INTEGRATED REPORT ON THE BATHYMETRIC SURVEY AND GEOLOGICAL INVESTIGATION COVERING THE PROPOSED NAVIGATIONAL ZONE AT THE PATRICK RIVER DELTA LOBES IN SITIO PANDAN, BARANGAY CLAUDIO SALGADO, MUNICIPALITY OF SABLAYAN, OCCIDENTAL MINDORO

I. INTRODUCTION

A bathymetric survey covering the proposed navigational zone fronting the Patrick River delta lobes in Sablayan, Occidental Mindoro was carried out on February 22 to 24, 2023, including travel time. This was undertaken so that the project proponent, PERRC Construction and Development Corporation, would be able to estimate the cost and timeframe of developing a safe navigational zone, as well as to estimate the approximate volume of seabed materials to be removed, in connection with its proposed dredging project along the trunk of Patrick River.

The survey consisted of:1) bathymetric measurements and resource estimation and, 2) geological investigations and seabed sampling.

The bathymetric survey utilized a single Beam Echo Sounder system, model CHC D230 with CHC I50 Base station of GNSS RTK system and a rover/receiver GPS. The transducer of the echosounder was mounted on the side of the motorized banca survey platform (Photo 1), while the base station was set-up at the beach ridge (Photo 2) for precise charting of water elevation/depth and location of the survey platform along the proposed track-lines at any given time. The bathymetric map generated from the water depth charting has its paramount importance in the design of a safe navigational zone for the dredging fleet to and from the Patrick River course, and in the estimation of the sand materials to be removed or to be dredged out to deepen the proposed navigation zone through the foreshore and delta lobe to avoid grounding and prevent downtimes and accidents.

The activities carried out under the geological investigations are a) characterization of the delta deposits and sea-bottom sediments, which include on-site megascopic identification; b) sea-bottom sediment sampling using dredge sampler in the deeper areas (Photo 3) and using sand pump in the shallow water areas (Photo 4), and laboratory analyses in order to have supplementary descriptions of the geological materials therein. In addition, literature research was undertaken on published geological maps of Mindoro to ascertain the provenance, or possible source areas, of the rock debris composing the delta deposit, as well as to be able to know the rock distribution and general stratigraphy around the survey area.

BATHYMETRIC SURVEY

Location of Survey Area

The bathymetric survey area is located in the foreshore/nearshore area fronting the southeastern and northwestern lobes of Patrick River delta in Sitio Pandan, Barangay Claudio Salgado, Municipality of Sablayan, Occidental Mindoro, as shown on Figures 1 thru 3 below

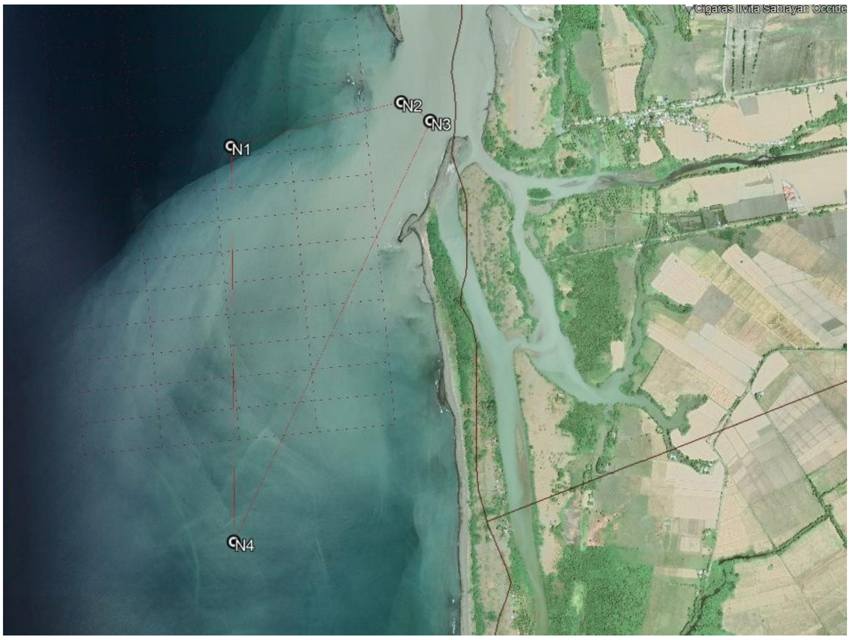


Figure 1. Location of the proposed navigational zone furnished by the proponent (Revised)

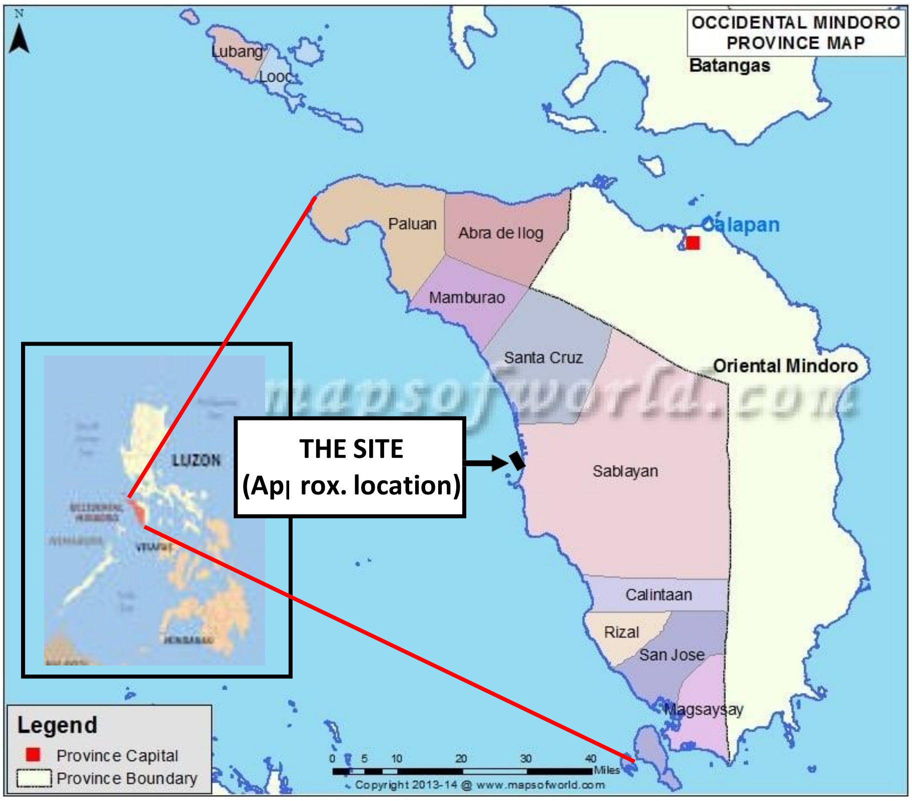


Figure 2. Map of Mindoro Island showing the approximate location of survey area

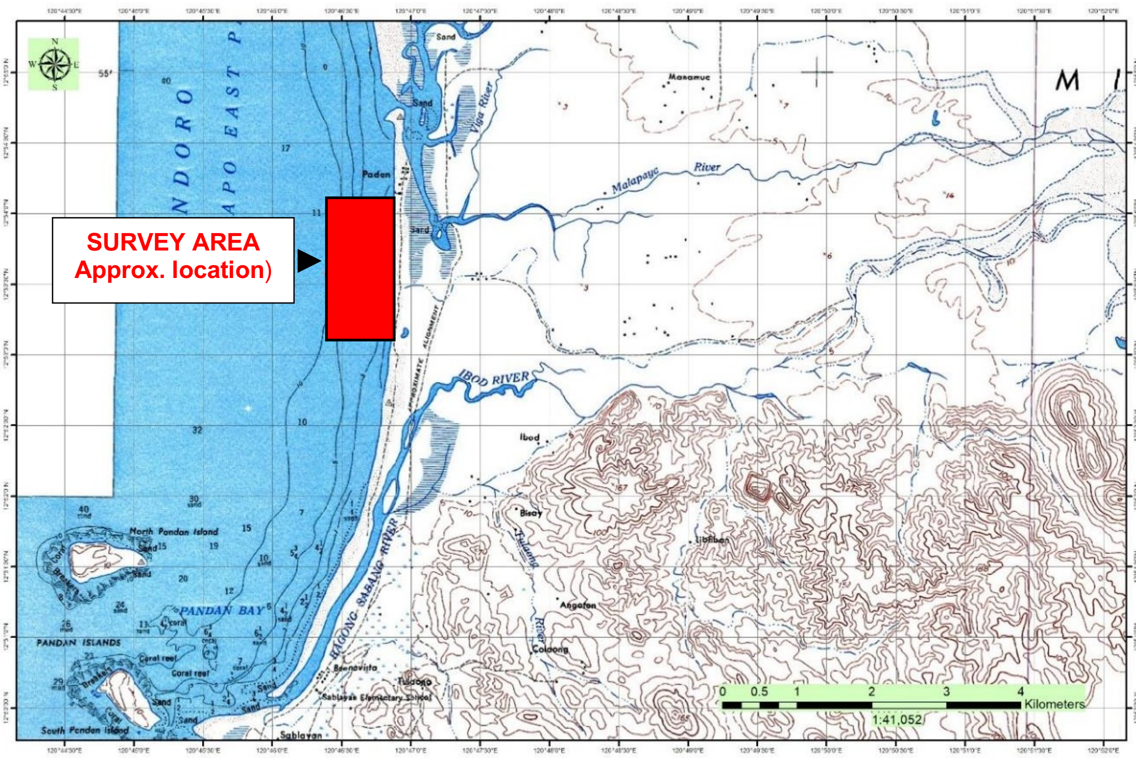


Figure 3. Approximate location of survey area on NAMRIA topographic map Sheet 3158-I

Methodology.

Prior to mobilization, a survey track-lines map (Figure 4) was prepared and inputted in the Hydrosurvey acquisition software. The survey area measures approximately 1.5 km along shore and 1.0 km seaward with an area of about 150 hectares, and covering largely the navigational zone proposed by the proponent. The 16 Traverse Lines are spaced 100 meters apart and oriented perpendicular to the shoreline, while the 5 Tie Lines, or cross lines, are parallel to shore. Total length of the track-lines is approximately 23.5 line-km, excluding the maneuvering areas of the survey platform.

Installation of CHC D230 transducer on the survey pole side mounted on the motorized banca. GNSS RTK rover is also installed on the same pole to acquire position (latitude and longitude) and elevation provided by the base station.

At the site, set up of CHC I50 Base station for GNSS RTK system at the beach ridge for the precise positioning of the survey platform (motorized banca) and elevation at any given time during the survey.

After all equipment are interconnected, a brief trial run was conducted to check whether or not the survey equipment is working properly.

Water depth charting along all pre-determined track-lines at a vessel speed of about 10 kph.

Data gathered was saved as csv file for processing and interpretation at the office.

Echosounding
Bathymetric surveying is the measurement and description of rhe offshore and the adjoining coastal area. A Global Navigation Satellite System (GNSS) is used as the primary positioning system and is coupled with digital single beam echo sounder (SBES) to record the water depth. The depth data are collected every second and are stored with GNSS positions and time tag. The depths are corrected for the draft of the transducer, tidal variation and sound velocity in water. The raw depths are reduced for change in sea level due to the tide and calibration parameters from the surface elevations to produce elevations on the bottom of the survey area. The elevations are used to produce contour map and 3-D views.

Objective
The objectives of the survey are to create fine resolution bathymetric data and to be able to estimate the volume of sediments to be excavated for dredger navigational entrance to the Patrick River.

Extent of Survey
The bathymetric survey of the Patrick River delta covers an area of approximately
1.5 sq. km. and bounded by coordinates from 12o53’15” N to 12o54’15” N latitude and from 120o46’0” E to 120o47’0” E. The coordinate system used in the survey is WGS84 UTM Zone 51N. The deepest recorded water depth is -26 meters.
Relatedly, the corner coordinates of the final version of the proposed navigational zone furnished by the project proponent at a date later than the actual field survey is shown on Table 1 below:

Corner	Latitude	Longitude
N1	12° 53’ 50.34”	120° 46’ 34.91”
N2	12° 53’ 54.84”	120° 46’ 53.02”
N3	12° 53’ 52.92”	120° 46’ 56.11”
N4	12° 53’ 09.34”	120° 46’ 35.24”

Table 1. Coordinates of the proposed final navigational zone

Vessel and Equipment
The survey vessel used was a motorized fishing boat. A pole side mounted with the vessel carries the transducer on the bottom and the GNSS antenna on top. The GNSS and the transducer are arranged so that they are vertically collinear to each other (Photo 1).

CHCNAV GNSS i50 RTK was used as the navigational positioning system. This is a full constellation receiver that tracks GPS, GLONASS, Galileo, BeiDou and

QZSS signals. It has a horizontal and vertical accuracies of 8mm and 15mm respectively.
CHC D230 single beam echo sounder was used for depth measurement. It has a sounding accuracy of 0.01m, detection range of 0.3m to 300m and transmitting in 200khz frequency.
Survey speed was carried out at a range of 7 to 10 km/hr.

Photo 1 Position of GNSS antenna and transducer in the survey vessel.

Coverage
Prior to the commencement of the survey, track-lines map was prepared at 100 meters x 250 meters line grid spacing and 1000 meters by 1500 meters line length. The final spacing in the field was then determined according to the

conditions and depth of water at the time of survey. The proposed track-lines are shown in Figure 4 and the actual shot points are shown in Figure 5.

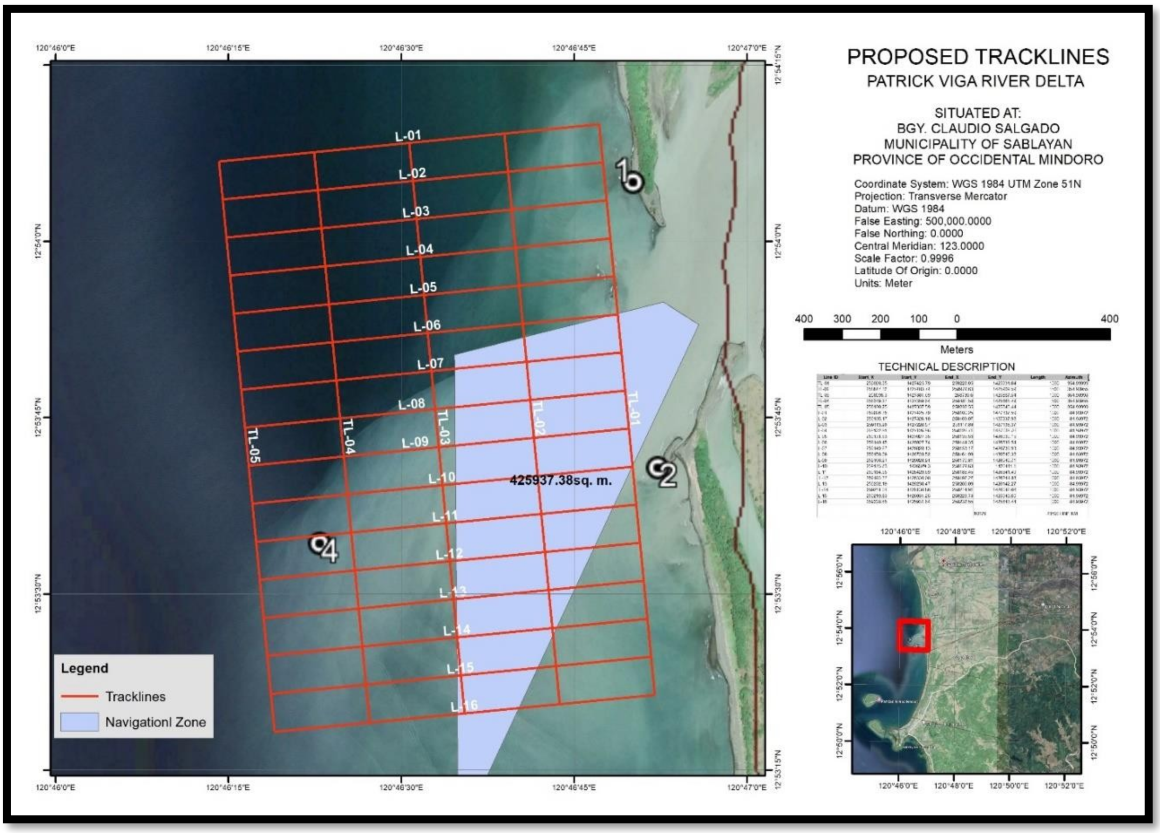


Figure 4. Proposed track-lines.

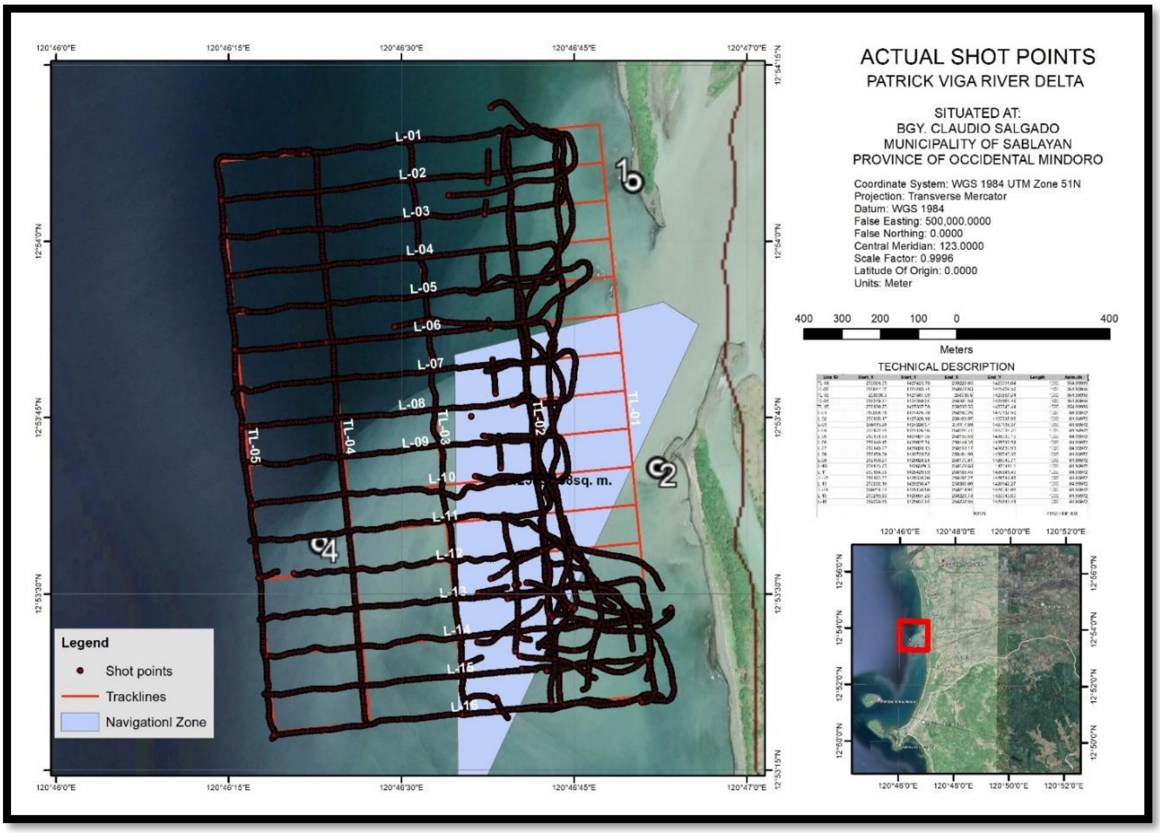


Figure 5. Actual shot points completed over the Patrick River delta.

The RTK base or reference station was erected in the immediate vicinity of the survey area using the observed coordinates. The reference station transmits GNSS derived coordinate corrections to the rover to provide real time, on the fly horizontal and vertical positions to centimeter accuracy. The coordinate of the base station in WGS84 Zone 51N is as follows:

LAT	LON	EASTING (m)	NORTHING (m)	ELEVATION (m)
12.89049	120.78215	259333.82	1426064.99	2.0

Photo 2. Setting up of RTK GNSS base station.

Data Processing

During the survey operation the changes in water level elevation is constantly monitor by the GNSS. Horizontal and vertical corrections were provided by the RTK base station. The vertically corrected water level was subtracted to the measured water depth to get the bottom elevation. This corrected elevation data together with its coordinates and time tag were imported to the Surfer 18 Software. The resulting xyz data was gridded into 1m x 1m resolution digital terrain model (DTM). The DTM is then used to create contour at whatever interval is required, relief and 3D visual representation of the data which can be overlain.

into the final drawing. Input, statistical and output data are shown in the Gridding Report below.

Gridding Report

Fri Mar 3 14:02:59 2023
Elapsed time for gridding: 44.2 seconds

Data Source

Source Data File Name: D:\PANCHO\SABLAYAN\Sbes\Patrick_BATHY.csv X Column: E
Y Column: D
Z Column: H

Filtered Data Counts
Active Data: 6537
Original Data: 6537
Excluded Data: 0
Deleted Duplicates: 0
Retained Duplicates: 0
Artificial Data: 0
Superseded Data: 0

Exclusion Filtering

Exclusion Filter String: Not In Use

Duplicate Filtering
Duplicate Points to Keep: First X Duplicate Tolerance: 0.00014
Y Duplicate Tolerance: 0.00019

No duplicate data were found.

Breakline Filtering

Breakline Filtering: Not In Use

Z Data Transform

Transformation method: Linear (use Z values directly) No untransformable data were found.
Data Counts
Active Data: 6537

Univariate Statistics

	X	Y	Z
Count:	6537	6537	6537
1%-tile:	258118.9202	1425869.544	-25.221
5%-tile:	258193.1482	1425921.329	-24.043
10%-tile:	258275.8679	1426000.613	-21.817
25%-tile:	258502.264	1426165.145	-16.256
50%-tile:	258836.7789	1426528.73	-6.295
75%-tile:	258967.6114	1426977.878	-3.088
90%-tile:	259060.6317	1427252.232	-2.025
95%-tile:	259160.1725	1427344.521	-1.641
99%-tile:	259240.1623	1427407.225	-1.153
Minimum:	258094.3371	1425826.019	-25.945
Maximum:	259279.5048	1427485.063	0.327
Mean:	258743.510452	1426576.85318	-9.57824509714
Median:	258836.7789	1426528.73	-6.295
Geometric Mean:	258743.340846	1426576.77889	N/A
Harmonic Mean:	258743.171174	1426576.70461	N/A
Root Mean Square:	258743.679991	1426576.92747	12.1957417173
Trim Mean (10%):	258750.484902	1426569.88923	-9.1919092794
Interquartile Mean:	258798.691737	1426540.9863	-7.64945937596
Midrange:	258686.92095	1426655.541	-12.809
Winsorized Mean:	258742.625859	1426575.32964	-9.40875179746
TriMean:	258785.8583	1426550.12075	-7.9835
Variance:	87747.7313752	211996.78325	57.0020568048
Standard Deviation:	296.222435638	460.431084149	7.54997064927
Interquartile Range:	465.3474	812.733	13.168
Range:	1185.1677	1659.044	26.272
Mean Difference:	333.531721919	529.356317525	8.33858112758
Median Abs. Deviation:	174.0638	391.935	4.236
Average Abs. Deviation:	242.751571547	403.037479578	6.30624301667

Quartile Dispersion: 0.000899274377354 0.000284855330927

N/A
Relative Mean Diff.: 0.001289043815380.000371067507752
N/A

Standard Error:	3.66377425048	5.69475957009	0.0933804625471
Coef. of Variation:	0.001144849720560.000322752386682		
N/A			
Skewness:	-0.514081210516	0.218755716244	-0.68116074437
Kurtosis:	2.21533797847	1.76953263518	2.05825584482
Sum:	1691406327.83	9325532889.22	-62612.9882
Sum Absolute:	1691406327.83	9325532889.22	62614.0882
Sum Squares:	4.37640984382e+14		1.33035907489e+16
	972287.99052		
Mean Square:	66948291935.5	2.03512172999e+12	
	148.736116035		

Inter-Variable Covariance

	X	Y	Z
X:	87747.731	-29550.222	2155.6852
Y:	-29550.222	211996.78	-74.355964
Z:	2155.6852	-74.355964	57.002057

Inter-Variable Correlation

	X	Y	Z
X:	1.000	-0.217	0.964
Y:	-0.217	1.000	-0.021
Z:	0.964	-0.021	1.000

Inter-Variable Rank Correlation

	X	Y	Z
X:	1.000	-0.246	0.925
Y:	-0.246	1.000	0.004
Z:	0.925	0.004	1.000

Principal Component Analysis

	PC1	PC2	PC3
X:	0.975115033924	0.975115033924	-0.0256449515802
Y:	0.220201904567	0.220201904567	-0.00322405432223
Z:	0.0257253151701	0.0257253151701	-0.00322405432223
Lambda:	218668.047822	81131.5279138	1.94094660717

Planar Regression: Z = AX+BY+C Fitted Parameters

	A	B	C
Parameter Value:	0.0256529162044	0.00322501781561	-11247.839604
Standard Error:	5.96189876787e-05	3.8356406308e-05	59.9818380415

Inter-Parameter Correlations

	A	B	C
A:	1.000	0.217	-0.455
B:	0.217	1.000	-0.968
C:	-0.455	-0.968	1.000

ANOVA Table

Source	df	Sum of Squares	Mean Square	F
Regression:	2	359870.935785	179935.467893	92614.7271211
Residual:	6534	12694.507491	1.94283861202	
Total:	6536	372565.443276		

Coefficient of Multiple Determination (R^2): 0.96592677147

Nearest Neighbor Statistics

Separation	|Delta Z|	
1%-tile:	0.851837566718	0.003
5%-tile:	1.76614976715	0.016
10%-tile:	2.59205729877	0.032
25%-tile:	5.00797048829	0.085
50%-tile:	5.10363175482	0.163
75%-tile:	5.23564921381	0.332
90%-tile:	5.34995879326	0.629
95%-tile:	5.40967180152	0.885
99%-tile:	5.50991270345	1.816
Minimum:	0.312907989639	0
Maximum:	23.9579855779	6.848
Mean:	4.66189929924	0.276289521187
Median:	5.10363175482	0.163
Geometric Mean:	4.40990248224	N/A
Harmonic Mean:	3.90825681252	N/A
Root Mean Square:	4.80512602982	0.449403475741
Trim Mean (10%):	4.8049126726	0.226643388851
Interquartile Mean:	5.11006745541	0.179152890792
Midrange:	12.1354467838	3.424
Winsorized Mean:	4.74065367086	0.231919825608
TriMean:	5.11272080294	0.18575
Variance:	1.35613854198	0.125646805357
Standard Deviation:	1.16453361565	0.35446693126
Interquartile Range:	0.227678725516	0.247
Range:	23.6450775883	6.848
Mean Difference:	0.978356652019	0.296529972668
Median Abs. Deviation:	0.113407260839	0.104
Average Abs. Deviation:	0.59893991244	0.194241945847
Quartile Dispersion:	0.0222263938077	N/A
Relative Mean Diff.:	0.20986224481	1.07325812211
Standard Error:	0.0144033258847	0.00438416088437
Coef. of Variation:	0.249798106072	1.28295466921
Skewness:	-1.23003449171	4.7073977543
Kurtosis:	17.0630283388	51.2763542942
Sum:	30474.8357192	1806.1046
Sum Absolute:	30474.8357192	1806.1046
Sum Squares:	150934.336794	1320.23529496
Mean Square:	23.0892361625	0.201963484008

Complete Spatial Randomness
Lambda: 0.00332461051271
Clark and Evans: 0.537604964756
Skellam: 3152.8890846

Gridding Rules

Gridding Method: Kriging
Kriging Type: Point

Polynomial Drift Order: 0
Kriging std. deviation grid: no

Semi-Variogram Model
Component Type: Linear
Anisotropy Angle: 0
Anisotropy Ratio: 1
Variogram Slope: 0.0838724

Search Parameters
Search Ellipse Radius #1: 100

Search Ellipse Radius #2: Search Ellipse200
Angle: 95

Number of Search Sectors: 4

Maximum Data Per Sector: 16
Maximum Empty Sectors: 3

Minimum Data: 8

Maximum Data: 64

Output Grid

Grid File Name: D:\PANCHO\SABLAYAN\Sbes\Patrick_BATHY.grd

Grid Size: 1666 rows x 1186 columns
Total Nodes: 1975876
Filled Nodes: 1501635
NoData Nodes: 474241
NoData Value: 1.70141E+38

Grid Geometry

X Minimum: 258095

X Maximum: 259280
X Spacing: 1

Y Minimum: 1425825

Y Maximum: 1427490
Y Spacing: 1

Univariate Grid Statistics

Z	
Count:	1501635
1%-tile:	-24.9830631454
5%-tile:	-23.9616698227
10%-tile:	-22.8249745344
25%-tile:	-19.0649085174
50%-tile:	-13.0841919538
75%-tile:	-5.47597850818
90%-tile:	-2.5787689913
95%-tile:	-1.89434822279
99%-tile:	-1.15216696073
Minimum:	-25.8968958464
Maximum:	0.286687080263
Mean:	-12.656664989
Median:	-13.0841919538
Geometric Mean:	N/A
Harmonic Mean:	N/A
Root Mean Square:	14.6742628057
Trim Mean (10%):	-12.6149633749
Interquartile Mean:	-12.7030341475
Midrange:	-12.8051043831
Winsorized Mean:	-12.6122289557
TriMean:	-12.6773177333
Variance:	55.1428569695
Standard Deviation:	7.42582365597
Interquartile Range:	13.5889300092
Range:	26.1835829266
Mean Difference:	N/A
Median Abs. Deviation:	6.8349085781
Average Abs. Deviation:	6.53562840658
Quartile Dispersion:	N/A
Relative Mean Diff.:	N/A
Standard Error:	0.00605985790259
Coef. of Variation:	N/A
Skewness:	0.000776141840687
Kurtosis:	1.66552145882

Sum:	-19005691.1308
Sum Absolute:	19005723.873
Sum Squares:	323353054.409
Mean Square:	215.333988891

Contouring and Modelling

The bathymetric map generated by the sounding is shown in Figure 6. A grid of regularly spaced depth values was generated from the processed shot points using ordinary kriging algorithm used by Golden Software Surfer version 18. A grid spacing of 1 meter was used. This node spacing was selected as an optimum value to avoid the generation of artificial artifact. Depth contours were generated from the grid at a 1 m interval spacing.

The shallow portion of the survey area down to -10m elevation shows chaotic contours signifying a rough surface sea floor consisting of cobbles, gravel, and sand. The contours below the -10 meters contour show a relatively gentle slope, mostly less than 5 degrees or 9% grade profile (Figure 7) toward the shoreline and is overlain by unconsolidated sand. The deepest value measured is -26 meters and the shallowest is 0.5 meters. Comparison of the grid values to the actual sounding values shows close agreement. Actual measurement points and cross sections toward the shoreline were shown in Figure 8 and Figure 9 below. A 3d viewed from the NW is shown in Figure 10.

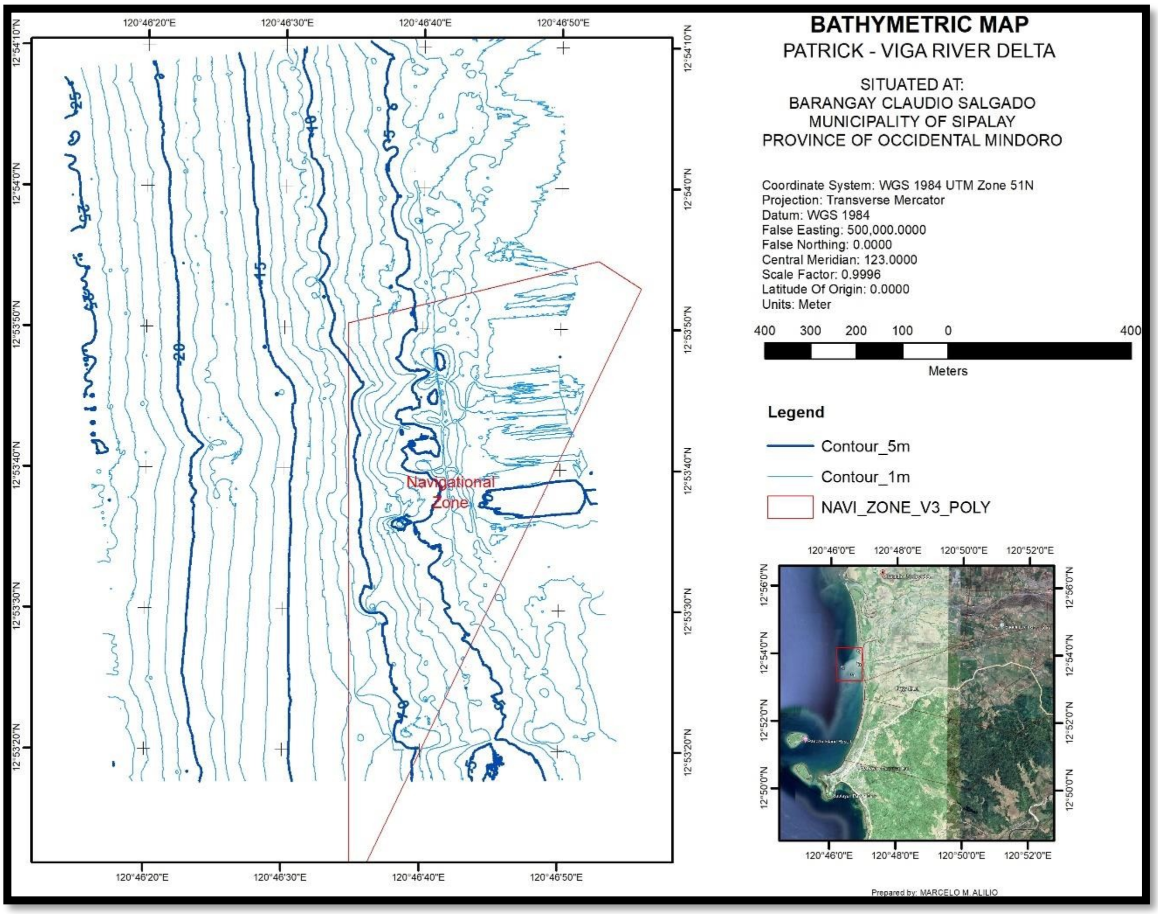


Figure 6 Bathymetry of the survey area.

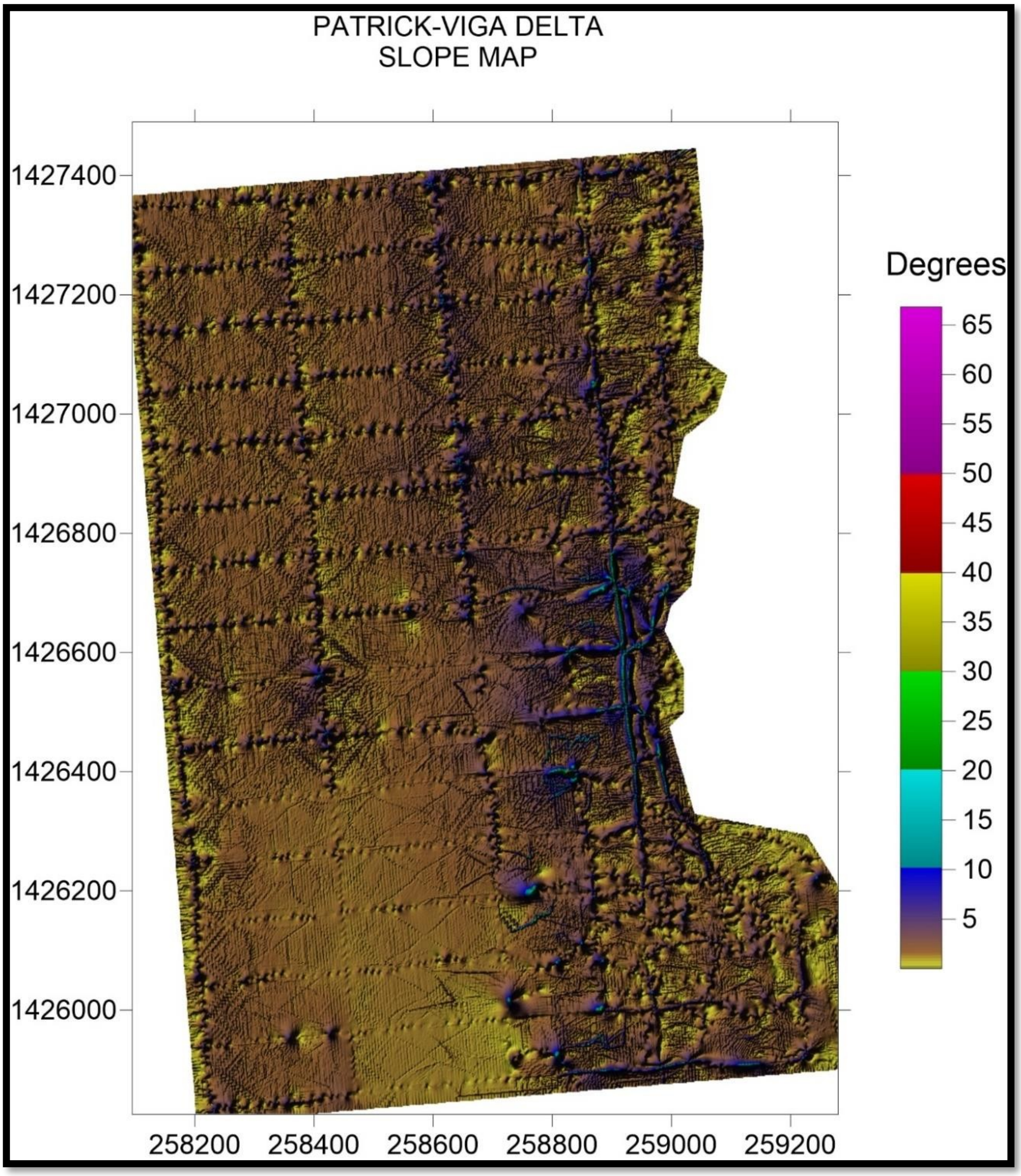


Figure 7. Patrick River delta slope map.

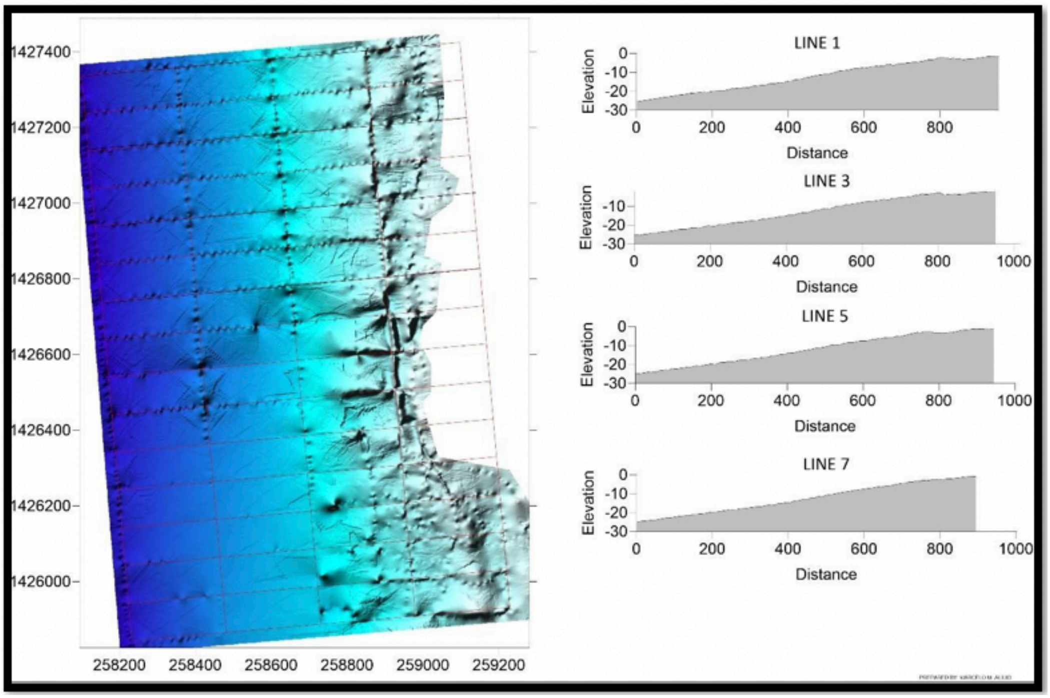


Figure 8 Bathymetry and cross section profile along the northern portion.

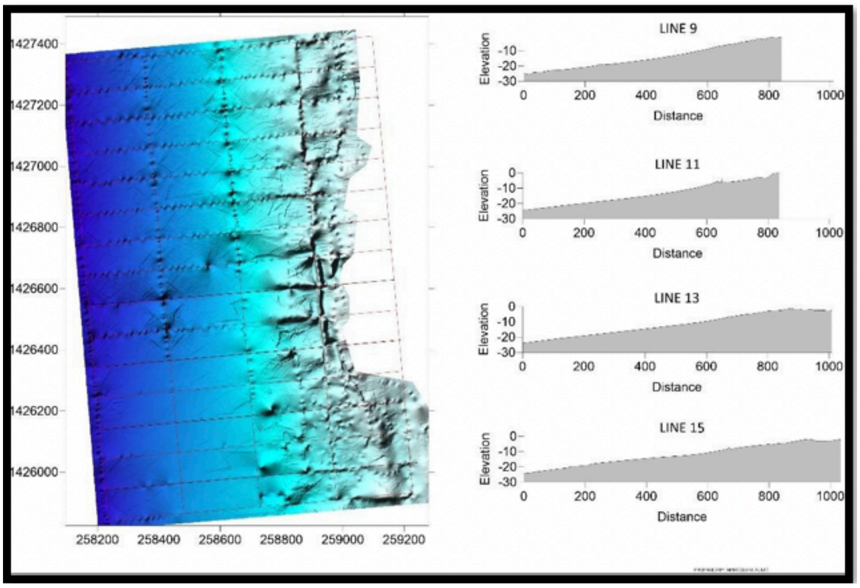


Figure 9 Bathymetry and bottom profile along the southern portion

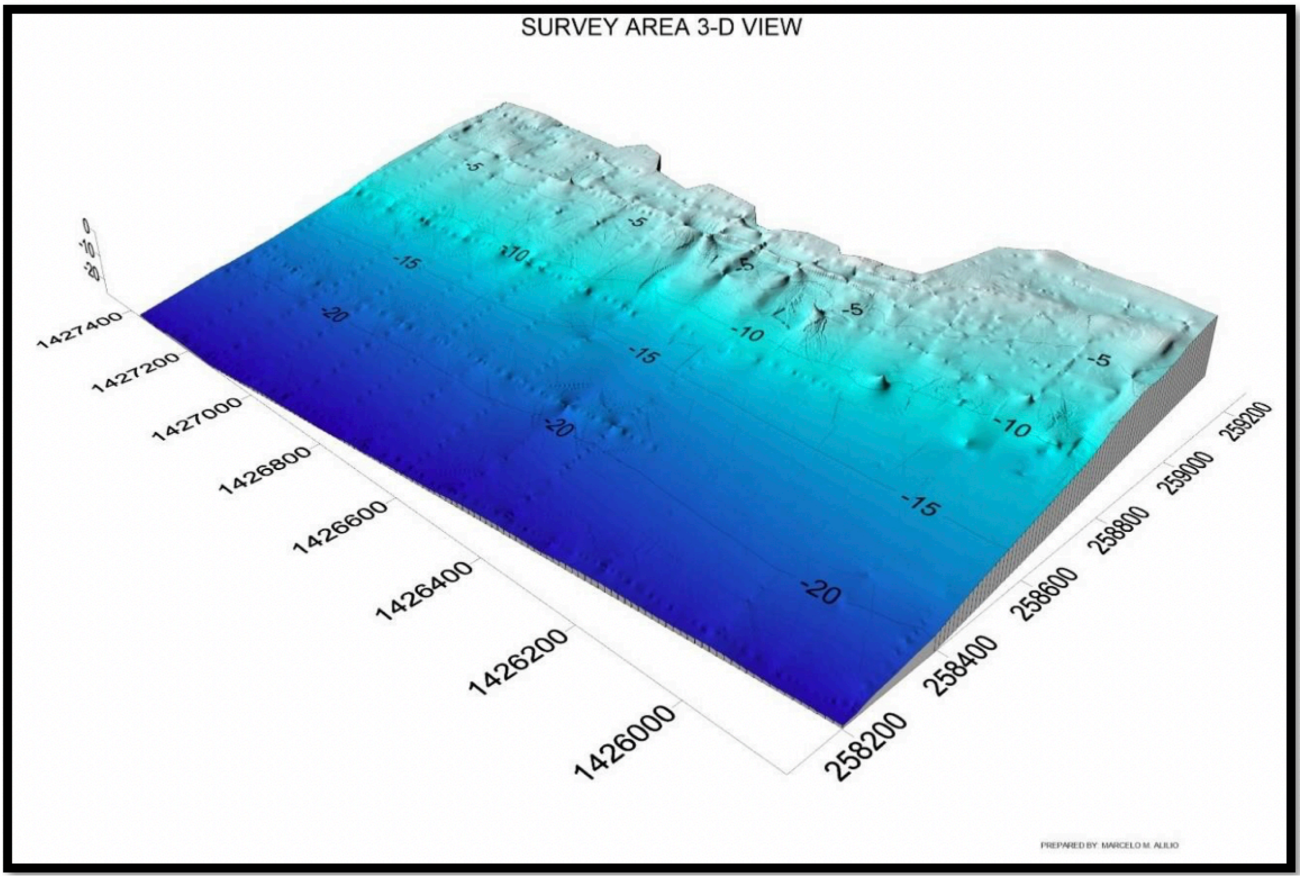


Figure 10. 3-D view of the survey area viewed from the NW

3.0 DREDGE MATERIAL VOLUME ESTIMATE

Calculation of dredging volume is very critical for project estimation and implementation. Safety and cost effectiveness are the important factors in navigations and for better navigation need to deepen the near-shore area, river, inlets, etc. In the dredging industry, quantifying the sediment is an important factor to estimate the cost of the project. This calculation was carried out using Grid model volume calculation, which can be easily used to compute dredge volume with bathymetry data. The volumes are calculated by creating two gridded surfaces of existing and design surface. The two surfaces have the same number of rows and columns and the same X and Y limits. In the grid model, different mathematical techniques like Simpson's rule and Trapezoidal rule used for volume computation. The collected echo sounder data made to equidistant grid data and the same is given as input in the grid model.

The bathymetric surface generated by the echo sounder data was extended inland using the available interferometric synthetic aperture radar (IFSAR) data of the Philippines (**Figure 11**). This was deemed necessary since the echo sounder survey was not able to penetrate the shallow portion near the shoreline, wherein the portion was included to our computation of dredge material volume estimate. This was also the upper surface (**Figure 11**) that we used in the volume computation of dredge material. The lower surface was designed such that the wall angle within the perimeter was less than 45 degrees from the horizontal as shown in **Figure 11** and **Figure 11**.

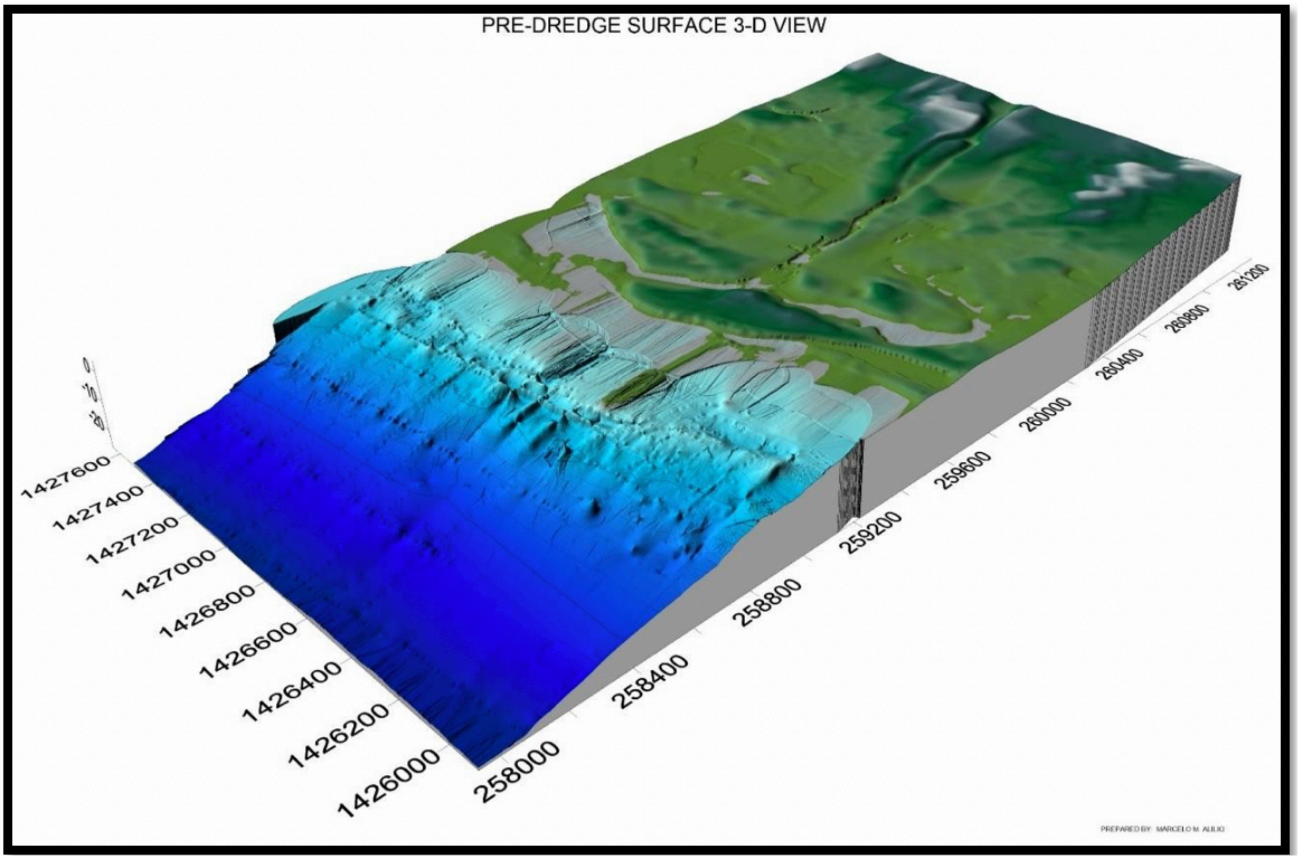


Figure 11. 3-D View of the pre-dredge surface.

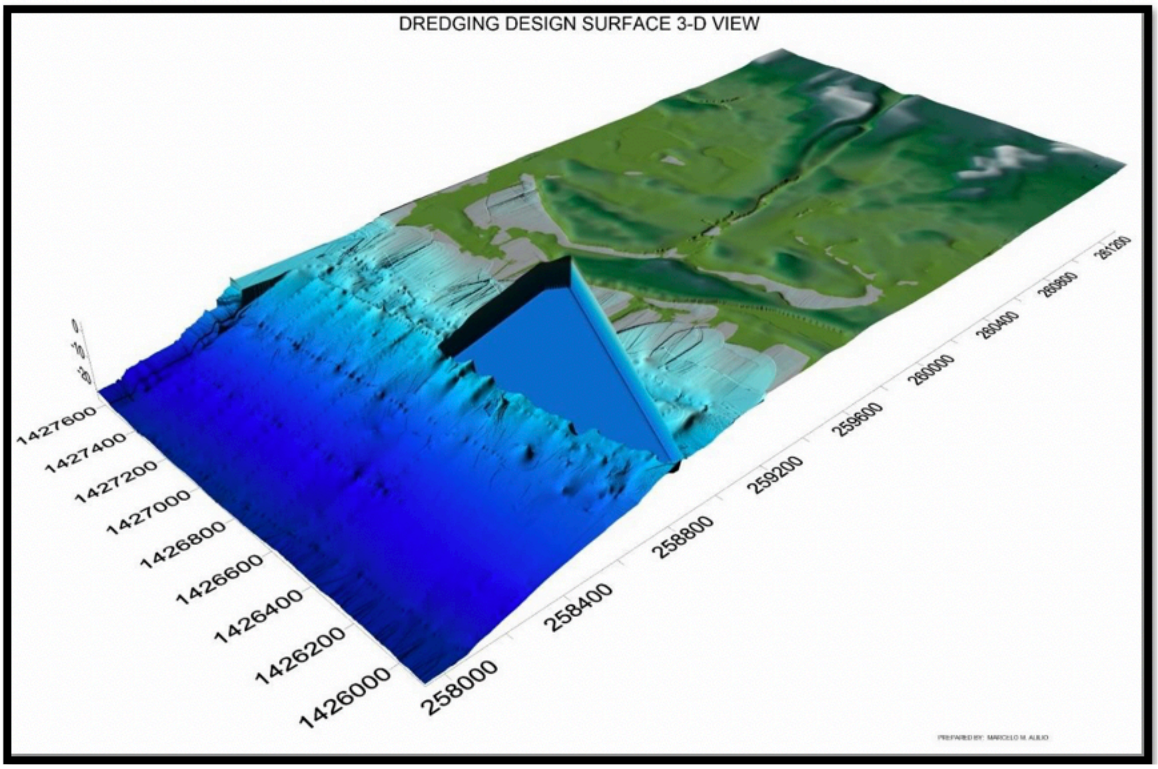


Figure 12. Dredging design for Patrick River 3-D View.

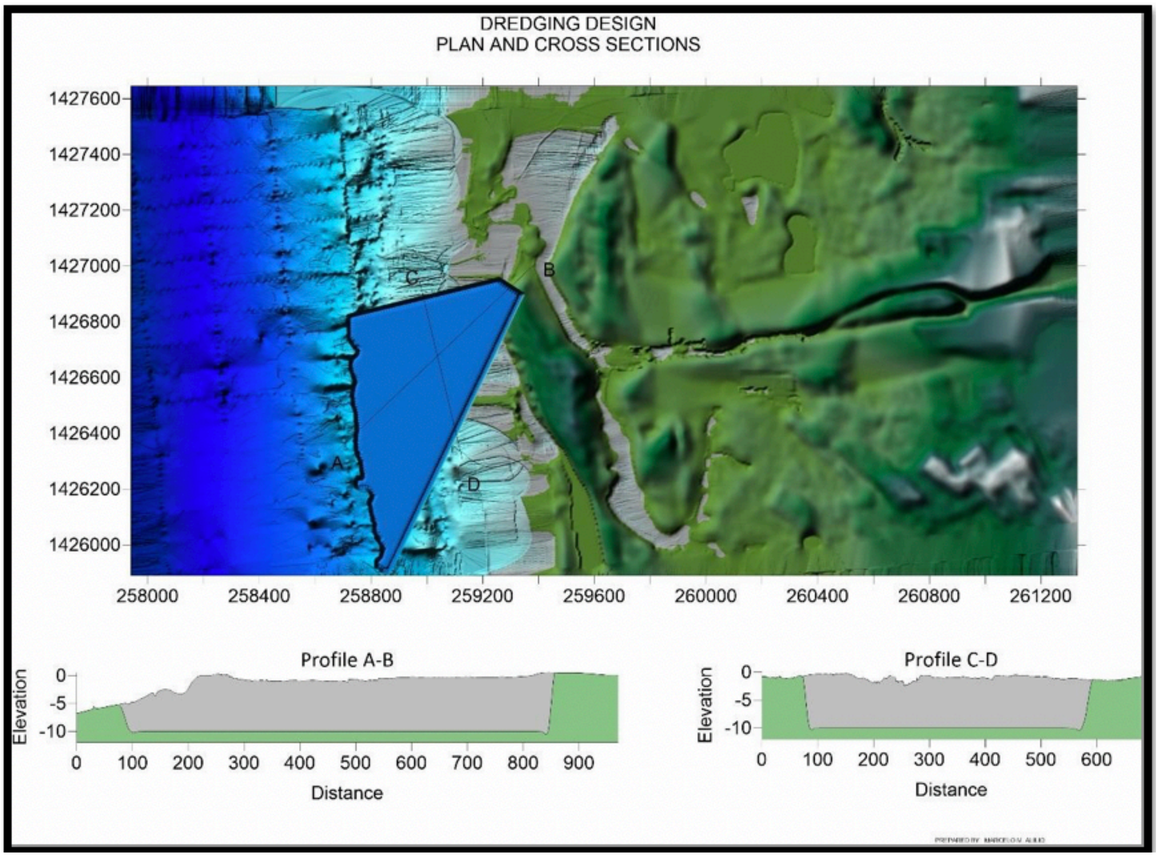


Figure 13. Plan view and cross sections of the dredging design within the Patrick River Delta.

Using the pre-dredge (Figure 11), dredge design surfaces (Figure 12) and the navigational zone polygon as limits, we were able to calculate the volume of dredge materials using the Surfer 18 as follows:

Grid Volume Computations

Fri Mar 10 04:10:03 2023

Upper Surface

Grid File Name: D:\PANCHO\SABLAYAN\IFSAR\Patrcick_LS.grd Grid Size: 1756 rows x 3391 columns
X Minimum: 257940
X Maximum: 261330
X Spacing: 1
Y Minimum: 1425890
Y Maximum: 1427645
Y Spacing: 1
Z Minimum: -25.954072860749
Z Maximum: 4.0549480944811
Lower Surface
Grid File Name: D:\PANCHO\SABLAYAN\IFSAR\Patrick_dredge_design.grd Grid Size: 1756 rows x 3391 columns
X Minimum: 257940
X Maximum: 261330
X Spacing: 1
Y Minimum: 1425890
Y Maximum: 1427645
Y Spacing: 1
Z Minimum: -25.95407285391
Z Maximum: 4.054948092166
Polygon Boundary

File Name: D:\PANCHO\SABLAYAN\tracklines\NAVI_ZONE_V3_POLY .shp

Number of Polygons:	1
Volume:	Inside

Volumes

Z Scale Factor:	1

Total Volumes by:

Trapezoidal Rule:	2821818.1826633
Simpson's Rule:	2821810.4528894
Simpson's 3/8 Rule:	2821818.4117197

Cut & Fill Volumes

Positive Volume [Cut]:	2821819.8400603
Negative Volume [Fill]:	1.6573969008029
Net Volume [Cut-Fill]:	2821818.1826634

Areas

Planar Areas

Positive Planar Area [Cut]:	
Negative Planar Area [Fill]:	
NoData Planar Area:	5550360.5
Total Planar Area:	5949450

Surface Areas

359165.40512857
39924.094871434

Positive Surface Area [Cut]:	367112.27186311
Negative Surface Area [Fill]:	39924.576932966

Based on the above, the amount of material needed to be excavated from the seabed is estimated to be approximately 2,821,818 cu. meters, equivalent to 7,929,308.58 dry metric tons of sand, using an average specific gravity of 2.81 of the sand samples therefrom. The total dredge area limit is 425,937 sq m while the total area of the positive cut is 367,112 sq m as determined by Surfer 18.

GEOLOGICAL INVESTIGATIONS

Regional Geologic Setting

The brief discussion on the geology around the project area is paraphrased herein from the geological map published by the Mines and Geosciences Bureau accompanying the 2010 2nd edition of the Geology and Mineral Resources of the Philippines (Figure I4). The works of JICA in Mindoro (Figure I5) was also largely consulted. From these references, it can be concluded that mainland Mindoro is composed of rocks of diverse types and origin, which range in age from Pre- Cretaceous to Quaternary. The older lithologies have also undergone various grades or intensities of metamorphism and deformation.

It is emphasized herein, however, that the brief discussion under this section is focused on the possible provenance, or source areas, of rock debris accumulated in the Patrick River delta lobes and nearshore area.

The oldest rock assemblage in Mindoro is the Basement Complex (BC) of Pre- Jurassic age, which was renamed Halcon Metamorphic Complex in the Second Edition of the Geology and Mineral Resources of the Philippines (2010). It is explained in the Legend of the map that the BC is composed of “broadly folded undifferentiated amphibolite, quartzo-feldspathic and mica schist, and phyllite- slates frequently associated with marble and quartzite(?). Some narrow zones of close folding broken by upthrusts. Prevailing schistosity generally parallel, some oblique and / or perpendicular to original bedding. This stratigraphic unit is distributed from Mt. Calavite to Puerto Galera and areas around Mt. Halcon; Lubang and Ambil islands”.

Overlying the Halcon Metamorphic Complex is the Jurassic Mansalay Formation composed of arkose, sub-graywacke, and mudstone.

Windows of Cretaceous and Paleogene rocks (KPg) also occur in the areas drained by the Pagbaahan River system. This rock assemblage is composed largely of graywacke and metamorphosed shale interbedded and/or intercalated with spillitic, basic and intermediate flows and/or pyroclastics.

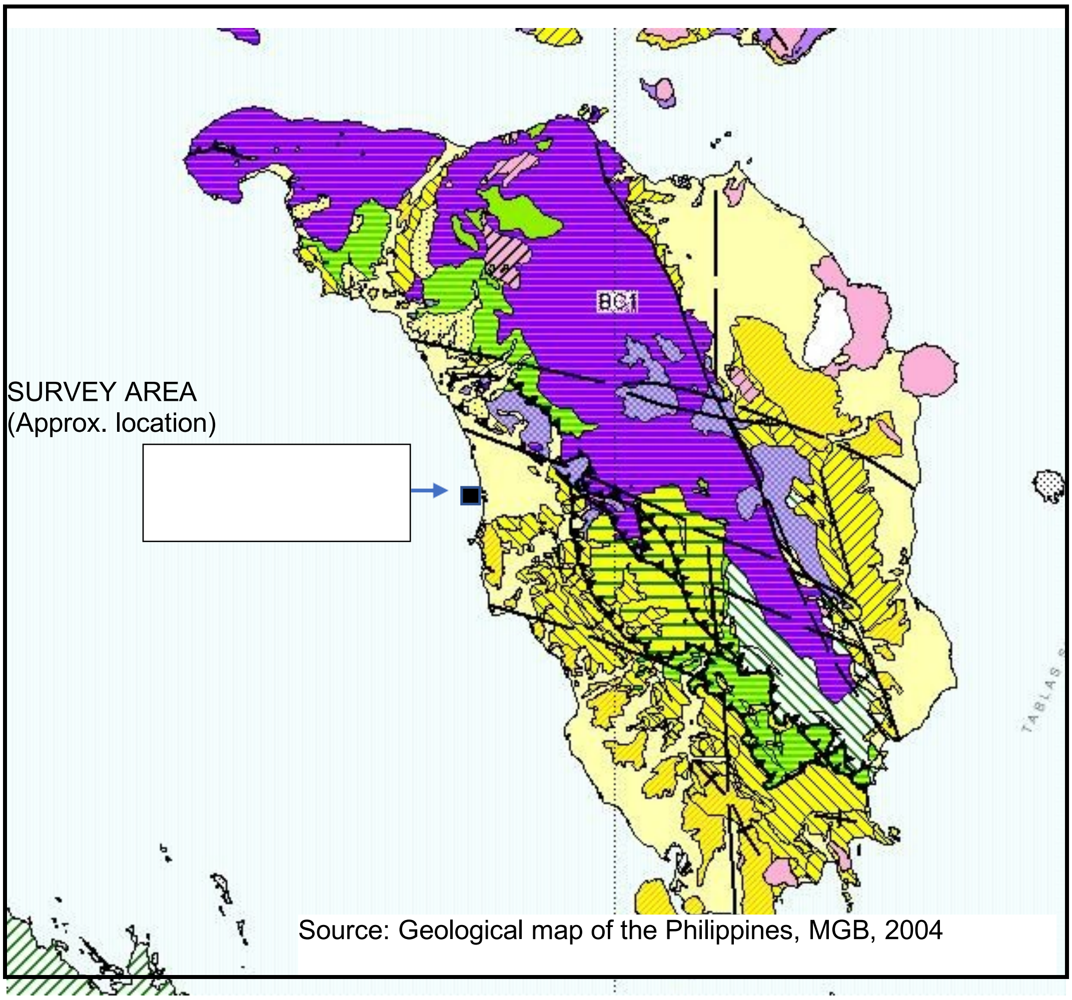


Figure 14 Geological Map of Mindoro

TABLE 2. LEGEND OF FIGURE 14

SEDIMENTARY AND METAMORPHIC ROCKS

R	RECENT	Alluvium, fluviatile, lacustrine, paludal, and beach deposits; raised coral reefs, atolls, and beachrock.
N3 + Q1	PLIOCENE-PLIESTOCENE (g-h)	Marine and terrestrial sediments (molasse). Associated with extensive reef limestone in Bicol region, Visayas, and Mindanao; with pyroclastics in western and southern Central Basin and in northern Bicol Lowland. Predominantly marl and reworked tuff in places. Sporadic terrace gravel deposits in some coastal and fluvial tracts. Plateau red earths and/or laterites in some elevated flat land surfaces. Deformation limited to gentle warping and vertical dislocation.
N2	UPPER MIOCENE-PLIOCENE (f_3-g)	Largely marine clastics (molasse) overlain by extensive, locally transgressive pyroclastics (chiefly tuff, tuffites) and tuffaceous sedimentary rocks. Associated with calcarenite and/or silty limestone in some parts of Luzon, central Visayas, and Mindanao. Reefs limestone lenses intercalated with dacite and andesite flows in Zamboanga (western Mindanao). Chiefly arkose and arenite in Palawan. Local bog iron; laterite deposits in some elevated near-peneplaned surfaces.
N1	OLIGOCENE-MIOCENE (e_1?-f_2)	Thick, extensive, transgressive mixed shelf marine deposits, largely wackes, shales, and reef limestone. Underlain by conglomerate and/or associated with paralic coal measures in places. Sometimes associated with basic to intermediate flows and pyroclastics within Luzon, Visayas, and Mindanao. Largely arkosic and quartzitic clastics (miogeosynclinal type?) in southern Mindoro and Palawan. Generally well indurated. Folded and locally intruded by quartz diorite. The epidermal cover of many folded mountains. In some places probably includes Oligocene (c-d).
PG2	OLIGOCENE (c-d)	Minor limestone and/or wackes and shales. Generally associated with keratophyre and andesite flows. Limestone remnants in Cebu.
PG1	PALEOCENE-EOCENE (a-b)	Thick, extensive, transgressive mixed shelf and deeper water marine deposits, largely wackes and shales (flysch) associated with minor basal conglomerate, reef limestone, and calcarenite, sometimes with dacitic and/or andesitic flows and pyroclastics; with intertongues of paralic coal measures in Catanduanes. Largely arkosic and quartzitic clastics in southern Mindoro and Palawan. Generally moderately folded and intruded by quartz diorite.
KPG	UNDIFFERENTIATED	Largely graywacke and metamorphosed shale interbedded and/or intercalated with spilitic, basic and intermediate flows, and/or pyroclastics. Undifferentiated as to age. Probably Cretaceous and Paleogene.
K	CRETACEOUS	Extensive, transgressive graywacke-shale sequence intercalated with spilites. Associated with tuffaceous clastics in Rizal, with limestone lenses in Caramoan Peninsula, Catanduanes, and Central Cebu. Metamorphism up to greenschist facies.
J	JURASSIC	Arkose, subgraywacke, mudstone in Mindoro (Mansalay fm.). Associated with chert in Busuanga and northern Palawan.
BC	BASEMENT COMPLEX (PRE-JURASSIC)	Undifferentiated amphibolite, quartzofeldspathic and mica schist, and phyllites-slates frequently associated with marble and quartzite (?). Broadly folded; some narrow zones of close folding broken by upthrusts. Prevailing schistosity generally parallel, some oblique and/or perpendicular to bedding

IGNEOUS ROCKS

INTRUSIVE ROCKS

NI	NEOGENE	Largely intra-Miocene quartz diorite. Mostly batholiths and stocks, some laccoliths; also sills, dikes, and other minor bodies. Include granodiorite and diorite porphyry facies and late Miocene dacite. Pervasive in Paleogene and Mesozoic, less widespread in early Miocene rock sequences.
PGL	PALEOGENE	Mostly quartz diorite. Probably includes the granodiorite in Camarines Norte and quartz monzonite in Palawan.
UC	CRETACEOUS-PALEOGENE	Undifferentiated ultramafic and mafic plutonic rocks. Predominantly peridotite associated with late gabbro and/or diabase dikes. Complex layered type in Zambales. Generally thrusted or upfaulted into Tertiary and older rock formations. Most bodies probably late Mesozoic to early Tertiary.
PJI	PRE-JURASSIC(?)	Granite in western Zamboanga. Granodiorite(?) in Batangas.

VOLCANIC ROCKS

VOLCANIC ROCKS

QAV	QUATERNARY	Active volcanoes (with eruptions and/or activity since 1616) such as Didicas, Taal, Mayon, Bulusan, Canlaon, Camiguin, Makaturin, Ragang, and Calayo.
QVP	PLIOCENE-QUATERNARY	Volcanic plain or volcanic piedmont deposits. Chiefly pyroclastics and/or volcanic debris at foot of volcanoes. Plateau basalt in Pagadian and Lanao regions, Mindanao; associated with pyroclastics north and east of Laguna de Bay, Luzon.
QV	PLIOCENE-QUATERNARY	Non-active cones (generally pyroxene andesite); also dacitic and/or andesitic plugs. Basaltic dikes in Binga, Mt. Province, Luzon and in Misamis Oriental, Mindanao.
N2	UPPER MIOCENE-PLIOCENE	Principally dacite and/or andesite flows, generally with pyroclastic. Sporadic in north Luzon. Locally thick and associated with reef limestone lenses in southern Zamboanga.
N1	OLIGOCENE-MIOCENE	Mostly submarine andesite and/or basalt flows. Intercalated with pyroclastics and clastic sedimentary rocks and/or reef limestone lenses. Largely confined within the axial zones of Luzon, Visayas, and Mindanao.
PG2	OLIGOCENE	Essentially keratophyre and andesite flows. Often with pyroclastics and chert of volcanic origin. Undifferentiated form early Miocene sedimentary rocks in some areas.
PG1	PALEOCENE (?)-EOCENE	Limited dacite and andesite flows and dikes, generally intercalated with and/or intrude Eocene clastics. Included with Eocene sedimentary rocks in this map.
UV	UNDIFFER-ENTIATED	Metamorphosed submarine flows, largely spilites and basalts, some keratophyres and andesites. Confined to structural highs and/or principal mountain ranges. Often designated in early literature as "Metavolcanics". Most units probably Cretaceous and Paleogene.
K	CRETACEOUS-PALEOCENE	Essentially spilitic and basic flows. Usually intercalated with graywackes. Transgressive on "basement" rocks. Some are included with Cretaceous sedimentary rocks in this map.

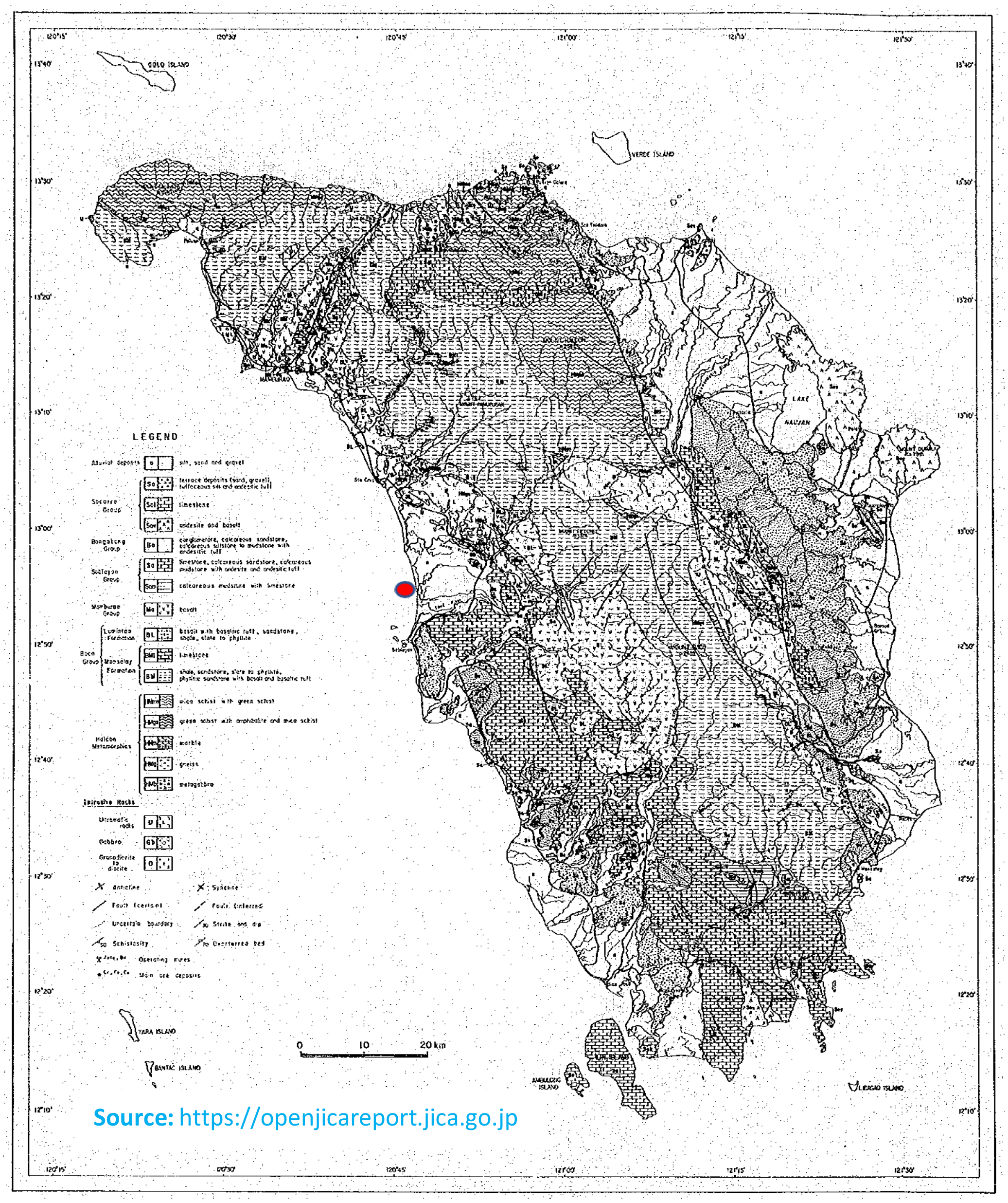
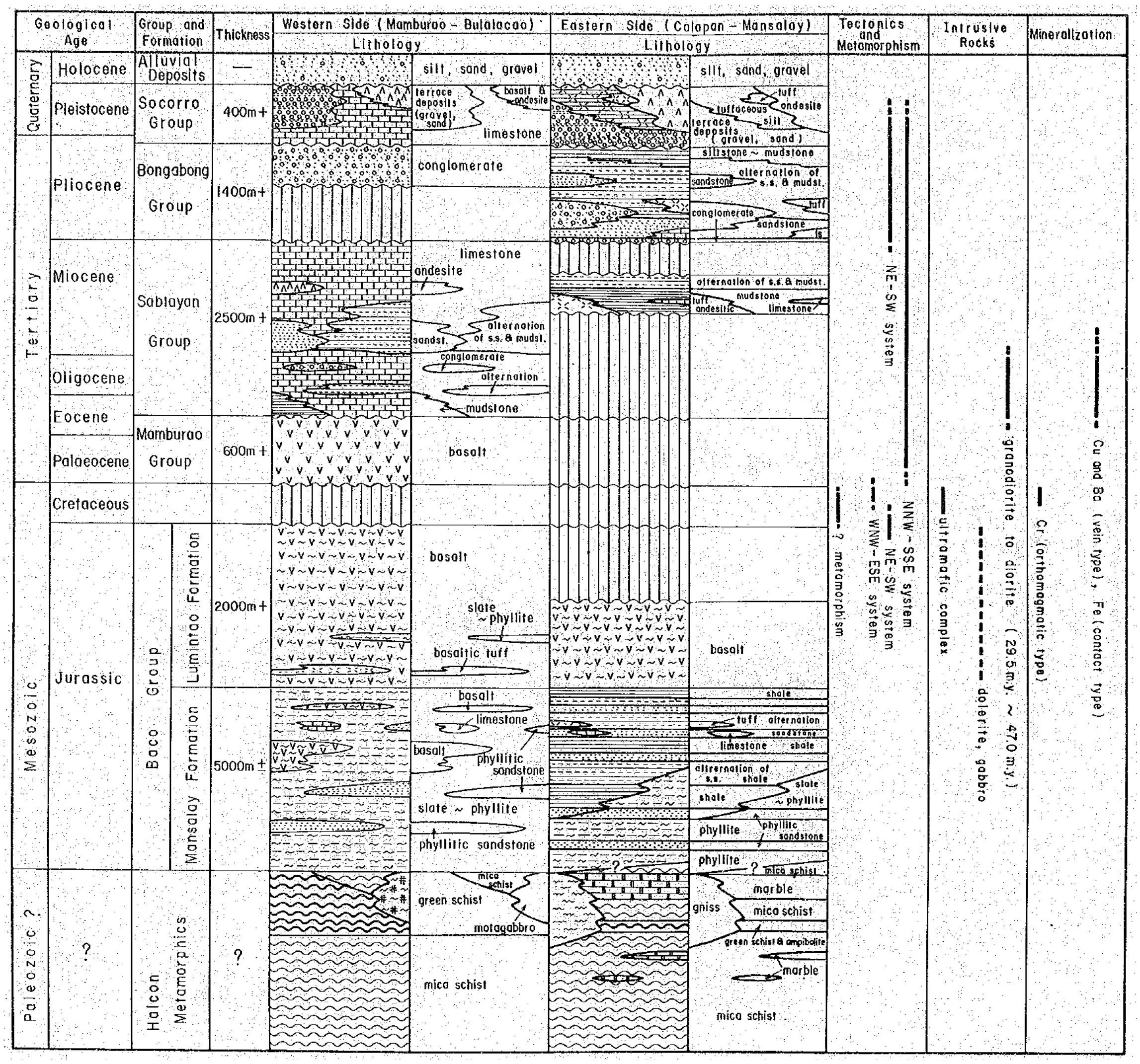


Figure 15. Geological Map of Mindoro Island



Source: https://openjicareport.jica.go.jp

Table 3. Generalized Stratigraphic Column of Mindoro

The delta front the area under consideration is nourished largely by the Patrick River system, the trunk of which is the subject of proposed dredging operations. A vast expanse of alluvial plain has developed on both flanks of the river channel (and adjacent smaller streams) that coalesce with the coastal plain (please refer to Figures 3). Evidently, a river south of the survey area had its mouth migrated southeasterly through time resulting from the extensive formation of a sandbar and development of a parallel stream. This indicates that the old river mouth and flanks had been totally dammed with sand, gravel and cobbles of various rock types. In the field, It is also apparent that a long but discontinuous "submerged" sandbars are actively developing about 20 to 30 meters seaward of the existing shoreline. This phenomenon enhances the swells or waves to grow in height then break forcefully as their wave base touch the shallow sea bottom, thereby creating a rough sea condition at the foreshore at the time of survey. This implies that the river mouth and foreshore is wave-dominated and that the longshore current direction is more pronounced towards the southeast.

In general, the seabed sand deposit, with some granules and pebbles, is supplied largely by the Patrick River system that is incised largely through the Halcon Metamorphic Complex, Mansalay Formation, Lumintao Formation, ultramafics, quartz diorite, metagabbro , volcanics and alluvium.

The beach and beach ridges at the seaward terminations of the Patrick River delta lobes are composed of unsorted and unconsolidated rock debris of various sizes, types and origin (Photo 3). Based on visual estimate on the relative abundances of particles, sand with some silt constitute the bulk of the deposit (~90%), followed by granules (~5%), pebbles (~3%) and small cobbles (~2%) [please refer to Table 4 below for size classes]. It was observed that the existing southeast delta lobe is generally coarser than the northwest lobe. This suggests that the water current of the river is stronger towards southeast than the northwest current during flood regimes.

The sand fraction of the delta deposit is a mixture of comminuted debris derived from the chemical and mechanical weathering of the various rock types that were further reduced to smaller sizes by abrasion and corrasion as they were transported downstream by stream runoff from the source areas several kilometers upstream. It is dark gay when wet and light brownish gray when dry. Sub-angular to sub-rounded particles of quartz/silica is abundant and ubiquitous. Ferromagnesians(?) and other mafic minerals and rock bits impart a dark gray color of the sand when wet.

Photo 3 The delta deposit at the south-eastern lobe (south bank) of estuary. It is composed of rock debris of various sizes, largely sand.

Particle Length (dr) mm	Ø	Grade	Class
	–12		Boulder
256.000	–8		Cobble
64.000			Pebble
4.000	–2		Granule
2.000	–1	Very Coarse	
1.000	0	Coarse	
0.500	1	Medium	Sand
0.250	2	Fine	
0.125	3	Very Fine	
0.061	4	Coarse	
0.031	5	Medium	Silt
0.016	6	Fine	
0.008	7	Very Fine	
0.004	8		Clay

Table 4. Wentworth size grade scale

The granules are subrounded to rounded fragments of basalt and andesite with quartz and other lithic fragments abundantly associated. Few magnetic fraction (magnetite) is associated.

The larger heterogenous fragments that compose the pebbles, gravel and small cobbles have smooth surfaces, are well-rounded fragments of basalt, andesite, quartz, slate, phyllite, some marble and other metamorphosed rocks derived most likely from the lithologies that make up the Halcon Metamorphic Complex, Mansalay Formation, Lumintao Formation and Mamburao Group. The quartz may have been derived mostly from the quartz segregation bands, or quartz boudinage, associated with the Halcon Metamorphic Complex.

Figure 16 is hereto attached as a visual guide in describing the sand grains as to their sizes, angularity and roundness.

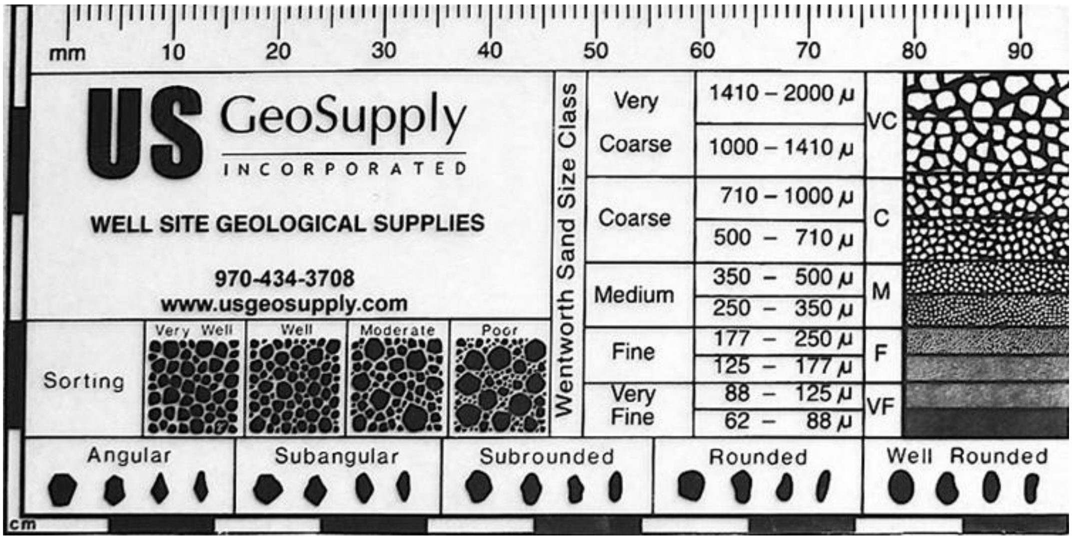


Figure 16. A visual guide in describing sand grains characteristics

Sea-bottom sediment sampling

Ten (10) sea-bottom sediment samples (Figure 17) in the nearshore area were randomly collected using a funnel-type dredge sampler (Photos 4) and a 2m-long fabricated sand pump, with 1m-long extender (Photos 5, 6) made of 1-inch diameter G.I. pipe. The sand pump samples were taken from the seabed substrate at water depths of more or less 1 m and numbered S-SPS-1, S-SPS-2. S-SPS-3 and S-SPS-4.

Dredge sampling was done in areas of more than 5 meters water depths. These were labeled S-DS-1 thru 7. The sampling was done in order to have a direct physical characterization of the seabed materials.

Figure 17. Sampling locality map of survey area

Photo 4. The funnel-shape dredge sampler showing various elements.

Photo 5. Sand pump sampling at the site of S-SPS-1 [12°53’45.48”/120°46’56.7”]

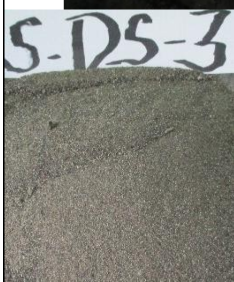
Photo 6. Pushing out the “core” of sand using the sampler’s piston

Description of the seabed samples
Megascopic description

The samples from the seabed surface and substrate were megascopically described with the aid of a 20x achromatic hand lens as follows:

S-SPS – 1. [Location:12° 53’ 45.48” / 120° 46’ 56.7”, at the southeast bank of existing Patrick River estuary]. Fine to medium SAND. with some pebbles. and granules. Dark gray when wet and light brownish gray when dry. Well-rounded lithic fragments of andesite, basalt and metamorpics abundant. Quartz grains abundant. With the aid of a microscope, “the sample consists of very fine sand-sized to granule-size subangular to subrounded grains of lithic fragments, quartz, altered fragments, magnetite grains and organic material. The aphanitic texture and platy appearance of lithic fragments indicate a volcanic and metamorphic origin. Colorless and white crystalline grains are identified as quartz. Reddish and greenish discoloration of altered fragments is attributed to iron oxidation and chloritization. About 10% of the sediments are probably magnetite or magnetic-bearing lithic fragments. Trace amount of organic material is also noted in the sample”.	S-SPS-1 
S-SPS – 2. [Location:12° 53’ 50.64” / 120° 46’ 57.06, at the southeast bank of existing Patrick River estuary and north of S-SPS-1]. Fine to medium SAND. with some granules and pebbles. Dark gray Dark gray when wet and light brownish gray when dry. Well-rounded lithic fragments of andesite, basalt and metamorpics abundant. Quartz grains abundant. With the aid of a microscope, “the sample consists of very fine sand-sized to granule-size subangular to subrounded grains of lithic fragments, quartz, altered fragments, magnetite grains and organic material. The aphanitic texture and platy appearance of lithic fragments indicate a volcanic and metamorphic origin. Colorless and white crystalline grains are identified as quartz. Reddish and greenish discoloration of altered fragments is attributed to iron oxidation and chloritization. About 10% of the sediments are probably magnetite or magnetic-bearing lithic fragments. Trace amount of organic material is also noted in the sample.”	S=SPS- 2 

S-SPS – 3.[Location: 12° 53’ 50.88” / 120° 46’ 53.46”, at the western end of Patrick River Estuary]. Fine to medium SAND. with granules and some pebbles. Dark gray Dark gray when wet and light brownish gray when dry. Well-rounded lithic fragments of andesite, basalt and metamorpics abundant. Quartz grains abundant. With the aid of a microscope, the sample consists of very fine sand-sized to granule-size subangular to subrounded grains of lithic fragments, quartz, altered fragments, magnetite grains and organic material. The aphanitic texture and platy appearance of lithic fragments indicate a volcanic and metamorphic origin. Colorless and white crystalline grains are identified as quartz. Reddish and greenish discoloration of altered fragments is attributed to iron oxidation and chloritization. About 10% of the sediments are probably magnetite or magnetic-bearing lithic fragments. Trace amount of organic material is also noted in the sample.	S-SPS 3  
S-SPS - 4 [Location:12° 54’ 0.42” / 120° 46’ 53.58”, at the existing foreshore of Patrick River delta’s northern lobe]. Pebbly fine to medium SAND. with granules. Dark gray Dark gray when wet and light brownish gray when dry Well-rounded lithic fragments of andesite, basalt and metamorpics abundant. Quartz grains abundant. With the aid of a microscope. the sample consists of very fine sand-sized to granule-size subangular to subrounded grains of lithic fragments, quartz, altered fragments, magnetite grains and organic material. The aphanitic texture and platy appearance of lithic fragments indicate a volcanic and metamorphic origin. Colorless and white crystalline grains are identified as quartz. Reddish and greenish discoloration of altered fragments is attributed to iron oxidation and chloritization. About 10% of the sediments are probably magnetite or magnetic-bearing lithic fragments. Trace amount of organic material is also noted in the sample.	S-SPS-4   3

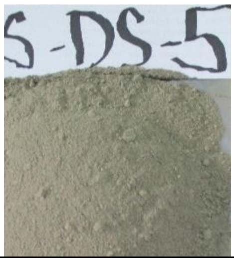
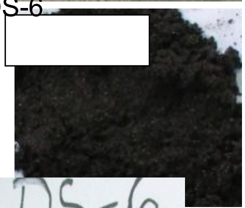
S-DS – 1. [Location:12° 53' 45.72" / 120° 46' 53.04". Near the mouth of the estuary, west of the site of S- SPS-1]. Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangulat to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts, slates and other metamorphic rocks	S-DS-1  
S-DS – 2. [Location:12° 53' 51.12" / 120° 46' 55.74". At the estuary, northwest of S-SPS-2]. Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangulat to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts, slates and other metamorphic rocks	S-DS-2  
S-DS – 3. [Loation:12° 53' 37.8" / 120° 46' 45.42". At the estuary, west of S-DS-2]. Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangulat to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts, slates and other metamorphic rocks	S-DS-3  

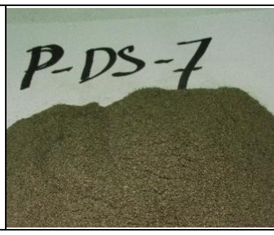
<table>
<tr>
<td>S-DS – 4. [Loation:12° 53’ 39.66” / 120° 46’ 40.62”.
At the neatshre area, northwest of S-DS-3].

Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangulat to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts, slates and other metamorphic rocks</td>
<td>S-DS-4

</td>
</tr>
<tr>
<td>S-DS – 5. [Loation:12° 53’ 32.28” / 120° 46’ 36.6”.
At the nearshore area southwest of S-DS-4].

Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangulat to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts, slates and other metamorphic rocks</td>
<td>S-DS-5

</td>
</tr>
<tr>
<td>S-DS – 6. [Location:12° 53’ 26.52” / 120° 46’ 40.2”]..
Nearshore area near the southern-most corner of the proposed navigational zone
Fine to medium sand with some granules and pebbles. Medium gray when wet; light brownish gray when dry. Sand-size particles are subangular to subrounded. Quartz particles abundant. Granules subrounded to rounded; pebble components are well rounded fragments of quartz, andesite, basalts,
slates and other metamorphic rocks</td>
<td>S-DS-6

</td>
</tr>
<tr>
<td>DS-7 Location: 13° 07’ 46.2” / 120° 40’ 52.02”
Silty Fine SAND. Sub-angular to sub-rounded. Dark gray when wet, light brownish gray when dry. Milky white grains of quartz/silica abundant; Black specks common. Few magnetite</td>
<td></td>
</tr>
</table>

Grain size distribution analysis

The samples were submitted at the Metallurgical Laboratory of the Mines and Geosciences Central Office for grain size distribution analysis by dry sieving using US Sieve Nos. 6, 10, 20 and 28 for the sand pump samples (SPS) and Nos. 20, 35, 48 and 100 for the dredge (DS) samples. The Percent Retained in each screen size/ sieve mesh were used to describe the grain sizes of the samples, whether pebbly, coarse to very coarse sand, medium sand with, silty fine sand etc, as the case may be. The Results of Metallurgical Tests on the samples are enclosed in red polygon as shown on the Results of Analysis (ROA 1) below:

ROA 1. SIEVE ANALYSIS ON SAMPLES

Republic of the Philippines
Department of Environment and Natural Resources
MINES AND GEOSCIENCES BUREAU
North Avenue, Diliman, Quezon City, Philippines
Tel No. (+63 2) 920-9120/920-9130 Trunkline No. 667-6700 loc. 134 Fax No. (+63 2) 920-1635 Email: central@mgb.g

REPORT OF METALLURGICAL TESTS
(Not Valid for Promotion Purposes)

27 February 2023

Lab. No. MT - 2023 - 22

Article and type of testing: Twenty-one (21) sand samples for Dry Sieve analysis.

Requested by: **PANCHO CACULITAN**
Bacoor, Cavite

Date Received/Started: February 21, 2023
Date Finished: February 27, 2023

Charge: ₱3, 240.00
Paid under O.R. # 5411470
Date: February 21, 2023

Results : (As Received Basis)

I. DRY SIEVE ANALYSIS

Sample Marked: P-SPS-1

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
6	3.36	6	12.41	87.59
10	1.68	12	14.67	72.92
20	0.841	20	30.32	42.60
28	0.595	30	15.91	26.69
Pan			26.69	0.00
TOTAL			100.00	

Sample Marked: P-SPS-2

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
6	3.36	6	18.30	81.70
10	1.68	12	18.47	63.23
20	0.841	20	47.44	15.79
28	0.595	30	13.99	1.80
Pan			1.80	0.00
TOTAL			100.00	

Sample Marked: P-SPS-3

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
6	3.36	6	14.85	85.15
10	1.68	12	14.37	70.78
20	0.841	20	23.35	47.43
28	0.595	30	14.09	33.34
Pan			33.34	0.00
TOTAL			**100.00**	

Sample Marked: S-SPS-1

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.80	98.2
35	0.420	40	9.00	89.2
48	0.297	50	24.59	64.61
100	0.149	100	23.46	41.15
Pan			41.15	0.00
TOTAL			**100.00**	

Sample Marked: S-SPS-2

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	2.02	97.98
35	0.420	40	10.12	87.86
48	0.297	50	22.27	65.59
100	0.149	100	33.98	31.61
Pan			31.61	0.00
TOTAL			**100.00**	

Sample Marked: S-SPS-3

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	8.91	91.09
35	0.420	40	27.31	63.78
48	0.297	50	23.29	40.49
100	0.149	100	18.22	22.27
Pan			22.27	0.00
TOTAL			**100.00**	

FO-METD-04
DATE ISSUED: MAY 02, 2022
REV: 1

Sample Marked: S-SPS-4

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	3.80	96.2
35	0.420	40	14.79	81.41
48	0.297	50	26.10	55.31
100	0.149	100	31.68	23.63
Pan			23.63	0.00
TOTAL			**100.00**	

Sample Marked: S-DS-1

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	0.99	99.01
35	0.420	40	11.96	87.05
48	0.297	50	37.53	49.52
100	0.149	100	42.78	6.74
Pan			6.74	0.00
TOTAL			**100.00**	

Sample Marked: S-DS-2

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.54	98.46
35	0.420	40	12.62	85.84
48	0.297	50	35.24	50.6
100	0.149	100	24.72	25.88
Pan			25.88	0.00
TOTAL			**100.00**	

Sample Marked: S-DS-3

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	0.55	99.45
35	0.420	40	2.19	97.26
48	0.297	50	9.29	87.97
100	0.149	100	29.06	58.91
Pan			58.91	0.00
TOTAL			**100.00**	

Sample Marked: S-DS-4

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	0.93	99.07
35	0.420	40	2.74	96.33
48	0.297	50	7.34	88.99
100	0.149	100	23.79	65.20
Pan			65.20	0.00
TOTAL			100.00	

Sample Marked: S-DS-5

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	5.06	94.94
35	0.420	40	6.20	88.74
48	0.297	50	15.39	73.35
100	0.149	100	40.18	33.17
Pan			33.17	0.00
TOTAL			100.00	

Sample Marked: S-DS-6

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.50	98.50
35	0.420	40	19.52	78.98
48	0.297	50	36.57	42.41
100	0.149	100	4.97	37.44
Pan			37.44	0.00
TOTAL			100.00	

Sample Marked: S-DS-7

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.24	98.76
35	0.420	40	3.57	95.19
48	0.297	50	10.37	84.82
100	0.149	100	27.19	57.63
Pan			57.63	0.00
TOTAL			100.00	

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	20.99	79.01
35	0.420	40	17.64	61.37
48	0.297	50	30.03	31.34
100	0.149	100	20.33	11.01
Pan			11.01	0.00
TOTAL			100.00	

Sample Marked: P-DS-2

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.81	98.19
35	0.420	40	13.44	84.75
48	0.297	50	15.49	69.26
100	0.149	100	33.46	35.80
Pan			35.80	0.00
TOTAL			100.00	

Sample Marked: P-DS-3

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	21.07	78.93
35	0.420	40	20.93	58.00
48	0.297	50	25.13	32.87
100	0.149	100	16.12	16.75
Pan			16.75	0.00
TOTAL			100.00	

Sample Marked: P-DS-4

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	1.55	98.45
35	0.420	40	23.60	74.85
48	0.297	50	40.32	34.53
100	0.149	100	21.89	12.64
Pan			12.64	0.00
TOTAL			100.00	

Sample Marked: P-DS-5

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	11.20	88.80
35	0.420	40	18.43	70.37
48	0.297	50	25.30	45.07
100	0.149	100	24.29	20.78
Pan			20.78	0.00
TOTAL			100.00	

Sample Marked: P-DS-6

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	0.72	99.28
35	0.420	40	4.91	94.37
48	0.297	50	9.53	84.84
100	0.149	100	14.57	70.27
Pan			70.27	0.00
TOTAL			100.00	

Sample Marked: P-DS-7

Screen Size			Weight Percent Retained, (%)	Wt. Cumulative Percent Passing, (%)
mesh	mm	US Sieve		
20	0.841	20	0.84	99.16
35	0.420	40	3.02	96.14
48	0.297	50	15.63	80.51
100	0.149	100	41.09	39.42
Pan			39.42	0.00
TOTAL			100.00	

HECTOR S. ANDRES
Chief, Mineral Processing Service
and Audit Section

Noted:

By Authority of the Director of Mines and Geosciences Bureau:

BERNARDO V. BITANGA
OIC, Metallurgical Technology Division

Specific gravity determinations
Two (2) composite samples were also submitted for Specific Gravity (SG) determinations at the MGB's Metallurgical Laboratory These are numbered S- SPS-1 and S-DS-1. S-SPS-1 is a composite of the sand pump samples S-SPS- 1 to S-SPS-4, while S-DS-1 is a composite of the dredge samples S-DS-1 thru 7. The SG determination finds its importance in the precise conversion from cubic meters to metric tons of sand dredgeates obtained in the resource estimate within the proposed navigational zone through the Patrick River delta front. The deepening of the proposed navigational zone to the river course is imperative to ensure safety of navigation and prevent grounding of the dredger and barges to be involved in the dredging operations.

The Report of Analysis on Specific Gravity determinations for the samples submitted is labeled as ROA 2 below. S-SPS-1 and S-DS-1 have SG values of 2.79 and 2.83, respectively. This indicates that the DS sample is finer and therefore heavier than the SPS sample. Corollarilly, the sand near the coastline is coarser than those deposited farther offshore.

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ROA 2. SPECIFIC GRAVITY DETERMINATIONS

REPORT OF ANALYSIS
(Not Valid for Promotion Purposes)

Date: February 28, 2023

Lab. No. CLSS 23-98

Four (4) sand samples marked P-SPS-1, P-DS-1, S-SPS-1 and S-DS-1 for true specific gravity.

Requested by: **PANCHO CACULITAN**
Bacoor, Cavite

Date Started: 02/22/2023
Date Finished: 02/28/2023

Charge: ₱ 1,000.00
Paid under O.R. # 5411471
Date: 02/21/2023

Results : (As Received Basis)

	P-SPS-1	P-DS-1	S-SPS-1	S-DS-1	Analytical Method
True Specific Gravity	2.73	2.78	2.79	2.83	Gravimetric

ROMMEL G. PATINGO, RCh
LICENSE NO. 0007592
CHIEF, CHEMICAL LABORATORY SERVICE SECTION

Noted:

BY AUTHORITY OF THE DIRECTOR OF MINES AND GEOSCIENCES BUREAU:

BERNARDO V. BITANGA
OIC, METALLURGICAL TECHNOLOGY DIVISION

CONCLUDING REMARKS

The major activities of the survey consisted of a) bathymetric survey and resource estimation, and, b) geological investigation and seabed sampling;

Water depth charting was conducted along pre-determined track-lines totaling approximately 23.5 line-kilometers that covers about 1.5 km2, using a single beam echo sounder system, model CHC D230, onboard a motorized banca survey platform. Though the final revised version of the proposed navigational zone proposed by the proponent came at a later date than the conduct of field survey, the bathymetric survey still effectively covered said revised zone at the central portion of the bathymetric survey area;

Water depths in the areas covered by the echo sounder survey range from -
0.5 to -26 meters. Isobath contours in the bathymetric map are generated at 1m intervals;

The shallow portion of the survey area down to -10m elevation shows chaotic contours signifying a rough surface sea floor probably due to the formation of new sandbars. This may be the reason why the sea condition is rough near the coastline;

A Global Navigation Satellite System (GNSS) was used as the primary positioning system, coupled with digital single beam echo sounder (SBES) to record the water depth. The depth data are collected every second and are stored with GNSS positions and time tag. The depths are corrected for the draft of the transducer, tidal variation and sound velocity in water. The raw depths are reduced for change in sea level due to the tide and calibration parameters from the surface elevations to produce elevations on the bottom of the survey area. The elevations are used to produce contour map and 3-D views;

The seabed has a low seaward slope of about 5 degree, or 9%;

Horizontal and vertical corrections were provided by the RTK base station. The vertically corrected water level was subtracted to the measured water depth to get the bottom elevation. This corrected elevation data together with its coordinates and time tag were imported to the Surfer 18 Software. The resulting xyz data was gridded into 1m x 1m resolution digital terrain model (DTM). The DTM is then used to create contour at whatever interval is required, relief and 3D visual representation of the data which can be overlayed onto the final drawing;

The resource estimate was carried out using Grid model volume calculation, which can be easily used to compute dredge volume with bathymetry data. The volumes are calculated by creating two gridded surfaces of existing and design surface. The two surfaces have the same number of rows and columns and the same X and Y limits. In the grid model, different mathematical techniques like Simpson's rule and Trapezoidal rule are used for volume computation. The collected echo sounder data made to equidistant grid data and the same is given as input in the grid model.

A dredging bottom of 10 meters below sea level at low tide regimes was used in the resource estimation to ensure safety of navigation of the dredging fleet to and from the Patrick River channel. This will prevent grounding of vessels and thus prevent accidents and downtimes. Besides, agitation and resuspension of the bottom sediments by the tug boat propeller shall be greatly minimized;

Approximately 2,821,818 cu. meters of sand materials could be dredged out within the proposed navigational zone and delta front. With a specific gravity of 2.81, this volume weighs about 7,929,308.58 dry metric tons;

Assuming a 2,000m3 /hr capacity of the Cutter Suction Dredger to used, it takes about 1,411 hours to develop the proposed navigational zone to desired dredging bottom. At a 24-hours dredging operation, it needs 58.8 days to remove the seabed materials in the proposed navigational zone;

The area under consideration is nourished largely by the Patrick River system, the trunk of which is the subject of proposed dredging operations.. An extensive alluvial floodplain has developed on both flanks of the river (and adjacent smaller creeks) that coalesce with the coastal plain. Apparently, the river mouth has migrated southeasterly through time. This indicates that the old river mouth and flanks had been totally dammed with sand, gravel and cobbles of various rock types. It could also be seen on Figures 3 that a parallel stream with its mouth migrated to the southeast had developed behind the long sandbar. This phenomenon also suggests that the river mouth and foreshore is wave-dominated and that the longshore current direction is more pronounced towards the southeast.

The Patrick River delta is composed of heterogenous, unconsolidated pebbly to gravelly coarse to fine sand. The larger fragments that compose the pebbles, gravel and small cobbles have smooth surfaces and are well-rounded fragments of basalt, andesite, quartz, slate, phyllite, some marble and other metamorphosed rocks derived most likely from the lithologies that make up the Halcon Metamorphic Complex, Mansalay Formation, Lumintao Formation and Mamburao Group. Few magnetite grains are associated;

Sand pump sampling was done in the foreshore with water depth of 1 meter or less, while dredge sampling was conducted in the survey area in water depths of more than 2 meters in order to be able to describe the physical properties of the sea bottom sediments in terms of grain size distribution and specific gravity. Comparatively, the sand pump samples are generally coarser than the dredge samples as evidenced by the result of field observations, sieve analysis and specific gravity determinations;

Detrital materials in the foreshore are composed largely of pebbly to gravelly coarse to fine SAND. The sand grains are sub-angular to sub-rounded. Milky white grains of quartz/silica are ubiquitous and abundant; Dark gray specks common. Few magnetite associated. Hard, gravel layer about 60cm to 75cm below seabed impenetrable by the sand pump; and

The dredge samples are largely fine to medium sand with silt. Dark gray when wet and light brownish gray when dry. Grains are sub-angular to sub-rounded. Quartz is ubiquitous and abundant. Few associated magnetite.