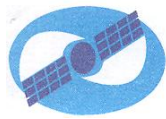


Annex A

TOPOGRAPHY



Mierag

Space Technologies Co.

Eastern Nile Technical Regional Office (ENTRO)

Eastern Nile Irrigation and Drainage Studies

Site Investigation Study Wad Meskin

**Topographic Surveys
Wad Meskin Project**

Final Report

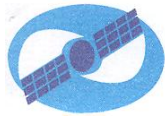
April 2010



Eastern Nile Technical Regional Office (ENTRO)
Eastern Nile Irrigation and Drainage Studies
Site Investigation Study Wad Meskin
Topographic Surveys
Final Report

Table of contents

1.1 INTRODUCTION	5
1.2 BACKGROUND	5
1.2.1 General	5
1.2.2 Project description	6
1.3 TOPOGRAPHIC SURVEY PROGRAM	7
1.4 Weather Conditions	8
1.5 SCOPE OF THE STUDY WORK	8
1.6 Study Methodology	10
1.6.1 Delineation of Irrigable Area for Survey	10
1.6.2 Mobilization	12
1.6.3 Establishment of benchmarks and tie to the National Network	13
1.7 Field Level Topographic Survey	15
1.7.1 GENERAL	15
1.7.2 Command Area Survey	15
1.7.3 Geometric Rectification of Satellite Images and Extraction of Topographic Features	15
1.8 Detail Survey of Barrage and Major Canal Structure Sites	15
1.9 Generation of Topographic Maps	16
1.10 Problems encountered	16
1.11 Conclusions	17



Appendices:

Appendix A1: Photographs of Topographic Survey Activities

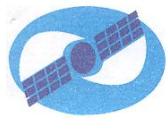
Appendix A2: Control List

Appendix A3: GPS Data (in CD Rom)

Appendix A4: Levels Data (in CD Rom)

Appendix A5: Coordinates of the Surveyed Sites

Appendix A6: List of BMs



Site Investigation Study Wad Meskin

TOPOGRAPHIC SURVEYS AND MAPPING

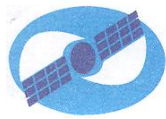
1.1 INTRODUCTION

The Eastern Nile Technical Office has awarded the preparation of Wad Meskin Irrigation System Site Investigation Study to BRLi, in January 2009, with Shoraconsult as a joint venture firm. Conducting the topographic survey of the project was among the principal components of the assignments that had to be carried as part of the complementary survey activities of the study, to provide the basic data and working documents for all the feasibility design tasks of the project that are planned to be carried out subsequently. Mieraj Co. Ltd is contracted as the field work subcontractor. This report, therefore, presents the approach and methodologies used to produce topographic maps of the project area, barrage sites and major crossing structures. The report further discusses the manpower and equipments deployed to undertake the assignments under section 1.6.2 of Mobilization, Topographic survey of the command area, link canal alignment, details of the barrages and structure sites under chapter 1.7 of the topographic survey, generation of Topographic maps under chapter 1.8, Problems Encountered and measures considered to tackle the constraints in chapter 1.9 and Conclusions under chapter 1.10.

1.2 BACKGROUND

1.2.1 General

The Wad Meskin area is located in the proposed Rahad II area, Gadarif state in the eastern region of Sudan. It is located east of Al Rahad River and south of Al Hawata town. The Project area is currently settled by the group of tribes (Hawssa, Fallata, Bargo, Barno, Massalit, Kawahlla, Gallien, Arakiein, and Gawassma). Agriculture is the main factor of the economy of the area.

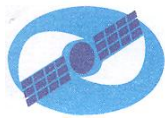


The people cultivate and produce different types of agricultural crops under rainfed and traditional irrigation during the rainy and dry seasons respectively. Livestock rearing, particularly fattening of bulls and keeping of goats is also part of the agricultural activities that keep the people to run a mixed farming system.

1.2.2 Project description

The cardinal objective of the study is to increase crop yields and improve the living standards of the people residing within the programme countries in general and the project area in particular. This objective is planned to be achieved by diverting water from (Dinder and Rahad Rivers) the two potential seasonal tributaries of the Blue Nile River, via a link canal joining two barrages. The purpose of this study is to run a topographic survey of the area for the study and design of irrigated agricultural development at feasibility level for a net area of 7,500 ha.

The Project site is located in the Eastern Region of Sudan (Gadarif State) at a distance of around 400 km South East of the capital Khartoum (Map 1).



In line with this, the survey was carried out in four subsequent phases, office preparation and preliminary delineation of the project area boundary, mobilization, and establishment of Benchmarks and linking of BMs with the national grid points and /or setting of BMs, and level collection and the maps preparation. An area of around 32,000 Hectares was planned to be surveyed, including forests, mayas, villages, hills, buffer zones and other un-required areas located within the project area.

All the field survey works were completed in 31 days. Due to survey of a wrong site of Wad Meskin barrage, a separate survey crew have revisited the site and surveyed the correct site in two days in mid June. An office work for data processing and map production have been done in June and beginning of July.

1.4 WEATHER CONDITIONS

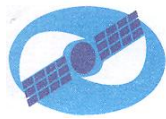
Generally, the climate of the project area was very hot during the execution of the field survey works and light rains started to fall. However, the weather conditions in the project area did not affect the progress of the survey works significantly until it was completed.

1.5 SCOPE OF THE STUDY WORK

Before starting mobilization to the field, a pre-planning of the project area including rough delineation of the targeted project area, according to the pre-defined contour line (447.5m), has been done. The routes of the survey lines and existing reference geodetic points and bench marks have been located on the site's rough map.

High resolution satellite imageries 60 cm from Quick Bird satellite for majority of project area and 50 cm resolution for the remaining area were being useful for the preparation of field survey work.

The teams to undertake the survey works were briefed about the methodology and planning of the survey work.



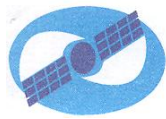
The teams include staffs experienced in their field in different levels. Camp accommodation in Al Hawata town close to the project area was made available by the consultant to facilitate the accessibility to the survey area.

The staff included Senior Surveyors with high qualifications in management and execution of the survey work beside supervision and control of activity.

A visit of one day from the Consultant to the survey team has taken place and gave them strengthening power.

All the survey works were performed in conformation to the requirements of the TOR at a feasibility level. The topographic survey of the project area was carried out for the preparation of feasibility design of the irrigation scheme, including selection of irrigation methods, preparation of irrigation layouts, preparation of bill of quantities and cost estimates, design of irrigation infrastructure, etc. In line with these:

- Within the topographic survey activities, delineation of the project boundaries was done according to the pre-defined limit of contour + 447.5m east, and Al Rahad River west. The exact project area is located South of Al Hawata town and extended south to cover an area of more than 30,000 Hectares north of Wad Meskin village.
- The eastern extent of the project area was delineated according to the route of the contour+ 447.5 above M.S.L, this due to the water level at the Barrage Site at Wed Meskin. Horizontal and Vertical BMs and control points were established, with known X-Y-Z co-ordinates. The control points were tied to the national grids of the country. These BMs and control points were established in grid form of 4x4 km according to the shape of the project area. These points have been established on stable manner for future reference and use.



-
- The CPs and benchmarks were established using differential GPS of dual accuracy under long period observation, and were tied with National Datum. The heights of these benchmarks were determined by levelling work and tied to the existing National BMs and M.S.L Datum.
 - The project area survey /ground levels collection/ and benchmarks network establishment covering the whole planned area of the project was carried out at appropriate grid intervals. The topographic maps were prepared at 0.25 m vertical contour interval and at a scales of 1:10,000 and 1:25,000 for current use and will be later on made at larger scales, up to 1:2,500, where required. Maps at barrage sites as well as major structure locations were prepared including profiles and DTM to give clear view of the site. The maps were prepared with contour lines of 0.25 m vertical interval and at scales of 1:500 and 1:750 according to the site size. Finally a base map at a scale of 1:50,000 covering the whole project area were prepared for general use (VOLUME 3, Maps and Drawings).
 - The topographic maps produced are being made to show every major feature of the areas including, rivers, gullies, hills, settlements, tracks, cattle crossings, water bodies, forest, etc.

1.6 STUDY METHODOLOGY

1.6.1 Delineation of Irrigable Area for Survey

At the commencement of the study, and in order to define the target (irrigable) area for survey, where the area was pre-defined to be below the contour line of + 447.5 m, a rough delineation of the area have been defined using the existing maps, high resolution Satellite images and SRTM Digital Elevation Model. The defined area for survey was then planned for topographic survey.

The planned area for survey is located South Al Hawata town and extended south up to Wad Meskin Village to cover an area of more than 30,000 ha.



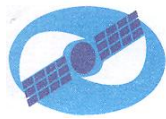
The eastern extent of the project area was pre-planned to extend above the contour of +447.5 m in order to ensure the complete determination of contour + 447.5 m.

The pre-planning of the area was made using GIS software, digital geo-referenced maps and satellite images. The delineation of the project area was carried out including forests, Maya's, villages, buffer zones, hills and other un-required areas located within the project site.

Following the rough delineation of the area, the project boundary and the surrounding areas were planned for topographic survey and the layout of the survey work have been defined. The satellite images with high resolutions were purchased and loaded on the laptops of the surveyors for use at field and to select the ground control points needed to rectify the images. These images were also being employed to keep track of the orientation of the survey group and for directing the survey activities and to extract some topographic features after image rectification.

Reference Benchmarks (BMs) have been established within the project area. The BM's were tied to the existing geodetic reference points from National Geodetic Network.

Ground levels were then collected by Levelling works using Automatic Levels at maximum grids of 200×100 m depending on the land topography. The x, y, z values of established BMs and reference points were then used by the GPS to generate a site calibration file which was then used by GPS to collect spot heights for non-regular and dense spots areas within the project (Appendix A3). Using the collected levels, topographic maps were prepared at scales of 1: 10,000 and 1:25,000 and at contour intervals of 0.25m.



1.6.2 Mobilization

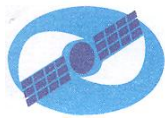
The surveying team mobilized to the site on April 18, 2009, reached to site in the same day and started the survey works in the day after. The survey crew rented a house in Al Hawata town which is located around few kilometres from the survey area. Five survey engineers, three technical labours, and eight local labours have contributed in the field survey in four survey crews. The survey team stayed on site and executed the mission within one month. The lists of equipments used are shown in Table 4.1 and that of the survey staff are shown on table 4.2.

Table 4.1: Survey equipments used

S. No.	Description	No. available on site
1	Digital Levels, LEICA, DNA03 with accuracy of 1 mm Double running 1 km, SD not exceed 0.5 mm.	2
2	Automatic Levels,	1
3	Communication devices	7
4	Office Equipment, ArcGIS 9.2- ERDAS- AutoCAD Software, PC Workstations,	5
5	Lap top computers	3
6	Dual frequency Differential GPS Horizontal ± 10 mm + 1 ppm RMS Vertical ± 20 mm + 1 ppm RMS	1 set (3 units)
7	Normal GPS	2
8	4WD, vehicles,	2

Table 4.2: Personnel mobilized to the project site

Sr. No.	List of Manpower	No. on site	Remarks
1	Team leader	1	
2	Chief surveyors	4	
3	Technical Labours	3	
4	Level man	8	
	Total	16	



1.6.3 Establishment of benchmarks and tie to the National Network

The establishment of the GPS points was done after the starting of the surveying. A set of Static (Trimble 5800) GPS have been used for the observations. Twenty three (23) Benchmarks and Control points with X, Y, Z coordinates were established and then used for the calibration process of GPS heights within the project area. The heights for these B.Ms points were derived from levelling works and tied to the national network of the country.

The resulting calibrated heights were used by GPS for surveying of the areas need dense spot heights, the Barrage sites, and crossing locations. Static observations were used to connect the survey of the project area to the National Reference Control. Trig. Station & Benchmarks (Trig. Stn No. 671 and Benchmarks 32837, 32838, 32839, 32851, 32852 and 32955) were used as reference points.

GPS Real Time (Trimble 5800), with the accuracy of maximum ± 1 cm horizontally and ± 2 cm vertically, have been used along the project area, for identifying and observing the pre-selected features' coordinates which were used as photo control points for rectifying the Satellite images to the correct coordinates. About 26 well identified and distributed points were used for this purpose. The rectified images were then used for digital extraction of the topographic features.

Digital Levels (Leica- DNA03) have been used for executing the levelling works and obtaining the mean see level heights for the vertical control points (23 BMs), with an accuracy of ± 1 mm in 1km.

The Automatic Levels have been used to collect the levelling heights along the X-section lines every 200 m intervals and 100 m along the lines.

Especial detail topographic surveys for the particular sites have been done with spot heights every 10 m as maximum grid distance.

GPS RTK with the GPS calibration file was used for the collection of spot heights of the inaccessible areas.

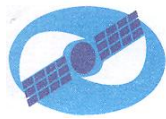


All benchmarks are clearly installed and numbered on the site and located on the maps. The bench mark lists, coordinates, levels are indicated in table 4.3. These BMS are also located on the produced topographic maps and shown clearly.

Table 4.3: List of Bench Marks established in the Project area

Name	Northing	Easting	Elevation	Code
BM01	1484263.026	678395.181	444.0063	BM
BM010	1467674.774	696013.532	446.306	BM
BM011	1465306.078	698057.236	448.7971	BM
BM012	1463644.528	700128.925	450.0173	BM
BM013	1461633.768	700889.212	449.8844	BM
BM014	1459073.246	702552.767	450.0949	BM
BM015	1457324.831	703421.41	450.8768	BM
BM016	1454645.45	705916.576	451.9612	BM
BM017	1477974.375	685385.88	443.0736	BM
BM018	1475517.651	683434.306	442.4705	BM
BM019	1474982.74	686842.298	442.7095	BM
BM02	1485437.885	681032.729	447.0615	BM
BM020	1473466.389	690019.45	442.639	BM
BM021	1471013.426	688301.041	443.981	BM
BM022	1469031.449	690879.811	445.2179	BM
BM023	1465686.693	693701.283	444.9433	BM
BM03	1481022.328	679644.028	442.5353	BM
BM04	1482314.71	682338.449	445.4862	BM
BM05	1479684.803	682713.412	443.2001	BM
BM06	1479604.805	686822.859	445.9784	BM
BM07	1477807.419	689225.14	444.4763	BM
BM08	1475870.774	691925.459	445.0128	BM
BM09	1470627.921	693466.282	445.3675	BM
BM32837	1485691.445	683718.848	449.616	Ref. BM
BM32838	1481698.463	679715.015	443.072	Ref. BM
BM32839	1481693.427	683714.423	445.979	Ref. BM
BM32851	1465688.817	695702.811	447.844	Ref. BM
BM32852	1465690.64	699699.752	451.57	Ref. BM
BM32955	1455729.157	704371.735	452.186	Ref. BM

A group of site reference points with X, Y, Z coordinates were established at each of the project specific sites (Wad Meskin barrage, Dinder barrage and Al Atshan stream crossing). Using differential GPS dual accuracy under long observations (Appendix A2).



1.7 FIELD LEVEL TOPOGRAPHIC SURVEY

1.7.1 GENERAL

As mentioned here before, the elevations of the new BMs have been derived by running level survey based on the existing national BMs.

The values of the benchmarks have been determined and then x, y values derived using the GPS observation.

1.7.2 Command Area Survey

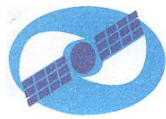
The field level survey was carried out in order to collect spot heights in a grid network of 200 × 100 meters (Appendix A4). The spacing between points is minimized to show the terrain undulation or specific features when such features faced. Automatic and digital levels were used to collect the levels. Spot heights were tied and referred to mean sea level, using the BMs in the project area.

1.7.3 Geometric Rectification of Satellite Images and Extraction of Topographic Features

In order to rectify the high resolution satellite images, a well defined points on the images and on ground, have been selected and observed using GPS. Well distributed points were used for the purpose using ERDAS Imagine Software to geometrically correct the images. The resulting images were used, in the office, with the ArcGIS software to extract the topographic features.

1.8 DETAIL SURVEY OF BARRAGE AND MAJOR CANAL STRUCTURE SITES

The detail surveys of Barrage and major structure sites were the activities that have been carried out in line with the topographic survey of the command area. Spot heights every 10 m as maximum grid distance were used for these topographical surveys. GPS RTK depending on the calibration result have used for the levelling survey of these areas. This survey was based on the site reference points established in these areas.



1.9 GENERATION OF TOPOGRAPHIC MAPS

The survey data collected each day were downloaded after working hours, and checked for consistency and errors. The laptops computers available in site were used for data installation, checking and processing.

The contour maps with contour interval of 0.25 meter were prepared at office using the collected field survey data. The digital topographic map with high resolution satellite image (as background) was prepared and printed at scales 1:10,000 and 1:25,000. The maps show features such as rivers, water bodies, roads and tracks, villages, gullies, and hills, etc. also the areas of dense trees and hills indicated from the satellite image. Both soft and hard copies of Topographic maps of the project area were produced and delivered to the client. ArcGIS, AutoCAD and other software were used in map production.

Digital topographic maps for barrage sites, as well as major structure locations were produced at scale 1:500 and 1:750 according to site size and contour interval of 0.25 m. Each map includes two cross-section profile and a digital terrain model. A calculated area of more than 8,369 ha is available for the project area excluding, forests, mayas, villages, hills, buffer zones and other not required areas located within the project area.

1.10 PROBLEMS ENCOUNTERED

The problems faced during the execution of the project were insignificant and were mainly related to the hot temperature and the inaccessibility of most of the project area with motorized vehicles. The hot temperature problem was solved by programming the works to be carried out in the early mornings and late afternoons. The inaccessibility problem was solved by travelling on foot to cover the whole project area.



1.11 CONCLUSIONS

The topographic survey study of the project area is completed within the planned period. The topographic survey has covered a gross irrigable area of more than 8,369 ha out of the planned 32,000 ha area, excluding, forests, villages, hills, mayas, buffer zones and other not required areas located within the project area.