GEOSERVICES
MARITIME PVT. LTD.

REPORT ON TOPOGRAPHIC & BATHYMETRIC SURVEY FOR ASSESSMENT OF RESERVOIR CAPACITY & SEDIMENTATION IN HATHMATI RESERVOIR, GUJARAT, INDIA UNDER NATIONAL HYDROLOGY PROJECT

GMPL REPORT NUMBER: P-SUR-BATHY-009-2020-WRD-HATHMATI
SURVEY PERIOD: Bathymetry: 03 FEB TO 20 FEB 2021
Topography: 17 FEB TO 23 FEB

Prepared for:	**Water Resources Investigation Division, Ahmedabad** **(Govt. Of Gujarat)**	Equity Efficiency Sustainability WRD
Client Reference:	**Executive Engineer** **Water resources investigation Division** **Ahmedabad.**	

LOCATION MAP

Figure 1.1-1 LOCATION MAP

LOCATION MAP SHOWING SURVEY AREA "HATHMATI RESERVOIR", GUJARAT, INDIA

DOCUMENT ARRANGEMENT

REPORT OF SURVEY WITH CHART / DRAWING

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1 INTRODUCTION, OBJECTIVE & SCOPE OF WORK

1.1 General

Water Resources Investigation Division (WRD) has awarded the contract to Geoservices Maritime Pvt Ltd (GMPL), Navi Mumbai for carrying out Topographic and Bathymetric Survey at Hathmati

Reservoir, Gujarat. The survey services provided by GMPL comprise of the provision of well-qualified survey personnel and equipment in order to obtain, interpret and report on acquired topographic & bathymetric survey data at the client specified locations.

This report contains the results of survey as against the scope of work and the methodology adopted to achieve the specifications and schedule of the survey work undertaken at Hathmati Reservoir.

1.1.1 LIST OF ABBREVIATIONS USED

CM	Central Meridian
DGPS	Differential Global Positioning System
CSRS	Canadian Spatial Reference System
FRL	Full Reservoir Level
GMPL	Geoservices Maritime Private Limited
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
KHz	Kilohertz
HSE	Health Safety Environment
MSL	Mean Sea Level
m	metre
M Cu. m	Million Cubic metre
Sq. Km	Square Kilometre
MDDL	Minimum Draw Down Level
m/s	meter per second
ms	milliseconds
MWL	Maximum Water Level
QA/QC	Quality Assurance / Quality Control
Rev	Revision
RTK	Real Time Kinematic
SBES	Single Beam Echo Sounder
TBM	Temporary Bench Mark
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984
WRD	Water Resources Investigation Division

1.1.2 Units

- UTM grid coordinates and all linear measurements expressed in metres (m).
- Angular values expressed in degrees (°).
- Time and dates expressed as “09:00 on 24 Jan 2021”.

1.2 Objective

The client's objectives were:

i) To estimate and study the sedimentation behaviour of reservoir in different zones including horizontal zones throughout the reservoir as well as vertical zones namely dead storage, live storage and flood storage if any.

ii) To upgrade Elevation-Area-Capacity table and curves of the reservoir at regular intervals.

iii) To emphasize on the importance of conducting hydrographic surveys at regular intervals for better operation and water management of the reservoir.

1.3 Scope of Work

The Scope of work for Geoservices Maritime Pvt Ltd was to mobilise, install, interface, operate all survey systems and provide all required survey personnel to undertake Topographic and Bathymetric survey services at Hathmati Reservoir.

The detailed scope of work was:

i) To measure the water depth of the Hathmati Reservoir at with respect to MSL.

ii) Line spacing shall be 25 m with continues echo sounding.

iii) Reservoir for water level changes during survey shall be tabulated.

iv) Data processing using HYPACK software shall be used.

v) Topographic survey shall be conducted from FRL water level with reasonable overlap with hydrographic survey.

vi) The area not covered under Hydrographic survey up to Maximum Water Level (MWL) shall be surveyed by taking levels at 25 m interval (25 m x 25 m grid).

vii) To carry out the data processing and interpretation of data and preparing of results, charts and drawings.

viii) Estimation of Sedimentation in the Reservoir shall be calculated if previous data is available.

ix) Gross and Live storage capacity of the Reservoir at every 10 m interval shall be provided.

x) Cross Sections showing the bed profile at 100 m interval shall be prepared.

xi) L-Section of the Reservoir may be prepared with lowest bed level at every survey line.

2 SALIENT FEATURES OF HATHMATI RESERVOIR

HATHMATI RESERVOIR PROJECT		
I	**LOCATION**	
	Coordinates	Latitude 23°42'26"N Longitude 73°12'28"E
	River	Hathmati River
	Village	Fatepur

	Taluka	Bhiloda
	District	Sabarkantha
	State	Gujarat
	Nearest Railway Station	Taranga Railway Station
	Purpose	Irrigation & Water Supply
II	**HYDROLOGY**	
	Catchment Area	595 km^2
	Mean Annual Rainfall	864 mm
III	**DAM**	
	Dam Type	Earthen
	Length of the top of the dam	933 m
IV	**RESERVOIR**	
	MDDL	170.69 m
	FRL	180.74 m
	HFL/MWL	183.18 m
	Gross Storage Capacity	161.31 M Cu. m
	Dead Storage Capacity	8.34 M Cu. m
	Live Storage Capacity	153.00 M Cu. m
	Area at FRL	37.15 Sq. km
V	**SPILLWAY**	
	Type	Waste Weir
	Length of Spillway	241 m
	Maximum Discharge	2943 m^3/s
	Type, Nos. and Size of Gates	Ungated
VII	**CANAL**	
	Length of canal	104 km
	Capacity	16 m3/s
	Gross command area	73817 ha
	Culturable command area	5166 ha

Table 2-1 SALIENT FEATURES OF RESERVOIR

3 EXECUTIVE SUMMARY OF RESULTS

GMPL had mobilised their survey team, equipment and Survey Boat "Aqua Marina" which was deployed in the Hathmati Reservoir survey area from 03 FEB to 20 FEB 2021 (Topography through 17 FEB TO 23 FEB) to acquire bathymetric survey data and Topographic data as per mutually agreed scope and relevant survey specifications.

Trimble DSM 232 DGPS system, Sonarmite BTX Echo sounder (215 kHz) were utilised to acquire the bathymetric data within the Hathmati Reservoir area. A value of 1500 m/s was used as the average velocity of sound in water, which was applied in the setup during acquisition. The data so obtained was then processed and contouring was done using Hypack software. Pentax RTK /Geomax Auto level and Tripod were used for topographic survey in the area.

Topographic and bathymetric data was reduced to Mean Sea Level (MSL). All the data is plotted on scale of 1:5000 for Hathmati reservoir area.

Pentax RTK base was used for DGPS observation on OBS-HATM. Four (4) hours of DGPS observation was carried out on OBS-HATM (Levelling was carried out from BC Line to above mention observation point and level of BC Line was provided by Dam Authority). Two rovers receiving RTK corrections from the base took spot level from water level to HFL.

The values depicted in the charts are the elevation with respect to MSL.

- The Minimum elevation within HATHMATI reservoir is 167.06 m above MSL and
- The Maximum depth within HATHMATI reservoir is 11.83 m.
- Area covered by bathymetric survey is 25.853 Sq. Km.
- Area covered by topographic survey is 16.242 Sq. Km.

According to recent survey, total area of reservoir at FRL 180.74 m is 33.262 Sq. Km, corresponding storage capacity is 148.753 M Cu. m and Dead storage at 170.69 m is 2.432 M Cu. m.

The rate of siltation in the reservoir (up to FRL 180.74 m) during the last 50 years (1971-2021), was found to be 0.251 M Cu. m / year.

The comparison between 1971 and 2021(50 years) data results in a rate of siltation (silt index) of 4.221 Ham/100 Sq. Km/year. Annual percentage loss of gross storage capacity, live storage capacity and dead storage capacity is 0.16%, 0.09% and 1.42% respectively.

4 RESOURCES FOR SURVEY WORK

4.1 Personnel

Following staff were involved during the survey work.

Offshore Survey Personnel	
Name	**Function**
Amit Singh	Party Chief
Pruthviraaj Mohile	Surveyor
Rohit Singh	Surveyor
Abhijith Cherapi	Land Surveyor
Samraj Dwivedi	Survey Enginner
Ashish Patil	Survey Engineer
Onshore Project Management and Data QC	
Sudhir Walia	Project Manager
KSN Murthy	Survey Manager
Dhaval Patel	Data Processor

Table 4.1-1 LIST OF PERSONNEL

4.2 Details of Equipment used

Following equipment and survey sensors were mobilised for the Topographic and Bathymetric survey data acquisition carried out at Hathmati reservoir. The equipment setup and configuration diagram has been presented in Figure 4.1.

Survey Equipment/Systems Used for the Data Acquisition	
Equipment/System	**Description/Make/Model**
Software / Navigation	HYPACK Navigation and Data Acquisition Software
Positioning	Trimble DSM 232 DGPS
Single Beam Echo Sounder	Sonarmite BTX Echo sounder with Accessories
RTK	Pentax RTK system
Auto Level	Geomax Auto Level & Tripod
Survey Boat	“Aqua Marine” with OBM
Laptop	Dell Laptops
Power Supply	12v Battery & Inverter

Table 4.2-1 LIST OF EQUIPMENT USED FOR SURVEY

4.3 Survey Vessel

Survey Boat 'Aqua Marine' was utilised for carrying out the bathymetric survey.

4.3.1 Survey Boat Specifications

Survey Boat 'Acqua Marine' Specifications	
Length overall	3.56m
Breadth moulded	1.88m
Draft	0.50m

Table 4.3-1 SURVEY BOAT SPECIFICATIONS - 'AQUA MARINE'

4.3.2 Survey Boat Offset Diagram

The location of the various survey sensors on the survey boat 'Aqua Marine' is given in the vessel-offset diagram on the chart accompanying this report.

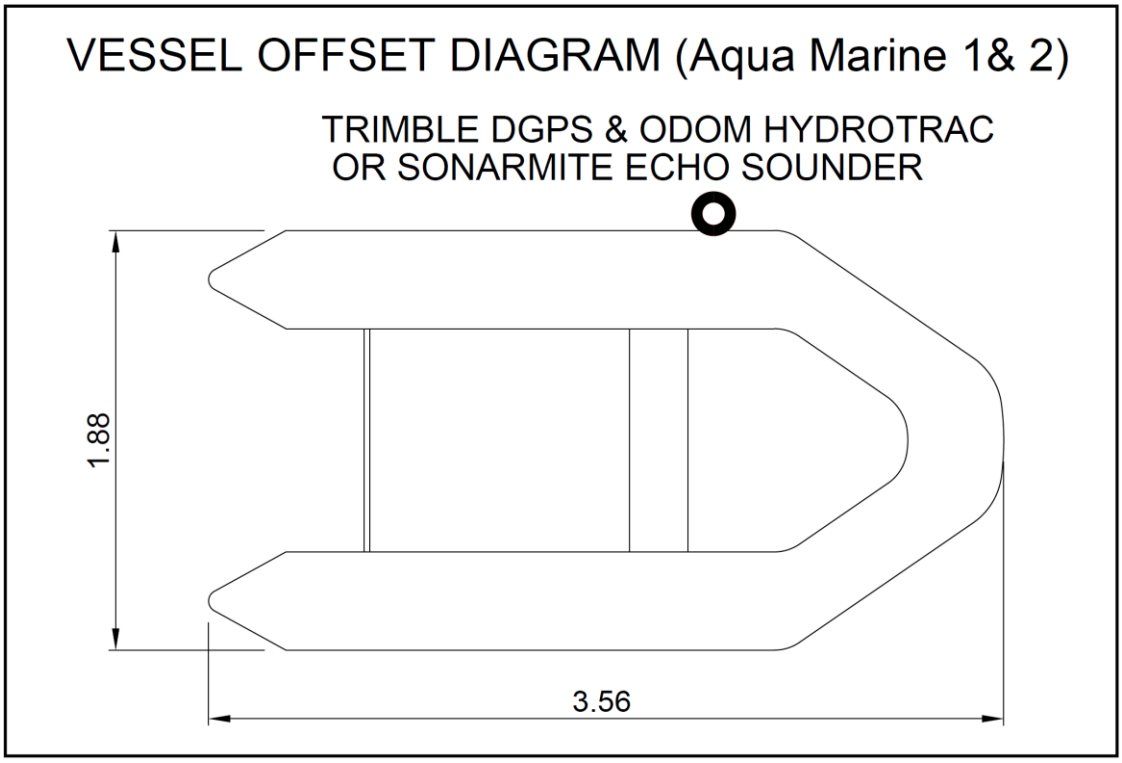

Figure 4.3-1 SURVEY BOAT ' AQUA MARINE' OFFSET DIAGRAM

5 DETAILED METHODOLOGY OF SURVEY

5.1 Mobilisation

The bathymetric survey equipment were mobilised on board "Aqua Marine" on 03 FEB 2021. After successful installation, testing and calibrations of survey equipment, the team proceeded for Data acquisition.

Pentax RTK, Geomax auto level, Tripod and necessary supporting equipment/tools were mobilised for Topographic survey.

All survey equipment was installed and configured for bathymetric Survey on board "Aqua Marine" as per **Figure** given below.

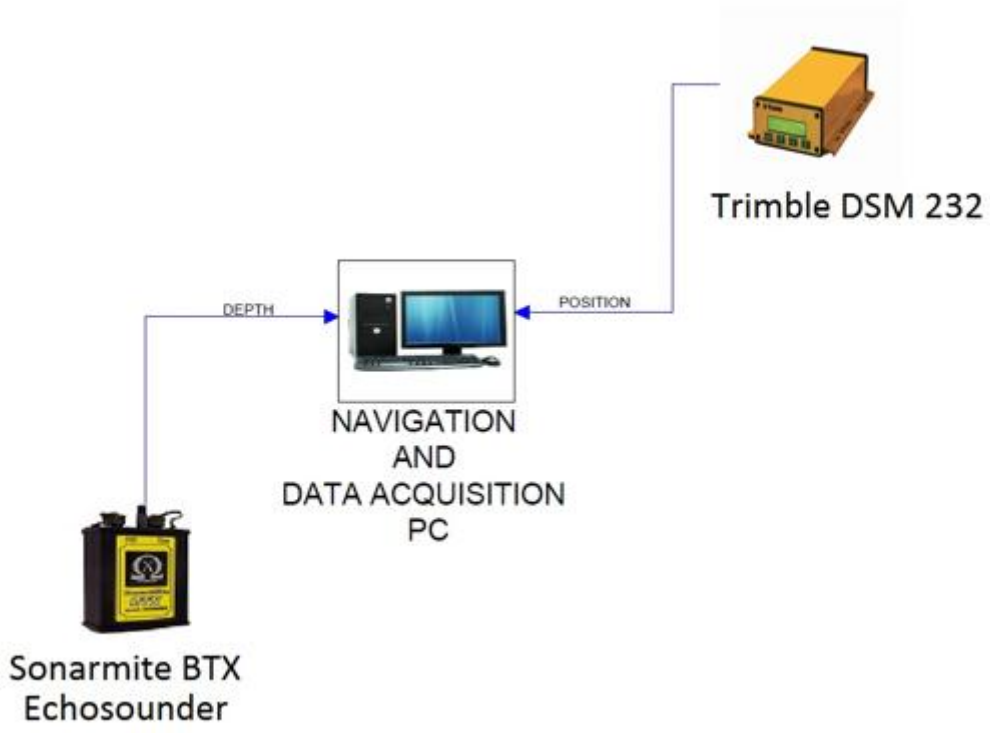

Figure 5.1-1 SBES SURVEY EQUIPMENT CONFIGURATION DIAGRAM ON BOARD

5.2 Geodesy

The survey operations were conducted in WGS 84 spheroid, Universal Transverse Mercator projection system based on following Geodetic parameters:-

Global Positioning System Geodetic Parameters	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Semi minor axis:	b = 6 356 752.314 245 m
Inverse Flattening:	$^1/_f$ = 298.257 223 563
Local Datum Geodetic Parameters	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Inverse Flattening:	$^1/_f$ = 298.257 223 563
Local Projection and Grid Parameters	
Map Projection:	Universal Transverse Mercator
Grid System:	UTM Zone 43 N
Central Meridian:	075° 00’ 00” East
Latitude of Origin:	0° 00’ 00” North
False Easting:	500 000 m
False Northing:	0 m

Table 5.2-1 GEODETIC PARAMETERS

5.3 Survey work at Field

5.3.1 Benchmark and Base station setup

The DGPS observation were made for about 4.5 Hours at Dam top near spill way. Two Temporary Bench Marks were established,
The details of Bench Marks are presented in the table below:

BM Observation and T.B.M. Information _ HATHMATI Reservoir South Gujarat					
Location	**Latitude (N)**	**Longitude (E)**	**Easting (m)**	**Northing (m)**	**Elevation (m) W.r.t MSL**
OBS-HATM	23°41'46.163"	073°11'5.702"	314934.024	2621765.831	185.69
T.B.M.01	23°44'15.021"	073°11'55.527"	316403.443	2626327.273	188.622
T.B.M.02	23°43'2.557"	073°11'26.098"	315541.678	2624108.629	185.322
T.B.M.04	23°40'53.917"	073°11'36.393"	315783.112	2620147.548	188.019

Table 5.3-1 BENCH MARK DETAILS

Figure 5.3-1 DGPS Observation at Dam top

5.3.2 Topographic and Bathymetric Survey

For topographic survey, Pentax RTK base was used for DGPS observation on OBS-HATM. Four (4) hours of DGPS observation was carried out on OBS-HATM (Levelling was carried out from BC Line to above mention observation point and level of BC Line was provided by Dam Authority). Two rovers receiving RTK corrections from the base took spot level from water level to HFL.

For bathymetric survey, Aqua Marine boat was mobilised as shown in Figure 5.1-1. Plan line for survey was prepared parallel to dam axis and at 25 m intervals. Survey boat was run on afore mentioned plan line to acquire position as well as depth.

5.4 Survey Systems

5.4.1 TRIMBLE DSM 232 DGPS:

TRIMBLE DSM 232 DGPS system was used during survey.
• Differential correction signals received on board during survey operations continuously from the Satellite based augmentation system.
• The positioning data as well as heading data received with high reliability and integrity.

TRIMBLE DSM 232 DGPS was the primary positioning system currently used for all the surveys. GMPL has provided, install, operate and maintain a Differential Global Positioning System (DGPS) acceptable to the EIC, which fully covered the site of the works and was constantly in operation during the all the surveys. The age of pseudo- range correctors used in position computation was not exceeded 20 seconds; however, any horizontal positioning interpolation was never exceeded the accuracy. Horizontal Dilution of Precision (HDOP) was monitored, and was never exceeded 2 nominally. Satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. Other variables, including satellite pseudo range residual, were used in conjunction with HDOP to estimate horizontal accuracy. A minimum of four satellites were used to compute all positions, Horizontal and Vertical offsets between the GPS antenna and transducer(s) were observed and applied with a precision better than 0.01m. The system was consisting of master receiving reference station (Base) and DGPS Navigator unit (Rover). The navigator's units (Rover) were installed on Survey launch. The composition was consisting navigational software, track plotters, data storage facilities, echo sounders, sufficient spares to enable uninterrupted operation of the system to the accuracy specified and on-board computers.

5.4.2 Single beam Echo sounder

The single beam echo sounder 'Sonarmite' with an accuracy of 0.01m was deployed and in principle, higher frequency of 215 kHz was operated. Echo Sounder equipment was calibrated daily before and after use, by means of a bar-check in the survey area. The calibration results were found satisfactory.

5.4.3 HYPACK Software

HYPACK is a Windows™-based software package used primarily for hydrographic surveying and data processing.

HYPACK performs all of the tasks necessary to complete Single Beam Echo sounder data acquisition /processing from beginning to end. This all-in- one module provides the surveyor with all of the tools needed to design their survey, collect data, process it, reduce it to w.r.t MSL, and generate final products. Whether collecting hydrographic survey data or environmental data, or positioning a vessel in an engineering project, HYPACK provides the tools needed to complete the job.

This software can be interfaced simultaneously to Echo sounders and attitude sensors.

5.4.4 RTK System

Pentax RTK system consists of one Base and Rover Module was used for Topographic Survey.

- RTK DGPS Base station was set up at OBS-HATM, Made by GMPL and configured to transmit the corrections.
- Pentax RTK base was used for DGPS observation on OBS-HATM. Four (4) hours of DGPS observation was carried out on OBS-HATM (Levelling was carried out from BC Line to above mention observation point and level of BC Line was provided by Dam Authority). Two rovers receiving RTK corrections from the base took spot level from water level to HFL.

5.5 Data Acquisition and Quality Control

5.5.1 Online Data Quality Control

The online navigation computer was interfaced to Sonarmite BTX Echo Sounder system. Laptop connected to the Navigation network were time synchronized with the GPS (high precision) time signal allowing all data to be precisely time stamped.

Navigation

The DGPS system performed well at all times and the performance of the system was continuously monitored.

Echo Sounder

The digital output from the Sonarmite BTX Echo Sounder was satisfactory throughout the duration of the survey. The qualities of obtained soundings were verified by running suitable cross lines and depths were found to be matching.

5.5.2 Data Processing

The bathymetric survey data was logged using Hypack on Navigation System. The quality of the bathymetric data acquired in the field was monitored continuously onboard the survey boat. Survey data was processed in office and handed over to the client.

5.6 Quality Assurance and HSE Procedures

GMPL has fully documented and self-audited Quality Assurance and Health, Safety and Environmental System procedures in place. The same were followed during all surveying tasks, which was undertaken by the company and its personnel.

Competent field survey staffs were deployed by GMPL to constantly monitor acquired data quality whilst the survey progressing, and was duly documented.

5.7 Demobilisation

Upon successful completion of topographic and bathymetric survey at Hathmati Reservoir with due, consent from Client Representative, the survey equipment on board were demobilised on 20 FEB 2021

5.8 SURVEY DATA PROCESSING AND INTERPRETATION METHODS

5.8.1 General

The survey data was logged and was processed using the HYPACK Software. Position and depth data were processed and checked to ensure good data quality. The same was used for the automated and manual processing of logged data sets.

5.8.2 Navigation and Positioning

The measured offsets for various survey sensors used during the survey were entered into the navigation system and post processed using Hypack processing to enable track charts to be plotted and the 'corrected' navigation files to be integrated with other sensor data at a later stage.

5.8.3 Bathymetry Data Processing and Analysis

- The SBES bathymetry survey data was logged using HYPACK and further processed.
- Corrected SBES offset position (computed from vessel antenna) was merged into single beam data for true horizontal positioning.
- Velocity value 1500 m/s was used in the survey area.
- SBES data was further corrected for the transducer draft from water level.
- The depth sounding obtained from SBES were reduced to MSL with the help of observed water level in the reservoir.
- The data was filtered, cleaned, and combined to create geographically positioned bathymetric data set that has been corrected for tides and sound speed.
- The water level were observed during the entire period of survey. The details are as follows:-

Date	Time	Water Level (meters)
03/02/2021	0700	179.07
	1900	179.07
04/02/2021	0700	179.04
	19:00	179.04
05/02/2021	0700	179.01
	1900	179.01
06/02/2021	0700	178.98
	1900	178.98
07/02/2021	0700	178.98
	1900	178.98
08/02/2021	0700	178.95
	1900	178.95

Date	Time	Water Level (meters)
09/02/2021	0700	178.98
	1900	178.98
10/02/2021	0700	178.95
	1900	178.95
11/02/2021	0700	178.92
	1900	178.92
12/02/2021	0700	178.92
	1900	178.92
13/02/2021	0700	178.92
	1900	178.92
14/02/2021	0700	178.92
	1900	178.92
15/02/2021	0700	178.89
	1900	178.89
16/02/2021	0700	178.87
	1900	178.87
17/02/2021	0700	178.86
	1900	178.86
18/02/2021	0700	178.83
	1900	178.83
19/02/2021	0700	178.83
	1900	178.83
20/02/2021	0700	178.79
	1900	178.79

Table 5.8-1 WATER LEVELS

5.8.4 Topographic Data Processing and Analysis

The topographic survey data was cleaned and converted into xyz format. The converted data was merged with the bathymetric data using TIN module of Hypack software and Gridded data (25 x 25 m) was created. This data was used for volume calculations.

5.8.5 Preparation of Drawings

Ten drawings have been prepared for Hathmati Reservoir, the details of which are presented in the table below:

Sr. No	Drawing Name	Description	Hard Copy format	Soft Copy format
1	P-SUR-004-HATHMATI-BATHY-01	Bathy Chart part 1	Paper size A0 (1:5000)	PDF & CAD
2	P-SUR-004-HATHMATI-	Bathy Chart part 2	Paper size A0	PDF & CAD

Sr. No	Drawing Name	Description	Hard Copy format	Soft Copy format
	BATHY-01		(1:5000)	
3	P-SUR-004-HATHMATI-BATHY-01	Bathy Chart part 3	Paper size A0 (1:5000)	PDF & CAD
4	P-SUR-004-HATHMATI-BATHY-01	Bathy Chart part 4	Paper size A0 (1:5000)	PDF & CAD
5	P-SUR-004-HATHMATI-BATHY-01	Bathy Chart part 5	Paper size A0 (1:5000)	PDF & CAD
6	P-SUR-004-HATHMATI-BATHY-01	Contour	Paper size A0	PDF & CAD
7	P-SUR-004-HATHMATI-OVERVIEW-01	Overview Map of Reservoir	Paper size A3	PDF & CAD
8	Area Capacity Curve Hathmati - 2021	Area Capacity curve of Reservoir	Paper size A3	PDF & CAD
9	Hathmati Cross Sections	64 Cross Section at 100 m interval	Only soft copy	CAD
10	Hathmati L-Section	L-Section of Reservoir	Paper size A3	CAD

Table 5.8-2 LIST OF CHARTS

6 DETAILED TOPOGRAPHIC AND BATHYMETRIC SURVEY RESULTS

6.1 General

Kindly refer to drawings in conjunction with the following:

Topographic and bathymetric data was reduced to the water level w.r.t MSL. All the data is plotted on scale of 1:5000 for Hathmati reservoir.

The values depicted in the charts are the depths with respect to MSL.

- The Minimum elevation within Hathmati reservoir is 162.83 m above MSL and
- The Maximum depth within Hathmati reservoir is 24.1 m.

6.2 Capacity and Area Calculation:

Hypack software's TIN (Triangulated Irregular Network) MODEL was used to calculate capacity and area of the reservoir at intervals of 10 cm. In addition, volume was also calculated using prismoidal formula as given below:

$$V=h/3\{A1+A2+\text{Square Root}(A1 * A2)\}$$

where V is volume in M Cu. m between two levels,

h is difference between two level and

A1 & A2 is area in Sq. Km of successive levels

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
167.00	0.000	0.000	0.000	0.000	0.000	
167.10	0.000	0.000	0.000	0.000	0.000	
167.20	0.000	0.000	0.000	0.000	0.004	
167.30	0.001	0.000	0.001	0.001	0.016	
167.40	0.003	0.000	0.003	0.003	0.032	
167.50	0.008	0.000	0.008	0.007	0.049	
167.60	0.013	0.000	0.013	0.013	0.066	
167.70	0.021	0.000	0.021	0.021	0.094	
167.80	0.032	0.000	0.032	0.032	0.125	
167.90	0.046	0.000	0.046	0.046	0.155	
168.00	0.063	0.000	0.063	0.063	0.184	
168.10	0.083	0.000	0.083	0.083	0.221	
168.20	0.107	0.000	0.107	0.107	0.262	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
168.30	0.136	0.000	0.136	0.135	0.304	
168.40	0.168	0.000	0.168	0.167	0.345	
168.50	0.205	0.000	0.205	0.203	0.385	
168.60	0.245	0.000	0.245	0.243	0.425	
168.70	0.290	0.000	0.290	0.288	0.473	
168.80	0.340	0.000	0.340	0.338	0.535	
168.90	0.397	0.000	0.397	0.395	0.600	
169.00	0.460	0.000	0.460	0.458	0.652	
169.10	0.528	0.000	0.528	0.526	0.709	
169.20	0.601	0.000	0.601	0.600	0.766	
169.30	0.681	0.000	0.681	0.680	0.828	
169.40	0.767	0.000	0.767	0.765	0.882	
169.50	0.858	0.000	0.858	0.856	0.937	
169.60	0.954	0.000	0.954	0.953	1.002	
169.70	1.058	0.000	1.058	1.057	1.060	
169.80	1.166	0.000	1.166	1.166	1.114	
169.90	1.281	0.000	1.281	1.280	1.166	
170.00	1.400	0.000	1.400	1.399	1.224	
170.10	1.526	0.000	1.526	1.525	1.301	
170.20	1.660	0.000	1.660	1.658	1.374	
170.30	1.801	0.000	1.801	1.799	1.451	
170.40	1.950	0.000	1.950	1.948	1.537	
170.50	2.108	0.000	2.108	2.106	1.621	
170.60	2.275	0.000	2.275	2.273	1.710	
170.69	**2.432**	**0.000**	**2.432**	**2.431**	**1.794**	**MDDL**
170.70	2.432	0.018	2.450	2.449	1.803	
170.80	2.432	0.203	2.636	2.634	1.902	
170.90	2.432	0.399	2.831	2.829	2.006	
171.00	2.432	0.605	3.037	3.035	2.118	
171.10	2.432	0.822	3.254	3.252	2.227	
171.20	2.432	1.051	3.483	3.481	2.344	
171.30	2.432	1.291	3.724	3.722	2.469	
171.40	2.432	1.545	3.978	3.976	2.612	
171.50	2.432	1.813	4.246	4.244	2.751	
171.60	2.432	2.096	4.528	4.526	2.898	
171.70	2.432	2.393	4.825	4.823	3.049	
171.80	2.432	2.706	5.138	5.136	3.214	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
171.90	2.432	3.035	5.468	5.465	3.369	
172.00	2.432	3.380	5.813	5.810	3.536	
172.10	2.432	3.743	6.175	6.172	3.714	
172.20	2.432	4.124	6.556	6.553	3.899	
172.30	2.432	4.521	6.954	6.951	4.054	
172.40	2.432	4.935	7.367	7.364	4.213	
172.50	2.432	5.364	7.797	7.793	4.377	
172.60	2.432	5.810	8.243	8.239	4.547	
172.70	2.432	6.274	8.707	8.703	4.732	
172.80	2.432	6.756	9.189	9.185	4.911	
172.90	2.432	7.257	9.689	9.686	5.106	
173.00	2.432	7.778	10.210	10.207	5.318	
173.10	2.432	8.321	10.753	10.750	5.543	
173.20	2.432	8.886	11.318	11.315	5.746	
173.30	2.432	9.470	11.903	11.900	5.953	
173.40	2.432	10.076	12.509	12.506	6.168	
173.50	2.432	10.705	13.138	13.135	6.409	
173.60	2.432	11.358	13.791	13.788	6.654	
173.70	2.432	12.036	14.469	14.466	6.911	
173.80	2.432	12.740	15.173	15.170	7.170	
173.90	2.432	13.470	15.903	15.900	7.433	
174.00	2.432	14.228	16.660	16.657	7.710	
174.10	2.432	15.013	17.445	17.442	7.998	
174.20	2.432	15.827	18.259	18.256	8.286	
174.30	2.432	16.670	19.102	19.099	8.572	
174.40	2.432	17.541	19.973	19.970	8.847	
174.50	2.432	18.440	20.873	20.869	9.139	
174.60	2.432	19.369	21.802	21.798	9.445	
174.70	2.432	20.330	22.762	22.759	9.771	
174.80	2.432	21.324	23.757	23.754	10.125	
174.90	2.432	22.354	24.786	24.783	10.455	
175.00	2.432	23.416	25.848	25.845	10.784	
175.10	2.432	24.510	26.942	26.939	11.097	
175.20	2.432	25.634	28.067	28.063	11.397	
175.30	2.432	26.790	29.223	29.219	11.720	
175.40	2.432	27.978	30.410	30.407	12.038	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
175.50	2.432	29.198	31.630	31.627	12.360	
175.60	2.432	30.450	32.882	32.879	12.681	
175.70	2.432	31.734	34.167	34.164	13.011	
175.80	2.432	33.053	35.485	35.482	13.353	
175.90	2.432	34.406	36.838	36.835	13.702	
176.00	2.432	35.793	38.225	38.222	14.046	
176.10	2.432	37.214	39.646	39.643	14.369	
176.20	2.432	38.667	41.100	41.096	14.707	
176.30	2.432	40.156	42.588	42.584	15.059	
176.40	2.432	41.679	44.111	44.107	15.405	
176.50	2.432	43.238	45.670	45.666	15.769	
176.60	2.432	44.832	47.265	47.261	16.126	
176.70	2.432	46.463	48.895	48.892	16.483	
176.80	2.432	48.128	50.560	50.557	16.821	
176.90	2.432	49.827	52.260	52.256	17.162	
177.00	2.432	51.560	53.992	53.989	17.490	
177.10	2.432	53.326	55.758	55.755	17.838	
177.20	2.432	55.128	57.561	57.557	18.213	
177.30	2.432	56.969	59.401	59.397	18.597	
177.40	2.432	58.848	61.281	61.277	19.002	
177.50	2.432	60.769	63.202	63.198	19.411	
177.60	2.432	62.731	65.164	65.160	19.824	
177.70	2.432	64.734	67.167	67.163	20.236	
177.80	2.432	66.779	69.212	69.208	20.664	
177.90	2.432	68.865	71.298	71.294	21.053	
178.00	2.432	70.989	73.422	73.418	21.420	
178.10	2.432	73.149	75.582	75.578	21.781	
178.20	2.432	75.345	77.777	77.774	22.138	
178.30	2.432	77.577	80.009	80.006	22.501	
178.40	2.432	79.845	82.278	82.274	22.867	
178.50	2.432	82.151	84.583	84.579	23.241	
178.60	2.432	84.494	86.927	86.923	23.647	
178.70	2.432	86.899	89.331	89.337	24.655	
178.80	2.432	89.410	91.842	91.847	25.393	
178.90	2.432	91.972	94.405	94.409	25.853	
179.00	2.432	94.580	97.012	97.016	26.292	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
179.10	2.432	97.230	99.662	99.665	26.698	
179.20	2.432	99.919	102.351	102.354	27.085	
179.30	2.432	102.646	105.079	105.082	27.467	
179.40	2.432	105.412	107.844	107.847	27.841	
179.50	2.432	108.215	110.647	110.650	28.220	
179.60	2.432	111.056	113.489	113.491	28.607	
179.70	2.432	113.937	116.369	116.372	29.009	
179.80	2.432	116.858	119.290	119.294	29.415	
179.90	2.432	119.820	122.252	122.256	29.817	
180.00	2.432	122.821	125.254	125.258	30.216	
180.10	2.432	125.863	128.295	128.300	30.621	
180.20	2.432	128.946	131.378	131.383	31.033	
180.30	2.432	132.071	134.503	134.508	31.468	
180.40	2.432	135.239	137.672	137.676	31.899	
180.50	2.432	138.450	140.882	140.886	32.309	
180.60	2.432	141.701	144.134	144.138	32.724	
180.70	2.432	144.993	147.426	147.430	33.112	
180.74	**2.432**	**146.321**	**148.753**	**148.757**	**33.262**	**FRL**
180.80	2.432	148.323	150.756	150.759	33.487	
180.90	2.432	151.691	154.123	154.127	33.869	
181.00	2.432	155.097	157.529	157.533	34.256	
181.10	2.432	158.542	160.975	160.978	34.646	
181.20	2.432	162.026	164.459	164.462	35.031	
181.30	2.432	165.548	167.981	167.984	35.413	
181.40	2.432	169.109	171.541	171.545	35.799	
181.50	2.432	172.707	175.140	175.143	36.168	
181.60	2.432	176.343	178.775	178.778	36.538	
181.70	2.432	180.015	182.447	182.450	36.905	
181.80	2.432	183.724	186.156	186.159	37.278	
181.90	2.432	187.470	189.902	189.905	37.644	
182.00	2.432	191.252	193.685	193.687	37.999	
182.10	2.432	195.069	197.501	197.503	38.328	
182.20	2.432	198.918	201.350	201.353	38.659	
182.30	2.432	202.801	205.233	205.236	38.995	
182.40	2.432	206.717	209.149	209.152	39.328	
182.50	2.432	210.666	213.099	213.102	39.671	

Level (m)	Dead Storage Capacity (M Cu. M)	Live Storage Capacity (M Cu. M)	Gross Storage Capacity using TIN (M Cu. M)	Gross Storage Capacity using Prismoidal formula (M Cu. M)	Spread Area (Sq. Km)	Remarks
182.60	2.432	214.652	217.084	217.087	40.029	
182.70	2.432	218.672	221.104	221.108	40.375	
182.80	2.432	222.727	225.160	225.163	40.729	
182.90	2.432	226.818	229.251	229.254	41.090	
183.00	2.432	230.945	233.378	233.381	41.451	
183.10	2.432	235.108	237.540	237.544	41.801	
183.18	**2.432**	**238.463**	**240.896**	**240.900**	**42.095**	**HFL**

Table 6.2-1 Capacity and Area

6.3 Comparative Statement of Hathmati Reservoir

Elevation	Capacity As per previous Survey (M Cu. m)	Area As per previous Survey (Sq. Km)	Capacity Year 2021 (M Cu. m)	Area Year 2021 (Sq. Km)	Remark
167.00	0.041	0.068	0.000	0.000	
168.00	0.583	0.514	0.063	0.184	
169.00	2.137	0.974	0.460	0.652	
170.00	4.418	1.433	1.400	1.224	
170.69	**7.021**	**2.613**	**2.432**	**1.794**	**MDDL**
171.00	4.419	2.838	3.037	2.118	
172.00	7.695	4.033	5.813	3.536	
173.00	13.197	6.512	10.210	5.318	
174.00	20.500	8.542	16.660	7.710	
175.00	30.195	10.933	25.848	10.784	
176.00	42.890	14.631	38.225	14.046	
177.00	59.255	17.821	53.992	17.490	
178.00	78.124	22.062	73.422	21.420	
179.00	102.009	26.092	97.012	26.292	
180.00	129.780	28.309	125.254	30.216	
180.74	**152.838**	**28.395**	**148.753**	**33.262**	**FRL**

Table 6.3-1 COMPARATIVE STATEMENT OF HATHMATI RESERVOIR

6.4 Gross Storage Capacity in M Cu. m of the Reservoir - Year 2021:

RL in m	0	0.1	0.18	0.2	0.3	0.4	0.5	0.6	0.69	0.7	0.74	0.8	0.9
167	0.000	0.000	0.000	0.000	0.001	0.003	0.008	0.013	0.020	0.021	0.025	0.032	0.046
168	0.063	0.083	0.102	0.107	0.136	0.168	0.205	0.245	0.285	0.290	0.309	0.340	0.397
169	0.460	0.528	0.586	0.601	0.681	0.767	0.858	0.954	1.047	1.058	1.101	1.166	1.281
170	1.400	1.526	1.633	1.660	1.801	1.950	2.108	2.275	**2.432**	2.450	2.523	2.636	2.831
171	3.037	3.254	3.436	3.483	3.724	3.978	4.246	4.528	4.795	4.825	4.949	5.138	5.468
172	5.813	6.175	6.478	6.556	6.954	7.367	7.797	8.243	8.659	8.707	8.897	9.189	9.689
173	10.210	10.753	11.203	11.318	11.903	12.509	13.138	13.791	14.400	14.469	14.747	15.173	15.903
174	16.660	17.445	18.094	18.259	19.102	19.973	20.873	21.802	22.665	22.762	23.156	23.757	24.786
175	25.848	26.942	27.839	28.067	29.223	30.410	31.630	32.882	34.037	34.167	34.690	35.485	36.838
176	38.225	39.646	40.806	41.100	42.588	44.111	45.670	47.265	48.731	48.895	49.557	50.560	52.260
177	53.992	55.758	57.197	57.561	59.401	61.281	63.202	65.164	66.964	67.167	67.979	69.212	71.298
178	73.422	75.582	77.335	77.777	80.009	82.278	84.583	86.927	89.085	89.331	90.328	91.842	94.405
179	97.012	99.662	101.810	102.351	105.079	107.844	110.647	113.489	116.079	116.369	117.533	119.290	122.252
180	125.254	128.295	130.758	131.378	134.503	137.672	140.882	144.134	147.095	147.426	**148.753**	150.756	154.123
181	157.529	160.975	163.759	164.459	167.981	171.541	175.140	178.775	182.078	182.447	183.926	186.156	189.902
182	193.685	197.501	200.578	201.350	205.233	209.149	213.099	217.084	220.701	221.104	222.722	225.160	229.251
183	233.378	237.540	**240.896**										

Table 6.4-1 GROSS STORAGE CAPACITY IN M cu. m YEAR -2021

Note: Gross storage capacity for FRL at 180.74 m is 148.753 M Cu. m, dead storage at 170.69 00 m is 2.432 M Cu. m and HFL at 183.18 m is 240.896 M Cu. m.

6.5 Live Storage Capacity in M Cu. m of the Reservoir - Year 2021:

RL in m	0	0.1	0.18	0.2	0.3	0.4	0.5	0.6	0.69	0.7	0.74	0.8	0.9
170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.091	0.203	0.399
171	0.605	0.822	1.004	1.051	1.291	1.545	1.813	2.096	2.363	2.393	2.516	2.706	3.035
172	3.380	3.743	4.046	4.124	4.521	4.935	5.364	5.810	6.227	6.274	6.465	6.756	7.257
173	7.778	8.321	8.771	8.886	9.470	10.076	10.705	11.358	11.967	12.036	12.315	12.740	13.470
174	14.228	15.013	15.662	15.827	16.670	17.541	18.440	19.369	20.232	20.330	20.723	21.324	22.354
175	23.416	24.510	25.407	25.634	26.790	27.978	29.198	30.450	31.604	31.734	32.258	33.053	34.406
176	35.793	37.214	38.374	38.667	40.156	41.679	43.238	44.832	46.298	46.463	47.125	48.128	49.827
177	51.560	53.326	54.765	55.128	56.969	58.848	60.769	62.731	64.532	64.734	65.547	66.779	68.865
178	70.989	73.149	74.903	75.345	77.577	79.845	82.151	84.494	86.653	86.899	87.895	89.410	91.972
179	94.580	97.230	99.378	99.919	102.646	105.412	108.215	111.056	113.647	113.937	115.100	116.858	119.820
180	122.821	125.863	128.326	128.946	132.071	135.239	138.450	141.701	144.662	144.993	**146.321**	148.323	151.691
181	155.097	158.542	161.326	162.026	165.548	169.109	172.707	176.343	179.646	180.015	181.494	183.724	187.470
182	191.252	195.069	198.146	198.918	202.801	206.717	210.666	214.652	218.268	218.672	220.290	222.727	226.818
183	230.945	235.108	**238.463**										

Table 6.5-1 LIVE STORAGE CAPACITY IN M cu. m YEAR -2021

Note: Live storage capacity for FRL at 180.74 m is 146.321 M Cu. m and HFL at 183.18 m is 238.463 M Cu. m.

6.6 Spread Area in Sq.Km of the Reservoir - Year 2021:

RL in m	0	0.1	0.18	0.2	0.3	0.4	0.5	0.6	0.69	0.7	0.74	0.8	0.9
167	0.000	0.000	0.003	0.004	0.016	0.032	0.049	0.066	0.091	0.094	0.106	0.125	0.155
168	0.184	0.221	0.253	0.262	0.304	0.345	0.385	0.425	0.467	0.473	0.497	0.535	0.600
169	0.652	0.709	0.754	0.766	0.828	0.882	0.937	1.002	1.055	1.060	1.082	1.114	1.166
170	1.224	1.301	1.360	1.374	1.451	1.537	1.621	1.710	1.794	1.803	1.842	1.902	2.006
171	2.118	2.227	2.320	2.344	2.469	2.612	2.751	2.898	3.034	3.049	3.114	3.214	3.369
172	3.536	3.714	3.866	3.899	4.054	4.213	4.377	4.547	4.713	4.732	4.802	4.911	5.106
173	5.318	5.543	5.707	5.746	5.953	6.168	6.409	6.654	6.884	6.911	7.014	7.170	7.433
174	7.710	7.998	8.227	8.286	8.572	8.847	9.139	9.445	9.736	9.771	9.911	10.125	10.455
175	10.784	11.097	11.336	11.397	11.720	12.038	12.360	12.681	12.978	13.011	13.150	13.353	13.702
176	14.046	14.369	14.636	14.707	15.059	15.405	15.769	16.126	16.449	16.483	16.617	16.821	17.162
177	17.490	17.838	18.136	18.213	18.597	19.002	19.411	19.824	20.194	20.236	20.414	20.664	21.053
178	21.420	21.781	22.066	22.138	22.501	22.867	23.241	23.647	24.541	24.655	25.091	25.393	25.853
179	26.292	26.698	27.007	27.085	27.467	27.841	28.220	28.607	28.967	29.009	29.174	29.415	29.817
180	30.216	30.621	30.950	31.033	31.468	31.899	32.309	32.724	33.075	33.112	**33.262**	33.487	33.869
181	34.256	34.646	34.954	35.031	35.413	35.799	36.168	36.538	36.867	36.905	37.053	37.278	37.644
182	37.999	38.328	38.592	38.659	38.995	39.328	39.671	40.029	40.340	40.375	40.516	40.729	41.090
183	41.451	41.801	**42.095**										

Table 6.6-1 SPREAD AREA IN SQ. KM YEAR -2021

Note: Spread Area for FRL at 180.74 m is 33.262 Sq. Km and HFL at 183.18 m is 42.095 Sq. Km.

6.7 Sediment Analysis:

6.7.1 Observed Rate of Sedimentation

The reservoir was impounded during the year 1971. As per report of the year 1971, gross storage capacity at FRL 180.74 m was 161.31 M Cu. m, and Dead storage at 170.69 m was 8.34 M Cu. m.

The reservoir was recently surveyed by means of integrated bathymetric and topographic survey in year 2021. As per survey recent survey, total area of reservoir at FRL 180.74 m is 33.626 Sq. Km, corresponding storage capacity is 148.753 M Cu. m and Dead storage at 170.69 m is 2.432 M Cu. m.

The rate of siltation in the reservoir (up to FRL 189.59m) during the last 50 years (1971-2021), was found to be 0.251 M Cu. m / year.

Original Reservoir data:

Year of Impounding : 1971
Catchment Area : 595 Sq. Km
Live storage at 180.74 m : 152.97 M Cu. m
Dead storage at 170.69 m : 8.34 M Cu. m
Gross storage at 180.74 m : 161.31 M Cu. m

Rate of Sedimentation (at FRL 180.74) with respect to impounding year 1971													
Sr. No	**Year of Survey**	**Capacity in M Cu. m**			**Period in years**	**Silt Deposited in M Cu. m**	**Silt Rate in M Cu. m/year**	**Loss in Capacity in M Cu. m and percentage**			**Silt Index ham/100 Sq. Km/Yr.**	**Annual % loss**	**Remarks**
		Dead	**Live**	**Gross**				**Dead**	**Live**	**Gross**			
1	1971	8.34	152.97	161.31	-	-	-	-	-	-	-	-	
2	2020 by integrated Bathymetric and Topographic survey	2.432	146.321	148.753	50	12.557	0.251	5.908 70.84%	6.649 4.35%	12.557 7.78%	4.221	0.16%	**Significant Category**

Table 6.7-1 RATE OF SEDIMENTATION

<u>According to IS -12182 (1987)</u>

Annual % loss	-	**Class of Reservoir**
Up to 0.1	-	Insignificant
0.1 to 0.5	-	Significant
Above 0.5	-	Serious

Rate of Silt = Loss in Gross Capacity in M Cu. m/No of Years
Silt Index = (Silt Rate/Catchment area) x 10000
Annual % Loss = Loss in % of Gross Capacity/No of years

6.8 Conclusion

- By above table we can conclude that the capacity of reservoir is decreased due to deposition of sediments in the reservoir especially at dead storage.
- The annual percentage loss from survey of the year 2021 is 0.16%.
- Reservoir is classified as "**Significant category**" as per IS 12182-1987 and requires actions to control deposition of sediments in the reservoir.

6.9 Methods for controlling the sedimentation

According to IS-6518:2017 there are several factors involved in controlling sedimentation in reservoirs and they relate to aspects on,

a) Design of reservoir.
b) Control of sediment inflow.
c) Control of sediment deposition.
d) Removal of sediments.

All these aspects are to be simultaneously taken note of and appropriate measures be adopted.

6.9.1 Design of Reservoirs

The capacity of reservoirs is governed by a number of factors which are covered in IS 5477 (Parts 1 to 4). From the point of view of sediment deposition, the following points may be given due consideration:

a) The sediment yield which depends on the topographical, geological and geomorphological set up, meteorological factors, land use/land cover, intercepting tanks, etc.;
b) Sediment delivery characteristics of the channel system;
c) The efficiency of the reservoir as sediment trap;
d) The ratio of capacity of reservoir to the inflow;
e) Configuration of reservoir;
f) Method of operation of reservoir; and
g) Provisions for silt exclusion.

- The rate of sediment delivery increases with the quantum of discharge.
- The percentage of sediment trapped by a reservoir with a given drainage area increases with the increased capacity. In some cases an increased capacity will however, result in greater loss of water due to evaporation. However, with the progress of sedimentation, there is decrease of storage capacity which in turn lowers the trap efficiency of the reservoir.
- The capacity of the reservoir and the size and characteristics of the reservoir and its drainage area are the most important factors governing the annual rate of accumulation of sediment. Periodical reservoir sedimentation surveys provide guidance on the rate of sedimentation. In the absence of observed data for the reservoir concerned, data from other reservoirs of similar capacity and catchment characteristics may be adopted.

- Sedimentation takes place not only in the dead storage but also in the live storage space in the reservoir. The practice for design of reservoir is to use the observed suspended sediment data available from key hydrologica1 networks and also the data available from hydrographic surveys of other reservoirs in the same region.

This data may be used to simulate sedimentation status over a period of reservoir life as mentioned in IS 12182.

- Raising the Dam at Periodic Intervals:

Engineering economic analysis of some reservoir projects probably would show that it is cheaper to build a substantially lower dam initially, and to raise it at intervals unti1 its ultimate height for the given original capacity so that long useful life may result. Stage-wise construction also provides lower trapping efficiency and less evaporation in the initial stages.

However, this method may not be feasible in all the existing dams. Wherever this method is contemplated, proper consideration should be given on the strength.

6.9.2 Control of Sediment Inflow

There are many methods for controlling sediment inflows and they can be divided as follows:

1. Watershed management/soil conservation measures to check production and transport of sediment in the catchment area

1.1. The engineering methods

1.1.1. Check Dams

a) They help to arrest degradation of stream bed thereby arresting the slope failure; and

b) They reduce the velocity of stream flow, thereby causing the deposition of the sediment load.

Check dams become necessary, where the channel gradients are steep and there is a heavy inflow of sediment from the watershed. They are constructed of local material like earth, rock, timber, etc. These are suitable for small catchment varying in size from 40 to 400 hectares. It is necessary to provide small check dams on the subsidiary streams flowing into the main streams besides the check dams in the main stream. Proper consideration should be given to the number and location of check dams required. It is preferable to minimize the height of the check dams. If the stream has, a very-steep slope, it is desirable to start with a smaller height for the check dams than may ultimately be necessary.

Check dams may generally cost more per unit of storage than the reservoirs they protect. Therefore, it may not always be possible to adopt them as a primary method of sediment control in new reservoirs. However, feasibility of providing check dams at later date should not be overlooked while planning the construction of a new reservoir

1.1.2. Contour Bunding and Trenching

These are important methods of controlling soil erosion on the hills and sloping lands, where gradients of cultivated fields or terraces are flatter, say up to 10 percent. By these methods the

hill side is split up into small compartments on which the rain is retained and surface run-off is modified with prevention of soil erosion. In addition to contour bunding, side trenching is also provided as per requirement.

1.1.3. Gully Plugging

This is done by small rock fill dams. These dams will be effective in filling up the gullies with sediment coming from the upstream of the catchment and also prevent further widening of the gully.

1.1.4. Bank Protection

This is achieved by terracing, revetment, retaining walls, gabions and spurs.

1.2. Agronomy

The agronomic measures include establishment of vegetative screen, contour farming, strip cropping and crop rotation.

1.3. Forestry

Forestry measures include forest conservancy, control on grazing, lumbering, operations and forest fires along with management and protection of forest plantations.

2. Preventive measures to check inflow of sediment into the reservoir

2.1. Restricting the waste/sediment entering into the reservoirs due to agricultural and infrastructural activities surrounding the submergence.

2.2. Construction of by-pass channels or conduits.

The various methods in this category require the construction of some type of diversion dam or weir at the head of the reservoir basin, and a canal, tunnel or conduit leading around the reservoir to a point below the dam where the flow may re-enter the main channels. In such cases the flood flows of sediment laden water are by-passed to the downstream of the dam. In some cases where topography permits construction of new off channel reservoirs can be considered. These reservoirs will invariably have a forebay and check dam on the upstream for trapping the sediment. The stored water in the fore bay is led to the reservoir and the sediment trapped is flushed through by by-pass channel/ conduit/tunnel to the main channel downstream of the dam.

6.9.3 Control of Sediment Deposition

The deposition of sediment in a reservoir may be controlled to a certain extent by designing and operating gates or other outlets in the dam in such a manner as to permit selective withdrawals of water having a higher than average sediment content. The suspended sediment content of the water in reservoirs is higher during and just after flood flow. Thus, more the water wasted at such times, the smaller will be the percentage of the total sediment load to settle into permanent deposits. There are generally three methods:

- **Density current**

Water at various levels of a reservoir often contains radically different concentrations of suspended sediment particularly during and after flood flows. If all wastewater could be withdrawn at those levels where the concentration is highest, a significant amount of sediment might be removed from the reservoir. Because a submerged outlet draws water towards it from all directions, the vertical dimension of the opening should be small with respect to the thickness of the layer and the rate of withdrawal also should be low.

- **Waste-water release**

Controlling the sedimentation by controlling waste- water release is obviously possible only when water can be or should be wasted. This method is applicable only when a reservoir is of such size that a small part of large flood flows will fill it.

In the design of the dam, sediment may be passed through or over it as an effective method of silt control by placing a series of outlets at various elevations. The percentage of total sediment load that might be ejected from the reservoir through proper gate control will differ greatly with different locations. It is probable that as much as 20 percent of the sediment inflow could be passed through many reservoirs by venting through outlets designed and controlled.

- **Scouring Sluicing**

This method is somewhat similar to both the control of waste-water release and the draining and flushing methods

The distinctions amongst them are the following:

a) The waste-water release method ejects sediment laden flood flows through deep spillway gates or large under-sluices at the rate of discharge that prevents sedimentation.

b) Drainage and flushing method involves the slow release of stored water from the reservoir through small gates or valves making use of normal or low flow to entrain and carry the sediment, and

c) Scouring sluicing depends for its efficiency on either the scouring action exerted by the sudden rush of impounded water under a high head through under-sluices or on the scouring action of high flood discharge coming into the reservoir

Scouring sluicing method can be used in the following:

i. Small power dams that depend to a great extent on pondage but not on storage;

ii. Small irrigation reservoirs, where only a small fraction of the total annual flow can be stored;

iii. Any reservoir in narrow channels, gorges, etc, where water wastage can be afforded; and

iv. When the particular reservoir under treatment is a unit in an interconnected system so that the other reservoirs can supply the water needed.

6.9.4 Removal of Sediment Deposit

The most practical means of maintaining the storage capacity are those designed to prevent accumulation of permanent deposits as the removal operations are extremely expensive, unless the material removed is usable. Therefore, the redemption of lost storage by removal should be adopted as a last resort. The removal of sediment deposit implies in general, that the deposits are sufficiently compacted or consolidated to act as a solid and, therefore, are unable to flow along with the water. The removal of sediment deposits may be accomplished by a variety of mechanical and hydraulic or methods, such as excavation, dredging, siphoning, draining, flushing, flood sluicing, and sluicing aided by such measures as hydraulic or mechanical agitation or blasting of the sediment. The excavated sediments may be suitably disposed off so that, these do not find the way again in the reservoir.

1. Excavation

The method involves draining most of or all the water in the basin and removing the sediment by hand or power operated shovel, dragline scraper or other mechanical means.

The excavation of silt and clay, which constitute most of the material in larger reservoirs, is more difficult than the excavation of sand and gravel. Fine-textured sediment cannot be excavated easily from larger reservoirs unless it is relatively fluid or relatively compact.

2. Dredging

This involves the removal of deposits from the bottom of a reservoir and their conveyance to some other point by mechanical or hydraulic means, while water storage is being maintained.

Dredging practices are grouped as:

a) Mechanical dredging by bucket, ladder, etc;
b) Suction dredging with floating pipeline and a pump usually mounted on a barge; and
c) Siphon dredging with a floating pipe extending over the dam or connected to an opening in the dam and usually with a pump on a barge.

NOTES

1) Practicality of the two methods, namely, excavation and dredging, requires to be carefully considered in any particular case.
2) Suitable measures to prevent deposition of the dredged silt in the natural channel where it is discharged need to be adopted.

3. Draining and Flushing

The method involves relatively slow release of all stored water in a reservoir through gates or valves located near bottom of the dam and the maintenance thereafter of open outlets for a shorter or longer period during which normal stream flow cuts into or directed against the sediment deposits. Therefore, this method may be adopted in flood control reservoirs.

4. Sluicing with Controlled Water

This method differs from the flood sluicing in that the controlled water supply permits choosing the time of sluicing more advantageously and that the water may be directed more

effectively against the sediment deposits. While the flood sluicing depends either on the occurrence of flood or on being able to release rapidly all of a full or nearly full supply of water in the main reservoir is empty. The advantage of this method is that generally more sediment can be removed per unit of water used than in flood scouring or draining and flushing.

5. Sluicing with Hydraulic and Mechanical Agitation

Methods that stir up break up or move deposits of sediment into a stream current flowing through a drained reservoir basin or into a lake current moving through and out of a full reservoir will tend to make the removal of sediment from the reservoir more complete. Wherever draining, flushing or sluicing appear to be warranted, the additional use of hydraulic means for stirring up the sediment deposits, or sloughing them off, into a stream flowing through the reservoir basin should be considered. It has, however, limited application.

6.10 Area – Capacity – Curve of Hathmati Reservoir:

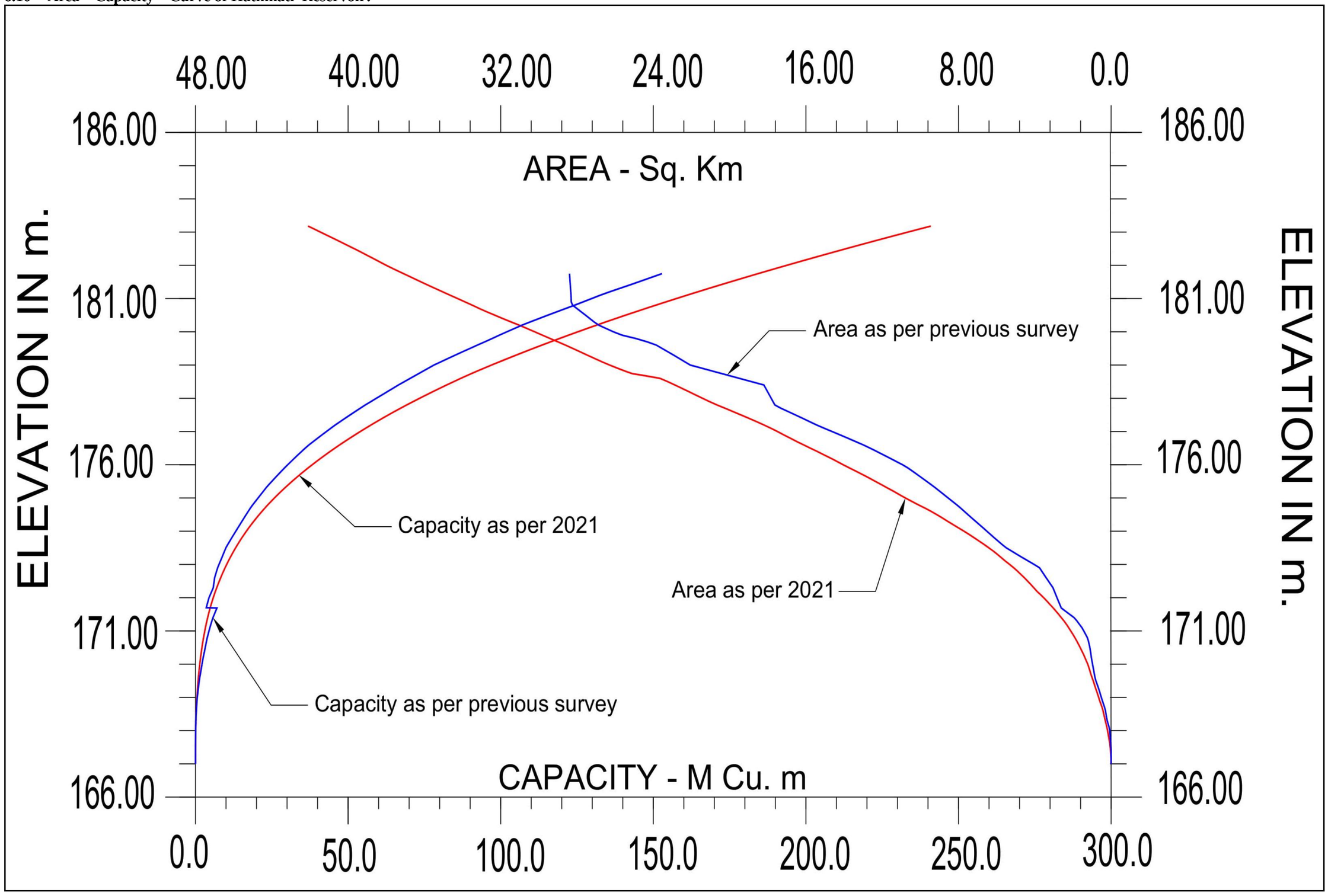

Figure 6.10-1 AREA – CAPACITY - CURVE

6.11 Segment map, Contour map, 3D Image and L-section:

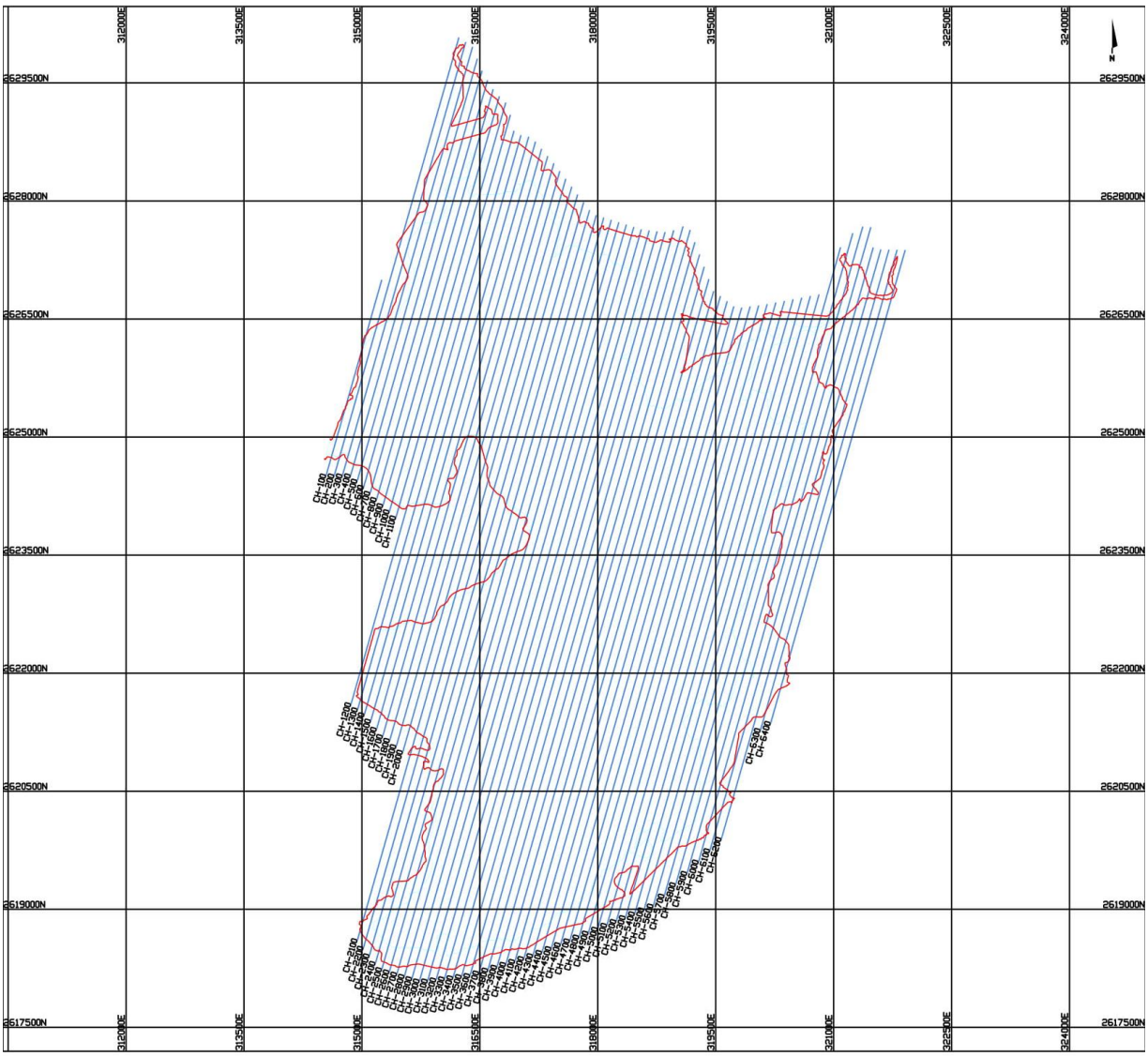

Figure 6.11-1 SEGMENT MAP FOR CROSS SECTION

Cross sections showing bed profile at 100m interval were prepared and are provided as soft copy in CD/Hard Disc. Total cross section 64 profiles were prepared.

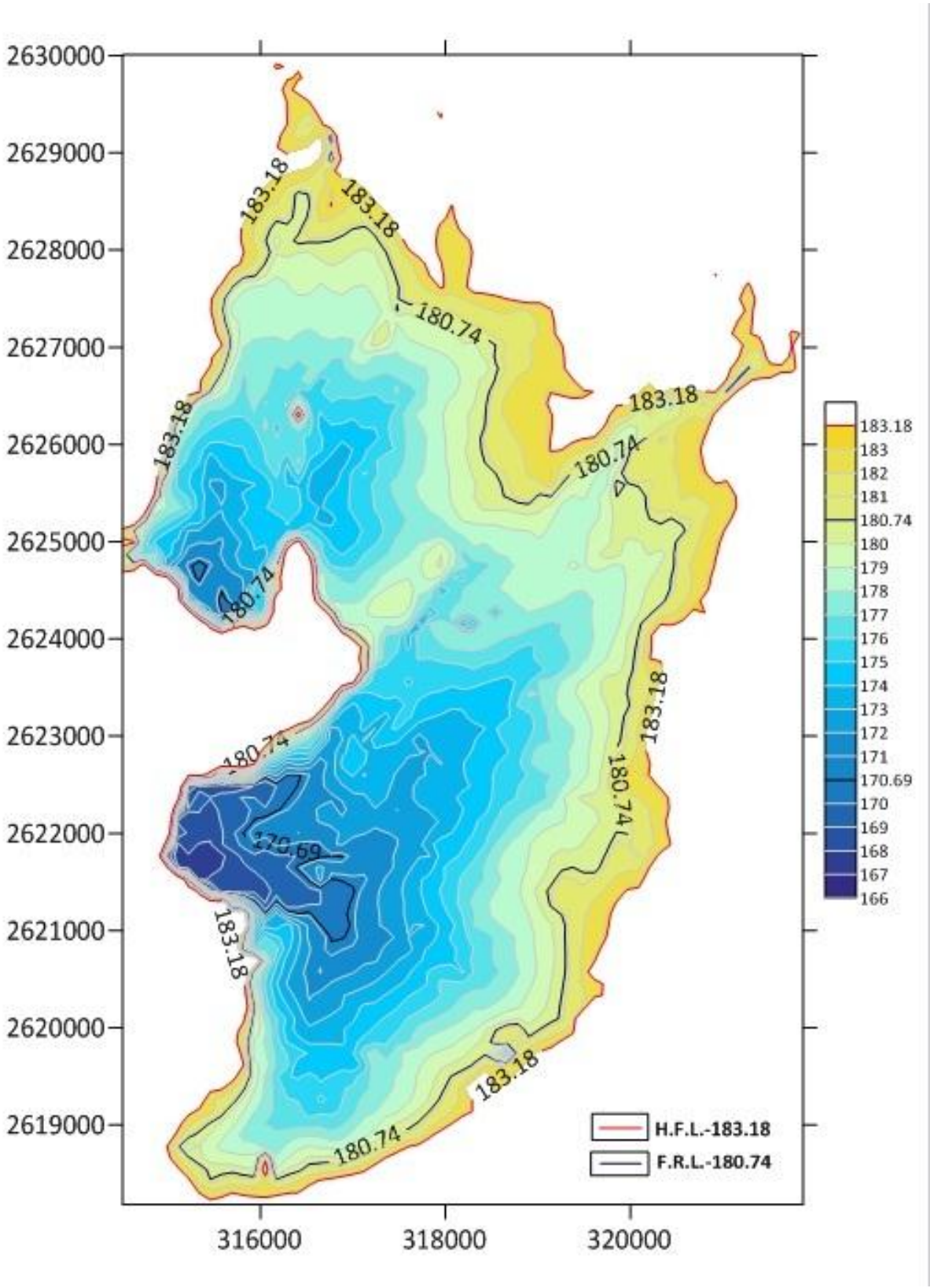

Figure 6.11-2 CONTOUR MAP

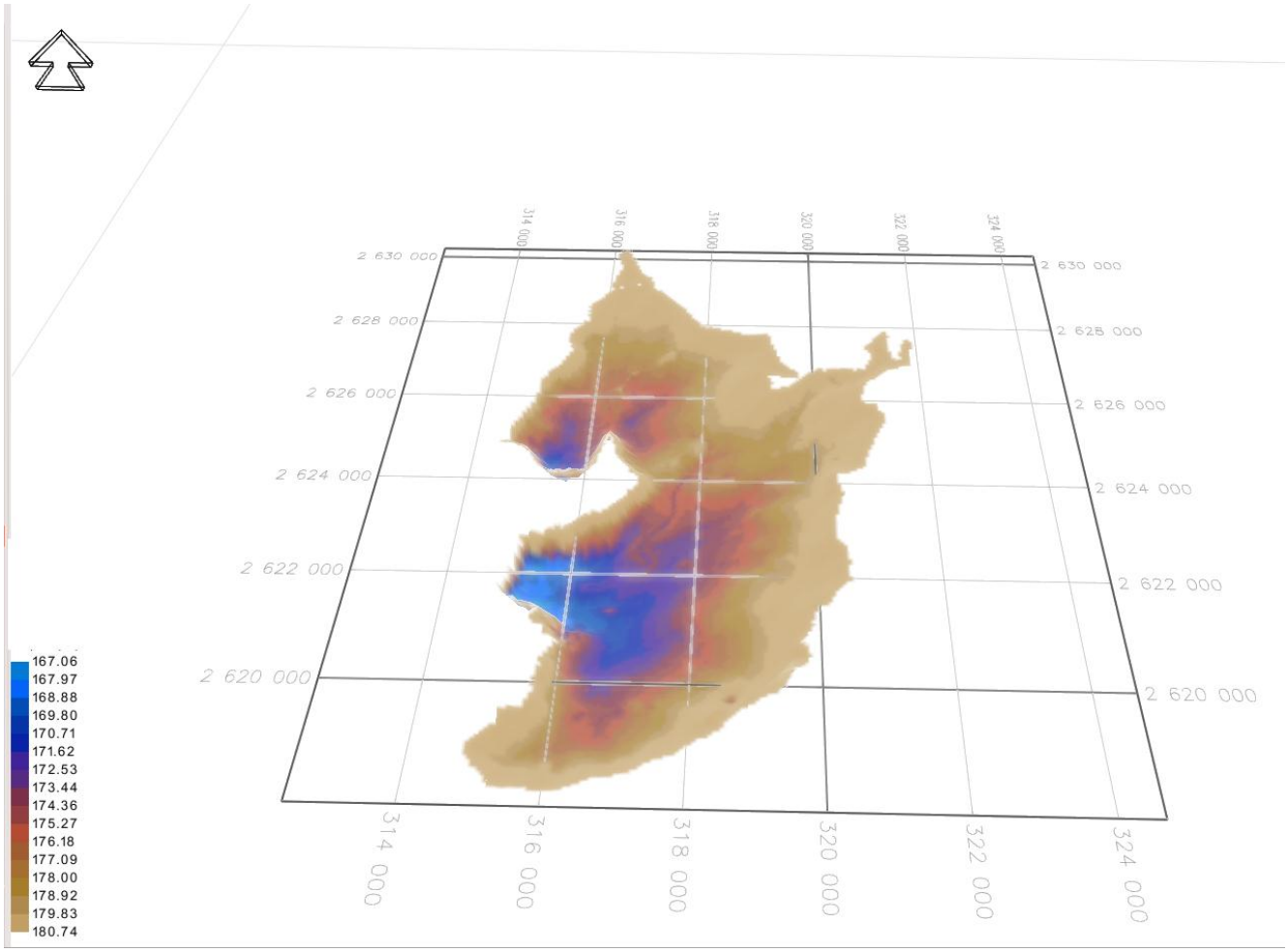

Figure 6.11-3 3D IMAGE

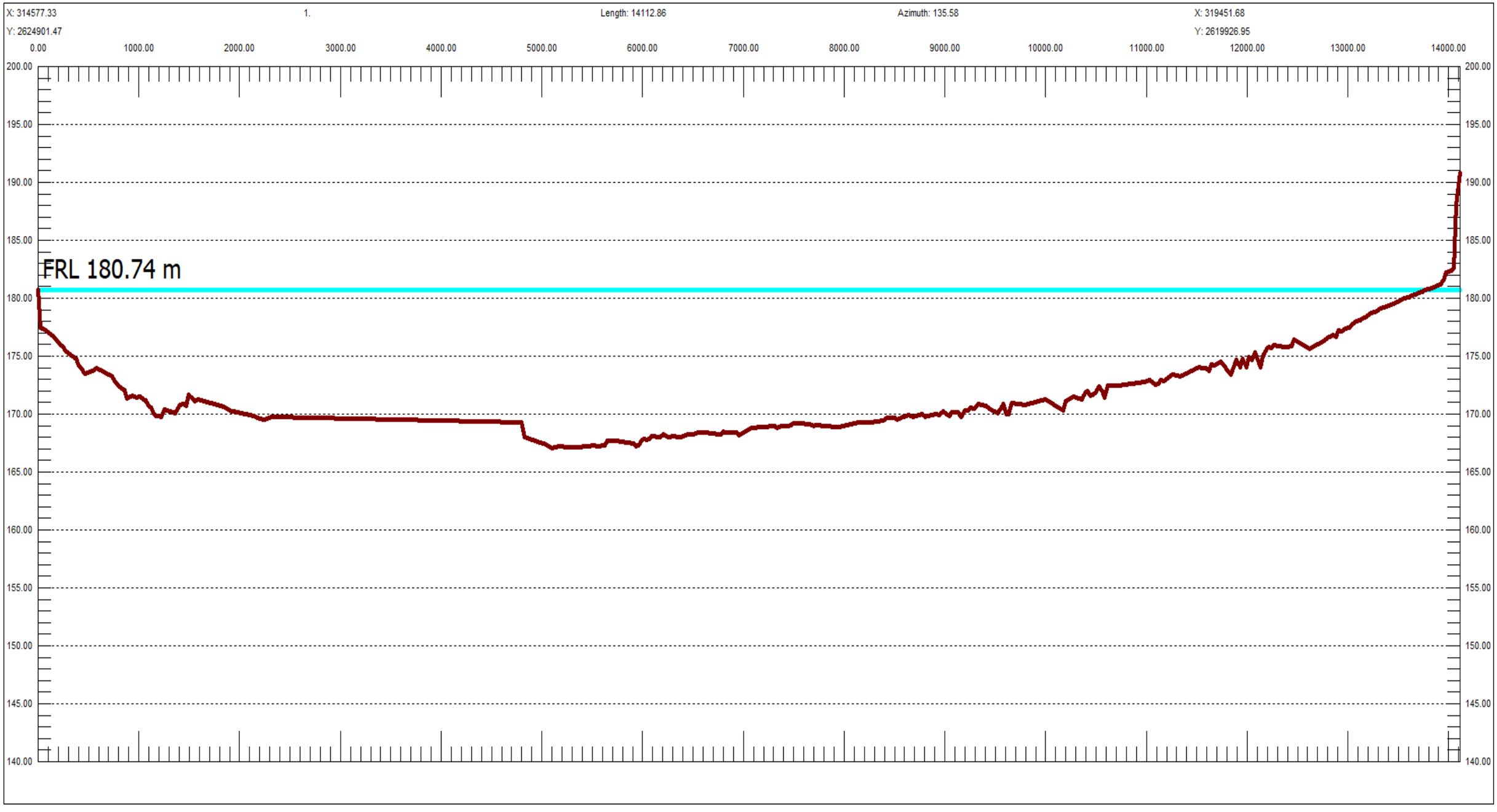

Figure 6.11-4 L-Section

7 DGPS OBSERVATION REPORT

AUSPOS GPS Processing Report

February 18, 2021

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 2.4) . The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is included in this report.

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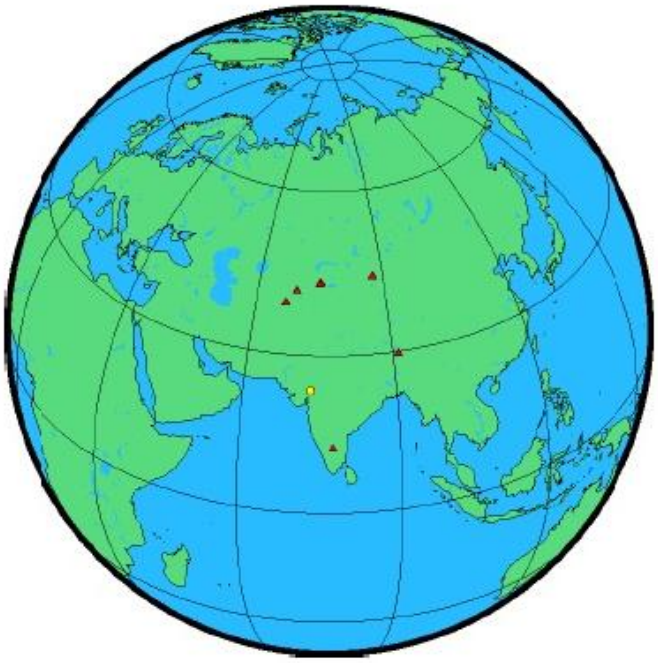
1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

Station (s)	Submitted File	Antenna Type	Antenna Height (m)	Start Time	End Time
HATM	HATM_17022021_153934.210	TIAPENG6 NONE	2.000	2021/02/17 07:40:00	2021/02/17 11:05:00

2 Processing Summary



Date	User Stations	Reference Stations	Orbit Type
2021/02/17 07:40:00	HATM	CHUM IISC KIT3 LHAZ POL2 TASH URUM	IGS ultra rapid

AUSPOS 2.4 Job Number: # 7707
User: samrajdwivedi@gmail.com

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3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
HATM	1690482.524	5593825.957	2547560.643	17/02/2021
CHUM	1228950.351	4508080.002	4327868.533	17/02/2021
IISC	1337935.754	6070317.124	1427877.337	17/02/2021
KIT3	1944944.701	4556652.353	4004326.060	17/02/2021
LHAZ	-106942.191	5549269.756	3139215.231	17/02/2021
POL2	1239970.924	4530790.156	4302578.869	17/02/2021
TASH	1695944.774	4487138.670	4190140.758	17/02/2021
URUM	193030.138	4606851.282	4393311.517	17/02/2021

3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/.

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
HATM	23 41 46.16300	73 11 05.70211	140.513	194.051
CHUM	42 59 54.60551	74 45 03.97456	716.332	759.322
IISC	13 01 16.21567	77 34 13.37607	843.690	929.611
KIT3	39 08 05.16364	66 53 07.62170	622.477	659.574
LHAZ	29 39 26.40333	91 06 14.51939	3624.614	3659.305
POL2	42 40 47.17463	74 41 39.37370	1714.201	1754.267
TASH	41 19 40.97922	69 17 44.05697	439.700	483.270
URUM	43 48 28.61961	87 36 02.41974	858.855	922.234

3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height(m)
HATM	314934.024	2621765.831	43	140.513	194.051
CHUM	479712.403	4760678.445	43	716.332	759.322
IISC	778796.704	1440886.657	43	843.690	929.611
KIT3	317236.774	4333861.159	42	622.477	659.574
LHAZ	316496.211	3282318.869	46	3624.614	3659.305
POL2	474951.461	4725300.183	43	1714.201	1754.267
TASH	524734.362	4575216.871	42	439.700	483.270
URUM	548313.463	4850717.934	45	858.855	922.234

AUSPOS 2.4 Job Number: # 7707
User: samrajdwivedi@gmail.com

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3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
HATM	0.012	0.012	0.053
CHUM	0.008	0.006	0.013
IISC	0.012	0.008	0.016
KIT3	0.008	0.006	0.015
LHAZ	0.012	0.008	0.016
POL2	0.008	0.006	0.013
TASH	0.008	0.006	0.013
URUM	0.011	0.009	0.028

AUSPOS 2.4 Job Number: # 7707
User: samrajdwivedi@gmail.com

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4 Ambiguity Resolution - Per Baseline

Baseline	Ambiguities Resolved	Baseline Length (km)
KIT3 - TASH	85.7 %	318.371
CHUM - POL2	72.2 %	35.732
HATM - TASH	84.6 %	1980.620
POL2 - UEUM	57.9 %	1053.614
CHUM - TASH	75.0 %	487.331
IISC - LHAZ	15.4 %	2299.530
AVERAGE	65.1%	1029.200

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of 50% or better for a baseline formed by a user site indicates a reliable solution.

5 Computation Standards

5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.

5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(e)^2$ where e is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.

5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

8 SINGLE BEAM ECHOSOUNDER BAR CHECK RESULTS

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
3-Feb-21	**14:30:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	7.97	0.03
4	3.99	0.01	6	5.98	0.02
6	5.98	0.02	4	3.99	0.01
8	8.01	-0.01	2	2	0

	Average	0.0050		Average	0.0150
	Std. Dev	0.0129		Std. Deviation	0.0129
				Cumulative Average	0.01
				Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
4-Feb-21	**09:0:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	8	7.99	0.01
4	4	0	6	6	0
6	5.99	0.01	4	3.97	0.03
8	8	0	2	2.1	-0.1

	Average	0.0000	Average	-0.0150
	Std. Dev	0.0082	Std. Deviation	0.0580
			Cumulative Average	-0.01
			Cumulative Std. Deviation	0.0353

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
5-Feb-21	**09:0:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4m				1500	10
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	8	7.99	0.01
4	3.98	0.02	6	6	0
6	6	0	4	3.99	0.01
8	7.99	0.01	2	2	0

	Average	0.0050		Average	0.0050
	Std. Dev	0.0129		Std. Deviation	0.0058
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0050

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
6-Feb-21	**09:0:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.01	-0.01	8	8	0
4	4	0	6	5.99	0.01
6	5.98	0.02	4	3.99	0.01
8	8	0	2	2	0

	Average	0.0025	Average	0.0050
	Std. Dev	0.0126	Std. Deviation	0.0058
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0048

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
7-Feb-21	**10:00:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8.01	-0.01
4	4	0	6	6	0
6	5.99	0.01	4	3.98	0.02
8	7.98	0.02	2	2	0

	Average	0.0075		Average	0.0025
	Std. Dev	0.0096		Std. Deviation	0.0126
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0021

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
8-Feb-21	**10:30:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	3.99	0.01	6	5.99	0.01
6	5.99	0.01	4	4.01	-0.01
8	8	0	2	2	0

	Average	0.0050		Average	0.0000
	Std. Dev	0.0058		Std. Deviation	0.0082
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0017

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
9-Feb-21			
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**5**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	4	0	6	5.99	0.01

Average	0.0000	Average	0.0050
Std. Dev	0.0000	Std. Deviation	0.0071
		Cumulative Average	0.00
		Cumulative Std. Deviation	0.0050

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
10-Feb-21	**09:0:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**8**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				1500	10
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	3.98	0.02	6	5.99	0.01
6	6	0	4	4	0
8	8	0	2	2	0

Average	0.0050		Average	0.0025
Std. Dev	0.0100		Std. Deviation	0.0050
		Cumulative Average		0.00
		Cumulative Std. Deviation		0.0035

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
11-Feb-21	**09:0:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**6**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				1500	10
Barcheck Frequency selected		Survey Frequency:		Manufacturer's Accuracy	
210		210		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	3.99	0.01	5.99	5.99	0
6	6	0	4	4	0

	Average	0.0033		Average	0.0000
	Std. Dev	0.0058		Std. Deviation	0.0000
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0041

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
12-Feb-21	**09:40:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**6**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	4	0	5.98	5.99	-0.01
6	6	0	4	4	0

Average	0.0000	Average	-0.0033
Std. Dev	0.0000	Std. Deviation	0.0058
		Cumulative Average	0.00
		Cumulative Std. Deviation	0.0041

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
13-Feb-21	**09:40:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**8**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	3.99	0.01	6	6	0
6	6	0	4	4	0
8	8	0	2	2	0

	Average	0.0025		Average	0.0000
	Std. Dev	0.0050		Std. Deviation	0.0000
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0035

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
14-Feb-21	**09:40:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**8**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	4	0	6	5.99	0.01
6	5.99	0.01	4	4	0

	Average	0.0033		Average	0.0033
	Std. Dev	0.0058		Std. Deviation	0.0058
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
15-Feb-21	**09:40:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**8**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	1.99	0.01	8	8	0
4	4	0	6	6	0
6	6	0	4	3.99	0.01

Average	0.0033	Average	0.0033
Std. Dev	0.0058	Std. Deviation	0.0058
		Cumulative Average	0.00
		Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
16-Feb-21	**10:10:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**10**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.02 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	3.99	0.01	6	5.99	0.01
6	5.99	0.01	4	4.01	-0.01
8	8	0	2	2	0

	Average	0.0050		Average	0.0000
	Std. Dev	0.0058		Std. Deviation	0.0082
			Cumulative Average		0.00
			Cumulative Std. Deviation		0.0017

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
17-Feb-21			
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**5**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	8	8	0
4	4	0	6	5.99	0.01

	Average	0.0000	Average	0.0050
	Std. Dev	0.0000	Std. Deviation	0.0071
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0050

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

Correction Required

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
18-Feb-21	**11:20:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**6**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**4**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	4	3.99	0.01
3	2.99	0.01	3	3	0
4	4	0	2	2	0

	Average	0.0033		Average	0.0033
	Std. Dev	0.0058		Std. Deviation	0.0058
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
19-Feb-21	**11:20:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**6**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**4**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	4	3.99	0.01
3	3	0	3	3	0
4	4	0	2	2	0

	Average	0.0000		Average	0.0033
	Std. Dev	0.0000		Std. Deviation	0.0058
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0041

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Inflatable Boat**	**HATHMATI**
Date:	Time:		
20-Feb-21	**10:50:00**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Pruthviraaj Mohile		**Sonarmite**	**6**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	Upto Depth
0.4 m				**1500**	**4**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.01 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2	0	4	3.99	0.01
3	2.99	0.01	3	3	0
4	4	0	2	2	0

	Average	0.0033		Average	0.0033
	Std. Dev	0.0058		Std. Deviation	0.0058
				Cumulative Average	0.00
				Cumulative Std. Deviation	0.0000

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

Approved By: Survey Manager

9 PHOTOGRAPHS

The following Photographs showing the Survey activities and features available at site

Configuration of SBES Equipment

Bathymetric survey at Dam

TREE ON SURVEY AREA

Demobilization of survey boat

END OF REPORT