P WMA 12/T30/00/5212/11

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: OPTIONS ANALYSIS

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT

TOPOGRAPHICAL SURVEYS

OCTOBER 2014

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT

APPROVAL

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LIST OF REPORTS

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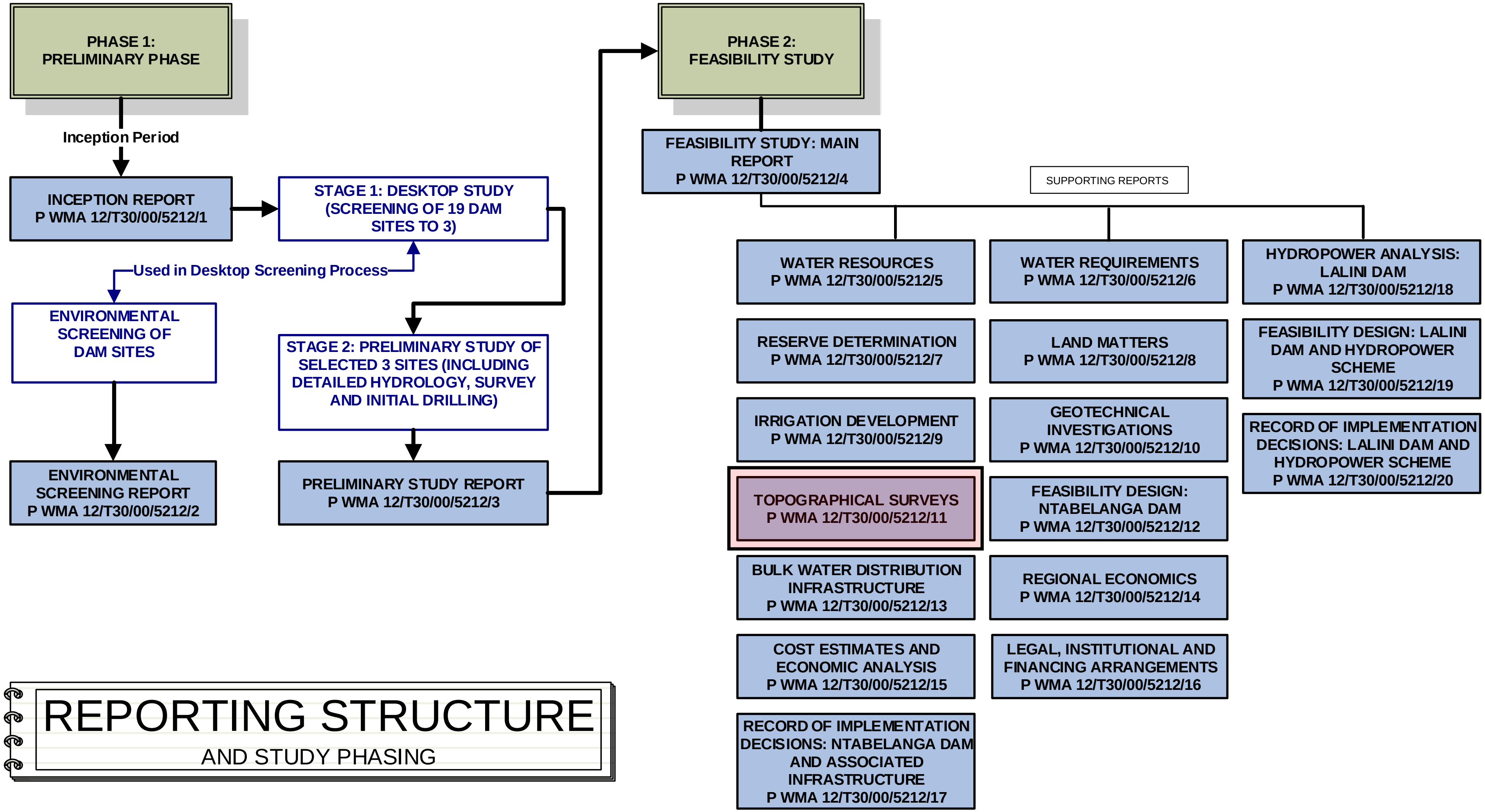

REPORTING STRUCTURE

AND STUDY PHASING

REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa (2014). ***Feasibility Study for the Mzimvubu Water Project: Topographical Surveys***

DWS Report No: P WMA 12/T30/00/5212/11

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Note on Departmental Name Change:

In 2014, the Department of Water Affairs changed its name to the Department of Water and Sanitation, which happened during the course of this study. In some cases this was after some of the study reports had been finalized. The reader should therefore kindly note that references to the Department of Water Affairs and the Department of Water and Sanitation herein should be considered to be one and the same.

Note on Spelling of Laleni:

The settlement named Laleni on maps issued by the Surveyor General is locally known as Lalini and both names therefore refer to the same settlement.

EXECUTIVE SUMMARY

Previous studies relating to the Mzimvubu River Basin have relied upon existing mapping which typically had contour intervals of 20 metres. Newer Google Earth imagery also only offers elevation accuracies of between ±15 and ± 30 metres.

Such accuracy was considered insufficient for Phase 1 of this study, as it was considered important to use more accurate elevation data to generate elevation verses area verses volume information for the three shortlisted dam sites, and the Lalini dam, as well as cross-sections of each of these dams being investigated in Phase 1.

This information was required to produce more accurate yield modelling as well as calculating quantities for the capital cost estimation of each dam.

It was therefore decided to utilize a part of the Provisional Sum allowed for in the Contract to undertake a detailed topographical survey of the dam wall centreline and the inundation footprint of each of the three identified dam sites at Ntabelanga on the Tsitsa river, and at Thabeng and Somabadi, on the Kinira river, as well as Lalini downstream of Ntabelanga during the extended study scope period.

In Phase 1 of the study, further extension of the survey area was required to provide wider areal coverage in the upstream area of inundation, and the downstream area immediately below the dam wall, of the selected best single dam option – the Ntabelanga dam. This provided sufficient information for other works to be planned and designed at a feasibility level of detail.

A Call for Quotations, incorporating a Scope of Work, Conditions of Quotation and Schedule of Quantities was prepared and quotations were invited from established specialist surveying companies for these services, through the DWS's normal procurement process.

The contract to undertake the topographical survey was awarded to Southern Mapping Geospatial (Pty) Ltd (SMG).

This report is based upon the outputs produced by SMG as required under their contract, and summarises the process undertaken and the resulting deliverables.

Contour plans of the Ntabelanga and Lalini Dam basins and dam sites are given in Appendix A

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LIST OF ACRONYMS AND ABBREVIATIONS

ASGISA-EC	Accelerated and Shared Growth Initiative for South Africa – Eastern Cape
CAPEX	Capital Expenditure
CFRD	Concrete-faced rockfill dam
CMA	Catchment Management Agency
CTC	Cost to Company
CV	Coefficient of Variability
DAFF	Department of Agriculture, Forestry and Fisheries
DBSA	Development Bank of Southern Africa
DEA	Department of Environment Affairs
DM	District Municipality
DME	Department of Minerals and Energy
DoE	Department of Energy
DRDAR	Department of Rural Development and Agrarian Reform
DRDLR	Department of Rural Development and Land Reform
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EC	Eastern Cape
ECRD	Earth core rockfill dam
EF	Earthfill (dam)
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPWP	Expanded Public Works Programme
ESIA	Environmental and Social Impact Assessment
EWR	Environmental Water Requirements
FSL	Full Supply Level
GERCC	Grout enriched RCC
GN	Government Notices
GW	Gigawatt
GWh/a	Gigawatt hour per annum
IAPs	Invasive Alien Plants
IB	Irrigation Board
IFC	International Finance Corporation
IPP	Independent Power Producer
IRR	Internal Rate of Return
IVRCC	Internally vibrated RCC
ISO	International Standards Organisation
kW	Kilowatt
LM	Local Municipality
ℓ/s	Litres per second

MAR_{NAT}	Mean Annual Runoff (Naturalised Flows)
MAR_{PD}	Mean Annual Runoff (Present Day Flows)
MEC	Member of the Executive Council
MIG	Municipal Infrastructure Grant
million m^3	Million cubic metres
MW	Megawatt
NEMA	National Environmental Management Act
NERSA	National Energy Regulator of South Africa
NHRA	National Heritage Resources Act
NOCL	Non-overspill crest level
NWA	National Water Act
NWPR	National Water Policy Review
NWRMS	National Water Resources Management Strategy
O&M	Operations and Maintenance
OPEX	Operational Expenditure
PICC	Presidential Infrastructure Co-Ordinating Committee
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PSC	Project Steering Committee
PSP	Professional Services Provider
RBIG	Regional Bulk Infrastructure Grant
RCC	Roller-compacted concrete
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RWI	Regional Water Institution
RWU	Regional Water Utilities
SEZ	Special Economic Zone
SIP	Strategic Integrated Project
SMC	Study Management Committee
SPV	Special Purpose Vehicle
TCTA	Trans Caledon Tunnel Authority
ToR	Terms of Reference
UOS	Use of System
URV	Unit Reference Value
WEF	Water Energy Food
WRYM	Water Resources Yield Model
WSA	Water Services Authority
WSP	Water Services Provider
WTE	Water Trade Entity
WUA	Water User Association

LIST OF UNITS

Description	Standard unit
Elevation	m a.s.l.
Height	m
Distance	m, km
Dimension	mm, m
Area	m^2 , ha or km^2
Volume (storage)	m^3
Yield, Mean Annual Runoff	m^3/a
Rotational speed	rpm
Head of Water	m
Pressure	Pa
Diameter	mm or m
Temperature	**ºC**

Description	Standard unit
Velocity, speed	m/s, km/hr
Discharge	m^3/s
Mass	kg, tonne
Force, weight	N
Gradient (V:H)	%
Slope (H:V) or (V:H)	1:5 (H:V) or 5:1 (V:H)
Volt	V
Power	W
Energy used	kWh
Acceleration	m/s^2
Density	kg/m^3
Frequency	**Hz**

GLOSSARY OF TECHNICAL TERMS

LiDAR	**Li**ght **D**etection **A**nd **R**anging or **L**aser **i**maging **D**etection **A**nd **R**anging) is an optical remote sensing technology that can measure the distance to, or other properties of, targets by illuminating the target with laser light and analyzing the back-scattered light.
ITRF08	This is a geo-refencing datum system. WGS84 and ITRF/IGS are within mm of each other and remain essentially equivalent even for higher accuracy projects.
Hart94	The Hartebeesthoek94 co-ordinate system became the official system in South Africa on 1 January 1999 and superseded the previous Cape Datum system of co-ordinates. The new system is based on the ITRF91 (epoch 1994.0) co-ordinates for the Hartebeesthoek Radio Astronomy Observatory (HartRAO) and uses the WGS84 reference system.
Lo29	A grid referencing system within WGS84 Bounds: 28.0000, -33.0000, 30.0000, -22.1000
SAG2010 Geoid model	The geoid is the equipotential surface of the Earth's gravity field approximating mean sea level in an optimum way, and extended under the continents. This is used to form a standard basis on which to base survey data. SAG2010 is the particular model used in this survey.
GeoTiFF	Geo-referenced tiff images
ECW files	**ECW** (Enhanced Compression Wavelet) is a proprietary wavelet compression image format optimized for aerial and satellite imagery.

1. INTRODUCTION

Previous studies relating to the Mzimvubu River Basin have relied upon existing mapping which typically had contour intervals of 20 metres. Newer Google Earth imagery also only offers elevation accuracies of between ±15 and ± 30 metres.

Such accuracy was considered insufficient for Phase 1 of this study, as it was considered important to use more accurate elevation data to generate elevation vs area vs volume information for the three shortlisted dam sites, as well as cross-sections of each of these three dams being investigated in Phase 1. This information was required to produce more accurate yield modelling as well as calculating quantities for the capital cost estimation of each dam.

It was therefore decided to utilize a part of the Provisional Sum allowed for in the Contract to undertake a detailed topographical survey of the dam wall centreline and the inundation footprint of each of the three identified dam sites at Ntabelanga on the Tsitsa River, and at Thabeng and Somabadi on the Kinira River and as Phase 2 of the study, further detailed topographical survey was required for the Lalini Dam site.

In Phase 1 of the study, further extension of the survey area was required to provide wider areal coverage in the upstream area of inundation, and the downstream area immediately below the dam wall, of the selected best single dam option – the Ntabelanga dam. This provided sufficient information for other works to be planned and designed at a feasibility level of detail.

A Call for Quotations, incorporating a Scope of Work, Conditions of Quotation and Schedule of Quantities was prepared and quotations were invited from established specialist surveying companies for these services, through the DWS's normal procurement process.

Towards the conclusion of Phase 2 of the study, it was decided that more detailed investigations of the Lalini Dam and hydropower scheme should be undertaken, and these included a detailed topographical survey of these additional areas, which was undertaken in May and June 2014.

This survey covered the dam wall and inundation areas that required high accuracy survey information, and could be undertaken within the budgets allocated. For other areas such as the bulk water distribution system and high potential irrigation areas, the 5 m contour information available from the Surveyor General was deemed to be adequate for feasibility design purposes.

The contract to undertake all of the topographical surveys was awarded to Southern Mapping Geospatial (Pty) Ltd (SMG)

This report is based upon the outputs produced by SMG as required under their contract, and summarises the process undertaken and the resulting deliverables.

1.1 Survey Locations

Figure 1-1 shows the project location for the surveys undertaken. Figure 1-2 shows the location of the survey undertaken for the Somabadi and Thabeng Dams, and Figure 1-3 shows the location of the survey undertaken for the Ntabelanga Dam and the Lalini Dam and hydropower scheme.

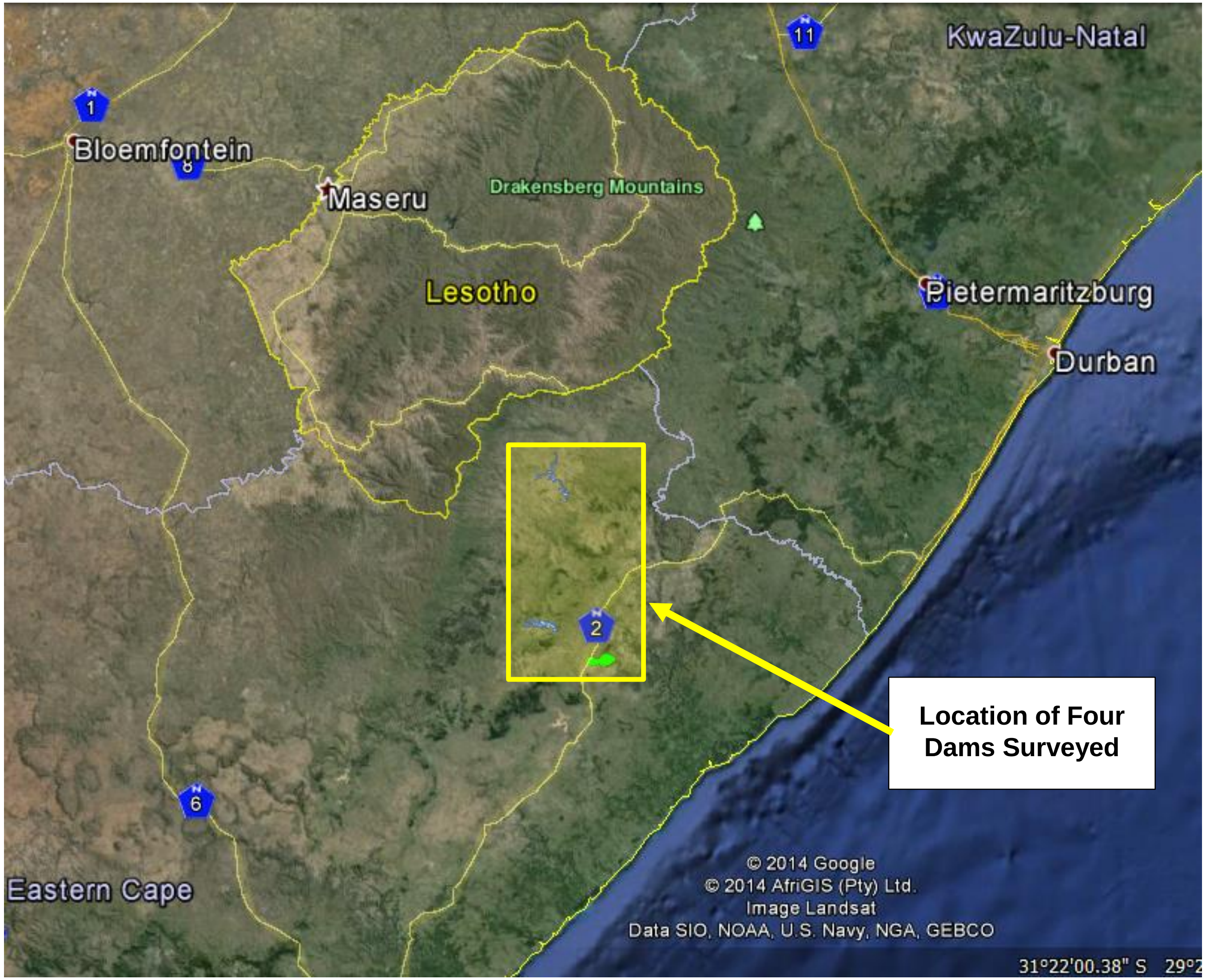


Figure 1-1: Project Locality Plan

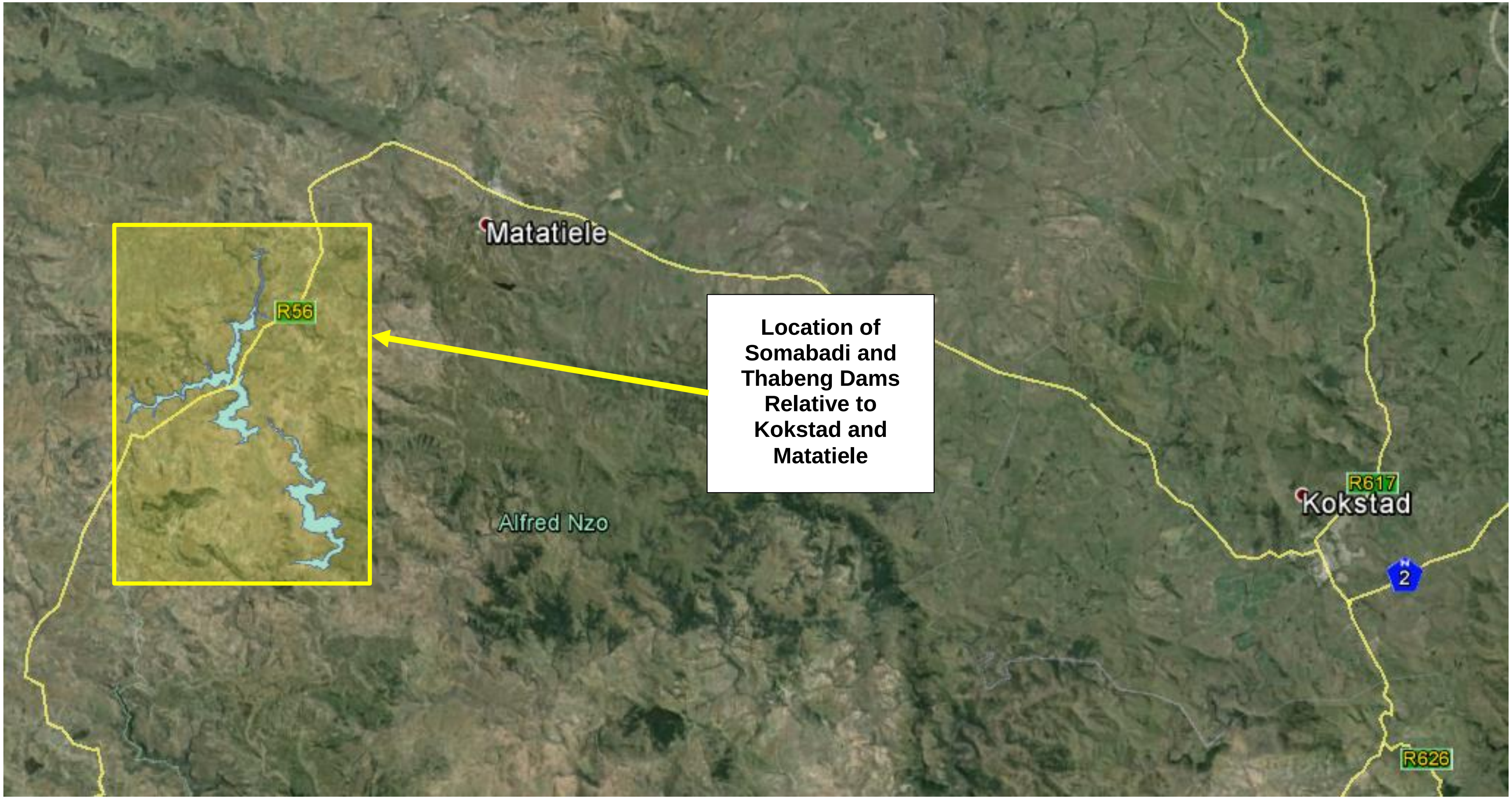


Figure 1-2: Somabadi and Thabeng Dams Locality Plan

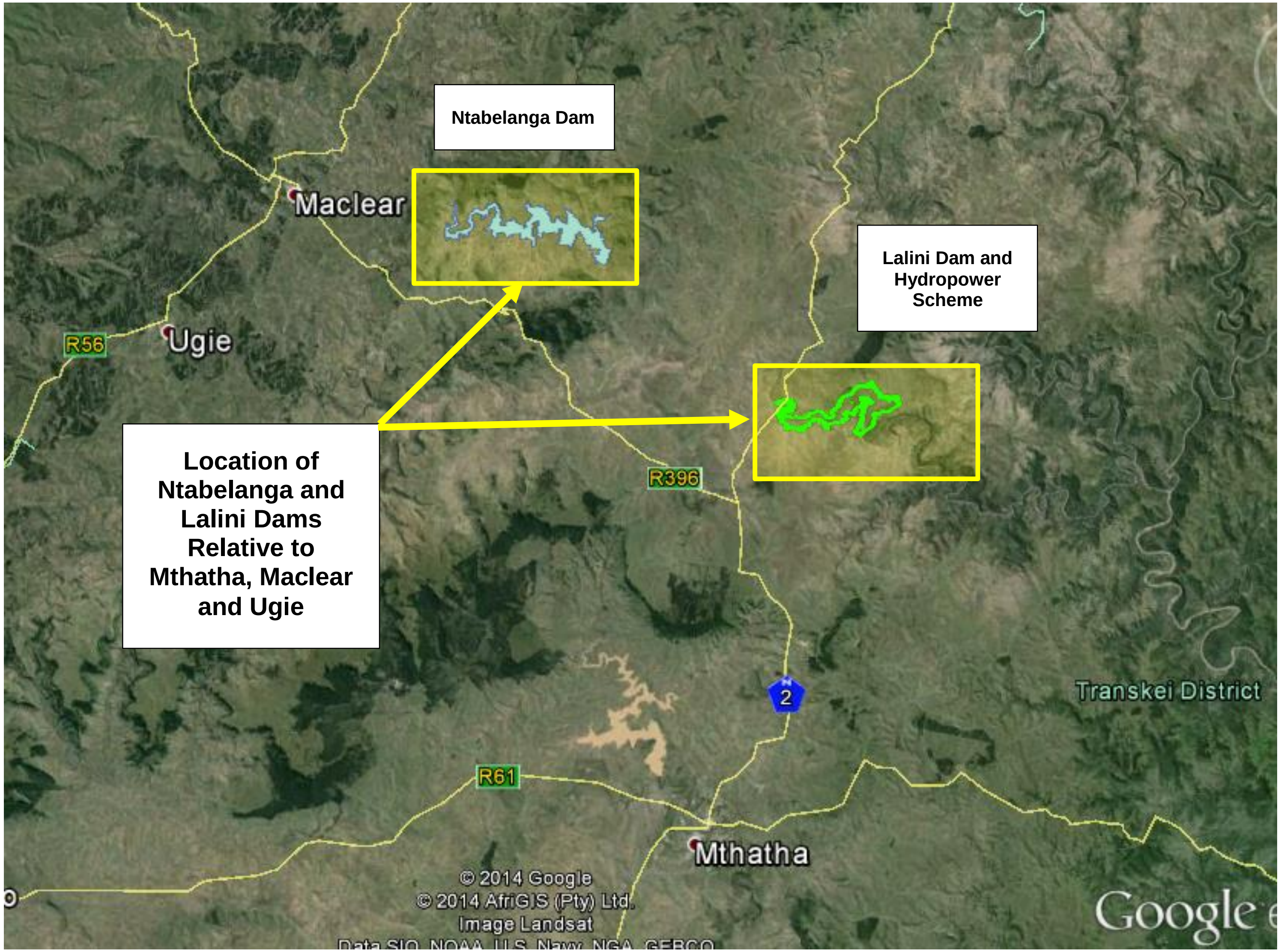


Figure 1-3: Ntabelanga and Lalini Dam and Hydropower Scheme Locality Plan

1.2 Survey Overview

The topographical surveys were undertaken by Southern Mapping Geospatial to produce a digital terrain model (DTM) of the project area. Rectified digital colour images were also taken from the aircraft and to produce colour orthophotos of the project area.

The surveys were carried out using an aircraft mounted LiDAR[1] system that scanned the ground below with a 70 kHz laser beam frequency rate resulting in a dense DTM of the ground surface and objects above the ground.

The survey was flown at a height of some 1200 m and an image pixel size of 15 cm was obtained.

For the Lalini dam phase of the project, the topographical survey was carried out using an aircraft mounted LiDAR system that scanned the ground below with a 125 kHz laser frequency rate and at a height of approximately 700 m and ortho-images with a 10 cm pixel resolution was produced.

1.3 Equipment Used

The equipment used to undertake the survey was as follows:

Table 1-1: Equipment Used to Undertake Surveys

Equipment	Somabadi, Thabeng & Ntabelanga	Lalini Dam and Hydropower Scheme
Aircraft	P68 Partenavia Observer	Cessna 206B
LiDAR Scanner	Optech Orion M200 ALTM	Leica ALS50-2
Camera	Rollei AIC with a 60 mega-pixel P65+ Phase One digital CCD	Phase One Industrial IXA180 Digital aerial camera

1.4 Survey Extent

Under Phase 1, the surveyed area extent covered three dam areas of:

- 1 410 ha for Thabeng dam,
- 1 250 ha for Somabadi dam and
- 2 910 ha for Ntabelanga dam.

Under the additional detailed investigations, the survey extent covered the Lalini dam and hydropower scheme area of:

- 7 100 ha for Lalini dam

1.5 Check Points

For this survey beacons were placed and the coordinates were calculated by SMG, and the results were ae as shown in Table 1-2.

[1] ***LiDAR** (**Li**ght **D**etection **A**nd **R**anging or **L**aser **i**maging **D**etection **A**nd **R**anging) is an optical remote sensing technology that can measure the distance to, or other properties of, targets by illuminating the target with laser light and analyzing the back-scattered light.*

Table 1-2: Ground Control Check Points for Ntabelanga, Somabadi and Thabeng Surveys

Name	Latitude	Longitude	Ellipsoidal Height	Orthometric Height
Ntabe 1	-31 0627.32	28 3427.55	962.55	929.80
Ntabe 2	-31 0618.96	28 3820.05	960.67	928.13
Soma 1	-30 3320.39	28 4039.24	1 337.20	1 303.41
Soma 2	-30 3226.67	28 4010.37	1 360.25	1 326.43
Thabeng 1	-30 2858.09	28 3724.95	1 396.24	1 362.30
Thabeng 2	-30 2802.02	28 3604.68	1 392.91	1 358.90

Coordinate System: ITRF08 – Geographic - Hart94: WGS84 Lo29

Name	Easting	Northing	Ellipsoidal Height	Orthometric Height
Ntabe 1	-40 609.08	-3 442 981.24	962.55	929.80
Ntabe 2	-34 448.67	-3 442 701.86	960.67	928.13
Soma 1	-30 935.75	-3 381 757.50	1 337.20	1 303.41
Soma 2	-31 710.09	-3 380 105.41	1 360.25	1 326.43
Thabeng 1	-36 140.76	-3 373 695.80	1 396.24	1 362.30
Thabeng 2	-38 288.04	-3 371 976.67	1 392.91	1 358.90

For the additional Lalini dam and hydropower survey, five ground control points were placed and surveyed, and the coordinates were used as vertical and horizontal check points on aerial LiDAR survey. The coordinates are as shown in Table 1-3.

Table 1-3: Ground Control Check Points for Lalini Dam and Hydropower Scheme Survey

Name	Easting	Northing	Orthometric Height
SGP14-11-1	-4 406.24	-3 462 191.49	763.21
SGP14-11-2	-3 510.76	-3 459 680.42	810.56
SGP14-11-3	-3 923.16	-3 457 125.20	774.53
SGP14-11-4	-9 083.76	-3 458 222.88	768.38
SGP14-11-5	-14 973.49	-3 457 821.05	804.27

Coordinate system: Hartebeesthoek94: WGS84 Lo29

1.6 LiDAR Point Processing, Calibration, Editing and Transformations

1.6.1 LiDAR Point Processing

The trajectory for each flight was post processed using Waypoint DGPS software, which combines the 1 Hz GPS readings with the 200 Hz inertial measurement system (IMU) readings and outputs a smoothed “best estimated” trajectory for the laser scanner and camera positions.

For the purpose of processing the laser points, the ITRF08 Geographical ellipsoidal coordinates were used. This is necessary as GPS works in the ITRF08 datum with ellipsoidal heights. The trajectory was calculated using Precise Point Positioning (PPP) as no base stations were occupied for the duration of the aerial survey.

The trajectory for each flight was post processed using Waypoint DGPS software, which combines the 1 Hz GPS readings with the 200 Hz inertial measurement system (IMU) readings and outputs a smoothed "best estimated" trajectory for the laser scanner and camera positions.

After this, the laser points were processed into raw ENH points, using Optech's DASHMap Survey Suite. The output was in the ITRF08 Gauss Conform WGS84 Lo29 South projection but with ellipsoidal heights.

The final output is in the required Hartebeesthoek94, with orthometric heights based on the SAG2010 geoidal model.

1.6.2 LiDAR Calibration

Overlapping LiDAR points from adjacent aircraft trajectories were used to check the LiDAR calibration for heading, roll, pitch and scale. These values were then used to make small flight-specific adjustments to the LiDAR data.

1.6.3 LiDAR Point Editing

A "1st run" automatic classification was carried out on the raw LiDAR points using *TerraSolid's TerraScan* software to separate the LiDAR points into ground hits and non-ground hits. This results in a greater than 90% correct classification. After this, a manual classification was done over the required area to edit the points with gross classification errors that may have occurred in the automatic classification process.

As requested by the study team, the ground points were also thinned into "key-points". Key-points are a data set with the redundant points removed and containing only the points needed to define the ground surface without losing the accuracy of the surface. This is done to make the data set more manageable.

1.6.4 LiDAR Point Transformations

The LiDAR points were initially calculated based on the ITRF08 datum with ellipsoidal heights. The LiDAR points were transformed from the ITRF08 coordinate system to the Hartebeesthoek94 WG29 coordinate system by using three nearby published trignometrical network (Trignet) stations – namely Aliwal North, Ixopo and Queenstown for Phase 1 and Ixopo, Scottburgh, and Queenstown for the additional Lalini survey.

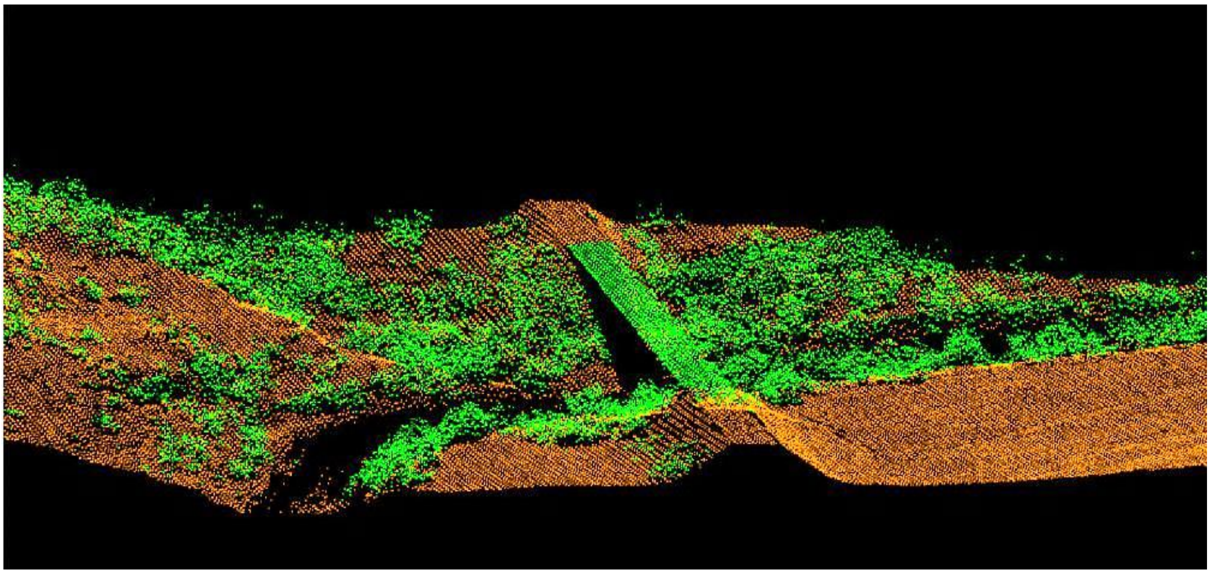


Figure 1-4: Laser points classification – Orange: Ground model, Green: Non-ground features

Table 1-4 shows Trignet stations used to transform Hartebeesthoek 94 Lo29 to co-ordinate system during Phase 1.

Table 1-4: Trignet Stations Used to co-ordinate system during Phase 1

ITRF 2008 Lo29		
Name	**Y**	**X**
ANTH	27 211.47	3 395 509.81
IXOP	89 715.56	3 336 670.60
QTWN	7 409.81	3 531 664.75
Hartebeesthoek 94 Lo29		
Name	**Y**	**X**
ANTH	27 211.59	3 395 510.27
IXOP	89 715.84	3 336 671.05
QTWN	7 409.95	3 531 665.27
Average Shifts	**0.18**	**0.48**

***Please note**: Signs in Table 1-4 will change in CAD*

Table 1-5: Trignet Stations Used to co-ordinate systems

TriNet Station	Easting	Northing	Height
Ixopo	-0.28	-0.45	0.05
Queenstown	-0.32	-0.47	-0.31
Scottsburgh	-0.14	0.52	-0.09
Average Shift	**-0.25**	**-0.52**	**-0.11**

Table 1-5 shows Trignet stations used to transform to Hartebeesthoek 94 WG29 co-ordinate system during the additional Lalini survey and average shifts.

The Hartebeesthoek94 WG29 ellipsoidal heights were then converted to orthometric heights using the SAG2010 Geoid model in *TerraScan* software.

1.7 Orthophoto Rectification Procedure

Images were rectified by identifying common pixel points in overlapping image tiles using a process known as "tie-pointing". See Figure 1-5 and Figure 1-6 below.

After completion of the "tie-point" process all images were adjusted for optimum heading, roll, pitch and scale values so as to ensure a seamless image mosaic was obtained.

Figure 1-5: Examples of 15 cm Pixel Resolution Images

Figure 1-6: Example of 10 cm Pixel Resolution Images as were produced for Lalini Dam

1.8 Check Points and Accuracies

1.8.1 Vertical accuracy

The mapping specialist used the acquired and calculated control points to calculate the vertical accuracy of the laser points. The following table shows the comparison between the ground check points, fixed by GPS, and the orthometric heights from the ground digital terrain model for the Hart94 Lo29 projection, with the SAG2010 geoid applied.

Table 1-6: Final Output Control Report to Establish a Vertical Accuracy for the LiDAR points

a) Thabeng dam and Somabadi dam

Name	Easting	Northing	Known Z	LIDAR Z	Dz
Ntabe 1	-40 609.08	-3 442 981.24	929.80	outlier	
Ntabe 2	-34 448.67	-3 442 701.86	928.13	outlier	
Soma 1	-30 935.75	-3 381 757.50	1 303.41	1 303.36	-0.05
Soma 2	-31 710.09	-3 380 105.41	1 326.43	1 326.39	-0.04
Thabeng 1	-36 140.76	-3 373 695.80	1 362.30	1 362.32	+0.02
Thabeng 2	-38 288.04	-3 371 976.67	1 358.90	1 358.96	+0.06

Average Dz	-0.002
Minimum Dz	-0.050
Maximum Dz	+0.060
Average Magnitude	0.042
Root Mean Square	0.045
Std Deviation	0.052

Please note that the easting and northing signs have been swapped for CAD purposes.

b) Ntabelanga dam

Name	Easting	Northing	Known Z	LIDAR Z	Dz
Ntabe 1	-40 609.08	-3 442 981.24	929.80	929.77	-0.03
Ntabe 2	-34 448.67	-3 442 701.86	928.13	928.16	+0.03

Average Dz	+0.000
Minimum Dz	-0.030
Maximum Dz	+0.030
Average Magnitude	0.030
Root Mean Square	0.030
Std Deviation	0.042

c) Lalini Dam

Name	Easting	Northing	Known Z (Ground Elevation)	LIDAR Z	Dz
SGP14-11-1	-4 406.24	-3 462 191.49	763.21	763.13	-0.069
SGP14-11-2	-3 510.76	-3 459 680.42	810.56	outlier	
SGP14-11-3	-3 923.16	-3 457 125.20	774.53	774.47	-0.009
SGP14-11-4	-9 083.76	-3 458 222.88	768.38	768.34	+0.008
SGP14-11-5	-14 973.49	-3 457 821.05	804.27	804.26	0.054

Average Dz	+0.063
Minimum Dz	+0.030
Maximum Dz	+0.100
Average Magnitude	0.063
Root Mean Square	0.068
Std Deviation	0.030

***Note**: Some points have been removed they are deemed to be outliers*

1.8.2 Horizontal Accuracy

The centre point of each of the pre-marked control points were digitised on the rectified orthophotos and the derived coordinate values were compared with the known ground survey values:

Table 1-7: Comparison of Rectified and Known Horizontal Positions

Name	Rectified Positions		Known Positions		Difference	
	Easting	Northing	Easting	Northing	Shift X (m)	Shift Y (m)
Ntabe 1	-38 288.08	-3 371 976.04	-38 288.04	-3 371 976.67	0.04	0.05
Ntabe 2	-36 140.71	-3 373 695.91	-36 140.76	-3 373 695.80	0.05	0.11
Soma 1	-31 710.28	-3 380 105.27	-31 710.09	-3 380 105.41	0.19	0.14
Soma 2	-30 935.81	-3 381 757.52	-30 935.75	-3 381 757.50	0.06	0.02
Thabeng 1	-40 609.11	-3 442 981.24	-40 609.08	-3 442 981.24	0.03	0.00
Thabeng 2	-34 448.78	-3 442 701.97	-34 448.67	-3 442 701.86	0.11	0.11
Avg. shift from known point:					0.08	0.07

1.9 Project Block Index

The following figures show the project block index for the imagery and data delivered under this assignment.

These files can be found in the electronic data supplied separately to DWS, and each block's file name is referenced as shown on the legends in Figures 1-7 to 1-10.

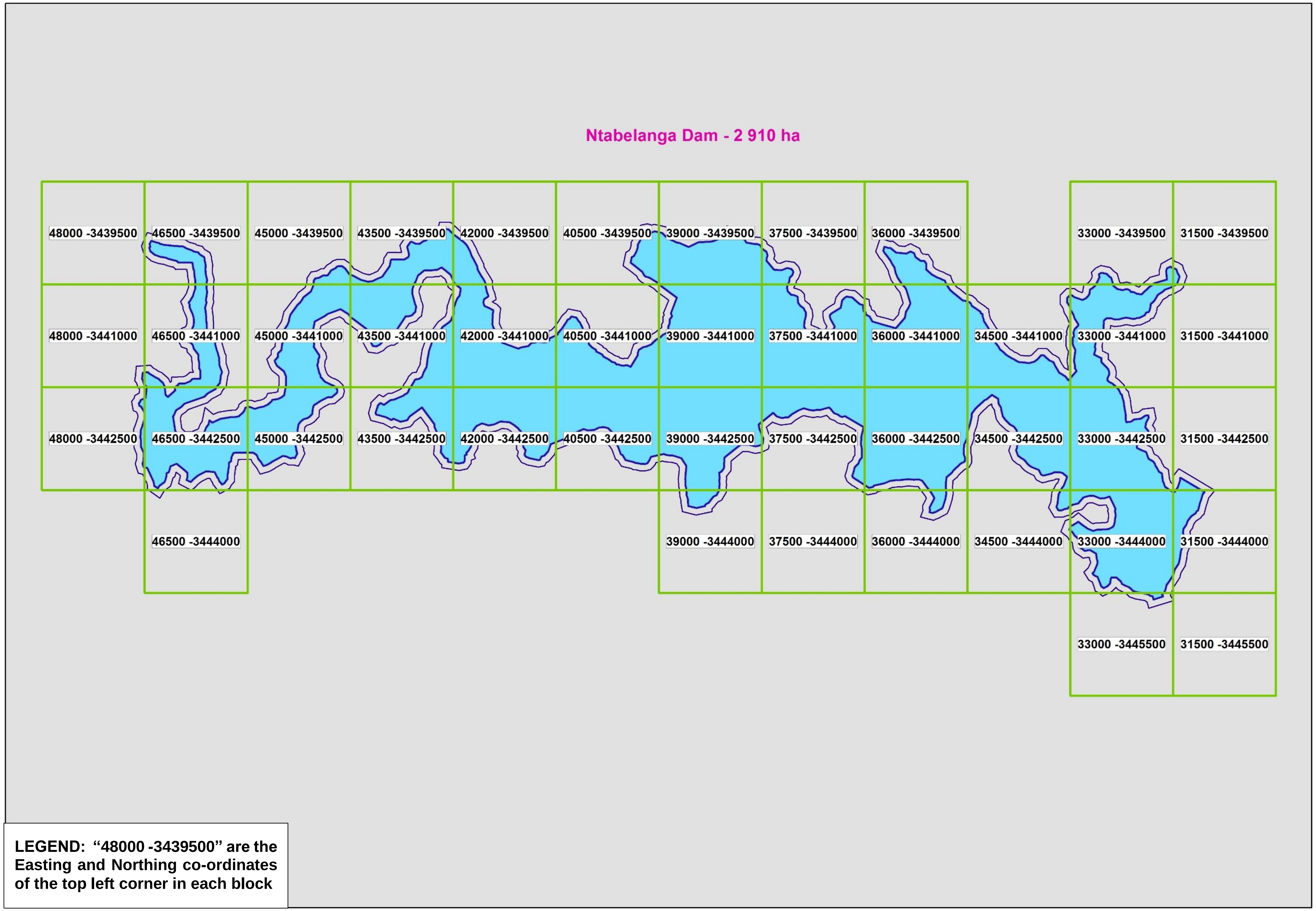


Figure 1-7: Block Index for Ntabelanga Dam Survey

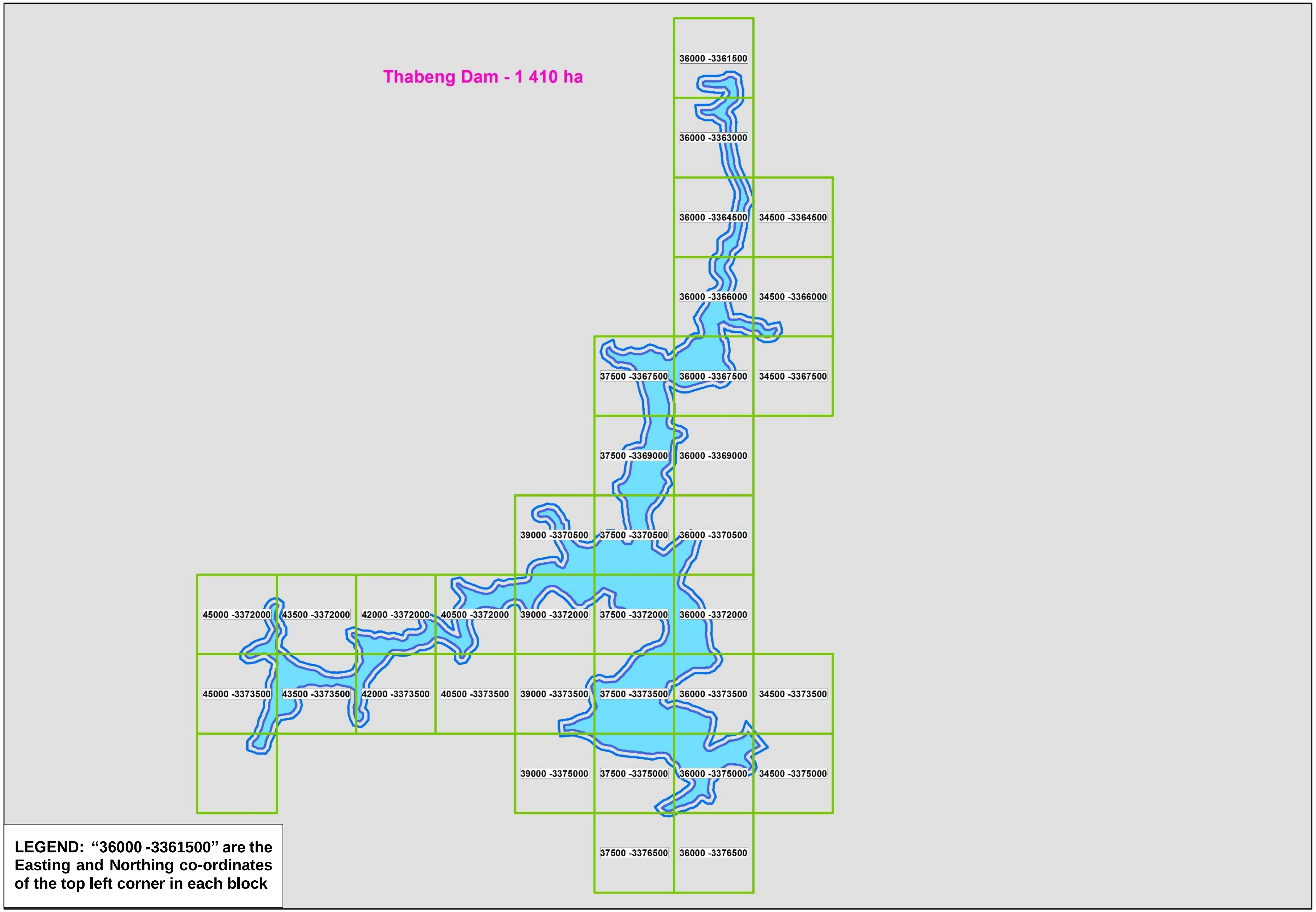


Figure 1-8: Block Index for Thabeng Dam Survey

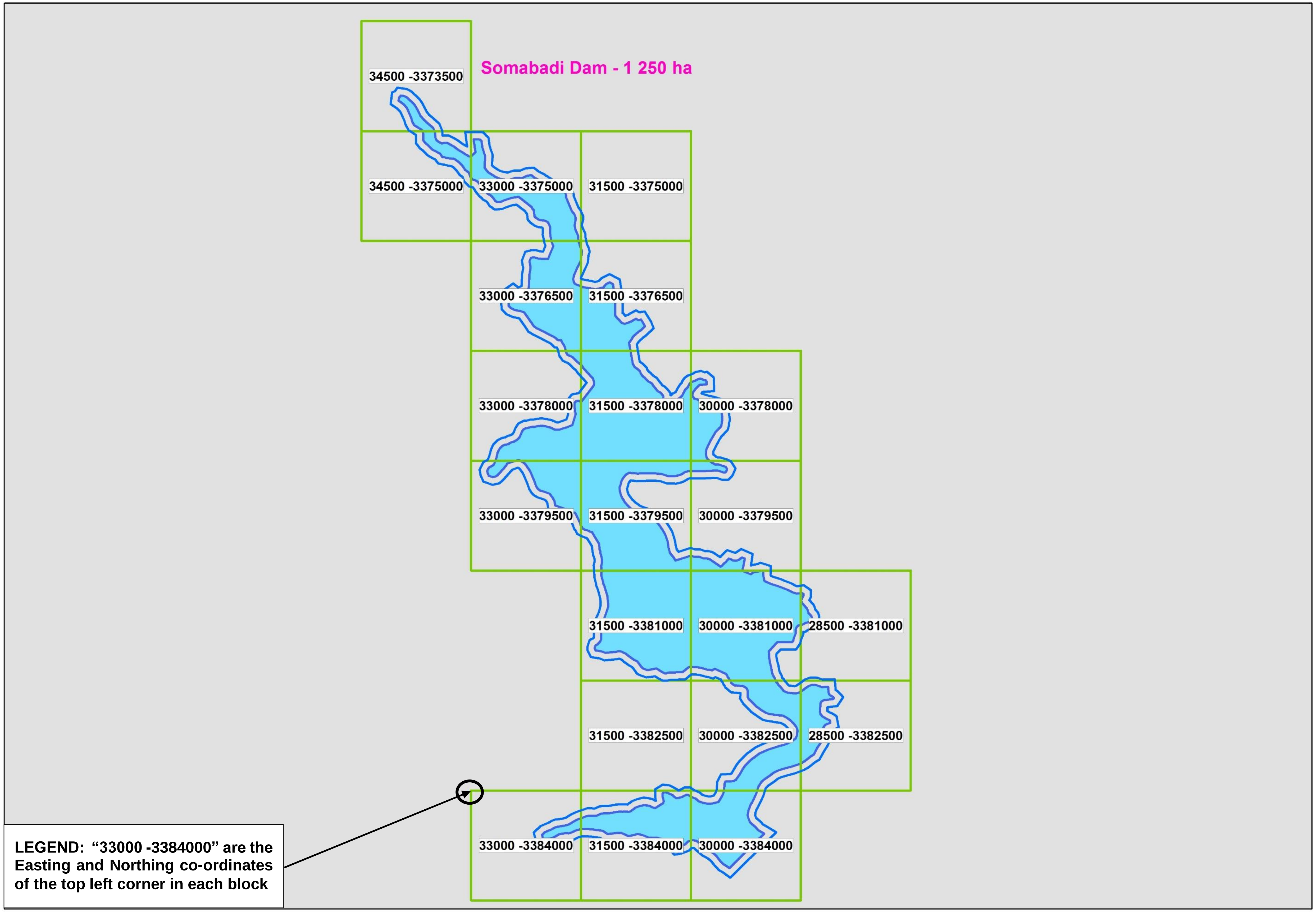


Figure 1-9: Block Index for Somabadi Dam Survey

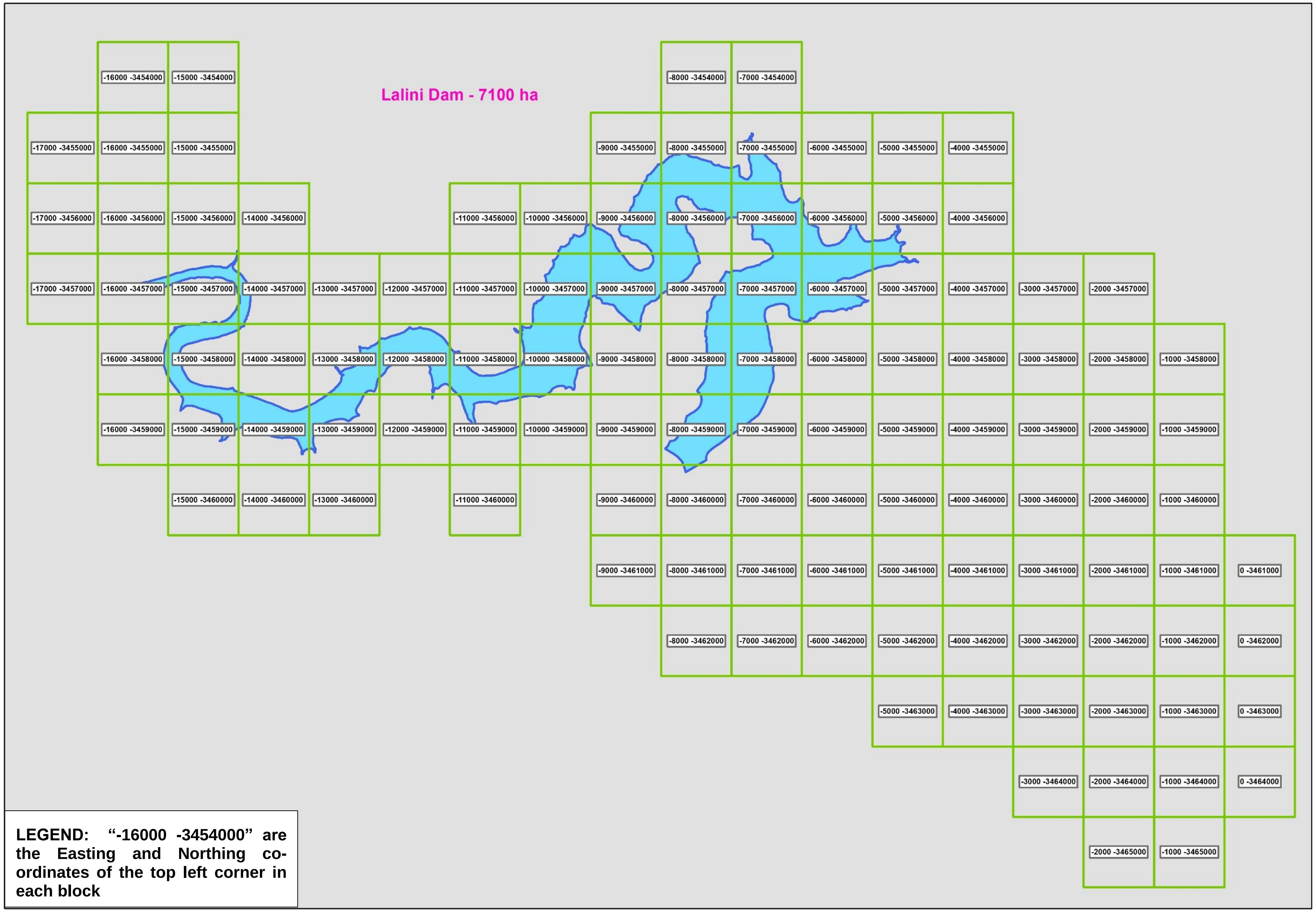


Figure 1-10: Block Index for Lalini Dam Survey

1.10 Shaded Relief Models

The following figures show the shaded relief models of each dam to provide a representation of the shape and extent of the inundated backwater areas of each dam. These are not to the same scale.

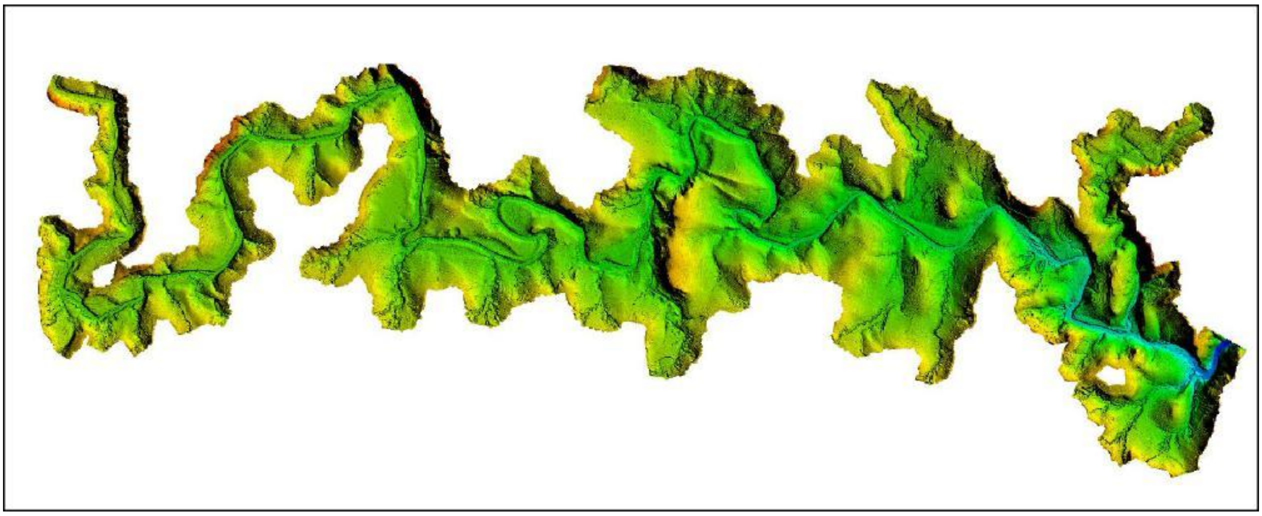


Figure 1-11: Shaded Relief Model of Ntabelanga Dam

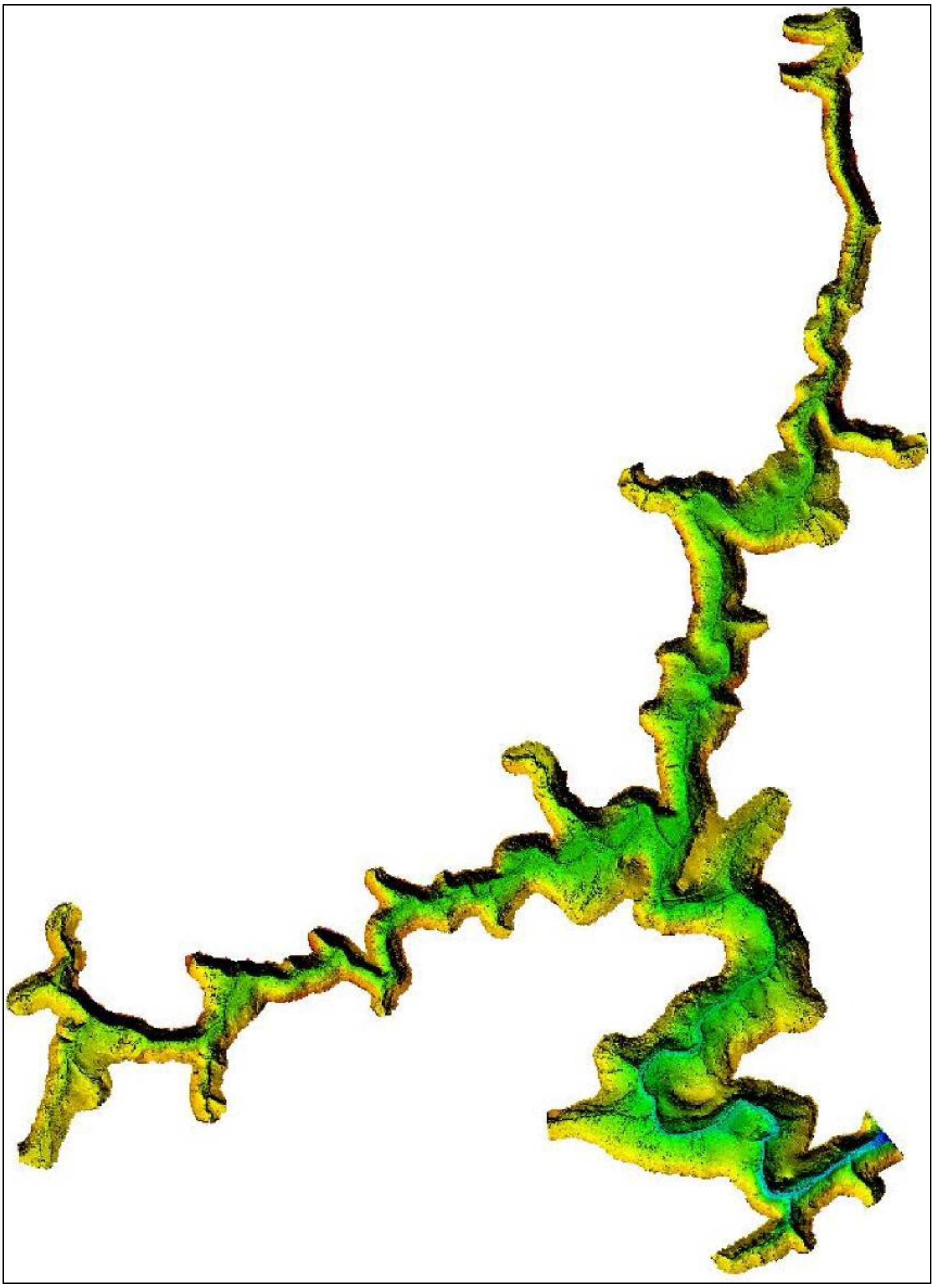


Figure 1-12: Shaded Relief Model of Thabeng Dam

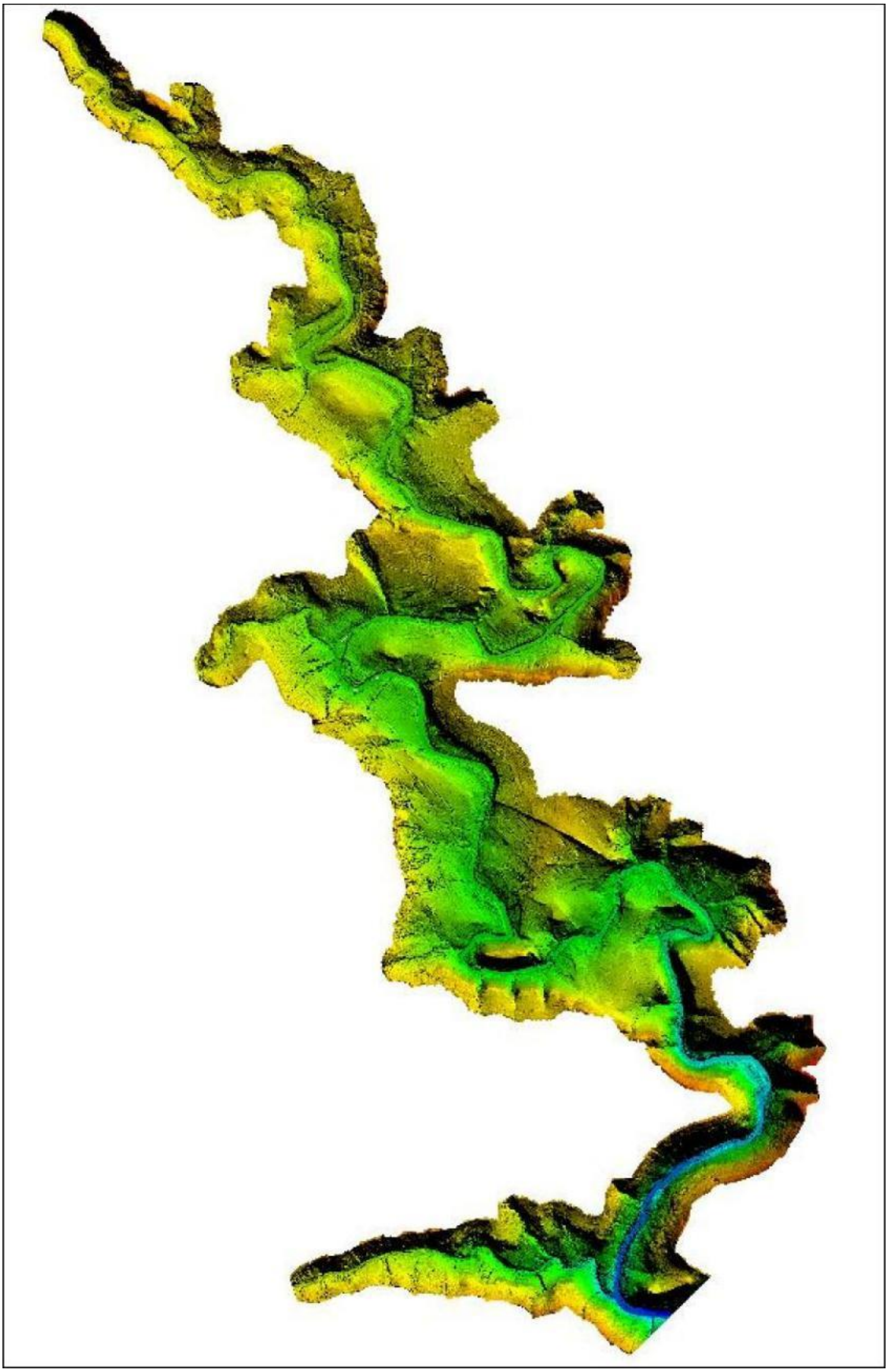


Figure 1-13: Shaded Relief Model of Somabadi Dam

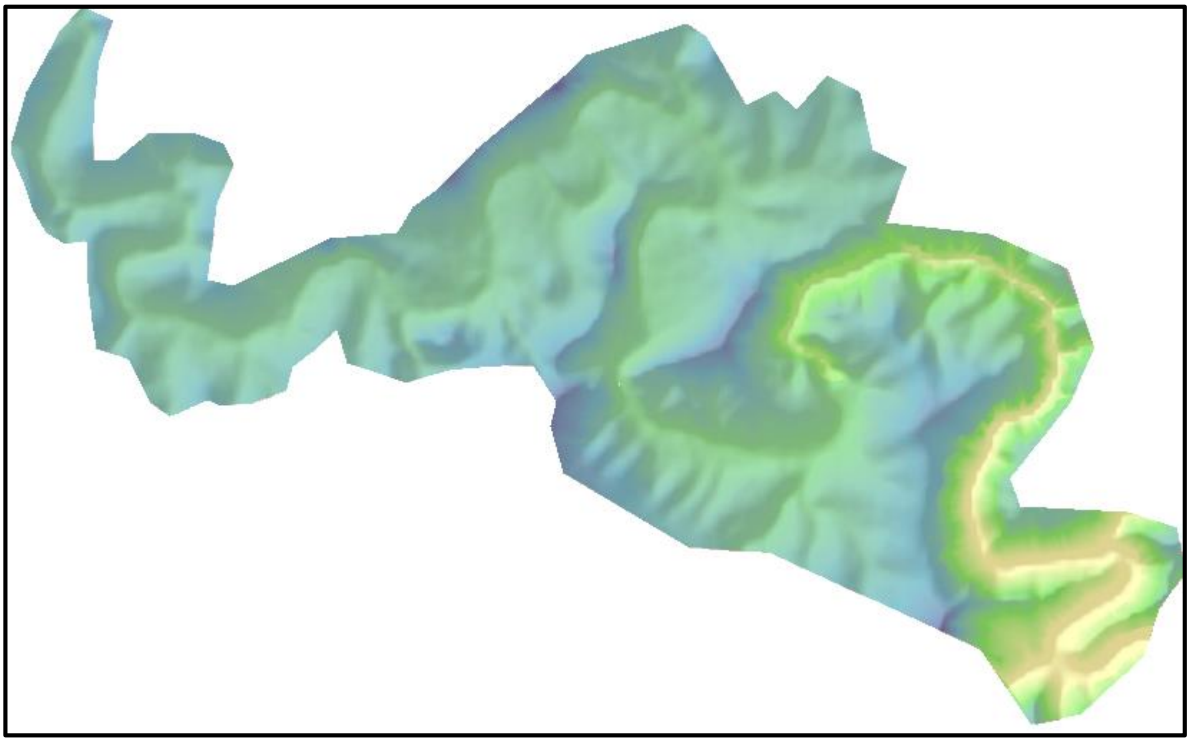


Figure 1-14: Shaded Relief Model of Lalini Dam

1.11 Phase 1 Additional Survey Inputs – Ntabelanga Dam

Following the recommendations of the Preliminary Study undertaken in Phase 1 (see Report number P WMA 12/T30/00/5212/3), it was decided to proceed with the full feasibility design of the Ntabelanga dam site. This required the extension of the survey coverage so that the various ancillary works immediately downstream of the dam wall (outlet works, water treatment works, access road, camps, laydown areas, offices, etc) could be planned using accurate topographical information. Similarly, survey information for the areas adjacent to, and above, the full supply level water line was also required to allow for rural road realignments and other mitigation works to be planned.

Fortunately, in flying the three dams in Phase 1, the topographical surveys service provider had captured these additional areas, and all that was required to produce accurate survey information for these additional areas was to electronically process the additional data already captured in Phase 1.

Figure 1-15 below shows the additional areas for which accurate topographical survey information was produced as an extension of Phase 1 of the study.

Planning of other areas, including the bulk water infrastructure and the areas considered as of high irrigation potential was undertaken using 5 m contour data available from the Surveyor General, which was deemed accurate enough for feasibility level design purposes.

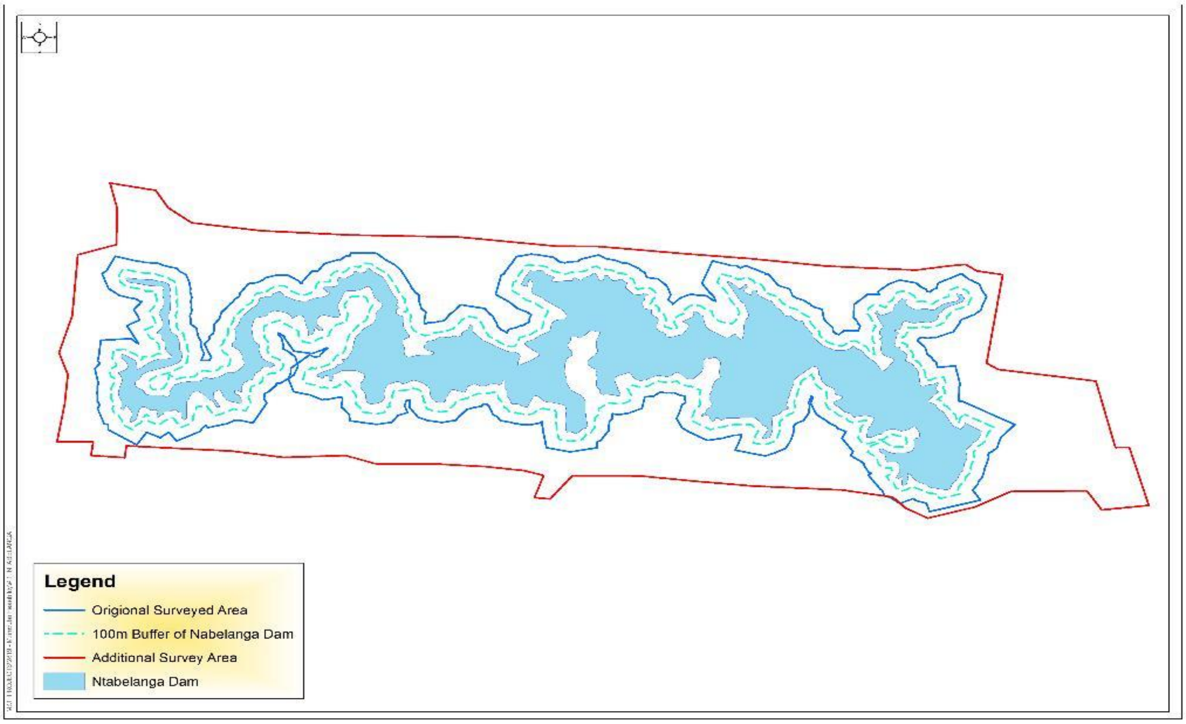


Figure 1-15: Additional Survey Area Undertaken in Phase 2

1.12 Deliverables

A full suite of survey data files and imagery was supplied to the Study Team on DVDs, and this information has been delivered to the Directorate: Options Analysis and Directorate: Spatial Land and Information Management.

This includes:
CAD design files in Microstation DGN, DWG and DXF format showing:

- Orthophoto tiles layout;
- LiDAR point block layout;
- Contours at 0.5 m, 2 m and 10 m intervals[2];
- The project area surveyed with boundaries;
- Ortho-rectified aerial images with a 15 cm and a 10 cm pixel resolution for Phases 1 and 2 respectively, in GeoTiFF and ECW format;
- Composite images of the different dam areas in 0.5 m pixel resolution;
- Thinned Ground and Non-ground LiDAR laser points in ASCII format; and
- Full Ground and Non-Ground LiDAR laser points in ASCII format.

All of the above data are in the Hart94 WG29 coordinate system with orthometric heights as calculated in TerraScan using the SAG2010 geoidal model.

Also provided on CD were the following supporting documentation:

- Google Earth Image Overlay
- Ground survey information

[2] *These contours have been smoothed and are merely an aesthetic representation of the ground shape*

APPENDIX A

CONTOUR PLANS FOR THE NTABELANGA AND LALINI DAM BASINS AND DAM SITES

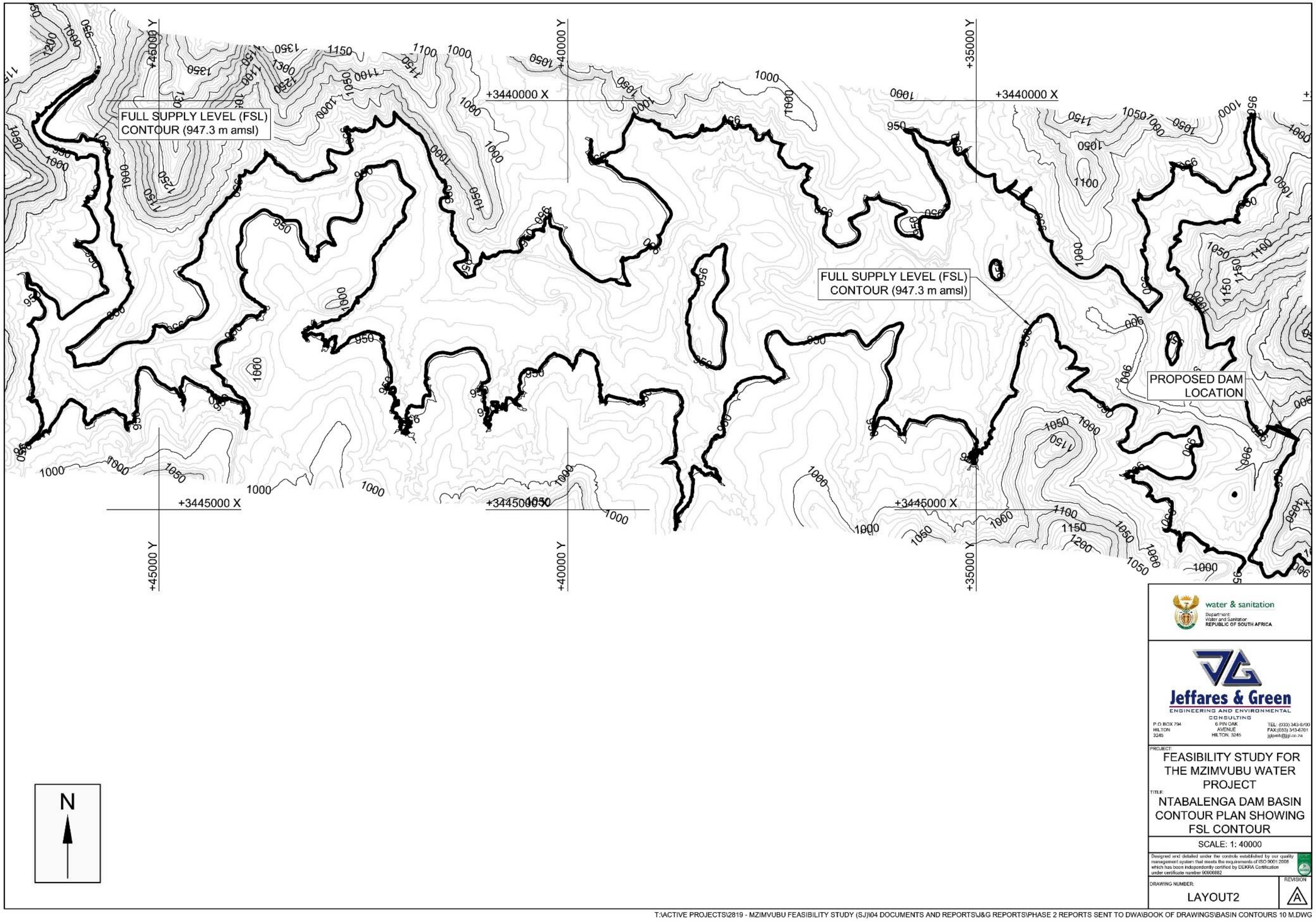
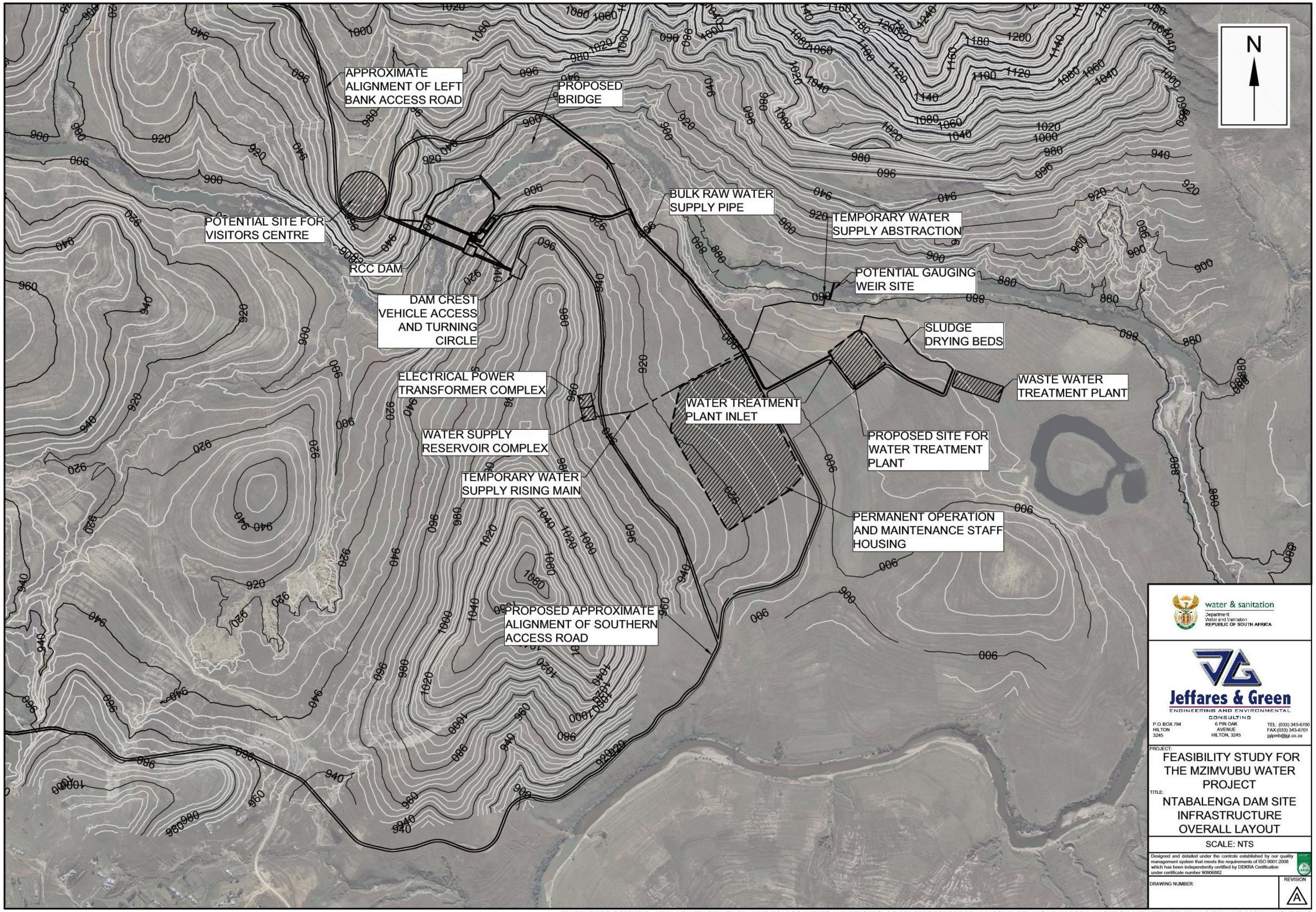
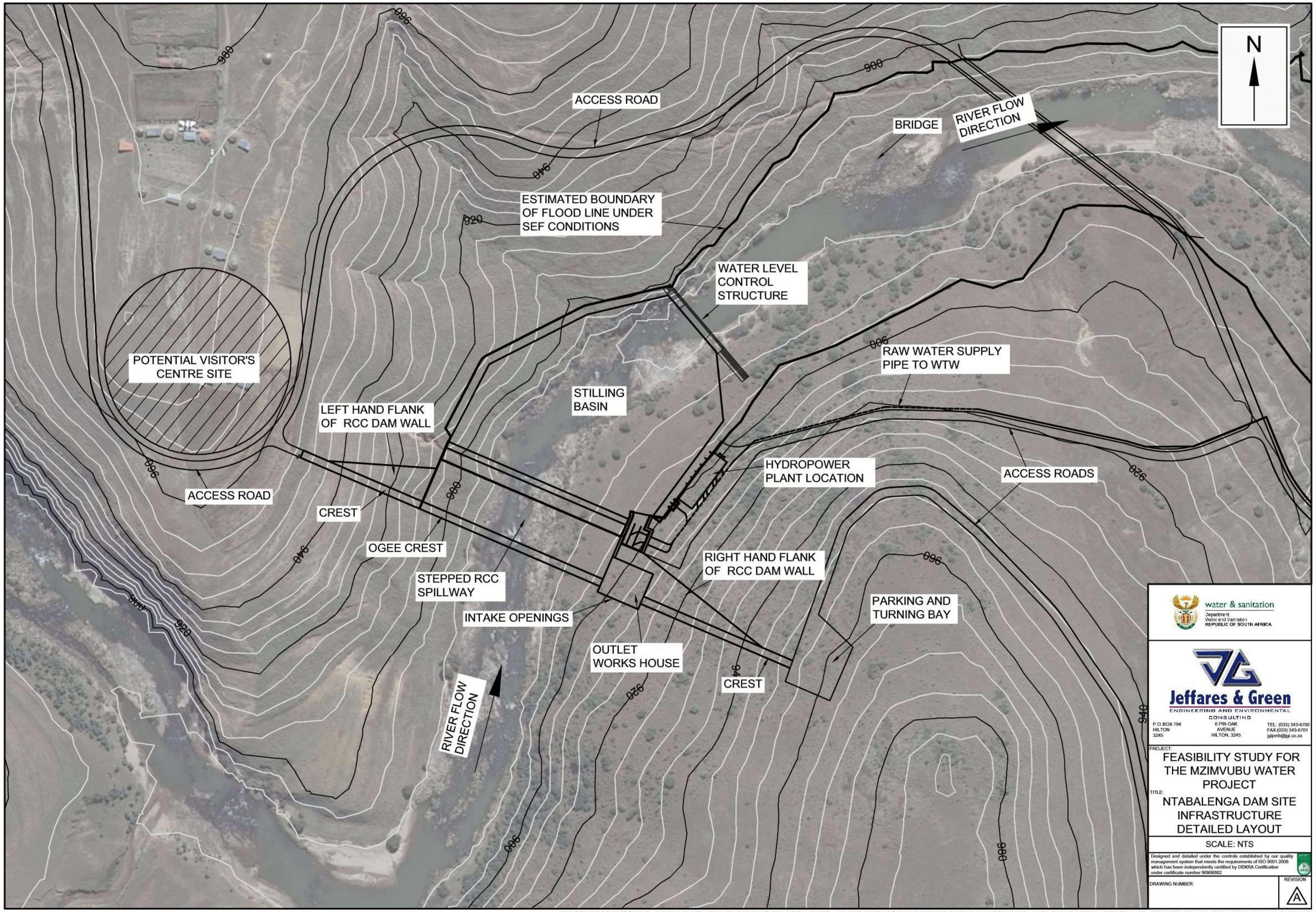


Figure A-1: Ntabelanga Dam Basin Contour Plan



T:\ACTIVE PROJECTS\2819 - MZIMVUBU FEASIBILITY STUDY (SJ)\04 DOCUMENTS AND REPORTS\J&G REPORTS\REPORT DRAWINGS\NTABELANGA DAM RCC DAM OPTION INFRASTRUCTURE AND STILLING BASIN LAYOUT.DWG

Figure A-2: Ntabelanga Dam Overall Site Contour Plan



T:\ACTIVE PROJECTS\2819 - MZIMVUBU FEASIBILITY STUDY (SJ)\04 DOCUMENTS AND REPORTS\J&G REPORTS\REPORT DRAWINGS\NTABELANGA DAM RCC DAM OPTION INFRASTRUCTURE AND STILLING BASIN LAYOUT.DWG

Figure A-3: Ntabelanga Dam Site Contour Plan

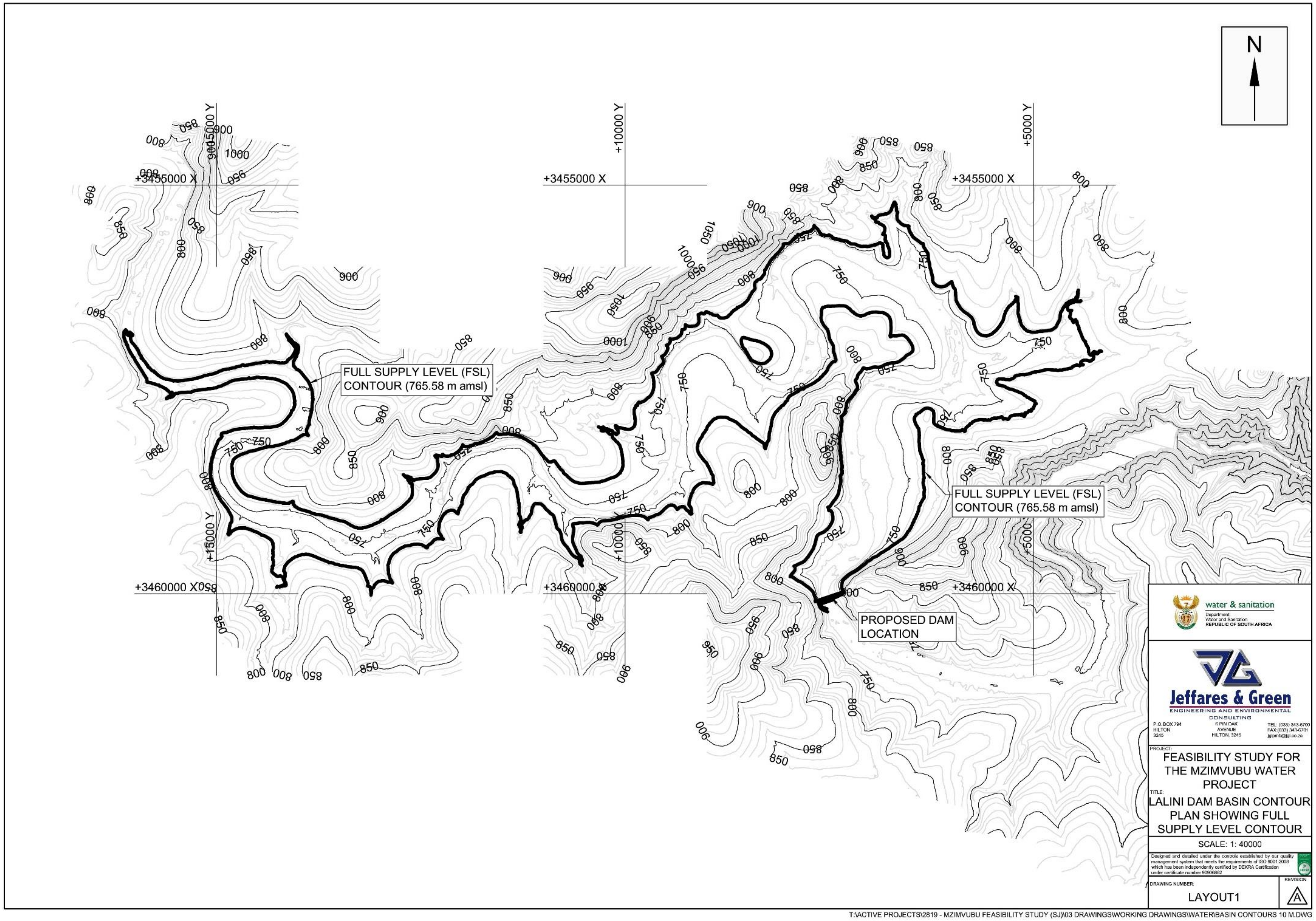


Figure A-4: Lalini Dam Basin Contour Plan

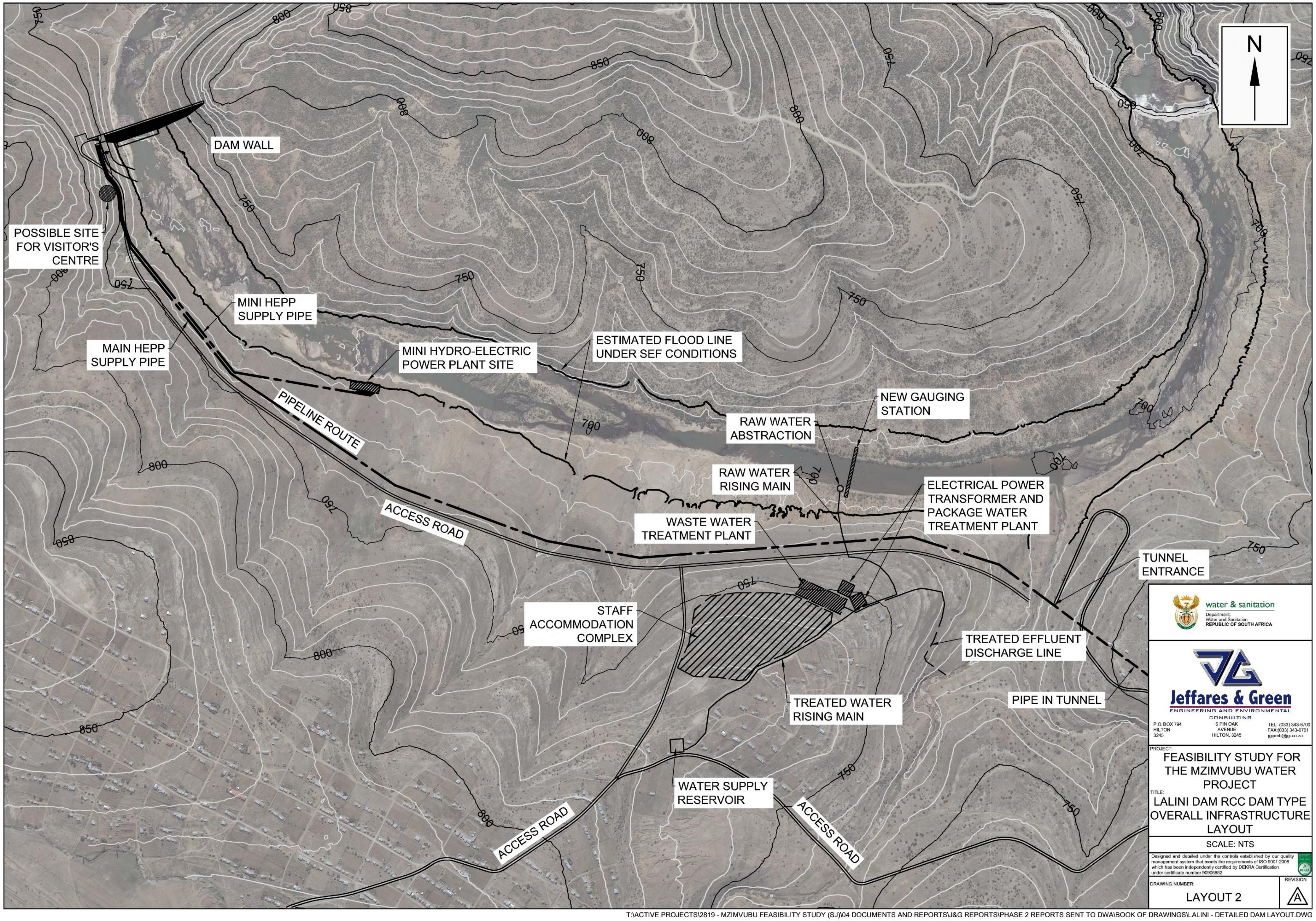
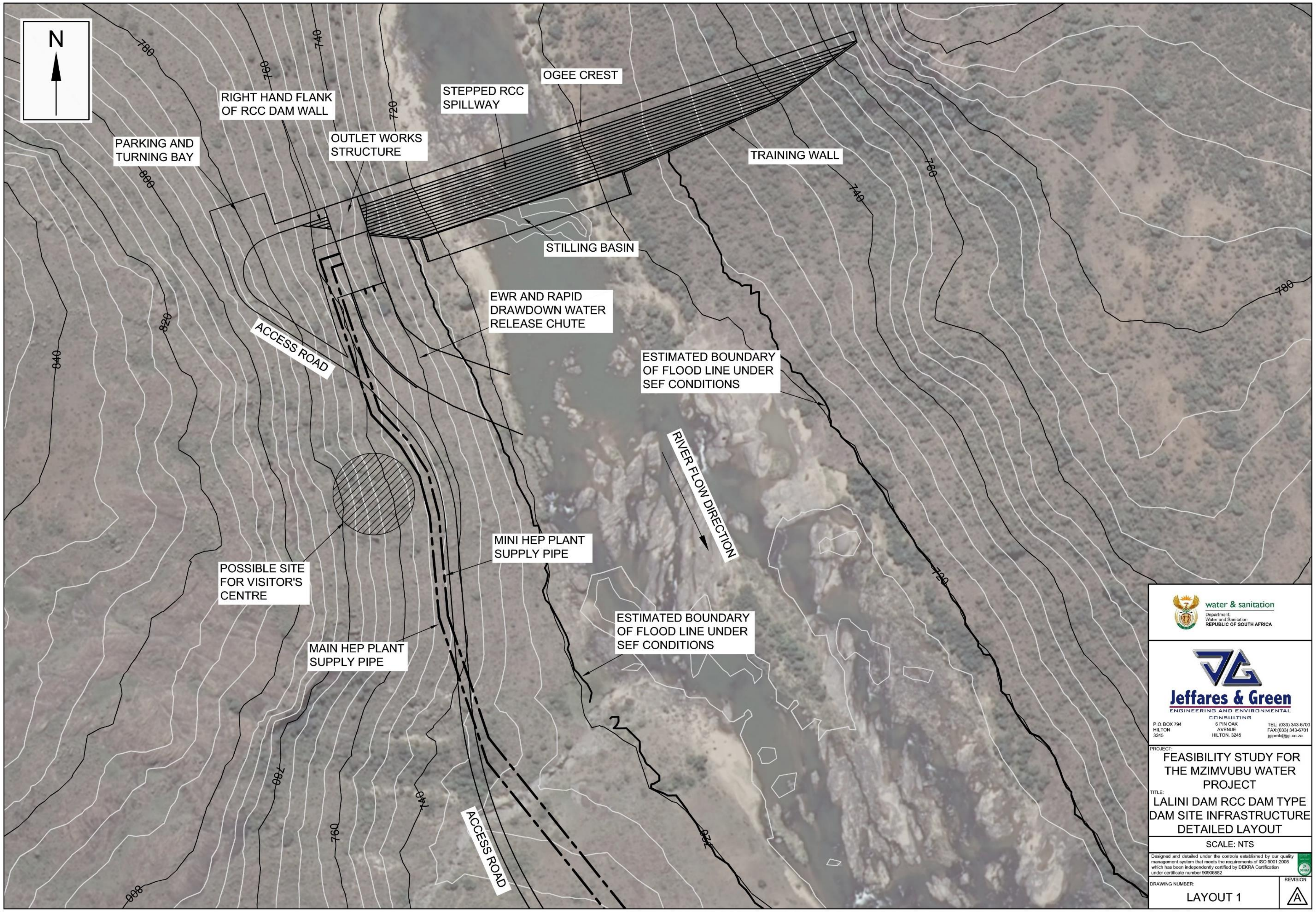


Figure A-5: Lalini Dam Overall Site Contour Plan



T:\ACTIVE PROJECTS\2819 - MZIMVUBU FEASIBILITY STUDY (SJ)\04 DOCUMENTS AND REPORTS\J&G REPORTS\PHASE 2 REPORTS SENT TO DWA\BOOK OF DRAWINGS\LALINI - DETAILED DAM LAYOUT.DWG

Figure A-6: Lalini Dam Site Contour Plan