with 21.

Diversity index based on Shannon Weiner was generally high, with the highest computed values observed from stations MW1-MW3 (3.05-3.14). On the other hand, the lowest was computed in MW7 with 2.89.

The computed index of evenness are relatively high in stations MW4 to MW7 ranging from 0.69-0.87 hence indicates a relatively balanced community. This is supported by Wilhm criteria (1975) wherein if the Shannon diversity index is <3.0 it is considered as a high diversity and more stable community.

Figure 2.139 Total phytoplankton density and richness

2.2.5.2.5 Zooplankton Community

Analysis of samples taken from the seven stations revealed a total of 10 zooplankton groups belonging to phylum Arthropoda, Chaetognatha, Chordata, and Echinodermata. The top 5 dominant zooplankton were copepod nauplius (39%), calanoid copepodite (23%), calanoida (22%), Sagitta (4%), cyclopoida (4%) and the remaining 8% was attributed to harpacticoida, oikepleuridae, cyclopoid copepodite, shrimp zoeae, and echinopluteus (**Figure 2.140**) It is generally recognized that zooplankton occupy an important role in the economy in the sea, both as consumer of phytoplankton and as contributors to the next higher trophic levels. Numerous studies have shown that small zooplankton (e.g. copepods, tintinnids, cladocerans, larval molluscs) are important component of larval fish food (Houde & Lovdal 1982, Balbontin, et al. 1986, Anderson 1994).

The mean zooplankton abundance in the sampling sites is15,026 individuals/m^3. Water sample collected from MW2 harbored the greatest number of taxa (9) and highest density of zooplankton with 29,466 individuals/m3 (**Figure 2.141**). The observed most depauperate stations are MW5 and MW7 with only 3 zooplankton groups, whereas the lowest zooplankton density was observed in station MW4 .The highest calculated diversity index based on Shannon Weiner is observed in the MW4 with 1.99 (**Table 2.47**). The index of evenness is relatively high in most stations except in station MW7 (<0.5). In this survey, most of the zooplankton are common types with no endemic or rare groups encountered.

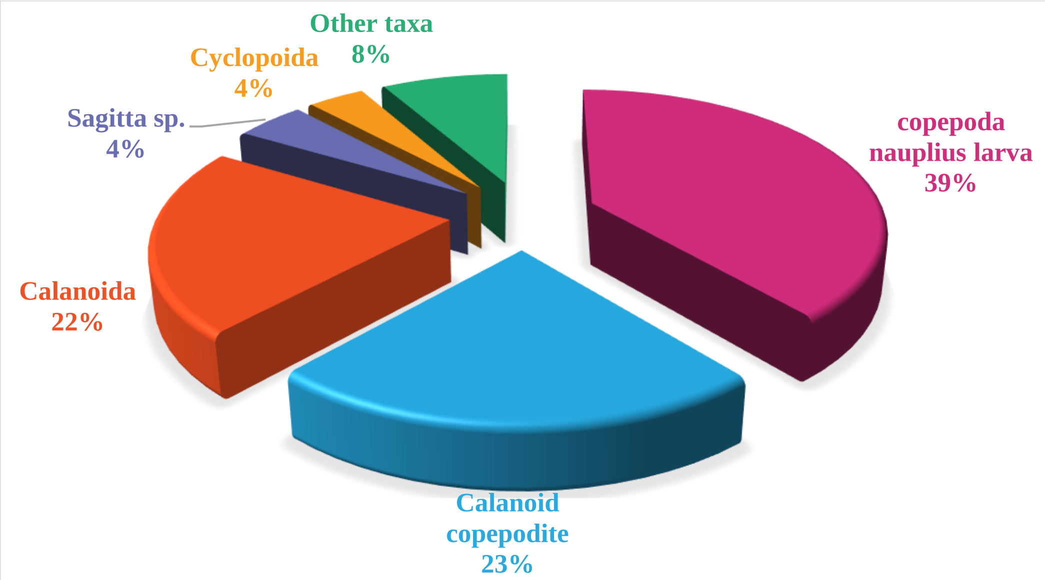


Figure 2.140 Percentage composition of top 5 zooplankton taxa

Table 2.47 Zooplankton composition, distribution, diversity and abundance (individuals/m^3)

Zooplankton indv/m^3	Sampling Stations							Grand Total	Rel. Abund.
	MW1	MW2	MW3	MW4	MW5	MW6	MW7		
Arthropoda	11,421	27,410	10,050	6,853	14,504	17,360	9,822	97,420	92.62
Calanoid copepodite	2,969	8,223	2,741	1,371	3,769	5,025		24,098	22.91
Calanoida	1,142	5,710	3,655	1,371	6,167	4,797		22,842	21.72
Copepoda nauplius larva	4,797	9,594	3,426	1,142	4,568	7,538	9,822	40,887	38.87
Cyclopoid copepodite				1,599				1,599	1.52
Cyclopoida		2,969		914				3,883	3.69
Harpacticoida	2,513	457		457				3,426	3.26
shrimp zoea larva		457	228					685	0.65
Chaetognatha	1,371	914	1,142	457		685	228	4,797	4.56
Sagitta sp.	1,371	914	1,142	457		685	228	4,797	4.56
Chordata	457	685	228	685			457	2,513	2.39
Oikopleuridae	457	685	228	685			457	2,513	2.39
Echinodermata		457						457	0.43
Echinopluteus larva		457						457	0.43

Zooplankton indv/m^3	Sampling Stations							Grand Total	Rel. Abund.
	MW1	MW2	MW3	MW4	MW5	MW6	MW7		
Grand Total	**13,248**	**29,466**	**11,421**	**7,995**	**14,504**	**18,045**	**10,507**	**105,186**	**100**
Richness	**6**	**9**	**6**	**8**	**3**	**4**	**3**		
Evenness (J')	**0.81**	**0.58**	**0.71**	**0.91**	**0.98**	**0.83**	**0.44**		
Diversity (H')	**1.58**	**1.66**	**1.46**	**1.99**	**1.08**	**1.20**	**0.28**		

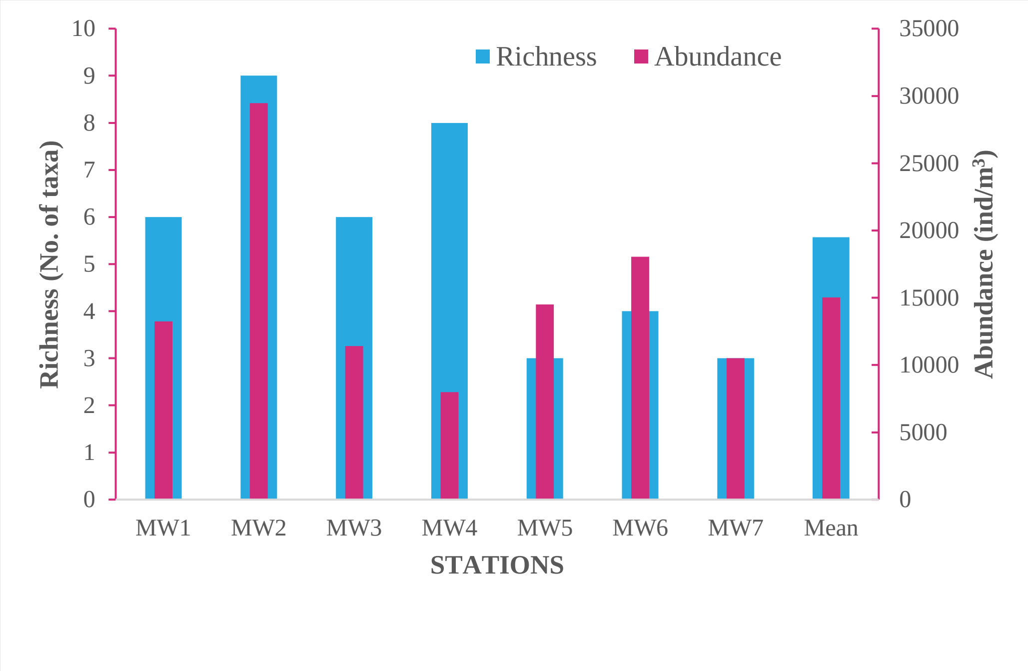


Figure 2.141 Total zooplankton density and taxa richness

2.2.5.2.6 Macrobenthos Fauna

The community of organisms that live on, or in the bottom (seafloor) of a water body is known as 'benthos' (from ancient Greek, meaning "depth, depth of sea, bottom"). Benthic animals are categorized according to size. Microbenthos are less than 0.063 mm in size, meibenthos range from 0.063 to 0.5 mm, macrobenthos range from 0.5 to 1.0 mm, and megabenthos are greater than 10.0 mm in size.

Benthic communities represent a vital link in relation to food chains within marine ecosystems. They serve as important food sources for certain fish and crustaceans. These organisms, therefore, are one of the main factors that influence fishing potential within any body of water. They likewise rework and oxygenate bottom sediments and serve an essential function in the breakdown of organic materials, detoxifying pollutants, dispersion and burial.

Table 2.48 presents the species composition, density, diversity and distribution of benthic fauna in four sampling stations along the coastal water in the vicinity of the project. A total of 2,308 individuals belonging to seven families/class taxa were recorded during the study, with different compositions at various sites.

Table 2.48 Density, Diversity, Abundance of Macrobenthos Fauna

Marine Benthos Taxa	Stations				Grand Total	Rel. Abund.
	Davao		IGaCoS			
	1	2	1	2		
Phylum Foraminifera	-	-	-	-	-	-
Family Peneroplidae	-	-	-	136	136	5.88
Phylum Sipunculida	-	-	-	90	90	3.92
Phylum Nematoda	181	-	-	-	181	7.84
Phylum Annelida	-	-	-	-	-	-
Class Polychaeta	-	-	-	-	-	-
Family Orbiniidae	-	181	-	90	271	11.76
Family Capitellidae	-	181	181	-	362	15.69
Family Spionidae	-	45	136	45	226	9.80
Family Cirratulidae	-	-	-	45	45	1.96
Family Cossuridae	-	-	45	-	45	1.96
Family Opheliidae	45	-	-	45	90	3.92
Family Pisionidae	-	45	-	-	45	1.96
Family Syllidae	-	-	-	45	45	1.96
Family Lumbrineridae	-	45	-	45	90	3.92
Family Nereididae	45	-	-	-	45	1.96
Family Goniadidae	-	-	45	-	45	1.96
Phylum Mollusca	-	-	-	-	-	-
Class Bivalvia	-	-	-	-	-	-
Family Tellinidae	-	-	-	45	45	1.96
Family Mytilidae	-	-	-	45	45	1.96
Class Gastropoda	-	-	-	-	-	-
Family Nassariidae	45	-	-	-	45	1.96
Class Scaphopoda	-	-	-	-	-	-
Family Dentaliidae	-	181	-	-	181	7.84
Phylum Arthropoda	-	-	-	-	-	-
Subclass Crustacea	-	-	-	-	-	-
Class Malacostraca	-	-	-	-	-	-
Order Tanaidacea	-	-	-	45	45	1.96
Order Cumacea	45	-	-	-	45	1.96
Order Amphipoda	-	-	-	-	-	-
Family Gammaridae	-	-	45	90	136	5.88
Order Stomatopoda	-	-	45		45	1.96
Grand Total	**362**	**679**	**498**	**769**	**2308**	**100**
Richness	**5**	**6**	**6**	**12**	**-**	**-**

Marine Benthos Taxa	Stations				Grand Total	Rel. Abund.
	Davao		IGaCoS			
	1	2	1	2		
Evenness (J')	**0.86**	**0.89**	**0.89**	**0.96**	**-**	**-**
Diversity (H')	**1.39**	**1.60**	**1.59**	**2.39**	**-**	**-**

Figure 2.142 shows the Relative Abundance (RA) of all macroinvertebrate families/class observed in the four sampling stations during the study. RA is the ratio of individuals in a certain taxon to the total number of individuals of all taxa, which is affected by various factors.

A community dominated by relatively few species could indicate environment stress (Plafkin et al., 1989 in ESS Group, Inc. (2001). High percent contribution by a taxon generally indicates community imbalance (Bode, 1988).

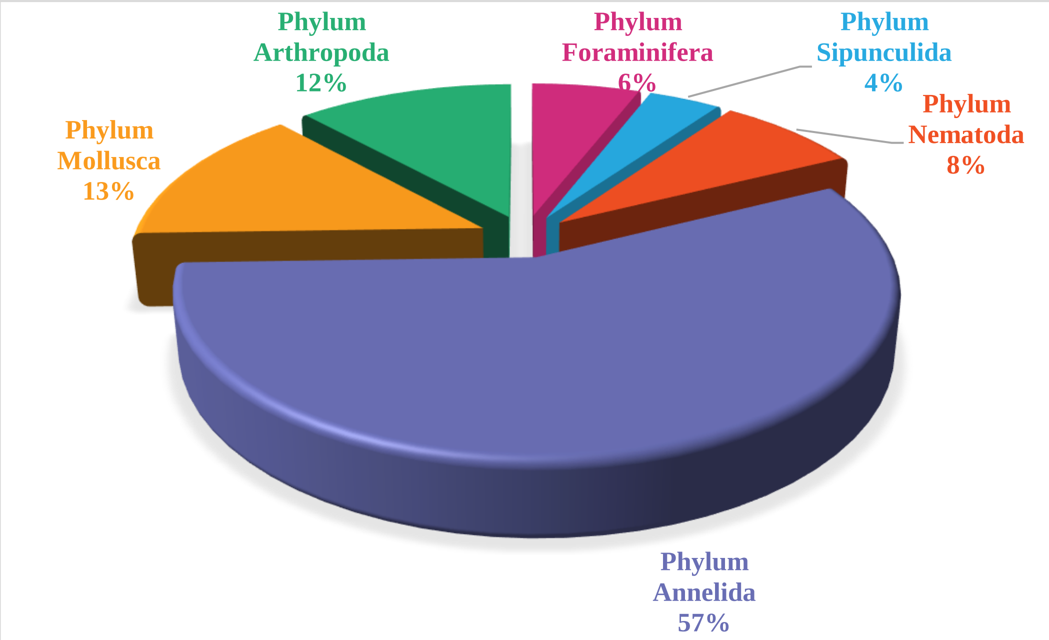


Figure 2.142 Percent composition Macroinvertebrates phyla recorded

Overall, the top three most abundant phyla were Annelida which accounted for 57% RA, followed by Mollusca with 13% RA and Arthropoda with 12% RA. Among the annelids, polychaetes belonging to family Capitellidae were the most dominant group constituting for 16% RA, followed by the family Orbiniidae with 12% RA. Polychaetes play a major role in the functioning of benthic communities, in terms of recycling and reworking of benthic sediments, bioturbating sediments and in the burial of organic matter. Among the mollusks, scaphods belonging to family Dentaliidae was the most abundant with 181 ind/m^2 (8% of the total composition).

The most notable arthropods were the amphipods of the family Gammaridae, which constituted for 6% of the total density and were only found in IGaCoS Stations 1 and 2. Gammarids represent important keystone species in aquatic ecosystems. As shredders and detritus feeders, they contribute to the detritus cycle and the microbial loop. They are also carnivorous, feeding on small invertebrates and carrion. Due to their widespread distribution, significance in the food web, and sensitivity to a wide range of pollutants, they are important bio-indicators for water quality assessment (Gerhardt et al 2011). Their presence in these two stations is noteworthy. **Figure 2.143** shows total density of benthic fauna observed in the four sampling stations.

In terms of spatial distribution, the highest macrobenthos count was recorded in IGaCoS Station 2 with 769 ind/m^2, while the lowest was recorded in Davao Station 1 with 362 ind/m^2. Taxa richness was generally low, with the highest observed in IGaCoS Station 2 at 12, while the lowest was recorded in Davao Station 1 at 5. Taxa evenness was high, ranging from 0.86-0.96, indicating an evenly distributed benthos community, but the diversity was generally low (<2), except for station IGaCoS Station 2 with 2.39.

The overall impression of the benthos assessment during this survey is poor, as indicated by low abundance, richness and diversity. The slight high diversity computed in station IGaCoS Station 2 is indicative of slightly better environmental conditions. Also, although common taxa were found in the surveyed marine environment, there were no endemic taxa were recorded for this study.

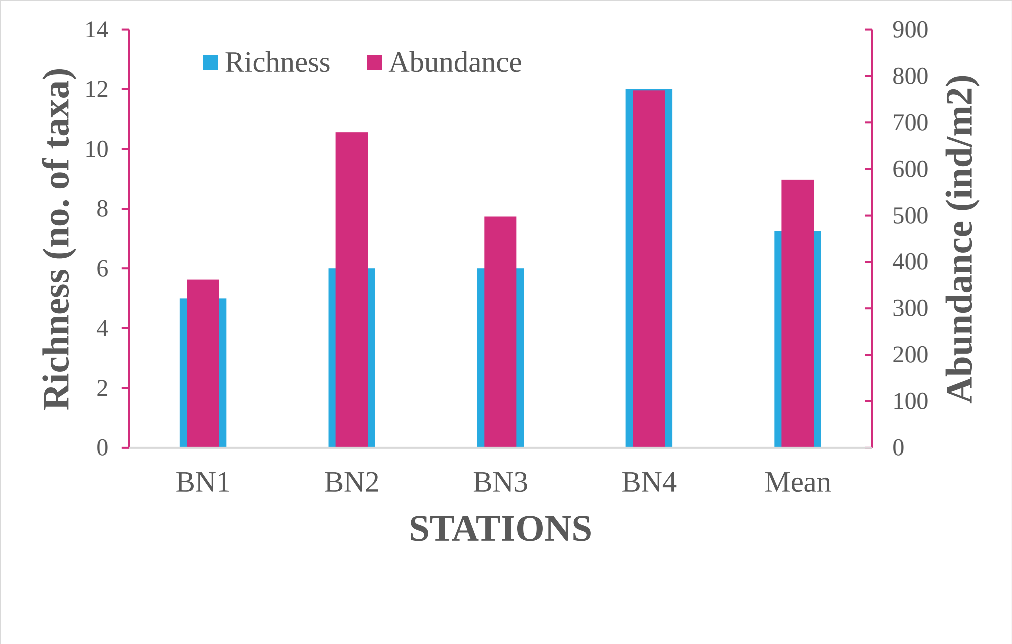


Figure 2.143 Total benthos abundance and richness in four stations sampled along the coast of the proposed project, September 2019

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Impacts on seagrass and seagrass beds

There would be little impact, if any on the seagrasses in the Davao side, as their presence is very sparse and distribution patchy. However, in the IGaCoS side, seagrasses are still abundant and thriving, especially in the intertidal area. The seagrass community, including the brown seaweed Sargassum are covered by the Fisheries Administrative Order No. 250 series of 2014, which regulates its collection, harvesting, gathering, selling, and exporting. It is therefore recommended that during construction, dredging be confined to the immediate construction site area to minimize any negative effects to the seagrass meadow and in protection to these resources.

Seagrasses can die when buried by sediment, but they can grow again as long the basic environmental requirements that they need are present, namely: (1) protection from strong waves and winds; (2) suitable substrate on which to attach their roots and rhizome; (3) light for photosynthesis and (4) just enough nutrients for photosynthesis and growth. If only a small part of the meadow will be affected during construction, the meadows on both sides of the impacted area can still receive seeds so long as the water movement along the area is not hampered or obstructed. Seagrass beds in Davao and Samal areas were observed to exhibit patchiness. However, if the seagrass cannot be avoided during bridge construction, seagrass transplantation should be conducted on receptor seagrass bed sites (i.e., >1 km) following the method of Matheson et al., 2017. There should be monitoring of the seagrass in the immediate construction area and the receptor site.

Impact Assessment on Coastal Reef Habitat, Associated Reef Fishes ad Invertebrates

Based on the results of the assessment, it has been determined that the introduction of hard substrates such as stockpiles and seawalls may result in local loss and disturbance of natural sedimentary habitats, including coral reefs and seagrass beds. This may also result in corresponding effects to the associated assemblages of animals (e.g. fishes and invertebrates) when affecting the surrounding soft seabed environments, which may be exacerbated by the rapid colonization of algae and marine animals of new artificial substrata.

Dredging and construction will result to the loss of isolated coral, seagrass bed and adjacent vegetation, given that bridge stock piles support only half the diversity of mobile organisms when compared to nearby natural coral substrates (coral reefs are home to more rare species than pier stockpiles). Since the reefs in both Davao and Samal Island are narrow, they should aim to be avoided by bridge stock piles. Consultations with a competent, experienced marine biologist should be undertaken during construction. However, if some of the hard corals cannot be avoided, they are easily relocated in adjacent receptor sites since most are branching *Acropora*. In addition, the average hard coral cover is low (Davao: HC=8.0% & Samal: 10.4%). Coral translocation on receptor sites (i.e., >1km), should be needed, will be conducted following the method of Gomez et al., 2010. Nevertheless, coral lost in the impact site would be minimal because of low hard coral cover and high survival of transplanted affected coral would be attained.

During the operation and maintenance phase, there may be a temporary disturbance of the sessile fauna, algae and mobile fauna that have colonized artificial hard structures. The SIDC may also obstruct the natural inland migration of coastal systems, therefore causing coastal squeeze. This process causes a reduction in the area of intertidal habitats such as coral reefs, seagrass and sandy beaches.

The presence of piers tends to cause an accumulation of sediments, mainly on the side where the current comes from. This causes a significant reduction in the abundance of corals, seagrasses and associated fishes and invertebrates. Bridges often can act as “stepping stones”, disrupting natural barriers to species distribution and providing new dispersal routes that permit the invasion of non-indigenous species, including pests. Nevertheless, disturbances during the construction phase have a negative but temporary effect on coastal habitats and associated animals. Hence it is recommended that seagrass and coral habitats be created to mitigate potential losses to be detailed in a Biodiversity Action Plan.

Mitigation measures usually involve engineering modifications to provide greater surface complexity to encourage marine growth, and the sculpting of the pier to mimic surrounding landforms may help avoid loss of community diversity.

The coral reefs in the area exist is generally in “*poor”* conditions. Recent perturbations have further stressed these reefs. Aside from natural disturbances (e.g., typhoons and coral bleaching), there are other human induced disturbances such as coastal development and increasing human population along coastal areas that contribute to stresses to coral reefs and other marine ecosystems. The impact of seawalls, groynes, piers and jetties along coastal areas may further deteriorate marine ecosystems. These hard substrates hinder water circulation and hamper longshore currents which transport sediments

Reef fish status, on the other hand, is generally categorized as “*poor* to *moderate”* in terms of species’ richness and abundance, and “*low* to *high*” in biomass relative to the other sites in the country based on national standards.

Expectedly, the key impacts of the proposed bridge project on the marine ecosystems (i.e., coral reefs, seagrass beds and associated reef fishes) would be high and likely increase in sediment load from construction materials. If a carefully-designed silt management scheme would not be put in place, the adjacent coastal habitats (coral reefs and seagrass beds) could be adversely affected. The expected deterioration of the water quality, particularly in the vicinity of the project site, could impact on the living hard coral and composition and associated reef fishes. Such scenario could make existing ecosystems decline through time.

If such deterioration in coastal water quality would approximate present conditions, the species’ composition and cover of seagrass and corals with associated reef fishes’ abundance and biomass might also significantly decrease. It is therefore strongly recommended that a well-designed silt-control scheme be implemented to prevent silt and coarser sediments from being discharged into coastal waters. In addition to silt-control measures, the study area should be protected and even enhanced to further mitigate the anticipated residual sediment loads of the project.

As this project intends to utilize coastal resources for construction-related materials, some level of impacts on coastal habitats may also be expected. More particularly, the project may physically impact on the habitats along the Davao-Samal Channel. The expected impact would be on coral reefs, seagrass beds and their associated animals such as reef fishes and invertebrates. Such a project would have severe implications not only on these habitats but also on the hydrodynamics and sediment transport and deposition within the coastal environment. Therefore, it is recommended that the engineering design of the bridge be done in such a way that does not hinder longshore currents.

During the operations phase, appropriate control measures have also to be put in place to prevent spillage of materials that may detrimentally affect the coastal habitat, such as oil and grease. Otherwise, the project will contribute to the deterioration, disruption and destruction of fish habitats, particularly in Samal. The impacts will be caused by permanent and temporary encroachment on fish habitats as well as modifications to water flow during the construction and operations phase. Fish habitats may be affected by the following activities:

- Land clearing and soil stripping
- Excavation and earthwork
- Work in aquatic environments
- Machinery transportation, operation and maintenance
- Infrastructure maintenance and repair, and
- Presence and use of infrastructure

Sediment resuspension will negatively affect habitat quality. The presence of temporary structures will likely change water movement and fish migration patterns in the area. Vibrations associated with operating large machinery might lead to mortality among certain fish, especially juveniles.

Monitoring and evaluation of benthic habitats (e.g., seagrass bed, coral reefs, associated fishes and other fauna) may be conducted quarterly or bi-annually to record changes brought about by the project in relation to other natural and anthropogenic activities in the area and remedial action will be taken where warranted.

Cetaceans and marine mammals

As previously stated, Samal Island is busy tourist destination and navigational route. The area has been identified as one of the country's top diversity sites for marine life. Species such as the dugong (*Dugong dugon*) thrive here. However, owing to the high volume of traffic along the strait and also along coastal areas around the island, stranding cases amongst cetaceans and marine mammals have been frequent occurrences. Causes for stranding of these creatures range from boat or ship strikes, diseases, parasites, entanglement in fishing gear, starvation, and harmful algal blooms such as red tide. However, one of the commonest causes of stranding can be traced to ingestion of plastic products and other pollutants.

Talikud Island, which is 17 km away from the proposed project site, appears to be the sightings of these cetaceans and marine mammals and, as such, the impact of the proposed project to these creatures is seen as very minimal. However, there had been an instance wherein a pygmy whale was stranded in the Sasa area within the Davao side. This indicates that they can cover large areas when chasing prey. Therefore, in order to mitigate any possible stranding incidents during construction and operation phases, warnings should be given to marine transport vessels to steer clear of identified habitats or migration paths of cetaceans and other marine mammals. In addition, a sound waste management plan for the project should be implemented to eliminate the possibility of ingestion by these creatures. This includes the safe transport, utilization, and proper disposal of solid waste materials.

Impacts on Plankton and Zooplanktons

Phytoplankton and Zooplankton would be generally subject to short-term impacts during construction. Threats to the plankton community would come from the increased load of suspended solids during the construction phase, resulting to depth reduction of phytoplankton photosynthetic activity. Similarly, highly turbid water would affect the grazing success of zooplankton. This would temporarily result to lower rates of photosynthesis and primary production. However, plankton population recovery after construction would be generally rapid due to quick reproduction periods, including recruitment and advection from adjacent unaffected areas. A laboratory experiment conducted over a two week period with different zooplankton showed that mortality was high at levels over 10,000 mg/L of TSS but, generally, studies have not shown any significant impact at the levels experienced from activities such as dredging (Clarke & Wilbur 2000). In addition, many larval stages are only in the plankton for short periods, and other groups have short life cycles, which means recovery can be relatively quick (less than a year) depending on the time of year and source of larvae (James et al 2015). Given the temporary and limited extent of the effect of highly turbid waters relative to the overall area, the project impact to the plankton community is predicted to be low in the long term. Mitigating measures, nevertheless, may be implemented to address the short-term negative impacts of highly turbid waters during construction.

Turbidity is chiefly caused by suspension of fine grained particles in the water column. Particulate matter can include clay and silt, fine organic and inorganic matter, soluble organic compounds, algae, and other microscopic organisms. Limiting the entry of these particulate matter into the water is one way by which turbidity can be mitigated.

2.3 The Air

This section presents secondary data from Davao Synoptic Stations and climate projections under medium range emission scenarios from the Philippine Atmospheric Geophysical, Astronomical Services Administration (PAGASA). Air sampling was also conducted near the proposed alignment. Data generated serve as baseline data to be compared with National Ambient Air Quality Guideline Values (NAAQGV) of the Implementing Rules and Regulations (IRR) of the Philippine Clean Air Act of 1999 (R.A. 8749). For noise, baseline environmental conditions of noise levels were compared with National Pollution Control Commission (NPCC) Memorandum Circular No. 002 Series of 1980 National Ambient Noise Standards and the 2007 Environmental, Health and Safety (EHS) Guidelines of the IFC for Noise Management. The mitigation measures were formulated for the pre-construction to operation phases of the project.

Methodology

For this module, a variety of methodologies were employed to determine baseline environmental conditions. These include:

a. Review of all available secondary information from PAGASA
b. Detailed field investigations
c. Air sampling and analysis
d. Noise sampling and analysis

The application of these methodologies is described in more details in the subsequent sections for this module.

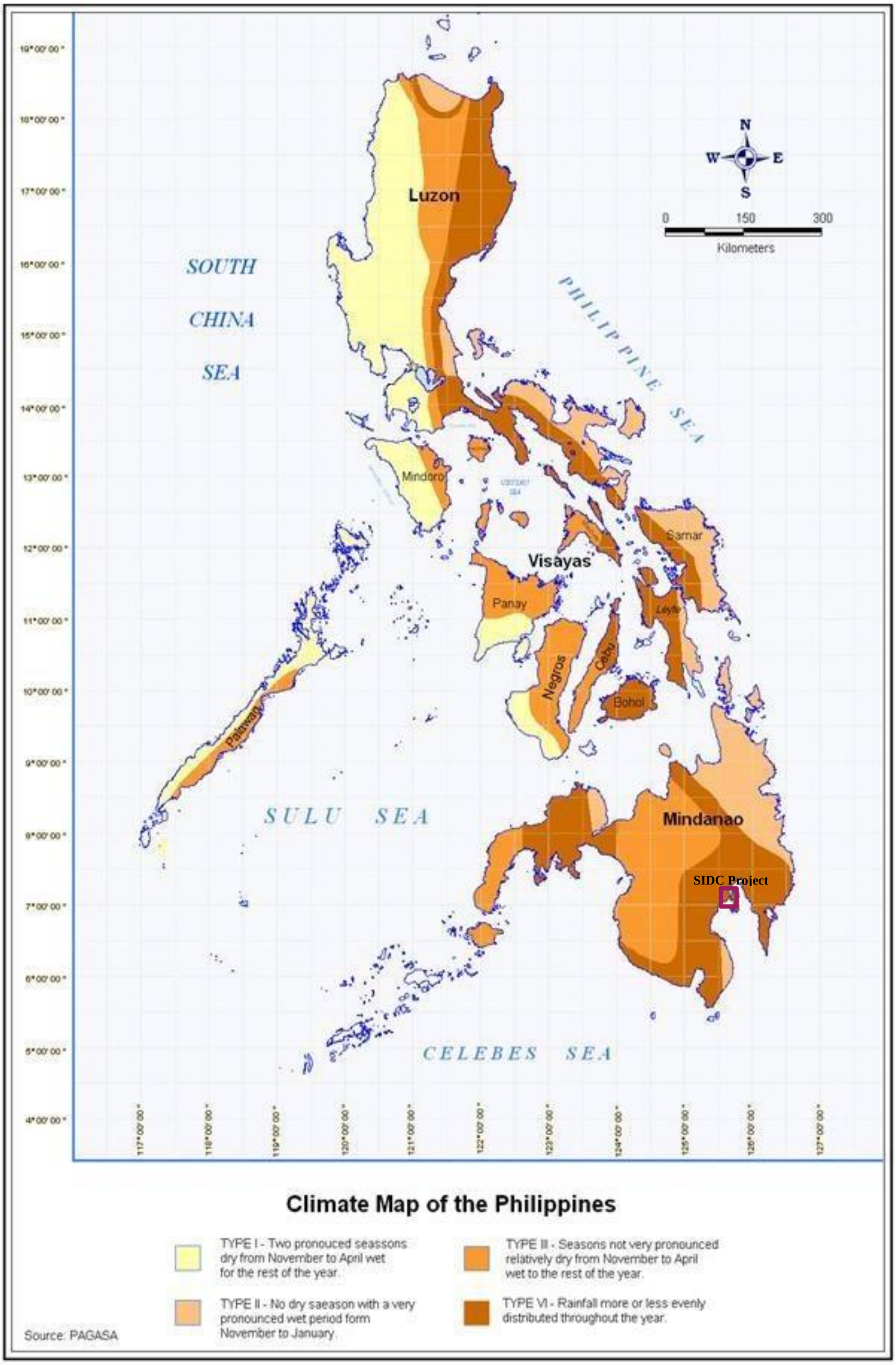
2.3.1 Meteorology/ Climatology

Baseline Environmental Conditions

Regional Meteorology

The climate at Davao City and IGaCoS generally falls under Type IV based on the Modified Coronas Classification of Philippine Climate, which means that rainfall is evenly distributed throughout the year (**Figure 2.144**).

The major factors that affect the climate of the project site are air streams, topography, and geographic setting. Two principal airstreams dominate the region, namely, the northeast monsoon (*Amihan*), which prevails from October to April and the southwest monsoon (*Habagat*), which is prevalent from May to September. Since the project site is located along the south coastal region of Mindanao Island, it is not significantly exposed to the effects of the southwest monsoon.

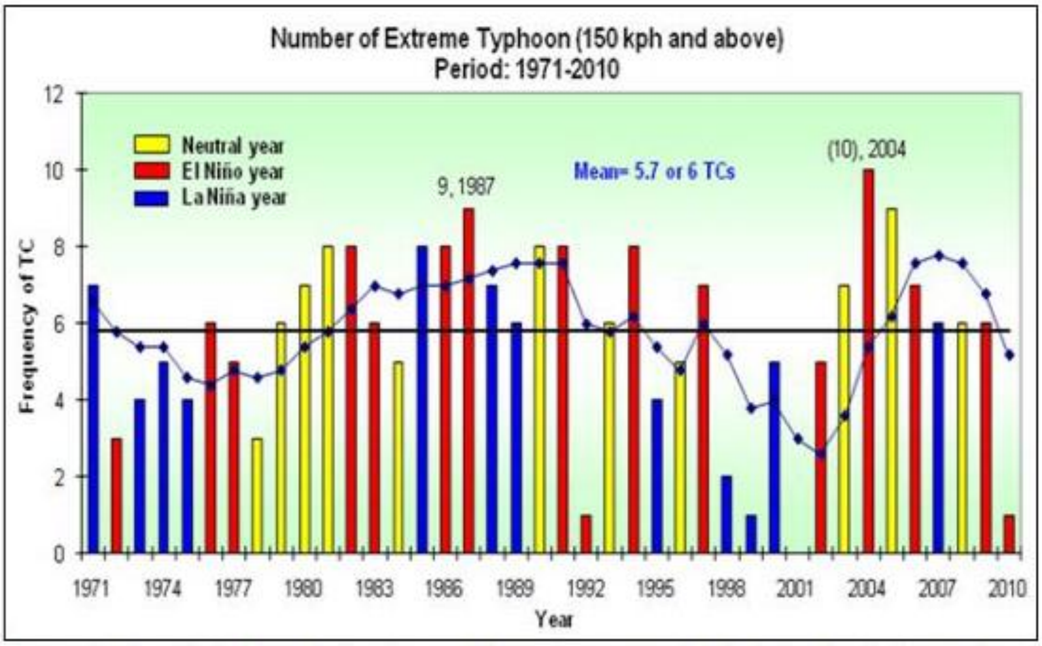


Source: PAGASA, 2011

Figure 2.144 Climate map of the Philippines

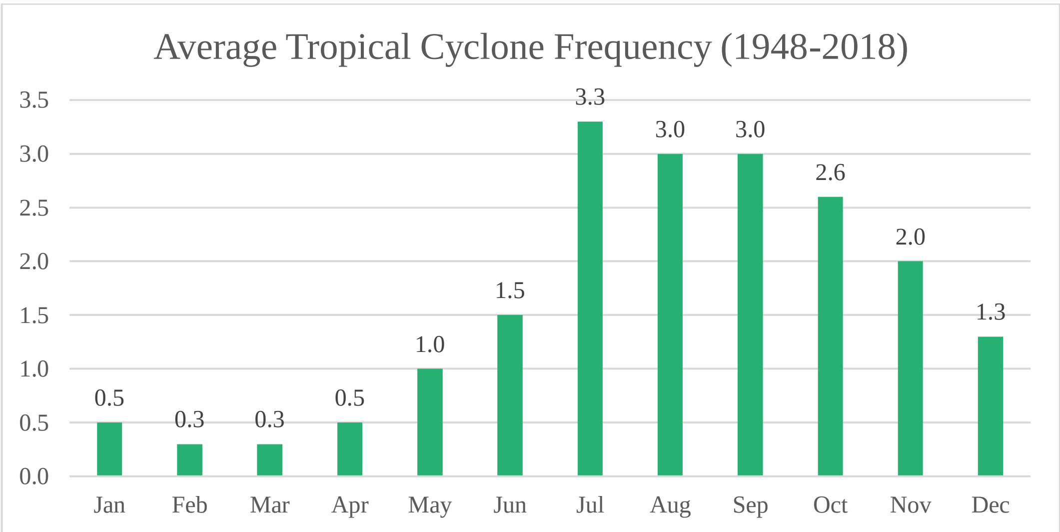
Frequency on Tropical Cyclones

Based on PAGASA's records of extreme typhoon incidences from 1971 to 2010, Philippines averages six (6) typhoons annually. In 2004, the country experienced 10 typhoons, the highest in Philippine history, during the El Niño phenomenon (**Figure 2.145**). Based on official records in 1948-2018, the country averages up to three (3) tropical cyclones per month normally from July to September (**Figure 2.146**). Davao Region however, has very low typhoon risk, with a frequency of only once in every 12 years to once per year. PAGASA Davao claims it has been nearly 50 years since the last typhoon in Malita, Davao Occidental.



Source: PAGASA

Figure 2.145 Number of extreme typhoon in the Philippines from 1971-2010



Source: PAGASA

Figure 2.146 Average Tropical Cyclone Frequency, 1948-2018

However, lately, the PAGASA Davao said weather disturbances and changes in weather pattern push tropical depressions and typhoons to Southern Mindanao. In the previous years, Davao Region was a typhoon-free area and was rarely visited by typhoons but recently, there have been weather disturbances and change of weather patterns. In fact, PAGASA Davao said it has been almost half a century since the last typhoon made landfall in Malita, Davao Occidental.

Typhoon Pablo (international name: Bopha) landed in Baganga town in Davao Oriental in 2012, while Typhoon Crising (international name: Shanshan) hit Davao del Sur in 2013. According to PAGASA Davao, this kind of phenomenon was very unusual for a tropical depression to land in the southern part of Mindanao after Chedeng moved towards Davao Occidental in March 2019. Typhoon Titang (international name: Kate) landed in the same town in 1970 which claimed hundreds of lives.

The recent tropical depression, *Chedeng*, landed in the southern part because of the high-pressure area in Luzon and the *Amihan* winds, which pushed *Chedeng* downward instead of going up, the usual direction of the storm entering the Philippine Area of Responsibility (PAR). Most parts of Mindanao, especially over Surigao del Sur, Agusan del Sur, Davao Region, Soccsksargen, and portions of Bangsamoro and Zamboanga Peninsula had experienced scattered winds with moderate to heavy rains.

Climatological Data

Long-term meteorological data of Davao is required by the EMB to represent the meteorological conditions at the project site. The nearest meteorological station at the proposed alignment is the PAGASA Davao City Synoptic Station. The geographical position of the synoptic station is 07°07'40.41"N and 125°39'17.43"E, with elevation of 18 meters above mean sea level. Long-term climatological normal and extremes were based on PAGASA’s latest available data from year 1981-2010.

Climatological normals are the averages of weather parameters based on different periods computed for a uniform and relative long period comprising of at least three successive 10-year periods. While, climatic extreme conditions are presented in a matrix with values recorded for relevant weather parameters, including lowest and highest ambient temperature, highest daily precipitation, and highest wind rate in a particular weather station. The most recent climatological data at Davao City's PAGASA Synoptic Weather Station are summarized in **Annex M**.

Average annual rainfall is 1759 mm, while the highest daily rainfall was recorded as 242.6 mm in 2 August 1902. Extreme temperatures can range between 16.1 (on 2 February 1962) and 37.3 ºC (on 5 May 1905), with an average of 27.9 ºC. Average wind speed is 2 mps but have been recorded to be as high as 31mps. More details are provided in the succeeding sections of this chapter.

Rainfall, mm

PAGASA average daily rainfall data from 1988 to 2017 indicates that the total monthly rainfall constantly ranges from 90-200 mm in a year. The highest average monthly rainfall reached 192 mm at Davao PAGASA Weather Station in June, while the lowest recorded is 96 mm in March (**Figure 2.147**). This is similar to climatological normals in 1981-2010 (**Annex M**). These trends are consistently characteristic of a Type IV climate, which has an evenly distributed rainfall throughout the year. The standard deviation of the monthly average rainfall values from 1981 to 2010 is only 27.95 mm. Standard deviation of average monthly rainfall for 2017 and 2018 is 72.77 mm and 72.09 mm, respectively, indicating that differences in monthly average rainfall is high compared to 1981 to 2010. Drastic differences in rainfall events between 1981-2010 and 2017-2018 may be due to climate change.

Rainfall has increased substantially from April to October, where rainy days ranged from 12 to 15 days. The total average rainfall from 1988-2017 is recorded at 1,808 mm, with an annual average of 173 rainy days (or about 47.4% of the year). The highest annual rainfall was 2,671 mm at Davao Weather Station in 2017, while the least annual rainfall was 1128 mm in 1967. The highest amount of rainfall was 242.6 mm, recorded on 2 August 1902 (**Annex M**).

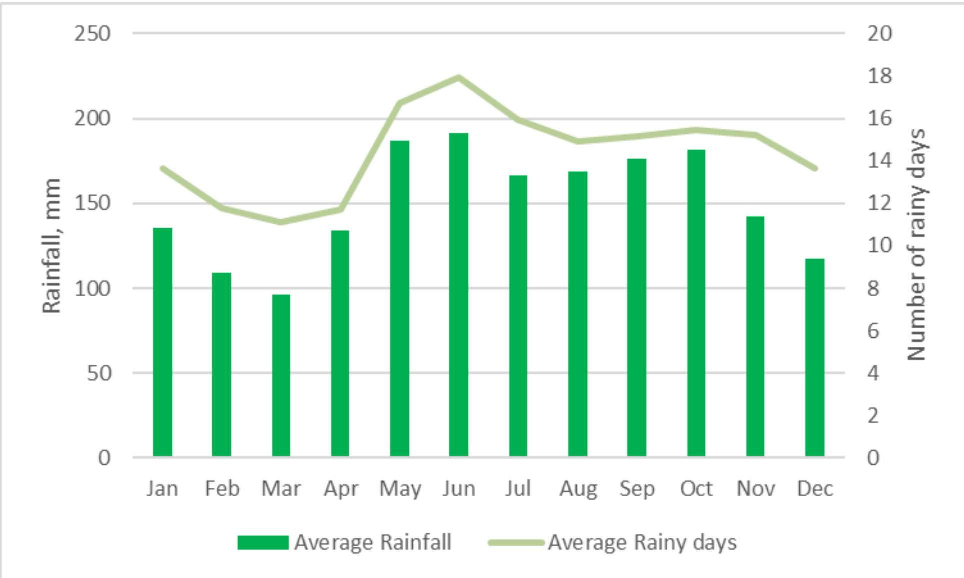


Figure 2.147 Average Monthly Rainfall from Davao Weather Station from 1988 – 2017

Temperature, °C

1981-2010 Temperature

Seasonal changes of atmospheric humidity and cloudiness greatly affect temperatures in the region. Average monthly temperature in Davao ranges from 32.6°C recorded in May to 23.3°C recorded in January. Highest and lowest mean monthly temperatures are 28.6°C and 27.1°C, which occur in April/May and January, respectively. Being in a coastal region, annual variation in the mean monthly temperature is insignificant. The mean annual temperature at the project site is 27.9°C, where January is the coldest month and April and May are warmest. Highest temperature recorded at Davao City station is 37.3 °C on 5 May 1905, while the coldest is 16.1°C on 3 February 1962 (**Annex M**).

1988-2017 Temperature

The temperature recorded from Davao consistently fluctuates from 1988-2017 (**Figure 2.148**). Average monthly temperature ranges from 32.0°C recorded in October to 21.9°C recorded in January. Highest and lowest mean monthly temperatures are 27.4°C and 25.9°C, which respectively occur in October and January. The mean annual temperature at the project site is 26.9°C.

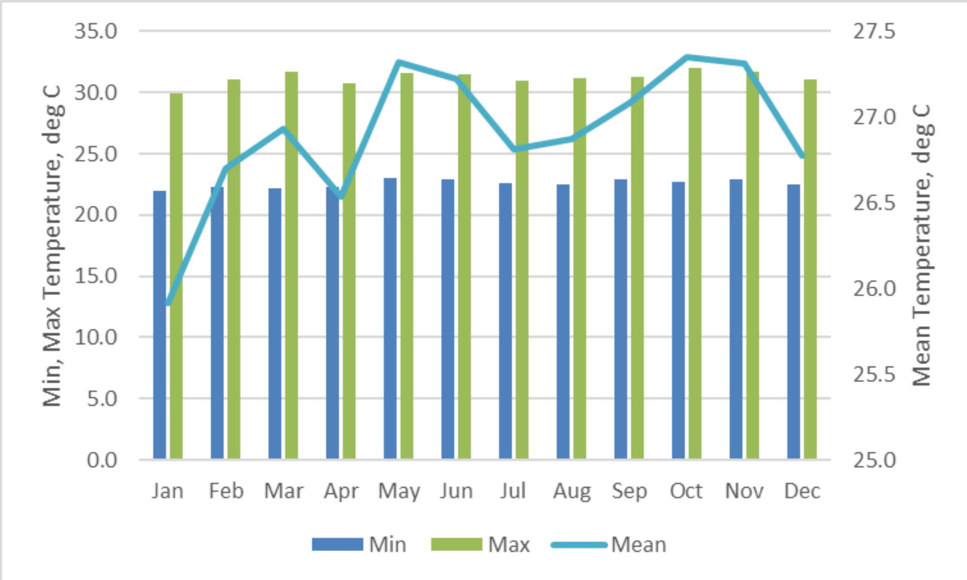


Figure 2.148 Monthly Temperature from Davao Weather Station, 1988 – 2017

2017-2018 Temperature

For the years 2017 and 2018, the average monthly temperature was 28.4°C and 29°C, respectively. In comparison, the 1981 to 2010 monthly average temperature was only 27.9°C. This considerable increase in monthly average in temperature may be attributed to greenhouse effect in Davao City. **Table 2.49** presents the 2017 and 2018 monthly average temperature from the Davao City PAGASA Synoptic Station.

Table 2.49 2017-2018 Monthly Average Temperature at Davao City PAGASA Synoptic Station

STATION: DAVAO CITY, DAVAO DEL SUR **LATITUDE** : 07º07'40.41"N

PERIOD : 2017 - 2018 **LONGITUDE** : 125º39'17.43"E

ELEVATION : 17.29m

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2017	27.5	27.5	28.1	29.1	29.3	28.7	28.7	28.2	-2.0	28.7	28.2	28.8	28.4
2018	27.9	28.9	29.1	29.5	29.6	28.9	28.8	28.9	29.0	29.3	29.0	28.7	29.0

NOTE -2 means no data

Prepared by: PAGASA/CAD/CDS

Relative Humidity, %

Atmospheric moisture content in the tropics is relatively higher than that in upper latitudes. Being situated in the tropics, atmospheric moisture content in the Philippines is expected to be relatively higher.

Records on relative humidity show that the average dry and wet bulb temperatures at the project site are 27.5°C and 24.5°C, respectively. This indicates that the annual average relative humidity is 81%. It should be noted that relative humidity is expressed as percentage water vapor present in the air as measured via dry and wet bulb temperatures and as plotted on psychrometric charts (Perry, 1973). From recorded data, the month of July is the most humid (83%) whereas the month of April is the least humid (77%). (**Annex M**).

Cloud, octa

The mean annual cloud amount at Davao City is 6 octas. Cloudy months are from May to February, a ten-month period.

Wind Speed and Direction

Wind vectors and stability conditions are most important modelling inputs to the assessment of material or pollutant dispersion in the atmosphere. The N wind and S wind are the major air streams influencing the wind pattern of the region. N wind prevails in November to April. S wind prevails in May until October. The mean annual wind speed in the region is 1.88 meters per second (m/s).

The southerly wind has an average wind speed of 1.61 m/s, while the northerly wind has an average wind speed of 2.16 m/s. Average monthly wind speed is uniform at 1.88 m/s. In May to October, which is characterized with southerly winds, are normally when rainfall is significant, as enhanced by the southwest monsoon.

Wind Rose

Windrose analysis was done to describe the prevailing wind in the project area in the past 30 years (1988-2017) based on wind speed and direction from the PAGASA Synoptic Station in Davao City.

Windrose analysis was conducted to define prevailing winds in the project area. A Windrose diagram is a graphical illustration representing a bi-variate frequency distribution of wind speed and wind direction. It represents the amount of time the wind is within a specified range for each of 16 points on a compass. The length of each segment of a spoke (speed group) is related to its frequency. Longer segments represent higher frequencies.

Table 2.50 shows the range of values for mean wind speed including their description as used in the succeeding plots. The number of observations were used to calculate the frequency distribution.

Table 2.50 Wind speed range

Wind speed range (mps)	Description
1-4	Light
5-8	Moderate
9-12	Moderate to Strong
13-16	Strong

Wind speed range (mps)	Description
17-24	Very Strong
Above 24	Violent

The Windrose Analysis for Davao City was taken from daily data in 1988-2017. For example, in January, the windrose diagram indicates that 53.8% of the time, the wind direction comes from the North with 53.33% ranging from 1 to 4 m/s and 0.32% ranging from 5 to 8 m/s. Wind direction in January is predominantly Northerly, with an average wind speed (mean) of 2.32 m/s. Calm conditions were observed 0.2% of the time.

Figure 2.149 presents the monthly windrose diagram from the Davao City Synoptic Station from 1988-2017. The prevailing wind from November to April comes from the North while the prevailing winds from May to October comes from both North and South. The average wind speed is 1.88 m/s (**Figure 2.150**).

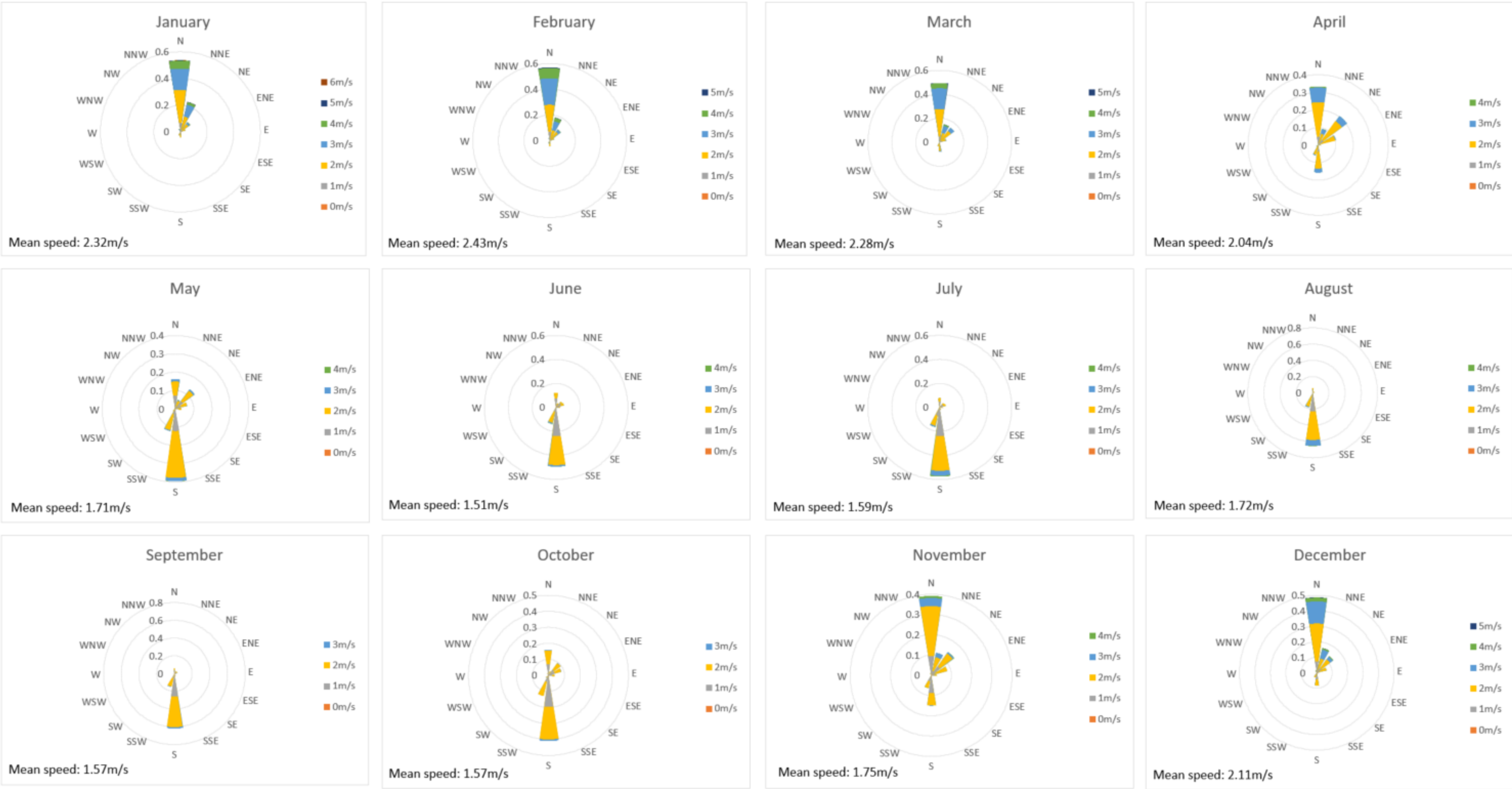


Figure 2.149 Windrose Diagrams for PAGASA Davao City Synoptic Station from 1988 – 2017

Figure 2.150 Annual windspeed and direction for PAGASA Davao City Synoptic Station from 1988 – 2017 (Google Earth, February 2020)

Mean Sea Level Pressure, mbs

Mean sea level pressure was similarly evaluated during climate assessments for the project area. Tropical cyclone passage causes a drop in sea level pressures due to cyclonic wind divergence. In contrast, high pressures signify wind divergence or fair weather conditions. The months from January to April exhibit the highest monthly mean sea level pressures averaging 1009.9 mbs whereas for the rest of the year monthly mean sea level pressures average 1008.9 mbs. November coincides to the lowest average monthly mean sea level pressure at 1008.5 mbs. The average annual mean sea level pressure is 1009.2 mbs

Lightning and Thunderstorms

In Davao City, the average number of days with lightning is 125 days per annum and the average number of days with thunderstorms is 148 per annum. The months from May to November are characterized by the highest number of lightnings and thunderstorms.

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Change in the local micro-climate

Impacts on meteorological conditions are evident in terms of micro-climate. Micro-climates are formed by differences in topography, wind circulation, energy absorbed and presence of water bodies. In a specific city or town, an urban heat island is caused by heavy industrial and construction activities. Road works and buildings absorb a lot of heat energy coming from the sun, hence, making the city warmer. In addition, tall structures tend to block air flow and trap heat within the area, which causes micro-climates. With the construction and operation of the SIDC, there will be a corresponding increase in construction activities, hence there will be increased risk of creating an urban heat island within the site in Davao City and in Samal.

Impacts of climate change to the SIDC Project

As seen in **Table 2.51** to **Table 2.53**, climate projections under a medium-range scenario shows temperature increase in the years 2020 and 2050. In both projected years, June, July and August (JJA) have the highest temperature increases. As for the seasonal rainfall change, December, January and February (DJF) will have a constant increase in rainfall, while March, April, and May will have the greatest decrease in rainfall. With this, extreme events may significantly increase in frequency.

Temperatures that reach over 35°C will occur more often in 2020 and even more so in 2050. The rise in temperature encourages evaporation, which will eventually lead to more rainy days, thereby decreasing the number of dry days and increasing days with precipitation of more than 150 mm. Therefore, flooding, landslides and illness brought by such hazards will most likely occur more often than before. This scenario will be exacerbated during the construction phase, as trees that aid in preventing flood and landslides will be cut down and the soil that helps absorb rainwater will either be transferred or covered.

Table 2.51 Seasonal Temperature Increases (in °C) in 2020 and 2050 under Medium-Range Emission Scenario in provinces in Region 11

Province	Observed Baseline (1971-2000)				Change in 2020 (2006-2035)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 11												
Davao del Norte	26.7	27.8	27.4	27.4	0.9	1.1	1.2	1.1	1.9	2.3	2.5	2.1
Davao del Sur	26.9	27.8	26.9	27.1	0.9	1.1	1.1	1.0	1.9	2.2	2.3	2

Source: PAGASA

Table 2.52 Seasonal Rainfall Change (in %) in 2020 and 2050 under Medium Range Emission Scenario in provinces in Region 11

Province	Observed Baseline (1971-2000)				Change in 2020 (2006-2035)				Change in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 11												
Davao del Norte	637	496.5	536	556.2	9.2	-12.5	-3.6	-1.5	1.1	-22.2	-7.9	-2.2
Davao del Sur	288	347.1	494	442.3	18.1	-9.8	-7.8	-2.4	15.2	-12	-13	-4.5

Source: PAGASA

Table 2.53 Frequency of Extreme Events in 2020 and 2050 under Medium-Range Emission Scenario in Provinces in Region 11

Stations	No. of Days w/ Tmax > 35C			No. of Dry Days			No. of Days w/ Rainfall >150 mm		
	Obs. (1971-2000)	2020	2050	Obs. (1971-2000)	2020	2050	Obs. (1971-2000)	2020	2050
Davao	109	2981	5373	7930	4789	5368	2	3	4

Source: PAGASA Note: OBS – Observed Baseline

2.3.2 Ambient Air Quality and Noise

As part of the Philippine EIS Scoping Checklist requirements for the project and with reference to the Philippine Clean Air Act of 1999 (R.A. 8749) and its IRR (DAO 2000-81), Ambient Air Quality Monitoring (AAQM) was undertaken in areas surrounding the site that were identified to have pollutant-sensitive receptors. AAQM was also undertaken to determine baseline conditions of ambient air, identify potential air quality impacts and design measures to mitigate adverse impacts, and to ensure project compliance with RA 8749.

2.3.2.1 Ambient Air Quality

Methodology

Ambient 24-hour air quality was measured in six (6) different locations, representing both upstream and downstream within the project area: 3 at Barangay Vicente Hizon Sr., Davao City and 3 at Barangay Limao, IGaCoS (**Figure 2.151** and **Figure 2.152)**. Concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulate (TSP), particulate matter with aerodynamic diameter less than 10 (PM10) and 2.5 (PM2.5), as recommended during EMB-facilitated Technical Scoping, were analyzed by ELARSI, a DENR-accredited environmental laboratory. The selection of the air sampling stations was based on the proximity of sensitive receptors and prevalent wind direction.

Methods for sampling and analysis are in accordance with Section 1(b) Rule VII Part II of the Philippine Clean Air Act of 1999. The BGI/MESA LABS PQ 200 TSP/PM10/PM2.5 High Volume Sampler was used to obtain TSP, $PM_{2.5}$, and PM_{10} samples from sampling locations. A leak test was conducted before running the sample to ensure the security of the filter sample. After the run, data was uploaded to a laptop and sample filters were secured inside the filter holder. The sampled filters were delivered to ELARSI Inc. for gravimetric analysis to solve for TSP, $PM_{2.5}$, and PM_{10} concentrations.

For SO_2 and NO_2, a 3-Gas Sampler was used to gather samples. Each container inside the gas bubbler was filled with 10-mL of a reagent. After the instrument run, solutions were placed inside sampling bottles and preserved with ice.

The 24-hour ambient air monitoring results were compared with NAAQGV from the DAO 2000-81and from the DAO 2013-13 Establishing Provisional National Ambient Air Quality Guideline Values (NAAQGV) for PM2.5. The NAAQGV are typically used as reference for baseline studies to assess the air quality of an airshed or a region/locale prior to the project implementation (**Table 2.54**).

Table 2.54 National Ambient Air Quality Guideline Values

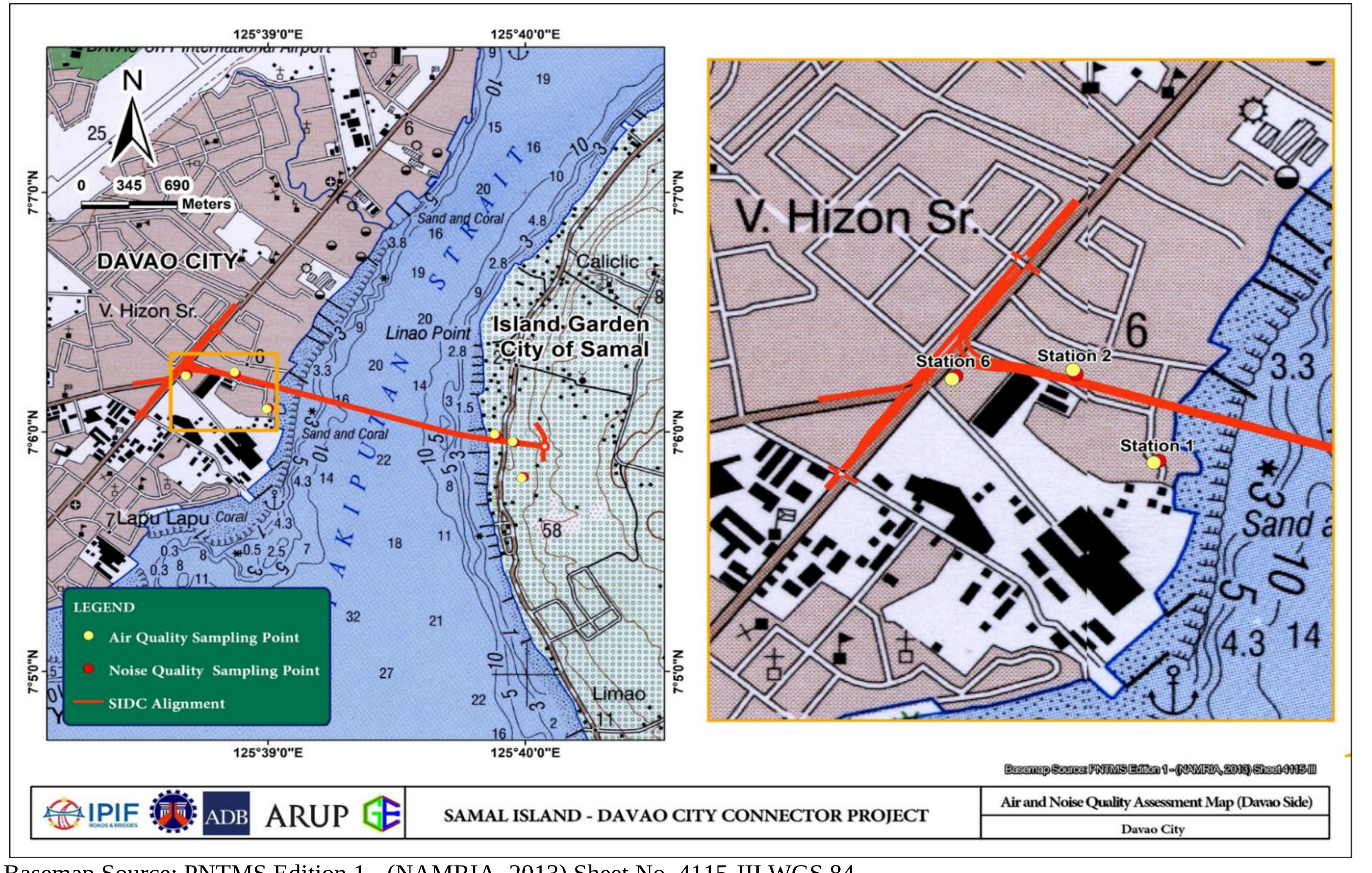
Guideline Values	TSP (µg/Ncm)	PM10, (µg/Ncm)	PM2.5, (µg/Ncm)	SO_2 (µg/Ncm)	NO_2 (µg/Ncm)
24-hour Sampling	230	150	50	180	150

The quality of the pollutants is evaluated through the Air Quality Indices (AQI) in **Table 2.55**. The AQI is used to classify the conditions of ambient air quality in the project area.

Table 2.55 Air quality indices

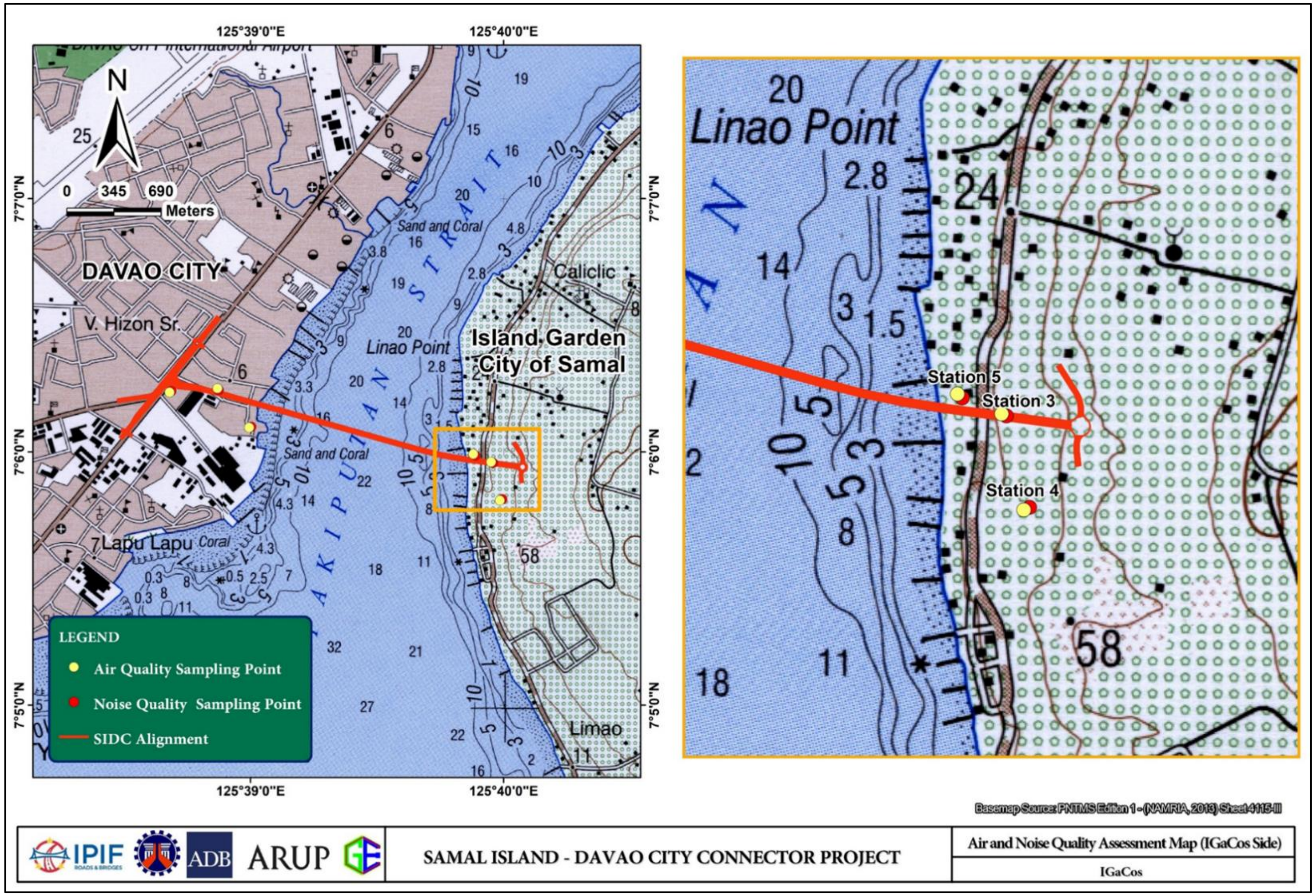
Type/ Classification	TSP, µg/Ncm (24-hour average)	PM_{10}, µg/Ncm (24-hour average)	SO_2, µg/Ncm (24-hour average)*	NO_2, ppm (1-hour average)*
Good	0 to 80	0 to 54	0 to 88.8	--
Fair	81 to 230	55 to 154	91.4 to 376.2	--
Unhealthy for sensitive groups	231 to 349	155 to 254	378.8 to 627.4	--
Very unhealthy	350 to 599	255 to 354	587.8 to 794.2	--
Acutely unhealthy	600 to 899	355 to 424	796.8 to 1577.9	1,220.5 to 2,328.3
Emergency	900 and above	425 to 504	1580.5 to 2100.3	2,347.0 to 3,079.3

*Conversion factor for SO_2: 1 ppm = 2,612.4 µg/Ncm; NO_2: 1 ppm = 1,877.6 µg/Ncm; Annex A of DAO 2000-81.



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS 84

Figure 2.151 Ambient Air and Noise Quality Sampling Stations in Davao



Basemap Source: PNTMS Edition 1 - (NAMRIA, 2013) Sheet No. 4115-III WGS 84

Figure 2.152 Ambient Air and Noise Quality Sampling Stations in IGaCoS

Baseline Environmental Conditions

Provided in **Table 2.56** and **Annex M** are the geographic coordinates of the air sampling stations in WGS 1984 datum. The sampling date as well as the location of the sampling points are displayed in the same table. While **Table 2.56** Air

Station No.	Location	Latitu	Longitu	Date of Sampling			
		GRS: WGS 1984		PM2	PM1	TSP	SO2
1	Brgy. Vicente Hizon Sr., Davao	7.1016	125.649	07/9-	07/1-	06/2	07/2
2	Brgy. Vicente Hizon Sr., Davao	7.1042	125.647	07/1	07/3-	07/2-	07/1
3	Brgy. Limao Paradise Property	7.0993	125.665	10/7-	09/2	09/2	10/7-
4	Brgy. Limao Paradise Property	7.0998	125.664	10/1	10/3-	10/2-	10/1
5	Brgy. Limao Blue Water Property	7.0968	125.666	10/8-	10/9-	10/1	10/8-
6	Barangay Vicente Hizon Sr. So	7.1039	125.644	10/2	10/2	10/2	10/2

Sampling GPS Coordinates in WGS 1984 datum

Table 2.57 presents the meteorological conditions at all sampling stations. Only TSP, $PM_{2.5}$, and PM_{10} have separate meteorological conditions since SO_2 and NO_2 were sampled on the same day with either TSP, $PM_{2.5}$, and PM_{10}. Sampled stations that indicated the occurrence of precipitation only experienced precipitation in a short period and did not require operations to cease. Average temperatures and pressure during the sampling period are 27°C and 753 mmHg, respectively.

Ambient concentration of particulate pollutant

As shown in **Table 2.58**, the results of TSP, PM10, PM2.5, SO_2 and NO_2 concentrations are within their respective DAO 2000-81 NAAQGV for 24-hour sampling periods. The quality of ambient air in project site vicinity in terms of particulate pollutants (i.e. TSP, $PM_{2.5}$, and PM_{10}) is generally good based on Air Quality Indices of DAO 2000-81.

Results for $PM_{2.5}$ and PM_{10} concentration after 24-hour monitoring ranges from 0.4 µg/Ncm to 0.8 µg/Ncm and 14.3 µg/Ncm to 34.7 µg/Ncm, respectively. Station 6 exhibited the highest PM10 concentration among the sampling stations. The PM_{10} concentrations in all stations were within the DAO 2000-81 NAAQGV of 150 µg/Ncm. The baseline conditions in all four (4) stations are classified as "good" based on Air Quality Indices of DAO 2000-81.

TSP varies from 18.3 µg/Ncm to 47.1 µg/Ncm within 24 hours. Station 1 has the highest TSP concentration among the sampling stations. The TSP concentrations in all four (4) stations were within the DAO 2000-81 NAAQGV of 230 µg/Ncm and are classified as "good" based on Air Quality Indices of DAO 2000-81.

Ambient concentration of gaseous pollutant

Table 2.58 summarizes the results of SO_2 and NO_2 monitoring for 24-hour sampling periods. The concentrations of SO_2 and NO_2 in all six (6) stations for 24-hour monitoring periods were within their respective DAO 2000-81 NAAQGV. Ambient air in the site vicinity in terms of gaseous pollutants is "good" based on the DAO 2000-81 air quality indices.

SO_2 is mainly generated from industrial activity and vehicles that burn fuel with high sulfur content. Exposure to SO_2 concentrations could lead to adverse respiratory health risks. High SO_2 concentrations may result in significant environmental impacts, including acid rain and haze formation.

SO_2 concentration ranges from 2.88 to 20.89 μg/Ncm and is in compliance with the NAAQGV of 180 μg/Ncm within 24 hours. Concentrations in all monitoring stations conform to the prescribed DAO 2000-81 NAAQGV and are classified as as “good” based on Air Quality Indices. Stations 3 (Paradise Property) and 5 (Blue Water Property) in Barangay Limao, respectively recorded SO_2 concentrations of 24.31 μg/Ncm and 20.89 μg/Ncm.

NO_2 is a highly reactive gas that is generated from fossil fuel combustion mostly from vehicles, power plants, and off-road equipment. Exposure to NO_2 poses respiratory health risks. High NO_2 concentrations may also lead to adverse environmental impacts, including acid rain, haze and ozone formation.

NO_2 concentration ranges from 0.16 μg/Ncm to 3.07 μg/Ncm within 24 hours. Concentrations in all stations comply with the NAAQGV of 150 μg/Ncm prescribed in the DAO 2000-81.

Table 2.56 Air Sampling GPS Coordinates in WGS 1984 datum

Station No.	Location	Latitude	Longitude	Date of Sampling			
		GRS: WGS 1984		PM2.5	PM10	TSP	SO_2 & NO_2
1	Brgy. Vicente Hizon Sr., Davao City	7.1016°	125.6499°	07/9-10/2019	07/1-2/2019	06/27-28/2019	07/27-28/2019
2	Brgy. Vicente Hizon Sr., Davao City	7.1042°	125.6478°	07/10-11/2019	07/3-4/2019	07/2-3/2019	07/10-11/2019
3	Brgy. Limao Paradise Property	7.099333°	125.665833°	10/7-8/2019	09/26-27/2019	09/27-28/2019	10/7-8/2019
4	Brgy. Limao Paradise Property	7.099861°	125.664667°	10/11-12/2019	10/3-4/2019	10/2-3/2019	10/11-12/2019
5	Brgy. Limao Blue Water Property	7.096806°	125.666417°	10/8-9/2019	10/9-10/2019	10/10-11/2019	10/8-9/2019
6	Barangay Vicente Hizon Sr. So Peng Kee Property	7.103917°	125.644667°	10/23-24/2019	10/22-23/2019	10/21-22/2019	10/23-24/2019

Table 2.57 Meteorological conditions

Station No.	Location	Parameter	Precipitation	Temperature	Pressure	Prevailing Wind Speed
				Unit (^{O}C)	Unit (mmHg)	
1	Brgy. Vicente Hizon Sr., Davao City	TSP	Yes	25.9	753	Light
		PM_{10}	Yes	25.1	753	Light
		PM2.5	Yes	23.8	754	Light
2	Brgy. Vicente Hizon Sr., Davao City	TSP	Yes	24.1	754	Light
		PM_{10}	Yes	24.3	754	Calm
		PM2.5	Yes	24.3	754	Light
3	Brgy. Limao Paradise Property	TSP	None	28.4	754	Calm
		PM_{10}	None	28.2	754	Light
		PM2.5	Yes	27.7	752	Calm
4	Brgy. Limao Paradise Property	TSP	None	27.5	755	Light
		PM_{10}	Yes	26.6	755	Calm

Station No.	Location	Parameter	Precipitation	Temperature	Pressure	Prevailing Wind Speed
				Unit (^{O}C)	Unit (mmHg)	
		PM2.5	Yes	27.1	754	Light
5	Brgy. Limao Blue Water Property	TSP	None	27.8	752	Calm
		PM_{10}	None	28.1	752	Calm
		PM2.5	None	27.7	752	Calm
6	Barangay Vicente Hizon Sr. So Peng Kee Property	TSP	None	29.4	753	Light
		PM_{10}	Yes	29.3	753	Light
		PM2.5	Yes	28.7	754	Light

Table 2.58 Ambient TSP, PM10, PM2.5, SO_2, and NO_2 Levels

Station No.	Location	Sampling results, µg/Nm^3				
		$PM_{2.5}$	**PM_{10}**	**TSP**	**SO_2**	**NO_2**
1	Brgy. Vicente Hizon Sr., Davao City	0.4	31.1	47.1	2.89	0.16
2	Brgy. Vicente Hizon Sr., Davao City	0.4	34.7	42.5	2.88	0.16
3	Brgy. Limao Paradise Property	0.4	16.5	18.3	24.31	3.07
4	Brgy. Limao Paradise Property	0.4	14.3	23.8	15.93	2.30
5	Brgy. Limao Blue Water Property	0.4	24.6	29.2	20.89	2.56
6	Barangay Vicente Hizon Sr. So Peng Kee Property	0.8	29.0	42.1	10.02	0.17
National Ambient Air Quality Guideline for Criteria Pollutants		**N/D**	**150**	**230**	**180**	**150**

2.3.2.2 Ambient Noise Level

The team coordinated with the landowners and locals and asked for permission before conducting noise sampling. Ambient noise levels were measured at less than a 1 km radius from the project site and compared with the DENR and IFC-WB EHS Standards.

Methodology

Provided in **Table 2.61** are the geographic coordinates of the noise sampling stations in WGS 1984 datum. The sampling date as well as the location of the sampling points are displayed in the same table.

Sampling was conducted at different periods of the day (i.e. morning, daytime, evening and nighttime) to note any predominant noise sources. A median of at least seven noise readings was taken during monitoring and was compared with the noise standards stipulated in NPCC MC No. 002 Series of 1980 (**Table 2.59**).

In 1978 the Philippine government, thru NPCC, has developed noise standards which are set according to the land use of the area and the time of the day. The Philippine noise standards has not been amended or modified since 1980 and it has been adopted by the DENR as the primary ambient noise standards in the country.

Table 2.59 Environmental Quality Standards for Noise in General Areas

Category of Area	Description	Maximum Allowable Noise Level, dB (A)		
		Daytime	Morning/ Early Evening	Night time
Class AA	Generally quiet areas such as areas within 100 meters from school sites, nursery schools, hospitals and special homes for the aged.	50	45	40
Class A	Areas primarily used for residential purposes	55	50	45
Class B	Areas zoned or used as commercial area	65	60	55
Class C	Areas zoned or used as a light industrial area	70	65	60
Class D	Areas zoned or used as a heavy industrial area	75	70	65

In addition, another noise monitoring was conducted using the LAeq in compliance with the IFC-EHS Guidelines for Noise Management, one in Daytime (7:00AM - 10:00 PM) and another in night time (10:00PM – 7:00AM). The results of these noise measurements were also compared to the 2007 IFC EHS Guidelines (**Table 2.60**).

Table 2.60 IFC Noise Level Guidelines

Receptor	**One Hour L_{Aeq} (dBA)**	
	Daytime (07:00-22:00)	**Night time (22:00-07:00)**
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Sensitive receptors will likely receive significant increase in noise level due to the construction. This sampling ensures that a broad distribution of noise level survey locations is chosen. These locations were selected as close to neighbouring noise sensitive receptors as practicable without causing undesirable impacts on bridge movements and safety.

Results are summarized in **Table 2.62** and **Annex M**.

Table 2.61 Noise Sampling GPS Coordinates in WGS 1984 datum

Station No.	Location	Latitude	Longitude	Date of Sampling
		GRS: WGS 1984		
1	Brgy. Vicente Hizon Sr., Davao City	7.1016°	125.6499°	06/27/2019
2	Brgy. Vicente Hizon Sr., Davao City	7.1042°	125.6478°	07/01/2019
3	Brgy. Limao Paradise Property	7.099417°	125.665778°	10/02/2019
4	Brgy. Limao Paradise Property	7.099800°	125.664600°	09/25/2019
5	Brgy. Limao Blue Water Property	7.096732°	125.666326°	10/08/2019
6	Brgy. Vicente Hizon Sr. So Peng Kee Property	7.103806°	125.644694°	10/21/2019

Table 2.62 Results of Noise Level Measurement

Station No.	Location	NPCC standards (dBA)					IFC Noise Level Guidelines	
		Class/ Category	Morning	Daytime	Early Evening	Nighttime	Daytime	Nighttime
1	Brgy. Vicente Hizon Sr., Davao City	A	61	57	58	58	57	59
2	Brgy. Vicente Hizon Sr., Davao City	A	59	57	58	57	58	57
3	Brgy. Limao Paradise Property	B	50	50	52	49	50	49
4	Brgy. Limao Paradise Property	B	51	49	50	51	50	51
5	Brgy. Limao Blue Water Property	B	58	51	60	58	55	58
6	Brgy. Vicente Hizon Sr. So Peng Kee	A	61	60	62	59	61	59

On the Davao side, the noise sampling results exceeded the NPCC standards and IFC noise level standards for Class A (residential areas). Although the location of noise sampling points in Barangay Hizon (Davao) are classified as residential areas, there are surrounding properties, which are commercial areas, which affected the noise results. Stations 1,2, and 6 have similar noise sources, which are mainly from airplanes passing, sounds of vehicles, animal sounds from birds, insects and roosters, people talking and music playing. The distinct noise observed during noise sampling was the sound of helicopters, dogs barking (Station 1 and Station 2) and boats passing (Station 1).

On the Samal side (Paradise and Blue Waters) the Class B (commercial areas), all noise sampling results passed both NPCC and IFC noise level standards.

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

The primary objective of any environmental air and noise assessment is to protect people from their adverse effects. Below are the identified impacts on air and noise and some of the recommended options for prevention, mitigation or enhancement.

Impacts to Air Quality

During construction, it is expected that particulates and gaseous pollutants' (PM2.5, PM10, TSP, SO_2 and NO_2) concentrations will increase at and in between landing sites. Fugitive emissions and fuel consumption by the project are the most significant source of dust and particulate pollutants (TSP, PM2.5 and PM10) during construction and operation phases. Minimising fuel consumption is not only economic; it may also have the potential to reduce GHG emissions and particulate and gaseous pollutants.

Construction vehicles will also ply the entire SIDC route, which will increase SO_2 and NO_2 concentrations. Although these types of emissions eventually dissipate, the following control measures are recommended to minimize the construction effects to air quality:

- All haul vehicles should be covered or transported soils be sprayed with water before leaving the site, especially during windy conditions
- Workers will be provided with the appropriate personal protective equipment pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989) to protect them from disease associated with dusts.
- Standard occupational health and safety practices will be implemented pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989).
- Use of efficient fuel and equipment (e.g. use of low sulfur fuel, scheduling of use to minimize idle and distances travelled)
- Proper scheduling hours for construction to minimize the potential impact to the sensitive receptors.

- Regular preventive maintenance of heavy equipment and service vehicles to be used on site must be observed by the contractors/ subcontractors to minimize emission of noxious gases and particulate material
- Requiring sub-contractors to undergo and pass the government vehicle emission tests prior to contract award.
- Traffic management guidelines will be incorporated in worker’s and subcontractor’s induction seminar.

During construction, regular monitoring of PM2.5, PM10, TSP, SO_2 and NO_2 concentrations shall be done to ensure that the levels of these pollutants are still within NAAQGV of DAO 2000-81. The sampling stations in this assessment may be used as monitoring stations once the project goes into construction and operations phase.

During operations, air pollution is anticipated to be at higher levels as opposed to the construction phase, as emissions will be regularly generated by vehicles using the SIDC. On the other hand, air pollution near the ferry jetty is likely to be improved due to the significant reduction in the number of idling vehicles, as most are anticipated to use the SIDC instead of ferry services. Conversely, an increase in traffic volume may cause a corresponding increase in the amount of exhaust and air pollutants. Nevertheless, the impact to the air quality by exhaust gas is assumed to be less than the amount of pollutants released by vehicles that use the existing ferry to and from Samal.

Enhancement of climate change impacts

The Project may have the potential to enhance climate change impacts in the area by introducing particulates and gaseous pollutants in the atmosphere. Measures to minimize the Projects’ contribution to the effects of climate change are the same as above.

Impacts to Noise and Vibrations

During construction, heavy equipment will generate noise which will disturb nearby residential and commercial areas. However, the impacts are deemed to be short term. Proper scheduling of construction hour is recommended to minimize the potential noise impact to the sensitive receptors. Speed of vehicles will be limited on roads, and vehicle horn signals will be kept at a low volume, if necessary, such that the noise generated by the ingress and egress of vehicles will be minimized.

During operations, the noise and vibrations from vehicles plying the bridge might exceed the National Standards for Noise in general areas. Nevertheless, and given that the SIDC crosses the gulf, the influence of noise and vibration on the areas surrounding the main structure is generally limited. Moreover, the approach sections of the project may be of the flyover type, which have less impact on noise and vibration compared to roads built on the ground. Should noise and vibrations near or exceed acceptable values, measures – such as the installation of insulating walls – may be undertaken.

Other recommended measures are listed below:

- Constantly inform the host communities of the duration and timing of any noisy construction.
- Appropriate personal protective equipment (PPE) that conforms to the Procedural Guidelines Governing Occupational
- Safety and Health in the Construction Industry as per BWC-DOLE DO 1998-13 will be provided to operators and workers who handle heavy equipment that generates high levels of noise. Work involving handling of noisy and/or vibrating power tools/equipment shall be a maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC-DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989).
- Regular maintenance of all vehicles, machinery, and heavy equipment will be ensured and noise generating equipment will be controlled by installation of noise damping barriers/guards.
- Ambient noise level monitoring will be done regularly within the perimeter of the Project and near the sensitive receptors in the baseline sampling stations discussed in this report to control noise levels and meet the recommended criterion.

2.4 The People

This module highlights socio-economic baseline information and existing conditions of the project affected area. Key points on the potential social impacts to identified stakeholders are discussed and options and mitigation plans of the proponent are presented to ensure that the project adheres to governing laws consistent with the Philippine EIS System guidelines. This includes sub-sections stipulated in the People module of the Technical Scoping Checklist:

- Demographic data
- Displacement of Settlers
- In-migration
- Cultural/Lifestyle change
- Impacts on physical cultural resources
- Threat to delivery of basic services / resource competition
- Threat to public health and safety
- Generation of Local Benefits
- Traffic congestion

Methodology

Primary Data

Primary data gathering was done through the conduct of public perception survey last 19 May to 01 June, 2019 and route inventory and condition survey last May 2019. The perception survey aims to find out people's understandings, views, judgments, and feelings about the Project. The result of the survey was utilized to gather and assess the concerns of stakeholders affected by the project. On the other hand, the purpose of route inventory and condition survey as well as meetings with the concerned utility companies were conducted. Its purpose is to identify the existing conditions in the project area and the utilities that will be affected by the project.

Secondary Data

Secondary data gathered were acquired from the most recent data of Philippine Statistics Authority (PSA), Comprehensive Land Use Plans of Davao City (2013-2022), Comprehensive Development Plan (CDP) of IGaCoS (2018 - 2023) and Barangay Profiles of Caliclic, Hizon, Limao and R. Castillo. In addition, as-built drawings of existing utilities from concerned utility companies were also used to locate aerial and underground utilities and verify the data gathered from the survey.

2.4.1 Demographic Data

Baseline Environmental Conditions

Land Area

The four (4) covered barangays of the Project has a total land area of about 13,737,800 m^2. Out of the total area, the estimated affected area of SIDC footprint is at 63,380 m^2. The project will only cover 21,052 m^2 in IGaCoS and 42,328 m^2 in Davao City. See **Table 2.63**.

Table 2.63 SIDC Footprint

City / Municipality	Barangay	Land Area, m^2	SIDC Project Footprint, m^2
Davao City	V. Hizon	2,168,800	**42,328**
	A. Angliongto	2,883,600	
	R. Castillo	445,400	
IGaCoS	Limao	8,240,000	**21,052**
Total		**13,737,800**	**63,380**

Source: City of Davao Comprehensive Land Use Plan (2019-2028). Population Desity by Barangay (2015)

Population

Recorded data of PSA shows that Davao and IGaCoS populations have been gradually increasing over the past years (2000 – 2015). In 2015, total population of Davao City is at 1,632,991, while IGaCoS has a total population of 104,123. According to PSA, Davao City population was growing annually by 2.30% and IGaCoS by 1.50% from 2010-2015, refer to **Table 2.64**.

Table 2.64 Population and Population Growth Rate of Davao City and IGaCoS

City/Municipality	Population Growth Rate (%)			Annual Population Growth Rate (%) (2010-2015)
	2000	2010	2015	
Davao City	1,147,116	1,449,296	1,632,991	2.30
IGaCoS	82,609	95,874	104,123	1.58

Sources: PSA (2015). Davao Region Results from the 2015 Census of Population;PSA (2015). Island Garden City of Samal Results from the 2015 Census of Population.

Impact Barangays

The four (4) affected barangays of SIDC has a total population of **33,084**.

Out of 182 barangays in Davao City, three (3) barangays will be directly affected by the project, including: Barangay Vicente Hizon Sr., Barangay Angliongto, Sr., and Barangay R. Castillo. In 2015, Barangay Vicente Hizon Sr. had 11,265; Barangay Angliongto had 13,539 people; and Barangay R. Castillo had 5,783 people. Population decreased from 2010-2015 by 618 residents in Vicente Hizon, Sr; 2,219 in Barangay Angliongto, Sr., and 556 in Barangay R. Castillo.

For IGaCoS, only one (1) out of 46 barangays will be directly affected by the project. Recorded settlers in Barangay Limao in 2015 is at 2,497. An increase of 56 inhabitants in Barangay Limao was recorded from 2010-2015, see **Table 2.65**.

Table 2.65 Population of Affected Barangays

Affected Area	Population (2015)
Davao City	**1,632,991**
Barangay Vicente Hizon, Sr., Davao City	11,265
Barangay Angliongto, Sr., Davao City	13,539
Barangay R. Castillo, Davao City	5,783
IGaCoS	**104,123**
Barangay Limao, IGaCoS	2,497
Total Population of Affected Barangays	**33,084**

Sources: PSA (2015). Davao Region Results from the 2015 Census of Population; PSA (2015). Island Garden City of Samal Results from the 2015 Census of Population.

Number of Households and Average Household Size

Based on latest PSA census data in 2015, total number of households in Davao City was about 410 households, which is about 22.5% more than households in 2010. Average household size in the city consists of 4 members.

For IGaCoS, the total number of households was recorded at 26,245 in 2015 which is higher by 3,443 compared with recorded number of households in 2010 and 5,414 compared in year 2000. Average household size in the city consists of 4 members.

Table 2.66 Number Households and Average Household Size of Davao City and IGaCoS

Census Year	Number of Households	Average Household Size
Davao City		
2000	240,057	4.80
2010	334,473	4.3
2015	409,951	4.0
IGaCoS		
2000	17,388	4.75
2010	22,802	4.2
2015	26,245	4.0

Sources: PSA (2015). Davao Region Results from the 2015 Census of Population; PSA (2015). Island Garden City of Samal Results from the 2015 Census of Population.

Gender - Age Profile

Of the 2015 Davao City population, 50.53% are male, while 49.47% are female. For IGaCoS, 51.58% of its recorded settlers in 2015 are male, while 48.42% are female. Age-sex distribution data further determined that the 15-64 year old age cohort was the largest age group in 2015 (PSA, 2015), where majority are 18-35 years old (CPDO SEI, 2018). The age in the Davao region was 23 years old in 2015.

Table 2.67 Total Population by Age Group of Davao City and IGaCoS

Age Group	Both Sexes		Male		Female	
	Davao City	IGaCoS	Davao City	IGaCoS	Davao City	IGaCoS
All Ages	**1,632,991**	**104,123**	**825,100**	**53,711**	**807,891**	**50,142**
0 - 4	168,380	13,232	87,427	6,796	80,953	6,436
0 - 14	496,058	38,371	255,644	19,760	240,414	18,611
15 - 64	1,071,196	75,775	540,475	39,113	530,721	36,662
18 years and over	1,039,153	73,535	520,150	37,803	519,003	35,732
60 years and over	109,562	7,893	50,219	3,832	59,343	4,061
65 years and over	65,737	4,604	28,981	2,168	36,756	2,436

Sources: PSA(2015). Total Population by Age Group, Davao City; PSA (2015). Total Population by Age Group, Island Garden City of Samal

Literacy Rate Profile and Educational Attainment

Literacy Rate

Data from the latest CPDO Literacy and People Empowerment Report indicates that in 2016, 98.9% of Davao City is literate. 50.04% of the Davao population consists of literate males, while 49.95% of the population are literate females. For IGaCoS, 51.56% of its total population are literate males, and 48.44% are literate females. Of the Davao and IGaCoS populations, the 15 – 24 age cohort is the most literate age group, refer to **Table 2.68.**

Table 2.68 Literacy of the Household Population 10 Years Old and Over by Age Group and Sex: 2015

Age Group	Literate					
	Both Sexes		Male		Female	
	Davao City	IGaCoS	Davao City	IGaCoS	Davao City	IGaCoS
Total	**1,276,130**	**80,244**	**638,657**	**41,375**	**637,473**	**38,869**
10 - 14	159,762	10,686	81,217	5,600	78,545	5,086
15 - 19	165,997	9,572	82,495	5,013	83,502	4,559
20 - 24	165,556	8,696	81,883	4,446	83,673	4,250
25 - 29	148,523	8,090	75,149	4,178	73,374	3,912
30 - 34	124,435	6,799	63,859	3,583	60,576	3,216
35 - 39	110,488	6,470	56,926	3,411	53,562	3,059
40 - 44	92,649	6,120	47,691	3,171	44,958	2,949
45 - 49	79,998	5,478	40,491	2,811	39,507	2,667
50 - 54	66,144	4,854	32,740	2,508	33,404	2,346
55 - 59	56,099	4,135	27,307	2,114	28,792	2,021

Age Group	Literate					
	Both Sexes		Male		Female	
	Davao City	IGaCoS	Davao City	IGaCoS	Davao City	IGaCoS
60 - 64	43,127	3,423	20,901	1,719	22,226	1,704
≥ 65	63,352	5,921	27,998	2,821	35,354	3,100

Sources: PSA (2015). Literacy of the Household Population 10 Years Old and Over by Age Group and ex: 2015. Davao City;PSA (2015). Literacy of the Household Population 10 Years Old and Over by Age Group and Sex: 2015. Island Garden City of Samal

Educational Attainment Profile

PSA Census data indicates that the highest educational attainment of the Davao City school-age population is high school, accounting for 38.4%, followed by elementary level, accounting for 27.5%. About 13.7% are academic degree holders, while 2% have not attained any educational level. In IGaCoS, majority have mostly attained elementary and high school, each accounting for nearly 40% of the school-age population. About 5.9% are academic degree holders, while 2.5% have not attained any educational level**.**

Table 2.69 Total Population 5 Years Old and Over by Highest Grade/Year Completed, Sex, and Age: 2015

Highest Grade/Year Completed	Total Population 5 Years Old and Over	
	Davao City	IGaCoS
Both Sexes	**1,464,611**	**92,604**
No Grade Completed	28,866	2,367
Pre-School	45,870	2,553
Special Education	652	38
Elementary	403,011	36,996
1st - 4th Grade	210,225	18,178
5th - 6th Grade	70,828	6,362
Graduate	121,958	12,456
High School	563,097	36,627
Undergraduate	223,106	16,773
Graduate	339,991	19,854
Post-Secondary	13,100	1,188
Undergraduate	1,985	101
Graduate	11,115	1,087
College Undergraduate	201,290	7,292
Academic Degree Holder	201,345	5,441
Post Baccalaureate	3,331	79
Not Stated	4,049	23

Sources: PSA (2015). Total Population 5 Years Old and Over by Highest Grade/Year Completed, Sex, and Age: 2015. Davao City and IGaCoS

Poverty and Food Poverty Indices

Based on the PSA 2018 Poverty Estimates, a five-member household in Davao Region would require a daily income of PHP 248 to meet food needs or a daily income of PHP 355 to stay out of poverty. The minimum per capita poverty and food poverty threshold has moreover, increased by 12% in 2018 from 2015, representing an average annual inflationary increase of 4%**.**

Table 2.70 Monthly and Daily Poverty Thresholds for a Family of Five in 2018: Region XI

	Monthly (PhP)	**Daily (PhP)**
Poverty Threshold	10,797	355
Food Threshold	7,533	248

Source: Philippine Statistics Authority. 2020. 2018 Poverty Estimates of Davao Region

The PSA 2018 Poverty Estimates Report also indicated that about 19% of Davao City population is in poverty, while about 6% are unable to meet basic food needs. Poverty incidence and subsistence incidence have decreased respectively by 20% and 33% from 2015 to 2018.

Table 2.71 Poverty and Subsistence Incidence and Magnitude of Poor and Subsistence Poor Population, Region XI (2012, 2015, 2018)

Indicator	**2012**	**2015**	**2018**	**Increase / Decrease 2015-2018 (%)**
Poverty Incidence among Population (%)	30.7	23.5	18.9	-19.6
Magnitude of Poor Population	1,411,063	1,146,740	968,800	-15.5
Subsistence Incidence among Population (%)	13.1	8.4	5.6	-33.3
Magnitude of Subsistence Poor Population	602,248	410,860	287,820	-29.9

Source: Philippine Statistics Authority. 2020. 2018 Poverty Estimates of Davao Region

Physical and Cultural Resources

Physical Cultural Resources are defined in the ADB Safeguard Policy Statement (2009) as “movable or immovable objects, sites, structures, natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance”.

Four (4) areas in Davao City are considered landmarks and areas with historical markers installed by the National Historical Commission of the Philippines (NHCP). Port Sta. Ana, which is recognized as the first port used by the Japanese, is approximately 3.5 km from the nearest point of the SIDC. Other landmarks in Davao City are more than 5 km from the project site. There are no places of worship within the SIDC’s landing point.

In IGaCoS, the nearest area with physical cultural resources is the Samal Island Protected Landscape / Seascape. The area is approximately 200 meters from the nearest point of the SIDC alignment and is situated in the northern part of the alignment. The Project is not within the NIPAS as decided by the DENR CENRO Panabo through the NIPAS Certificate released on 13 May 2020 (**Annex H**).

Table 2.72 Physical Resources Area

Landmark	**Significance**	**Nearest Distance to the Alignment**
Davao City		
Andres Bonifacio Monument in Toril Park, Davao City	Monument is the founder of the Katipunan.	13.36 kilometers
Davao City Hall	Was built in 1926 and reconstructed in 1947 after the damages in World War II	5.48 kilometers
Ohta Kyozaburo Monument in Mintal, Davao City	Founder of First abaca company of the Japanese in the country	Approximately 16 kilometers
Port Sta.Ana in Magsaysay Park, Davao City	First port used by the Japanese agricultural workers of Davao	3.50 kilometers
IGaCoS		
Samal Island Protected Landscape / Seascape	Protected Area per Proclamation 2152 s, 1981	Approximately 200 meters based on the data of DENR-Region 11
Samal Island declared as Mangrove Forest Swamp Reserve	Protected Area per Proclamation 2152 s, 1981	Approximately 5 kilometres based on the data of DENR-Region 11
Ancestral Domain of Sama Tribe	CADT Area	Approximately 5 kilometers

Sources: Retrieved from https://en.wikipedia.org/wiki/List_of_historical_markers_of_the_Philippines_in_the_Davao_Region. Retrieved on January 2020, retrieved from https://r11.denr.gov.ph/index.php/100-statistical-data/341-list-of-protected-areas-with-pamb. Retrieved on January 2020

Public Access and ROW

Several existing roads will be affected by SIDC. The proposed alignment traverses Lizada Street and connects to Daang Maharlika Highway. The intersection of Daang Maharlika, J.P. Laurel Avenue, and R. Castillo Street is also affected due to the proposed Directional T-Interchange in Davao City. The alignment will also connect to the Circumferential Road at the IGaCoS side, see **Figure 2.153.**

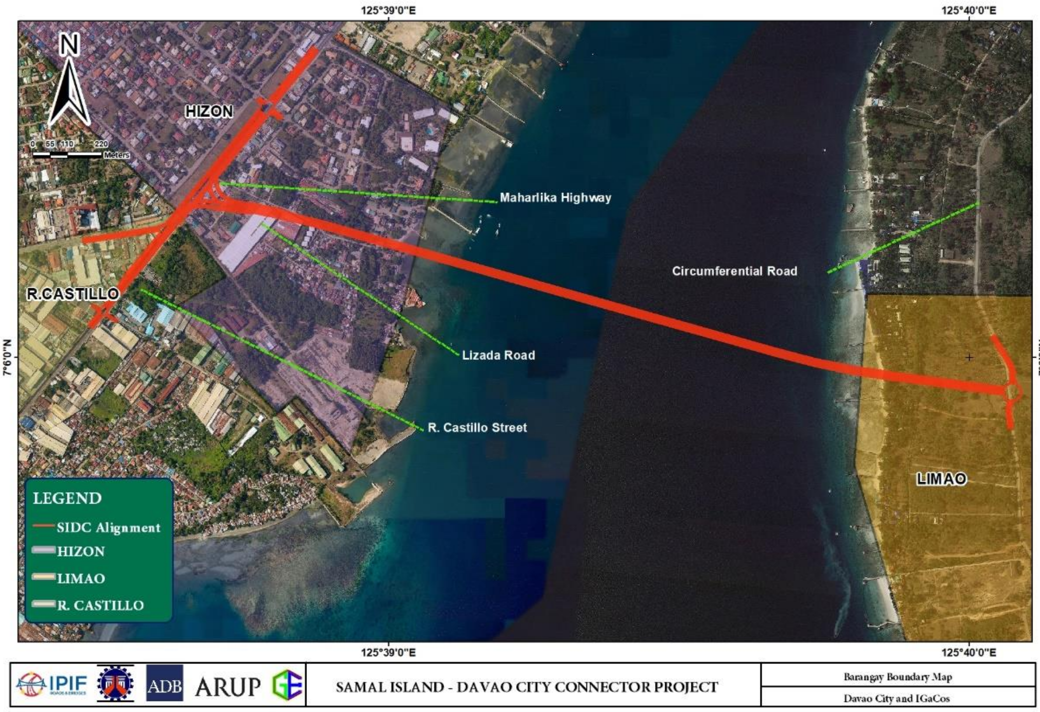


Figure 2.153 Affected Existing Road (Google Earth, March 2020)

Description of affected existing roads affected by SIDC project is provided in **Table 2.73.**

Table 2.73 Summarized Affected Existing Road

Affected Street / Road Description	Existing Condition
Davao City	
Lizada Street Lizada Street is the main access road to the Lizada Village and to various developments. It is a 4m-wide, single lane, two-way road with a portland concrete cement wearing course.	

Affected Street / Road Description	Existing Condition
Daang Maharlika Highway Daang Maharlika Highway is a major arterial road of Davao City. It is a 3-lane dual carriageway, with a median. Lane width is 3.35m. The highway is made of asphalt concrete and is in good condition. Some portions of the outer lane of Daang Maharlika are paved with portland cement concrete	
R Castillo Street R Castillo Street serves as an extension of the Daang Maharlika Highway to the south. It is two-lane, dual carriageway, with a lane width of 3.35m. The road is paved with asphalt concrete in optimal condition. LGU has indicated plans to expand the R. Castillo Street to a total of 6 lanes.	
IGaCoS	
Circumferential Road The Circumferential Road is a single-lane, two-way road, with an open canal at the east side. Lane width is 3.45m. The wearing course is portland concrete cement. The existing road surface is in good condition.	

Initial Inventory of Properties

In Davao City, the inland portion of the bridge will intersect 63 lots with different land uses, including: (1) lots adjacent to existing Right-of-Way (ROW) in R. Castillo St. in Barangay R. Castillo and Daang Maharlika and Lizada St. in Barangay Hizon, (2) vacant and unused titled properties, and (3) properties used for commercial and residential purposes. It will directly impact the following: Lanang Beach Club, particularly the Aplaya Beach Resort, Residence 1234 (apartment), Caltex gasoline station, Petron gasul outlet, Mindanao Trucking Corporation, Daruma Industries, staff house of Acacia Hotel employees, a commercial space and guard house along the West Insular Village main road, and several commercial businesses in a building owned by Damosa Land.

In the IGaCoS side, the proposed roundabout will be connected to the circumferential road. The IGaCoS inland section of the SIDC lies within Barangay

Limao, near the developed resort areas in the southern section of Barangay Caliclic. The direct impact area is the Paradise Island Park and Beach Resort while the indirect impact area includes the Costa Marina Beach Resort. The inland portion of the bridge will traverse nine (9) lots that are mostly undeveloped, but directly bounded and abutted by, thereby considered as influence areas of fully-developed commercial tourism resorts (i.e. Paradise Island and Costa Marina).

Figure 2.154 Potential Affected Properties Along Lizada Street, Davao City (Google Earth, March 2020)

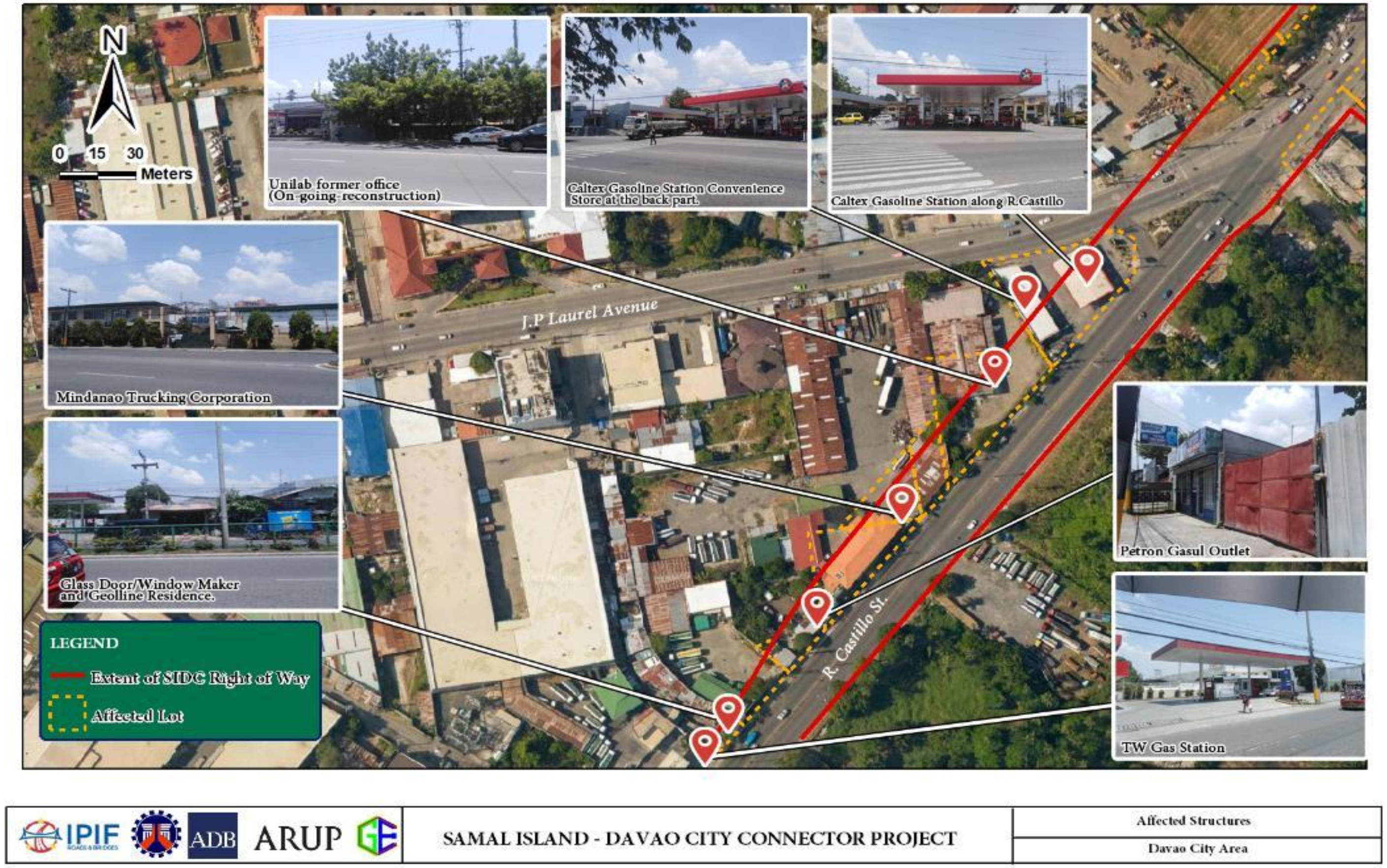


Figure 2.155 Potential Affected Properties Along R. Castillo, Davao City (Google Earth, March 2020)

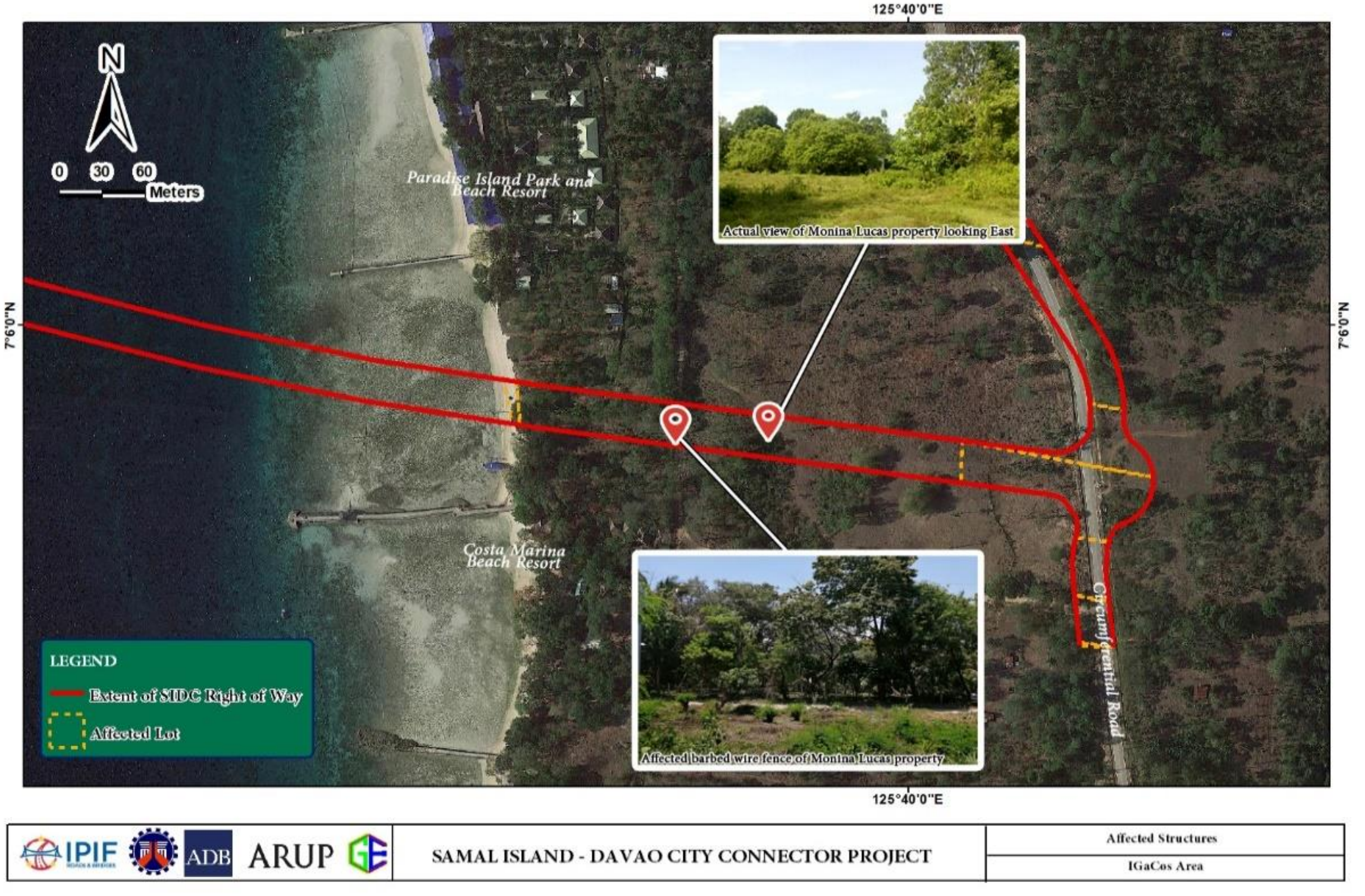


Figure 2.156 Potential Affected Areas in Barangay Limao, IGaCoS (Google Earth, March 2020)

Initial Inventory of Utilities along the Proposed Alignment

The proposed alignment which will be connected to Daang Maharlika Highway and R. Castillo through a Directional T-interchange in Davao City will be widened to accommodate the proposed ramps, while maintaining the current number of lanes for through traffic. Identified utilities are as follows:

Electrical Utilities

- Electrical Wire
- Electrical/Telecom Concrete Pole
- Electrical/Telecom Wooden Pole
- Electrical Steel Pole
- Double Arm Light Post
- Single Arm Light Post
- Traffic Light

Telecommunication Utilities

- Telecom Wire
- Globe Underground Fiber
- Hand Holes
- PLDT Underground Fiber/Copper
- Telecom Manhole

Waterlines/Drainage Utilities

- Waterline
- Drainage
- Curb Inlet Manhole

In IGaCoS side, minimal utilities were found since the proposed alignment traverses a vacant property between Paradise Island Park and Beach Resort and Costa Marina Beach Resort. Existing overhead electrical lines along the access road to the resorts and the existing drainage along the Circumferential Road were seen. Electrical utilities seen during the survey were verified with the Davao del Norte Electrical Cooperative (DANECO).

No water lines were observed in IGaCoS as most of the resorts source water from deep wells

Existing Navigation System in Pakiputan Strait

Literature from the Philippine Ship Spotters Society revealed some local RoRo vessel routes cross the Pakiputan Strait. These are as follows:

1. Mae Wess Ferry Company offers return RoRo services from SASA wharf (Mae Wess Terminal) to Samal Ferry Terminal. This route serves about 8,800 vessel movements annually. See yellow line in **Figure 2.157**.

2. Vessels carrying only passengers, travel between Kilometer 11 (Km11- Davao) and Babak port in IGaCoS daily. This route serves about 17,000 vessel movements annually. See violet line in **Figure 2.157**.

3. Davao Samal Link (DavSam) offers return RoRo services from Kudos Wharf to Babak Port in IGaCoS. This route serves about 7,300 vessel movements per year. See orange line in **Figure 2.157**.

Figure 2.157 Main local routes for the public across the strait. (Google Earth, September 2019)

Type of vessels serving the local routes across the strait

Mae Wess 4

LOA =28.4m

Breadth=6.3m

Draught=3m

Can carry 30 light vehicles,

180 Passengers

Serving route "Mae Wess Terminal-Samal Ferry Terminal" (Orange Route)

*From PPA Data and unofficial sources such as ship spotters society

Tateishi-DavSam II

LOA =32.8m

Breadth=10.6m

Draught=3m

Can Carry 100 passengers

Serving route "Kudos Wharf Terminal Babak Port"(Red Route)

*Specs info from Marine Traffic

Marybel II

LOA=15m

Breadth=2.9m

Draught=1.7m

Serving route "KM11 Babak Port" (Pink Route)

*Specs and other info from PPA data, and ship spotters society

Typical boat carrying clients of private resorts across the strait

Could be serving the routes towards Paradise Island, Blue Jazz Resort and others

In addition to the public routes discussed, passenger-only vessels serving private resorts also regularly operate in three identified routes in the area (**Figure 2.158**). Two green routes serve visitors of the Paradise Island Resort departing from Sasa Port and the Waterfront Insular Hotel (Davao City), generating about 35,040 vessel movements per year. The blue route serves visitors of the Blue Jazz Resort, generating about 13,870 vessel movements per year. The chosen location for the construction of the bridge is provided in **Figure 2.159**.

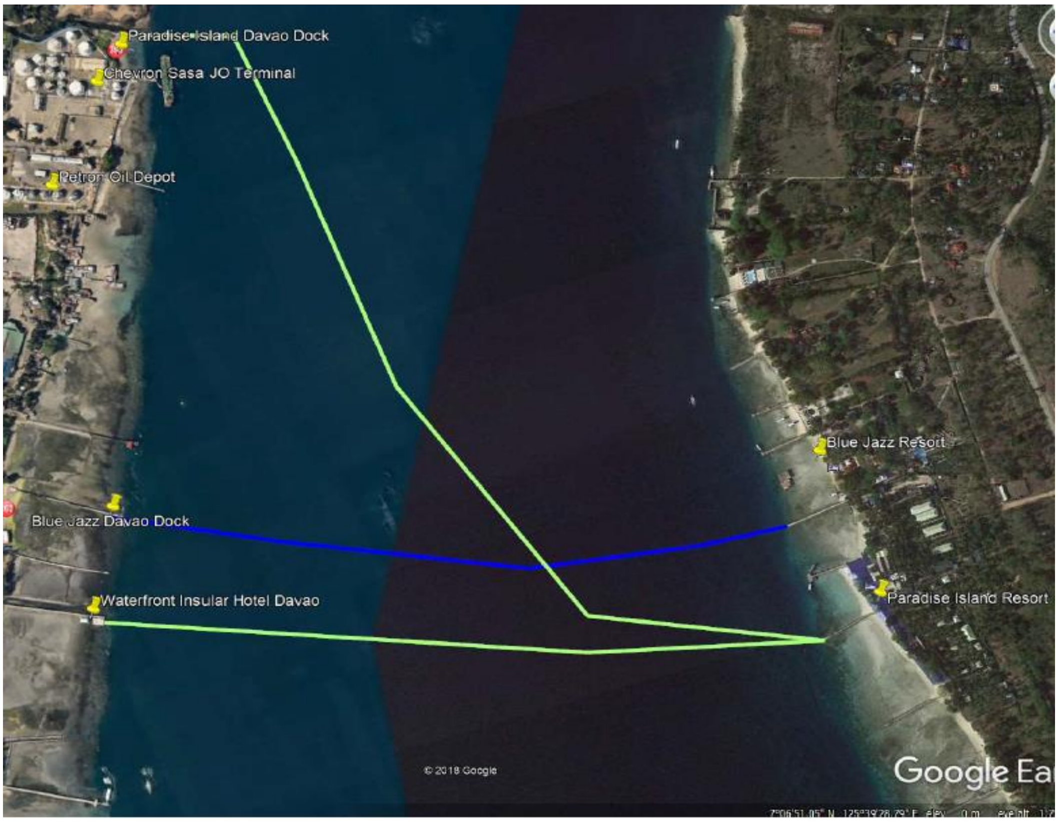


Figure 2.158 Local routes established by private resorts. (Google Earth, September 2019)

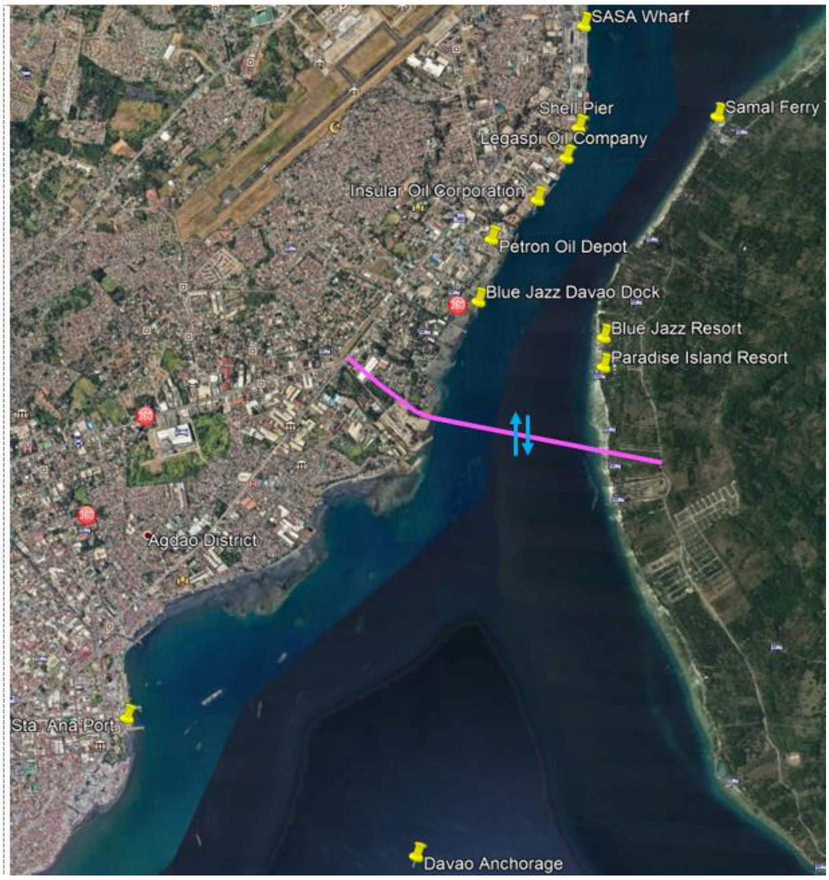


Figure 2.159 Map showing the chosen location for the construction of the bridge (Google Earth, Google Earth, September 2019)

Aside from the routes across the strait, several longer routes going south, out of the strait were identified. Vessels operating along these routes typically depart from the main passenger terminal of Sasa Port and make a stop at General Santos City in Sarangani Bay and continue on to Iloilo and then Manila. Other vessels traveling to General Santos City are further bound for international destinations, such as Bitung, in Indonesia. 2GO ferries and Supershuttle RoRo ferries operate in these routes. To summarise, the identified longer routes and the vessels served are:

1. Davao (Sasa Port)-General Santos -Iloilo -Manila ferry route, serves 2GO Passenger/RoRo ferries (i.e. “St. Leo the Great” and “St. Michael)
2. “DavaFo (Sasa Port)-General Santos – Bitung”, ferry route, serves passenger and cargo Supershuttle RORO vessels

The above routes are estimated to generate 4 movements per week (approximately 200 movements annually). Main specifications of vessels operating along these routes are shown in **Figure 2.161**.

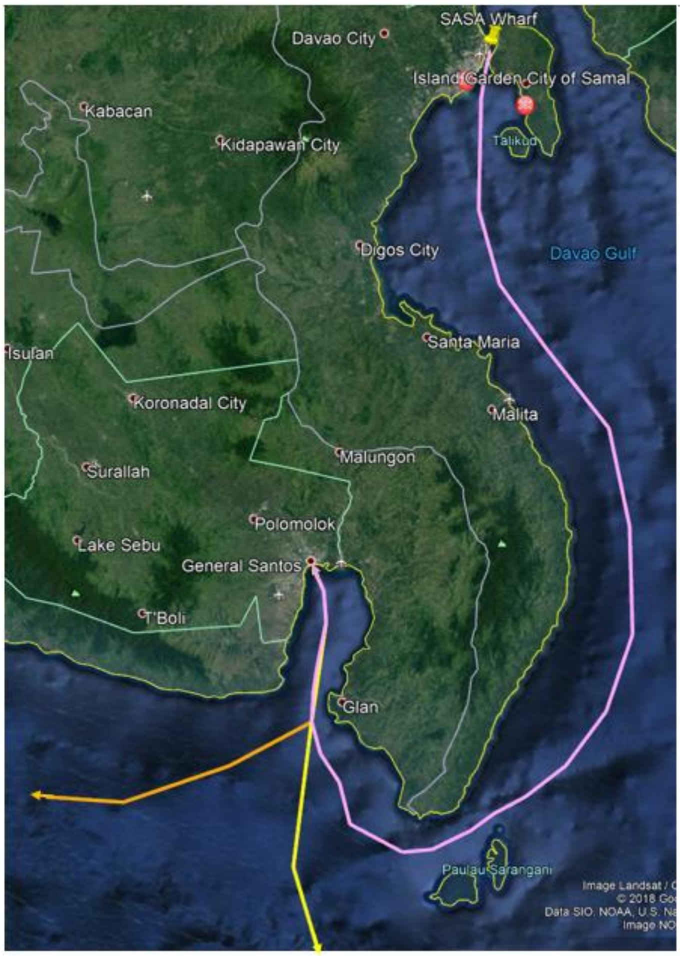


Figure 2.160 Routes going out of the strait. (Google Earth, Google Earth, September 2019)

- Super shuttle Roro 9
- LOA = 170.9m
- Breadth = 23m
- Draught = 6.1m

- St.Michael the Archangel
- LOA = 157.87m
- Breadth = 25m
- Draught = 6m

- St.Leo the Great
- LOA = 150.88m
- Breadth = 25m
- Draught = 5.6m

Figure 2.161 Vessels serving the longer routes, out of the strait

Potential Impacts and Options for Prevention and Mitigation and/or Enhancement

Potential Impacts

Displacement of Settler / Disturbance of Properties and Change / Conflict in Land Ownership

The project is anticipated to have direct and indirect impacts on structures, properties, and landowners, and the assumed costs for the acquisition of ROW, structures and trees and relocation will have temporary and permanent impacts. In addition, it was initially identified that there are 6 informal settler families (ISF) affected by the existing ROW and may result to relocation. Furthermore, ROW acquisition cost includes the alignment, the ramp and the road widening, see **Table 2.5**.

There are also affected electrical, telecommunication utilities (aerial and underground), and water lines and drainage along the median and both carriageways of Daang Maharlika and R. Castillo St. which need to be relocated to the side when road will be widened. There are also electrical and telecommunication utilities along Lizada St that will be affected by the land viaduct that will cross over the said street. In IGaCoS side, minimal utilities affected include existing electical lines along access road to Coasta Marina Beach Resort and Paradise Park and Beach Resort as well as existing drainage along Circumferential Road.

Photographs of initial affected electrical utilities

Figure 2.162 Electrical utilities along the center and both sides of Daang Maharlika

Figure 2.163 Electrical utilities on junction of Daang Maharlika, R. Castillo and J. P. Laurel

Figure 2.164 Electrical utilities along R. Castillo Street

Figure 2.165 Water Utilties Along Daang Maharlika

Figure 2.166 Electrical and Telecommunication Utilities along Lizada Street, and Existing drainage along Circumferential Road, IGaCoS

Figure 2.167 Existing electrical lines along access road to Costa Marina Beach Resort and Paradise Island Park and Beach Resort

Conflict of Right-Of-Way (ROW) / Impact on Public Access

ROW conflict and impact on public access is anticipated within existing road and water access that will be blocked or diverted. Impacts on existing road access includes temporary closure of identified roads during construction phase along Daang Maharlika Highway, R. Castillo Street and J.P. Laurel Avenue in Davao City and adjacent beach resorts in IGaCoS landing point. Impacts of the project on existing navigational access is expected in Pakiputan

Strait during construction phase. Local vessel routes that carry vehicles and passengers in the Pakiputan Strait may be affected by the project. In addition, larger vessels with regular longer routes may need re-routed around IGaCoS. These vessels will pass by the area where the SIDC traverses Pakiputan Strait. Given the bridge design and height restriction, the project may have negative impacts particularly for larger vessels regularly passing across the Pakiputan Strait during operations phase. Lastly, restricting areas where bridge construction activities will be undertaken limits the access of cargo and passenger vessels, large vessels and even fishers in Davao City and IGaCoS.

In- migration

In-migration is an anticipated demographic phenomenon associated with the project, which involves the tendency of people to move to areas where there are opportunities for employment. Estimated job opportunities during construction phase (2021-2024) is 500 to 1000. Hiring of professionals and skilled workers and the lack qualified manpower within Davao City and IGaCoS will result to in-migration of workers from neighbour / other cities and municipalities.

While the proposed project is to enhance the economic activity in both cities, especially IGaCoS, it is also expected that the development will brought an increase in-migration influx. Hence the local government must ensure to plan ahead for the possibility of uncontrolled influx.

Cultural/ Lifestyle Change

The project does not lie within a declared CADT area hence there are no indigenous people within the project area, as confirmed by NCIP Region XI through issuance of Certificate of Non-Overlap, see **Annex J**. However, the project may still have impacts on local culture and lifestyle from increased exposure to different lifestyles, dialects, attitudes and cultures of migrant workers from other cities and/or municipalities. This may attract business development in the area which will directly contribute to lifestyle change of locals due to increased income.

Impacts on Physical and Cultural Resources

The project will have no impacts on existing physical and cultural resources. There are no known archaeologic, chronological, or traditional features within the proposed alignment nor landing points in Davao City and IGaCoS. In addition, the nearest area considered to have physical and cultural resources is the Samal Island Protected Landscape / Seascape (see **Figure 2.169**). The said area is approximately 200 meters north from the nearest point of SIDC alignment and is not expected to have any major construction activities within the protected area. This has already been decided by DENR CENRO Panabo clearing that the project area is not within the NIPAS, through the NIPAS Certificate released on 13 May 2020 (**Annex H**).

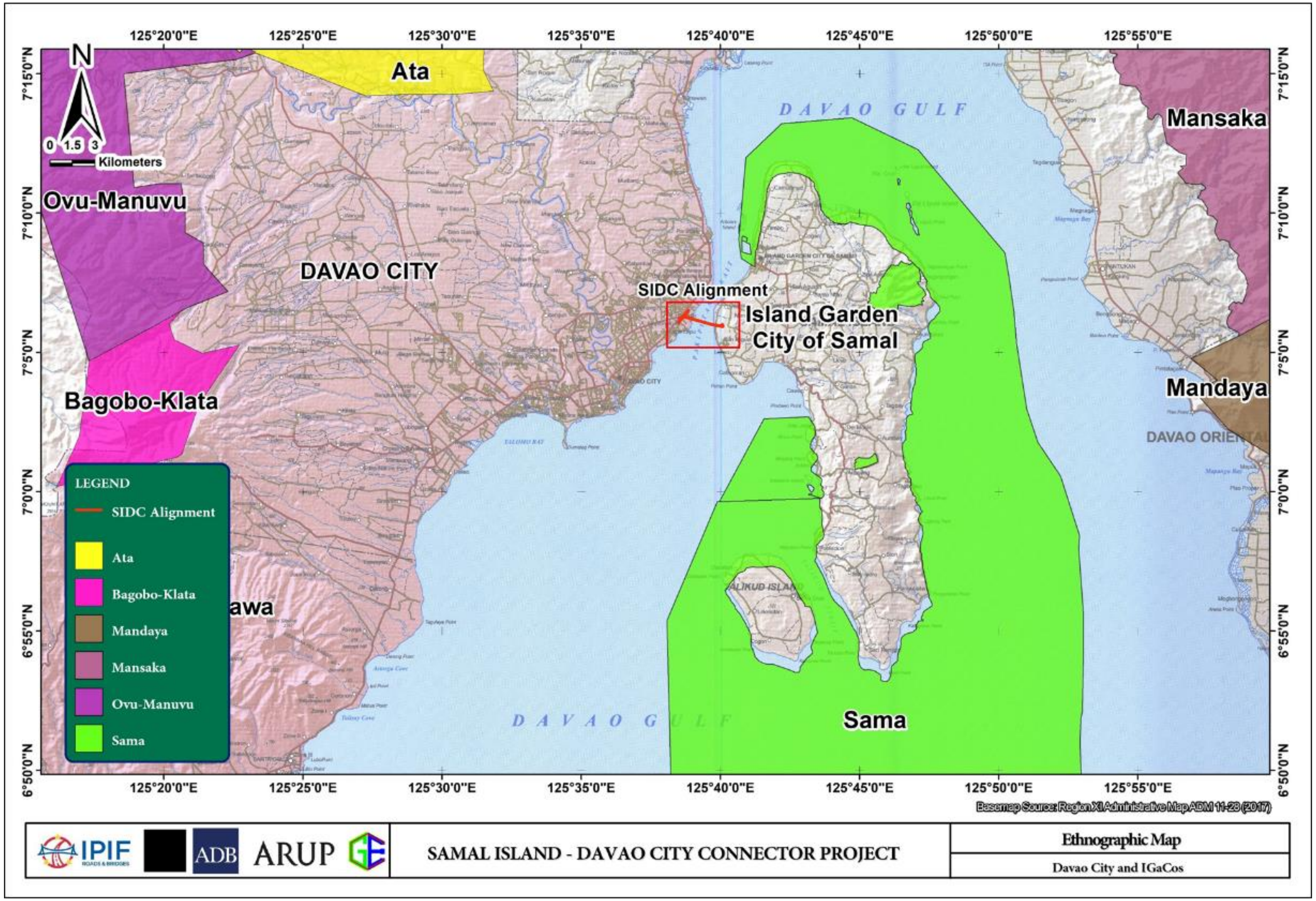
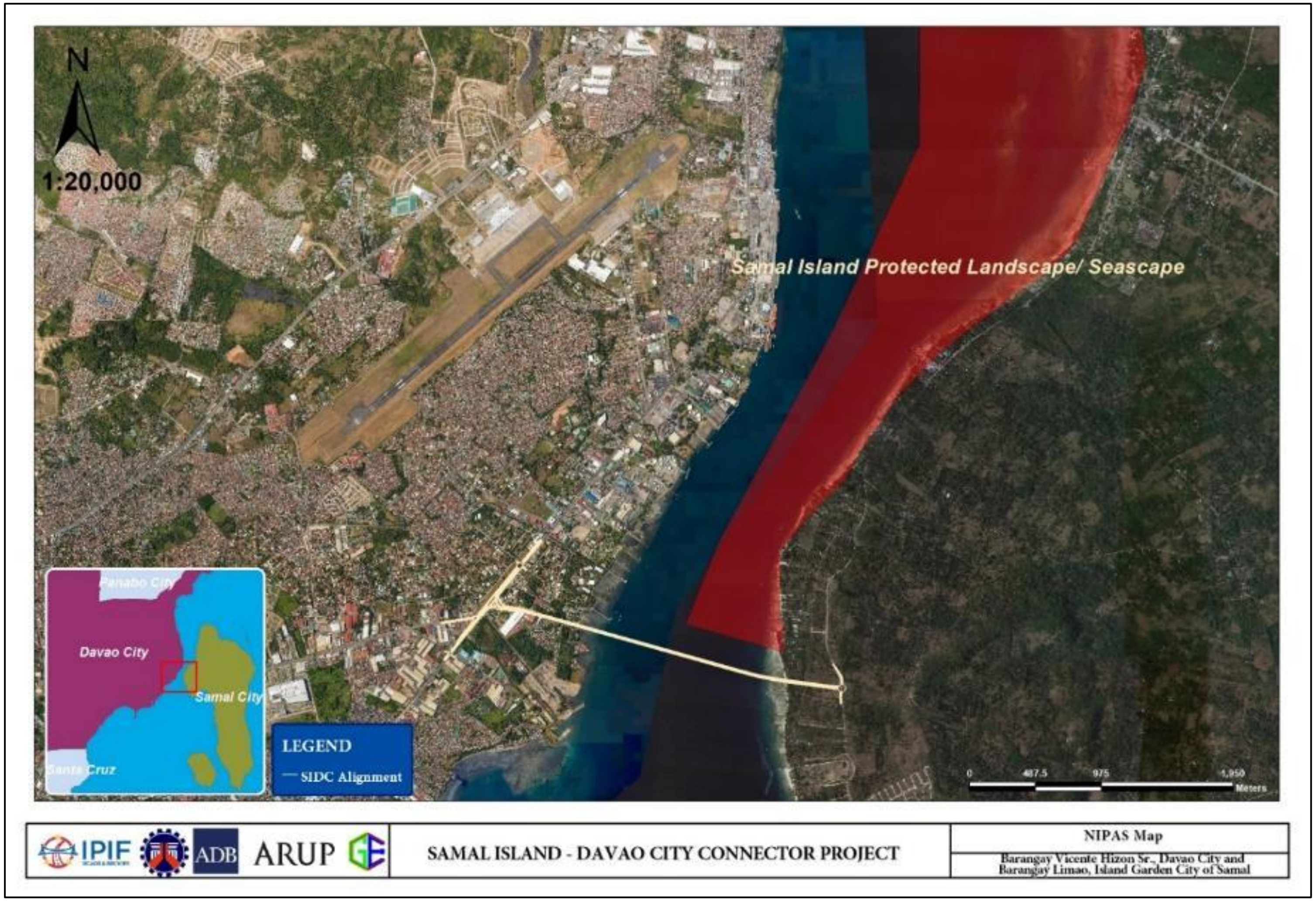


Figure 2.168 Map indicating CADT Areas and the Proposed SIDC Alignment (Source: Land Management Bureau (LMB) and (DENR-XI Data One Control Map, 2018) (Basemap Source: PNTMS Edition 1 - (NAMRIA,2013) Sheet No. 4115-III WGS 84)



Source: Department of Environmental and Natural Resources (DENR) Region XI. Expanded NIPAS map of Region XI: Protected Landscape and Seascape

Figure 2.169 National Integrated Protected Areas System (Google Earth, January 2020)

Options for Prevention and Mitigation

Displacement of Settler/ Disturbance of Properties and Conflict of ROW/ Impact on Public Access

It is observed that the project will have land acquisition and temporary impacts on land along with affected structures. During Pre-Construction phase, appropriate governing laws on RA 10752 – ROW Act, DPWH ROW Acquisition Manual (DRAM) or DOTr ROW Site Acquisition Manual (ROWSAM) and resettlement policy for the affected settlers and disturbed properties may be exercised by the proponent. ROW and compensation process will be completed before the start of construction.

Socio-Economic Profiling will be conducted to identify project impacts and properly provide mitigating measures. A Resettlement Action Plan aligned with ADB policy on Involuntary Resettlement will be prepared for the project. The proponent and its consultants will have meaningful consultations with the affected stakeholders, Davao City and IGaCoS LGU and host barangays and identified concerned civic groups during pre-construction and construction activities. Transparency and timely disclosure of important information about the project will be discussed and consulted with the stakeholders. Stakeholders views and opinions will be taken into considerations particularly concerns of disadvantaged and vulnerable groups.

Inventory of affected utilities will also be conducted and a Utilities Relocation Plan will be prepared during pre-construction phase. Relocation and replacement of affected utilities will be paid by the proponent and will be carried out by the relevant utility companies. If service utilities will be temporarily disrupted during utility relocation, affected stakeholders will be informed ahead. Attention will be made on utilities that will be relocated and will be closely monitored during the implementation of utility relocation.

Lastly, possible changes to existing shipping routes may be required to achieve the minimum navigation clearance. Approval of the navigation clearance dimensions is being sought from the Philippine Coast Guard in accordance with Memorandum Circular No. 01-14. The latest correspondence between DPWH and the Philippine Coast Guard (PCG) regarding the approvals is attached in **Annex N**. Consultations with LGUs, host barangays, PCG and concerned shipping companies / operators will be conducted during pre-construction phase. Given the Pakiputan Strait is rarely used by vessels exceeding 200 m in length, and with these larger vessels typically continuing through the Strait and onto Ports in Davao Del Norte; it appears possible to develop the minimum navigation channel (both horizontal and vertical clearance), without hindering the operation of most of the vessels using the Strait.

The minimum navigation channel could be achieved by implementing marine traffic controls in the Pakiputan Strait to limit vessel movements to a specified channel and to ensure two large vessels do not attempt to pass under the bridge simultaneously. These controls could be limiting the size of vessels navigating the Strait to 220 m or less, along with appropriate airdraft restrictions and having a one-way channel. The larger vessels could be re-routed around IGaCoS, as shown in **Figure 2.170**.

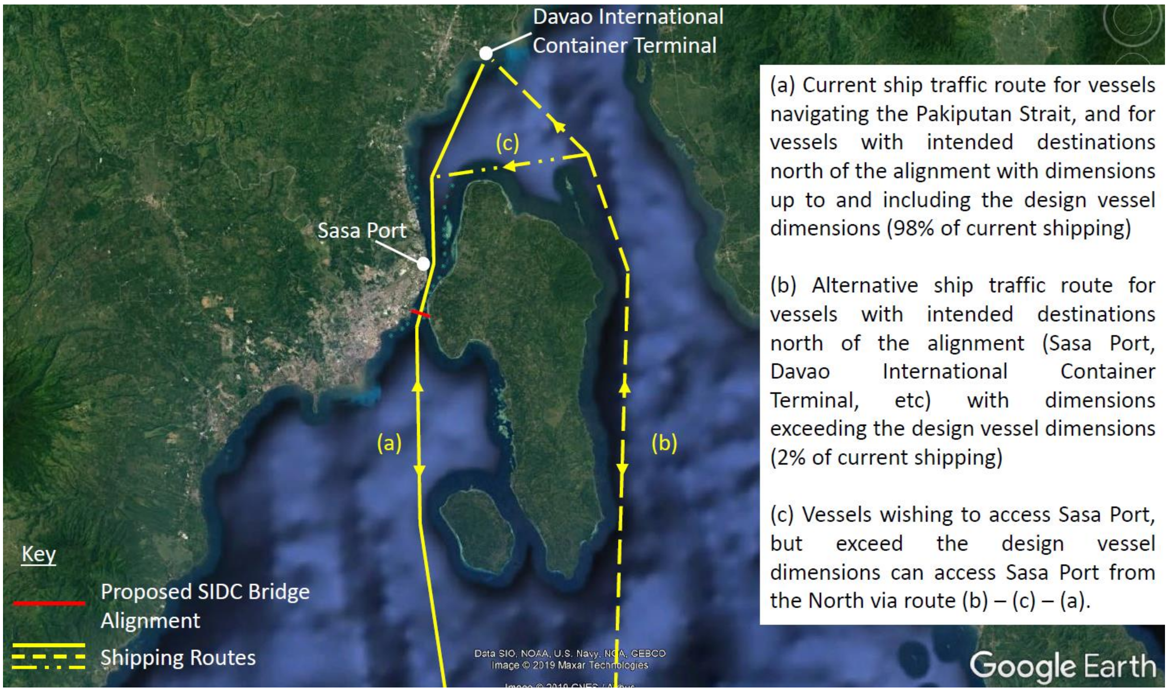


Figure 2.170 Possible future shipping routes (Source: Google Earth, 2019)

Poverty and Food Poverty Indices

In terms of socio-economic perspective, the project will accelerate business growth not only in terms of development but also the rate at which transactions are completed. Accordingly, the project is expected to decrease the market value of goods imported from Davao City - IGaCoS as well as from neighboring municipalities and provinces. Faster transport of goods will result to cheaper commodities thus making it more affordable to locals particularly in IGaCoS.

In addition, the project will provide employment during construction phase to qualified residents which may be of help in terms of regular income. Also, livelihood rehabilitation assistance in the form of livelihood packages and skills training and additional allowances for affected vulnerable stakeholders will be provided as necessary.

In- migration and Cultural/ Lifestyle Change

To mitigate in-migration, the proponent will prioritize residents of Davao City and IGaCoS during construction phase. DPWH will strictly enforce RA 6685. This Act requires private contractors to ensure its workforce sources at least 50% of the qualified unskilled and at least 30% of the qualified skilled workers from the host city or municipality of the project. Training will be provided during pre-construction to enhance local skills of hired workers. Job applicants will have equal opportunities and the contactor / proponent will review the skills and competencies of the applicants regardless of gender, disability, group or age. Equal benefits will be provided.

Also, the proponent will establish construction barracks and temporary housing facilities for migrant workers. Adequate sanitation facilities to avoid associated health and sanitation issues will be provided.

Moreover, in order to ensure that the IGaCoS side can deal with large scale potential in migration and visitor numbers, the LGU shall ensure that a stringent masterplan is developed and waste management facilities are well implemented. The project will be integrated in the plans (i.e Comprehensive Land Use Plan) of Davao City and IGaCoS to avoid unregulated development and mitigate in-migration.

2.4.2 Basic Services / Public Resources

A key facilitator of economic and social well-being is access to basic resources and health services. A discussion on how the project would affect or compete with basic services in the area is required under the PEISS. Required baseline information stipulated in Technical Scoping Checklist is presented below.

Baseline Environmental Conditions

Water Supply

Davao City

The Davao City Water District (DCWD) serves 176 barangays including SIDC affected barangays. DCWD is the primary distributor of potable water in the city. Other water sources include springs, deep wells and shallow wells mostly servicing 76 barangays unserved by the DCWD. Latest available data indicates that DCWD serves 193,613 households in 2017, a 2.73% increase from 2016. Data indicates water supply and consumption has gradually increased from 2013-2017.

Table 2.74 Water Supply, City Water District, 2013-2017

Indicator	2013	2014	2015	2016	2017	% Change (2016-2017)
Household Served	174,190	178,560	182,698	188,613	193,768	2.73
Ave. Volume of Water Supply/day in cu.m	254,925	264,809	275,716	291,551	296,974	1.86
Ave. Volume of Water Consumption day in cu.m	188,694	188,259	193,700	201,669	208,218	2.86

Source: City Planning Department Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Development Office.

IGaCoS

The major water supply service provider in IGaCoS is IGaCoS Water District and the barangay based -Barangay Water System Association (BAWASA) created by the Barangay Government under the management and control of the barangay council. Based on IGaCoS' Comprehensive Development Plan (2018-2023), of the forty-six (46) barangays in the entire city, IGaCoS Water District is currently providing Level III water supply services among the twenty-one (21) barangays with a total of 7,165 household served and 0.5453 average household consumption per day. Remaining barangays are being provided with water supply services under BAWASA, see **Table 2.75**.

Table 2.75 Level III Type of Water Connection, IGaCoS

Type of Connections	Barangays Served	Total Number of HHs Served	Average Consumption Per Day
Level III	21	7,165	0.5453 per HH

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Power Supply

Davao City

The Davao Light and Power Company (DLPC) is the main power service provider in Davao City. Based on the Davao City CLUP, 176 barangays use electric power, while 6 barangays utilize off-grid (i.e. solar, mini hydro) sources. Power peak requirement in Davao has increased from 2013-2017. Industrial sources are consistently the largest energy consumers, accounting for about 57% of all sources and utilizing 97,341,303 kWh monthly on average in 2017. SIDC's host barangays are all supplied by DLPC.

Table 2.76 Projected Connections by Type of Users and Average Consumption

Indicator	2013	2014	2015	2016	2017	% Change (2016-2017)
Power Requirement, Peak Demand (kWh)	336,536	343,734	354,479	379,980	404,196	6.37
Monthly Average Energy Consumption (kWh)						
Residential	42,457,357	43,960,229	46,597,107	50,442,484	51,229,136	1.56
Commercial	15,931,817	15,992,378	16,865,846	18,093,647	18,453,924	2.00
Industrial	70,222,754	84,063,613	86,764,431	89,396,834	97,341,303	8.88
Others	2,639,565	2,728,243	2,797,879	2,883,565	2,851,467	-1.11
Total Monthly Average Energy Consumption	**131,251,483**	**146,744,463**	**153,025,263**	**160,766,530**	**169,875,831**	**5.67**
Electric Power: 176 barangays Off Grid (Solar or Mini Hydro): 6 barangays						

Source: City Planning Department Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Department Office.

IGaCoS

DANECO is the main power supply provider in IGaCoS, with power sourced from the National Power Corporation (NAPOCOR) through a submarine cable technology system between Barangay Caliclic, IGaCoS and Barangay Pampanga, Davao. Based on the IGaCoS CDP (2018-2023), the projected power requirement of IGaCoS has consistently increased by about 5% yearly from 2015-2019. Bulk of the power requirement is to service residential users, see **Table 2.77**.

Table 2.77 Projected Connections by Type of Users and Average Consumption

Connections/Users	Projected Power Requirement (kWh)				
	2015	2016	2017	2018	2019
Residential	1,164,782	12,221,992	1,282,011	1,344,978	1,411,038
Commercial	481,857	505,524	530,353	556,402	583,730
Industrial	209,223	219,499	230,280	241,591	253,457
Public Building	160,215	168,084	176,339	185,000	194,087

Connections/Users	Projected Power Requirement (kWh)				
	2015	2016	2017	2018	2019
Streetlight	12,789	13,417	14,076	14,768	15,493
Total	2,028,866	2,128,516	2,233,060	2,342,739	2,457,805

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Communications / Transportation

Davao City

Telephone and mobile services are available in Davao City. Internet service are also adequately available. Four (4) telephone service providers and three (3) mobile phone service providers operate in Davao City. Telecommunication service subscribers have significantly increased by about 32% from 2016 to 2017.

Table 2.78 Communication Network, 2013-2017, Telecommunications

Indicator	2013	2014	2015	2016	2017
No. of Telephone Companies	3	3	3	4	4
No. of Mobile Phone Companies	3	3	3	3	3
No. of Subscription to Landline / Telephone Services	105,249	104,859	104,245	122,630	162,430

Source: City Planning Department Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Department Office.

IGaCoS

There are only thirteen cell site networks present in IGaCoS, six (6) sites of Globe Network, four (4) from Smart Communications and three (3) from Sun Cellular resulting to poor signal in other barangays/areas. Internet communications in the island is also available but said to be limited. Improvement is needed to meet the current and projected needs of the city. On the other hand, only one post office in the island is present, see **Table 2.79**.

Table 2.79 Communication Service Facilities, Island Garden City of Samal (2014)

Type	Year Constructed
Postal Services	2000
Cell Site Network	2003
Letter/Package	2013
Internet Connection/internet cafe	2015

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Peace and Order / Crime

Davao City

Reported crimes in Davao City have gradually decreased from 2014 to 2017. Data from the Davao City Police Office indicated a 66% decline in crimes from 2015 to the first half of 2019, which is attributed to anti-criminality programs of the LGU. Crime solution efficiency has also gradually improved from 2013-2019 (CPDO, 2018; Davao City Police Office, 2019), indicating the increase of solved cases out of the total crimes reported. Police human resource has also increased from 2013-2016, though reduced by about 2% from 2016-2017.

Table 2.80 Peace and Public Safety, 2013-2017

Indicator	**2013**	**2014**	**2015**	**2016**	**2017**
Crime Reported	10,880	18,030	13,720	10,269	7,576
Police Human Resource	1,387	1,401	1,401	1,989	1,948

Source: City Planning Development Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Development Office

IGaCoS

Based on the CDP of IGaCoS, the city has no adequate number of police personnel to assist the growing number of tourists, guests and locals in the island. Current number of police personnel is not ideal police to population ratio. Personnel to population ratio in IGaCoS' district jail is at 1:13 wherein ideal ratio is 1:5, see **Table 2.81**.

Table 2.81 Protective Services Personnel and Personnel to Population Ratio (2014 & 2015)

Type of Services	**Number of Personnel**	**Personnel to Population Ratio**
District Jail	14	1:5 Ideal 1:13 current
City Jail	14	1:608
Headquarters	49	1:1,362
Substation	32 24	1:304
Outpost	4	1:449

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Educational Facilities

Residents of IGaCoS experience barriers in accessing the schools and universities and other services, which are concentrated in Davao City. Whilst IGaCoS has approximately 20 elementary schools and five secondary schools, there are no university campuses in the city. Increased infrastructure programs for new educational facilities in Davao Region has significantly decreased classroom backlog from 2010-2016, based on the Davao Regional Development Plan 2017-2022 (NEDA, 2018).

Classroom backlog for elementary level was reduced by 40% from 1,328 in 2010 to 796 classrooms in 2015. For secondary level, a classroom backlog of 1,112 in 2010 was reduced by 35% to 725 in 2015. In 2016, 272 secondary level classrooms and 1,407 senior high school classrooms were completed in the first semester, while 1,293 elementary classrooms were completed in the first quarter.

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Potential Impacts

Threat to delivery of Basic Services/ Resource Competition

The project is expected to increase growth and economic development in the coming years. The road link offers the best opportunity to Davao and IGaCoS to expand their local economy hence reliable utility infrastructure is needed. Currently, Mindanao Island has problems on adequate water and power supply. Long drought in Mindanao has resulted to power interruptions. The realization of future growth opportunities for Davao City and IGaCoS can result to resource competition in the future.

For water and power competition, the project will have no significant impacts. During construction phase, primary power supply will be sourced from diesel generator sets. An uninterruptible power supply (UPS) system will cover the power demand of the vital functions, should power fails, before turning over to the back-up source. During operations phase, the power requirement is minimal and only intended for street lightning.

Threat to peace and order

The only anticipated impacts to peace and order may be attributed to the influx of workers during construction phase. Estimated manpower requirement is 500-1000 hence migrants of workers may increase safety risks not only within the project site and temporary housing facilities of workers but also Davao City and IGaCoS as well adjacent cities / municipalities.

Options for Prevention and Mitigation

Threat to delivery of Basic Services/ Resource Competition

An inventory of affected utilities will be conducted. A Utilities Relocation Plan will be prepared during pre-construction phase and identified utilities needed for relocation and replacement will be coordinated to relevant utilities company. Affected stakeholders will be informed if there are temporary disruption of utilities. For anticipated resource competition, it is important that the project will be integrated in the plans (i.e Comprehensive Land Use Plan) of Davao City and IGaCoS to properly plan and allocate future power and water demands.

Threat to Peace and Order

Project's threat to existing peace and order of Davao City and IGaCoS can be attributed to influx of migrant workers. The hiring of 500-1000 workers during construction phase may result in safety risks to the community, migrant workers and adjacent cities or municipalities. Increase of police visibility near the project is needed during construction and operations phase.

Increase in police visibility near the project will be needed during construction and operations phase. The construction site should be well-lit, secured and guarded, equipped with CCTV monitoring, and bridge perimeters secured, as necessary. Installation of robust hoardings and site fencing is also suggested to prevent access into the site and adjacent areas. This should be coordinated with the contractor/ DPWH and concerned agencies to ensure safety and reduce negative impacts to the community and environment.

2.4.3 Health and Safety

Baseline Environmental Conditions

Public Health and Safety

Davao City

Live births have decreased on average per day by 15% from 2016 to 2017. The crude birth rate has also decreased since 2015.

Morbidity in the city is unpredictable, as trends have indicated erratic changes with steep increases and decreases in 2013-2017. Latest available data indicates that leading causes of morbidity in 2015 are acute respiratory infection (15,805 cases) and pneumonia (14,966 cases) based on the Davao City Health Office (2015).

Table 2.82 General Health Situation

Indicator	2013	2014	2015	2016	2017	% Change (2016-2017)
Average birth deliveries per day	120	119	124	120	102	-15
Crude Birth Rate per 1,000 population	27.97	27.28	27.91	26.30	21.90	-4.4
Morbidity Rate per 1,000 population	69.25	74.87	54.23	81.27	56.28	-24.99

Source: City Planning Department Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Department Office.

IGaCoS

Based on the Comprehensive Development Plan of IGaCoS, the average Crude Birth Rate (CBR) in the IGaCoS is 20.8. The Total Fertility Rate (TFR) which is the average number of children that a woman can have during her entire reproductive period is 2.7. Under morbidity, the General Medical and Consultation which include output coming from Barangay Outreach Program of the LGU that marked its peak in 2011 which 33,992 and in 2012 is 21,497. The Hospitalization Rate steadily increased from 2011 to 2014 which is attributed to availability and accessibility of health facilities and services. Crude Death Rate (CDR) average for the past 5 years is 4.9/1000 population. Highest Infant Death was reported in 2013 which is 15% from deaths in 2010. There were only 3% infant deaths reported in 2014. Each year from 2010 to 2013, there was 2% maternal deaths reported and only 1% in 2014 (*pg 33)*.

Table 2.83 General Health Situation of Island Garden City of Samal (2010-2014)

Health Indicator	2010	2011	2012	2013	2014
Fertility					
Crude Birth Rate (CBR)	20/,000	23/1,000	21/1,000	21/1,000	19/1,000
Total Fertility Rate (TFR)	2.9%	2.6%	2.8%	2.53%	2.7%
Morbidity					
General medical	16,217	33,992	21,497	9,067	15,654

Health Indicator	2010	2011	2012	2013	2014
Consultation Rate	17%	33.82%	22.50%	9.36%	14.8%
Hospitalization Rate	3.4%	3.5%	3.38%	4.5%	5%
Mortality					
Crude Death rate (CDR)	5/1,000	5/1,000	4.8/1,000	4.9/1,000	4.8/1,000
Proportioned Mortality					
Rate (PMR)					
Infant Mortality Rate	14%	9%	8%	15%	3%
Young Infant Mortality Rate (YCRM)	0.008%	0.002%	0.006%	0.003%	0.005%
Maternal Mortality Rate (MMR)	2 %	2 %	2 %	2 %	1%

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Moreover, the leading causes of morbidity for the last 5 years in IGaCoS is Acute Respiratory Tract Infection which is manifested by common cough and colds. Other diseases that figure prominently include hypertension, diarrhea, urinary tract infection, soft tissue infection and systemic viral infection.

Public Services

Davao City

Based on the Davao City CLUP (2013-2022), the city has 27 private hospitals and 2 government-owned hospitals. The health care workforce supporting private hospitals in the city consisted of 162 doctors, 1,476 nurses, and 14 dentists. Total bed capacity of private hospitals was about 2,292. The city also operates about 126 private lying-in facilities.

IGaCoS

Based on the Comprehensive Development Plan of IGaCoS (2018-2023), 46 barangays of the island have Barangay Health Station. In addition, twenty (20) Barangay Health Stations and three (3) Main Health Centers were upgraded or renovated under the Health Facility Enhancement Program of the Department of Health in 2012. There were 3 safe birthing facilities cwith Local Government Unit support in 2014 to 2015.

Environmental Health and Sanitation

Table 2.84 shows that nearly all Davao City households have access to potable water, 92.34% have access to sanitary toilets, and solid waste collected was reduced by about 10% from 2016-2017. **Table 2.85** indicates IGaCoS has few households with water-sealed toilets. According to the World Health Organization (WHO) in 2018, better water and sanitation could prevent deaths of children under 5 years old. Furthermore, this reduces malnutrition and the spread of intestinal worms, and promotes dignity.

Table 2.84 Vital Health and Environment Statistics (Davao City)

Indicator	2013	2014	2015	2016	2017
% Households with access to potable water	98.65	98.76	98.80	98.80	98.80
% Household with Sanitary Toilet	88.60	89.89	90.00	91.60	92.34

Indicator	2013	2014	2015	2016	2017
Average Volume of Solid Waste Collected & Disposed (kg. / day)	441,137	460,286	490,865	638,920	575,130

Source: City Planning Division Office. Socio-Economic Indicators 2018. Davao City: City Planning Division Office.

Table 2.85 Housing Facilities, 2014 (IGaCoS)

Facilities	No. of Household			
	Served	%	Unserved	%
Water-Sealed Toilets	19,805	27.98	4,941	10.20
Garbage Collection System	17,545	24.79	5,838	12.05

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Potential Impacts

Threat to Public Health and Safety

SIDC is expected to have higher risks to health during construction phase due to influx of workers. Migration of workers may result to poor sanitation and improper management of waste disposal. This can lead to communicable diseases within the project site and host barangays. Lack of potable and clean water to workers poses negative health implications. Construction workers and road users during operations phase are exposed to more emissions, increased air pollution, and fugitive dusts from increased traffic which may lead to respiratory illness.

Options for Prevention and Mitigation

Threat to Public Health and Safety

Provision of potable water and temporary sanitation facilities will be provided on-site and temporary housing of workers. In addition, the contractor will ensure the implementation of proper housekeeping at all time. Trainings on good hygiene and good construction sanitation practices will be regularly conducted to all construction workers. Coordination with LGUs and host barangays will be done for the regular collection of waste and proper disposal. Trash bins will be placed in strategic locations and waste segregation will be applied during construction phase.

The DPWH and the Contractor must develop an Emergency Plan and Health and Safety Program for all workers. Contractors must provide adequate PPE to all construction workers.

2.4.4 Income and Employment

Baseline Environmental Conditions

Main Sources of Income

Davao City

Public funding for the City has increased from 2016-2017, consisting of: (i) general fund for city expenditures and (ii) special education fund for education purposes. Income is mainly generated from taxes, operating and miscellaneous revenue, special accounts which includes profit from toll and terminal fees in Sta. Ana, market operations, slaughterhouse, overland transport, cemeteries and rents from Davao City Recreational Center (DCRC), Magsaysay Park, Philippine Ports Authority and Business-Income-Pasalubong. Reports added that in 2018, the City was provided a budget of PHP 7.6 billion, which increased to PHP 8.8 billion in 2019 (Davao Today, 2018).

Table 2.86 City Government Income

Source	2013	2014	2015	2016	2017
General Fund (PHP)	4,878,542,417.80	5,445,692,529.74	6,798,006,117.08	6,284,215,375.54	7,635,198,362.67
Special Education (PHP)	368,978,095.10	393,091,036.93	509,589,184.58	459,111,967.01	596,980,327.64
% Change	**22.56**	**6.54**	**29.64**	**23.66**	**30.03**
Total (PHP)	**5,247,520,512.90**	**5,838,783,566.67**	**7,307,595,301.66**	**6,743,327,342.55**	**8,232,178,690.31**

Source: City Planning Department Office. 2018. Socio-Economic Indicators 2018. Davao City: City Planning Department Office.

IGaCoS

Based on the Comprehensive Development Plan of IGaCoS (2018-2023), IGaCoS total revenue in 2014 is at 446,754,351.84. According to Supetran (2018), IGaCoS which is classified as fourth-class component city has received PhP 92 million internal revenue allocation from the government. Biggest industry in the island is tourism which employs workers benefitted by the informal employment sector.

Table 2.87 IGaCoS Total Revenue (2012-2014)

Item	2012	2013	2014
Total Revenue	377,668,971.62	399,447,325.42	446,754,351.84

Source: Comprehensive Development Plan of Island Garden City of Samal (2018-2023)

Employment rate / profile

Employment rate in Davao Region improved to 95.5% in 2016, a marginal increase of 1% from 2015. Unemployment rate was also reduced to 4.5% in 2016, translating to a 2% improvement. However, underemployment rate also increased to 16.7% in 2016, a 12.8%

increase from 2015. According to PSA, underemployment indicates workers working less than 40 hours a week (Perez, 2019).

Table 2.88 Labor Force, 2012-2016

Indicator	2012	2013	2014	2015	2016
Employment Rate (%)	95.2	93.1	94.5	94.5	95.5
Unemployment Rate (%)	4.8	6.9	5.5	5.5	4.5
Underemployment Rate	16.1	17.3	16.7	14.8	16.7

Source: Socio-Economic Profile (2017) Davao City. City Environment and Natural Resources Office

Sources of Livelihood

Fishing is a key source of livelihood for the coastal area of Davao City, with about 490,000 people in 2016 (DA, 2016). The City has about 8,610 municipal fishermen in 2016 (DA, 2016), more than double of the registered fishermen in 2013. In 2016, municipal fisheries generated about 820.97MT of fishes and produced 200MT of fish corral (DA, 2016). Other fishing operators and species cultured in 2016 included: 15 brackish water fishpond operators culturing bangus; 30 operators producing milkfish / siganids; 45 seaweed operators; 172 freshwater fishpond operators culturing tilapia, hito, and pangasius; and 24 nursery and hatchery operators. Locally, the CLUP 2013-2022 notes that fishing is mainly done by hook and line (catching pasal, palangre, undak-undak, sagiwsiw), gill nets (catching palaran, panamban, pante), and fish traps (catching bentol, bubo, bunsod), with an average fishing trip of about 6 hours. The CLUP 2013-2022 further notes that barangay consultations in 2005 indicates some fishermen operate beyond their coastal barangay. Therefore, with the proposed SIDC, the impact on existing fishing activities and public access may be deemed as a significant constraint.

On the other hand, 89.53% of IGaCoS lies in an area dedicated for agricultural purposes, where its major food crops are coconut and mango. Other crops known abundant in the island are rice, corn, fruit trees, root crops, and vegetables. Farming and fishing remain as the main economic activity of most of the residents in the Island. Based on the Comprehensive Development Plan of IGaCoS (2018-2023), IGaCoS produces about an average of 5,286.7 MT fishery productions in CY 2014 with a total value of about P264.34 Million at an average farm gate price of P50.00/kilogram. Computed average of monthly gross income is P5,332.00 for every registered fisherfolk.

Income Generation from Toll and Terminal Fees (Sta. Ana Port)

Latest available data on toll and terminal revenues indicate that the revenue generated in Sta. Ana Port has significantly decreased by 75% from 2012-2016, as provided in the CPDO Socio-Economic Profile (2017) (**Table 2.89**). From 2015-2016, revenues decreased by 2.5%. As observed in **Figure 2.171**, the number of passengers has an overall increasing tendency from 2000 to 2018. Significantly less passengers were observed from 2004 to 2013, with the least number of passengers in 2011. This may have been due to decreased available routes and less frequent ferry schedules between Davao City and IGaCoS. Following the increase of passengers from 2011 to 2014, a consistent decline in passengers has been recorded until 2018.

Table 2.89 Revenue from Toll and Terminal Fees

Special Accounts Revenue	2012	2013	2014	2015	2016
Income from Toll & Terminal Fees (Sta. Ana Port)	5,417,130.39	4,334,797.69	4,487,781.78	1,422,783.96	1,387,510.88

Source: Socio-Economic Profile (2017) Davao City. City Environment and Natural Resources Office

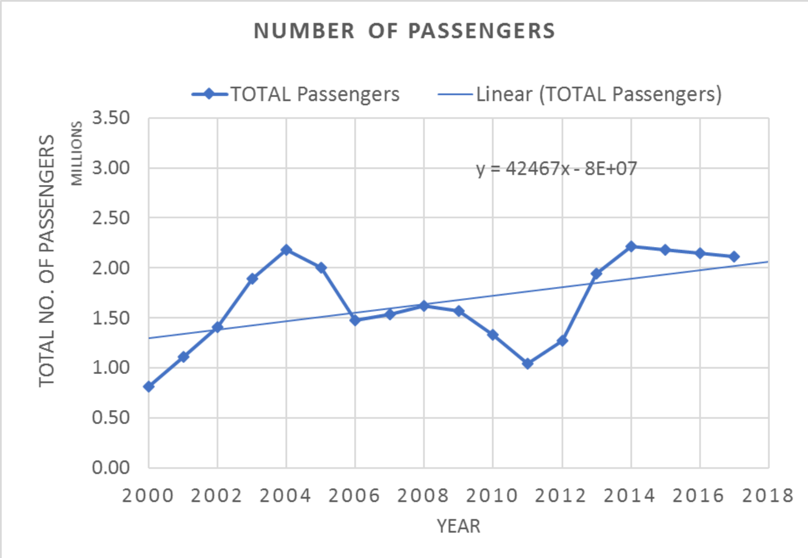


Figure 2.171 Total Passenger numbers. Data obtained from PPA website.

Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

Potential Impacts

Existing Fishing Activities

Impacts on existing fishing activities is expected during construction phase because most of the construction works will be confined to Pakiputan Strait. Restriction in areas where bridge construction activities will be undertaken and would limit access of fishers in Davao City and IGaCoS. Fishers would need to fish farther away from the construction site which may affect existing income or lead to economic displacement.

Existing Ferry Services

The current peak demand for journeys between Davao City and IGaCoS requires typically 4 ferry trips per hour. With the implementation of the bridge, in the long term the demand for ferry journeys will be greatly reduced. In addition, establishing a new ferry service on the Eastern Side in IGaCoS to Davao Oriental is anticipated.

Options for Prevention

Existing Fishing Activities

Livelihood restoration should be assessed and implemented upon identifying affected fishers. Consultations with the fishers group, relevant government offices and other vulnerable group will be conducted to provide appropriate mitigating measures for any possible income loss.

Existing Ferry Services

The project will establish new ferry service and will be included in the LGU's Master Plan for the Island. As such with proper consultation, the project is expected to have smooth transfer of operations from Pakiputan Strait to Davao Oriental crossing whereby there should be no significant impacts or loss of employment as the new service will employ the existing ferry operators.

Local Benefits of the Project

It is expected that through the project Davao City will continue to be a major service-led urban economy and IGaCoS will grow in importance as a major tourist destination.

The lack of a permanent transport link presents a significant physical impediment to economic integration. Access can often involve multiple modes of travel, long wait times, long transfer times and long ferry journey times. This is reflected in the divergence of income in Davao City and IGaCoS. A second key impact involves changes in private sector investment and business competitiveness in IGaCoS. The costs of transporting goods including construction material to IGaCoS adds to business costs. Unregulated influx of visitors may reduce the attractiveness of the area for target industries including tourism. Providing a road link offers the best opportunity to integrate IGaCoS into Davao's expanding economy and to drive economic growth through better access to labour and capital. Infrastructure will be critical to raising the competitiveness of local industries and realising the growth opportunities.

2.4.5 Traffic

Key Transport Facilities

Five ports provide public and private ferry services between Davao and IGaCoS, including: (i) Samal Ferry Wharf; (ii) Sasa Ferry Terminal; (iii) DavSam Ferry Terminal; (iv) Samal Ferry Terminal; and (v) Babak Lansa Terminal. The first three terminals are in Davao, while the latter two are in IGaCoS. **Figure 2.172** shows the terminal locations along with the SIDC.

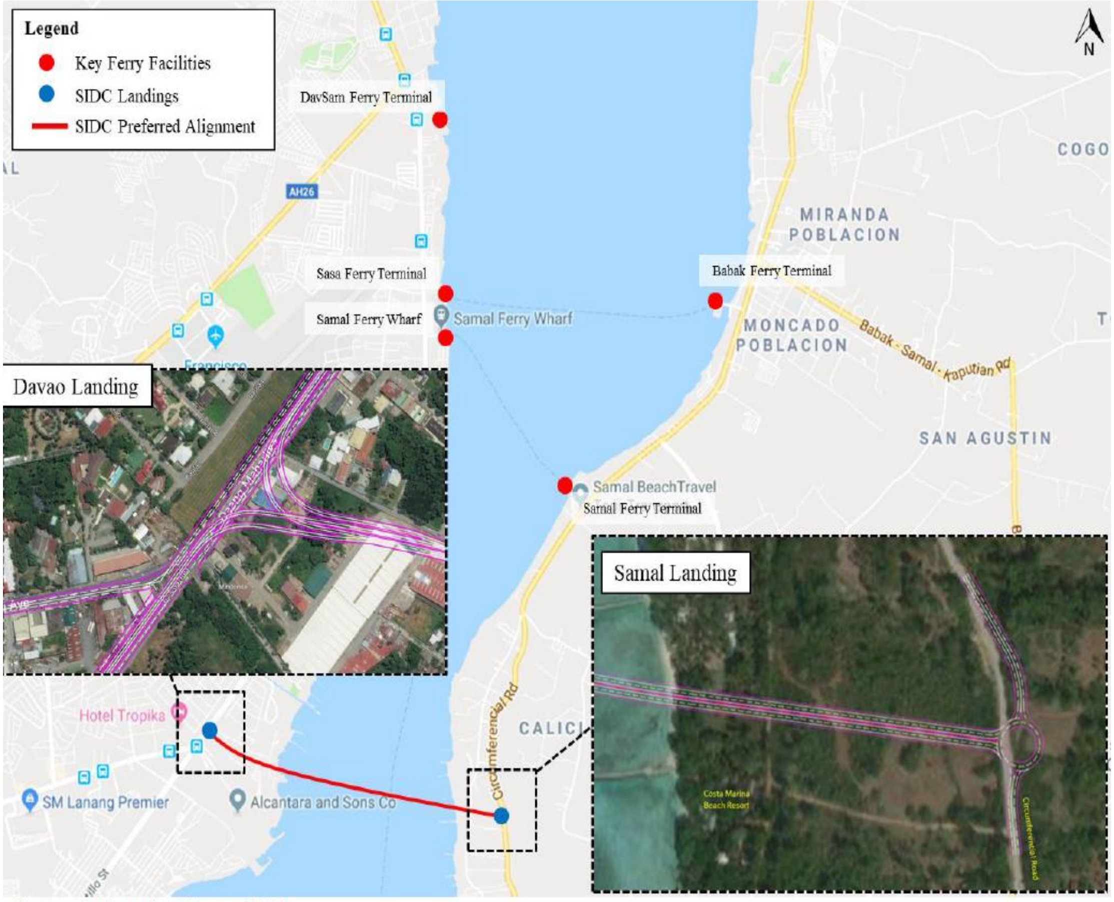


Figure 2.172 Key Ferry Facilities on Davao and IGaCoS Source: Google Maps (2019)

Ferry Services

Three principal routes serve Davao and IGaCoS, with the different ports providing different types of services (i.e. passenger-only and Ro-Ro). No formal demand data is available as the ports are private and do not typically provide data to the Philippine Ports Authority (PPA). A summary of the ferry services is provided below in **Table 2.90**.

Table 2.90 Profile of Ferry Services between Davao and IGaCoS

From	To	Operating Hours	Peak Headway (minutes)	Type of Service
Samal Ferry Wharf (on Davao Side)	Samal Ferry Terminal	6:00AM–6:00PM	15	Ro-Ro
Sasa Ferry Terminal	Babak Ferry Terminal	6:00AM–10:00PM	15	Passenger-Only
DavSam Ferry Terminal	Babak Ferry Terminal	6:00AM–6:00PM	15	Ro-Ro

Note: No official information is provided online by the operators. Therefore, operating hours and headway are assumed based on posted information as of April 2019.

Methodology

Baseline volume of crossings made using existing ferry services traveling between Davao City and IGaCoS were determined through count surveys to understand the current level of demand for use of the bridge crossing. All surveys and interviews were conducted during terminal operating hours.

- Vehicle-classified counts on RoRo vessels and counts of passengers of vehicles aboard RoRo vessels ('vehicle passengers') were conducted in terminals servicing RoRo vessels (i.e. DavSam Terminal and the Samal Ferry Terminal).
- Ferry passengers ('walk-up passengers') were also counted in the Samal Ferry Terminal, Sasa Ferry Terminal, and DavSam Terminal.
- Walk-up passenger interviews were conducted aboard the Samal Ferry Service, Babak Lunsa Ferry Service, and DavSam Link Ferry Service to determine the transport mode used in accessing the terminal.

Current performance of the surrounding road network was then assessed to determine the level of improvements needed to accommodate future travel demand. To assess road performance, the following were undertaken:

- Annual average daily traffic (AADT) 2017 data for various road corridors in Davao City was gathered from the DPWH BQS. 24-hour vehicle-classified counts were conducted in 21 junctions and road links in Davao City and IGaCoS to supplement AADT data.

Seven vehicle classes were counted and converted into passenger car units (PCU), referenced from the DPWH Guidelines (**Table 2.91**)

Table 2.91 Vehicle Classification and Equivalent PCU Factor

Vehicle Type	PCU Factor [A]
Motorcycle/ Tricycle/ Pedicab	0.75
Private Sedan/ SUV/Van/ Pick-Up/ Jeep (Owner Type)	1.0
Taxi	1.0
Jeepney/ Multicab/ Mini-bus/UV Express	1.5
Standard Bus	2.0
Light Goods Vehicle/Van/Pickup	2.0
All Trucks	2.5

[A] PCU factors based on DPWH typical classifications, except for motor-tricycles which are assigned an equivalent of 0.75 PCU based on international practice and Hong Kong's Transport Planning and Design Manual or TPDM.

- Volume-to-capacity (V/C) ratios, indicating the proportion of road capacity used by peak hour traffic volume, were determined for each road link. Road capacity is defined by road type, width, and roadside friction, which were referenced from the DPWH Highway Planning Manual (**Table 2.92**). Assessments on the V/C ratio were referenced from Hong Kong's Transport Planning and Design Manual (**Table 2.93**). Any road performance at or above 1.2 V/C is considered unacceptable.

Table 2.92 Hourly Road Link Capacities by Road Type

Road Type	2-Way Carriageway Width (m)	Carriageway Width (m) per lane[A]	Roadside Friction	2 -Way Hourly Capacity (PCU)	1-Way Hourly Capacity (PCU)[B]
Highway	≤ 4.0	≤ 2.0	None or Light	600	300
Highway	4.1 – 5.0	2.05 – 2.5	None or Light	1,200	600
Highway	5.1 – 5.5	2.05 – 2.75	None or Light	1,800	900
Highway	5.6 – 6.1	2.8 – 3.05	None or Light	1,900	950
Highway	6.2 – 6.5	3.1 – 3.25	None or Light	2,000	1,000
Highway	6.6 – 7.3	3.3 – 3.65	None or Light	2,400	1,200
Highway	2 x 7.0	2 × 3.5	None or Light	7,200 (Expressway)	3,600
Urban Street	≤ 6.0	≤ 3.0	Heavy	1,200	600
Urban Street	6.1 – 6.5	3.05 – 3.25	Heavy	1,600	800
Urban Street	6.6 – 7.3	3.3 – 3.65	Heavy	1,800	900
Urban Street	2 x 7.0	2 × 3.5	Heavy	6,700	3,350

Source: Highway Planning Manual of the DPWH (1982 Edition)

Note:

[A] Two-way carriage width (m) is divided by two to derive the carriageway width (m) per lane

[B] Two-way hourly capacity is divided by two to derive the one-way hourly capacity

Table 2.93 Volume-to-Capacity Ratio Criteria

V/C	Description of Traffic Flow
Up to 0.3	Free-flow conditions Travel speeds at the free-flow speed generally prevail Ability to manoeuvre within traffic stream almost unimpeded
0.3 – 0.5	Easy flow conditions Travel speeds close to free-flow speed Ability to manoeuvre within traffic stream slightly restricted
0.5 – 0.75	Generally easy flow conditions. Travel speeds begin to be restricted by traffic conditions. Ability to manoeuvre within traffic stream is noticeably restricted.
0.75 – 1.0	Well used flow conditions. Travel speeds reduced by increasing traffic volumes. Ability to manoeuvre within traffic stream is severely restricted.
1.0 – 1.2	Unstable flow conditions Travel speeds substantially reduced and are highly variable & unpredictable Little or no room to manoeuvre within traffic stream
> 1.2	Forced or breakdown flow conditions. Crawling travel speed. Highly unstable traffic operations with widespread congestion and extensively long traffic queues.

Source: Hong Kong Transportation Planning and Design Manual (TPDM)

Future vehicular demand was estimated for ports and local and approach roads were estimated to provide an indication on the number of lanes needed for the bridge, approach roads, and the local road network. Forecasts were generated for three toll scenarios:

- Scenario A: No Toll
- Scenario B: Toll rate equal to the existing ferry fare
- Scenario C: Toll rate 50% higher than existing ferry fare

Economic assessments for travel time impacts were also conducted.

The detailed traffic study, providing assumptions, detailed methodology, detailed results, and limitations of the traffic model are provided in **Annex O.**

Ferry Walk-Up Passenger Survey Results

Table 2.87 presents the walk-up passenger volumes from the survey. A total of about 8,100 walk-up passengers from Davao to IGaCoS and 8,600 walk-up passengers from IGaCoS to Davao were counted respectively. It is noted that for this day, more overall passengers are heading "westbound" from IGaCoS to Davao instead of "eastbound" from Davao to IGaCoS. This directional pattern is used in the analysis.

Table 2.94 Walk-Up Passenger Count Results

Item	Station A: Samal Ferry Terminal		Station B: Sasa Ferry Terminal		Station C: DavSam Ferry Terminal		Total	
	Davao to IGaCoS	IGaCoS to Davao	Davao to IGaCoS	IGaCoS to Davao	Davao to IGaCoS	IGaCoS to Davao	Davao to IGaCoS	IGaCoS to Davao
Walk-Up Passengers	3,387	3,177	4,545	5,032	204	414	8,136	8,623

Table 2.95 and **Table 2.96** show the access mode share to/from the ferry terminals by transport mode. In terms of two-way trips to/from the Davao City ferry terminals, jeepney/multicab were the most popular access mode (at 68.3%), followed by taxi/Grab (at 14.0%), and bus (at 5.4%), respectively. In terms of two-way trips to/from the Samal ferry terminals, motorcycle was the most popular (at 50.2%), followed by tricycle (at 36.2%), and bus (at 4.1%), respectively.

Table 2.95 Summary of Ferry Walk-Up Passenger Access Mode Share to/from Ferry Terminals in Davao

Mode	Passengers Using Specific Mode to Davao Ferry Terminals		Passengers Using Specific Mode from Davao Ferry Terminals		Two-Way Volume	
	Total	% of Total	Total	% of Total	Total	% of Total
Motorcycle	8	2.3%	3	1.0%	11	1.7%
Tricycle	5	1.4%	5	1.7%	10	1.6%
Private Car	14	4.0%	3	1.0%	17	2.7%
Taxi/ Grab	51	14.7%	38	13.2%	89	14.0%
School Bus	3	0.9%	3	1.0%	6	0.9%
Jeepney/ Multicab	217	62.4%	217	75.6%	434	68.3%
UV Express	22	6.3%	1	0.3%	23	3.6%

Mode	Passengers Using Specific Mode to Davao Ferry Terminals		Passengers Using Specific Mode from Davao Ferry Terminals		Two-Way Volume	
	Total	% of Total	Total	% of Total	Total	% of Total
Bus	23	6.6%	11	3.8%	34	5.4%
Other	5	1.4%	6	2.1%	11	1.7%
Total	348	100.0%	287	100.0%	635	100.0%

Table 2.96 Summary of Ferry Walk-Up Passenger Access Mode Share to/from Ferry Terminals in IGaCoS

Mode	Passengers Using Specific Mode to IGaCoS d Ferry Terminals		Passengers Using Specific Mode from IGaCoS Ferry Terminals		Two-Way Volume	
	Total	% of Total	Total	% of Total	Total	% of Total
Motorcycle	150	52.3%	169	48.6%	319	50.2%
Tricycle	107	37.3%	123	35.3%	230	36.2%
Private Car	9	3.1%	4	1.1%	13	2.0%
Taxi/ Grab	1	0.3%	1	0.3%	2	0.3%
School Bus	3	1.0%	3	0.9%	6	0.9%
Jeepney/ Multicab	2	0.7%	5	1.4%	7	1.1%
UV Express	0	0.0%	7	2.0%	7	1.1%
Bus	6	2.1%	20	5.7%	26	4.1%
Other	9	3.1%	16	4.6%	25	3.9%
Total	287	100.0%	348	100.0%	635	100.0%

Ferry Vehicle and Vehicle Passenger Survey Results

Table 2.97 presents the ferry vehicle and vehicle passenger volumes from the surveys. A total of 2,400 vehicles from Davao to IGaCoS and 2,800 vehicles from IGaCoS to Davao were counted – these carried a total of 6,900 and 7,000 vehicle passengers, respectively.

Motorcycle/tricycle/pedicab accounted for the highest share (more than 50%), while private cars make up just over 30% of RoRo vehicles in the Samal Ferry Terminal and DavSam Ferry Terminal.

Vehicle passengers (i.e. passengers on vehicles aboard the ferry) modal split at the terminals shows that motorcycle/tricycle and car are the most popular modes to travel between Davao and IGaCoS, accounting for more than 70% of total ferry vehicle passengers.

Table 2.97 Ferry Vehicle and Vehicle Passenger Count Results

Type	**Station A: Samal Ferry Terminal**				**Station C: DavSam Ferry Terminal**				**Total**			
	Davao to IGaCoS	**% of Share**	**IGaCoS to Davao**	**% of Share**	**Davao to IGaCoS**	**% of Share**	**IGaCoS to Davao**	**% of Share**	**Davao to IGaCoS**	**% of Share**	**IGaCoS to Davao**	**% of Share**
Motorcycle/ Tricycle [A]	1,079	50.8%	1,487	57.0%	127	47.7%	102	53.4%	1,206	50.4%	1,589	56.8%
Car	806	37.9%	863	33.1%	78	29.3%	31	16.2%	884	37.0%	894	32.0%
Taxi	11	0.5%	14	0.5%	0	0.0%	2	1.0%	11	0.5%	16	0.6%
Jeepney/ Multicab/ Mini-bus/UV Express	16	0.8%	18	0.7%	2	0.8%	9	4.7%	18	0.8%	27	1.0%
Standard Bus	34	1.6%	45	1.7%	0	0.0%	0	0.0%	34	1.4%	45	1.6%
Light Goods Vehicle/Van/ Pickup	79	3.7%	24	0.9%	0	0.0%	9	4.7%	79	3.3%	33	1.2%
All Trucks	100	4.7%	156	6.0%	59	22.2%	38	19.9%	159	6.6%	194	6.9%
Total	2,125	100.0%	2,607	100.0%	266	100.0%	191	100.0%	2,391	100%	2,798	100.0%
Motorcycle/ Tricycle	1,555	24.7%	2,161	32.4%	200	33.7%	151	42.2%	1,755	25.5%	2,312	32.9%
Car	2,958	47.0%	2,962	44.4%	239	40.3%	72	20.1%	3,197	46.4%	3,034	43.1%
Taxi	39	0.6%	37	0.6%	0	0.0%	5	1.4%	39	0.6%	42	0.6%

Type	Station A: Samal Ferry Terminal				Station C: DavSam Ferry Terminal				Total			
	Davao to IGaCoS	% of Share	IGaCoS to Davao	% of Share	Davao to IGaCoS	% of Share	IGaCoS to Davao	% of Share	Davao to IGaCoS	% of Share	IGaCoS to Davao	% of Share
Jeepney/ Multicab/ Mini-bus/UV Express	108	1.7%	134	2.0%	3	0.5%	16	4.5%	111	1.6%	150	2.1%
Standard Bus	1,153	18.3%	967	14.5%	0	0.0%	0	0.0%	1,153	16.7%	967	13.7%
Light Goods Vehicle/Van/ Pickup	224	3.6%	80	1.2%	0	0.0%	25	7.0%	224	3.3%	105	1.5%
All Trucks	255	4.1%	337	5.0%	151	25.5%	89	24.9%	406	5.9%	426	6.1%
Total	6,292	100.0%	6,678	100.0%	593	100.0%	358	100.0%	6,885	100.0%	7,036	100.0%

Local Road Performance

Peak hours were generally found to be 8:15AM – 9:15AM and 5:15PM – 6:15PM. However it is noted at specific locations, peak hours may differ from these defined peak hours.

The link performance calculated from the existing peak hours in PCU/hour as surveyed are shown in **Table 2.98**.

The results indicate that all assessed key road links are currently operating at satisfactory levels under design capacity (i.e. under V/C 1.2).

Table 2.98 Existing Peak Hour Flow and Performance of Major Road Links

Road Link		Bound	Carriageway Width (m) per Lane	1-Way Hourly Capacity (PCU)	No. of Lanes	1-Way Hourly Capacity (PCU)	Year 2019 Surveyed Flow (PCU/Hour)		Year 2019 Surveyed Flow V/C Ratio	
							AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	3.2	800	2	1,600	580	700	0.36	0.44
		SB	3.2	800	2	1,600	620	780	0.39	0.49
L2	Circumferential Road	NB	3.2	800	1	800	300	470	0.37	0.58
		SB	3.2	800	1	800	290	330	0.37	0.41
L3	Circumferential Road	NB	3.2	800	1	800	140	190	0.17	0.24
		SB	3.2	800	1	800	150	140	0.19	0.18
L4	Pan-Philippine Highway	NB	3.4	900	2	1,800	1,600	1,650	0.89	0.92
		SB	3.4	900	2	1,800	1,730	1,480	0.96	0.82
L5	Pan-Philippine Highway	NB	3.4	900	3	2,700	1,900	1,310	0.70	0.48
		SB	3.4	900	3	2,700	2,280	1,690	0.84	0.62
L6	C.P. Garcia Highway	NB	3.4	900	3	2,700	1,830	1,590	0.68	0.59
		SB	3.4	900	3	2,700	2,100	2,080	0.78	0.77
L7	Davao City-Panabo City Road	NB	3.3	800	3	2,400	2,060	1,800	0.86	0.75
		SB	3.3	800	3	2,400	1,970	1,310	0.82	0.54
L8	Davao City-Panabo City Road	NB	3.4	900	3	2,700	2,060	1,920	0.76	0.71
		SB	3.4	900	3	2,700	2,160	1,420	0.80	0.53
L9		NB	3.4	900	2	1,800	900	1,130	0.50	0.63

Road Link		Bound	Carriageway Width (m) per Lane	1-Way Hourly Capacity (PCU)	No. of Lanes	1-Way Hourly Capacity (PCU)	Year 2019 Surveyed Flow (PCU/Hour)		Year 2019 Surveyed Flow V/C Ratio	
							AM Peak	PM Peak	AM Peak	PM Peak
	Daang Maharlika Highway	SB	3.4	900	2	1,800	850	940	0.47	0.52
L10	R. Castillo Street	NB	3.4	900	2	1,800	1,160	1,430	0.64	0.79
		SB	3.4	900	2	1,800	1,100	1,160	0.61	0.65
L11	Pan-Philippine Highway	NB	3.4	900	2	1,800	820	850	0.46	0.47
		SB	3.4	900	2	1,800	850	1,140	0.47	0.64
L12	Daang Maharlika Highway	NB	3.4	900	2	1,800	1,480	1,300	0.82	0.72
		SB	3.4	900	2	1,800	1,320	840	0.73	0.47
L13	R. Castillo Street	NB	3.4	900	2	1,800	1,740	1,460	0.97	0.81
		SB	3.4	900	2	1,800	1,660	1,490	0.92	0.83
L14	Leon Garcia Street	NB	3.4	900	4	3,600	2,300	1,610	0.64	0.45
		SB	3.4	900	4	3,600	2,260	2,150	0.63	0.60
L15	C.M. Recto	NB	3.4	900	3	2,700	2,110	2,140	0.78	0.79
L16	Quezon Blvd	NB	3.4	900	2	1,800	1,640	1,260	0.97	0.70
		SB	3.4	900	2	1,800	1,590	1,680	0.88	0.93
L17	Elpidio Quirino Ave	NB	3.5A	1,675 A	2	3,350	2,420	2,720	0.72	0.81
		SB	3.5A	1,675 A	2	3,350	3,080	3,100	0.92	0.92
L18	Quezon Blvd	NB	3.4	1,675 A	2	3,350	2,440	1,810	0.72	0.54

Road Link		Bound	Carriageway Width (m) per Lane	1-Way Hourly Capacity (PCU)	No. of Lanes	1-Way Hourly Capacity (PCU)	Year 2019 Surveyed Flow (PCU/Hour)		Year 2019 Surveyed Flow V/C Ratio	
							AM Peak	PM Peak	AM Peak	PM Peak
		SB	3.4	1,675 A	2	3,350	1,590	1,540	0.47	0.46

Note:

A The road capacity is based on an "urban street" road type with 2 x 7.0m two-way carriage width (m) in **Table 2.92**.

Traffic Demand Forecasts

Future Port Demand – Scenario (Bridge Crossing)

Table 2.99 presents the theoretical vehicle demand from port-related traffic that forms the potential pool of vehicles that may use the bridge link (this means the observed vehicles using the Ro-Ro service recorded by this study survey plus the "equivalent" vehicle trips to handle walk-up passengers).

Thus, if it is assumed that walk-up passengers divert to a surface mode to potentially cross the bridge link, there are over 8,900 daily vehicle trips (including the observed survey 5,189 vehicle trips). This sum is then assumed to increase in line with population-adjusted GRDP growth up to Year 2055, which would require nearly 33,000 vehicle trips from port-related demand. It is noted that the survey data in 2019 finds that the westbound flows are higher than the eastbound ones. As the 2019 data is used to project future demand, this imbalanced demand pattern is assumed to continue.

Table 2.99 Theoretical Equivalent Port-Related Vehicle Demand (Assuming Walk-Up Passengers Divert to a Road-based Mode to Cross Fixed Link)

Year	Forecast Equivalent Vehicles/Day Generated by Port-Related Demand [A, B]								
	Direction	Motorcycle/ Tricycle	Car	Taxi	Jeepney/ Multicab/ Mini-bus/ UV Express	Standard Bus	Light Goods Vehicle/ Van/ Pickup	All Trucks	Total [C]
2019	Eastbound	1,423	1,000	445	1,070	34	79	159	4,210
2019	Westbound	1,819	1,017	476	1,142	45	33	194	4,726
2020	Eastbound	1,515	1,065	474	1,139	36	84	169	4,481
2020	Westbound	1,936	1,083	507	1,216	48	35	206	5,030
2025	Eastbound	1,985	1,395	621	1,493	47	110	222	5,873
2025	Westbound	2,537	1,419	664	1,593	63	46	271	6,593
2030	Eastbound	2,503	1,760	783	1,882	60	139	280	7,406
2030	Westbound	3,200	1,789	837	2,009	79	58	341	8,314
2035	Eastbound	3,049	2,143	953	2,293	73	169	341	9,021
2035	Westbound	3,897	2,179	1,020	2,447	96	71	416	10,126
2040	Eastbound	3,589	2,523	1,122	2,699	86	199	401	10,619
2040	Westbound	4,588	2,566	1,200	2,881	114	83	489	11,920
2045	Eastbound	4,090	2,875	1,279	3,075	98	227	457	12,100
2045	Westbound	5,228	2,923	1,368	3,282	129	95	558	13,583
2050	Eastbound	4,660	3,276	1,457	3,504	111	259	521	13,788
2050	Westbound	5,957	3,331	1,559	3,740	147	108	635	15,478
2055	Eastbound	5,310	3,733	1,660	3,993	127	295	593	15,711
2055	Westbound	6,788	3,796	1,776	4,262	168	123	724	17,637

Note:

Year	Forecast Equivalent Vehicles/Day Generated by Port-Related Demand [A, B]								
	Direction	Motorcycle/ Tricycle	Car	Taxi	Jeepney/ Multicab/ Mini-bus/ UV Express	Standard Bus	Light Goods Vehicle/ Van/ Pickup	All Trucks	Total [C]

[A] This estimate assumes that walk-up passengers would theoretically uses a road-based transport mode to cross the bridge link once in service. The 2019 value represent the theoretical number of vehicles that would be needed to carry all passengers across a bridge link and is only included for reference.

[B] These vehicle volumes represent the “pool” of potential port-related traffic that may potentially use the bridge crossing. However, as shown in the next stage, it is assumed that only a portion of this pool will use the bridge crossing.

[C] The observed demand for the specific set of survey days in 2019 finds that westbound demand to Davao is higher than eastbound demand to IGaCoS. As this survey data in 2019 is used to project future demand, this imbalance is carried forward into the future year traffic flow.

Estimated Bridge Demand[4]

Forecast Annual Cumulative Demand

The bridge demand is estimated by assuming that some theoretical port-related demand will divert to use the bridge. In addition to diverted port-related vehicle volumes, induced demand currently not using the ports must be accounted for. Induced demand may be generated as the bridge crossing will be more convenient and direct than the existing ferry service. Assumptions on diversion rates, traffic factors in generating enduced demand, and results of diverted and induced demand are detailed in **Annex O.**

The port-related demand and the induced demand are then added together to generate the cumulative demand for the three scenarios, which are shown in the tables below. Some 18.9 million vehicles annually are forecast in 2055 for Scenario A, 14.9 million for Scenario B, and 10.6 million for Scenario C, respectively.

Table 2.100 Cumulative Annual Vehicle Volumes (Diverted + Induced) on SIDC – Scenario A (No Toll)

PCU Equivalent [A]		0.75	1	1	1.5	2	2	2.5		
Year	**Direction**	**Motorcycle/ Tricycle [B]**	**Car**	**Taxi**	**Jeepney/ Multicab/ Mini-bus/ UV Express**	**Standard Bus**	**Light Goods Vehicle/ Van/ Pickup**	**All Trucks**	**Total (Vehicles/ Year) [C]**	**Total (PCU/ Year) [C]**
2025	Eastbound	844,341	618,903	7,701	951,485	23,804	55,309	111,319	2,612,862	3,123,610
2025	Westbound	1,112,485	625,904	11,202	1,013,985	31,505	23,104	135,823	2,954,008	3,441,222
2030	Eastbound	1,355,095	993,287	12,360	1,527,051	38,203	88,767	178,657	4,193,419	5,013,126
2030	Westbound	1,785,444	1,004,523	17,978	1,627,359	50,563	37,080	217,984	4,740,930	5,522,867
2035	Eastbound	1,650,533	1,209,844	15,055	1,859,980	46,532	108,120	217,608	5,107,672	6,106,092
2035	Westbound	2,174,708	1,223,530	21,898	1,982,157	61,587	45,164	265,509	5,774,552	6,726,967
2040	Eastbound	1,942,963	1,424,195	17,722	2,189,518	54,777	127,275	256,162	6,012,612	7,187,925
2040	Westbound	2,560,007	1,440,306	25,777	2,333,341	72,499	53,166	312,550	6,797,645	7,918,802
2045	Eastbound	2,213,979	1,622,850	20,194	2,494,925	62,417	145,028	291,893	6,851,287	8,190,539

[4] As a reminder, the demand presented in this section is the unconstrained demand.

PCU Equivalent [A]		**0.75**	**1**	**1**	**1.5**	**2**	**2**	**2.5**		
Year	**Direction**	**Motorcycle/ Tricycle** [B]	**Car**	**Taxi**	**Jeepney/ Multicab/ Mini-bus/ UV Express**	**Standard Bus**	**Light Goods Vehicle/ Van/ Pickup**	**All Trucks**	**Total (Vehicles/ Year)** [C]	**Total (PCU/ Year)** [C]
2045	Westbound	2,917,092	1,641,208	29,373	2,658,809	82,611	60,582	356,146	7,745,821	9,023,364
2050	Eastbound	2,522,798	1,849,215	23,011	2,842,932	71,124	165,258	332,608	7,806,945	9,333,004
2050	Westbound	3,323,985	1,870,134	33,470	3,029,676	94,134	69,032	405,823	8,826,253	10,281,996
2055	Eastbound	2,874,692	2,107,154	26,220	3,239,481	81,044	188,309	379,002	8,895,903	10,634,827
2055	Westbound	3,787,634	2,130,991	38,139	3,452,273	107,265	78,661	462,430	10,057,391	11,716,189

Note:

[A] PCU equivalents based on DPWH typical classifications, except for motor-tricycles (which are assigned an equivalent of 0.75 PCU based on international practice and Hong Kong's Transport Planning and Design Manual or TPDM).

[B] Based on the vehicular count surveys at the Davao ferry terminals, the split between motorcycle and tricycle is counted as 95% and 5%, respectively. When SIDC is implemented, it is assumed that this split between motorcycle and tricycle will be similar.

[C] Forecasts are based on 2019 surveys, which finds that westbound demand to Davao is higher than eastbound demand to IGaCoS.. As this survey data in 2019 is used to project future demand, this imbalance is carried forward into the future year traffic flow.

Table 2.101 Cumulative Annual Vehicle Volumes (Diverted + Induced) on SIDC – Scenario B (Toll Same as Existing Ferry Fare)

PCU Equivalent [A]		**0.75**	**1**	**1**	**1.5**	**2**	**2**	**2.5**		
Year	**Direction**	**Motorcycle/ Tricycle** [B]	**Car**	**Taxi**	**Jeepney/ Multicab/ Mini-bus/ UV Express**	**Standard Bus**	**Light Goods Vehicle/ Van/ Pickup**	**All Trucks**	**Total (Vehicles/ Year)** [C]	**Total (PCU/ Year)** [C]
2025	Eastbound	736,879	540,134	6,721	789,246	20,774	48,270	97,151	2,239,175	2,664,348
2025	Westbound	970,896	546,244	9,776	841,329	27,495	20,163	118,536	2,534,440	2,937,843
2030	Eastbound	1,084,076	794,629	9,888	1,161,116	30,563	71,013	142,925	3,294,210	3,919,713
2030	Westbound	1,428,355	803,618	14,382	1,237,739	40,451	29,664	174,387	3,728,596	4,322,071

PCU Equivalent [A]		**0.75**	**1**	**1**	**1.5**	**2**	**2**	**2.5**		
Year	**Direction**	**Motorcycle/ Tricycle [B]**	**Car**	**Taxi**	**Jeepney/ Multicab/ Mini-bus/ UV Express**	**Standard Bus**	**Light Goods Vehicle/ Van/ Pickup**	**All Trucks**	**Total (Vehicles/ Year) [C]**	**Total (PCU/ Year) [C]**
2035	Eastbound	1,320,427	967,875	12,044	1,414,263	37,226	86,496	174,086	4,012,417	4,774,292
2035	Westbound	1,739,766	978,824	17,518	1,507,592	49,270	36,131	212,407	4,541,508	5,264,373
2040	Eastbound	1,554,370	1,139,356	14,178	1,664,832	43,821	101,820	204,929	4,723,307	5,620,167
2040	Westbound	2,048,005	1,152,245	20,622	1,774,696	57,999	42,533	250,040	5,346,139	6,197,077
2045	Eastbound	1,771,183	1,298,280	16,155	1,897,053	49,934	116,023	233,514	5,382,142	6,404,101
2045	Westbound	2,333,673	1,312,967	23,498	2,022,241	66,089	48,465	284,917	6,091,850	7,061,481
2050	Eastbound	2,018,238	1,479,372	18,408	2,161,665	56,899	132,206	266,086	6,132,875	7,297,382
2050	Westbound	2,659,188	1,496,107	26,776	2,304,315	75,307	55,225	324,659	6,941,577	8,046,458
2055	Eastbound	2,299,754	1,685,723	20,976	2,463,187	64,836	150,647	303,201	6,988,325	8,315,264
2055	Westbound	3,030,107	1,704,793	30,511	2,625,735	85,812	62,929	369,944	7,909,829	9,168,826

Note:

[A] PCU equivalents based on DPWH typical classifications, except for motor-tricycles (which are assigned an equivalent of 0.75 PCU based on international practice and Hong Kong’s Transport Planning and Design Manual or TPDM).

[B] Based on the vehicular count surveys at the Davao ferry terminals, the split between motorcycle and tricycle is counted as 95% and 5%, respectively. When SIDC is implemented, it is assumed that this split between motorcycle and tricycle will be similar.

[C] Forecasts are based on 2019 surveys, which finds that westbound demand to Davao is higher than eastbound demand to IGaCoS. d. As this survey data in 2019 is used to project future demand, this imbalance is carried forward into the future year traffic flow.

Table 2.102 Cumulative Annual Vehicle Volumes (Diverted + Induced) on SIDC – Scenario C (Toll 50% Higher than Existing Ferry Fare)

PCU Equivalent [A]		**0.75**	**1**	**1**	**1.5**	**2**	**2**	**2.5**		
Year	**Direction**	**Motorcycle/ Tricycle [B]**	**Car**	**Taxi**	**Jeepney/ Multicab/ Mini-bus/ UV Express**	**Standard Bus**	**Light Goods Vehicle/ Van/ Pickup**	**All Trucks**	**Total (Vehicles/ Year) [C]**	**Total (PCU/ Year) [C]**
2025	Eastbound	540,378	396,098	4,929	627,289	19,043	37,610	80,149	1,705,497	2,060,924
2025	Westbound	711,991	400,579	7,169	668,609	25,204	15,711	97,792	1,927,055	2,270,965
2030	Eastbound	743,366	544,889	6,780	862,924	26,197	51,738	110,257	2,346,151	2,835,092
2030	Westbound	979,443	551,053	9,862	919,766	34,672	21,612	134,527	2,650,935	3,124,032
2035	Eastbound	905,435	663,686	8,259	1,051,060	31,908	63,018	134,295	2,857,661	3,453,201
2035	Westbound	1,192,983	671,193	12,012	1,120,294	42,231	26,324	163,857	3,228,894	3,805,136
2040	Eastbound	1,065,854	781,273	9,722	1,237,279	37,561	74,183	158,088	3,363,961	4,065,014
2040	Westbound	1,404,347	790,111	14,141	1,318,779	49,713	30,988	192,888	3,800,966	4,479,302
2045	Eastbound	1,214,526	890,249	11,078	1,409,862	42,800	84,531	180,140	3,833,186	4,632,026
2045	Westbound	1,600,233	900,320	16,113	1,502,730	56,648	35,310	219,793	4,331,147	5,104,101
2050	Eastbound	1,383,935	1,014,426	12,623	1,606,518	48,771	96,322	205,266	4,367,861	5,278,128
2050	Westbound	1,823,443	1,025,902	18,361	1,712,340	64,549	40,236	250,451	4,935,281	5,816,052
2055	Eastbound	1,576,974	1,155,925	14,384	1,830,605	55,573	109,757	233,898	4,977,116	6,014,353
2055	Westbound	2,077,788	1,169,001	20,922	1,951,187	73,553	45,848	285,385	5,623,683	6,627,309

Note:

[A] PCU equivalents based on DPWH typical classifications, except for motor-tricycles (which are assigned an equivalent of 0.75 PCU based on international practice and Hong Kong's Transport Planning and Design Manual or TPDM).

[B] Based on the vehicular count surveys at the Davao ferry terminals, the split between motorcycle and tricycle is counted as 95% and 5%, respectively. When SIDC is implemented, it is assumed that this split between motorcycle and tricycle will be similar.

[C] Forecasts are based on 2019 surveys, which finds that westbound demand to Davao is higher than eastbound demand to IGaCoS.. As this survey data in 2019 is used to project future demand, this imbalance is carried forward into the future year traffic flow.

Surrounding Road Network Demand

Demand on surrounding roads after SIDC implementation is based on:

- Natural growth in port-related demand based on 2019 traffic counts projected to account for GRDP growth and adjusted by population changes;
- Port-related traffic that would divert to use the bridge and continue to use RoRo services;
- Induced traffic using the bridge;
- Additional vehicle trips generated by new developments near the Davao landing point

Assumptions, detailed methodology, results of estimated traffic that will divert from surrounding roads to new road projects and estimated trips generated by new developments are provided in **Annex O**.

Peak hour traffic demand on surrounding roads under the existing road network (i.e without the Davao City Coastal Road, and Davao City Bypass Tunnel and without SIDC) across all scenarios are presented in **Table 2.103** to **Table 2.106**.

Table 2.103 Vehicle Demand on Surrounding Roads (Existing Road Network) – Without Project

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	811	981	1,023	1,237	1,246	1,506
		SB	862	1,092	1,087	1,377	1,324	1,677
L2	Circumferential Road	NB	417	651	526	821	640	1,000
		SB	411	460	519	580	632	707
L3	Circumferential Road	NB	190	272	239	343	291	418
		SB	211	197	266	248	324	302
L4	Pan-Philippine Highway	NB	2,227	2,308	2,808	2,910	3,421	3,544
		SB	2,409	2,066	3,038	2,606	3,701	3,174
L5	Pan-Philippine Highway	NB	2,646	1,824	3,337	2,300	4,064	2,802
		SB	3,179	2,352	4,009	2,966	4,883	3,612
L6	C.P. Garcia Highway	NB	2,552	2,223	3,218	2,803	3,920	3,414
		SB	2,925	2,900	3,688	3,656	4,493	4,453
L7	Davao City-Panabo City Road	NB	2,972	2,805	3,724	3,461	4,516	4,152
		SB	3,065	1,915	3,783	2,391	4,539	2,892
L8	Davao City-Panabo City Road	NB	2,980	3,003	3,731	3,702	4,522	4,437
		SB	3,376	2,090	4,161	2,608	4,988	3,153
L9	Daang Maharlika Highway	NB	1,799	1,742	2,125	2,154	2,469	2,589
		SB	1,326	1,730	1,637	2,071	1,965	2,430
L10	R. Castillo St	NB	2,048	2,121	2,469	2,642	2,913	3,190
		SB	1,742	2,283	2,141	2,706	2,563	3,152
L11		NB	1,147	1,194	1,446	1,503	1,761	1,830

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
	Pan-Philippine Highway	SB	1,185	1,596	1,494	2,012	1,819	2,451
L12	Daang Maharlika Highway	NB	2,286	1,874	2,827	2,347	3,395	2,845
		SB	1,947	1,505	2,428	1,812	2,935	2,135
L13	R. Castillo St	NB	2,601	2,095	3,234	2,628	3,900	3,190
		SB	2,364	2,247	2,967	2,789	3,602	3,360
L14	Leon Garcia St	NB	3,302	2,272	4,138	2,857	5,019	3,474
		SB	3,172	3,079	3,993	3,862	4,859	4,688
L15	C.M. Recto	NB	2,938	2,986	3,704	3,765	4,512	4,586
L16	Quezon Blvd	NB	2,431	1,757	3,065	2,216	3,733	2,699
		SB	2,216	2,346	2,795	2,959	3,404	3,604
L17	Elpidio Quirino Ave	NB	3,381	3,798	4,264	4,789	5,193	5,834
		SB	4,303	4,320	5,425	5,448	6,608	6,635
L18	Quezon Blvd	NB	3,404	2,520	4,292	3,178	5,228	3,871
		SB	2,217	2,146	2,796	2,706	3,405	3,296

Table 2.104 Vehicle Demand on Surrounding Roads (Existing Road Network) – Scenario A (No Toll)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	858	494	1,150	1,254	1,401	1,528
		SB	808	1,064	1,083	1,402	1,319	1,707
L2	Circumferential Road	NB	791	1,029	1,260	1,520	1,535	1,851
		SB	752	617	1,192	1,006	1,452	1,226
L3	Circumferential Road	NB	172	262	232	345	283	420
		SB	224	194	299	258	364	315
L4	Pan-Philippine Highway	NB	2,240	2,315	2,842	2,936	3,462	3,577
		SB	2,460	2,110	3,138	2,690	3,822	3,276
L5	Pan-Philippine Highway	NB	2,660	1,832	3,374	2,330	4,110	3,614
		SB	3,236	2,400	4,120	3,059	5,018	3,726
L6	C.P. Garcia Highway	NB	2,672	2,296	3,454	2,967	4,207	3,614
		SB	2,943	2,901	3,796	3,738	4,624	4,553
L7	Davao City-Panabo City Road	NB	3,316	3,189	4,358	4,179	5,288	5,026
		SB	3,220	2,207	4,176	3,004	5,017	3,639
L8	Davao City-Panabo City Road	NB	3,324	3,387	4,365	4,420	5,294	5,312
		SB	3,531	2,383	4,554	3,221	5,466	3,900
L9		NB	1,824	1,756	2,211	2,199	2,574	2,644

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
	Daang Maharlika Highway	SB	1,328	1,729	1,657	2,086	1,989	2,448
L10	R. Castillo St	NB	2,235	2,202	2,848	2,866	3,374	3,463
		SB	1,786	2,304	2,353	2,876	2,821	3,359
L11	Pan-Philippine Highway	NB	1,212	1,236	1,547	1,596	1,916	1,942
		SB	1,191	1,595	1,543	2,050	1,879	2,496
L12	Daang Maharlika Highway	NB	2,321	1,887	2,896	2,384	3,480	2,890
		SB	1,949	1,505	2,448	1,827	2,959	2,153
L13	R. Castillo St	NB	2,764	2,164	3,559	2,816	4,296	3,418
		SB	2,376	2,239	3,095	2,885	3,759	3,477
L14	Leon Garcia St	NB	3,428	2,327	4,389	3,004	5,324	3,652
		SB	3,180	3,072	4,092	3,936	4,979	4,778
L15	C.M. Recto	NB	2,938	2,986	3,704	3,765	4,512	4,586
L16	Quezon Blvd	NB	2,557	1,812	3,316	2,362	4,039	2,877
		SB	2,225	2,339	2,893	3,032	3,542	3,694
L17	Elpidio Quirino Ave	NB	3,456	3,827	4,412	4,871	5,374	5,933
		SB	4,309	4,319	5,475	5,485	6,669	6,681
L18	Quezon Blvd	NB	3,422	2,526	4,328	3,197	5,271	3,894
		SB	2,215	2,143	2,798	2,707	3,408	3,297

Table 2.105 Vehicle Demand on Surrounding Roads (Existing Road Network) – Scenario B (Toll Same as Existing Ferry Fare)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	829	925	1,081	1,196	1,316	1,457
		SB	781	1,039	1,018	1,341	1,241	1,634
L2	Circumferential Road	NB	678	935	992	1,294	1,209	1,576
		SB	648	519	945	774	1,151	943
L3	Circumferential Road	NB	165	256	217	330	264	402
		SB	217	188	282	244	344	297
L4	Pan-Philippine Highway	NB	2,232	2,309	2,825	2,920	3,441	3,557
		SB	2,447	2,098	3,104	2,661	3,781	3,242
L5	Pan-Philippine Highway	NB	2,652	1,825	3,355	2,311	4,086	2,815
		SB	3,221	2,387	4,082	3,027	4,973	3,687
L6	C.P. Garcia Highway	NB	2,636	2,266	3,369	2,895	4,103	3,526
		SB	2,906	2,867	3,710	3,657	4,518	4,454

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L7	Davao City-Panabo City Road	NB	3,390	3,088	4,389	3,939	5,326	4,735
		SB	3,325	2,104	4,254	2,757	5,113	3,338
L8	Davao City-Panabo City Road	NB	3,398	3,286	4,396	4,180	5,332	5,020
		SB	3,637	2,279	4,633	2,974	5,562	3,599
L9	Daang Maharlika Highway	NB	1,827	1,744	2,178	2,171	2,533	2,610
		SB	1,321	1,723	1,640	2,070	1,968	2,429
L10	R. Castillo St	NB	2,173	2,149	2,701	2,741	3,195	3,311
		SB	1,720	2,243	2,196	2,730	2,629	3,181
L11	Pan-Philippine Highway	NB	1,193	1,220	1,528	1,557	1,861	1,895
		SB	1,174	1,578	1,501	2,010	1,827	2,448
L12	Daang Maharlika Highway	NB	2,310	1,877	2,869	2,362	3,447	2,863
		SB	1,942	1,498	2,430	1,811	2,938	2,133
L13	R. Castillo St	NB	2,712	2,120	3,435	2,712	4,146	3,292
		SB	2,327	2,194	2,890	2,777	3,618	3,345
L14	Leon Garcia St	NB	3,387	2,293	4,294	2,924	5,208	3,555
		SB	3,142	3,037	4,002	3,852	4,869	4,675
L15	C.M. Recto	NB	2,938	2,986	3,704	3,765	4,512	4,586
L16	Quezon Blvd	NB	2,517	1,778	3,221	2,282	3,923	2,780
		SB	2,187	2,304	2,803	2,984	3,415	3,591
L17	Elpidio Quirino Ave	NB	3,431	3,806	4,355	4,823	5,305	5,875
		SB	4,291	4,302	5,433	5,445	6,617	6,632
L18	Quezon Blvd	NB	3,416	2,522	4,314	3,185	5,255	3,880
		SB	2,212	2,141	2,792	2,702	3,401	3,291

Table 2.106 Vehicle Demand on Surrounding Roads (Existing Road Network) – Scenario C (Toll 50% Higher than Existing Ferry Fare)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	791	892	1,012	1,138	1,232	1,386
		SB	744	1,004	953	1,280	1,160	1,559
L2	Circumferential Road	NB	531	810	727	1,070	885	1,304
		SB	511	390	698	543	850	661
L3	Circumferential Road	NB	157	248	201	316	245	385
		SB	208	180	266	230	324	280
L4	Pan-Philippine Highway	NB	2,221	2,298	2,805	2,902	3,417	3,535
		SB	2,426	2,080	3,066	2,630	3,735	3,203

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L5	Pan-Philippine Highway	NB	2,640	1,813	3,333	2,291	4,060	2,791
		SB	3,197	2,367	4,041	2,992	4,922	3,644
L6	C.P. Garcia Highway	NB	2,587	2,225	3,281	2,821	3,997	3,437
		SB	2,858	2,821	3,623	3,575	4,412	4,355
L7	Davao City-Panabo City Road	NB	3,242	2,957	4,123	3,704	5,001	4,449
		SB	3,170	1,966	3,975	2,508	4,773	3,035
L8	Davao City-Panabo City Road	NB	3,250	3,156	4,130	3,945	5,008	4,734
		SB	3,841	2,141	4,354	2,725	5,222	3,296
L9	Daang Maharlika Highway	NB	1,810	1,729	2,147	2,145	2,496	2,578
		SB	1,312	1,714	1,623	2,054	1,948	2,410
L10	R. Castillo St	NB	2,093	2,081	2.558	2,618	3,021	3,161
		SB	1,632	2,162	2,038	2,585	2,437	3,004
L11	Pan-Philippine Highway	NB	1,167	1,198	1,481	1,517	1,803	1,847
		SB	1,150	1,556	1,459	1,971	1,776	2,400
L12	Daang Maharlika Highway	NB	2,296	1,866	2,844	2,341	3,417	2,837
		SB	1,932	1,489	2,413	1,794	2,917	2,114
L13	R. Castillo St	NB	2,646	2,065	3,317	2,612	4,002	3,171
		SB	2,264	2,134	2,866	2,671	3,480	3,216
L14	Leon Garcia St	NB	3,337	2,250	4,202	2,847	5,097	3,462
		SB	3,093	2,991	3,914	3,769	4,762	4,574
L15	C.M. Recto	NB	2,938	2,986	3,704	3,765	4,512	4,586
L16	Quezon Blvd	NB	2,466	1,735	3,130	2,205	3,812	2,686
		SB	2,138	2,258	2,715	2,865	3,307	3,490
L17	Elpidio Quirino Ave	NB	3,402	3,781	4,301	4,778	5,239	5,820
		SB	4,268	4,280	5,391	5,406	6,566	6,584
L18	Quezon Blvd	NB	3,409	2,516	4,301	3,175	5,239	3,867
		SB	2,210	2,138	2,788	2,698	3,395	3,286

Some roads will experience reduced peak hour volumes upon implementation of new infrastructure projects (i.e. Davao City Coastal Road and Davao City Bypass Tunnel). Traffic volumes expected under all scenarios, assuming future changes in the road network, are provided in **Table 2.107** to **Table 2.110**.

Table 2.107 Vehicle Demand on Surrounding Roads (Future Road Network) – Without Project)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	811	981	1,023	1,237	1,246	1,506
		SB	862	1,092	1,087	1,377	1,324	1,677
L2	Circumferential Road	NB	417	651	526	821	640	1,000
		SB	411	460	519	580	632	707
L3	Circumferential Road	NB	190	272	239	343	291	418
		SB	211	197	266	248	324	302
L4	Pan-Philippine Highway	NB	1,678	1,759	2,214	2,316	2,766	2,889
		SB	1,759	1,416	2,334	1,901	2,924	2,398
L5	Pan-Philippine Highway	NB	2,092	1,270	2,737	1,700	3,403	2,141
		SB	2,523	1,695	3,299	2,255	4,100	2,829
L6	C.P. Garcia Highway	NB	2,109	1,779	2,738	2,323	3,391	2,885
		SB	2,400	2,374	3,120	3,088	3,866	3,827
L7	Davao City-Panabo City Road	NB	2,861	2,694	3,604	3,341	4,383	4,020
		SB	2,934	1,784	3,640	2,249	4,382	2,735
L8	Davao City-Panabo City Road	NB	2,869	2,893	3,611	3,582	4,390	4,305
		SB	3,245	1,959	4,019	2,465	4,831	2,996
L9	Daang Maharlika Highway	NB	1,354	1,323	1,644	1,702	1,945	2,096
		SB	869	1,286	1,143	1,591	1,426	1,906
L10	R. Castillo St	NB	1,083	1,219	1,427	1,666	1,777	2,128
		SB	762	1,335	1,083	1,681	1,409	2,035
L11	Pan-Philippine Highway	NB	704	751	966	1,024	1,232	1,301
		SB	660	1,071	925	1,444	1,192	1,824
L12	Daang Maharlika Highway	NB	1,841	1,456	2,345	1,895	2,871	2,352
		SB	1,490	1,062	1,934	1,332	2,396	1,612
L13	R. Castillo St	NB	1,636	1,192	2,191	1,653	2,765	2,127
		SB	1,384	1,298	1,908	1,764	2,449	2,243
L14	Leon Garcia St	NB	2,337	1,370	3,095	1,882	3,883	2,412
		SB	2,192	2,131	2,935	2,873	3,705	3,571
L15	C.M. Recto	NB	2,499	2,633	3,226	3,380	3,964	4,146
L16	Quezon Blvd	NB	1,481	1,007	2,029	1,398	2,544	1,760
		SB	938	987	1,400	1,475	1,802	1,899
L17	Elpidio Quirino Ave	NB	2,455	2,872	3,164	3,690	3,863	4,503
		SB	3,366	3,384	4,315	4,337	5,266	5,293
L18	Quezon Blvd	NB	2,768	1,884	3,539	2,425	4,319	2,962
		SB	1,571	1,500	2,032	1,942	2,484	2,375

Table 2.108 Vehicle Demand on Surrounding Roads (Future Road Network) – With Project - Scenario A (No Toll)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	858	949	1,150	1,254	1,401	1,528
		SB	808	1,064	1,083	1,402	1,319	1,707
L2	Circumferential Road	NB	791	1,029	1,260	1,520	1,535	1,851
		SB	752	617	1,192	1,006	1,452	1,226
L3	Circumferential Road	NB	172	262	232	345	283	420
		SB	224	194	299	258	364	315
L4	Pan-Philippine Highway	NB	1,690	1,766	2,248	2,324	2,807	2,922
		SB	1,810	1,459	2,433	1,985	3,046	2,500
L5	Pan-Philippine Highway	NB	2,106	1,278	2,774	1,730	3,449	2,177
		SB	2,580	1,743	3,409	2,348	4,235	2,943
L6	C.P. Garcia Highway	NB	2.228	1,853	2,974	2,487	3,678	3,085
		SB	2,417	2,375	3,228	3,170	3,998	3,927
L7	Davao City-Panabo City Road	NB	3,205	3,078	4,238	4,059	5,155	4,894
		SB	3,089	2,076	4,033	2,862	4,860	3,482
L8	Davao City-Panabo City Road	NB	3,213	3,277	4,245	4,300	5,162	5,180
		SB	3,400	2,251	4,412	3,079	5,310	3,743
L9	Daang Maharlika Highway	NB	1,397	1,338	1,730	1,747	2,049	2,151
		SB	871	1,285	1,163	1,606	1,450	1,925
L10	R. Castillo St	NB	1270	1,299	1,805	1,89-	2,238	2,400
		SB	807	1,355	1,295	1,851	1,668	2,242
L11	Pan-Philippine Highway	NB	769	793	1,094	1,116	1,388	1,413
		SB	666	1,070	975	1,481	1,252	1,870
L12	Daang Maharlika Highway	NB	1,876	1,468	2,415	1,932	2,955	2,397
		SB	1,492	1,061	1,954	1,347	2,420	1,630
L13	R. Castillo St	NB	1,800	1,262	2,516	1,840	3,160	2,356
		SB	1,397	1,291	2,037	1,860	2,605	2,361
L14	Leon Garcia St	NB	2,463	1,424	3,346	2,028	4,188	2,590
		SB	2,201	2,124	3,033	2,911	3,825	3,661
L15	C.M. Recto	NB	2,499	2,633	3,226	3,380	3,964	4,146
L16	Quezon Blvd	NB	1,607	1,062	2,279	1,544	2,849	1,939
		SB	947	980	1,498	1,548	1,922	1,989
L17	Elpidio Quirino Ave	NB	2,530	2,901	3,313	3,722	4,044	4,603
		SB	3,733	3,383	4,365	4,375	5,326	5,339
L18	Quezon Blvd	NB	2,786	1,891	3,575	2,444	4,363	2,985
		SB	1,569	1,497	2,034	1,943	2,487	2,376

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak

Note

^ In the traffic assessment, walk-up passengers are assumed to shift to jeepneys after the implementation of SIDC. This may result in a reduction of total vehicles in the future versus the "Without Project" scenario.

Table 2.109 Vehicle Demand on Surrounding Roads (Future Road Network) – With Project - Scenario B (Toll Same as Existing Ferry Fare)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	829	925	1,081	1,196	1,316	1,457
		SB	781	1,039	1,018	1,341	1,241	1,634
L2	Circumferential Road	NB	678	935	992	1,294	1,209	1,576
		SB	648	519	945	774	1,151	943
L3	Circumferential Road	NB	165	256	217	330	264	402
		SB	217	188	282	244	344	297
L4	Pan-Philippine Highway	NB	1,683	1,759	2,230	2,326	2,786	2,902
		SB	1,796	1,447	2,400	1,957	3,005	2,465
L5	Pan-Philippine Highway	NB	2,098	1,271	2,755	1,712	3,425	2,154
		SB	2,564	1,730	3,372	2.317	4,189	2,904
L6	C.P. Garcia Highway	NB	2,193	1,823	2,889	2,415	3,574	2,997
		SB	2,381	2,341	3,141	3,088	3,892	3,827
L7	Davao City-Panabo City Road	NB	3,279	2,977	4,269	3,819	5,193	4,602
		SB	3,194	1,973	4,112	2,615	4,956	3,182
L8	Davao City-Panabo City Road	NB	3,287	3,176	4,276	4,060	5,200	4,888
		SB	3,506	2,148	4,490	2,832	5,405	3,442
L9	Daang Maharlika Highway	NB	1,382	1,325	1,697	1,719	2,009	2,117
		SB	864	1,279	1,146	1,590	1,429	1,905
L10	R. Castillo St	NB	1,208	1,247	1,658	1,765	2,059	2,248
		SB	741	1,294	1,137	1,705	1,476	2,064
L11	Pan-Philippine Highway	NB	750	777	1,048	1,077	1,332	1,367
		SB	648	1,053	932	1,441	1,201	1,821
L12	Daang Maharlika Highway	NB	1,865	1,459	2,388	1,909	2,923	2,370
		SB	1,485	1,054	1,936	1,331	2,399	1,610
L13	R. Castillo St	NB	1,747	1,217	2,393	1,736	3,010	2,229
		SB	1,348	1,245	1,921	1,752	2,465	2,229
L14	Leon Garcia St	NB	2,423	1,390	3,251	1,948	4,072	2,492
		SB	2,163	2,088	2,943	2,827	3,716	3,558

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L15	C.M. Recto	NB	2,499	2,633	3,226	3,380	3,964	4,146
L16	Quezon Blvd	NB	1,567	1,028	2,185	1,464	2,733	1,841
		SB	909	944	1,408	1,464	1,812	1,886
L17	Elpidio Quirino Ave	NB	2,505	2,880	3,256	3,724	3,975	4.545
		SB	3,355	3,366	4,322	4,335	5,275	5,290
L18	Quezon Blvd	NB	2,780	1,886	3,561	2,432	4,346	2,971
		SB	1,566	1,495	2,028	1,938	2,480	2,370

Note

^ In the traffic assessment, walk-up passengers are assumed to shift to jeepneys after the implementation of SIDC. This may result in a reduction of total vehicles in the future versus the "Without Project" scenario.

Table 2.110 Vehicle Demand on Surrounding Roads (Future Road Network) – With Project - Scenario C (Toll 50% Higher than Existing Ferry Fare)

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
L1	Circumferential Road	NB	791	892	1,012	1,138	1,232	1,386
		SB	744	1,004	953	1,280	1,160	1,559
L2	Circumferential Road	NB	531	810	727	1,070	885	1,304
		SB	511	390	698	543	850	661
L3	Circumferential Road	NB	157	248	201	316	245	385
		SB	208	180	266	230	324	280
L4	Pan-Philippine Highway	NB	1,672	1,749	2,211	2,307	2,762	2,880
		SB	1,775	1,429	2,362	1,925	2,959	2,427
L5	Pan-Philippine Highway	NB	2,086	1,259	2,733	1,692	3,399	2,130
		SB	2,541	1,711	3,330	2,281	4,138	2,861
L6	C.P. Garcia Highway	NB	2,144	1,782	2,802	2,343	3,468	2,908
		SB	2,333	2,296	3,054	3,007	3,786	3,728
L7	Davao City-Panabo City Road	NB	3,131	2,847	4,003	3,585	4,869	4,316
		SB	3,039	1,834	3,833	2,366	4,616	2,879
L8	Davao City-Panabo City Road	NB	3,139	3,045	4,010	3,825	4,876	4,602
		SB	3,350	2,009	4,212	2,583	5,066	3,139
L9	Daang Maharlika Highway	NB	1,365	1,311	1,666	1,693	1,971	2,085
		SB	855	1,270	1,129	1,574	1,409	1,886
L10	R. Castillo St	NB	1,128	1,178	1,515	1,642	1,885	2,098
		SB	653	1,213	980	1,560	1,284	1,887
L11		NB	723	755	1,001	1,038	1,274	1,318

Road Link		Direction	Year 2025 Flow (PCU/Hour)		Year 2030 Flow (PCU/Hour)		Year 2035 Flow (PCU/Hour)	
			AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
	Pan-Philippine Highway	SB	625	1,031	890	1,402	1,150	1,774
L12	Daang Maharlika Highway	NB	1,851	1,447	2,363	1,888	2,892	2,344
		SB	1,475	1,045	1,919	1,315	2,378	1,590
L13	R. Castillo St	NB	1,682	1,162	2,275	1,637	2,866	2,108
		SB	1,285	1,186	1,808	1,646	2,326	2,099
L14	Leon Garcia St	NB	2,372	1,348	3,160	1,872	3,961	2,399
		SB	2,114	2,042	2,855	2,744	3,608	3,457
L15	C.M. Recto	NB	2,499	2,633	3,226	3,380	3,964	4,146
L16	Quezon Blvd	NB	1,516	986	2,093	1,387	2,622	1,748
		SB	860	898	1,320	1,381	1,705	1,786
L17	Elpidio Quirino Ave	NB	2,476	2,855	3,202	3,679	3,909	4,490
		SB	3,331	3,344	4,280	4,295	5,223	5,242
L18	Quezon Blvd	NB	2,773	1,880	3,548	2,422	4,330	2,958
		SB	1,564	1,492	2,023	1,934	2,474	2,365

Note

^ In the traffic assessment, walk-up passengers are assumed to shift to jeepneys after the implementation of SIDC. This may result in a reduction of total vehicles in the future versus the “Without Project” scenario.

Implications on Transport Facilities

Sizing of the bridge, approach roads, and surrounding road network is based on the hourly PCU and the assumed capacity based on the road type. Lane capacities were referenced from the DPWH Highway Planning Manual:

- **Bridge Crossing** – 1,200 PCU/lane (or 2,400 two-way PCU for a two-way, single lane road with a carriageway width of 6.6-7.3m)
- **Approach Roads and Surrounding Road Network** – 1,000 PCU/lane (or 2,400 two-way PCU for a two-way, single lane road with a carriageway width of 6.6-7.3m)

Sizing of the bridge and approach ramps were assessed under two conditions:

- **Unconstrained** – Estimated demand is assumed to be accommodated by the road, which will be widened by one lane upon reaching a V/C ratio of 1.2.
- **Constrained** – Demand is assumed to be constrained such that it does not exceed a V/C ratio of 1.2 and roads would not be further widened.

Unlike bridge demand analysis, Year 2035 was assumed as the cut-off year for road network demand, which provides a 10-year traffic analysis timeframe used internationally for already congested, urban road networks (given uncertainties in future road and land use developments).

Key findings on sizing implications of transport facilities are provided below for each demand scenario (i.e. Scenario A – No Toll; (ii) Scenario B – Toll Same as Existing Ferry

Fare; and (iii) Scenario C – Toll 50% Higher than Existing Ferry Fare). Detailed analyses on the proposed number of lanes for each direction of the bridge and road facility for Scenario A, B, and C up to 2055 are provided in **Annex O**.

Bridge Sizing

Unconstrained

- **Scenario A (No Toll) –** A two-lane facility (one lane in each direction) would be sufficient up to 2025. At 2030, two lanes would be necessary in each direction. By 2045, three lanes would be required if no other connection between Davao City and IGaCoS is built.
- **Scenario B (Toll Same as Ferry Fare)** - A two-lane facility (one lane in each direction) would be sufficient up to 2030 if the toll is the same as the ferry fare. At 2035, two lanes would be necessary in each direction. By 2055, three lanes would be required.
- **Scenario C (Toll 50% Higher than Ferry Fare)** - A two-lane facility (one lane in each direction) would be sufficient up to 2035 if the toll is 50% higher than the ferry fare. At 2040, two lanes would be necessary in each direction. By 2055, two lanes will still suffice.

Constrained

- **Scenario A (No Toll) –** As each approach road volume is capped so they do not exceed V/C of 1.2, a two-lane facility (one lane in each direction) should operate sufficiently up to 2055.

Approach Ramps Sizing

Unconstrained

- **Scenario A (No Toll) –** SIDC approach ramps on Davao should operate sufficiently with one lane in each direction until 2040. By 2040, the eastbound approach ramp (from the south) will require 2 lanes. By 2045 and 2050, the westbound approach ramp (to the south) also will require 2 lanes. By 2055, every approach ramp from all directions requires two lanes in each direction to cater for the full estimated traffic demand.
- **Scenario B (Toll Same as Ferry Fare)** - SIDC approach ramps on Davao should operate sufficiently with one lane in each direction until 2050 when the toll is the same as that on the ferry. By 2050, the eastbound approach ramp (from the south) will require 2 lanes. By 2055, the westbound approach ramp (to the south) also will require 2 lanes.
- **Scenario C (Toll 50% Higher than Ferry Fare)** – SIDC approach ramps on Davao should operate sufficiently with one lane in each direction up to 2050.

Constrained

- **Scenario A (No Toll) –** As each approach road volume is capped so each road does not exceed V/C of 1.2, the SIDC approach ramps on Davao should operate sufficiently with one lane in each direction up to 2055.

Surrounding Road Sizing

Due to the growth in this region, numerous local road segments will already be congested and would require road widening despite new road infrastructure projects. SIDC would "accelerate" the required widening in the immediate area of the landings by five years for most of the local roads

Key findings from traffic impact comparison between the "Without Project" and "With Projects" are as follows:

- **Scenario A (No Toll) vs. "Without Project" –** Widening would be accelerated by five years on 8 segments compared to the "Without Project" Scenario. New widening due to SIDC would be required on 6 segments compared to the "Without Project" Scenario.
- **Scenario B (Toll Same as Ferry Fare) vs. "Without Project" –** Widening would be accelerated by five years on 7 segments compared to the "Without Project" Scenario. New widening due to SIDC would be required on 4 segments compared to the "Without Project" Scenario.
- **Scenario C (Toll 50% Higher than Ferry Fare) vs. "Without Project" -** Widening would be accelerated by five years on 2 segments compared to the "Without Project" Scenario. New widening due to SIDC would be required on 1 segment compared to the "Without Project" Scenario.

Table 2.111 Road Segments with New or Accelerated Proposed Widening for the "With Project" vs. the "Without Project" Scenarios

Road Link [A]	Scenario	# of Additional of Lanes	Year Widening Required	Note
L6-SB	Without Project	1	2035	Widening required in 2035
	Scenario A		2030	Requires widening 5 years earlier than "Without Project" Scenario
	Scenario B			
	Scenario C		2035	No change in year widening required
L7-NB	Without Project	1	2030	Widening required in 2030
	Scenario A		2025	Requires widening 5 years earlier than "Without Project" Scenario
	Scenario B			
	Scenario C			
	Without Project	2	2035	Widening required in 2035
	Scenario A		2030	Requires widening 5 years earlier than "Without Project" Scenario
	Scenario B			
	Scenario C			
	Without Project	3	No Widening Proposed	No widening proposed
	Scenario A		2035	Require new widening in 2035
	Scenario B			
	Scenario C			
L7-SB	Without Project	2	2035	Require widening in 2035
	Scenario A		2030	

Road Link [A]	**Scenario**	**# of Additional of Lanes**	**Year Widening Required**	**Note**
	Scenario B			Requires widening 5 years earlier than “Without Project” Scenario
	Scenario C			
	Without Project	3	No Widening Proposed	No widening proposed
	Scenario A		2035	Require new widening in 2035
	Scenario B			
	Scenario C		No Widening Proposed	No change compared to Without Project case
L8-NB	Without Project	1	2030	Require widening in 2030
	Scenario A		2025	Requires widening 5 years earlier than “Without Project” Scenario
	Scenario B			
	Scenario C		2030	No change in year widening required
	Without Project	2	2035	Require widening in 2035
	Scenario A		2030	Requires widening 5 years earlier than “Without Project” Scenario
	Scenario B		2035	No change in year widening required
	Scenario C			
	Without Project	3	No Widening Proposed	No widening proposed
	Scenario A		2035	Require new widening in 2035
	Scenario B		No Widening Proposed	No change compared to Without Project case
	Scenario C			
L8-SB	Without Project	2	2035	Require widening in 2035
	Scenario A		2030	Requires widening 5 years earlier than “Without Project” Scenario
	Scenario B			
	Scenario C		2035	No change compared to “Without Project” Scenario
L9-NB	Without Project	1	No Widening Proposed	No widening proposed
	Scenario A		2035	Require new widening in 2035
	Scenario B		No Widening Proposed	No change compared to “Without Project” Scenario
	Scenario C			
L10-NB	Without Project	1	No Widening Proposed	No widening proposed
	Scenario A		2035	Require new widening in 2035
	Scenario B			
	Scenario C		No Widening Proposed	No change compared to “Without Project” Scenario
L10-SB	Without Project	1	No Widening Proposed	No widening proposed

Road Link [A]	Scenario	# of Additional of Lanes	Year Widening Required	Note
	Scenario A		2035	Require new widening in 2035
	Scenario B			
	Scenario C		No Widening Proposed	No change compared to "Without Project" Scenario
L16-NB	Without Project	1	2035	Require widening in 2035
	Scenario A		2030	Requires widening 5 years earlier than "Without Project" Scenario
	Scenario B			
	Scenario C		2035	No change compared to "Without Project" Scenario

Notes:
[A] Only segments that are proposed for new or accelerated widening compared to the "Without Project" Scenario are shown.

Proposed Lane Configurations

The Preliminary Design of the bridge crossing is being developed on the basis of 2 lanes in each direction across the main bridge. The four approach roads on the Davao side will have 1 lane only. This is considered to be a reasonable scale for the new bridge, which will be sufficient for many years in all scenarios. If tolls are charged, this configuration of lanes will be sufficient for longer than if no tolls are charged.

Implications of SIDC on Ferry Services and Travel Time

Implications on Existing Ferry Services

The current peak demand for journeys between Davao City and IGaCoS requires typically 4 ferry trips per hour. Based on the survey work undertaken this peak demand covers 7:00am to 11:30am, and 4:30pm to 6pm on typical weekdays. As the GDRP continues to grow in the region, increase in demand for the ferry crossings to 15 ferry trips per hour by 2055 is expected without SIDC implementation.

With the implementation of the bridge, the demand for ferry journeys will be greatly reduced. Based on the assumed diversion rates (**Annex O**), ferry demand in 2055 could be satisfied with 1 trip per hour, assuming the same occupancy are as observed in the surveys. If there were more frequent trips, then the occupancy rate would be lower.

Traffic Congestion Impacts during Construction

During construction, vehicles will experience slower travel speeds due to temporary lane closures. This impact is focused along Daang Maharlika Highway, R. Castillo St. and JP Laurel junction where one lane in each direction are assumed to be closed during construction of the approach roads.

The cumulative time delay during the peak periods during construction are: (i) 8,681,685 seconds in the AM Peak; and (ii) 6,992,980 seconds in PM Peak. The locations of the assessed road segment are presented in **Figure 2.173** below while the calculations are presented in **Table 2.112 - Table 2.115**.

Figure 2.173 Assessed Road Segments for Traffic Congestion Impact. Google Earth, June 2019

Table 2.112 Time Delay Estimation - Daang Maharlika Highway (North of J.P. Laurel Ave.) – Section A Northbound

Item	Component		Unit	AM Peak	PM Peak
1	Traffic on Daang Maharlika Highway Year 2019	A	Vehicles	5,240	6,574
2	Travel Distance (meter)	B	m	450	450
3 = Item 3 / 1,000	Travel Distance (kilometer)		km	0.45	0.45
Before Construction					
4	2019 Road Configuration before Construction: Speed	C	km/hr	13.7	7.2
5	2019 before Construction: Journey Time per Vehicle		Seconds	118.0	225.7
During Construction					
6	2019 Road Configuration during Construction: Speed	C	km/hr	3	3
7	2019 Road Configuration during Construction: Journey Time per Vehicle		Seconds	540.0	540.0
8 = (Item 5 - Item 7)	During Construction: Journey Time Delay		Seconds	-422.0	-314.3
9 = (Item 8 × Item 1)	Car Time Delay during Construction: Total Journey Time Delay		Seconds	-2,211,133	-2,066,289

Item	**Component**	**Unit**	**AM Peak**	**PM Peak**

Note:
[A] The traffic data is based on the traffic count survey for this study which conducted in April 2019;
[B] The travel distance is measured from Google Maps; and
[C] Assume the maximum speed along Daang Maharlika Highway is 30 km/hr and used the Speed-Flow relationship to derive the estimated speed before and during construction.

Table 2.113 Time Delay Estimation - Daang Maharlika Highway (South of J.P. Laurel Ave.) – Section B Northbound

Item	**Component**		**Unit**	**AM Peak**	**PM Peak**
1	Traffic on Daang Maharlika Highway Year 2019	A	Vehicles	3,316	3,723
2	Travel Distance (meter)	B	m	400	400
3 = Item 3 / 1,000	Travel Distance (kilometer)		km	0.4	0.4
Before Construction					
4	2019 Road Configuration before Construction: Speed	C	km/hr	16.8	10.9
5	2019 before Construction: Journey Time per Vehicle		Seconds	85.8	131.7
During Construction					
6	2019 Road Configuration during Construction: Speed	C	km/hr	3	3
7	2019 Road Configuration during Construction: Journey Time per Vehicle		Seconds	480.0	480.0
8 = (Item 5 - Item 7)	During Construction: Journey Time Delay		Seconds	-394.2	-348.3
9 = (Item 8 × Item 1)	Car Time Delay during Construction: Total Journey Time Delay		Seconds	-1,235,925	-1,296,748

Note:
[A] The traffic data is based on the traffic count survey for this study which conducted in April 2019;
[B] The travel distance is measured from Google Maps; and
[C] Assume the maximum speed along Daang Maharlika Highway is 30 km/hr and used the Speed-Flow relationship to derive the estimated speed before and during construction.

Table 2.114 Time Delay Estimation - Daang Maharlika Highway (North of J.P. Laurel Ave.) – Section A Southbound

Item	**Component**		**Unit**	**AM Peak**	**PM Peak**
1	Traffic on Daang Maharlika Highway Year 2019	A	Vehicles	6,212	4,763
2	Travel Distance (meter)	B	m	450	450
3 = Item 3 / 1,000	Travel Distance (kilometer)		km	0.45	0.45
Before Construction					
4	2019 Road Configuration before Construction: Speed	C	km/hr	14.5	13.9
5	2019 before Construction: Journey Time per Vehicle		Seconds	112.0	116.4
During Construction					
6	2019 Road Configuration during Construction: Speed	C	km/hr	3	3
7	2019 Road Configuration during Construction: Journey Time per Vehicle		Seconds	540.0	540.0

Item	Component		Unit	AM Peak	PM Peak
8 = (Item 5 - Item 7)	During Construction: Journey Time Delay		Seconds	-428.0	-423.6
9 = (Item 8 × Item 1)	Car Time Delay During Construction: Total Journey Time Delay		Seconds	-2,658,911	-2,017,970

Note:
[A] The traffic data is based on the traffic count survey for this study which conducted in April 2019;
[B] The travel distance is measured from Google Maps; and
[C] Assume the maximum speed along Daang Maharlika Highway is 30 km/hr and used the Speed-Flow relationship to derive the estimated speed before and during construction.

Table 2.115 Time Delay Estimation - Daang Maharlika Highway (South of J.P. Laurel Ave.) – Section B Southbound

Item	Component		Unit	AM Peak	PM Peak
1	Traffic on Daang Maharlika Highway Year 2019	A	Vehicles	3,792	3,014
2	Travel Distance (meter)	B	m	400	400
3 = Item 3 / 1,000	Travel Distance (kilometer)		km	0.4	0.4
Before Construction					
4	2019 Road Configuration before Construction: Speed	C	km/hr	18.0	16.7
5	2019 before Construction: Journey Time per Vehicle		Seconds	79.9	86.4
6	2019 Road Configuration during Construction: Speed	C	km/hr	3	3
7	2019 Road Configuration during Construction: Journey Time per Vehicle		Seconds	480.0	480.0
During Construction					
8 = (Item 5 - Item 7)	During Construction: Journey Time Delay		Seconds	-400.1	-393.6
9 = (Item 8 × Item 1)	Car Time Delay During Construction: Total Journey Time Delay		Seconds	-1,517,404	-1,186,263

Note:
[A] The traffic data is based on the traffic count survey for this study which conducted in April, 2019;
[B] The travel distance is measured from Google Maps; and
[C] Assume the maximum speed along Daang Maharlika Highway is 30 km/hr, and used the Speed-Flow relationship to derive the estimated speed before and during construction.

Travel Time Savings

Journey times were estimated for the current situation (using RoRo ferries) and for the future with the bridge link constructed. Journey time consists of several components depending on the mode. This can include waiting time for one's bus or taxi, in-vehicle or in-ferry time, queuing time at the ferry terminal, loading/unloading time at the ferry terminal, etc. Operating speeds differ by vehicle type and when such vehicles operate on the bridge link crossing compared to urban and rural roads on Davao City and IGaCoS.

Figure 2.174 below present the journey time estimations, including the various components for waiting, queuing, loading/unloading, and in-vehicle time for the seven scenarios. Key findings are as follows:

- As stated in **Annex O**, on the approach roads and SIDC itself, the travel speeds in 2035 are slightly lower when the speed-flow curve approach is adopted. It is found that the generated traffic would result in a reduction in travel speeds of 15% and 36% compared to the travel speeds on the bridge and approach roads, respectively, before taking congestion into account. Given the relatively short distances involved, the reduction in travel time savings due to congestion is relatively minor and the bridge and approach roads travel times still represent a small component.
- Journey times are considerably lower for the bridge crossing "With Project" scenario compared to the "Without Project" scenario, as waiting time (including queue and loading/unloading time) is substantially reduced or eliminated altogether.
- Journey times are reduced by between 2 to 3 times in the fixed link crossing scenario compared to the "Without Project" scenario (which results in lower queuing times).
- The largest time savings is generated for car, trucks/good vehicles, which experience journey times exceeding 75-110 minutes in the "Without Project" scenario, compared to about 24-50 minutes in the "With Project" scenario.

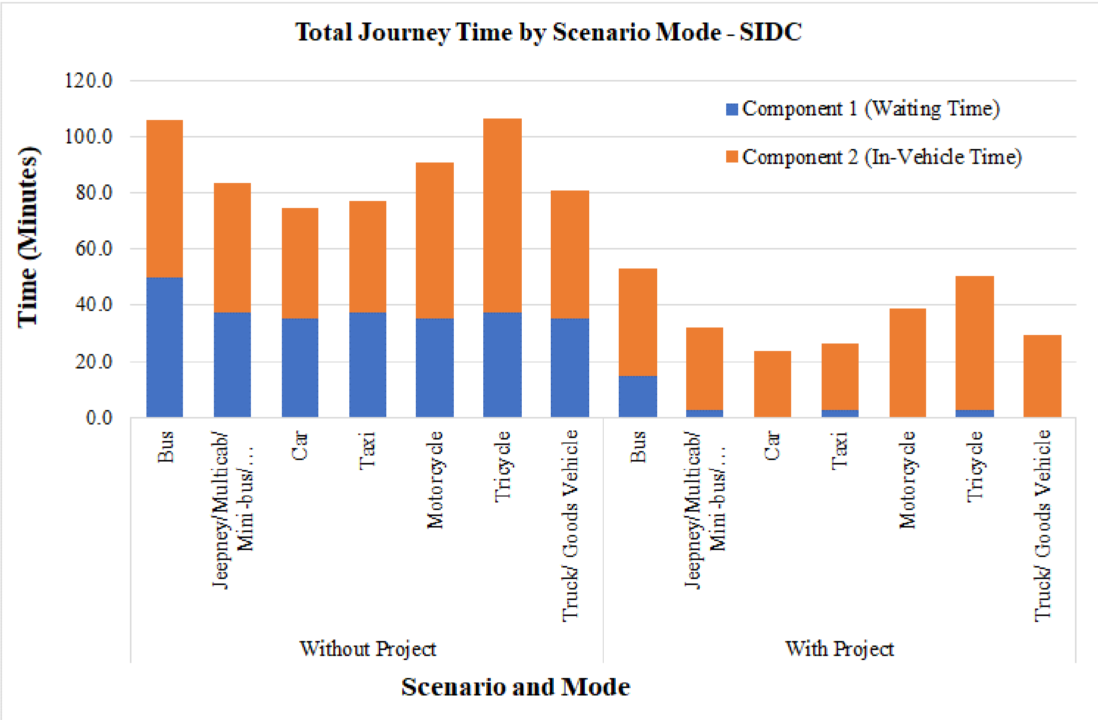


Figure 2.174 Journey Time by Mode and Scenario

Table 2.116 Journey Time by Component for Different Scenarios

START POINT: People's Park Davao							Travel Time Component on Davao									Travel Time Component between Davao - IGaCoS					Travel Time Component on IGaCoS		END POINT Samal Island Park on IGaCoS		
			Operating Speed (km/h)				Access Time	Headway	Wait Time for Passenger	In-Vehicle Time on Davao (Minutes)		Headway	Wait Time for "Walk Up" Passenger	Queuing Time for Vehicles	Loading Time for Vehicles	Ferry Time	Unloading Time for Vehicles	In-Vehicle Time between Davao – IgaCoS (Minutes)		Wait Time for "Walk Up" Passenger	In-Vehicle Time on Samal Island (Minutes)				
Scenario	User Type	Mode	In Davao	On Approach Road	On Bridge	In IGaCoS	to People's Park Davao	for Bus/MC/ Jeepney/ etc	at People's Park Davao	Veh: People's Park Davao to Samal Ferry Wharf	Veh: People Park's Davao - Davao Bridge Landing (Southern Corridor)	for RoRo at Samal Ferry Wharf on Davao	at Samal Ferry Wharf on Davao	at Samal Ferry Wharf on Davao	at Samal Ferry Wharf on Davao	Ferry: Davao - Samal Ferry Terminal on IGaCoS	At Samal Ferry Terminal on IGaCoS	Veh: Davao – IGaCoS Bridge Approach Road	Veh: Davao - Samal Island Bridge	Wait Time at Samal Ferry Terminal on IGaCoS for "Walk Up" Passenger	Veh: Samal Ferry Terminal to Samal Island Park	Veh: IGaCoS Bridge Landing (Southern Corridor) to Samal Ferry Terminal to Samal Island Park	Total Journey Time	Component 1 (Waiting Time)	Component 2 (In-Vehicle Time)
Formula			A1	A2	A3	A4	B	C	D=C/2	E = Len / 60*A1	F = Len / 60*A1	G	H=G/2	I	J	K	L	M1=LEN / 60*A2	M2=LEN / 60*A3	N=G/2	O=LEN / 60*A4	P=LEN / 60*A4	Q = Summation by Component	R=D+H+ I+J+L+ N	S=E+F+ K+M1+ M2+O+P
									Length (km):	10.1	5						Length (km):	0.5	2.2	Length (km):	7.9	9.5			
Without Project	Ferry Vehicle Associated Passenger	Bus	20.0	32.1	42.4	30.0	-	30.0	15.0	30.3	-	-	-	15.0	10.0	10.0	10.0	-	-	-	15.8	-	106.1	50.0	56.1
		Jeepney/ Multicab/ Mini-bus/ UV Express	25.0	41.8	55.1	40.0	-	5.0	2.5	24.2	-	-	-	15.0	10.0	10.0	10.0	-	-	-	11.9	-	83.6	37.5	46.1
		Car	30.0	51.4	67.8	50.0	-	-	-	20.2	-	-	-	15.0	10.0	10.0	10.0	-	-	-	9.5	-	74.7	35.0	39.7
		Taxi	30.0	51.4	67.8	50.0	-	5.0	2.5	20.2	-	-	-	15.0	10.0	10.0	10.0	-	-	-	9.5	-	77.2	37.5	39.7
		Motorcycle	20.0	25.7	33.9	30.0	-	0.0	0.0	30.3	-	-	-	15.0	10.0	10.0	10.0	-	-	-	15.8	-	91.1	35.0	56.1
		Tricycle	15.0	25.7	33.9	25.0	-	5.0	2.5	40.4	-	-	-	15.0	10.0	10.0	10.0	-	-	-	19.0	-	106.9	37.5	69.4
		Truck/ Goods Vehicle	25.0	38.6	50.9	40.0	-	-	-	24.2	-	-	-	15.0	10.0	10.0	10.0	-	-	-	11.9	-	81.1	35.0	46.1
With Project	Former Ferry Vehicle Associated Passenger Using Bridge	Bus	20.0	32.1	42.4	30.0	-	30.0	15.0	-	15.0	-	-	-	-	-	-	0.9	3.1	-	-	19.0	53.0	15.0	38.0
		Jeepney/ Multicab/ Mini-bus/ UV Express	25.0	41.8	55.1	40.0	-	5.0	2.5	-	12.0	-	-	-	-	-	-	0.7	2.4	-	-	14.3	31.9	2.5	29.4
		Car	30.0	51.4	67.8	50.0	-	-	-	-	10.0	-	-	-	-	-	-	0.6	1.9	-	-	11.4	23.9	0.0	23.9
		Taxi	30.0	51.4	67.8	50.0	-	5.0	2.5	-	10.0	-	-	-	-	-	-	0.6	1.9	-	-	11.4	26.4	2.5	23.9
		Motorcycle	20.0	25.7	33.9	30.0	-	0.0	0.0	-	15.0	-	-	-	-	-	-	1.2	3.9	-	-	19.0	39.1	0.0	39.1
		Tricycle	15.0	25.7	33.9	25.0	-	5.0	2.5	-	20.0	-	-	-	-	-	-	1.2	3.9	-	-	22.8	50.4	2.5	47.9

START POINT: People's Park Davao								Travel Time Component on Davao									Travel Time Component between Davao - IGaCoS					Travel Time Component on IGaCoS		**END POINT Samal Island Park on IGaCoS**		
Scenario	**User Type**	**Mode**	**Operating Speed (km/h)**				**Access Time**	**Headway**	**Wait Time for Passenger**	**In-Vehicle Time on Davao (Minutes)**		**Headway**	**Wait Time for "Walk Up" Passenger**	**Queuing Time for Vehicles**	**Loading Time for Vehicles**	**Ferry Time**	**Unloading Time for Vehicles**	**In-Vehicle Time between Davao – IgaCoS (Minutes)**		**Wait Time for "Walk Up" Passenger**	**In-Vehicle Time on Samal Island (Minutes)**		**Total Journey Time**	**Comp-onent 1 (Waiting Time)**	**Comp-onent 2 (In-Vehicle Time)**
			In Davao	**On Approach Road**	**On Bridge**	**In IGaCoS**	**to People's Park Davao**	**for Bus/MC/ Jeepney/ etc**	**at People's Park Davao**	**Veh: People's Park Davao to Samal Ferry Wharf**	**Veh: People Park's Davao - Davao Bridge Landing (Southern Corridor)**	**for RoRo at Samal Ferry Wharf on Davao**	**at Samal Ferry Wharf on Davao**	**at Samal Ferry Wharf on Davao**	**at Samal Ferry Wharf on Davao**	**Ferry: Davao - Samal Ferry Terminal on IGaCoS**	**At Samal Ferry Terminal on IGaCoS**	**Veh: Davao – IGaCoS Bridge Approach Road**	**Veh: Davao - Samal Island Bridge**	**Wait Time at Samal Ferry Terminal on IGaCoS for "Walk Up" Passenger**	**Veh: Samal Ferry Terminal to Samal Island Park**	**Veh: IGaCoS Bridge Landing (Southern Corridor) to Samal Ferry Terminal to Samal Island Park**			
Formula			**A1**	**A2**	**A3**	**A4**	**B**	**C**	**D=C/2**	**E = Len / 60*A1**	**F = Len / 60*A1**	**G**	**H=G/2**	**I**	**J**	**K**	**L**	**M1=LEN / 60*A2**	**M2=LEN / 60*A3**	**N=G/2**	**O=LEN / 60*A4**	**P=LEN / 60*A4**	**Q = Summation by Component**	**R=D+H + I+J+L+ N**	**S=E+F+ K+M1+ M2+O+P**
									Length (km):	**10.1**	**5**						**Length (km):**	**0.5**	**2.2**	**Length (km):**	**7.9**	**9.5**			
		Truck/ Goods Vehicle	25.0	38.6	50.9	40.0	-	-	-	-	12.0	-	-	-	-	-	-	0.8	2.6	-	-	14.3	29.6	0.0	29.6

Notes: (i) no access time assumed at the start of the journey to reach Point A in Davao; (ii) reserve trip from Point B to Point A assumed to have the same journey time; (iii) the SIDC alignments based on the Study Team's concept designs; (iv) local road length is based on measurements from Google Maps; (v) current queue time for the No Project Scenario is assumed to be 15 minutes for all other types of vehicles; (vii) ferry travel time from Davao to IGaCoS and vice versa is 10 minutes based on the site observation.

2.4.6 Perception Survey

The Samal Island - Davao City Connector (SIDC) Project is one of the 75 big-ticket flagship projects under the "Build, Build, Build" program of President Rodrigo Roa Duterte in the Philippines. The landing points of the proposed approximately 2.70 km-bridge are in Barangays Vicente Hizon Sr., Angliongto, and R. Castillo in Davao City, and Barangay Limao in the Island Garden City of Samal (IGaCoS).

The construction of this bridge aims to reduce travel time and to promote ease and access for tourists, both local and international coming from Davao City and going to IGaCoS and vice versa. Further, it also aims to reduce road network congestion in and around ferry terminals as well as to support IGaCoS economic development and diversification through better links to industry, commerce and trade, among others.

Before this project could proceed, there are several government requirements that have to be accomplished such as securing an Environmental Compliance Certificate (ECC) of which the submission of an Environmental Impact Statement or EIS report is needed. Public Scoping and conduct of Information and Education Campaign (IEC) are also required.

Perception survey about the project had to be conducted in order to know the concerns and perceptions of the households living within the barangays. Hence, this perception survey.

Objectives of the Perception Survey

- To determine the socio-demographic profile of the respondents in the barangays which will be affected by the project including their education, livelihood sources, tenure status over their house and lot, materials of their house, frequency of travel, among others;
- To gauge the perception and social acceptability of the project;
- To investigate their social, environmental, economic and political concerns about the project; and,
- To provide baseline data on possible compensations that is due to the affected families.

Methodology

Research Locale

This survey covered three barangays namely: Vicente Hizon Sr. in Davao City; and Caliclic and Limao in IGaCoS.

Questionnaire

A pre-designed survey questionnaire was prepared to gather data from the respondents coming from the randomly selected households of Barangays Hizon, Caliclic and Limao. The questionnaire was divided into several parts namely: respondents' profile; perceptions about the project, concerns about the project, degree of importance of concern, agreements or disagreements on statements provided and acceptance of the project.

To assess the reliability of the survey questionnaire, a pre-test to 20 respondents was conducted. Cronbach's alpha was used to measure reliability (Cronbach, 1951). According to Nunnally and Bernstein (1994), an alpha of at least 0.70 or higher is considered highly reliable. As a result, an alpha of 0.805 was attained which indicates that the survey questionnaire is reliable.

In terms of survey implementation, a pre-survey briefing with the different teams was conducted. The Barangay Health Workers (BHW) in every barangay was also tapped to help in data gathering. Prior to dispatch in their areas of assignment, they were thoroughly briefed to ensure understanding and uniform interpretation of items in the survey questionnaire**.**

Population and Sampling

To provide a more precise estimates of the perception, a stratified random sampling was conducted. Moreover, sample size was computed based on Cochran (1963) sample formula with a desired level of precision 0.05, estimated proportion of 0.5, and confidence of 95% (Lohr,1999).

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

$$n_0 = \frac{z^2 p(1-p)}{e^2}$$

Where,

n_0 is Cochran's sample size recommendation;
z is the z-value in standard normal distribution
p is the estimated proportion of the population which has the attribute to the question
e is the desired level of precision
N is the population size;
n is the new, adjusted sample size

From 3,728 households in Barangay Hizon, Limao, and Caliclic, a total of 349 was computed as the number of sample size for the research. Then, the sample was proportionally allocated to provide an ample representation of all the barangays involved in the research.

$$n_{stratum} = \frac{N_{stratum}}{N_{pop'n}} \times n$$

Presented in **Table 2.117** is the allocation of sample in each barangay. Also, the number of responses in each barangay are presented.

Table 2.117 Sample Size Allocation

Barangays	Total Number of Households	Sample Size Allocation	Total Number of Response	Response Rate
Hizon, Davao City	2,685	251	202	80%
Limao, IGaCoS	553	52	75	144%
Caliclic, IGaCoS	490	46	67	146%
Total	3,728	349	344	99%

Statistical Treatment

While the overall response rate is good, due to the low response rate at Barangay Hizon in Davao City, a post-stratification technique (Westfall, 2011) was used in calculating the overall project perception to adjust the effect of underrepresentation of Barangay Hizon. Furthermore, an adjusted sampling weights was implemented on per barangay perception estimates of the mean.

Due to the continuous nature of interpretation of the Likert scales, the research assumes that each level of the scale is equally spaced, thus, a computation of the mean is feasible. This applies to data interpretation pertaining to levels of concern of respondent on various issues including social, economic, environmental and political aspects; and general acceptability of the project. Table below presented the scale and data interpretation for the research.

Table 2.118 Scale and Data Interpretation

Scale	Range	Interpretations
5	4.50 – 5.00	Very High Concern/Very High Importance/Very High Acceptance
4	3.50 – 4.49	High Concern/Highly Important/ High Acceptance
3	2.50 – 3.49	Moderate Concern/Moderate Importance/Moderate Acceptance
2	1.50 – 2.49	Low Concern/Low Importance/Low Acceptance
1	0.50 – 1.49	Very Low Concern/Very Low Importance/ Very Low Acceptance

Baseline Environmental Conditions

Demographics

Almost 2/3 of the respondents are females. This implies that females are the most available when the survey was conducted.

The highest number of the respondents are within the age group 46-55 while the lowest number belong to age group 16-25 years old. Only ten percent of the total respondents belong to age group 60 and above. This suggests that a greater majority of the respondents are still within their working age. Further, 8.2 percent of the respondents are comprised of those who belong to age group 12-25 years old which implies that some of the respondents are still students.

Employment

More than half of the respondents are unemployed and less than ¼ are employed. Interestingly, a portion or 8.2 percent of the respondents are also self-employed. There are more females who are unemployed compared to males.

The highest number of respondents who are employed are working in Davao City. Most of those employed in Barangays Caliclic and Limao work just within their respective barangays. However, there are also few respondents from these barangays who work in Davao City. No respondents from Barangay Hizon, Davao City work in any part of IGaCos.

Education

The highest number of the respondents are high school graduates; followed by those who were able to study up to college level; and, the college graduates. Based on gender disaggregated data, there are more male than female college graduates. However, there is only a very slight difference between male and female high school graduates as well as those who have studied up to high school level.

Tenure Status for House and Lot

Majority of the respondents revealed that they own their house and they have a title for their lot. Less than 20 percent are renters while some are unsure of their land tenure status. They claimed that they have a Certificate of Ancestral Domain Title (CADT), but upon checking with the National Commission on Indigenous Peoples (NCIP), there is no CADT issued in the area yet (**Annex J**).

Further, there are less than ten percent of the respondents who build their house in an untitled lot. A few own their house that are built on a rent-free lot with consent from the owner.

In general, while majority of the respondents have title for their lot but there are also few informal settlers that can possibly be affected by the project.

House Materials

Construction materials used for the external wall of the house are also considered in the determination of house/structural compensation. The highest number of respondents used concrete for the external walls of their houses, followed by those who used light materials such as bamboo or wood.

Almost all of the respondents used galvanized iron for their roof. Very few used palm/leaf and makeshift or reused materials.

Frequency of Travel

In terms of frequency of travel from IGaCoS to Davao City and vice-versa, the highest number of respondents travel from and to IGaCos once a month. However, based on gender-disaggregated data, more females travel once a month than the males. There are also more males who travel 2-3 and 4-5 times a week. This implies that males travel more than females.

There are more respondents from Barangay Hizon who travel once a month to IGaCos and vice-versa compared to respondents from Barangays Caliclic and Limao who travel from IGaCos and vice-versa. Respondents from Barangay Limao registered highest in terms of traveling 2-3 times a week from and IGaCoS while respondents from Barangay Caliclic registered highest travelling from and to IGaCoS 4-5 times a week.

Perception About the project

Most of the respondents have an idea about the project. The highest number of respondents revealed that they are excited about the project; followed by those who are thankful; and, a few, said they are worried.

Segregating the result by gender, it can be inferred that more males have an idea about the project compared to females. Majority of the females are willing to attend the public consultation compared to males.

The top three topics that the respondents want to be discussed by the project implementers are the following: work opportunities, communities affected by the project and impacts of the project on the environment and economic activities of people.

Social, Economic, Environmental and Political Related Concerns

Social concerns are topics, issues and values that are most prevalent in the minds of the community. The respondents have high to very high social concerns about the project. They have a very high concern on the equal representation of men and women during public consultation and that public consultation must be conducted with affected communities. This implies that the project implementers have to make sure that women are well represented during consultations.

Furthermore, the respondents have high concerns on resettlement, acquisition of land at low price, destruction of property improvement such as fences without compensation, social disintegration, distance from work and schools in case of relocation, inconveniences to domestic activities, disruptions and safety issues during construction, issues on right of way and so on. This implies the need to further discuss these concerns to the residents and LGUs of the affected barangays.

The respondents have high economic concerns. Their highest concern is the non-prioritization of local residents, both males and females, in job hiring-in case they are qualified. Based on gender disaggregated data, females have higher economic concerns compared to males. Most of the males and females are willing to work for the project, if there are opportunities for them.

The respondents have high environmental concerns during the construction phase of the project. Their top three highest environmental concerns are: air pollution due to dust and gas emission during construction; followed by the absence of Environmental Compliance Certificate; and, solid waste due to construction. Further the respondents are also concerned about uncontrolled noise during construction, contamination of ground and sea water and change of landscape in the place, among others.

The respondents also have high environmental concerns during the operational phase of the project. Their highest concern is the increase of solid waste due to the possible influx of both local and foreign tourists when the bridge will be operational. It can be assumed that once the travel time going to and from IGaCoS and vice-versa are shortened and traffic congestion are addressed, the number of tourists will eventually increase. Further, the respondents are also concerned about the shortage of water supply in the area and the weak enforcement of environmental laws which may result to serious environmental concern like that of Boracay. This result suggests that the respondents are not only concerned about the environment, but they are also concerned about their health. For example, uncontrolled noise can have effects on their health as it can disrupt their sleep and may cause stress. This poses a great challenge to both the Local Government Units (LGUs) and the concerned agencies to come up with activities and projects to avoid environmental problems in the future.

Political concerns refer to the set of activities associated with the governance of an area or a project. The respondents have high political concerns. They disclosed that the LGUs should constantly monitor progress of the project; followed by the need for proper coordination among the agencies governing the project; and, the need for barangay officials' participation and involvement in meetings and project planning. The participation of barangay officials in meetings can assure the residents of the area that their concerns will be heard because they have representatives during meetings and project development. Barangay officials are one the sources of reliable information on project implementation in their respective areas.

The respondents perceived that the environment is their highest concern, followed by their economic and social concerns. They perceived the importance of political concerns as moderately high only.

Knowledge About the Project

The respondents are already knowledgeable about the benefits they can get from the project. When asked whether they agreed or disagreed with certain statements about the project, respondents agreed most with the following: development of complete construction signages containing work schedules and rules to avoid untoward accident (92.3%); prioritization of locals, both men and women, in job hiring (92.7%); that the bridge will cut travel time of locals and tourists to and from the Island (92.4%); and endorsement of the project from the local officials is very important (92.4%).

83.40% agrees with selling their property when given the right compensation. There are few respondents who are not willing to sell their properties (12.2%) even when offered right compensation. Hence, in case these residents will be affected by the project, further negotiations have to be done to avoid involuntary relocation.

Overall, 90.9% agrees with the construction of the bridge.

Project Acceptability

Generally, both male and female respondents highly accept the project. On a per barangay basis, it shows that the respondents of barangay Caliclic have a very high level of project acceptance while respondents from barangays Hizon and Limao have high level of project acceptance.

Survey Result

Profile of the Respondents

Of the total 344 respondents, 216 or 62.8% are females and 126 or 36.6% are males while 0.6% did not respond (**Table 2.119**). This suggests that the females are more available during the conduct of the survey.

Table 2.119 Gender of the Respondents

Barangay	Male		Female		No Response		Total	
	No.	%	No.	%	No.	%	No.	%
Caliclic	24	35.8	43	64.2	0	0	67	100.0
Hizon	68	33.7	132	65.3	2	1.0	202	100.0
Limao	34	45.3	41	54.7	0	0	75	100.0
Total	126	36.6	216	62.8	2	0.6	344	100.0

Table 2.120 shows the age distribution of the respondents. The highest number of the respondents, equivalent to 22.1%, is within the age range of 46-55 years old, followed by the respondents within the age group 26-35 and 36-45 years old, both with the same percentage of 21.5%. Respondents belonging to age group 50-59 years old is 15.1% and 60 above is only 10.2%. The least of the respondents, equivalent to only 8.4% of the total number of respondents, belong to age group 16-25 years old. This implies that most of the respondents are still within their working age.

Table 2.121 presented the type of employment of the respondents. More than half of the respondents are not employed (54.0%). Interestingly, there are respondents that are self-employed. Less than ¼ of the respondents are employed.

When disaggregated by sex, there are more females who are unemployed compared to males while the number of females and males who are self-employed are almost the same.

Table 2.120 Age Distribution of the Respondents

	16-25 years old			**26-35 years old**			**36-45 years old**			**46-55 years old**			**50-59 years old**			**60 above**			**No Response**			**Total**		
	Male	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**Total**
Caliclic		4	*4*	5	11	*16*	8	6	*14*	3	13	*16*	6	6	*12*	2	3	*5*	*0*	*0*	*0*	24	43	67
Hizon	8	14	*22*	20	27	*47*	10	32	*42*	8	23	*31*	13	18	*31*	9	18	*27*	2	*0*	*2*	70	132	202
Limao	1	2	*3*	5	6	*11*	10	8	*18*	13	16	*29*	2	7	*9*	2	2	*4*	1	*0*	*1*	34	41	75
No of Respondents	9	20	*29*	30	44	*74*	28	46	*74*	24	52	*76*	21	31	*52*	13	23	*36*	3	0	*3*	128	216	344
%	7.0	9.3	*8.4*	23.4	20.4	*21.5*	21.9	21.3	*21.5*	18.8	24.1	*22.1*	16.4	14.4	*15.1*	10.2	10.6	*10.5*	2.3	0.0	*0.9*	37.2	62.8	100.0

Table 2.121 Type of Employment of the Respondents

Status of Employment	**Caliclic**				**Hizon**		**Limao**			**Total**			
	Male	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**Total**	**%**
Employed	1	0	1	37	15	52	5	2	7	43	17	60	20.9
Self-employed	15	9	24	9	22	31	8	0	8	32	31	63	22.0
Unemployed	8	33	41	24	90	114	0	0	0	32	123	155	54.0
NR	0	4	4	0	5	5	0	0	0	0	9	9	3.1
Total Respondents	24	46	70	70	132	202	13	2	15	107	180	287	100
%	22.4	25.6	24.4	65.4	73.3	70.4	12.1	1.1	5.23	37.3	62.7	100	

ST: Sub-Total; NR: No Response

The respondents who are working were asked of their place of work. From **Table 2.121**, it can be noted that most (69.5%) of the respondents did not give answer at all. This is comprised of those who are unemployed and, those who refused to give answer during the interview.

Based on the result, the highest number or 21.2% of the respondents who are employed are working in Davao City, followed by those who work in Barangay Limao with 3.8% and Barangay Caliclic with 2.9%. Very few or 0.6% coming from Barangay Hizon work overseas. Further, most of the respondents in Barangays Caliclic and Limao actually work just within their respective Barangay. There are no respondents from Barangay Hizon, Davao City who work in IGaCos probably because currently economic activities or employment opportunities in that place are limited.

Disaggregating the data, more male (44) respondents work in Davao City compared to females with 29 respondents.

Table 2.122 Place of Work of the Respondents

	Caliclic			**Hizon**			**Limao**			**Total**			**%**
PLACE OF WORK	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	
Overseas	0	0	0	2	0	2	0	0	0	2	0	**2**	**0.6**
Brgy. Caliclic, IGaCoS	2	8	10	0	0	0	0	0	0	2	8	**10**	**2.9**
Brgy. Limao, IGaCoS	0	0	0	0	0	0	7	6	13	7	6	**13**	**3.8**
Darong, Davao del Sur	0	0	0	1	0	1	0	0	0	1	0	**1**	**0.3**
Davao City	1	2	3	36	25	61	7	2	9	44	29	**73**	**21.2**
Within IGaCoS	0	0	0	0	0	0	4	2	6	4	2	**6**	**1.7**
NR (No Response)	21	33	54	31	107	138	16	31	47	68	171	**239**	**69.5**
No. of Respondents	**24**	**43**	**67**	**70**	**132**	**202**	**34**	**41**	**75**	**128**	**216**	**344**	**100.0**
%	**6.98**	**12.50**	**19.48**	**20.35**	**38.37**	**58.72**	**9.88**	**11.92**	**21.80**	**37.21**	**62.79**	**100.00**	

Education is widely accepted to be fundamental resource, both for individuals and society. The highest level of education that individuals complete is another common measure of attainment (Roser and Ortiz-Ospina, 2019).

Based on the gender disaggregated data, it can be gleaned that the number of male college graduates (21.1%) are higher than the number of female graduates (15.5%). However, there is only a very slight difference between the number of male and female High School graduates (0.8%) as well as those who have studied up to high school level (0.2%). On the other hand, more females were able to study up to college level (21.8%) than males (18.0%).

In general, it can be concluded that most of the respondents are educated as evidenced the high school graduates (36.8%), followed by those who have college level education with 20.8% and college graduates with 17.8%.

Table 2.123 Educational Attainment of the Respondents

	A	B	C	D	E	F	G	Total
Male								
Caliclic	1	7	6	3	6	1	*0*	24
Hizon	2	0	7	25	15	21	*0*	70
Limao	4	1	3	19	2	5	*0*	34
Sub total	*7*	*8*	*16*	*47*	*23*	*27*	*0*	*128*
Male %	*5.5*	*6.3*	*12.5*	*36.7*	*18.0*	*21.1*	*0*	*100.0*
Female								
Caliclic	3	3	8	17	7	3	0	41
Hizon	6	5	13	52	30	26	0	132
Limao	5	2	7	10	11	5	1	41
Sub total	*14*	*10*	*28*	*79*	*48*	*34*	*1*	*214*
Female %	*6.4*	*4.5*	*12.7*	*35.9*	*21.8*	*15.5*	*0.5*	*100.0*
TOTAL	21	18	44	126	71	61	1	342
%	6.1	5.3	12.9	36.8	20.8	17.8	0.3	100.0

A- Elem. Level, B- Elem. Graduate, C- High School Level, D- HS Graduate, E-College Level, F- College Graduate, G- No Response

The land and house ownership data of the respondents can be used for the computation of their compensation in case they will be resettled, so these data were gathered during the survey.

In terms of the land tenure status and ownership of the house, 52% or 179 of the respondents from the three Barangays namely Caliclic, Hizon and Limao are the owners of their land and houses. Others rent their house and lot (19.5%). There is only one person (or 0.3 percent) who own his house but rents the lot. Further, it can also be gleaned that there some respondents who build their house in an untitled lot with 9.0%; own the house, rent free but with consent from the owner with 2.6%.

There are 10.5% of the respondents who revealed they have other tenure for their land such as the CADT. However, upon checking with the NCIP, it was found out that there was no CADT issued in IGaCoS and also in Hizon, Davao City (**Annex J**). It can be perceived that those who said they have other land tenure were actually unsure of their land tenure status. During the conduct of the interview, the respondents were not requested to show a proof of their lot ownership, they were only asked of their land tenure status, hence this result. 6.1% of the respondents provided no answer.

Table 2.124 Tenure Status for Lot and House

	A	B	C	D	E	F	G	Total
Caliclic	50	3	0	4	1	4	5	67
Hizon	86	60	1	18	2	20	15	202
Limao	43	4	0	9	6	12	1	75
Sub total	179	67	1	31	9	36	21	344
%	52.0	19.5	0.3	9.0	2.6	10.5	6.1	100.0

A- Owner, B- Renter (house/lot), C- Own house/rent lot, D- Own house untitled lot, E- Own house, rent free w/ consent, F- Other Tenure (CADT), G- No Response

Construction materials used for the external wall of the house are also considered in the determination of house/structural compensation. In **Table 2.125** the highest number of respondents (37.2%) used concrete for the external wall for their house, followed by those who used light materials such as wood and bamboo with 36.3% and those who used half hollow blocks/half-light materials with 20.3%. There were a few (4.4%) who used mixed materials while others requested that their response on this be left blank.

The result implies that 36.3% of the respondents used semi-permanent materials for the external wall of their house. Semi-permanent materials such as wood, plywood and bamboo can actually be reused, in case the respondents will be relocated as an effect of the project.

Table 2.125 Construction Materials Used For the External Wall of the House

Construction Material used for the external wall of the house	A	B	C	D	E	F	Total
Caliclic	24	23	0	20	0	0	67
Hizon	78	23	0	81	15	5	202
Limao	23	24	0	27	0	1	75
Sub total	125	70	0	128	15	6	344
%	36.3	20.3	0.0	37.2	4.4	1.7	100.0

A- Light Materials-wood, plywood and bamboo, B- Half Hollow Block/half-light materials, C- Makeshift, D- All concrete, E- Others mixed materials, F- No Response

As presented in **Table 2.126**, almost all of the respondents (96.8%) used galvanized iron for their roof. Very few used palm/ leaf and makeshift or reused materials. It can be noted that galvanized iron can still be reused by the respondents to build their new house, in case they will be resettled.

Table 2.126 Type of Roofing

TYPE OF ROOFING	A	B	C	D	E	Total
Caliclic	64	2	0	1	0	67
Hizon	196	0	0	0	6	202
Limao	73	0	0	0	2	75
TOTAL	333	2	0	1	8	344
%	96.8	0.6	0.0	0.3	2.3	100.0

A- Galvanized iron, B- Thatch/ palm/ leaf, C- Sod/Grass/Cogon, D- Makeshift/cardboard/reused materials, E- No Response

In terms of frequency of travel of the respondents from IGaCoS to Davao City and vice-versa, more than half of the respondents (57.8%) travel once a month while 34 respondents (or approximately 10%) travel once a week. Only 4 respondents (or 1.2%) travel more than 5 times a week. Out of the 344 respondents, only 9 of them did not indicate their frequency of travel.

Most of female respondents (62.5%) and fifty percent of the male respondents travel to and from IGaCos once a month. Moreover, there are more males (13.3%) who travel 2-3 times a week compared to females (6.5%). This suggests that males travel more frequently than females to and from IGaCoS and vice-versa.

Based on number of responses tallied per barangay, it can be gleaned that there are more male (38) and female (92) respondents coming from Barangay Hizon who travel once a week compared to Barangays Caliclic and Limao. No male respondents from Caliclic and Hizon and no female respondents from Limao travel more than five times a week from IGaCos and vice-versa. No male respondents from all barangays travel from and to IGaCos once a year.

The result implies that the frequency of travel of the respondents vary, however, there are also some respondents 10.9% for males and 8.3% for females who have not travelled at all to and from IGaCoS.

Table 2.127 Frequency of Travel To and From IGaCoS and Vice-Versa

Frequency of Travel to and from IGaCos	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Total**
Male										
Caliclic	0	4	3	3	11	3	0	0	0	24
Hizon	0	1	4	6	38	10	0	10	1	70
Limao	1	1	10	5	15	1	0	0	1	34
Sub total	1	6	17	14	64	14	0	10	2	128
%	0.8	4.7	13.3	10.9	50.0	10.9	0.0	7.8	1.6	100.0
Female										
Caliclic	2	2	3	5	18	5	1	1	6	43
Hizon	0	1	7	5	92	13	11	2	1	132
Limao	1	1	4	10	25	0	0	0	0	41
Sub total	3	4	14	20	135	18	12	3	7	216
%	1.4	1.9	6.5	9.3	62.5	8.3	5.6	1.4	3.2	100.0
TOTAL	4	10	31	34	199	32	12	13	9	344
%	1.2	2.9	9.0	9.9	57.8	9.3	3.5	3.8	2.6	100.0

A- More than 5 times, B- 4-5 times, C- 2-3 times, D- once a week, E- once a month, F- never, G- Once a year, H- once in 2 months, I- No Response

Most of the respondents said they have already an idea about the project, while 14.8% said they do not have an idea and 3.5% did not give answer at all. Segregating the result by gender, it can be concluded that more males (86.7%) have an idea about the project compared to females with only 78.7%.

Table 2.128 Idea or Knowledge About the Project

Any idea about SIDC?	Yes			No			No Response			Total		
	Male	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**Total**
Caliclic	19	25	44	5	14	19	0	4	4	24	43	67
Hizon	62	108	170	5	20	25	3	4	7	70	132	202
Limao	30	37	67	3	4	7	1	0	1	34	41	75
No of Respondents	111	170	281	13	38	51	4	8	12	128	216	344
%	86.7	78.7	81.7	10.2	17.6	14.8	3.1	3.7	3.5	37.2	62.8	100.0

When asked about how they feel about the project, majority of the respondents revealed that they are excited (67.7%); followed by those who are thankful (13.7%); and, a few who are worried (8.7%). Those who are worried are concerned about their properties, in case they will be affected by the project. Those who are excited and thankful have understood the purpose of the project and the benefits that they can get out of it. Likewise, some are eager of the development that can happen in their area once the project will be operational.

In terms of gender, more males (73.4%) are excited about the project compared to females (64.4%). There is a very slight difference between the males (13.3%) and females (13.9%) who revealed they are thankful about the project. There are 8.6% males and 8.8% females who are worried about the project.

Table 2.129 Feelings about the project

How do you feel about the project	Excited			Worried			Thankful			No Response			Total		
	Male	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**ST**	**Male**	**Female**	**Total**
Caliclic	14	24	38	6	0	6	4	7	11		12	12	24	43	67
Hizon	54	85	139	4	16	20	7	15	22	5	16	21	70	132	202
Limao	26	30	56	1	3	4	6	8	14	1	0	1	34	41	75
No of Respondents	94	139	233	11	19	30	17	30	47	6	28	34	128	216	344
%	73.4	64.4	67.7	8.6	8.8	8.7	13.3	13.9	13.7	4.7	13.0	9.9	37.2	62.8	100.0

The respondents were asked if they are willing to attend a public consultation before the project implementation. Majority of the females (50.5%) revealed they are willing to attend the consultation compared to males (48.4%).

There are more females (24.5%) compared to males (16.4%) who revealed they are undecided whether they will attend the public consultation or not. There are more males (11.7%) than females who (4.2%) did not give their response. Generally, it can be concluded that less than half of the respondents are willing to attend the public consultation.

Table 2.130 Willingness to Attend Public Consultation

Willingness to Attend Public Consultation	Yes			No			Undecided			No response			Total		
	Male	Female	ST	Male	Female	ST	Male	Female	ST	Male	Female	ST	Male	Female	Total
Caliclic	18	22	40	4	13	17	2	8	10	0	0	0	24	43	67
Hizon	29	56	85	20	31	51	9	36	45	12	9	21	70	132	202
Limao	15	31	46	6	1	7	10	9	19	3	0	3	34	41	75
No of Respondents	62	109	171	30	45	75	21	53	74	15	9	24	128	216	344
%	48.4	50.5	49.7	23.4	20.8	21.8	16.4	24.5	21.5	11.7	4.2	7.0	37.2	62.8	100.0

Public consultation aims to engage key stakeholders such as the citizens, NGOs, agencies, interest groups to provide input into the planned development especially on those impacts that directly or indirectly affect people's livelihoods. Effective public participation requires that project planners inform and involve interested actors during public consultation; ensure that relevant sectors are represented; comments are explicitly addressed; and concerns as well as inputs, both in documentation and decision making, are considered (IISD, 2016).

Those who are willing to attend the public consultation were asked what topics they wanted to be discussed. The highest number of male (24.5%) and female (23.3%) female respondents said that they want work opportunities to be discussed. This implies that the respondents are expecting that there will be work opportunities for them.

In general, it can be gleaned that the top three topics that the respondents want to be discussed during the public consultation are: work opportunities (23.7%), impacts on affected communities (18.8%) and impacts on the environment (15.7%).

They are also interested on discussions as regards the affected communities, local endorsements and impacts of the project on the environment. All of the male respondents gave their responses, while 6.5% of the female respondents did not give answer at all.

Table 2.131 Topics that Respondents Want to be Discussed During Public Consultation

Topics	A	B	C	D	E	F	G	Total
Male								
Caliclic	4	15	7	1	11	16	0	54
Hizon	18	4	6		1	12	0	41
Limao	11	11	9	9	13	11	0	64
Sub total	33	30	22	10	25	39	0	159
%	20.8	18.9	13.8	6.3	15.7	24.5	0.0	100.0
Female								
Caliclic	3	14	4	1	10	22	0	54

Topics	A	B	C	D	E	F	G	Total
Hizon	14	21	17	8	11	25	29	125
Limao	16	19	15	15	24	20	0	109
Sub total	33	54	36	24	45	67	29	288
%	11.5	18.8	12.5	8.3	15.6	23.3	10.1	100.0
TOTAL	66	84	58	34	70	106	29	447
%	14.8	18.8	13.0	7.6	15.7	23.7	6.5	100.0

A-Projects design including exact location, B-affected communities, C-Local endorsement, D-Compliance to government requirements, E-Impacts on environment and economic activities of people, F-Work opportunities, G- No Response

Those who are not willing to attend the public consultation were asked of their reasons. The highest number of male respondents or 46.4% said they have other concerns to do while 41.1% said they have work. On the other hand, the highest number of females or 41.9% did not respond followed by those who said they are busy with household chores with 37.6% and those who are working with 16.1%. Some have other reasons that they do not want to disclose. All males responded to the question, while 41.9% of the females did not respond.

Table 2.132 Respondents' Reasons for Unwillingness to Attend Public Consultation

Barangays/Gender	A	B	C	D	Total
Male					
Caliclic	0	0	24	0	24
Hizon	18	3	1	0	22
Limao	5	4	1	0	10
Sub total	23	7	26	0	56
%	41.1	12.5	46.4	0.0	100.0
Female					
Caliclic	1	13	0	0	14
Hizon	14	15	4	39	72
Limao	0	7	0	0	7
Sub total	15	35	4	39	93
%	16.1	37.6	4.3	41.9	100.0
TOTAL	38	42	30	39	149
%	25.5	28.2	20.1	26.2	100.0

A-I have work, B-I am busy with household chores, C-Others, D- No Response

Social, Environmental, Economic and Political Concerns about the Project

To gauge the level of concern of respondents to various issues relevant to the project inlcuding social, environmental, economic, and political aspects, the respondents were asked to rate from 1 to 5 each of the issues identified in **Table 2.129** to **Table 2.140**. 1 means very low concern, 2 means low concern, 3 means moderate concern, 4 means high concern, and 5 means very high concern. The researchers then computed for the mean levels of concerns of all respondents.

Due to the continuous nature of interpretation of the Likert scales, the research assumes that each level of the scale is equally spaced, thus, a computation of the mean is feasible. The table below presents the data interpretations.

Table 2.133 Scale and Data Interpretations

Scale	Range	Interpretations
5	4.50 – 5.00	Very High Concern/Very High Importance/Very High Acceptance
4	3.50 – 4.49	High Concern/Highly Important/ High Acceptance
3	2.50 – 3.49	Moderately High Concern/Moderately High Importance/Moderately High Acceptance
2	1.50 – 2.49	Low Concern/Low Importance/Low Acceptance
1	0.50 – 1.49	Very Low Concern/Very Low Importance/ Very Low Acceptance

Social concerns are topics, issues and values that are most prevalent in the minds of the community. Social concerns when not clarified or answered may cause anxiety. In general, respondents have a high to very high concern to social related concerns. This is evident, such that, regardless of Barangays and sex of the respondents, the mean range of their responses are from 4.19 to 4.47 or High concern. (See legend below the table for interpretation of the mean results).

In totality, social concerns of the respondents are high with a mean of 4.33. Among this, the equal representation of men and women during public consultation is the highest social concern with a total mean of 4.47. This is closely followed by the concern of respondents regarding the conduct of public consultation with the affected community which garnered a mean of 4.46. The lowest mean based on the social concerns is the distance from schools or work in case of resettlement.

When disaggregated by barangay, Barangay Caliclic, on average, has high social concerns with mean ranging from 4.61 to 4.91. This is also consistent when disaggregated by gender. Furthermore, males are highly concerned on resettlement, destruction, congestion of routes, and equal representation of men and women on public consultation-all have means of 5.

On the other hand, Barangay Limao is most concerned on public consultation and representation of men and women with a mean of 4.56 and 4.53, respectively. For Barangay Hizon, most of the social concerns are high. Same with Barangay Limao, public consultation and representation of men and women is their top most concern with a mean of 4.22 and 4.31, respectively. This implies the need for project implementers to clarify and address these issues/concerns of the barangays. Further, public consultations and IEC must be conducted to discuss these concerns.

Resettlement being one of the high concerns of the respondents must be addressed objectively. According to the International Hydropower Association Limited (2016), when resettlement cannot be avoided, it has the potential to add more project complexity to the project, regardless of the number of people to be relocated. Good planning is not enough because successful resettlement program requires effective implementation and long-term monitoring and evaluation of the affected people.

It further stated that resettlement covers a whole lot of effects on the affected families perhaps because of their personal attachment to their current place, neighbors, associations, among others. Resettlement is an aspect of any project development that requires a great deal of expertise and sensitivity, and is often a risk factor in causing project delays. During the project preparation phase, clear resettlement strategies and programs for compensation and improvement of affected livelihood should be designed in partnership with affected people. Generally, the potential risk of resettlement increases with the number of people to be resettled and the risk can have impacts on project cost. If possible, those who will be resettled should be involved in choosing compensation methods (International Hydropower Association Limited, 2016).

In terms of gender disaggregated data, it can be concluded that male and female respondents have high social concern with a mean of 4.36 and 4.28, respectively.

The overall mean obtained is 4.33 which implies that regardless of barangays and gender, the respondents social concern is highly prevalent in the minds of the respondents.

Table 2.134 Mean Levels of Concern of Respondents to Social Issues

SOCIAL CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
1. Resettlement of houses	5	4.86	4.91	4.04	3.96	3.99	4.09	4.22	4.36	4.38	4.35	4.38
2. Acquisition of land at low price.	4.75	4.53	4.61	3.84	3.98	3.93	4.09	4.2	4.24	4.23	4.24	4.24
3. Destruction of property improvement e.g. fence swithout compensation	5	4.86	4.91	3.91	4.06	4.00	4.24	4.2	4.37	4.38	4.37	4.39
4. Social disintegration	4.79	4.53	4.63	3.99	4.05	4.03	4.06	3.98	4.22	4.28	4.19	4.25
5. Distance from schools or work in case of resettlement.	4.71	4.49	4.57	3.79	3.89	3.85	4.12	4.12	4.18	4.21	4.17	4.19
6. Issues on right of way	4.92	4.65	4.75	4.16	4.13	4.14	4.15	4.02	4.32	4.41	4.27	4.35
7. Inconveniences to domestic activities	4.96	4.67	4.78	3.84	4.05	3.97	4.06	4	4.26	4.29	4.24	4.28
8. Disruption and safety issues associated with construction.	4.92	4.84	4.87	3.87	4.13	4.03	4.38	4.17	4.38	4.39	4.38	4.39
9. Congestion of traffic routes during construction phase	5	4.84	4.90	3.96	4.06	4.02	3.94	4	4.30	4.3	4.3	4.34
10. Disruption of ferry boats' schedule due to construction.	4.96	4.79	4.85	3.94	4.08	4.03	4.03	3.76	4.25	4.31	4.21	4.29

SOCIAL CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
11. Conduct of public consultation with the affected community	4.92	4.84	4.87	4.2	4.23	4.22	4.56	4	4.43	4.56	4.36	4.46
12. Equal representation of men and women during public consultation	5	4.72	4.82	4.3	4.32	4.31	4.53	4.02	4.45	4.61	4.35	4.47
Total	4.91	4.72	4.79	3.99	4.08	4.05	4.19	4.06	4.31	4.36	4.28	4.33

Legend: 4.50 – 5 Very High Concern; 3.50-4.49 High Concern; 2.50 -3.49 Moderate Concern; 1.50 -2.49 Low Concern; 0.5 -1.49 Very Low Concern

The respondents have high economic concern with a mean range from 3.92 to 4.51. Their highest concern is on the non-prioritization of local residents, both male and female, in job hiring in case they are qualified with a mean of 4.51; and fare hikes with a mean of 4.44. They are also highly concerned with the loss of of livelihood with a mean of 4.32. Losing a job or means of livelihood is an issue for those who will be affected, hence compensation package that will be provided should include restoration of livelihood or provision of income generating projects. According to Wilmot (2012) “one of the reasons project-affected people have been having a difficult time creating livelihoods from the rehabilitation and resettlement package is the disconnection between their original lifestyles and livelihoods, and the compensation provided.

Moreover, it can also be noted that the respondents have high concern on the loss of their livelihood, for example, the street vendors and owners of small retailing stores with a mean of 4.34. Possible influx of big businesses in IGaCos when the bridge will be operational is a big challenge to those who own small business with a mean of 4.09.

In terms of gender disaggregated data, result revealed that females have higher economic concern with an overall mean 4.27 compared to males with a mean of 4.19. Females usually devote time budgeting the family’s income on food, education, health, among others. This partly explains why they have higher economic concern compared to males.

Table 2.135 Mean Levels of Concern of Respondents to Economic Issues

ECONOMIC CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
1. Loss of means of livelihood e.g. side walk vendors, small retailing stores	4.88	4.56	4.68	3.97	4.23	4.13	4.32	4.05	4.32	4.39	4.28	4.34
2. Not prioritizing local residents, both male and female, in job hiring in case they are qualified	4.92	4.84	4.87	4.06	4.36	4.25	4.38	4.39	4.50	4.45	4.53	4.51
3. Fare hikes	4.92	4.74	4.81	4.07	4.23	4.17	4.41	4.27	4.43	4.47	4.41	4.44
4. Loss of jobs for those working with ferry boats	4.13	4.47	4.34	3.59	3.89	3.78	3.35	3.61	3.88	3.69	3.99	3.92
5. Influx of big businesses thus affecting local small business owners	4.33	4.44	4.40	3.69	3.97	3.87	3.85	4.05	4.08	3.96	4.15	4.09
Total	4.64	4.61	4.62	3.88	4.14	4.04	4.06	4.07	4.24	4.19	4.27	4.26

Legend: 4.50 – 5 Very High Concern; 3.50-4.49 High Concern; 2.50 -3.49 Moderate Concern; 1.50 -2.49 Low Concern; 0.5 -1.49 Very Low Concern

In general, it appeared that there are more respondents (19) in Barangay Hizon who have business near the construction site compared to Barangay Limao with only 2. No respondent from Barangay Caliclic have business near the construction site. Out of the total respondents, only 6.5% of the males and 9.6% females have business close or within the project construction site.

During the conduct of socio-economic survey for 'project-affected persons,' there will be a need to identify their specific businesses to determine compensation packages. For example, if a business is a retailing store, transfer and re-establishing the business can be considered as part of the compensation package. It must also be noted that the transfer areas for businesses should be in strategic locations. Re-establishing a business in a new location is a challenge for the business owners because they will have to cater to new customers.

Table 2.136 Respondents with Business Close or Within the Identified Construction Site

Business within or close to the identified construction site	YES			NO			Total		
	Male	Female	ST	Male	Female	ST	Male	Female	Total
Caliclic	0	0	0	21	36	57	21	36	57
Hizon	4	15	19	54	92	146	58	107	165
Limao	3	2	5	25	33	58	28	35	63
No of Respondents	7	17	24	100	161	261	107	178	285
%	6.5	9.6	8.4	93.5	90.4	91.6	100.0	100.0	100.0

In **Table 2.137** it can be gleaned that most of the males (89.4%) and females (74.7%) are willing to work for the project if there are opportunities for them. This implies that the female respondents are as interested as the males to work for the project.

By barangays, there are 39 respondents (91%) in Barangay Caliclic who are willing to work for the project if there are opportunities, while 4 respondents (9%) are not interested. Also, 132 of the respondents of Barangay Hizon (80%) are interested with the opportunities that the project can offer, whereas 34 respondents (20%) are not willing at all. Barangay Limao's 34 respondents (72%) are willing to work in the said project area and 13 respondents (28%) are not willing.

Survey results show that the respondents have high to very high environmental concerns during the construction phase of the project with a mean range from 4.30 to 4.51. Their top three highest environmental concerns are: air pollution due to dust and gas emission during construction with a mean of 4.51 or very high concern; solid waste due to construction with a mean of 4.49 or high concern; and, absence of Environmental Compliance Certificate as well as contamination of ground and sea water, both with a mean of 4.47 or high concern. Further, the respondents are also concerned about uncontrolled noise during construction, contamination of ground and sea water, change of landscape in the place, among others. In general, the respondents have high environmental concerns during construction with a mean of 4.43. The respondents do not actually need to worry about ECC because the project cannot proceed without complying with this government requirement. During the public consultation and IEC, it was made clear that before the project implementation, an ECC will still be secured first.

The respondents' concern on uncontrolled noise pollution implies that they are not only concerned about the environment, but also about their health. Therefore, the project implementers must ensure that noise mitigating measures e.g. noise barriers are included during the planning stage of the project. According to Rojas of the Barcelona Institute of Health as cited by Roberts (2018), noise produces stimulus to the central nervous system and this stimulus releases some hormones. This increases the risk of hypertension and hypertension has been related to many other cardiovascular and cerebrovascular diseases like infraction (heart attacks) and stroke. Moreover, Rojas added that "while pregnant women and young children are particularly vulnerable to this urban pollutant such as noise, the problem affects everybody, regardless of life stages.

Combining the result, it can be concluded that females have higher environmental concern with a mean of 4.47 compared to males with a mean of 4.35. Generally, the respondents have high environmental concern during construction with an overall mean of 4.43.

In terms of Barangays, it appeared that the respondents in Barangay Caliclic have the highest obtained mean of 4.90 which suggests that they have very high environmental concerns during construction, compared to Barangay Limao and Hizon with a mean of 4.43 and 4.06, respectively.

Shown in **Table 2.138** and **Table 2.139** are the environmental concerns during project operation. Results revealed that they have high to very high environmental concern ranging from 4.47 to 4.52. Their top concern is on the increase of solid waste due to the influx of tourists, both local and foreign, once the bridge is operational with a mean of 4.52 or very high concern. It can be assumed that once the travel time going to and from IGaCoS and vice-versa is shortened and traffic congestion are addressed, the number of tourists will eventually increase.

The respondents have also high concern about the weak enforcement of environmental laws which may result to serious environmental concern like that of Boracay with a mean of 4.49 and shortage of water supply in the area with a mean of 4.47. This shows that even if the respondents know that economic development will take place in the area, they are also concerned about the environment. This poses a challenge on both the local government units and the concerned government agencies to come up with plans and programs to avoid environmental problems in the future.

Based on gender disaggregated data, it can be concluded that females have very high environmental concern during the bridge operationalization with a mean of 4.53 compared to the males whose concern is only high with a mean of 4.41.

Based on the result per Barangay, it appeared that Barangay Caliclic got the highest mean of 4.93 which means that the respondents have very high environmental concern during bridge operation. On the other hand, Barangays Limao and Hizon got a mean of 4.49 and 4.14, respectively implying that they have high environmental concern during the bridge operation.

Table 2.137 Willingness to Work for the Project

Work Opportunities	YES			NO			Total		
	Male	Female	ST	Male	Female	ST	Male	Female	Total
Caliclic	8	31	39	0	4	4	8	35	43
Hizon	49	83	132	6	28	34	55	111	166
Limao	27	7	34	4	9	13	31	16	47
No of Respondents	84	121	205	10	41	51	94	162	256
%	89.4	74.7	80.1	10.6	25.3	19.9	100.0	100.0	100.0

Table 2.138 Mean Levels of Concern of Respondents to Environmental Issues During Construction

CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
1. Change of landscape in the place	4.96	4.95	4.95	3.9	3.85	3.87	4.26	4.44	4.40	4.37	4.41	4.39
2. Reduction of vegetative cover	5	4.95	4.97	3.77	3.86	3.83	3.79	4.17	4.28	4.19	4.33	4.30
3. Contamination of ground and sea water	4.96	4.88	4.91	3.99	4.22	4.14	4.29	4.34	4.45	4.41	4.48	4.47
4. Uncontrolled noise during construction	5	4.6	4.75	4.07	4.2	4.15	4.12	4.56	4.43	4.4	4.45	4.43
5. Cutting of trees for bridge construction	5	4.93	4.96	3.83	4.17	4.04	3.74	4.24	4.35	4.19	4.45	4.39
6. Destruction of marine habitats (e.g. Mangrove, coral reef)	4.92	4.88	4.89	3.9	4.31	4.16	4.15	4.29	4.43	4.32	4.49	4.45

CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
7. Air pollution due to dust & gas emissions during construction	4.92	4.95	4.94	4.01	4.2	4.13	4.32	4.54	4.51	4.42	4.56	4.51
8. Solid waste due to construction	4.92	4.95	4.94	3.96	4.19	4.11	4.29	4.51	4.49	4.39	4.55	4.49
9. Absence of Environmental Compliance Certificate	4.83	4.72	4.76	4.09	4.17	4.14	4.38	4.66	4.49	4.43	4.52	4.47
Total	4.95	4.87	4.90	3.95	4.13	4.06	4.15	4.42	4.43	4.35	4.47	4.43

Legend: 4.50 – 5 Very High Concern; 3.50-4.49 High Concern; 2.50 -3.49 Moderate Concern; 1.50 -2.49 Low Concern; 0.5 -1.49 Very Low Concern

Table 2.139 Mean Level of Concern of Respondents to Environmental Issues During Bridge Operation

CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
1. Increased Solid waste due to influx of tourists once the bridge is operational (local and foreign)	4.92	4.95	4.94	4.01	4.27	4.17	4.26	4.51	4.51	4.4	4.58	4.52
2. Shortage of water supply for domestic use due to influx of tourists	4.92	4.86	4.88	4.07	4.19	4.15	4.24	4.46	4.47	4.41	4.5	4.47
3. Weak enforcement of environmental laws (Island might have same problems as with Boracay)	4.92	5	4.97	4.07	4.14	4.11	4.24	4.41	4.48	4.41	4.52	4.49
Total	**4.92**	**4.94**	**4.93**	**4.05**	**4.2**	**4.14**	**4.25**	**4.46**	**4.49**	**4.41**	**4.53**	**4.49**

Legend: 4.50 – 5 Very High Concern; 3.50-4.49 High Concern; 2.50 -3.49 Moderate Concern; 1.50 -2.49 Low Concern; 0.5 -1.49 Very Low Concern

Political concerns refer to the set of activities associated with the governance of an area or project. Survey result revealed that the respondents have high political concern with an overall mean of 4.35. They have high concern that Local Government Units (LGUs) should constantly monitor progress of the project and proper coordination among agencies governing the project, both with a mean of 4.38. They have also high concern on barangay officials' participation and involvement in meetings and project planning with a mean of 4.30. The participation of barangay officials in meetings will help assure the residents knowing that they have representatives in the project development. Usually, Barangay Officials are the source of information on project implementation in their respective area. Their ideas and suggestions matter to their constituents.

Based on the gender disaggregated data, it can be concluded that male and female respondents have high political concern about the project. However, they vary in terms of the mean obtained which is 4.27 for males and 4.43 for females.

In terms of Barangay data, it can be gleaned that Barangay Limao got the highest mean of 4.37; followed by Barangays Caliclic and Hizon, both with a mean of 4.31. Interpreting the mean obtained for all Barangays imply that the respondents have high political concerns.

The respondents were asked about how they perceived the importance of the different concerns about the project. Result shows that the respondents perceived the environment to be their highest concern with a mean of 4.46; followed by the political, social and economic concerns with a mean ranging from of 4.35 to 4.26

Per data according to Barangays, it can be concluded that Barangay Caliclic perceived that environmental concern is of very high importance with a mean of 4.92. On the other hand, Barangay Hizon perceived political concern as the most important with a mean of 4.31 and Barangay Limao also perceived the environment as their most important concern with a mean of 4.34.

On gender disaggregated data, it shows that both males and females perceived all the concerns highly important.

Shown in **Table 2.142** are the responses on the agreements and disagreements of the respondents on the statements provided. The result clearly shows that the respondents are already knowledgeable about the benefits they can get out of the project. There are 93.3% of the respondents who agreed on the development of complete construction signages containing work schedules and rules to avoid untoward accident; 92.7% agreed that the project should prioritize hiring of the locals, both women and men; Moreover, 90.1% of the respondents also agreed that they do not oppose the construction of the bridge and 83.4% said they are willing to sell their properties, if the price is right.

A high percentage of the respondents agreed that the bridge should be near the key locations of Davao City and IGaCos. The statements that most of them agreed on also include items that they would want the project implementers to consider during the project implementation.

When disaggregated by sex, there are 14.8% males who disagreed with the cutting of trees even though this is subject to approval of concerned agencies, 12.5% who are not willing to sell their property, and 5.5% opposes the construction of the bridge. This implies that not all male respondents are willing to sell their properties and that there are respondents, very few though, who are opposed to the construction of the bridge.

For females, there are 12.0% who are not willing to sell their properties, 11.1% disagreed with the cutting of trees even though this is subject to approval of concerned agencies and 6.0% opposes the idea that the establishment of the bridge will provide employment to the local community. 6.0% also opposes the construction of the bridge.

Overall, for both males and females, the top 3 highest disagreements are on cutting of trees with 12.5%; selling of property with 12.2%; and the construction of the bridge with 5.8%.

Table 2.140 Mean Level of Concern of Respondents to Political Issues

CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
1. LGU should constantly monitor progress of the project	4.17	4.53	4.40	4.29	4.29	4.29	4.53	4.46	4.39	4.33	4.43	4.38
2. Barangays officials' participation and involvement in meetings and project planning	4.17	4.33	4.27	4.21	4.25	4.24	4.44	4.44	4.31	4.27	4.34	4.30
3. Proper coordination among agencies governing the project	3.96	4.42	4.25	4.1	4.6	4.42	4.53	4.51	4.40	4.2	4.51	4.38
Total	4.1	4.43	4.31	4.2	4.38	4.31	4.5	4.47	4.37	4.27	4.43	4.35

Legend: 4.50 – 5 Very High Concern; 3.50-4.49 High Concern; 2.50 -3.49 Moderate Concern; 1.50 -2.49 Low Concern; 0.5 -1.49 Very Low Concern

Table 2.141 Degree of Importance of Concerns

CONCERNS	Caliclic			Hizon			Limao			Total		
	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$	M	F	$\bar{x}$
Environment	4.94	4.91	4.92	4	4.17	4.10	4.2	4.44	4.46	4.38	4.5	4.46
Political	4.1	4.43	4.31	4.2	4.38	4.31	4.5	4.47	4.37	4.27	4.43	4.35
Social	4.91	4.72	4.79	3.99	4.08	4.05	4.19	4.06	4.31	4.36	4.28	4.33
Economic	4.64	4.61	4.62	3.88	4.14	4.04	4.06	4.07	4.24	4.19	4.27	4.26
Total	4.65	4.67	4.66	4.02	4.19	4.13	4.24	4.26	4.34	4.30	4.37	4.35

Table 2.142 Agreement and Disagreement on Certain Statements about the Project

Statements	TOTAL								Over-All total			
	Male				Female				A	D	NR	TR
	A	D	NR	TR	A	D	NR	TR				
	%	%	%		%	%	%		%	%	%	
1. The establishment of the bridge will provide employment to the local community	92.2	3.9	3.9	128	91.2	6.0	2.8	216	91.6	5.2	3.2	344
2. The project should prioritize hiring of the locals, both women and men	93.8	2.3	3.9	128	92.1	3.7	4.2	216	92.7	3.2	4.1	344
3. The bridge will cut travel time of locals and tourists to and from the Island	93.0	3.1	3.9	128	92.1	3.2	4.6	216	92.4	3.2	4.4	344
4. The bridge is a convenient transport route going to and from the Island	92.2	3.9	3.9	128	91.7	3.7	4.6	216	91.9	3.8	4.4	344
5. Cutting of trees must be approved by concerned agencies	81.3	14.8	3.9	128	84.3	11.1	4.6	216	83.1	12.5	4.4	344
6. I am willing to sell my property like land and house if the price is right	83.6	12.5	3.9	128	83.3	12.0	4.6	216	83.4	12.2	4.4	344
7. I do not oppose to the construction of the bridge	90.6	5.5	3.9	128	89.8	6.0	4.2	216	90.1	5.8	4.1	344

Statements	TOTAL								Over-All total			
	Male				Female				A	D	NR	TR
	A	D	NR	TR	A	D	NR	TR				
	%	%	%		%	%	%		%	%	%	
8. Endorsement from the local officials is very important	93.0	3.1	3.9	128	92.1	3.2	4.6	216	92.4	3.2	4.4	344
9. The bridge should be near the key locations of Davao City and IGACOS	92.2	3.9	3.9	128	91.2	4.2	4.6	216	91.6	4.1	4.4	344
10. Development of complete construction signages containing work schedules and rules to avoid untoward accident.	94.5	1.6	3.9	128	92.6	3.2	4.2	216	93.3	2.6	4.1	344
11. The bridge should be connected to the major roads such as coastal and bypass roads.	92.2	3.9	3.9	128	92.1	3.7	4.2	216	92.2	3.8	4.1	344

A=Agree; D=Disagree; NR=No Response; TR=Total Respondents

At the end of the perception survey, respondents were asked to rate from 1 to 5 their level of acceptance of the project. 1 means very low acceptance, 2 means low acceptance, 3 means moderate acceptance, 4 means high acceptance, and 5 means very high acceptance. The researchers then computed for the mean level of acceptance.

Results of the survey revealed that respondents generally accept the project with a mean of 4.37. When analyzed per barangay, it shows that respondents of Barangay Caliclic rated their acceptance as very high with a mean of 4.68. Those from Barangay Limao, on the other hand, highly accepts the project (mean of 4.49). The level of acceptance of respondents from Barangay Hizon is the lowest with a mean of 3.95.

When disaggregated by sex, it can be noted that both male and female respondents highly accept the project with a mean of 4.41 and 4.33 respectively.

Table 2.143 Acceptance of the Samal-Davao Connector Project

Barangays	**Acceptance Level**		
	Male	**Female**	**$\bar{x}$**
Caliclic	4.63	4.72	4.68
Hizon	4.13	3.77	3.95
Limao	4.47	4.51	4.49
Total	4.41	4.33	4.37

Legend: 4.50 – 5 Very High Acceptance; 3.50-4.49 High Acceptance; 2.50 -3.49 Moderate Acceptance; 1.50 -2.49 Low Acceptance; 0.5 -1.49 Very Low Acceptance

3 Environmental Management Plan

The Environmental Management Plan (EMP) details the prevention, mitigation, compensation, contingency and monitoring measures to enhance positive impacts and minimize negative impacts and risks associated with a project. An EMP is formulated to ensure that commitments made in the Environmental Impact Assessment (EIA) process are implemented throughout the project life.

The EMP details the following:

- Environmental components – these pertain to the land, water, air and people aspects which require management considerations
- Potential impacts – possible impacts identified in the EIS that are likely to occur
- Performance objectives – goals to be attained through strategic management actions
- Performance indicators – standards and criteria where performance levels are measured against
- Monitoring – procedural flow of validating the proponent's performance in reference to commitments encapsulated through the EIA in the Environmental Compliance Certificate (ECC)
- Responsibility – identifies relevant institutions or persons responsible for carrying out specific tasks
- Reporting – the process of documenting monitoring results
- Corrective action – remedial or enhancement measures in case of non-compliance with environmental management controls, undertaken by the institution or person responsible for the action

Environmental mitigation measures are fully implemented upon the commencement of a project's construction, development and operation stages. The proponent's environmental performance is monitored regularly, and findings and actual impacts are delineated and embodied in the environmental monitoring plan as per DAO 2003-30 (Annex 2-17). It must be noted that an EMP is not static. Rather, it is a living document that requires updating and amendments.

For monitoring key environmental impacts on each project phase, the proponent (DPWH) shall follow the generic template or the Pro-Forma Proponent Compliance Monitoring Report (CMR) together with the Compliance Monitoring and Validation Report (CMVR) of the Multi-Partite Monitoring Team (MMT).

summarizes the project plan for environmental management and is referred to as the Impact Management Plan.

Table 3.1 **S**ummary Matrix of the Impact Management Plan

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
PRE-CONSTRUCTION						
Employment – Hiring of local workers	The People	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	• Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs; • Compliance with RA 6685; and • Contractors to provide trainings for hired workers.	LGU DOLE	Part of development cost	Incorporated as part of the project
Health and Safety – Hiring of local workers	The People	Health and Safety of construction workers.	• Use of Personal Protective Equipment to all construction workers; • DPWH and Contractor to provide emergency and health and safety program for workers; • Provide Medical Kit and first aid; • Provide potable water and temporary sanitation facilities; • Provide trash bins in strategic locations and coordinate with LGUs and host barangays for regular waste collection and disposal;	LGU DOLE	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Conduct frequent safety, hygiene, and construction sanitation training for workers; and • Training of personnel and staff during emergencies.			
Loss of livelihood of residents and business owners	The People	Displacement and loss of livelihood of residents and business owners during ROW land acquisition.	• Preparation of Resettlement Action Plan, Utilities Relocation Plan, Securing ROW, Land Acquisition, Socio-Economic Profiling, and conduct consultations guided by processes and directives under the Philippine Government, DPWH, DOTr, and ADB (i.e. RA 10752 – ROW Act; DPWH ROW Acquisition Manual; or DOTR ROW Site Acquisition Manual; and resettlement policy); and • Proper compensation and/or relocation of affected residents and landowners.	LGU	Part of development cost	Incorporated as part of the project
CONSTRUCTION PHASE						
Land Use	The Land	Impact in terms of compatibility with existing land use due to site preparation, clearing, and/ or	• Reclassification of direct impact areas for infrastructure use and integration of the project in LGU land use and development plans	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		tree cutting activities	• Reclassification of appropriate land use development and rezoning, particularly on Samal Island Master Plan			
Terrestrial Ecology and Geology and Geomorphology	The Land	Loss of topsoil due to vegetation clearing may trigger soil erosion and may induce landslides in some areas during clearing, and/ or tree cutting activities, excavation, use of heavy equipment, and installation of columns/ foundations and construction of interchanges and bridge structure.	• Prepare and implement a materials handling program or a site protection and rehabilitation program; • Immediate compaction of the all-weather road by means of a road roller to prevent any splash and soil erosion.	LGU	Part of development cost	Incorporated as part of the project
Terrestrial Ecology	The Land	Loss of vegetation during clearing operation (i.e. fruit bearing trees, and forest trees);	• Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; • Secure applicable and relevant permits, including tree cutting permit should be secured prior to tree cutting	LGU DENR-EMB	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Possible change in floral community structure	activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02. Earth balling of big trees native trees and vegetation will be planted to compensate for any loss or replacement seedlings will be provided by the proponent; • Compensation to owners of non-timber species that will be cut; • Native flora species shall be at least conserved in selected areas to serve as refuge and forage for wildlife species; • Creation of dedicated habitat areas to achieve no net loss habitat or rehabilitate native species in Samal and Davao; • A competent, experienced ecologist will oversee the clearance of native flora. • Coordination with LGUs.			
Terrestrial Ecology	The Land	Disturbance or loss of habitat and will affect existing wildlife during site preparation, clearing, and/ or	• Clear areas that are only necessary for site preparation to prevent impact on terrestrial ecology; • Secure applicable and relevant permits, including tree cutting permit should be secured prior to tree cutting	LGU DENR	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		tree cutting activities	activity. Replacement of cut trees will be based to the DENR Memorandum Order (DMO) 2012-02. Earth balling of big trees or replacement seedlings will be provided by the proponent; • Gradual conversion of the area to provide sufficient time for wildlife movement; • A biodiversity protection plan, restoration plans, and a stand-alone monitoring plan will be created to detail the restoration and habitat creation of native flora, as necessary; • Creation of dedicated habitat areas to achieve no net loss habitat or rehabilitate native species in Samal and Davao, as necessary; and • Coordination with LGUs.			
Accumulation of solid wastes	The Land	Accumulation of solid wastes during site preparation, clearing, and/ or tree cutting activities, excavation and other construction and installation works;	• Implement an organized waste storage, collection, and proper waste management system; • Housekeeping measures can also prevent possible contamination in soil and water; • Non-recyclable waste will be collected daily by a licensed 3rd party contractor to ensure cleanliness in the workplace;	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	**Environmental Component Likely to be Affected**	**Potential Impact**	**Options for Preventions or Mitigation or Enhancement**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
		Devaluation of land value as a result of improper solid waste management	• Trainings will be provided to site workers to improve the awareness on proper solid waste management practices; • Prepare Solid Waste Management Plan in accordance with RA 9003; and • Ensure compliance to national and local waste regulations.			
Geology and geomorphology	The Land	May trigger siltation during site preparation, clearing, and/ or tree cutting activities, excavation, use of heavy equipment and installation of columns/ foundations and construction of interchanges and bridge structure.	• Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods; • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to the adjacent water bodies to ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;	DENR-EMB LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Silt traps will be installed for all nearby water bodies; and • The waste soil and other debris will be properly handled and disposed on a regular basis.			
Geology and Geomorphology	The Land	Change in sub-surface geology and underground conditions due to project inducement of subsidence, karst subsidence, liquefaction, and mass movements during excavation, use of heavy equipment and installation of columns/ foundations and construction of interchanges and bridge structure.	• Consider ground acceleration values in the final project design, particularly pile and pylon foundations; • Conduct detailed geotechnical and subsurface investigations during DED leading to the design of ground improvement activities to be implemented during construction; • Design structures and facilities to withstand ground subsidence where suspected to occur; and • Investigate underlying soils and rocks during DED.	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Visual aesthetics	The Land	Impairment of visual aesthetics during excavation and other construction works.	• Final project design to consider aesthetic impacts; • Harmonize with existing surroundings considering engineering, safety, environmental, and its aesthetic impacts; and • Ensure that iconic and elegant bridge be maintained and visually appealing during construction phase.	LGU	Part of development cost	Incorporated as part of the project
Traffic	The Land	Traffic congestion during construction works	• Follow the Traffic Management Plan to aid in avoiding traffic congestion; • Contractors to provide traffic enforcers in areas where construction is on-going; and • Coordinate with LGUs to provide alternative routes.	LGU	Part of development cost	ECC Condition
Soil contamination; Hazardous materials	The Land	Soil contamination from leaks of lubricants agents and used oil due to excavation, and other construction works.	• Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil;	LGU DENR-EMB	Part of development cost	Compliance to Solid Waste Management Plan; RA 9003; RA 6969 Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility.	• Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place). • Maintenance and proper use of construction materials and heavy vehicles; • Disposal of non-recyclable wastes by a licensed contractor; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.			
Water Quality	The Water	Degradation of water quality due to generation of domestic wastewater during installation of site facilities – Temporary Facilities (field offices and barracks) and columns and other	• Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods; • Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment	LGU DENR-EMB	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		construction works on land	• Soil debris and other excavated materials should be hauled out from the site • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • Locate motor-pool area at least 500 meters away from any body of water; • Set up of portable sanitary facilities and collect wastewater to be disposed accordingly; • The contractor will be required to comply with the Civil Works Guidelines; • Project shall be equipped with an oil-water separator to remove oil from effluents prior to discharge to water bodies; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable			

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			area with appropriate secondary containment; • Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place).			
Water Quality	The Water	Degradation of water quality due to dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Apply appropriate siltation control measures such as well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality	LGU DENR-EMB PCG	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	**Environmental Component Likely to be Affected**	**Potential Impact**	**Options for Preventions or Mitigation or Enhancement**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
			and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase; • The contractor will be required to comply with the Civil Works Guidelines; and • Compliance to MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14.			
Water Quality	The Water	Degradation of water quality due to oil, fuel or other lubricant agents leaks due to works, installation and other construction works on land	• Project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies; • Locate motor-pool area at least 500 meters away from any body of water; • Set-up portable sanitary facilities and collect wastewater to be disposed of accordingly; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment;	LGU DENR-EMB	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; and • Emergency and contingency plan in case of spills (health and safety management plan must be in place).			
Solid Wastes	The Water	Accumulation of solid wastes and impact on sediments during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water; • Storage or disposal sites of the excavated or dredged sediments should be properly secured to prevent leakage of sediments, contaminants or pollutants through surface runoff; • Slope protection on the bridge landing site, particularly on IGaCoS	LGU Philippine Coastguard (PCG)	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			side, to minimize surface runoff and sedimentation; • Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices; • Compliance to MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14; and • Prepare Solid Waste Management Plan in accordance with RA 9003.			
Water contamination	The Water	Water contamination due to fuel, oil and other hazardous materials leakages during dredging, operation of	• Implement an organized waste collection and storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Implement a proper waste management (handling, storage and	LGU PCG	Part of development cost	Incorporated as part of the project; RA 6969

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		vessels and installation of columns/ foundations and construction of bridge structure	disposal) and housekeeping measures to prevent possible contamination in water; • Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater; • Emergency and contingency plan in case of spills (health and safety management plan must be in place); • Maintenance and proper use of construction materials and heavy vehicles; and • Ensure compliance to PCG Memorandum # 07-14.			
Flooding	The Water	Increase in flooding susceptibility due to excavation, use of heavy equipment and installation of columns/ foundations and construction of interchanges and bridge structure.	• Provide proper drainage canals that consider surface water flows and existing structures in the area; • Control water inflow by placing water-shut panels, intercept drainages and pump stations in strategically selected areas; and • Provide overflows to avoid water build-up on bridges when drainage infrastructure is blocked.	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Marine Ecology	The Water	Seagrass in IGaCoS side are still abundant and thriving and may decline when buried by sediment during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Biodiversity protection plan to be drawn up to detail methods to minimize impacts on seagrass beds and detail seagrass habitat creation and subsequent monitoring. • Surveys to be undertaken to explore opportunities for suitable translocation and habitat creation sites for seagrass beds, should be necessary. • Dredging must be confined at the immediate area so that only a small part of the meadow will be affected.	LGU	Part of development cost	ECC Condition
Marine Ecology	The Water	Local loss and disturbance of natural sedimentary habitats due to introduction of hard substrates and increase in sediment loads	• Engineering modifications to provide greater surface complexity and encourage marine growth; • Engineering design does not hinder longshore currents and ensures free circulation of water; • Well-designed silt control scheme; • Proper disposal of debris;	LGU	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		from construction materials Deterioration, destruction and disruption of fish habitats in IGaCoS side during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Any debris or concrete waste must be removed as quickly as possible; • Monitoring and evaluation of benthic habitats to be conducted quarterly or bi-annually to capture changes; • Secure storage or disposal sites of excavated or dredged sediments to prevent leakage of sediments, contaminants or pollutants through surface run-off; and • Provide slope protection on bridge landing site, particularly on the IGaCoS side, to minimize surface runoff and sedimentation.			
Marine Ecology	The Water	Changes in channel beds and impacts on fish and aquatic life during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Strict observance and implementation of Site Protection and Rehabilitation Program and materials handling which provide for soil erosion control measures; • Observe best practices in proper construction procedures that promote care and minimal disturbance to the existing environment; • Monitoring and evaluation of benthic habitats, including habitat created/ translocated and remedial actions taken, if required;	LGU	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Should there be any affected corals and seagrasses, coral translocations/ seagrass mitigation / translocation of any benthic species should be undertaken by a suitably qualified marine ecologist. • Biodiversity protection plan to be drawn up to detail methods to minimize impacts.			
Visual Aesthetics	The Water	Impairment of visual aesthetics during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Final project design to consider aesthetic impacts • Harmonize with existing surroundings considering engineering, safety, environmental, and its aesthetic impacts; and • Ensure that iconic and elegant bridge be maintained and visually appealing during construction phase.	LGU	Part of development cost	Incorporated as part of the project
Marine Navigation	Water	Disruption of marine navigation route along Pakiputan Strait during dredging, operation of vessels and installation of	• Coordinate with Marina, PPA and Coastguard for the rerouting of sea vessels; and • Vessels will observe speed restriction and follow routing clearance to avoid sensitive marine areas.	Marina PPA PCG concerned shipping companies / operators	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		columns/ foundations and construction of bridge structure				
Air Quality	The Air	Alteration of air quality from fugitive dust and equipment use, during site preparation, clearing, and/ or tree cutting activities, construction and installation of site facilities – Temporary Facilities (field offices and barracks), excavation, installation and transport of materials, and during dredging, operation of vessels and installation of	• Regular and adequate sprinkling of water should be done in the premises to minimize the dust particles generated; • Preventive maintenance of heavy equipment and vehicle; • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQGV. • Workers will be provided with the appropriate personal protective equipment (PPE) and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards; and • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	DENR-EMB LGU	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		columns/ foundations and construction of bridge structure				
Noise Level	The Air	Disturbance in nearby communities due to generation of noise during site preparation, clearing, and/ or tree cutting activities, construction and installation of site facilities – Temporary Facilities (field offices and barracks), excavation, installation and transport of materials	• Use equipment which generates less noise, and/or will be fitted with muffler or silencers; • The host communities will be kept informed of the duration and timing of any noisy construction; • Limit the construction time to a given standard hours or limit night work to avoid distraction of nearby establishments like residential areas; • Periodic monitoring and evaluation of noise levels; • Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989); • Regular maintenance of all vehicles, machinery, and heavy equipment; and	DENR-EMB LGU	Part of development cost	ECC Condition

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• The project can use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be used to control noise impacts.			
		Disturbance due to during dredging, operation of vessels and installation of columns/ foundations and construction of bridge structure	• Construction vessels that will be used will have on-board noise reduction to protect construction workers from excessive noise exposure, in accordance with the International Convention for the Safety of Life at Seas (SOLAS).			
Health and Safety	The People	Potential threat to health and safety of people / communities during Construction works	• Ensure site is well-lit, secured and guarded; • Formulate security procedures with local police and LGUs for provision of needed facilities, guard posts. • Provision of Grievance Redress Mechanism for any issues and complaints; and • Coordinate with concerned agencies to ensure safety and reduced negative impacts to the community and environment.	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Disruption of public services	The People	Temporary disruption of public services, such as water and electric supply during Site preparation, clearing, and/ or tree cutting activities	• Relocation and replacement of affected utilities will be paid by the proponent and will be carried out by the relevant utility companies; • Inform affected stakeholders ahead of any temporary disruption during utility relocation; and • Attention will be made on utilities that will be relocated and will be closely monitored during implementation of utility relocation.	LGU	Part of development cost	Contractor’s construction agreement
OPERATION PHASE						
Accumulation of Solid Waste due to movement of passengers	The Land	Increase in solid waste generation from passengers and operational works	• Provision of waste bins that will allow proper waste segregation at both ends of the bridge; • Regular waste audits and collection of wastes for recycling or disposal; • Samal LGU to highly consider Solid Waste Management for the likely huge increase in development; and • Local authorities to control littering and entry to the island.	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Water Flow and Currents	The Water	Disruption of natural water flows and currents	• Monitor sediment transport loads; • Samal landfall pier positioning to avoid ephemeral stream locations; • Provide silt removal facilities; and • Site formation design to re-direct surface runoff to appropriate discharge points at each landfall location.	LGU	Part of development cost	Incorporated as part of the project
Marine Navigation	The Water	Disruption of marine navigation route along Pakiputan Strait	• Coordinate with Marina, Philippine Ports Authority (PPA) and Philippine Coast Guard for the rerouting of sea vessels.	LGU	Part of development cost	Incorporated as part of the project
Noise Level	The Air	Noise from vehicles may exceed national standards for noise in general areas	• Portions of existing viaduct deck high above the sensitive receivers; • Alert signage to reduce noise placed on the bridge; and • Install noise barriers such as insulating walls.	LGU	Part of development cost	Mandated LGU action
Employment – Hiring of local workers	The People	Increase in employment opportunities and livelihood	• Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and	LGU DOLE	Part of development cost	Contractor’s construction agreement RA 6685

Project Phase/ Environmental Aspect	**Environmental Component Likely to be Affected**	**Potential Impact**	**Options for Preventions or Mitigation or Enhancement**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
			women, skilled and unskilled, and PWDs; • Compliance to RA 6685; and • Contractors to provide trainings for hired workers.			Local hiring agreement with LGUs
Health and Safety of workers	The People	Health and Safety of personnel	• Use of Personal Protective Equipment to all site workers; • DPWH and Contractor to provide emergency and health and safety program for workers; • Provide Medical Kit and first aid; • Provide trash bins in strategic locations and coordinate with LGUs and host barangays for regular waste collection and disposal; • Conduct frequent safety, hygiene, and sanitation training for staff; and • Training of personnel and staff during emergencies.	LGU DOLE barangay	Part of development cost	Incorporated as part of the project
Health and Safety to nearby communities	The People	Potential threat to health and safety of people / communities	• Deploy security personnel and incorporate a control center with CCTV and other monitoring systems; • Ensure site is well-lit, secured and guarded; • Formulate security procedures with local police and LGUs for provision of needed facilities, guard posts; and	LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	**Environmental Component Likely to be Affected**	**Potential Impact**	**Options for Preventions or Mitigation or Enhancement**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
			• Implementation of Emergency Response Team for accidents and other emergency cases.			
Health and Safety to users	The People	Health and Safety of drivers bridge end-users (e.g. drivers and passengers)	• Regular inspection of bridge; • Good signage and clear direction of traffic and bridge users; and • Training of personnel and staff during emergencies	LGU	Part of development cost	DPWH/ Contractor's Agreement; Security protocols by the LGU/ concerned agencies
Economic Development	The People	Boost economic development of Samal Island by improving tourism competitiveness		LGU	Part of development cost	Incorporated as part of the project
Mobility and linkages	The People	Accelerate infrastructure development that would enhance internal circulation, mobility and external linkages to support the growth potential of Davao Region		LGU	Part of development cost	Incorporated as part of the project

Project Phase/ Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Preventions or Mitigation or Enhancement	Responsible Entity	Cost	Guarantee/ Financial Arrangements
ABANDONEMENT PHASE						
Soil and Land Value	Land	Land	• Complete soil/land evaluation to determine residual impacts and appropriate corrective actions, if applicable.		Part of development cost	
Water Quality	Water	Water	• Assess groundwater capacity and monitoring of surface water quality to evaluate impacts during operation of project and provide possible mitigation measures.		Part of development cost	
Air Quality	Ambient Air	Unlikely air impacts due to dispersion of mobile source emissions	• Assess temporary impacts during demolition; and • Assess unlikely impacts due to dispersion of mobile source emissions to the atmosphere and dilution of pollutants released when bridge was in operation		Part of development cost	
Economy and Livelihood	People	Loss of economic benefits and livelihood and employment	• Assess loss of economic benefits; • Assess Loss of livelihood and employment; • Implement a Labor Retrenchment and support package and labor support programs		Part of development cost	

4 Environmental Risk Assessment (ERA) & Emergency Response Policy and Guidelines

4.1 Introduction

4.1.1 Objective of the ERA

The Environmental Risk Assessment (ERA) aims to identify and analyze the hazards and assess the risks associated with the proposed SIDC Project. It includes characterization of consequences for identified potential hazards in terms of loss of human lives or injuries, damage to or loss of assets and environmental risks.

4.1.2 Scope and Limitations

This ERA deals with the analysis of various potential safety (fire, explosion, toxicity) and physical hazards related with the SIDC project. It complies with the requirements of the Procedural Guidelines for Scoping of Environmental Risk Assessment (Annex 2-7e of the Revised Procedural Manual of DAO 03-30) and focuses on safety risks, which are characterized as low probability, high consequence, accidental in nature and with acute effects (EMB-EIAMD, 2007).

The study does not discuss geological, geo-technical and detailed structural risks, as these issues are tackled in the separate Engineering Geological and Geohazard Assessment Report (EGGAR) (**Annex K**) for the project. It also does not include environmental impacts from normal and other planned operations, which are discussed in detailed discussion of the EIA.

4.1.3 ERA Framework

The Procedural Manual for DAO 2003-30 (Annex 2-7e) defines environmental risk assessment as "the use of universally accepted and scientific methods to assess the risks associated with a project. Risk is defined as a measure of potential human injury death, economic loss, or environmental damage. It is determined based on the probability (likelihood) of the loss, injury/ death or damage occurring and the severity (magnitude) of the loss, injury/death or damage if it occurs. In simple terms, risk involves two measurable parameters: severity and probability.

The general ERA process is illustrated in **Figure 4.1**. The various elements/ steps in the risk assessment procedure are elaborated in the succeeding sections.

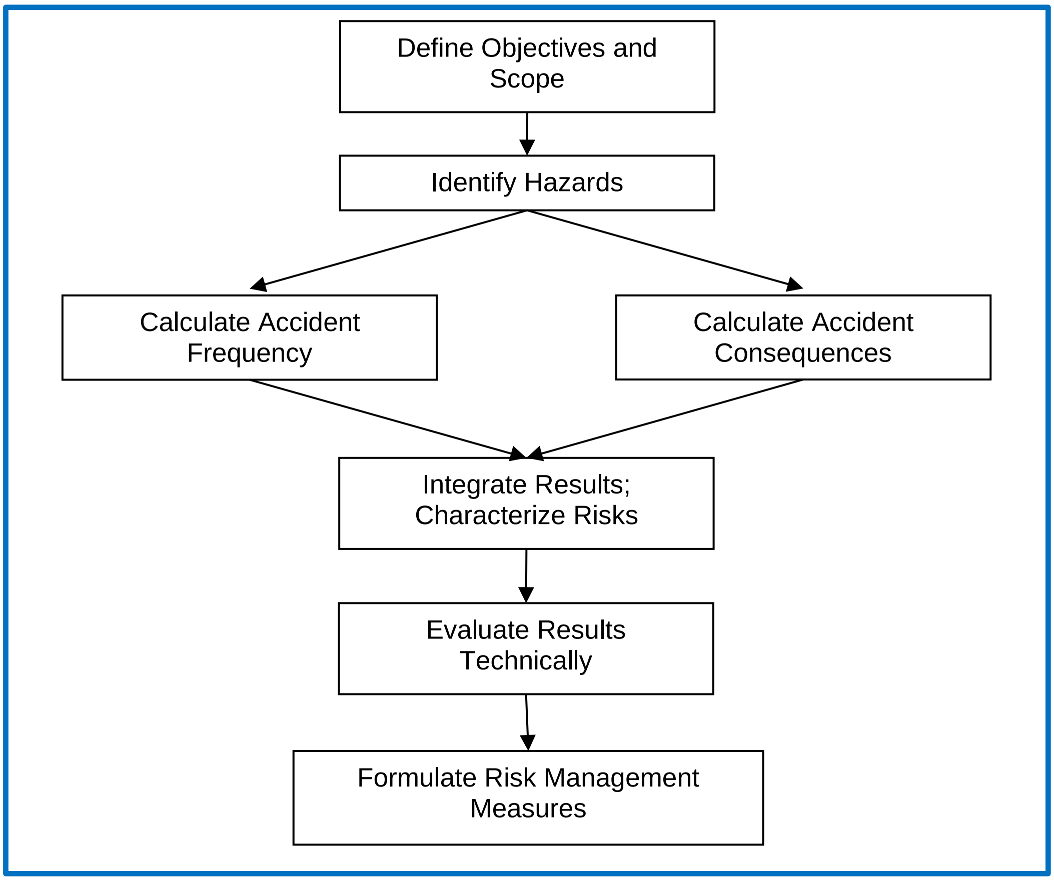


Figure 4.1 The Risk Assessment Procedure

4.2 ERA Methodology

Hazards are rated as to their consequence severity (C) and their frequency or probability of occurrence (F) using 5x5 Rating Charts. **Table 4.1** and **Table 4.2** show the rating charts for consequence severity and frequency of occurrence, respectively. Indicative risks are characterized by integrating the results of the Consequence Severity Rating (C) and the Frequency of Occurrence Rating (F) using a 5x5 Risk Rating Matrix as shown in **Table 4.3**.

4.2.1 Consequence Severity Analysis

Consequence severity analysis involves the qualitative description of possible impacts on people, assets and the environment in case of occurrence of accidents or incidents due to the identified hazards. Accident or consequence is graded according to a Consequence Severity Rating Chart as shown in **Table 4.1**. The rating ranges from 1 to 5, with 1 being the lowest consequence and 5 having the highest consequence severity.

Table 4.1 Consequences severity rating chart used in consequence analysis

Rating	Description	Consequence/ Impact		
		On-site Health and Safety	**Environment and Community**	**Assets**
1	Very low	Self-administered first aid treatment; No specific treatment	No community complaints; no corrective actions required; No breach of regulations	No property damage
2	Low	First Aid treatment injury	Impacts confined to site; corrective actions required; no breach of regulations	Slight/temporary damage and nuisance to one or more properties
3	Moderate	Medical treatment injury; possible loss time injury	Off-site environmental/ community damage could easily be contained or prevented; breach of regulations	Significant but temporary damage to property
4	High	Injuries require hospitalization	May result to uncontained environmental or community damage; multiple community complaints; may result to civil prosecution	Sustained damage to property lasting many months
5	Very High	Fatalities; Permanent disabilities	Long term environmental damage; May result to criminal prosecution	Long term and possible permanent loss of property

4.2.2 Probability/ Frequency Analysis

Probability/ frequency analysis of accidents or incidents due to the realization of project hazards are described using a Probability of Occurrence Rating Chart as shown in **Table 4.2**. Probability (frequency) is assigned value ranging from 1 to 5, with the value of 1 corresponding to the lowest probability and 5 having the highest probability value.

Table 4.2 Probability of occurrence rating chart used in consequence analysis

Rating	Description	Explanation
1	Rare	Might occur at some time in exceptional circumstances
2	Unlikely	Could occur at some time although unlikely
3	Possible	Might occur at some time
4	Likely	Will probably occur, has happened
5	Almost Certain	Expected to occur, quite common

4.2.3 Risk Characterization

Risk characterization involve the integration of the results of the consequence severity analysis and consequence probability analysis. For purposes of risk prioritization, indicative risk (IR) values are computed for each identified hazard by computing the product of the severity rating and probability rating values. **Table 4.3** shows the guide for interpreting the risk matrix.

Table 4.3 Risk matrix

Qualitative Risk Matrix			Probability/Frequency				
			1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost Certain
Consequence/ Impact	5	Very High	5	10	15	20	25
	4	High	4	8	12	16	20
	3	Moderate	3	6	9	12	15
	2	Low	2	4	6	8	10
	1	Very Low	1	2	3	4	5

Low Risk   Medium Risk   High Risk

4.3 ERA Scoping and Risk Screening of Hazardous Substances at the Project Site

ERA scoping and risk screening was done according to the process and criteria described in the Revised Procedural Manual of DAO 2003-30: Guidelines for the Conduct of Environmental Risk Assessment, particularly Annex 2-7e. Results of the ERA scoping showed that the level of ERA coverage for the SIDC Project is *Risk Screening Level*. **Figure 4.2** shows the process and result of the ERA Scoping.

The level of ERA coverage is defined by the type of hazardous substance and the expected maximum inventory of this substance to be stored or handled at the project site at any one time. The levels of ERA coverage are as follows (*Annex 2-7e of the RPM of DAO 2003-30*):

- Level 2 – for facilities that will use, manufacture, process or store hazardous materials in excess of **Level 2** threshold inventory shall be required to conduct a Quantitative Risk Assessment (QRA) and prepare an Emergency/ Contingency Plan based on the results of the QRA;
- Level 1 – for facilities that will use, manufacture, process or store hazardous materials in excess of **Level 1** threshold inventory shall be required to prepare an Emergency/ Contingency Plan based on the worst-case scenario. The Plan shall be based on a Hazard Analysis study; and
- Risk screening level – specific facilities or the use of certain processes shall require the conduct of a risk screening study even if the projected or estimated inventory does not reach the threshold levels.

The Project is not expected to use, handle, transport, or store significant amounts of substances that are explosive, flammable, oxidizing, or toxic. It may use minimal amount of a flammable substance (acetylene gas) for welding purposes during the construction phase but the amount of the said substance will be below DENR Level 1 Threshold Inventory, which is 10 tons for extremely flammable substances.

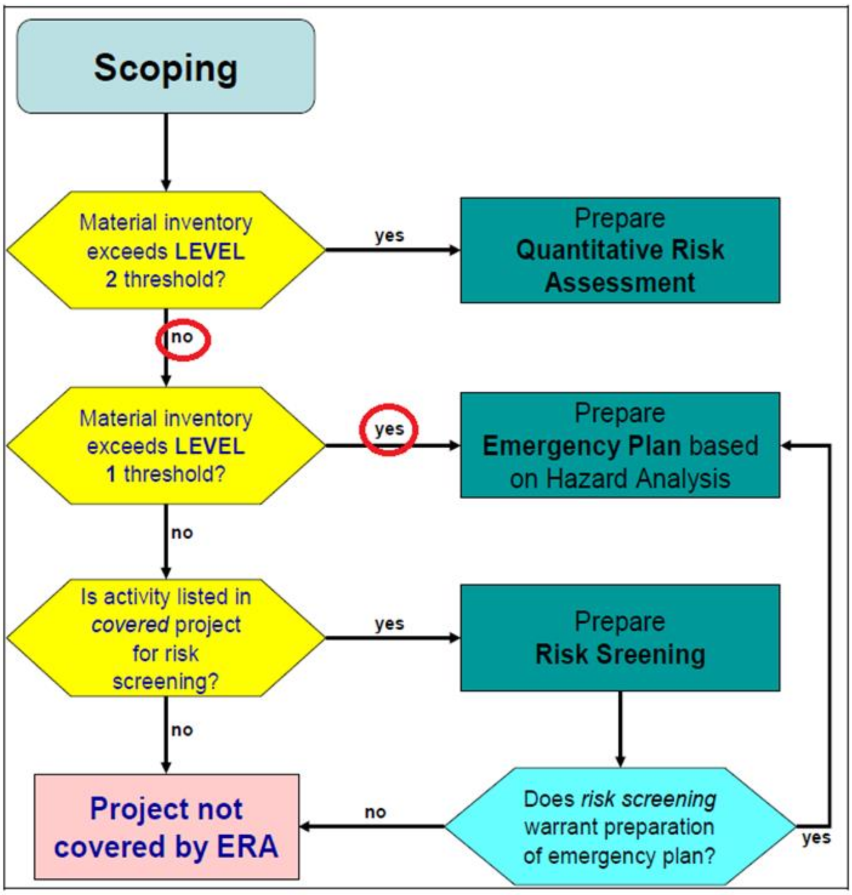


Figure 4.2 Result of ERA Scoping for the SIDC Project

4.4 Hazard Identification

Various hazards associated with the project were identified and reviewed for this risk assessment. These include physical, chemical, natural, internal and external hazards for the construction and operation phases of the project, as well as those associated with occupational health and safety. Emphasis was given to those that could result to damage and failure of structures, as well as to injury and fatality of SIDC workers and the general public – particularly bridge users.

Chemical hazards include those that have the potential to cause fires, explosions and toxic releases, which makes it imperative to identify all hazardous substances to be used, handled and stored during various project phases. Natural factors include earthquakes, extreme weather events, flooding, tsunami and storm surge. Internal factors include design errors, deficiencies in construction, material defects and lack of maintenance. External factors include sabotage and terrorism, mechanical impacts, overloading, fires and explosion and environmental degradation.

Table 4.4 presents 33 identified hazards associated with the project during the construction and operation phases, which were assessed in terms of risk, contributing factors and at-risk sectors. Hazards were rated as to their consequence severity (C) and their frequency or probability of occurrence (F) using 5x5 Rating Charts, as described in **Section 4.2** (Methodology).

Table 4.1 and **Table 4.2** show the consequence severity chart and the frequency of occurrence chart, respectively. Indicative risks were characterized by integrating the results of the Consequence Severity Rating (C) and the Frequency of Occurrence Rating (F) using a 5x5 Risk Rating Matrix as shown in **Table 4.3** in **Section 4.3**.

Table 4.4 SIDC Project Hazards List and Risk Characterization

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
A.	Construction Phase						
1	Construction vehicles and equipment movement, especially at locations where bridge intersects existing roads (Traffic accidents)	Traffic accidents (collision with other vehicles, hitting pedestrians and workers) Fatalities/ injuries	Human error Vehicle/ equipment malfunction Insufficient warning signages	Workers Pedestrians Assets	4	3	12
2	Working in areas adjacent to population centers or residential areas	Accident resulting to potential damage to property or injury/fatality	Human error Vehicle/ equipment malfunction	Residents/ general public Properties Personnel	4	3	12
3	Construction works in locations where there is live electric line or overhead power line	Electrocution		Workers	4	3	12
4	Collapse/malfunction of construction equipment and structures (e.g. construction cranes)	Damage to bridge structures under construction Possible fatalities/injuries Damage to nearby properties	Extreme weather events Earthquakes Collision/ mechanical impacts Lack of maintenance	Workers Assets Public	4	3	12
5	Storage and use of flammable liquids and gases (e.g. liquid fuels, acetylene gas)	Fire/ Explosion accidents Injuries, possible fatalities, Damage to bridge structures and other assets	Spillage of fuel and subsequent ignition Mechanical impacts on fuel tanks/ cylinders	Workers Public Assets Environment	4	3	9

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
6	Collision/ mechanical impact upon bridge structure from ships, trucks and large debris	Damage to bridge structures that could lead to its failure/ collapse Fatalities/ injuries	Human error Tsunamis Extreme climate events	Workers Public Assets	5	3	15
7	Design errors, deficiency in construction, material defects	Damage to bridge structures that could lead to bridge failure/ collapse Fatalities/injuries Damage to properties	Failure to follow current construction standards and codes Erroneous analysis Inadequate supervision and monitoring of construction Lack of quality control for materials	Workers Public Assets	5	3	15
8	Extreme climate events (very strong typhoons, torrential and prolonged rains, floods, storm surge)	Damage to bridge structure that may lead to its failure/ collapse Work stoppage and interruptions Delays to the project Damage to construction equipment and installed facilities Additional cost for remedial	Natural events Climate change factors	Workers Public Assets	5	3	15
9	Earthquake hazards (ground shaking, subsidence, landslides, lateral spread, ground rupture, tsunamis, etc.)	Damage to bridge structures that may lead to bridge failure/ collapse Work stoppage and interruptions Fatalities/ injuries	Natural event Davao area is transected and affected by several fault systems	Workers Public Assets	5	3	15

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
B.	Occupational Hazards during Construction Phase						
10	Working near moving vehicles, equipment and equipment parts	Struck by vehicles/ construction equipment Fatalities/ injuries	Human error Vehicle/ equipment malfunction Inadequate lighting	Workers	4	3	12
11	Working at height	Fall leading to fatality or injury	Inadequate PPE Inadequate guards Lack of training	Workers	4	3	12
12	Electrical contact	Electrocution, electrical shock, burns	Inadequate PPE Damaged electricals Lack of training	Workers	4	3	12
13	Working over/ near water	Fall into water that may cause drowning	Inadequate PPE Inadequate training	Workers	4	3	12
14	Working near moving equipment/machinery parts or between moving equipments	Caught-in Equipment or Object Injury/ Fatality	Inadequate machine guards Inadequate training Inappropriate work clothes	Workers	4	3	12
15	Working near moving vehicles, equipment	Being ran over, backed over or struck	Driver/operator error Inadequate training Failure to follow SOPs Inadequate PPEs	Workers	4	3	12
16	Exposure to harmful substances and agents (e.g. cement and sanding dusts, welding and brazing fumes,	Occupational diseases (e.g. silicosis, metal fever, blindness, burns, contact dermatitis, etc)	Inadequate PPE Lack of training Inadequate housekeeping	Workers	3	3	9

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
	welding radiation, paint fumes, corrosives, degreasing solvents, oils and lubricants, hot surfaces, etc.)	Chemical burns Burns	Unsafe work practices				
17	Uneven, slippery or irregular surfaces	Slips, trips and falls	Inadequate housekeeping Inadequate PPEs Lack of training Heavy rains	Workers	2	3	6
18	Working near or in deep excavations	Fall into excavation	Inadequate guarding Inadequate warning signages Inadequate PPEs Not fit to work (drunk, sick, sleepy, etc)	Workers	4	2	8
19	Working under water (for divers)	Drowning, Bends (decompression) sickness	Inadequate PPEs Inadequate training Failure to follow SOPs Unsafe work practices	Workers	4	3	12
20	Exposure to high level noise	Hearing loss or impairment stress	Inadequate hearing PPEs Failure to follow SOPs	Workers	3	2	6
21	Operation of tools and equipment	Cuts in body parts Mechanical impacts Body parts caught in machine Crushing of body parts and other injuries	Inadequate training Inadequate PPEs Inappropriate work clothes Inadequate machine guards Inadequate warning signages	Workers	4	3	12

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
		Burns from hot surfaces Eye damage from welding arcs	Failure to follow SOPs				
22	Ergonomic hazards (heavy lifting, prolonged standing, repetitive movement, awkward postures, etc.)	Bodily injuries Stress	Inadequate training Inadequate rest periods Prolonged exposure to unsafe work conditions	Workers	2	3	6
23	High impact vibration from operation of hand-held drilling equipment and other vibrating tools/equipment	Hand-arm vibration syndrome (HAVS) Stress	Inadequate equipment maintenance Prolonged exposure to high impact vibrations	Workers	3	3	9
24	Falling/flying debris and large objects from loose construction materials and equipment parts or rock falls	Hit by falling/flying objects	Inadequate housekeeping Inadequate PPEs Unsafe work practices	Workers Assets	4	3	12
C.	Operational Phase						
25	Movement of Vehicles on the bridge	Traffic accidents (collisions, hitting pedestrians, etc.)	Unsafe actions of drivers Vehicular malfunction and deficiencies Inefficient traffic system	Commuting public and bridge users Assets	4	3	12
26	Collision/ mechanical impact on bridge structure from ships, vehicles, large debris	Damage to bridge structures that may lead to bridge failure Fatalities/ injuries	Human error Tsunamis Extreme climate events (very strong typhoons)	Bridge users Drivers/ operators and passengers of ships and vehichles Public	5	3	15

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
			Floods	Assets			
27	Fire/ Explosion resulting from transport accident on the bridge (e.g. overturning of fuel tanker resulting to fire)	Damage to bridge structurers that may predispose to bridge failure Fatalities/ injuries	Human error Extreme climate events (strong winds, heavy rains) Unsafe driving parctices Transport accidents (collision, etc.)	Bridge users Drivers and passengers of vehichles Public Assets	5	2	10
28	Erosion of stream bed or bank materials from bridge foundations (scouring)	Damage to bridge structurers that may predispose to bridge failure	Floods Water pressure Floating debris Lack of maintenance	Bridge users Drivers and passengers of vehichles Public Assets	5	3	15
29	Environmental degradation of bridge structures (e.g. corrosion of steel components by airborne chloride, metal fatigue)	Damage to bridge structurers that may predispose to bridge failure	Airborne chlorides and other environmental corrosives Inadequate maintenance	Bridge users Drivers and passengers of vehichles Public Assets	5	2	10
30	Overloading of bridge (bridge design load capacity is exceeded)	Damage to bridge structurers that may predispose to bridge failure	Inadequate design of bridge capacity Failure to properly project traffic characteristics at the bridge Overloaded trucks	Bridge users Drivers and passengers of vehichles Public Assets	5	3	15
31	Earthquake/Seismic Hazards (ground shaking, subsidence, landslides, lateral spread,	Damage to bridge structures that may lead to bridge failure/ collapse Fatalities/ injuries	Natural event Davao area is transected by several fault systems	Bridge users Public Assets	5	3	15

HN	Activity / Hazard	Consequence/ Risk	Causes/ Contributing Factors	At Risk Sectors	C	F	Risk*
	ground rupture, tsunamis, etc.)						
32	Extreme climate events (increased frequency and intensity of typhoons, storm surge, torrential and prolonged rains during rainy seasons, floods)	Damage to bridge structure that may lead to bridge failure Unsafe transport route (slippery, high winds, etc) that may predispose to transport accidents Fatalities/injuries Additional cost for remedial	Natural events Climate change factors	Bridge users Public Assets	5	3	15
33	Terroristic attacks and/or sabotage of bridge	Major damage that may lead to bridge failure/collapse Fatalities/ injuries to people	Inadequate security Peace and order problems	Bridge users General Public Assets	5	2	10

4.5 Severity Analysis

Consequence severity analysis involves the qualitative description of possible impacts on people, assets and the environment in case of occurrence of accidents or incidents due to the identified hazards. Accident or consequence is graded according to a Consequence Severity Rating Chart as shown in **Table 4.1** in Section 4.2.1**.** The rating ranges from 1 to 5, 1 being the lowest consequence and 5 as the highest consequence severity. Results of the consequence severity ratings are shown in **Table 4.4** in **Section 4.4**.

4.6 Probability/ Frequency Analysis

Probability/frequency analysis of accidents or incidents due to realization of project hazards were described using a Probability of Occurrence Rating Chart as shown in **Table 4.2** in Section 4.2.2**.** Probability (frequency) were assigned with values ranging from 1 to 5, with the value of 1 corresponding to the lowest probability value and 5 having the highest probability value. Results of the frequency analysis ratings are shown in **Table 4.4** in Section 4.4.

4.7 Risk Characterization

Risk characterization involved the integration of the results of the consequence severity analysis and consequence probability analysis. For purposes of risk prioritization, indicative risk (IR) values were computed for each identified hazard by computing the product of the severity rating and probability rating values. **Table 4.3** (Section 4.2.3) shows the guide for interpreting the risk matrix. Results of the risk ratings for the various hazards are shown in **Table 4.4** (Section 4.4).

The identified hazards associated with the SIDC project have the potential to result either to medium risks (24 of the 33 hazards) or high risks (9 of the 33 hazards).

Damage to bridge structures predisposing to bridge failure or collapse is the main high-risk factor associated with the SIDC project with potential consequence, at worst case, of multiple fatalities and total bridge failure. There are eleven (11) hazards contributing to bridge damage, nine (9) of which are high risk and the other two (2) medium risk.

4.7.1 Risk of damage to bridge structures

As described above, damage to bridge structures resulting to partial or total bridge failure/collapse with multiple injuries and fatalities was identified as the main high-risk factor of the SIDC Project. The economic consequences of such an event is not limited to the cost of the damaged bridge and its replacement but also includes the cost of services and goods that fail to be transported and the loss of time in the process. Nine (9) hazards were identified to contribute to bridge damage and failure, four (4) of which are during construction phase and the remaining five (5) during the operations phase of the project (refer to **Figure 4.3**).

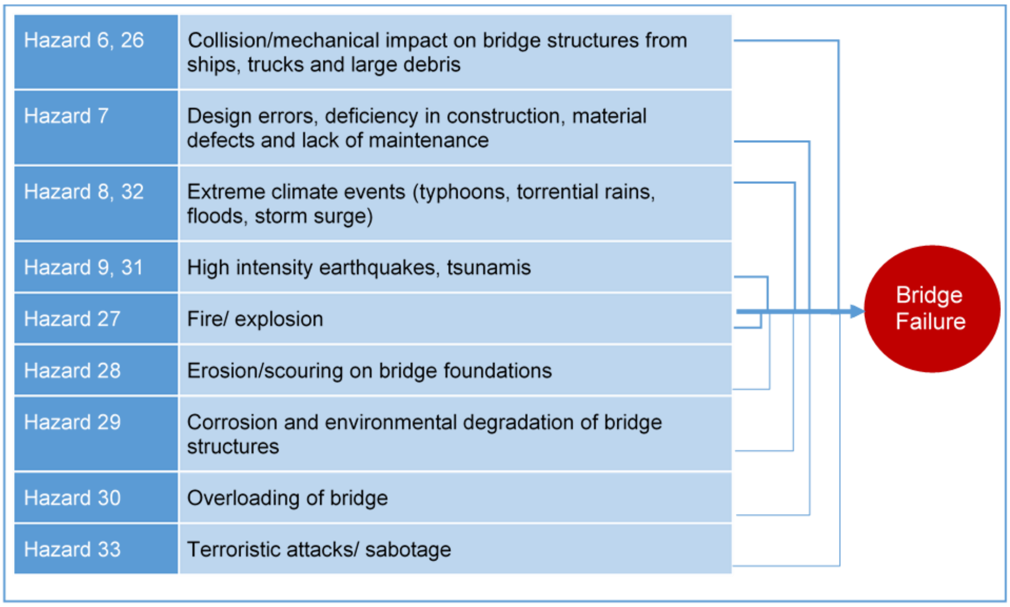


Figure 4.3 Risk of damage to bridge and associated hazards

A study conducted by Lee et al. (2013) on bridge failures/collapse within the period 1980 to 2012 revealed that of the total of 1,062 bridges that collapsed/failed within the period, the five leading causes of failures were the following factors: floods (28.3%), scour (18.8%), collision (15.3%), overload (12.7%), and internal causes (11.1%). Internal causes include the following factors: faulty design, error in construction, low quality materials, and lack of maintenance. The other factors that contributed or caused bridge failures are the following: environmental degradation (6.7%), fire (2.8%), earthquakes (1.9%), wind (1.6%), and others (0.7%). The study included incidents of collapsed bridges worldwide but mostly focused on the North American region (Lee, 2013).

Flooding

As shown in the study by Lee et al. (Lee, 2013), floods rank number one in factors that cause the collapse of bridges. Floods can result from torrential rains and typhoons that have been made frequent and more intense by climate change. Davao City has been affected by several extreme flooding incidents recently. The land viaducts of the project can be exposed to floods. Floods can collapse a bridge in several ways. A common cause is the gradual erosion of earth and soil around the piers of the bridge. Bridges can also collapse if struck by large debris (cars, trees, houses, etc.) carried by high velocity floods. The following factors has been identified as contributing to bridge failures due to floods:

- Erroneous estimates of the magnitude of floods in the area during the bridge design stage due to lack of hydrological data
- Insufficient knowledge of the hydraulics of flow through bridge waterways and around bridge piers
- Lack of reliable methods for estimating scour at bridge piers, and
- Lack of or erroneous prediction of the occurrence of and impact of debris accumulation against bridge structures

Based on MGB's combined flood and landslide susceptibility map of Davao City, the project alignment will cross sections that are moderately and highly susceptible to flooding. This was confirmed by field inspection. Flooding in the area could be due to the lack of drainage canals to efficiently remove storm waters, its proximity to the water line, and the low elevation of the site (refer to **Section 2.1.2**).

Very Strong Typhoons

Aside from the floods that may result from typhoons, strong wind is a disastrous component to infrastructures, including bridges. In the case of Hurricane Katrina that struck the USA in 2005, for example, 29 bridges collapsed as a consequence. In addition, another 17 bridges collapsed in the USA due to impacts of wind from 1980 to 2012 (Lee, 2013). Typhoons play a major role in the collision of ships and other sea vessels upon bridge piers. The Philippines, including Davao City and Samal Island, is subjected to several typhoons per year. As a consequence of climate change, some of these typhoons, as in the case of super typhoon Yolanda with its associated storm surge, can be very disastrous to infrastructure. Discussion of tropical cyclones and typhoons are discussed in **Section 2.3.1** of this report.

Scouring around Bridge Foundations

Scouring is the erosion of stream beds or bank material from bridge foundations due to the action of water flows. In the case of the SIDC project, water action on bridge foundations may be expected from tidal flows and currents, as well as from floods. Integration of this factor in the bridge design, as well as regular inspection and corrective action, are key in maintaining bridge integrity.

Collision upon Bridge Piers and Foundation

Collision from ships, barges and other sea vessels may happen on bridge foundations of the marine viaducts and extradosed components of the bridge. Collisions may be triggered by losing control of the vessel due to strong winds, vessel malfunction or human error. On the land viaducts, the mechanical impacts or collisions from moving trucks, vehicles or tankers may cause enough damage to the bridge integrity and cause it to fail. This may be exacerbated especially through cascading events such as prior exposure of foundations to fire, explosion or scouring.

Earthquake/ Seismic Hazards

Seismic hazards include the following: ground shaking, ground rupture, liquefaction, landslides, rock falls and tsunami. The Davao-Samal areas are affected by several earthquake generators, the more significant of which are the following: the Central Davao Fault System, the Mati and Compostela Segments of the Philippine Fault Zone, and the Philippine Trench. As such, earthquake/seismic hazards should be significant considerations in the engineering design and monitoring of the project. More recently, Davao City was adversely affected by a series of earthquakes this year that originated from a fault system in the Tulunan, North Cotabato area. Davao City sustained several damaged buildings and injuries to people from the impacts of the North Cotabato-originating recent earthquakes (M5.6 on July 9, M6.3 on Oct. 16, M6.6 on Oct. 29, and M6.5 on Oct. 31 all in 2019) (Sabillo, 2019) (PHIVOLCS, 2019).

The nearest earthquake generator to the project site is the Central Davao Fault System, a fault system comprised of five (5) segments, namely the Tamugan Fault, Lacson Fault, Dacudao Fault, Pangyan-Biao Escuela Fault and the New Carmen Fault. The fault system may generate earthquakes greater than Magnitude 6.5. It is worth mentioning that on September 2, 2019, PHIVOLCS launched the *Earthquake Atlas for Building Resiliency in Metro Davao* to "prepare Metro Davao for the Big Ones" and "to aid engineers in the earthquake-resilient design of buildings and structures" (PHIVOLCS, 2019) (Revita, 2019).

Ground Shaking. The most noticeable effect of an earthquake is ground shaking or acceleration, which is usually measured in a particular area in terms of intensity scale. The impacts of ground motion on objects above ground can also be measured through peak ground acceleration. Among the earthquake hazards, ground shaking is usually the most destructive earthquake effect on rigid civil projects. Seismic waves may manifest as up and down or sideways vibrations, both of which may cause significant stresses to rigid structures like concrete and steel. Instability and damage that could lead to eventual collapse and destruction to structures could result in the event that allowable thresholds of dynamic movement of said structures are exceeded by the ground movement.

Based on the earthquake model generated by PHIVOLCS for the Davao City area, a Magnitude 7.3 (M7.3) earthquake originating from the Philippine Fault Zone (PFZ) is expected to produce a destructive ground shaking of Intensity 7 (Philippine Earthquake Intensity Scale, PEIS) at the proposed project site. The PFZ has a history of generating high-magnitude earthquakes of ≥M7.0. A Magnitude 7.9 earthquake originating from the Philippine Trench near the Davao area, on the other hand, is expected to produce very strong and destructive ground shaking at the project site. Philippine Trench, a subduction zone that runs along the eastern offshore area of Mindanao Island, may generate earthquakes of greater than M7 (refer to **Section 2.1.2**).

Liquefaction. Liquefaction is a destructive phenomenon wherein an earthquake causes the ground to behave like fluid due to the increased pore pressure brought about by the dynamic movement of the different sand grains. This phenomenon may occur in low-lying, water-saturated and sandy areas near banks and shorelines. It may manifest as subsidence or sand boils. Liquefaction can cause the damage and collapse of structures that are on the affected ground. Based on the PHIVOLCS Liquefaction Potential Map of the Philippines, the Davao side of the SIDC Project is within a zone that is prone to liquefaction (refer to **Section 2.1.2**).

Subsidence and Lateral Spread. Earthquake events may cause the horizontal movement of soil layers, a destructive phenomenon known as lateral spread. This earthquake phenomenon usually takes place in areas with thick soil profile that are bounded by slopes. Though the Samal end of the project features an almost vertical terrace risers, the thin soil profile at the site will not result to significant lateral spreads during earthquake events. The relatively gentle slopes at the Davao City side of the project is not conducive to lateral spreads. However, the submarine areas within the Pakiputan Strait features a relatively steeper slope based on bathymetry data. Its susceptibility to horizontal movement downslope will depend on the thickness of sediment, which will be determined during the detailed geotechnical assessment.

Subsidence or ground settlement resulting from earthquake events is brought about by consolidation of underlying sediments or the collapse of subsurface cavities. This phenomenon is not expected to affect the Davao City side of the SIDC Project. The Samal end of the project, however could be highly susceptible to dissolution and subsidence, as it is underlain by limestone or carbonate rocks. During the geological assessment of the project site, one sinkhole was identified adjacent to the location of the alignment. Also, areas along the coastline exhibit clear indications of limestone dissolution features, as manifested by a cave system at the Samal end. Furthermore, based on the Karst Subsidence Mapping by the MGB Regional Office 11, the majority of the areas within Samal Island is highly susceptible to karst subsidence refer to **Section 2.1.2**).

Tsunamis. Tsunamis may result as a consequence submarine earthquake events, volcanic eruptions or landslides. The transect of the SIDC project crosses the Pakiputan Strait which is bounded by the shores of Davao City and Samal Island. The site is prone to trench, local and distant tsunami events. Thus, mitigation measures such as breakwaters or wave dissipating block and coastal structures should be considered (refer to **Section 2.1.2**).

4.7.2 Medium risk factors during the construction phase

Medium risk factors during the construction phase were identified, as follows: traffic accidents, damage to nearby properties, electrocution, fire/explosion accidents from stored flammables and occupational risks. Occupational hazards/risks include the following: struck by construction vehicles/equipment, fall from heights, electrocution, electrical shock, electrical burns, fall into water and drowning, caught in equipment or object, ran over, backed over by construction vehicles or equipment, occupational diseases, slips, trips and falls, fall into excavation, drowning, bends sickness (decompression sickness) from diving, hearing impairment, cuts, burns, crushing injuries, eye damage; ergonomic injuries and diseases; and hand-arm vibration syndrome (HAVS).

4.7.3 Medium risk factors during the operation phase

Medium risk factors during the operations phase were identified, as follows: traffic accidents on the bridge, fire/ explosion accidents from fuel carrying tankers/ vehicles, environmental degradation of bridge structures and terroristic attacks and sabotage.

4.8 Risk Management

The risk assessment showed that potential inherent (unmitigated) risks from the project are high and must be prevented and/or controlled with the application of appropriate mitigation measures. Measures for the prevention and control of project-associated risks should be specified in the risk management and emergency plan of the SIDC project, including capability-building (if required) and resources.

The identified risks should be managed and reduced to as low as reasonably practicable (ALARP). Reasonable in this context means a balance between the benefits of increased safety, environmental protection or lives saved and the costs involved in the process of risk reduction. Major considerations in risk reduction are:

- Appropriate infrastructure design of the bridge that takes into consideration resilience for earthquakes, tsunamis, floods, storm surge, high winds, and load projections, among other factors
- Compliance with local, national and international design standards and building codes for bridges and highways (construction and operation)
- Quality control of construction materials and close supervision and monitoring of construction processes/activities
- Regular and timely inspection and maintenance of the infrastructures and facilities
- Installation and proper maintenance of safety systems (e.g. traffic signaling and control systems)
- Well-trained and motivated workers
- Use of appropriate construction equipment and personal protection equipment to keep workers safe
- Adequate supervision and monitoring of workers to ensure compliance with safety systems and standard operating procedures
- Conduct of necessary training and drills especially for emergency situations (e.g. earthquake, tsunamis, fire, bomb threats, work accidents) among the entire workforce, and
- Establishment of appropriate emergency response and contingency systems

4.9 Summary and Recommendations

As previously described and discussed, a total of 33 hazards were identified to be associated with the project during construction and operation, that have the potential to result either to medium risks (24 of the 33 hazards) or high risks (9 of the 33 hazards). Damage to bridge structures that could predispose to partial or total bridge failure/collapse was identified as the main high-risk factor of the SIDC Project. Its worst-case consequence is multiple fatalities and injuries and total bridge failure or collapse.

Hazards that could contribute or bring about the identified risk are the following:

- Design errors, deficiency in construction, material defects and lack of maintenance
- Collision/mechanical impact on bridge structures from ships, trucks and large debris
- Extreme climate events (typhoons, torrential rains, floods, storm surge)
- High intensity earthquakes, tsunamis
- Fire/ explosion
- Erosion/scouring on bridge foundations

- Corrosion and environmental degradation of bridge structures
- Overloading of bridge, and
- Terroristic attacks/ sabotage

Measures for the prevention and control of project-associated, particularly recommendations to mitigate and manage these hazards, are presented in **Table 4.5** in the next page. The risks should be managed and reduced to as low as reasonably practicable. Reasonable in this context means a balance between the benefits of increased safety, environmental protection or lives saved and the costs involved in the process of risk reduction.

Table 4.5 Identified Hazards and Risks and Corresponding Recommended Mitigating Measures

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
A.	Construction Phase		
1	Construction vehicles and equipment movement, especially at locations where bridge intersects existing roads (Traffic accidents)	Traffic accidents (collision with other vehicles, hitting pedestrians and workers) Fatalities/ injuries	Safety barriers (e.g. fence) and signages Traffic management (including ingress/egress of vehicles at construction site), including properly trained personnel to manage traffic flow (i.e. banksman) Authorised road closures Implement pedestrian walkways Ensure that contractor’s vehicles, trucks an equipment are of good working condition through timely inspections of construction sites Ensure that the contactor employs properly trained crew and operators, especially drivers of large equipment like cranes and earth moving vehicles.
2	Working in areas adjacent to population centers or residential areas	Accident resulting to potential damage to property or injury/fatality	Safety barriers (e.g. fence) and signages
3	Construction works in locations where there is live electric line or overhead power line	Electrocution	Safety barriers and signages Coordination with local power utility to provide power isolation, if required. Awareness training/briefing of construction personnel Working method to ensure safe distances from electric/power line can be maintained at all times.
4	Collapse/ malfunction of construction	Damage to bridge structures under construction	Training and drills on emergency preparedness Use of appropriate and well-maintained equipment

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
	equipment and structures (e.g. construction cranes)	Possible fatalities/injuries Damage to nearby properties	Provision and use of appropriate PPEs Safety barriers and signages
5	Storage and use of flammable liquids and gases (e.g. liquid fuels, acetylene gas)	Fire/ Explosion accidents Injuries, possible fatalities, Damage to bridge structures and other assets	Proper fuel storage – liquid fuel tanks to be provided with secondary containment Good housekeeping Fire protection system
6	Collision/ mechanical impact on bridge structure from marine vessels and trucks	Damage to bridge structures that could lead to its failure/ collapse Fatalities/ injuries	Coordinate with and orient officers of safety vessels of ongoing bridge construction Install visibility signal lights and other signages to alert approaching marine vessels or vehicles of ongoing construction Stop construction activities during extreme climate events
7	Design errors, deficiency in construction, material defects	Damage to bridge structures that could lead to bridge failure/ collapse Fatalities/injuries Damage to properties	Appropriate infrastructure design of the bridge that takes into consideration resilience to earthquakes, tsunamis, floods, storm surge, high winds, and load projections, among other factors Compliance with local, national and international design standards and building codes for bridges and highways (construction and operation) Quality control of construction materials and close supervision and monitoring of construction processes
8	Extreme climate events (very strong typhoons, torrential and prolonged rains, floods, storm surge)	Damage to bridge structure that may lead to its failure/ collapse Work stoppage and interruptions leading to delays in construction targets	Appropriate bridge infrastructure design that considers factors for floods, storm surge and high winds (design for adequate drainage, water diversion in flood prone areas) Compliance with design and construction standards and codes Regular and timely inspection and maintenance of the infrastructures, equipment and facilities (particularly drainage water diversion systems, bridge piers and foundation) Installation and proper maintenance of safety systems (e.g. Emergency warning systems etc.) Formulate and disseminate Emergency Preparedness Plan, Evacuation Plan and SOPs to all workers and personnel

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
			Conduct of regular emergency preparedness training and drills, which includes earthquake events, for all workers and personnel Stop construction activities during adverse weather conditions
9	Earthquake hazards (ground shaking, subsidence, landslides, lateral spread, ground rupture, tsunamis, etc.)	Damage to bridge structures that may lead to bridge failure/ collapse Work stoppage and interruptions and delays in construction targets Fatalities/ injuries	Appropriate bridge infrastructure design with due consideration to earthquake resilience and seismicity in the area Compliance with design standards and codes (construction and operation) Regular inspection and maintenance of the infrastructures, equipment and facilities; Installation and proper maintenance of safety systems (e.g. Emergency warning systems etc.) Formulate and disseminate Emergency Preparedness Plan, Evacuation Plan and SOPs to all workers and personnel Conduct of regular emergency preparedness training and drills, which includes earthquake events, for all workers and personnel Provision of easily accessible emergency equipment and kits Stop construction activities during earthquakes and implement evacuation procedures
B.	Occupational Hazards during Construction Phase		
10	Working near moving vehicles and equipment	Struck by vehicles/ equipment parts Fatalities/ injuries	Train workers on occupational hazards and safety Regular and timely maintenance of vehicles and equipment Provide adequate lighting during night time work PPEs- hard hats, visibility safety vests, etc.
11	Working at height	Fall leading to fatality or injury	Training of workers Safety barriers and signages Approved scaffold designers Use of fall arrest system (e.g. nets) PPE - hard hats, safety harness

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
12	Electrical contact	Electrocution, electrical shock, burns	Safety barriers and signages to isolate high voltage areas Coordination with local power utility to provide power isolation, if required. Awareness training/briefing of construction personnel Working method to ensure safe distances from electric/power line can be maintained at all times Appropriate PPEs for electrical workers (e.g. electricity resistant gloves, shoes, aprons, etc.)
13	Working over/ near water	Fall into water that may cause drowning	Training of workers Safety barriers and signages Use of appropriate equipment to keep workers safe Swimming skills for workers to work over water Provision and use of appropriate PPEs – safety harness, etc. Easily accessible emergency water rescue equipment and team
14	Working near moving parts of equipment or objects	Caught-in Equipment or Objects Injury/ Fatality	Training of workers on occupational hazards and safety Ensure installation of machine guards Appropriate work clothes to prevent entangling of clothes on machine parts
15	Working near moving vehicles, equipment	Being ran over, backed over or struck	Training of drivers and equipment operators Safety barriers and signages PPEs – safety vests for easy visibility
16	Exposure to harmful substances and agents (e.g. cement and sanding dusts, welding and brazing fumes, welding radiation, paint fumes, corrosives, degreasing solvents, oils and lubricants, hot surfaces, etc.)	Occupational diseases (e.g. silicosis, metal fever, blindness, burns, contact dermatitis, etc) Chemical burns Burns	Training/briefing of workers/personnel on occupational hazards Use materials with the least hazardous chemical content (e.g. no lead paints, no or minimal asbestos, no PCBs, no mercury, etc.) Ensure proper segregation, storage and disposal of spent hazardous materials Provision of PPE to workers engaged in hazardous activities (e.g. welding masks and goggles, respirators and goggles for sanders and painters, etc.)

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
17	Uneven, slippery or irregular surfaces	Slips, trips and falls	Safety barriers and signages Good housekeeping PPEs – non-slip safety shoes, hard hats, etc.
18	Working near or in deep excavations	Fall into excavation	Training of workers Safety barriers and signages Approved scaffold designers Use of fall arrest system (e.g. net PPE - hard hats, safety harness
19	Working under water	Drowning, Bends (decompression) sickness	Workers/personnel to engage in underwater work should be trained divers Provide appropriate diving equipment and gears Training/briefing of workers on diving and safety procedures Accessible emergency rescue equipment and personnel
20	Excessive noise levels	Hearing loss or impairment to workers and other receptors Stress to people Public complaints Environmental violations that could lead to restrictions from DENR, delays on project	Provide hearing protective PPEs for exposed personnel/workers Proper maintenance of equipment to reduce noise Isolate noisy equipment Avoid noisy construction activities during night time
21	Operation of tools and equipment	Cuts in body parts Mechanical impacts Body parts caught in machine Crushing of body parts and other injuries Burns from hot surfaces Eye damage from welding arcs	Training/briefing of workers All equipment and tools to be handled in accordance with safety procedures. Use battery powered tools or low voltage equipment Regular maintenance of tools and equipment. Guards in place Provision and use of appropriate PPEs Install warning signages as necessary Provide easily accessible emergency and medical equipment and kits
22	Ergonomic hazards (heavy lifting, prolonged standing, repetitive movement, awkward postures, etc.)	Bodily injuries Stress	Training on appropriate body mechanics at work (e.g. proper lifting, etc.) Rotation of workers to reduce exposure time for stressful and unsafe work conditions Observe appropriate break times and rest periods

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
23	High impact vibration from operation of hand-held drilling equipment and other vibrating tools/equipment	Hand-arm vibration syndrome (HAVS) Stress	Use of appropriate and well-maintained equipment Rotation of workers to reduce exposure time Observe appropriate break times and rest periods PPE's – hand/arm guards, etc.
24	Falling/flying debris and large objects	Hit by falling/flying objects	Good housekeeping PPEs – hard hats, safety googles, safety shoes, etc. Train workers on occupational hazards and safety
C.	Operational Phase		
25	Movement of Vehicles on the bridge	Traffic accidents (collisions, hitting pedestrians, etc.)	Install traffic signages and signalling system (traffic lights, etc.) Deploy traffic officers near or along the bridge to monitor and ensure compliance to traffic regulations
26	Collision/ mechanical impact on bridge structure from ships, vehicles, large debris	Damage to bridge structures that may lead to bridge failure Fatalities/ injuries	Coordination with and orientation of officers of ships and barges that may pass through or near the bridge on safety procedures Coordination with the Coast Guard to ensure safety of marine bridge piers and foundations Install visible signal lights and signages on bridge piers and on the bridge to alert approaching marine vessels
27	Fire/ Explosion resulting from transport accident on the bridge (e.g. overturning of fuel tanker resulting to fire)	Damage to bridge structurers that may predispose to bridge failure Fatalities/ injuries	Implement appropriate speed and tonnage limits on the bridge Regulate passage of fuel tankers and carriers through the bridge during extreme weather conditions Regular inspections of land viaducts to ward off squatters who may reside under the bridge
28	Erosion of stream bed or bank materials from bridge foundations (scouring)	Damage to bridge structurers that may predispose to bridge failure	Appropriate infrastructure design, material and construction Regular inspection for scouring and implement maintenance and/or rehabilitation as needed
29	Environmental	Damage to bridge structurers that may	Appropriate infrastructure design, material and construction

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
	degradation of bridge structures (e.g. steel corrosion by airborne chloride, metal fatigue)	predispose to bridge failure	Regular and timely inspection (e.g. signs of corrosion, cracks, etc.), maintenance and/or rehabilitation as needed
30	Overloading of bridge (bridge design load capacity is exceeded)	Damage to bridge structurers that may predispose to bridge failure	Appropriate infrastructure design that takes into consideration projections on traffic loads and other loads that will be imposed on the bridge Implement weight (tonnage) restrictions for vehicles passing the bridge. Install signage on tonnage at the approach of the bridge Regulate traffic volume on the bridge in accordance with the bridge’s load capacity
31	Earthquake hazards (ground shaking, subsidence, landslides, lateral spread, ground rupture, tsunamis, etc.)	Damage to bridge structures that may lead to bridge failure/ collapse Fatalities/ injuries Loss of transport route for bridge users and on the transport of goods and services	Appropriate bridge infrastructure design with due consideration to earthquake resilience and seismicity in the area Compliance with design and construction standards and codes (construction and operation) For tsunami and storm surge hazards: Install breakwaters or wave dissipating blocks and coastal structures Regular inspection and maintenance of the infrastructures, equipment and facilities; Installation and proper maintenance of safety systems (e.g. Emergency warning systems etc) Conduct of mandatory damage assessment after strong earthquake events. Conduct repairs and rehabilitation, as necessary Stop vehicles from passing through the bridge during earthquake events Formulate and implement appropriate contingency and evacuation plans
32	Extreme climate events (increased frequency and intensity of typhoons, storm surge, torrential and prolonged rains during rainy	Damage to bridge structure that may lead to bridge failure Unsafe transport route (slippery, high winds, etc) that may predispose to transport accidents Fatalities/injuries	Appropriate bridge infrastructure design that considers factors for floods, storm surge and high winds (design for adequate drainage, water diversion in flood prone areas) Compliance with design and construction standards and codes Regular and timely inspection and maintenance of the infrastructures, equipment and facilities (particularly bridge piers and foundation)

SN	Activity/ Hazard	Consequence/Risk	Recommended Control Measures
	seasons, floods)		Mandatory damage assessment of the bridge structures after strong typhoon, flooding, storm surge events Stop vehicles from passing through the bridge during extreme weather events Formulate and implement appropriate contingency and evacuation plans
33	Terroristic attacks and/or sabotage of bridge	Major damage that may lead to bridge failure/collapse Fatalities/ injuries to people	Deploy security personnel to monitor and secure the bridge perimeters, as necessary Follow security announcement/advice from government's (national and local) security agency

4.10 Emergency Response Policy and General Guidelines

4.10.1 Emergency Response and Disaster Preparedness Plan

DPWH must maintain comprehensive records of safety information (incidents, near –incidents, injuries etc). The information will not only be helpful for regulatory purposes but also for corporate management. An Emergency Response Plan (ERP) serves as a guide in carrying out what needs to be done during a disaster.

4.10.2 Objectives

This ERP has the following objectives:

- Provide the proponent, workers and the public with guidelines for responding to the different emergency situations;
- Prepare the employees with training for them to act efficiently during emergencies;
- Mitigate to reduce impact brought by the disaster;
- Safeguard the welfare of the public; and
- Seek assistance from LGUs related to disaster risk reduction

4.10.3 Definition of Emergencies

An emergency is a serious and an unexpected dangerous situation that needs immediate response. There are several factors that can help assess the magnitude of a specific emergency such as the nature, size and extent of the problem. In addition, the impact on people and the surroundings must be considered as well as the potential of the situation to elevate. The different risks brought by the various hazards of the proposed project is identified in this ERA.

4.10.4 Specific Emergencies

A hazard is referred to as something which could be dangerous. Specific hazards have different actions to be taken. Listed below are possible hazards and their respective emergency response procedures.

4.10.4.1 Earthquake

- Evacuate staff and people from places with falling objects windows
- Protect your head all the time while during evacuation
- Follow the duck cover and hold when there are no available exits
- Roll calls will be done to make sure that everyone is safe
- Inspect possible damages

4.10.4.2 Tsunami

- Dissemination of emergency warnings and information
- Guide people to the nearest evacuation areas or to high ground
- Restrict the access of people to impact areas

4.10.4.3 Flood

- If possible, unplug electric devices
- Move the people and important belongings to higher ground

4.10.4.4 Car Accident

- Contact the local hospital and police immediately
- Report the staff or officer in charge of the bridge

4.10.4.5 Bomb Threat

- Contact the local Police immediately
- Stay calm and do not announce it publicly to avoid stampede

4.10.4.6 Airplane accident

- Contact the Civil aviation authority of the incident
- Abrupt evacuation of people from the impact area

4.10.5 Plan Implementation

Each emergency has its own plan that must be executed accordingly. The general guidelines on how to deal with these events is shown in **Table 4.6**.

Table 4.6 Guidelines for emergency situations

Phase	Emergency Action Plan
Before an emergency	The proposed bridge must reduce the effects of hazards by providing emergency exit routes, firewall, sprinklers and early warning systems as part of mitigation, an emergency and medical kit must be prepared Evacuation routes should be well defined and known to passengers and personnel An on-site team leader should be pre-determined. Trainings and seminars shall be held such as proper use of Personnel Protective Equipment (PPE), First Aid, training in the handling of injured persons; training in rescue operation and fire-fighting. The proponent shall organize and conduct regular trainings and seminars with the help of professionals in safety and emergency management.
During an emergency	Alert officials and the public by turning on the siren or alarm in the event of a disaster The team leader must be in charge of evacuating the people Conduct rescue operation First aid must be administered to injured people Contact associated LGUs for help
After an emergency	Audit and investigate the cause of incident (if man made) Give financial help to those affected

4.10.6 Emergency Action Team (EAT)

An emergency action team is composed of assigned personnel who have specific roles and responsibilities to help in protecting the people before professionals arrive. The members of the EAT are listed below:

Team Leader – leads the public to safe areas and informs the supervisor of an emergency

Announcer – guides the people to emergency exit routes and alarms them of an emergency

Medic – treats injured people by applying first aid

Patrol – guards the safety of the public and helps alert them of emergencies

4.10.7 Emergency Contact Numbers

There must be a close coordination with the different organizations connected with disaster risk reduction management. Listed below are the different agencies that should be known and posted for the public.

Table 4.7 Contact persons for emergency situations in Davao City

Agency Resources/Contact Persons	Telephone No.
Local Government Agencies	
City Mayors Office	(082) 227 2500
Fire Station	(082) 224 0524

Agency Resources/Contact Persons	Telephone No.
Southern Philippines Medical Center	(082) 227 2731
Police Station	(082) 224 1313
Local Disaster Risk Reduction Management	(082) 295 2387
Proponent’s Staff	
Safety Engineer Or Pollution Control	TBD
Contractor’s Personnel	TBD
Project Manager	TBD
Site Engineer	TBD

Table 4.8 Contact persons for emergency situations in IGaCoS

Agency Resources/Contact Persons	Telephone No.
Local Government Agencies	
City Mayors Office	(+63) 917-135-6613
Fire Station	(+63) 9954882176
Hospital	
Provincial Police Station	(+63) 9173148754
Local Disaster Risk Reduction Management	(+63) 939459902
Proponent’s Staff	
Safety Engineer Or Pollution Control	TBD
Contractor’s Personnel	TBD
Project Manager	TBD
Site Engineer	TBD

5 Social Development Program/ Framework (SDP) and IEC Framework

5.1 Social Development Program (SDP)

The formulation of the project SDP was based on priority issues and concerns identified in the EIA study of the project and through a series of IEC and consultation activities in affected communities.

Major concerns expressed by project-affected people (PAP) are related to displacement of settlers and income, compensation, employment, livelihood, access and delivery of basic services and public health and safety.

Given these, presents proposed social development programs for the project particularly benefitting the host barangays with considerations of vulnerable persons such as fishers, senior citizen, women and children.

Table 5.1 Social Development Plan Framework

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of fund
Livelihood					
Income or restoration programs for affected fishers and small vessel operators	President of registered fishermen group President of small vessel operators Host Barangays	DPWH LGU (Davao and IGaCoS)	DPWH	Pre-construction	Proponent
Livelihood assistance for displaced settlers and ISFs	Host Barangays Displaced Settlers	DPWH LGU (Davao and IGaCoS)	DPWH	Pre-construction	Proponent
Skills and Training for vulnerable sectors	Host Barangays President of different registered sectors (i.e	DPWH LGU (Davao and IGaCoS)	DPWH	Pre-construction	Proponent LGU

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of fund
	women's group, senior citizens)				
Hiring of Qualified Locals	Host Barangays LGUs Residents of host barangays	DPWH LGU (Davao and IGaCoS)	DPWH	Pre-construction	Proponent
Health					
Barangay health centres Improvement (Host Barangays)	Barangay Kagawad for health Residents of host barangays	DPWH LGU (Davao and IGaCoS)	DPWH	Construction	Proponent LGU
Health and Sanitation Development Program		DPWH LGU (Davao and IGaCoS)	DPWH	Construction	Proponent LGU
Solid Waste Management Program	Barangay Kagawad for environment	LGU	DPWH	Construction	Proponent
Peace and Order	Host Barangays	LGU Philippine National Police	DPWH	Construction – Operations Phase	LGU and PNP
Education					
Educational assistance to qualified students	Barangay Kagawad for Education Barangay Captain of host barangays	Department of Education Barangay	DPWH	Construction – Operations Phase	Proponent LGU

5.2 Information and Education Campaign (IEC)

Information and Education Campaign (IEC) for the project will utilize the use of different forms of media to communicate with affected persons and all relevant stakeholders of the project.

Table 5.2 Information and Education Campaign

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
Affected Informal Settlers and Land Owners	Discussion of project and Resettlement Action Plan Understanding entitlements and Grievance Redress Mechanism Discussion of Project Timeline	Group meeting	Power Point Presentation Focus Group Discussion	After RAP Formulation and prior to start of construction	PHP 30,000
Host Barangays	Full Understanding of the Project Socio-economic benefits Health and Safety Risk of the Project Solid Waste Management	Group meeting	Power Point Presentation Focus Group Discussion	Prior to start of construction	PHP 30,000

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
Project Beneficiaries	Employment Opportunities Livelihood and Training Programs	Group meeting	Print, broadcast and interactive and social media Power Point Presentation Public Notices	After RAP Formulation and prior to start of construction	PHP 30,000
Business Owners and Employees Affected Vessels,	Affected Businesses Full Understanding of Projects including Mitigating Measures	Group meeting	Print, broadcast and interactive and social media Focus Group Discussion	After RAP Formulation and prior to start of construction	PHP 30,000

Target Sector Identified as Needing Project IEC	Major Topic/s of Concern in Relation to Project	IEC Scheme/ Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
Government agencies with related mandates	Full Understanding, Establishment of project representatives for monitoring of the project Presentation of project background and regular updates about the project Discussion of key roles during project construction and implementation	Group meeting	Key Informant Interviews	After RAP Formulation and prior to start of construction	PHP 30,000
Public – SIDC End Users	Project Updates	Group methods	Print, broadcast and interactive and social media	Quarterly prior to start of and during construction phase, Annually thereafter	PHP 30,000

6 Environmental Compliance Monitoring

This chapter presents the Environmental Monitoring Plan (EMoP) for the project based on possible impacts during the construction and operation phases, indicating the methodology, frequency and duration of monitoring activities, as well as the Environmental Quality Performance Level (EQPL) management scheme. The DPWH guarantees strict compliance to environmental laws, rules and regulations by conducting self-monitoring activities to ensure the careful implementation of sound environmental management practices. Furthermore, potential roles and responsibilities of the Multi-sectoral Monitoring Team, as well as the establishment of an Environmental Guarantee and Monitoring Fund are discussed in this section.

6.1 Self- monitoring Plan

As per Annex 2-20 of the Revised Procedural Manual (RPM) from DAO 2003-30, the self-monitoring plan is summarized in **Table 6.1** in the next page. On the other hand, the description of the EQPL is provided in the table below.

Table 6.1 EQPL Definition

EQPL Level	Description
Alert or Red Flag	Early warning
Action Level	Point where management measures must be employed so as not to reach the regulated threshold or limit level, or to reduce deterioration of affected environmental component to pre-impact or optimum environmental quality
Limit Level	Regulated threshold of pollutant (standard that must not be exceeded); point where emergency response measures must be employed to reduce pollutants to lower than standard limit.

It is worth noting that the EQPL component of the EMoP is filled out only if they are willing to be committed by the proponent at the pre-ECC stage. Otherwise, the proponent may opt to have EQPLs established post-ECC, which are then mutually agreed upon by the Proponent, EMB and other MMT members. Otherwise, only the Limit Level shall be the reference for regulatory compliance. This means that formulated environmental measures are not to exceed this regulated threshold.

In the case of the project, the EQPL component will be established post-ECC.

Table 6.2 Summary of Monitoring Plan (EMoP) with Environmental Quality Performance Levels (EQPLs)

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION PHASE													
General													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	2,000,000.00	One near miss accident	One recorded accident	Two recorded accidents	Assess the source of accident	Investigate the root cause of injuries	Temporary stoppage of work until incident properly assess and mitigated
General Construction works	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	1 no lost time injury	>1 no lost time injury	1 lost time injury	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Preparation and Construction of Temporary Facilities													
Site preparation, clearing, and/ or tree cutting activities	Displacement and loss of livelihood of residents and business owners during ROW land acquisition.	Resettlement Action Plan	Technical Review	Once	Project Management Office (PMO)	DPWH, Design Contractor;	Part of construction cost	Not applicable					
		Affected residents and land owners and corresponding compensation packages	Inventory and Survey	Quarterly	Direct and Indirect Impact Areas	DPWH, LGU	Part of construction cost	Not applicable					
		Employment records	Number of locals hired	Monthly	At construction site	Social Safeguard Specialist, PMO-DPWH	Part of construction cost	Increased number of unemployed affected people					
	Temporary disruption of public services, such as water and electric supply	Affected communities and businesses	Ocular inspection	Daily during preparation and construction	Direct Impact Areas	Project Contractor Proponent	Not Applicable	Formal complaint					
	Loss of topsoil due to vegetation clearing may trigger soil erosion and may induce landslides in some areas.	Soil and bedrock components	Geologic Investigation	After every major earthquake and during pile driving	At construction site	Project Engineer	Part of contract cost	Presence of cracks, vertical displacement and mass movement					

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Loss of vegetation during clearing operation (i.e. fruit bearing trees, and forest trees);	Terrestrial habitat and trees removed and planted making sure loss has been compensated; survival rate of introduced species	Ocular inspection; Tree count	Monthly	At construction site	PCO of the Contractor, DPWH-PMO, Biodiversity Management Bureau	Part of Contract Cost	Degradation/reduction of vegetative cover relative to the project site					
	Disturbance or loss of habitat and will affect existing wildlife	Inventory of lost habitats and affected population of certain fauna species	Fauna inventory and habitat logging	Quarterly	Davao and Samal Sites	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
	May trigger siltation	Volume of sediments stored or disposed	Volume estimation	Weekly	At construction site	Proponent	Part of contract cost	Degradation on its physical aesthetics due to accumulation of suspended sediments.					
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction and installation of site facilities – Temporary Facilities (field	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
offices and barracks)			accredited service provide										
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregatio n of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Degradation of water quality: Impacts on groundwater and freshwater quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
	Degradation of water quality: Impacts on marine water quality	Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100mL		Provision and repair of proper sanitary facility	
		Total coliform								10,000 MPN/100mL			
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction, bore piling and installation of piers and columns on land and marine – Permanent Structure													
Dredging and excavation on land and water; Earthmoving through use of heavy equipment; Operation of vessels Installation of columns/ foundations and construction of interchanges and bridge structure.	May trigger soil erosion and induce landslides in some areas (including impacts on Earthquakes, Ground settlement and lateral spread, Mass movements)	Detailed Engineering Design	Technical Review	Once	Project site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Geohazards	Measurement of displacement caused by geohazards in an area Size of flooded areas and flood heights	Geohazard survey	Quarterly	Project site	DENR-MGB/ DPWH Environment Officer	300,000.00	Not applicable					
	Liquefaction	Ground vertical displacement	Geologic Investigation	After every major earthquake and during pile driving	Project site	Project Manager	300,000.00	Not applicable					
	Ground subsidence (from solution cavities and caves)	Dissolution cracks and volume of solution cavities	Geologic Investigation	Quarterly	Project site – IGaCoS	Project Manager	300,000.00	Not applicable					
	Change in sub-surface geology and underground conditions due to the project, inducement of subsidence, karst subsidence, liquefaction and mass movements Damage or collapse due to strong ground shaking	Detailed Engineering Design	Technical Review	Once	Project Management Office	DPWH and Design Contractor	Incorporated as part of the design cost	Not applicable					

Project Activity	**Impact**	**Parameter to be Monitored**	**Sampling & Measurement Plan**			**Lead Person**	**Annual Estimated Cost (Php)**	**EQPL Management Scheme**					
			Method	**Frequency**	**Location**			**Environmental Quality Performance Level**			**Management Measure**		
								Alert	**Action**	**Limit**	**Alert**	**Action**	**Limit**
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregatio n of wastes	Monitoring of trash bins	Proper disposal of solid waste
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregatio n of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Impairment of visual aesthetics	Final Project Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Increase in flooding susceptibility	Detailed Engineering Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
		Size of flooded areas and flood heights	Geohazard survey	After every flooding event	At construction site	Proponent	Part of contract cost	Exceeded the carrying capacity of flood mitigating measures applied					
	May trigger siltation; Degradation of water quality due to oil, fuel or other lubricant agents leaks; Water Quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
		Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100m L		Provision and repair of proper	

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		Total coliform								10,000 MPN/100mL		sanitary facility	
	Traffic congestion	Traffic Management Plan	Monitoring and evaluation of TMP implementation	Daily during onshore construction	Project site	Project Contractor Proponent	Not Applicable	Formal complaint			Coordinate with LGUs on Traffic Management Reassess Traffic Management Plan		
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Dredging and excavation on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure	Seagrass in IGaCoS side are still abundant and thriving and may decline when buried by sediment.	Biodiversity Protection Plan's detail seagrass habitat creation and subsequent monitoring; translocated/ habitat relocated sites	Ecological inventory	Semi-annual	Davao and Samal Sites	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Local loss and disturbance of natural sedimentary habitats due to introduction of hard substrates and increase in sediment loads from construction materials; Deterioration, destruction and disruption of fish habitats in IGaCoS side	Monitoring and evaluation of benthic habitats to capture changes; Should there be any affected corals and seagrasses, coral translocations/ seagrass mitigation / translocation of any benthic species should be	Ecological inventory	Semi-annual	Davao and Samal Sites	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		undertaken by a suitably qualified marine ecologist.											
	Changes in channel beds and impacts on fish and aquatic life	Monitoring and evaluation of benthic habitats to capture changes based on Biodiversity Protection Plan	Ecological inventory	Semi-annual	Davao and Samal Sites	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
OPERATION PHASE													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
Hiring of local workers	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	2,000,000.00	One near miss accident	One recorded accident	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily
Operation of the bridge	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	1 no lost time injury	>1 no lost time injury	1 lost time injury	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Movement of passengers	Increase in solid waste generation from passengers and operational works	Proper management and disposal of wastes	Checking compliance to RA 9003 and RA 6969	Weekly	Project site	PMO	Part of the operation cost	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
Movement of vehicles along the bridge	Noise from vehicles may exceed national standards for noise in general areas	Noise levels	Noise monitoring	Daily	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects

6.2 Multi-Sectoral Monitoring Framework

6.2.1 MMT Composition

Based on DAO 2017-15, ECP as SIDC need to form a Multi-partite Monitoring Team (MMT) to promote greater stakeholder vigilance and appropriate check and balance mechanism in monitoring project impacts as well as encouraging the community to participate in environmental protection. The formation of MMT is initiated by the proponent (DPWH) through holding a meeting with the concerned EMB office. MMT shall be comprised of the following:

a. LGU representatives

   - 1 representative from MENRO/ CENRO and Provincial Government (PG) ENRO or Municipal/ Provincial Planning and Development Officer (MPDO/ PPDO) or the chairman of the environment committee of Sangguniang Bayan), Rural Health Unit (RHU) Chief and concerned Barangay Captain

b. 1 representative from Davao City and IGaCoS LGU-accredited Non-Government Organizations (NGOs)

c. Maximum of 2 representatives from locally recognized community leaders who can represent vulnerable sectors including indigenous populations, women and senior citizens and representatives from academe may be included as member of the MMT in addition to the LGU-accredited NGO

d. Maximum of 3 representatives from government agencies with related mandate on the type of project and its impact during project implementation shall be included in the MMT membership (e.g. from Philippine Coast Guard (PCG) and DENR if the project is endorsed by the concerned Bureau Director)

MMT shall not exceed to ten (10) members except in cases where the location of the project facilities covers more than one (1) barangay.

6.2.2 Monitoring Responsibility

In relation to the implementation of the EMP, a number of parties are involved. Specific management responsibilities are summarized in **Table 6.3**.

Table 6.3 Roles and Responsibilities in Monitoring

Role	Responsibilities
Project Proponent	Monitor potential and actual impacts of the construction of the bridge Monitor implementation of the EMP Designate Pollution Control Officer in areas that require in-depth monitoring Prepare and submit regular Self-Monitoring Reports (SMR) and Compliance Monitoring Reports (CMR)

Role	Responsibilities
Multi-partite Monitoring Team	Encourage public participation to promote greater stakeholder vigilance and provide appropriate check and balance mechanisms in the monitoring of project implementation Validate project compliance with the conditions stipulated in the ECC and the EMP Validate Proponent's conduct of self-monitoring Receive complaints, gather relevant information to facilitate determination of validity complaints or concerns about the project and timely transmit to the Proponent and EMB recommended measures to address the complaint Prepare, integrate and disseminate simplified validation reports to community stakeholders; Make regular and timely submissions of MMT Reports based on the EMB-prescribed format
Third Party	Undertake validation monitoring in accordance with DAO 03-30 Monitoring, Validation and Evaluation/Audit Procedures Review and verify self-monitoring data as reported by the proponent to provide an unbiased perspective on project status
Environmental Management Bureau	Overall evaluation and audit of the Proponent's monitoring and MMT validation Form composite teams composed of EIAMD and PCD personnel to jointly evaluate the effectiveness of environmental management measures being implemented by the proponent Prioritize the inclusion of EQD/PCD personnel in the activities of the MMT sectoral team Prepare Compliance Evaluation Report (CER) semi-annually EMB CO shall provide policy guidelines and if necessary, technical assistance EMB CO shall conduct periodic monitoring and validation performance audits

Annex 3-2 under DAO 2003-30 provides the generic Compliance Monitoring and Validation Report (CMVR) which shall serve as the MMT Report Form.

6.3 Environmental Guarantee and Monitoring Fund Commitments

The DPWH shall initiate a Memorandum of Agreement (MOA) in coordination with the concerned EMB Office on the formation of a Multipartite Monitoring Team (MMT), as well as the establishment of an Environmental Monitoring Fund (EMF) and Environmental Guarantee Fund (EGF). The establishment of the EMF and EGF shall be in accordance with the prescribed guidelines and procedures of the Revised Procedural Manual for DENR Administrative Order No. 2003-30. These funds are allocated for the expenses and services of the MMT and for the following purposes:

- Conduct necessary environmental monitoring of the project

- Expenses that will be used to compensate communities that will be negatively impacted by the project
- Proper preparation measures (i.e. damage preventive programs, capacity building) to reduce vulnerability to hazards, and
- Repairing deteriorated environmental areas that were damaged from the project's construction and operation phases

6.3.1 Environmental Monitoring Fund (EMF)

In support of the activities of the MMT for compliance monitoring, an Environmental Monitoring Fund (EMF) shall be allotted by the proponent. The EMF will be established as agreed upon and specified in the MOA between DENR-EMB and the Proponent, with conformity of the MMT members. An EMF is required for all MMTs of EIS based projects. The indicative amount for the EMF is PHP. 1,000,000.00

However, the final proposed amount for the EMF will be based on the costs of monitoring activities and environmental programs stated in the Environmental Management Plan that shall be carried out by the MMT. Further, the Administration and Management Guidelines for EMF is provided in Annex 3-5 of RPM for DAO 2003-30.

6.3.2 Environmental Guarantee Fund

An Environmental Guarantee Fund (EGF) is required to be established for all co-located or single projects that have been determined by DENR to pose a significant public risk or where the project requires rehabilitation or restoration. The EGF shall be established and used exclusively for the following purposes:

- The immediate rehabilitation of areas affected by damages to the environment and the resulting deterioration of environmental quality as a direct consequence of project construction, operation and abandonment
- The just compensation of parties and communities affected by the negative impacts of the project
- The conduct of scientific or research studies related to the project that will aid in the prevention or rehabilitation of accidents and/or environmental damages, and
- For contingency clean-up activities, environmental enhancement measures, damage prevention programs and social equity measures (e.g. livelihood, social development programs) including the necessary IEC and capability building activities related to the project.

Additionally, the Administration and Management Guidelines for EGF is provided in Annex 3-6 of RPM for DAO 2003-30.

6.3.2.1 Establishment of EGF

EGF Trust Fund

The DPWH shall open an account for the Trust Fund in the amount of TWO MILLION PESOS (PhP 2,000,000.00) in the form of insurance policy. The Trust Fund will be used to compensate aggrieved parties for any damages to life or property, undertake community-based environmental programs, conduct environmental research aimed at strengthening measures to prevent environmental damage and to finance restoration and rehabilitation of environmental quality of the project-affected area.

The Trust Fund shall be replenished to its original amount annually or whenever the amount goes below the mutually agreed amount of PhP 1,000,000. The Trust Fund shall also be renewed upon every expiration. The proponent shall immediately inform EMB Central and RO should it fail to renew the Trust Fund (e.g. insurance policy) on its stated expiration date or should the Trust Fund be cancelled or voided by the Insurer because of non-payment of the required premiums or any other cause allowed by the Insurance Code or pertinent issuances of the Insurance Commission.

7 Decommissioning/ Abandonment/ Rehabilitation Policy

Abandonment can be defined as the cessation of a certain activity with no definite intention of when to restart. Therefore, projects are considered abandoned if the works are suspended without any confirmed date of resumption (Abdul, E. et. al., 2018). In any case that abandonment or decommissioning of the project occurs, the following activities shall be executed:

- Inform the community of the decommissioning plan
- Isolate contaminated areas
- Remove all structures and equipment
- Clear all irrelevant or unused infrastructure such as, among others, roads and transmission lines
- Implement proper solid waste removal and management
- Conduct public consultations to addressing environmental and social concerns within and around the area
- Gradually reclaim disturbed land

The proponent will hire a consultant to prepare a separate comprehensive decommissioning plan and/or rehabilitation management plan (RMP) to address specific issues with regards to the abandonment of the project. This shall be prepared and submitted to DENR for review and approval prior to actual project decommissioning.

8 Institutional Plan for EMP Implementation

This chapter describes the establishment of a unit responsible for the implementation of the Environmental Management Plan (EMP) of the project, especially in terms of upholding environmental regulations, policies and safeguards while optimizing available resources and manpower for the purpose. The importance of setting up a capable and competent unit with properly defined tasks cannot be over emphasized, as this is crucial for sustainable project operations.

Purpose

The Environmental Unit is accountable for the environmental performance of the project. It ensures implementation of the environmental safeguards and controls for all phases of the Samal Island Davao City Connector (SIDC) Project. The unit is also responsible for ensuing compliance of project activities to all pertinent environmental requirements and regulatory obligations. The formation of the EU will be headed by DPWH.

The main functions of the unit may be defined by the following general aspects:

- Systems and Procedures
- Environmental Safeguards and Implementation
- Government Regulatory Compliance
- Environment, Health and Safety (EHS) Program, Awareness and Compliance

Set up

In most circumstances, the EU conducts the post-EIA compliance and implementation process in partnership with other technical support groups. Shown below is the initial organizational chart for the environmental unit of the SIDC Project.

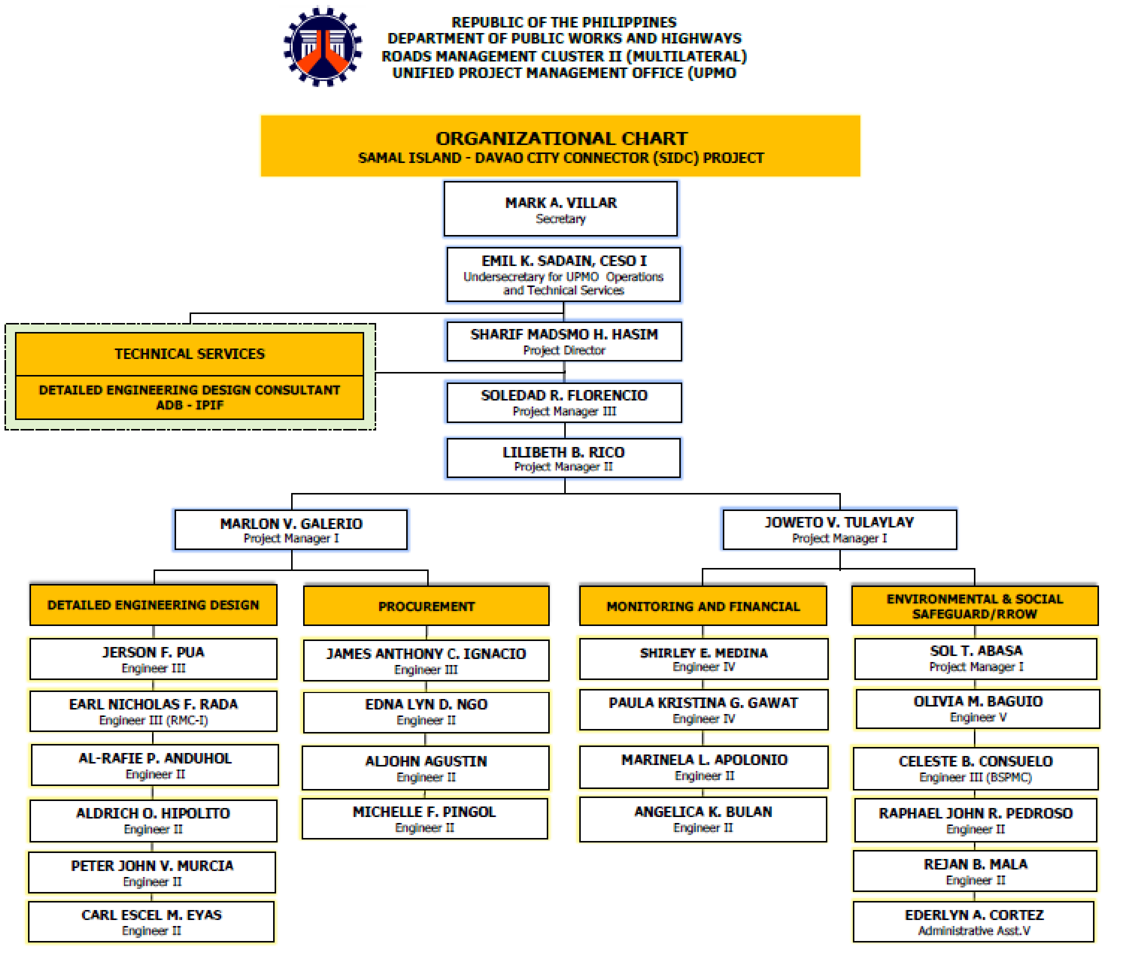


Figure 8.1 The Initial Organization Chart

Roles and Responsibilities

This section describes the general role of the EU for each major phase of the project. During the Pre-Construction Phase, key personnel of the EU:

- Assist during the right-of-way acquisition process
- Facilitate clearing of obstructions along the project alignment
- Solicit community approval of the project
- Support resettlement of affected informal households

Coordinate with concerned agencies to ensure safety and security of project facilities, equipment and personnel and reduce negative impacts to the community and environment.

During the Construction Phase, the key EU personnel is the Pollution Control Officer, whose functions include the monitoring of all types of pollution sources directly associated with the project and ensuring the implementation of mitigating measures to address unacceptable levels of pollutants, including solid waste.

During the Operations Phase and in addition to the PCO, two additional departments will be mobilized under the EU: Operations and Maintenance and Engineering.

The Operations Department is responsible for acquiring required inputs and devising the best project operation methods. The Operations Manager ensures smooth passenger transport and vehicle flows along the bridge, in addition to the following general functions of the department:

- Bridge operations
- Safety and morale of personnel
- Schedule attainment
- Leadership and direction
- Customer interface and
- Company policy enforcement

The Maintenance and Engineering Department, on the other hand, is in charge of conducting regular inspections, continuous improvement and maintenance and repairs of the bridge as well as associated equipment. In addition, the Project Engineer oversees automation control, optimization, safety and testing.

All key personnel are likewise responsible for creating regular reports in relation to their respective functions. The technical departments of the EU are complemented by an Administrative and Finance Department, which is in charge of personnel, finance, publications, public relations, conferences, sale of documents and similar administrative functions. Their specific functions include:

- Personnel affairs
- Organization and supervision of training programs

- General services, including the general register of staff and services
- Rendering consultations with other departments on organizational matters
- Preparation of studies on administrative organization
- Maintenance and auditing of accounts
- Budget preparation
- Administrative services for conferences and meetings, and
- Maintenance and organization of documents and archives

Skills and Competencies

Choosing competent and effective personnel to staff the EU is imperative, and the qualification of applicants will be guided by the following requirements, as applicable to their roles and responsibilities within the unit:

- Must understand environmental management, legal regulatory framework, environmental impact assessment and reporting and environmental compliance and monitoring
- Well-versed and accustomed to the application of local laws and environmental rules and regulations.
- Experienced in integrated environmental assessment.
- With good connections to environmental regulatory authorities
- With the capability to converse with different stakeholders from the public and private sectors
- With the capacity to build consensus on key environmental issues, and
- Possess good skills on oral and written communication, project coordination, monitoring and audits, scientific research and development, project planning, policy formulation and training and facilitation

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