GEOSERVICES
MARITIME PVT. LTD.

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

GMPL REPORT NUMBER: P-SUR-BATHY-004-2020-WRD-JHUJ
SURVEY PERIOD: 21 OCT TO 24 OCT 2020

Prepared for:	**Water Resources Investigation Division, Ahmedabad** **(Govt. of Gujarat)** **Narmada Water Resources, Water Supply and Kalpsar Department**	Equity Efficiency Sustainability WRD
Client Reference:	**Executive Engineer** **Water resources investigation Division Ahmedabad.** **Deputy Executive Engineer** **River Gauging Sub Division Navsari.**	

LOCATION MAP

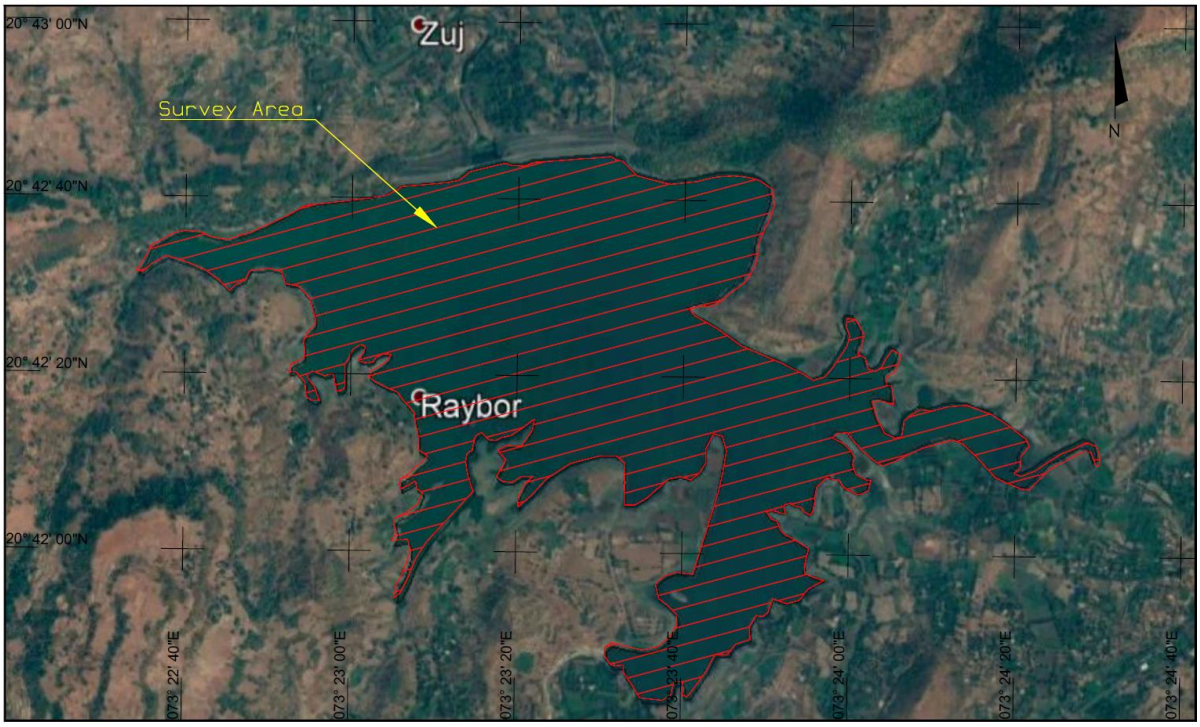

Figure 1.1-1 LOCATION MAP

LOCATION MAP SHOWING SURVEY AREA "JHUJ RESERVOIR", GURAJAT, 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 Jhuj 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 Jhuj 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 Jhuj Reservoir.

The detailed scope of work was:

i) To measure the water depth of the Jhuj 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.

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, drawings and report.

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 0.10 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 JHUJ RESERVOIR

Jhuj Irrigation Scheme envisage construction of Dam across river Ambica a tributary of river Kaveri near village Jhuj of Dang district in Gujarat. The scheme was impounded in the year 1990, and the project is mainly for irrigation.

The total Catchment Area of Jhuj Reservoir is 42.99.00 Sq. Km. Full Reservoir Level (FRL) is 167.50 m and Minimum Draw Down Level (MDDL) is 147.00 m. The gross storage capacity at time of impounding is 28.65 M Cu. m, dead storage is 1.07 M Cu. m and live storage is 27.58 M Cu. m.

I	**LOCATION**	
	State	Gujarat
	District	Dang
	River	Ambika (Tributary of Kaveri)
II	**HYDROLOGY**	
	1. Catchment Area	42.99 Sq. Km
	2. Average Annual weighted Rainfall.	1970 mm
	3. Maximum Discharge	1553.70 cumecs
III	**RESERVOIR**	**As per original project report**
	Full Reservoir level (FRL)	167.50 m
	Maximum Water level (HFL)	171.00 m
	Minimum Draw Down Level (MDDL)	147.00 m
	Gross Storage Capacity at FRL	28.65 M Cu. m
	Dead Storage Capacity at 147.00 m	1.07 M Cu. m
	Live Storage Capacity at FRL	27.58 M Cu. m
	Submergence (spreaded area) at F.R.L.	3.56 Sq. Km
IV	**DAM**	
	Type of Dam	Rolled filled zone type
	Length of Dam	840 m
	Top of Dam	174.50 m
	Max. height from deepest foundation level	47.50 m
	Length of Spillway	97 m
	Crest level of Spillway	167.50 m
	Shape of Crest	Ogee
	Gated/un-gated	Un-gated
V	**CANAL SYSTEM**	**R.B.M.C**
	Capacity	3.51 cumecs (124 cusecs)
	Length	15.06 Km
	Command Area Gross	8950 Ha
	Culturable Command Area	6695 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 Jhuj Reservoir survey area from 21 Oct to 24 Oct 2020 to acquire bathymetric survey data and Topographic data as per mutually agreed scope and relevant survey specifications.

Geomax DGPS system, Reson Navisound Echo sounder (215 kHz) were utilised to acquire the bathymetric data within the Jhuj 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. Geomax RTK was 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 Jhuj reservoir area.

Four (4) hours of DGPS observation was carried out on TBM Fly (Elevation 174.55m. was provided by dam authority). Six (6) Temporary Bench Marks, TBM Juj (Dam Top Gate near light pole), TBM 1, TBM 2, TBM 3 (On Culvert Top near Mankunia Village), TBM 4 (On Culvert Top near Raibor Village) & TBM 5.

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

- The Minimum elevation within Jhuj reservoir is 141.66 m above MSL and
- The Maximum depth within Jhuj reservoir is 25.89 m.
- Area covered by bathymetric survey is 2.485 Sq. Km.
- Area covered by topographic survey is 1.015 Sq. Km.

According to recent survey, total area of reservoir at FRL 167.50m is 2.486 Sq. Km, corresponding storage capacity is 24.844 M Cu. m, and Dead storage at 147.00m is 0.283 M Cu. m.

The comparison between 1990 and 2020(30 years) data results in a rate of siltation (silt index) of 29.51 Ham/100 Sq. Km/year. Annual percentage loss of gross storage capacity, live storage capacity and dead storage capacity is 0.44%, 0.36% and 2.45 % respectively for FRL 167.50 m.

The comparison of 2013 and 2020 data with respect to 1990 impounding data at FRL 167.50 m results in silt index of 45.238 Ham/100 Sq. Km/year and 29.51 Ham/100 Sq. Km/year 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
Kalicharan Prusty	Surveyor
Vishnu S	Land Surveyor
Rohit Patwal	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 Jhuj reservoir. The equipment setup and configuration diagram has been presented in Figure 5.1-1.

Survey Equipment/Systems Used for the Data Acquisition	
Equipment/System	**Description/Make/Model**
Software / Navigation	HYPACK Navigation and Data Acquisition Software
Positioning	Geomax DGPS
Single Beam Echo Sounder	Reson Navisound Echo sounder with Accessories
RTK	Geomax 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 'Aqua 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.

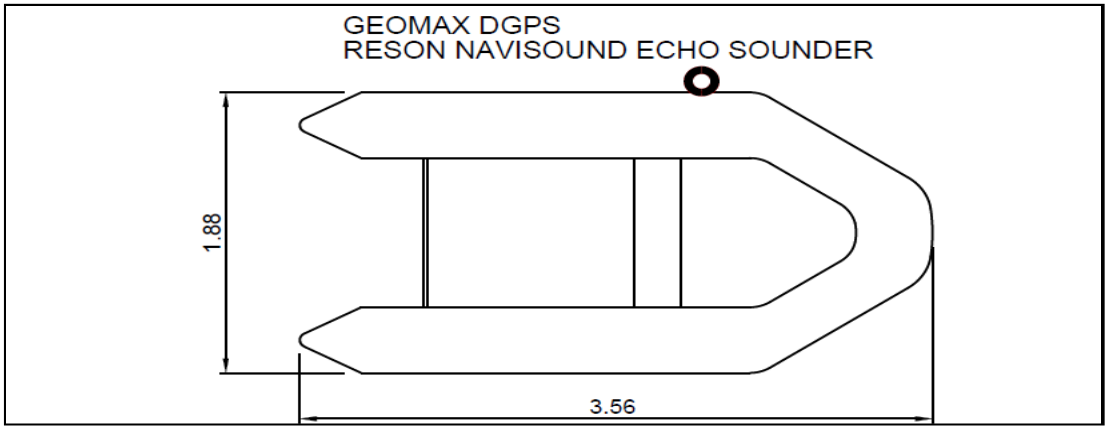

Figure 4.3-1 SURVEY BOAT ' AQUA MARINE' OFFSET DIAGRAM

5 DETAILED METHODOLOGY OF SURVEY

5.1 Mobilisation

The bathymetric survey equipment were mobilised on board "Aqua Marine" on 21 Oct 2020. After successful installation, testing and calibrations of survey equipment, the team proceeded for Data acquisition.

Geomax RTK, auto 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.

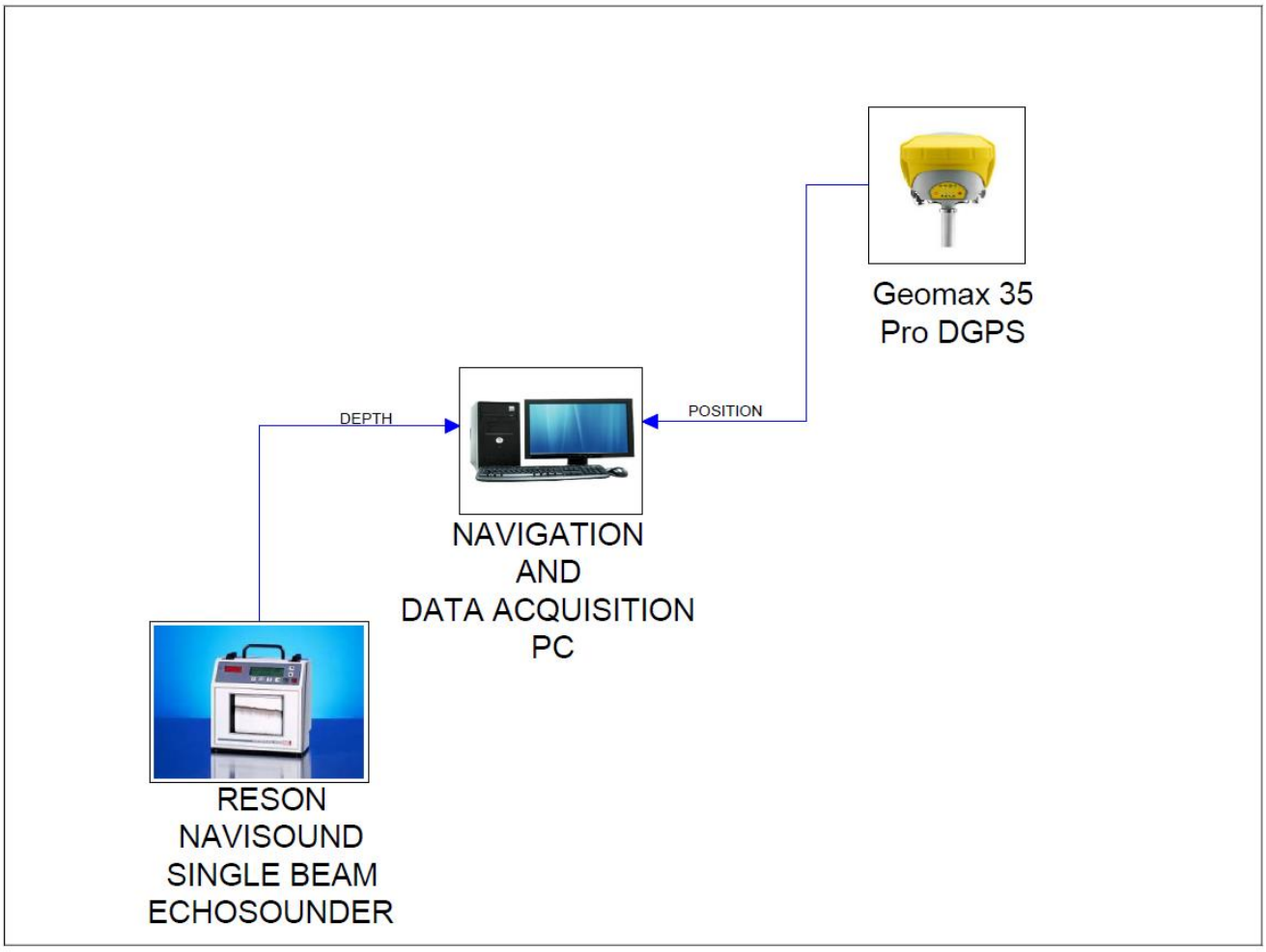

Figure 5.1-1 SBES SURVEY EQUIPMENT CONFIGURATION DIAGRAM ON BOARD

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

RTK DGPS Base station was set up at TBM Fly (174.55 m above MSL) and configured to transmit the correction.

Four (4) hours of DGPS observation was carried out on TBM Fly (Elevation 174.55m. was provided by dam authority). Six (6) Temporary Bench Marks, TBM Juj (Dam Top Gate near light pole), TBM 1, TBM 2, TBM 3 (On Culvert Top near Mankunia Village), TBM 4 (On Culvert Top near Raibor Village) & TBM 5.

T.BM. Information - Jhuj Reservoir, South Gujarat					
Location	**Latitude (N)**	**Longitude (E)**	**Easting (m)**	**Northing (m)**	**Elevation (m) W.r.t MSL**
T.B.M. Fly	20°42'44.318"	73°23'17.897"	332162.767	2291135.026	174.55
T.B.M. Juj	20°42'44.5524"	73°23'19.3425"	332204.750	2291150.618	174.487
T.B.M. 1	20°42'45.3088"	73°23'23.6758"	332330.307	2291167.817	174.569
T.B.M. 2	20°42'44.318"	73°23'33.7381"	332621.483	2291169.741	175.015
T.B.M. 3	20°41'25.5221"	73°23'21.0331"	332229.505	2288719.910	173.508

T.BM. Information - Jhuj Reservoir, South Gujarat					
Location	**Latitude (N)**	**Longitude (E)**	**Easting (m)**	**Northing (m)**	**Elevation (m) W.r.t MSL**
T.B.M. 4	20°41'43.3868"	73°23'43.5719"	332887.144	2289262.790	169.754
T.B.M. 5	20°42'42.0859"	73°23'5.6097"	331806.667	2291078.730	174.679

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, Geomax RTK base was used for DGPS observation on TBM Fly. Four Hrs. of DGPS observation was carried out. Dam authority provided benchmark elevation value of 174.55 m. RTK DGPS Base station was set up at TBM Fly (174.55 m above MSL) andconfigured to transmit the correction. 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 GEOMAX DGPS:

GEOMAX 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.

GEOMAX 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 'Reson NaviSound' 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 altitude sensors.

5.4.4 RTK System

Geomax RTK system consists of one Base and two Rover Module. Base is set up on a known point usually Benchmark whose co-ordinates are known and is configured to transmit correction in real time to the two rovers using radio modem.

5.5 Data Acquisition and Quality Control

5.5.1 Online Data Quality Control

The online navigation computer was interfaced to Reson Navisound 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 Reson Navisound Echo Sounder was satisfactory throughout the duration of the survey. The quality 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 Keliya Reservoir with due, consent from Client Representative, the survey equipment on board were demobilised on 20 October 2020.

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)
21/10/2020	0900	167.55
21/10/2020	1900	167.55
22/10/2020	0700	167.55
22/10/2020	1900	167.55
23/10/2020	0700	167.55
23/10/2020	1900	167.55
24/10/2020	0700	167.55
24/10/2020	1900	167.55

Table 5.8-1 WATER LEVEL

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

After the data processing phase, five drawings has been prepared for Jhuj 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-JHUJ-BATHY-01	Chart contains bathy , contour and cross section segments	Paper size A0 (1:5000)	PDF & CAD
2	P-SUR-004-JHUJ-OVERVIEW-01	Overview Map of Reservoir	Paper size A3	PDF & CAD
3	Area Capacity Curve Jhuj -2020	Area Capacity curve of Reservoir	Paper size A3	PDF & CAD
4	Jhuj Cross Sections	20 Cross Section at 100 m interval	Only soft copy	CAD
5	Jhuj 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 Jhuj reservoir.

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

- The Minimum elevation within Jhuj reservoir is 141.66 m above MSL and
- The Maximum depth within Jhuj reservoir is 25.89 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 model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
141.60	0.000	0.000	0.000	0.000	0.000	
141.70	0.000	0.000	0.000	0.000	0.000	
141.80	0.000	0.000	0.000	0.000	0.000	
141.90	0.000	0.000	0.000	0.000	0.000	
142.00	0.000	0.000	0.000	0.000	0.000	
142.10	0.000	0.000	0.000	0.000	0.001	
142.20	0.000	0.000	0.000	0.000	0.001	
142.30	0.000	0.000	0.000	0.000	0.002	
142.40	0.001	0.000	0.001	0.001	0.002	
142.50	0.001	0.000	0.001	0.001	0.003	
142.60	0.001	0.000	0.001	0.001	0.004	
142.70	0.002	0.000	0.002	0.002	0.005	
142.80	0.002	0.000	0.002	0.002	0.006	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
142.90	0.003	0.000	0.003	0.003	0.007	
143.00	0.004	0.000	0.004	0.004	0.008	
143.10	0.004	0.000	0.004	0.004	0.009	
143.20	0.005	0.000	0.005	0.005	0.011	
143.30	0.007	0.000	0.007	0.007	0.013	
143.40	0.008	0.000	0.008	0.008	0.014	
143.50	0.009	0.000	0.009	0.009	0.016	
143.60	0.011	0.000	0.011	0.011	0.018	
143.70	0.013	0.000	0.013	0.013	0.020	
143.80	0.015	0.000	0.015	0.015	0.023	
143.90	0.018	0.000	0.018	0.018	0.026	
144.00	0.020	0.000	0.020	0.020	0.029	
144.10	0.023	0.000	0.023	0.023	0.031	
144.20	0.027	0.000	0.027	0.027	0.034	
144.30	0.030	0.000	0.030	0.030	0.036	
144.40	0.034	0.000	0.034	0.034	0.039	
144.50	0.038	0.000	0.038	0.038	0.041	
144.60	0.042	0.000	0.042	0.042	0.045	
144.70	0.047	0.000	0.047	0.047	0.048	
144.80	0.052	0.000	0.052	0.052	0.052	
144.90	0.057	0.000	0.057	0.057	0.056	
145.00	0.063	0.000	0.063	0.063	0.060	
145.10	0.069	0.000	0.069	0.069	0.064	
145.20	0.076	0.000	0.076	0.076	0.068	
145.30	0.083	0.000	0.083	0.083	0.073	
145.40	0.090	0.000	0.090	0.090	0.080	
145.50	0.099	0.000	0.099	0.099	0.085	
145.60	0.107	0.000	0.107	0.107	0.091	
145.70	0.117	0.000	0.117	0.117	0.096	
145.80	0.127	0.000	0.127	0.127	0.101	
145.90	0.137	0.000	0.137	0.137	0.106	
146.00	0.148	0.000	0.148	0.148	0.111	
146.10	0.159	0.000	0.159	0.159	0.117	
146.20	0.171	0.000	0.171	0.171	0.121	
146.30	0.184	0.000	0.184	0.184	0.126	
146.40	0.196	0.000	0.196	0.196	0.131	
146.50	0.210	0.000	0.210	0.210	0.136	
146.60	0.224	0.000	0.224	0.224	0.140	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
146.70	0.238	0.000	0.238	0.238	0.145	
146.80	0.252	0.000	0.252	0.252	0.149	
146.90	0.268	0.000	0.268	0.268	0.153	
147.00	**0.283**	**0.000**	**0.283**	**0.283**	**0.157**	**MDDL**
147.10	0.283	0.016	0.299	0.299	0.160	
147.20	0.283	0.032	0.315	0.315	0.163	
147.30	0.283	0.048	0.331	0.331	0.167	
147.40	0.283	0.065	0.348	0.348	0.170	
147.50	0.283	0.082	0.365	0.365	0.174	
147.60	0.283	0.100	0.383	0.383	0.178	
147.70	0.283	0.118	0.401	0.401	0.182	
147.80	0.283	0.136	0.419	0.419	0.186	
147.90	0.283	0.155	0.438	0.438	0.191	
148.00	0.283	0.175	0.458	0.458	0.196	
148.10	0.283	0.194	0.477	0.477	0.201	
148.20	0.283	0.215	0.498	0.498	0.205	
148.30	0.283	0.236	0.519	0.519	0.212	
148.40	0.283	0.257	0.540	0.540	0.218	
148.50	0.283	0.279	0.562	0.562	0.224	
148.60	0.283	0.302	0.585	0.585	0.233	
148.70	0.283	0.326	0.609	0.609	0.242	
148.80	0.283	0.350	0.633	0.633	0.250	
148.90	0.283	0.376	0.659	0.659	0.258	
149.00	0.283	0.402	0.685	0.685	0.266	
149.10	0.283	0.429	0.712	0.712	0.274	
149.20	0.283	0.457	0.740	0.740	0.282	
149.30	0.283	0.485	0.768	0.768	0.291	
149.40	0.283	0.515	0.798	0.798	0.299	
149.50	0.283	0.545	0.828	0.828	0.308	
149.60	0.283	0.576	0.859	0.859	0.316	
149.70	0.283	0.608	0.891	0.891	0.325	
149.80	0.283	0.641	0.924	0.924	0.333	
149.90	0.283	0.675	0.958	0.958	0.341	
150.00	0.283	0.710	0.993	0.993	0.349	
150.10	0.283	0.745	1.028	1.028	0.358	
150.20	0.283	0.781	1.064	1.064	0.366	
150.30	0.283	0.818	1.101	1.101	0.375	
150.40	0.283	0.856	1.139	1.139	0.383	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
150.50	0.283	0.895	1.178	1.178	0.392	
150.60	0.283	0.934	1.217	1.217	0.400	
150.70	0.283	0.975	1.258	1.258	0.408	
150.80	0.283	1.016	1.299	1.299	0.416	
150.90	0.283	1.058	1.341	1.341	0.425	
151.00	0.283	1.101	1.384	1.384	0.435	
151.10	0.283	1.145	1.428	1.428	0.445	
151.20	0.283	1.190	1.473	1.473	0.456	
151.30	0.283	1.236	1.519	1.519	0.467	
151.40	0.283	1.283	1.566	1.566	0.477	
151.50	0.283	1.332	1.615	1.615	0.488	
151.60	0.283	1.381	1.664	1.664	0.498	
151.70	0.283	1.431	1.714	1.714	0.507	
151.80	0.283	1.482	1.765	1.765	0.516	
151.90	0.283	1.534	1.817	1.817	0.525	
152.00	0.283	1.587	1.870	1.870	0.534	
152.10	0.283	1.641	1.924	1.924	0.543	
152.20	0.283	1.696	1.979	1.979	0.551	
152.30	0.283	1.751	2.034	2.034	0.560	
152.40	0.283	1.808	2.091	2.091	0.570	
152.50	0.283	1.865	2.148	2.148	0.580	
152.60	0.283	1.924	2.207	2.207	0.590	
152.70	0.283	1.983	2.266	2.266	0.600	
152.80	0.283	2.044	2.327	2.327	0.610	
152.90	0.283	2.105	2.388	2.388	0.619	
153.00	0.283	2.168	2.451	2.451	0.629	
153.10	0.283	2.231	2.514	2.514	0.639	
153.20	0.283	2.295	2.578	2.578	0.649	
153.30	0.283	2.361	2.644	2.644	0.659	
153.40	0.283	2.427	2.710	2.710	0.669	
153.50	0.283	2.495	2.778	2.778	0.680	
153.60	0.283	2.563	2.846	2.846	0.690	
153.70	0.283	2.633	2.916	2.916	0.701	
153.80	0.283	2.704	2.986	2.987	0.713	
153.90	0.283	2.775	3.058	3.058	0.724	
154.00	0.283	2.848	3.131	3.131	0.735	
154.10	0.283	2.922	3.205	3.205	0.746	
154.20	0.283	2.997	3.280	3.280	0.756	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
154.30	0.283	3.074	3.357	3.357	0.767	
154.40	0.283	3.151	3.434	3.434	0.777	
154.50	0.283	3.229	3.512	3.512	0.788	
154.60	0.283	3.308	3.591	3.591	0.799	
154.70	0.283	3.389	3.672	3.672	0.811	
154.80	0.283	3.471	3.754	3.754	0.822	
154.90	0.283	3.553	3.836	3.836	0.834	
155.00	0.283	3.637	3.920	3.920	0.845	
155.10	0.283	3.722	4.005	4.005	0.857	
155.20	0.283	3.809	4.092	4.092	0.869	
155.30	0.283	3.896	4.179	4.179	0.880	
155.40	0.283	3.985	4.268	4.268	0.892	
155.50	0.283	4.075	4.358	4.358	0.904	
155.60	0.283	4.166	4.449	4.449	0.917	
155.70	0.283	4.258	4.541	4.541	0.929	
155.80	0.283	4.351	4.634	4.634	0.941	
155.90	0.283	4.446	4.729	4.729	0.954	
156.00	0.283	4.542	4.825	4.825	0.967	
156.10	0.283	4.640	4.923	4.923	0.981	
156.20	0.283	4.738	5.021	5.021	0.994	
156.30	0.283	4.838	5.121	5.121	1.007	
156.40	0.283	4.940	5.223	5.223	1.020	
156.50	0.283	5.042	5.325	5.325	1.034	
156.60	0.283	5.147	5.430	5.430	1.047	
156.70	0.283	5.252	5.535	5.535	1.061	
156.80	0.283	5.359	5.642	5.642	1.076	
156.90	0.283	5.467	5.750	5.750	1.090	
157.00	0.283	5.577	5.860	5.860	1.105	
157.10	0.283	5.688	5.971	5.971	1.119	
157.20	0.283	5.801	6.084	6.084	1.133	
157.30	0.283	5.915	6.198	6.198	1.147	
157.40	0.283	6.030	6.313	6.313	1.162	
157.50	0.283	6.147	6.430	6.430	1.176	
157.60	0.283	6.265	6.548	6.548	1.190	
157.70	0.283	6.385	6.668	6.668	1.204	
157.80	0.283	6.506	6.789	6.789	1.218	
157.90	0.283	6.629	6.912	6.912	1.231	
158.00	0.283	6.752	7.035	7.035	1.244	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
158.10	0.283	6.877	7.160	7.160	1.258	
158.20	0.283	7.004	7.287	7.287	1.271	
158.30	0.283	7.132	7.415	7.415	1.284	
158.40	0.283	7.261	7.544	7.544	1.298	
158.50	0.283	7.391	7.674	7.674	1.311	
158.60	0.283	7.523	7.806	7.806	1.324	
158.70	0.283	7.656	7.939	7.939	1.337	
158.80	0.283	7.790	8.073	8.073	1.350	
158.90	0.283	7.926	8.209	8.209	1.363	
159.00	0.283	8.063	8.346	8.346	1.375	
159.10	0.283	8.201	8.484	8.484	1.388	
159.20	0.283	8.340	8.623	8.623	1.400	
159.30	0.283	8.481	8.764	8.764	1.413	
159.40	0.283	8.623	8.906	8.906	1.425	
159.50	0.283	8.766	9.049	9.049	1.437	
159.60	0.283	8.910	9.193	9.193	1.449	
159.70	0.283	9.056	9.339	9.339	1.461	
159.80	0.283	9.202	9.486	9.485	1.474	
159.90	0.283	9.351	9.634	9.634	1.487	
160.00	0.283	9.500	9.783	9.783	1.499	
160.10	0.283	9.650	9.933	9.933	1.511	
160.20	0.283	9.802	10.085	10.085	1.523	
160.30	0.283	9.955	10.238	10.238	1.535	
160.40	0.283	10.109	10.392	10.392	1.547	
160.50	0.283	10.264	10.547	10.547	1.559	
160.60	0.283	10.421	10.704	10.704	1.571	
160.70	0.283	10.579	10.862	10.862	1.583	
160.80	0.283	10.737	11.020	11.020	1.595	
160.90	0.283	10.897	11.180	11.180	1.606	
161.00	0.283	11.059	11.342	11.342	1.618	
161.10	0.283	11.221	11.504	11.504	1.629	
161.20	0.283	11.385	11.668	11.668	1.641	
161.30	0.283	11.549	11.832	11.832	1.653	
161.40	0.283	11.715	11.998	11.998	1.664	
161.50	0.283	11.882	12.165	12.165	1.676	
161.60	0.283	12.050	12.333	12.333	1.688	
161.70	0.283	12.220	12.503	12.503	1.701	
161.80	0.283	12.391	12.674	12.674	1.713	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
161.90	0.283	12.562	12.845	12.845	1.725	
162.00	0.283	12.736	13.019	13.019	1.737	
162.10	0.283	12.910	13.193	13.193	1.749	
162.20	0.283	13.085	13.368	13.368	1.762	
162.30	0.283	13.262	13.545	13.545	1.775	
162.40	0.283	13.440	13.723	13.723	1.788	
162.50	0.283	13.620	13.903	13.903	1.801	
162.60	0.283	13.801	14.084	14.084	1.815	
162.70	0.283	13.983	14.266	14.266	1.828	
162.80	0.283	14.166	14.449	14.449	1.840	
162.90	0.283	14.351	14.634	14.634	1.852	
163.00	0.283	14.537	14.820	14.820	1.865	
163.10	0.283	14.724	15.007	15.007	1.878	
163.20	0.283	14.912	15.195	15.195	1.890	
163.30	0.283	15.102	15.385	15.385	1.903	
163.40	0.283	15.293	15.576	15.576	1.917	
163.50	0.283	15.485	15.768	15.768	1.930	
163.60	0.283	15.679	15.962	15.962	1.944	
163.70	0.283	15.874	16.157	16.157	1.957	
163.80	0.283	16.070	16.353	16.353	1.971	
163.90	0.283	16.268	16.551	16.551	1.984	
164.00	0.283	16.467	16.750	16.750	1.997	
164.10	0.283	16.667	16.950	16.950	2.009	
164.20	0.283	16.869	17.152	17.152	2.021	
164.30	0.283	17.072	17.355	17.355	2.034	
164.40	0.283	17.276	17.559	17.559	2.048	
164.50	0.283	17.481	17.764	17.764	2.059	
164.60	0.283	17.688	17.971	17.971	2.070	
164.70	0.283	17.895	18.178	18.178	2.081	
164.80	0.283	18.104	18.387	18.387	2.091	
164.90	0.283	18.313	18.597	18.596	2.101	
165.00	0.283	18.524	18.807	18.807	2.111	
165.10	0.283	18.736	19.019	19.019	2.122	
165.20	0.283	18.948	19.231	19.231	2.132	
165.30	0.283	19.162	19.445	19.445	2.142	
165.40	0.283	19.377	19.660	19.660	2.153	
165.50	0.283	19.593	19.876	19.876	2.163	
165.60	0.283	19.809	20.093	20.092	2.173	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
165.70	0.283	20.027	20.310	20.310	2.184	
165.80	0.283	20.246	20.529	20.529	2.194	
165.90	0.283	20.466	20.749	20.749	2.205	
166.00	0.283	20.687	20.970	20.970	2.216	
166.10	0.283	20.909	21.192	21.192	2.226	
166.20	0.283	21.133	21.416	21.416	2.237	
166.30	0.283	21.357	21.640	21.640	2.249	
166.40	0.283	21.582	21.865	21.865	2.260	
166.50	0.283	21.809	22.092	22.092	2.272	
166.60	0.283	22.037	22.320	22.320	2.284	
166.70	0.283	22.266	22.549	22.549	2.298	
166.80	0.283	22.496	22.779	22.779	2.311	
166.90	0.283	22.728	23.011	23.011	2.326	
167.00	0.283	22.962	23.245	23.245	2.343	
167.10	0.283	23.197	23.480	23.480	2.365	
167.20	0.283	23.435	23.718	23.718	2.391	
167.30	0.283	23.675	23.958	23.958	2.420	
167.40	0.283	23.919	24.202	24.202	2.450	
167.50	**0.283**	**24.166**	**24.448**	**24.449**	**2.486**	**FRL**
167.60	0.283	24.417	24.699	24.700	2.536	
167.70	0.283	24.674	24.956	24.957	2.607	
167.80	0.283	24.939	25.221	25.222	2.689	
167.90	0.283	25.211	25.493	25.494	2.753	
168.00	0.283	25.489	25.772	25.772	2.807	
168.10	0.283	25.772	26.055	26.055	2.856	
168.20	0.283	26.060	26.342	26.343	2.897	
168.30	0.283	26.351	26.634	26.634	2.934	
168.40	0.283	26.646	26.929	26.929	2.968	
168.50	0.283	26.945	27.227	27.228	3.000	
168.60	0.283	27.246	27.529	27.529	3.031	
168.70	0.283	27.551	27.834	27.834	3.061	
168.80	0.283	27.858	28.141	28.141	3.089	
168.90	0.283	28.168	28.451	28.451	3.112	
169.00	0.283	28.481	28.764	28.764	3.131	
169.10	0.283	28.795	29.078	29.078	3.149	
169.20	0.283	29.110	29.393	29.393	3.167	
169.30	0.283	29.428	29.711	29.711	3.184	
169.40	0.283	29.747	30.030	30.030	3.200	

Level (m)	Dead Storage Capacity (M Cu. m)	Live Storage Capacity (M Cu. m)	Gross Storage Capacity using TIN model (M Cu. m)	Gross Storage using Prismoidal formula (M Cu. m)	Spread Area (Sq. Km)	Remarks
169.50	0.283	30.068	30.351	30.351	3.217	
169.60	0.283	30.390	30.673	30.673	3.233	
169.70	0.283	30.715	30.998	30.998	3.249	
169.80	0.283	31.040	31.323	31.323	3.266	
169.90	0.283	31.368	31.651	31.651	3.282	
170.00	0.283	31.697	31.980	31.980	3.298	
170.10	0.283	32.027	32.310	32.310	3.314	
170.20	0.283	32.360	32.643	32.643	3.330	
170.30	0.283	32.693	32.976	32.976	3.345	
170.40	0.283	33.029	33.312	33.312	3.361	
170.50	0.283	33.365	33.648	33.648	3.376	
170.60	0.283	33.704	33.987	33.987	3.392	
170.70	0.283	34.044	34.327	34.327	3.408	
170.80	0.283	34.385	34.668	34.668	3.423	
170.90	0.283	34.728	35.012	35.011	3.439	
171.00	0.283	35.073	35.356	35.356	3.455	
171.10	0.283	35.420	35.703	35.703	3.472	
171.20	0.283	35.768	36.051	36.051	3.488	
171.25	**0.283**	**35.942**	**36.225**	**36.225**	**3.497**	**HFL**

Table 6.2-1 CAPACITY AND AREA

6.3 Comparative Statement of Jhuj Reservoir

RL in m	Impounding Year 1990		As per 2013 Survey		As per 2020 survey		Remarks
	Gross Capacity in M Cu. m	Area in Sq. Km	Gross Capacity in M Cu. m	Area in Sq. Km	Gross Capacity in M Cu. m	Area in Sq. Km	
142	0.150	0.089	0.000	0.000	0.000	0.000	
143	0.233	0.122	0.000	0.001	0.004	0.008	
144	0.392	0.162	0.005	0.010	0.020	0.029	
145	0.552	0.201	0.027	0.040	0.063	0.060	
146	0.798	0.247	0.083	0.074	0.148	0.111	
147	1.070	0.293	0.175	0.110	0.283	0.157	**MDDL**
148	1.395	0.356	0.313	0.173	0.458	0.196	
149	1.746	0.411	0.563	0.345	0.685	0.266	
150	2.245	0.502	0.946	0.420	0.993	0.349	
151	2.745	0.594	1.402	0.494	1.384	0.435	
152	3.426	0.685	1.941	0.593	1.870	0.534	
153	4.108	0.776	2.604	0.716	2.451	0.629	
154	5.040	0.898	3.359	0.795	3.131	0.735	
155	5.973	1.020	4.210	0.919	3.920	0.845	
156	7.125	1.151	5.186	1.031	4.825	0.967	
157	8.227	1.287	6.270	1.133	5.860	1.105	
158	9.674	1.398	7.444	1.218	7.035	1.244	
159	11.071	1.508	8.714	1.329	8.346	1.375	
160	12.681	1.611	10.093	1.422	9.783	1.499	
161	14.292	1.714	11.553	1.500	11.342	1.618	
162	16.149	1.858	13.093	1.579	13.019	1.737	
163	18.002	2.003	14.736	1.735	14.820	1.865	
164	20.152	2.148	16.566	1.911	16.750	1.997	
165	22.299	2.292	18.553	2.056	18.807	2.111	
166	24.757	2.459	20.678	2.197	20.970	2.216	
167	27.215	2.625	22.962	2.362	23.245	2.343	
167.5	28.650	2.718	24.252	2.446	24.488	2.486	**FRL**

Table 6.3-1 COMPARATIVE STATEMENT OF JHUJ RESERVOIR

6.4 Gross Storage Capacity in M Cu. m of the Reservoir - Year 2020

RL (m)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
142	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.003
143	0.004	0.004	0.005	0.007	0.008	0.009	0.011	0.013	0.015	0.018
144	0.020	0.023	0.027	0.030	0.034	0.038	0.042	0.047	0.052	0.057
145	0.063	0.069	0.076	0.083	0.090	0.099	0.107	0.117	0.127	0.137
146	0.148	0.159	0.171	0.184	0.196	0.210	0.224	0.238	0.252	0.268
147	**0.283**	0.299	0.315	0.331	0.348	0.365	0.383	0.401	0.419	0.438
148	0.458	0.477	0.498	0.519	0.540	0.562	0.585	0.609	0.633	0.659
149	0.685	0.712	0.740	0.768	0.798	0.828	0.859	0.891	0.924	0.958
150	0.993	1.028	1.064	1.101	1.139	1.178	1.217	1.258	1.299	1.341
151	1.384	1.428	1.473	1.519	1.566	1.615	1.664	1.714	1.765	1.817
152	1.870	1.924	1.979	2.034	2.091	2.148	2.207	2.266	2.327	2.388
153	2.451	2.514	2.578	2.644	2.710	2.778	2.846	2.916	2.986	3.058
154	3.131	3.205	3.280	3.357	3.434	3.512	3.591	3.672	3.754	3.836
155	3.920	4.005	4.092	4.179	4.268	4.358	4.449	4.541	4.634	4.729
156	4.825	4.923	5.021	5.121	5.223	5.325	5.430	5.535	5.642	5.750
157	5.860	5.971	6.084	6.198	6.313	6.430	6.548	6.668	6.789	6.912
158	7.035	7.160	7.287	7.415	7.544	7.674	7.806	7.939	8.073	8.209
159	8.346	8.484	8.623	8.764	8.906	9.049	9.193	9.339	9.486	9.634
160	9.783	9.933	10.085	10.238	10.392	10.547	10.704	10.862	11.020	11.18
161	11.342	11.504	11.668	11.832	11.998	12.165	12.333	12.503	12.674	12.845
162	13.019	13.193	13.368	13.545	13.723	13.903	14.084	14.266	14.449	14.634
163	14.820	15.007	15.195	15.385	15.576	15.768	15.962	16.157	16.353	16.551
164	16.750	16.950	17.152	17.355	17.559	17.764	17.971	18.178	18.387	18.597
165	18.807	19.019	19.231	19.445	19.660	19.876	20.093	20.310	20.529	20.749
166	20.970	21.192	21.416	21.640	21.865	22.092	22.320	22.549	22.779	23.011
167	23.245	23.480	23.718	23.958	24.202	**24.448**	24.699	24.956	25.221	25.493
168	25.772	26.055	26.342	26.634	26.929	27.227	27.529	27.834	28.141	28.451
169	28.764	29.078	29.393	29.711	30.030	30.351	30.673	30.998	31.323	31.651
170	31.980	32.310	32.643	32.976	33.312	33.648	33.987	34.327	34.668	35.012
171	35.356	35.703	36.051							
171.25	**36.225**									

Table 6.4-1 GROSS STORAGE CAPACITY IN M cu. m YEAR -2020

Note: Gross storage capacity for FRL at 167.50 m is 24.448 M Cu. m, dead storage at 147.00 m is 0.283 M Cu. m and HFL at 171.25 m is 36.225 M Cu. m.

6.5 Live Storage Capacity in M Cu. m of the Reservoir - Year 2020:

RL (m)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
147	0.000	0.016	0.032	0.048	0.065	0.082	0.100	0.118	0.136	0.155
148	0.175	0.194	0.215	0.236	0.257	0.279	0.302	0.326	0.350	0.376
149	0.402	0.429	0.457	0.485	0.515	0.545	0.576	0.608	0.641	0.675
150	0.710	0.745	0.781	0.818	0.856	0.895	0.934	0.975	1.016	1.058
151	1.101	1.145	1.190	1.236	1.283	1.332	1.381	1.431	1.482	1.534
152	1.587	1.641	1.696	1.751	1.808	1.865	1.924	1.983	2.044	2.105
153	2.168	2.231	2.295	2.361	2.427	2.495	2.563	2.633	2.703	2.775
154	2.848	2.922	2.997	3.074	3.151	3.229	3.308	3.389	3.471	3.553
155	3.637	3.722	3.809	3.896	3.985	4.075	4.166	4.258	4.351	4.446
156	4.542	4.64	4.738	4.838	4.94	5.042	5.147	5.252	5.359	5.467
157	5.577	5.688	5.801	5.915	6.030	6.147	6.265	6.385	6.506	6.629
158	6.752	6.877	7.004	7.132	7.261	7.391	7.523	7.656	7.790	7.926
159	8.063	8.201	8.340	8.481	8.623	8.766	8.901	9.056	9.203	9.351
160	9.500	9.650	9.802	9.955	10.109	10.264	10.421	10.579	10.737	10.897
161	11.059	11.221	11.385	11.549	11.715	11.882	12.050	12.220	12.391	12.562
162	12.736	12.910	13.085	13.262	13.440	13.620	13.801	13.983	14.166	14.351
163	14.537	14.724	14.912	15.102	15.293	15.485	15.679	15.874	16.070	16.268
164	16.467	16.667	16.869	17.072	17.276	17.481	17.688	17.895	18.104	18.314
165	18.524	18.736	18.948	19.162	19.377	19.593	19.810	20.027	20.246	20.466
166	20.687	20.909	21.133	21.357	21.582	21.809	22.037	22.266	22.496	22.728
167	22.962	23.197	23.435	23.675	23.919	**24.165**	24.416	24.673	24.938	25.21
168	25.489	25.772	26.059	26.351	26.646	26.944	27.246	27.551	27.858	28.168
169	28.481	28.795	29.110	29.428	29.747	30.068	30.390	30.715	31.040	31.368
170	31.697	32.027	32.360	32.693	33.029	33.365	33.704	34.044	34.385	34.729
171	35.073	35.420	35.768							
171.25	**35.942**									

Table 6.5-1 LIVE STORAGE CAPACITY IN M cu. m YEAR -2020

Note: Live storage capacity for FRL at 167.50 m is 24.165 M Cu. m and HFL at 171.25 m is 35.942 M Cu. m.

6.6 Spread Area in Sq.Km of the Reservoir - Year 2020:

RL (m)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
142	0.000	0.001	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007
143	0.008	0.009	0.011	0.013	0.014	0.016	0.018	0.02	0.023	0.026
144	0.029	0.031	0.034	0.036	0.039	0.041	0.045	0.048	0.052	0.056
145	0.060	0.064	0.068	0.073	0.080	0.085	0.091	0.096	0.101	0.106
146	0.111	0.117	0.121	0.126	0.131	0.136	0.140	0.145	0.149	0.153
147	0.157	0.160	0.163	0.167	0.170	0.174	0.178	0.182	0.186	0.191
148	0.196	0.201	0.205	0.212	0.218	0.224	0.233	0.242	0.250	0.258
149	0.266	0.274	0.282	0.291	0.299	0.308	0.316	0.325	0.333	0.341
150	0.349	0.358	0.366	0.375	0.383	0.392	0.400	0.408	0.416	0.425
151	0.435	0.445	0.456	0.467	0.477	0.488	0.498	0.507	0.516	0.525
152	0.534	0.543	0.551	0.560	0.570	0.580	0.590	0.600	0.610	0.619
153	0.629	0.639	0.649	0.659	0.669	0.680	0.690	0.701	0.713	0.724
154	0.735	0.746	0.756	0.767	0.777	0.788	0.799	0.811	0.822	0.834
155	0.845	0.857	0.869	0.880	0.892	0.904	0.917	0.929	0.941	0.954
156	0.967	0.981	0.994	1.007	1.020	1.034	1.047	1.061	1.076	1.090
157	1.105	1.119	1.133	1.147	1.162	1.176	1.190	1.204	1.218	1.231
158	1.244	1.258	1.271	1.284	1.298	1.311	1.324	1.337	1.350	1.363
159	1.375	1.388	1.400	1.413	1.425	1.437	1.449	1.461	1.474	1.487
160	1.499	1.511	1.523	1.535	1.547	1.559	1.571	1.583	1.595	1.606
161	1.618	1.629	1.641	1.653	1.664	1.676	1.688	1.701	1.713	1.725
162	1.737	1.749	1.762	1.775	1.788	1.801	1.815	1.828	1.840	1.852
163	1.865	1.878	1.890	1.903	1.917	1.930	1.944	1.957	1.971	1.984
164	1.997	2.009	2.021	2.034	2.048	2.059	2.070	2.081	2.091	2.101
165	2.111	2.122	2.132	2.142	2.153	2.163	2.173	2.184	2.194	2.205
166	2.216	2.226	2.237	2.249	2.260	2.272	2.284	2.298	2.311	2.326
167	2.343	2.365	2.391	2.420	2.450	**2.486**	2.536	2.607	2.689	2.753
168	2.807	2.856	2.897	2.934	2.968	3.000	3.031	3.061	3.089	3.112
169	3.131	3.149	3.167	3.184	3.200	3.217	3.233	3.249	3.266	3.282
170	3.298	3.314	3.330	3.345	3.361	3.376	3.392	3.408	3.423	3.439
171	3.455	3.472	3.488							
171.25	**3.497**									

Table 6.6-1 SPREAD AREA IN SQ. KM YEAR -2020

Note: Spread Area for FRL at 167.50 m is 2.486 Sq. Km and HFL at 171.25 m is 3.497 Sq. Km.

6.7 Sediment Analysis:

6.7.1 Observed Rate of Sedimentation

The reservoir was impounded during the year 1990. As per the original report, total area of reservoir at FRL 167.50m was 2.718 Sq. Km, corresponding storage capacity was 28.65 M Cu. m, and Dead storage at 147.00m was 1.07 M Cu. m.

G.E.R.I surveyed the reservoir by Remote Sensing Technique in the year 2013. As per survey of the year 2013, total area of reservoir at FRL 167.50 m was 2.466 Sq. Km and corresponding storage capacity was 24.252 M Cu. m, and Dead storage at 147.00 m was 0.175 M Cu. m.

The reservoir was recently surveyed by means of integrated bathymetric and topographic survey in year 2020. As per recent survey, total area of reservoir at FRL 167.50m is 2.486 Sq. Km, corresponding storage capacity is 24.844 M Cu. m, and Dead storage at 147.00m is 0.283 M Cu. m.

Rate of siltation in reservoir (up to FRL 167.50m) during last 30 years (1990-2020) is
0.127 M Cu. m / year.

Original Reservoir data:

Year of Impounding : 1990
Catchment Area : 42.99 Sq. Km
Surface area at FRL 167.50m : 3.56 Sq. Km
Live storage at FRL 167.50m : 27.58 M Cu. m
Dead storage at 147.00m : 1.07 M Cu. m
Gross storage at FRL 167.50m : 28.65 M Cu. m

Rate of Sedimentation (at FRL 167.50) with respect to impounding year 1990													
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	1990	1.07	27.58	28.65	-	-	-	-	-	-	-	-	
2	2013 By Remote Sensing	0.175	24.002	24.177	23	4.473	0.194	0.9 83.64%	3.58 12.97%	4.47 15.61%	45.238	0.68%	**Serious Category**
3	2020 by integrated Bathymetric and Topographic survey	0.283	24.561	24.844	30	3.806	0.127	0.787 73.55%	3.019 10.95%	3.806 13.28%	29.51	0.44%	**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

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6.8 Conclusion

- By above table we can conclude that the capacity of reservoir is decreased significantly due to deposition of sediments in the reservoir. The annual percentage loss from survey of the year 2013 and 2020 is observed to be 0.68% and 0.44% respectively.
- The decrease in annual percentage loss from 0.68% (2013 survey) to 0.44% (2020 survey) is because at initial stage after dam construction sedimentation takes place at higher rate compare to later on.
- The increase in storage capacity (0.667 M Cu. m increased in gross storage capacity) in 2020 survey data compared to 2013 survey data is due to difference in method used to acquire survey data of the reservoir during 2013 and 2020.
- Remote Sensing method used in previous survey works on estimations of water spread area. In remote sensing method, the difference between water spread area between year of survey and earlier survey year is a real extent of silting at these levels. This change in water spread area at that water level is used to calculate storage capacity. This is the disadvantage of this method as it can only estimate area. In addition, this method is time consuming, as we will have to wait for water level to change from MDDL (lowest water level reservoir has recorded) to FRL. Also data acquired by this method is less reliable as compared to recent survey method.

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 Jhuj Reservoir:

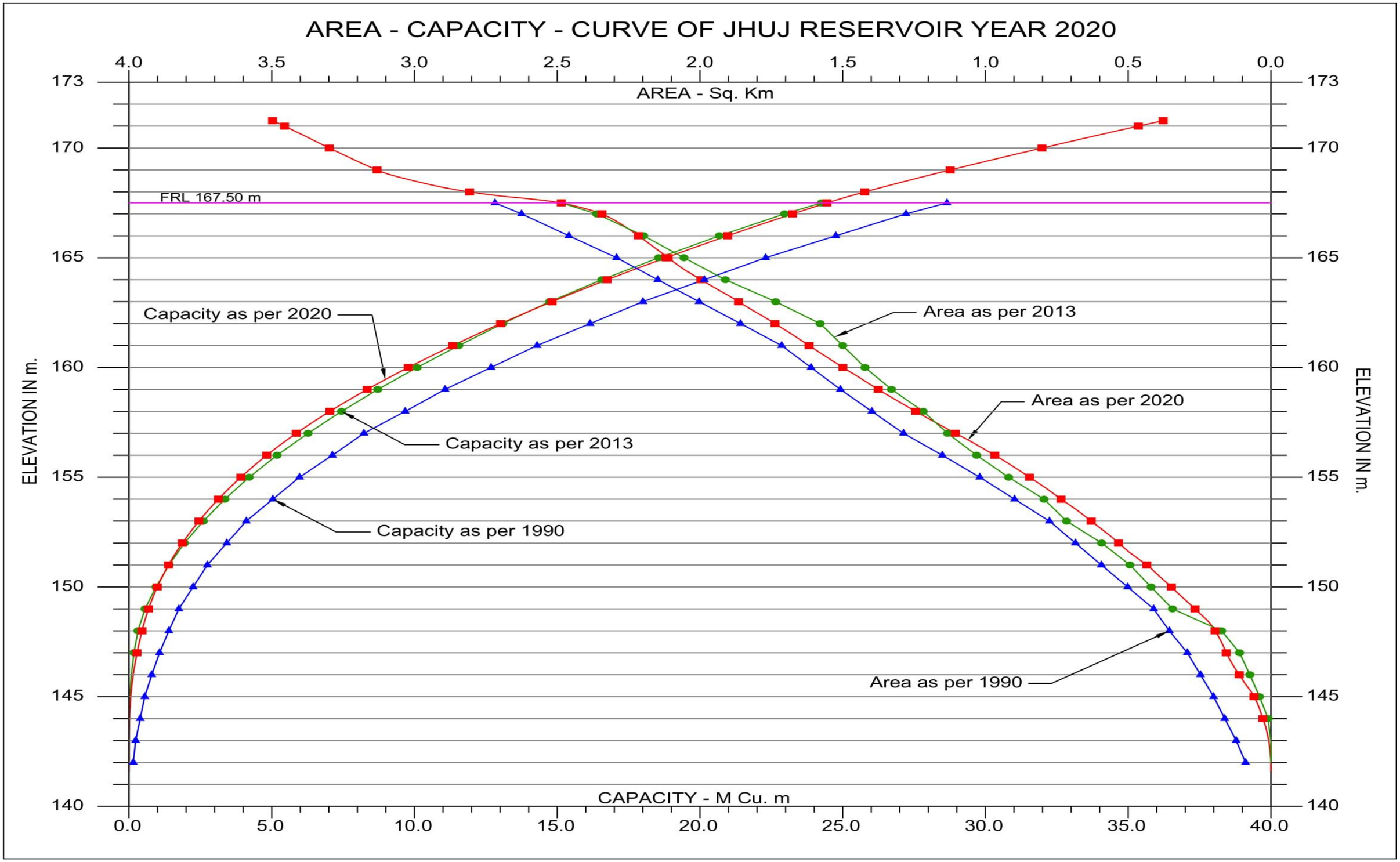


Figure 6.10-1 AREA – CAPACITY - CURVE

6.11 Segment, Contour, Wire Frame Map and L section:

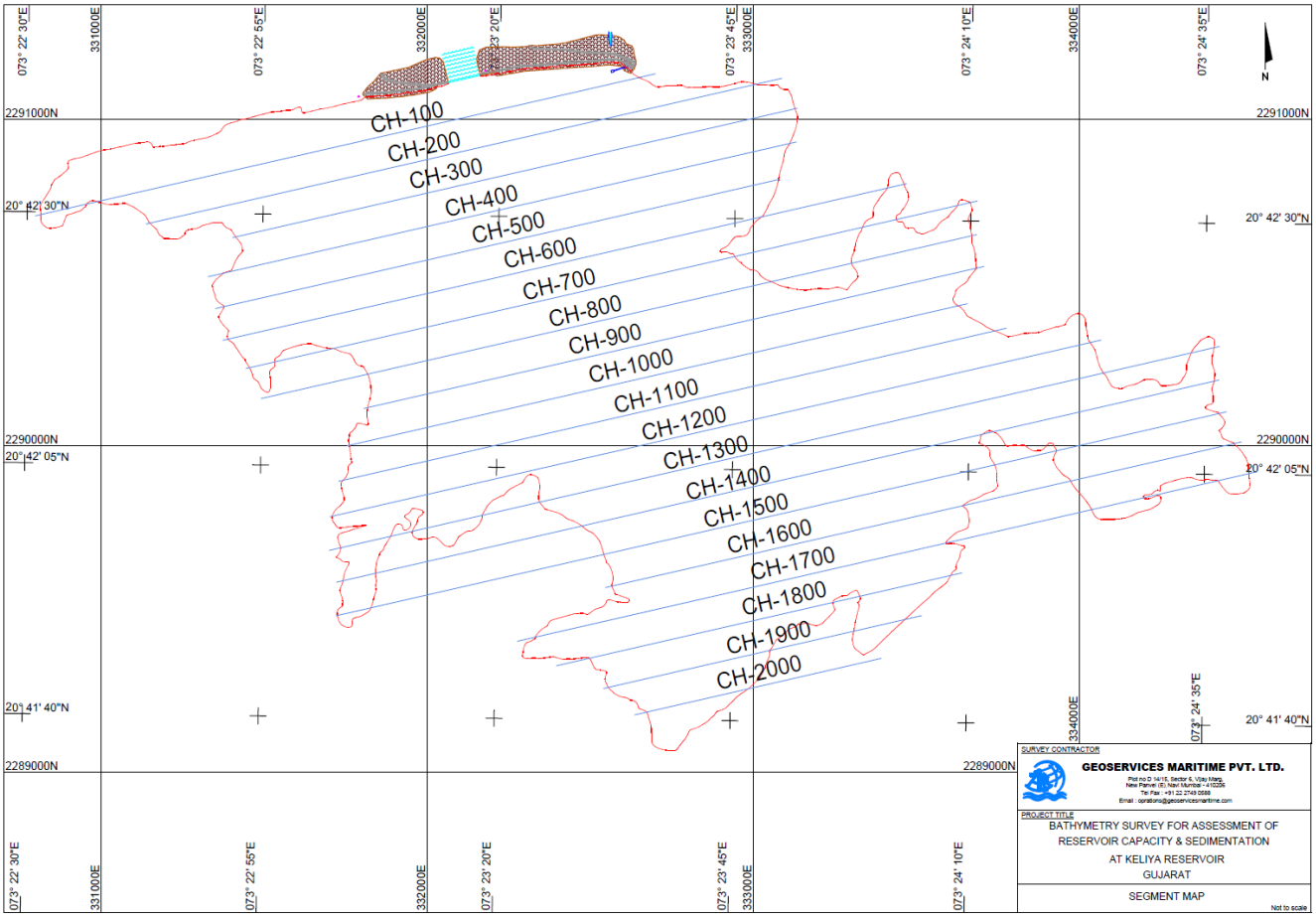


Figure 6.11-1 SEGMENT MAP FOR CROSS SECTION

Cross sections showing bed profile at 100m interval were prepared and are provided as soft copy in CD/Hard Disc. Total 20 cross section profiles were prepared.

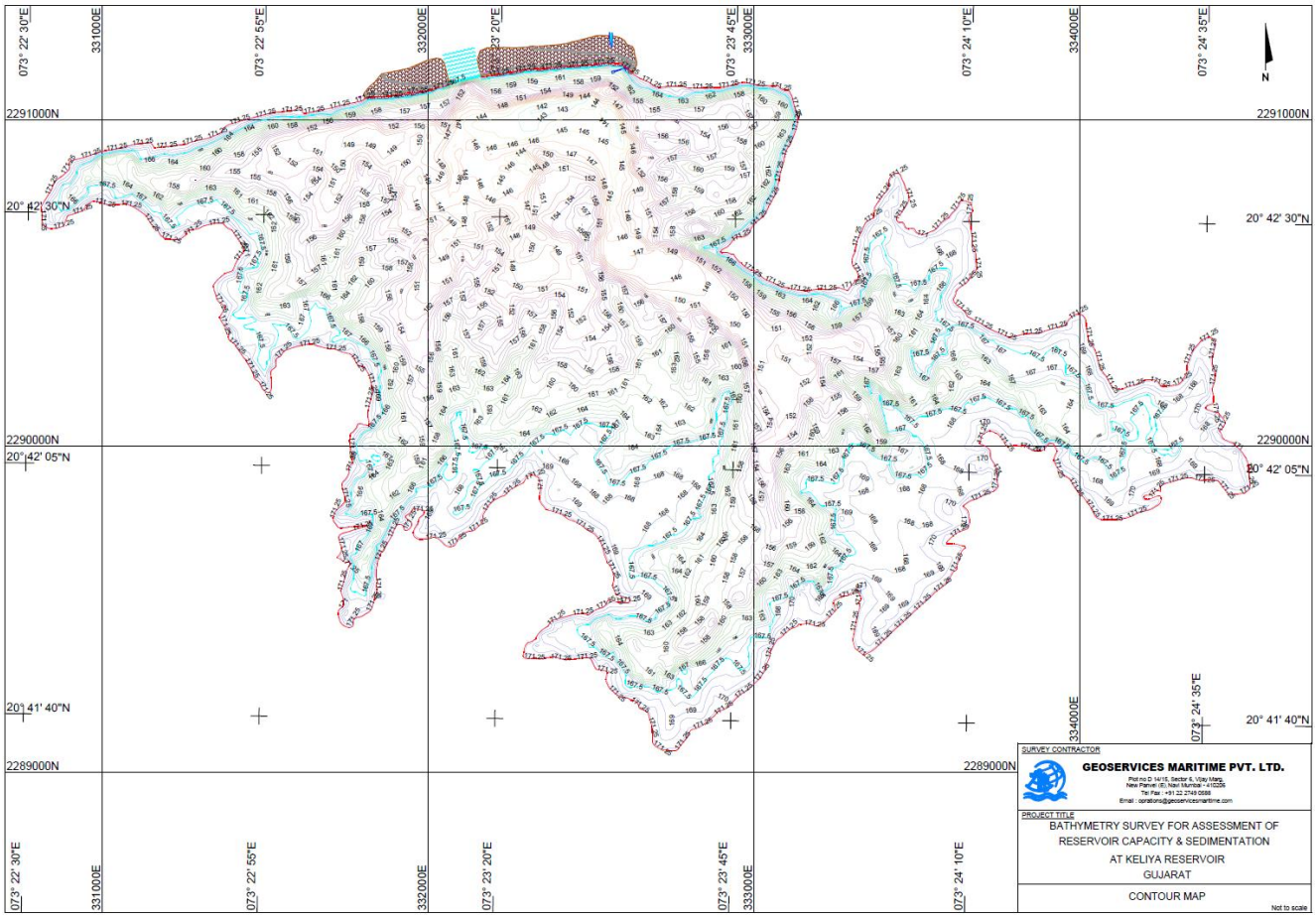


Figure 6.11-2 CONTOUR MAP

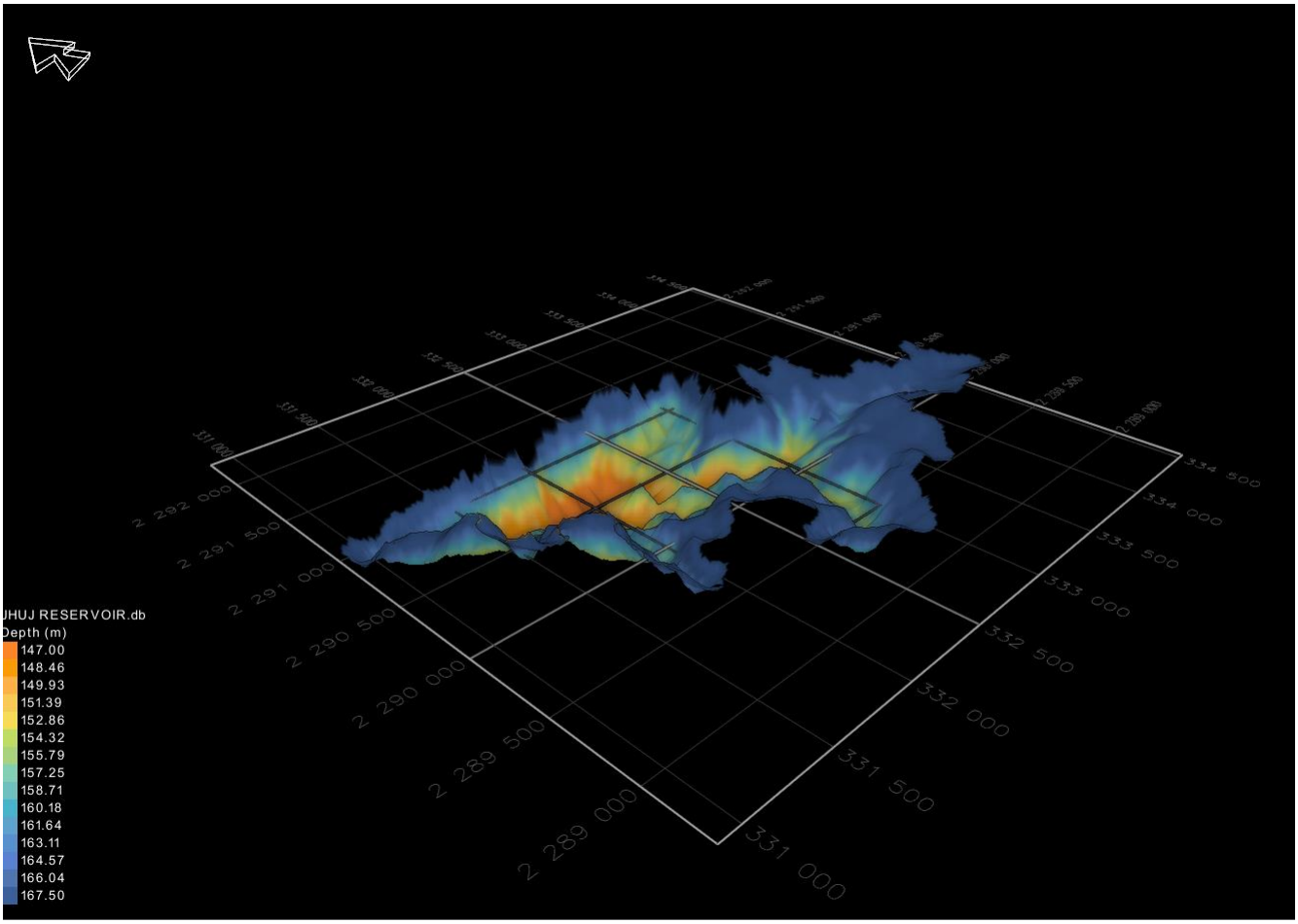


Figure 6.11-3 WIRE FRAME MAP

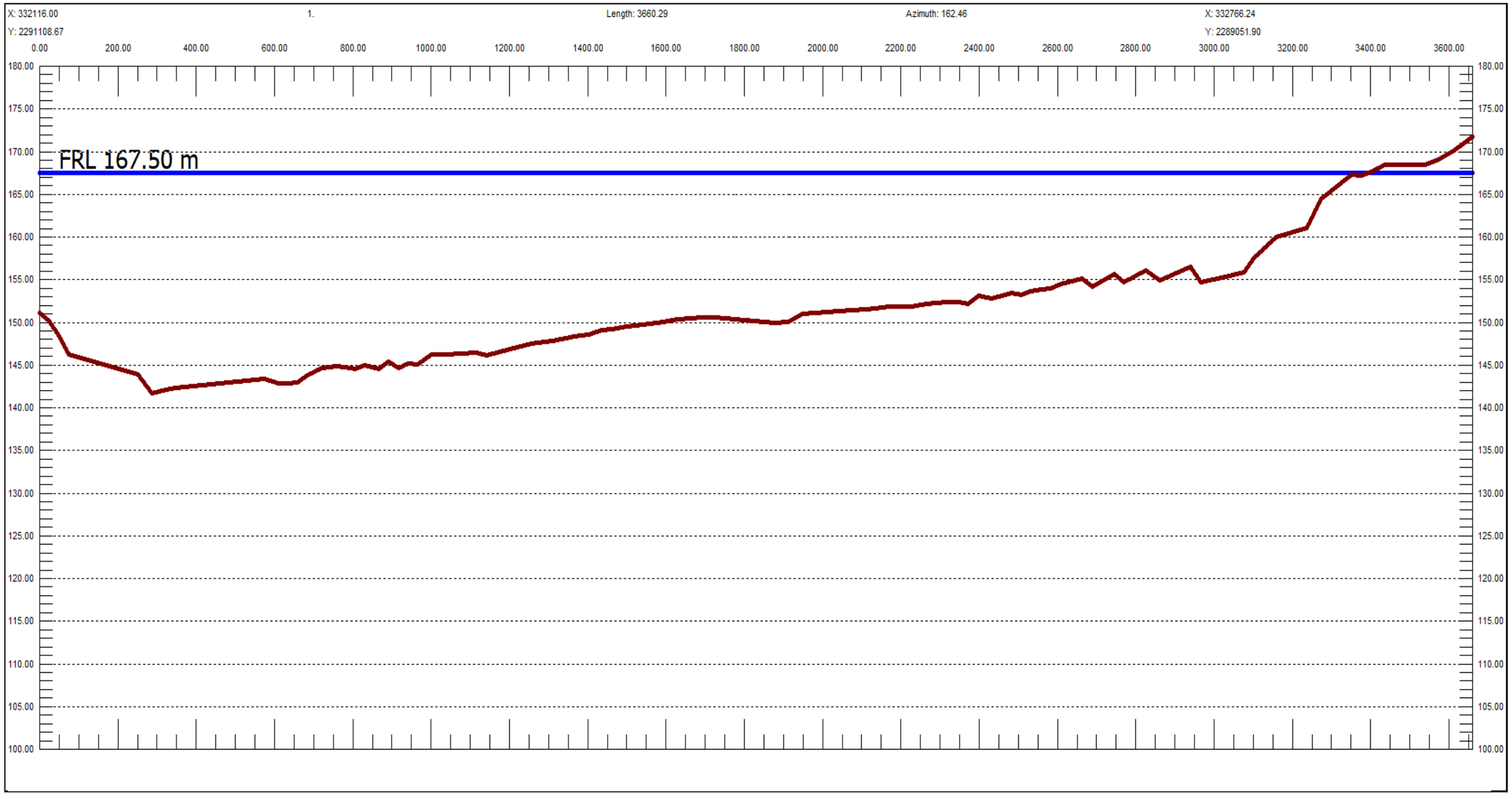


Figure 6.11-4 L section

7 DGPS OBSERVATION REPORT

CSRS-PPP 3.45.0 (2020-07-08)

TBM_295j00.20O
TBM FLY

Data Start	Data End	Duration of Observations
2020-10-21 03:01:00.00	2020-10-21 07:06:00.00	4:05:00
Processing Time		**Product Type**
09:18:31 UTC 2020/10/21		NRCan Ultra-rapid
Observations	**Frequency**	**Mode**
Phase and Code	Double	Static

Elevation Cut-Off	Rejected Epochs	Fixed Ambiguities	Estimation Steps
7.5 degrees	0.00 %	95.37 %	60.00 sec

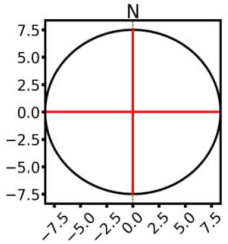
Antenna Model	APC to ARP	ARP to Marker
GMXZENITH35	L1 = 0.125 m L2 = 0.132 m	H:1.600m / E:0.000m / N:0.000m

(APC = antenna phase center; ARP = antenna reference point)

Estimated Position for TBM_295j00.20O

	Latitude (+n)	Longitude (+e)	Ell. Height
NAD83(CSRS) (2020.8)	20° 42' 44.03179"	73° 23' 17.89696"	105.283 m
Sigmas(95%)	0.006 m	0.007 m	0.031 m
A priori*	20° 42' 44.03737"	73° 23' 17.95494"	109.315 m
Estimated – A priori	-0.172 m	-1.678 m	-4.032 m

95% Error Ellipse (mm)
semi-major: 8 mm
semi-minor: 7 mm
semi-major azimuth: 90° 0' 0.0"



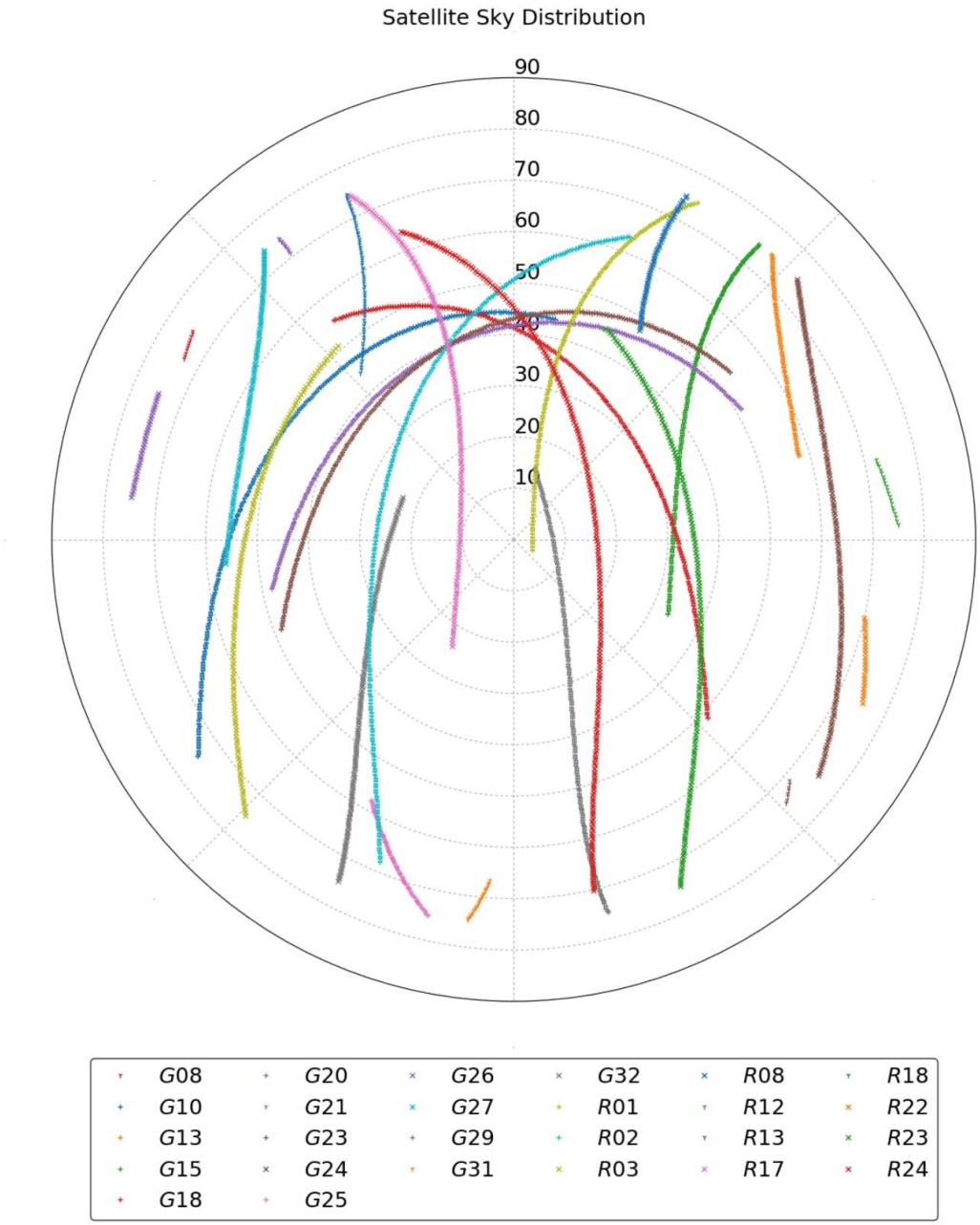
UTM (North)
Zone 43

2291135.026 m (N)
332162.767 m (E)

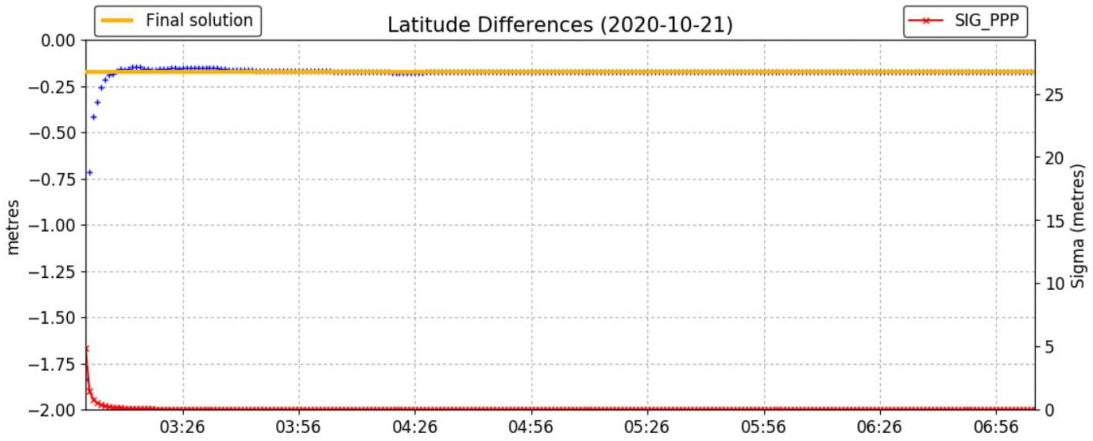
Scale Factors
0.99994813 (point)
0.99993159 (combined)

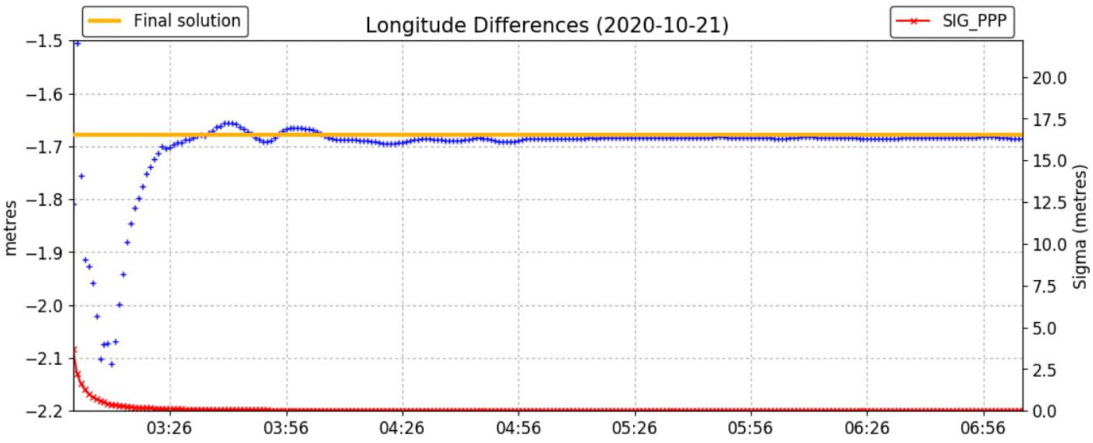
*(Coordinates from RINEX header used as a priori position)

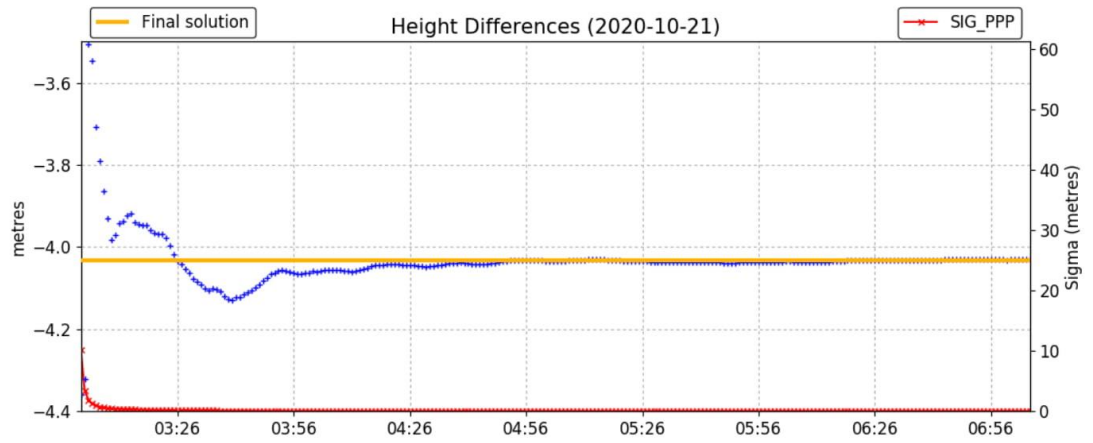
1


Satellite Sky Distribution
90
80
70
60
50
40
30
20
10
G08
G10
G13
G15
G18
G20
G21
G23
G24
G25
G26
G27
G29
G31
G32
R01
R02
R03
R08
R12
R13
R17
R18
R22
R23
R24

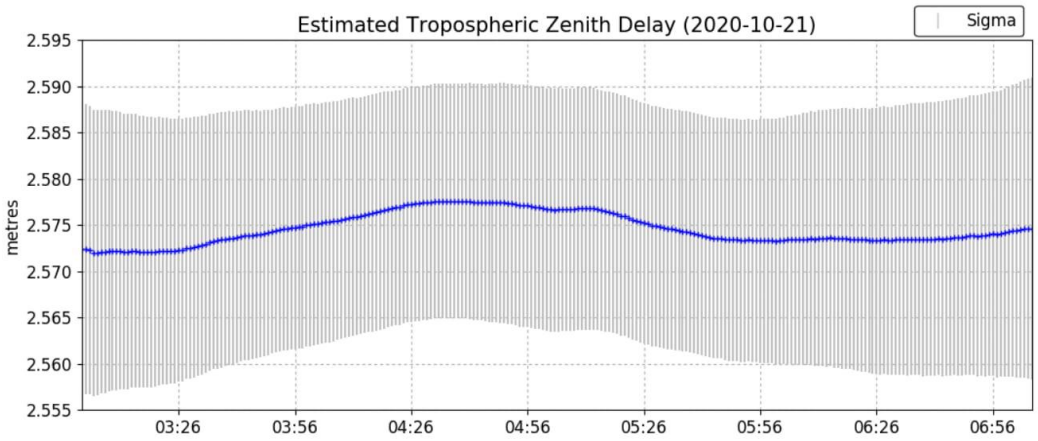
2

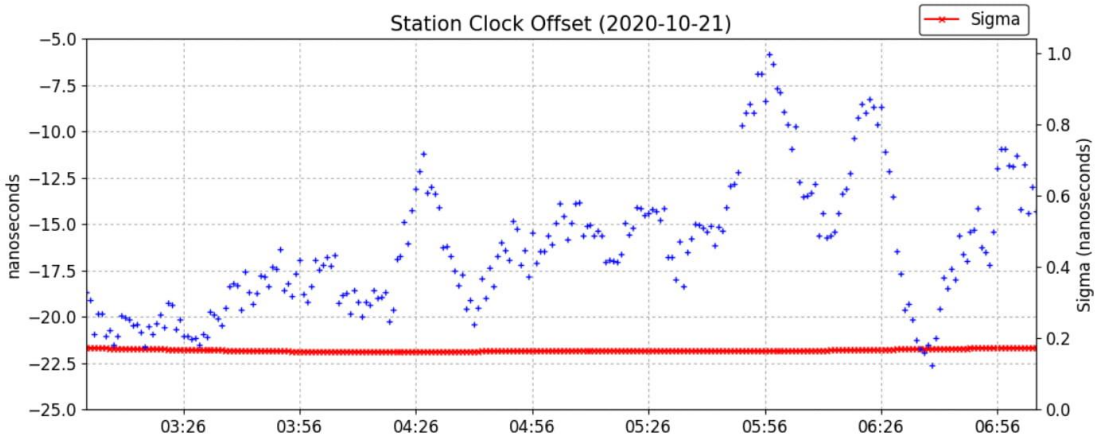

Final solution
Latitude Differences (2020-10-21)
SIG_PPP
metres
Sigma (metres)
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
−1.50
−1.75
−2.00
25
20
15
10
5
0
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56

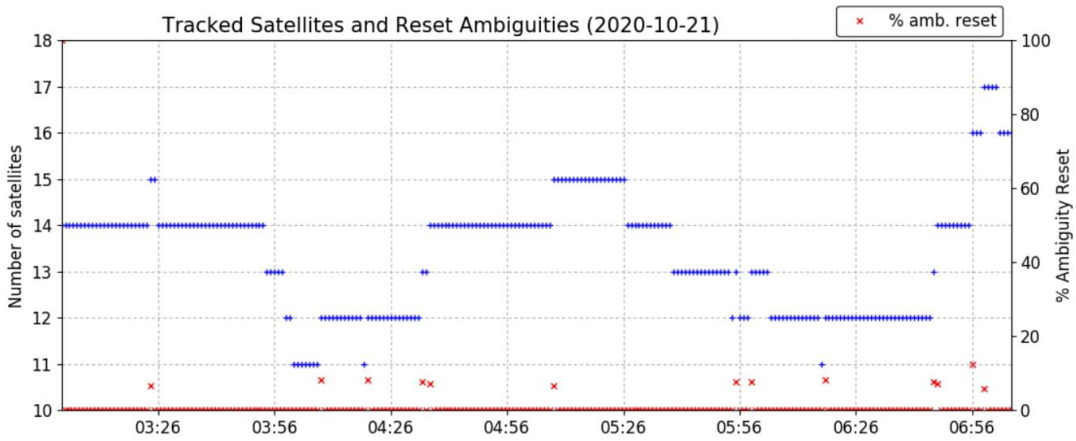

Final solution
Longitude Differences (2020-10-21)
SIG_PPP
metres
Sigma (metres)
−1.5
−1.6
−1.7
−1.8
−1.9
−2.0
−2.1
−2.2
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56


Final solution
Height Differences (2020-10-21)
SIG_PPP
metres
Sigma (metres)
−3.6
−3.8
−4.0
−4.2
−4.4
60
50
40
30
20
10
0
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56

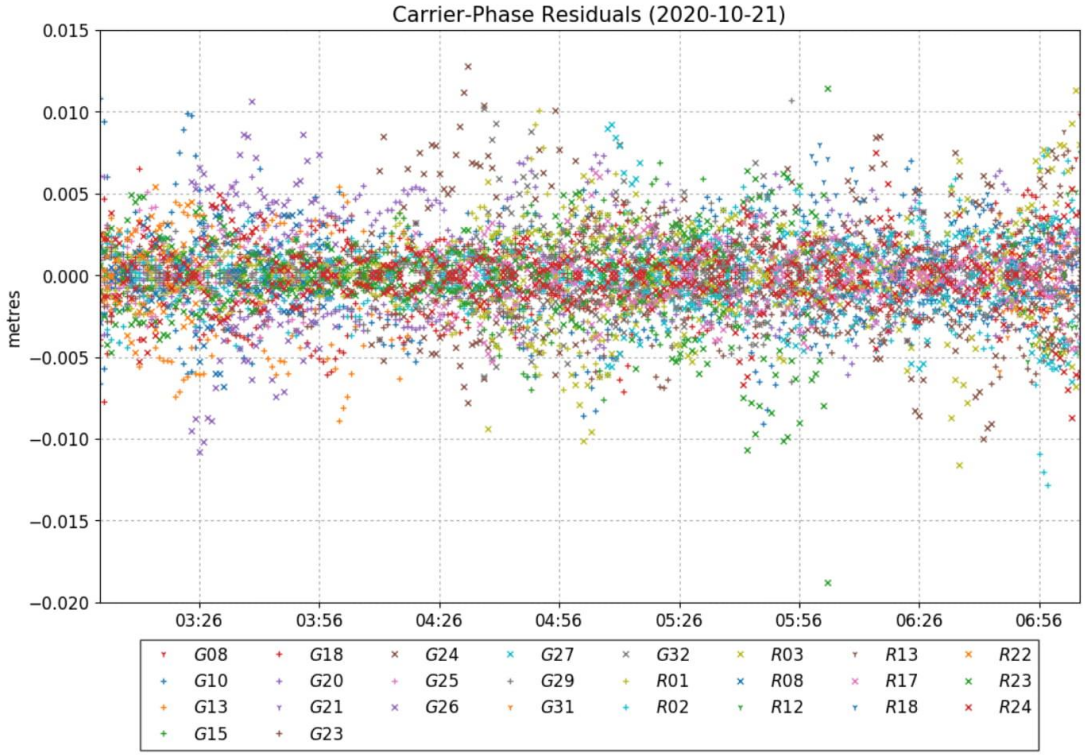
3

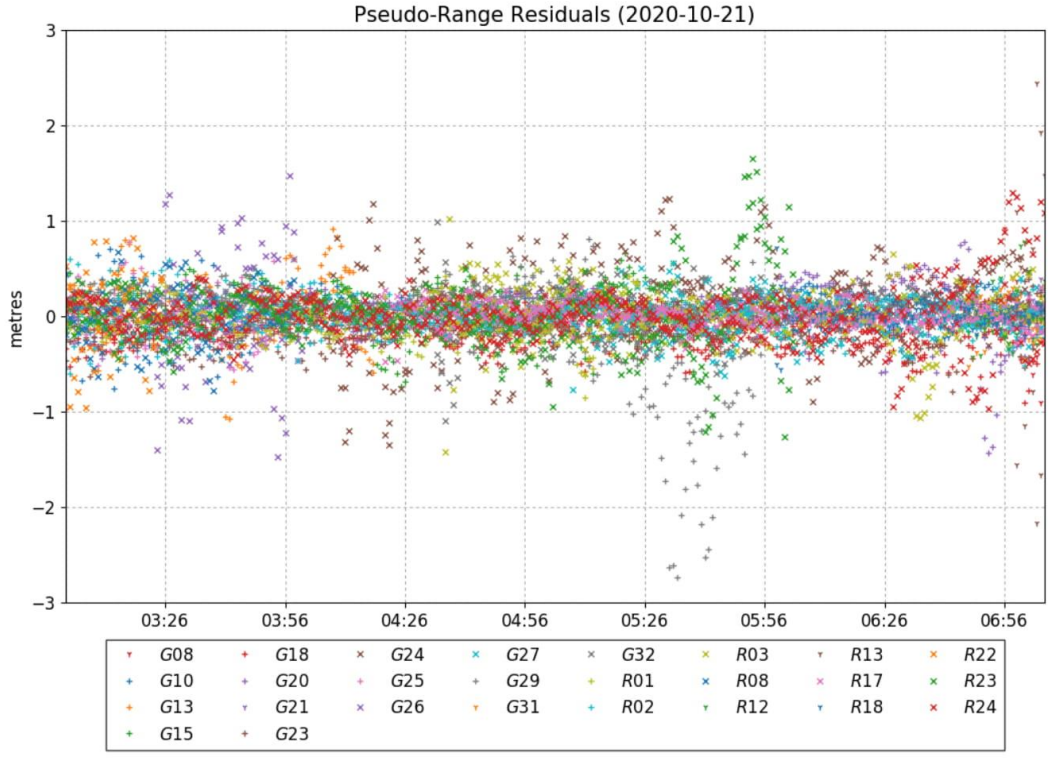

Estimated Tropospheric Zenith Delay (2020-10-21)
Sigma
metres
2.595
2.590
2.585
2.580
2.575
2.570
2.565
2.560
2.555
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56


Station Clock Offset (2020-10-21)
Sigma
nanoseconds
Sigma (nanoseconds)
−5.0
−7.5
−10.0
−12.5
−15.0
−17.5
−20.0
−22.5
−25.0
1.0
0.8
0.6
0.4
0.2
0.0
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56


Tracked Satellites and Reset Ambiguities (2020-10-21)
% amb. reset
Number of satellites
% Ambiguity Reset
18
17
16
15
14
13
12
11
10
100
80
60
40
20
0
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56

4


Carrier-Phase Residuals (2020-10-21)
metres
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56
G08 G18 G24 G27 G32 R03 R13 R22
G10 G20 G25 G29 R01 R08 R17 R23
G13 G21 G26 G31 R02 R12 R18 R24
G15 G23


Pseudo-Range Residuals (2020-10-21)
metres
3
2
1
0
−1
−2
−3
03:26
03:56
04:26
04:56
05:26
05:56
06:26
06:56
G08 G18 G24 G27 G32 R03 R13 R22
G10 G20 G25 G29 R01 R08 R17 R23
G13 G21 G26 G31 R02 R12 R18 R24
G15 G23

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	**Aqua Marina**	**Juj Dam**
Date:	Time:	Client:	
21-Oct-20	**1600hrs**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Reason Navisound 215**	**14**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.6				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.03 m

Observations while lowering			Observations while hoisting		
Bar Depth (m)	ES Reading (m)	Difference (m)	Bar Depth (m)	ES Reading (m)	Difference (m)
2	2.02	-0.02	10	9.98	0.02
4	4.03	-0.03	8	8.02	-0.02
6	6.02	-0.02	6	6.01	-0.01
8	8.01	-0.01	4	4.03	-0.03
10	10.03	-0.03	2	2.01	-0.01

	Average	-0.0220	Average	-0.0100
	Std. Dev	0.0084	Std. Deviation	0.0187
			Cumulative Average	-0.02
			Cumulative Std. Deviation	0.0073

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Aqua Marina**	**Juj Dam**
Date:	Time:	Client:	
22-Oct-20	**0750hrs**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Reason Navisound 215**	**16**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.6				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.03 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	10	10.01	-0.01
4	4.01	-0.01	8	8.02	-0.02
6	6.01	-0.01	6	5.99	0.01
8	7.99	0.01	4	4.01	-0.01
10	10.01	-0.01	2	1.99	0.01

	Average	-0.0040	Average	-0.0040
	Std. Dev	0.0089	Std. Deviation	0.0134
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0032

The Echosounder Barcheck Values are Negligible for Application

GMPL Party Chief

GEOSERVICES MARITIME PVT. LTD.

QUALITY MANUAL AND PROCEDURE

Singlebeam Echosounder Barcheck Correction Table

Project No.	Project Title:	Vessel:	Place:
	Bathymetric Survey	**Aqua Marina**	**Juj Dam**
Date:	Time:	Client:	
23-Oct-20	**0820hrs**		
Observed By:		Echosounder Model and SL. No.	Area Depth
Amit Singh		**Reason Navisound 215**	**15**

Echosounder Settings

Draft HI	Index "k" HI	Draft LO	Index "k" LO	Sound Velocity	
				Average	**Upto Depth**
0.6				**1500**	**10**
Barcheck Frequency selected		**Survey Frequency:**		Manufacturer's Accuracy	
210		**210**		0.20 % of Depth	0.03 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	10	9.98	0.02
4	3.99	0.01	8	8.02	-0.02
6	6.03	-0.03	6	5.99	0.01
8	8.01	-0.01	4	4.01	-0.01
10	9.99	0.01	2	1.99	0.01

	Average	-0.0060	Average	0.0020
	Std. Dev	0.0167	Std. Deviation	0.0164
			Cumulative Average	0.00
			Cumulative Std. Deviation	0.0002

The Echosounder Barcheck Values are Negligible for Application

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GMPL Party Chief

9 PHOTOGRAPHS

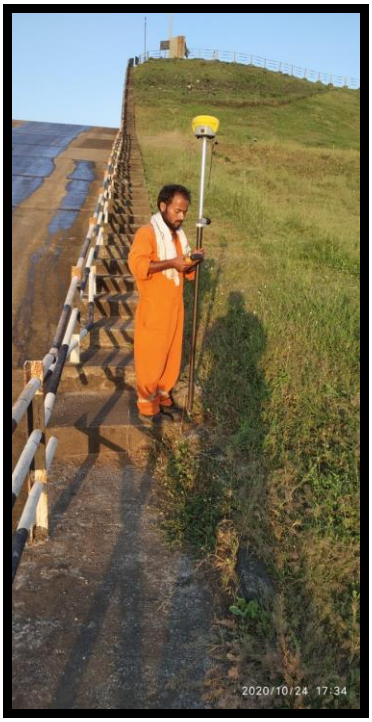
The following Photographs showing the Survey activities and features available at site

Bathy Survey at Jhuj Dam

RTK Base Set up At Dam

Control Cabin

Dam Top



Near Spillway

Farm Area

END OF REPORT