GOVERNMENT OF MALAYSIA
ECONOMIC PLANNING UNIT OF THE PRIME MINISTER'S DEPARTMENT

MALAYSIA

FEASIBILITY STUDY REPORT ON THE TEKAI HYDROELECTRIC POWER DEVELOPMENT PROJECT

Volume II Survey

SEPTEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of Malaysia, the Government of Japan decided to conduct a feasibility study on the Tekai Hydro-electric Power Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Malaysia a survey team headed by Mr. Keiichi Takahira from March 1, 1981 to December 15, 1982.

The team exchanged views with the officials concerned of the Government of Malaysia and conducted a field survey in the Tekai Project area, in Pahang State. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

Tokyo, August 1983

Keisuke Arita
President
Japan International Cooperation Agency

The feasibility study report is composed of the following volumes.

Executive Summary	
Volume I	Main Report
Volume II	Survey
Volume III	Hydrology
Volume IV	Geology
Volume IV	Geology Appendix
Volume V	Design and Construction Planning
Volume VI	Drawings
Supplementary Data	Estimated Construction Cost and Unit Price

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1. OUTLINE

1. OUTLINE

1.1 Purposes

The only existing topographical maps covering the surveyed areas of this project are the 1:25,000 scale map prepared in 1975 and the 1:63,360 scale map prepared in 1975 (both maps have a 50-foot contour interval). These maps can be used to examine the overall profile of the basin in question, but they are not suited for detailed studies in view of the scales used. To remedy this situation, new topographical maps with a 1:5,000 scale (dam sites) and 1:10,000 scale (environs of storage reservoirs) were prepared by taking new aerial photographs of the upper and lower dam sites and the environs of the lower storage reservoir where the access road will be constructed and by utilizing aerial photographs of the environs of the upper dam site taken in 1966 and 1967 by a Canadian air photogrammetry company.

Longitudinal profiling and cross sectioning of the dam sites was carried out in 1981 with the purpose of obtaining data for rough design. Topographical maps of the upper Tekai and lower Tekai were prepared using the results of the topographical survey (1:500) carried out in 1982 with the purpose of providing data for the detailed design.

A ground control survey, leveling survey and traversing survey required to conduct the aforementioned survey work were also carried out at the project site.

* The list of work carried out each year (Table 1.1) and the respective time schedules (Table 1.2, 3) are indicated in the Appendix.

1. Outline

1.2 Survey area

The area covered by the survey work described herein is located along the Tekai River, in the southern part of the National Park, approximately at the center of the Malay Peninsula. Practically the whole project area is densely covered with virgin tropical forest and is mainly in a wild state with the exception of some areas where timbering is carried out on a minor scale. Transportation routes available in this area are the two woodland paths from Jerantut to the lower dam site and the upper course of the upper dam storage reservoir and the fluvial navigation boats. The woodland paths become impassable during rainfall and the fluvial navigation boats are the most effective means of transportation in this area.

1.3 Period of survey

Aereial photography

- From July 15 (departure from Japan) to September 12, 1981 (return to Japan)

Ground control survey and leveling survey:

- From June 17 (departure from Japan) to september 29, 1981 (return to Japan)
- From May 23 (departure from Japan) to September 7, 1982 (return to Japan)

Longitudinal profilling and cross sectioning

- From June 17 (departure from Japan) to October 29, 1981 (return to Japan)

Traversing survey

- From May 23 (departure from Japan) to October 27, 1982 (return to Japan)

Topographical survey

- From May 16 (departure from Japan) to November 1, 1982 (return to Japan)

1.4 Types and volume of work

Aerial photography:

- Number of flight courses:	4
- Number of photos:	72
- Scale of photos:	1:20,000

Ground control survey:

- Number of points	13
(1 master station, 12 slave stations)	

Leveling survey

- Length of leveling:	
Jarantut - Lower Dam	60 km
Lower Dam - Upper Dam	25 km
Total	85 km

Longitudinal profiling and cross sectioning

- Length of longitudinal profiling:	1,400m
- Length of cross sectioning:	17,650m

Topographical survey:

- Scale:	1:500
- Area of topographical surveying	
Upper dam site:	1.6 km^2
Lower dam site:	0.5 km^2

1.5 Principal equipment and materials

Aerial photography:

- Aircraft (Piper Aztec)		1 unit
- Aerial photography camera	(Wild RC-10)	1 set
- Automatic film developer:		1 set

Ground control survey:

- JMR-3 and JMR-4 Doppler survey set	3 sets

Longitudinal profiling and cross sectioning

- Optical rangefinder (Hewlett-Packard 3800)	2 sets
- Theodolite (Wild T2)	1 unit
- Theodolite (Topcon TL-10)	2 units
- Level (Sokkisha B2)	3 units

2. AERIAL PHOTOGRAMMETRY

2. AERIAL PHOTOGRAMMETRY

2.1 Preparations for aerial photography

At the present time there is no private company in Malaysia fully equipped to carry out aerial photography. MALAYSIA AIR CHARTER CO., LTD. (MAC) has one aircraft for aerial photography. For aerial photography cameras, only the Malaysia Survey Department possesses this kind of equipment. The Survey Department is currently carrying out its own aerial photography project, and it has a long-term aircraft chartering contract with MAC with a duration of two years.

Accordingly, we were forced to charter the aforementioned aircraft from the MAC and the photographs were taken by Survey Department staff.

Thanks to the cooperation of the Survey Department, photography for the Tekai Project was given top priority. Kuala Lumpur International Airport was used as the base for aerial photography and the processing of the films was carried out at the laboratory of the Survey Department.

2.2 Aerial photography plan

Number of flight courses: 4
Number of photographs: 72

Aerial photography is used for aerial triangulation and plotting required in preparing the 1:5,000 and 1:10,000 topographical maps. In particular, the area photographed is extended beyond the plotting area to ensure accurate control points for aerial triangulation.

Four aerial photography flight courses were selected in a NW-SE direction, in accordance with the plotting area.

2.3 Photographic work

Photographic work was carried out in 1981. Work was initially scheduled to commence in late July, but actually commenced August 13 due to the necessity of making repairs to the MAC aircraft. The surveyed area consisted of valleys with topography prone to cloudiness and weather conditions not suited to aerial photography most of the time. In spite of successive flights beginning August 13, conditions presented us from taking photographs for several days. Weather conditions improved for two hours on the morning of August 23, and all four flight courses were successfully photographed during that period. In fact, weather conditions at the project area were suitable for aerial photography for only two hours during the 60 days the aerial photography team were in Malaysia.

Photographic work was actually concluded August 23, but developing and printing of the film was delayed until September 3 because laboratory equipment was inoperative at that time.

2.4 Plotting

Plotting work was carried out in 1981 and 1982 in accordance with the schedule of Table 2.1

Table 2.1

Year	Scope	Scale	Area (km^2)	Contour interval	No. of models of aerial triangulation	Photographing year
1981	Rough design of upper and lower dam sites	1:5,000	15	5	80	1981
	Lower dam storage reservoir	1:10,000	131	5		
1982	Upper dam storage reservoir	1:10,000	300	10	110	1967

The contour interval is 5m in the construction areas (plotted in 1981) of the dams, construciton of the temporary facilities, location of the construction roads, etc., and 10m in the upper dam storage reservoir (plotted in 1982) that contains no structures. (Figure 2.1 ∿ 15).

3. GROUND CONTROL SURVEY

3. GROUND CONTROL SURVEY

3.1 Distribution of the Control Points

As previously mentioned, the surveyed area is densely covered with virgin tropical jungle and therefore it is very difficult to set up control points using conventional survey methods. Thus, the NNSS (Navy Navigation Satellite System) was adopted to set up the control points.

As for the distribution of the control points, 13 points, consisting of one master point and 12 slave points (eight points in 1981 and four points in 1982) were planned, distributed evenly throughout the surveyed area, to principally be used in the course of subsequent aerial triangulation. However, the selection of the control point sites indicated that those located in the tributaries were not accessible by fluvial navigation boats. Therefore, they were moved to the mainstream and observed therein. (Figure 3.1).

It was initially planned to first set up the existing triangulation points located nearby and the master control point by traversing, in order to attribute the coordinate values of the existing geodesical system to the control points. However, we were informed by the Survey Bureau that the coordinates of the existing triangulation points were unavailable. Therefore decided to change the working method, i.e., we decided to convert the control points to the existing geodesical system by attributing the lift (with regard to the existing geodesical system) to the values of the coordinates determined by calculations carried out in Japan.

3.2 Establishment of Aerial Signals

Of the NNSS observation points previously mentioned, aerial signals were established at eight control points (slave points) implemented in 1981, in order to make them clearly visible in the aerial photographs. The four points implemented in 1982 were set up by means of traversing frmo the control points clearly visible in the aerial photographs.

3.3 NNSS observation

1) The positions of the control points were determined by observing the Doppler displacement of the waves emitted by the NNSS satellites by means of JMR-3 and JMR-4 Doppler sets (three units in total, including one spare unit).

The translocation observation method with simultaneous observation of two points was adopted, to determine the relative position of the various slave stations with regard to the master station.

2) When the survey was carried out in 1981, one of the five NNSS satellites ceased emitting waves and consequently the auto-alert function did not work. Under the circumstances it was necessary to convert to manual observation and therefore the observation work was extremely difficult, due to the change of power supply and other factors.

Furthermore, an unexpected accident occurred during the observations carried out that year when data recorded in a cassette tape were lost because it was struck by lightning.

3) The observations were carried out continuously for 24 hours, but the number of effective paths covered per day was small, due to the low latitude and the topographical characteristics of the site. We succeeded in observing four to five paths per day when the equipment and instruments were working satisfactorily.

4) Calculations of the satellite Doppler survey

Cassette tapes containing satellite data collected by the Doppler survey at the project site were brought back to Japan and the relevant calculations were carried out in the host computer after transferring the cassette tape data to magnetic tapes. (Table 3.1). Calculations were carried out using the translocation method, and the relative accuracy of the master point and the various slave stations was of the order of 2 to 3m both in terms of ground and height. The host computer used for satellite Doppler survey calculations was a UNIVAC VANGUARD 1100.

* Refer to the attached data for further details.

3.4 Leveling survey

A leveling survey was carried out in 1981 and 1982 from Jarantut to the upper dam site.

In 1981 a leveling survey was carried out with the purpose of providing the height reference for NNSS observation and dam site longitudinal profiling and cross sectioning.

There is no bench mark in the surveyed area. Accordingly, a leveling survey was carried out from the national bench mark located in Jarantut to the NNSS master control point and the lower dam site via woodpaths and two bench marks (one original bench mark and one reference bench mark) were established as a result. The length of the leveling survey was approximately 60 km. Round-trip observation was carried out in the leveling survey and master control points were established at intervals of the order of 1.0 to 1.5 km on average.

In 1982 a leveling survey was carried out from the bench mark established in 1981 at the lower dam site to the upper dam site SS3, with round-trip observation over a distance of approximately 25 km.

It was initially planned to construct woodpaths to carry out the leveling survey, but the tropical jungle was too dense at the work site and too much time and manpower were required for construction of the paths. Therefore we decided to carry out part of the leveling survey by using the old logging road and the rest along the rivers. (Figure 3.2) Two bench marks (one original bench mark and one refernece bench mark) were established on each bank of the river in the vicinity of the upper dam site, totaling four new bench marks.

The newly established bench marks are solid concrete structures sized 1m x 1m, with approximately 80 cm depth.

<u>Results of leveling survey</u>

- Master station		68.65
- Lower dam bench mark		117.748
- Upper dam bench marks		
Right-bank	UBM1	105.839
	UBM2	105.111
Left-bank	UBM3	98.436
	UBM4	96.174
	SS3	187.896

4. LONGITUDINAL PROFILING AND CROSS SECTIONING

4. LONGITUDINAL PROFILING AND CROSS SECTIONING

4.1 Plan for Longitudinal Profiling and Cross Sectioning

Longitudinal profiling and corss sectioning of the upper dam site and lower dam site was carried out to provide reference data for 1:5,000 aero-photogrammetric mapping. Longitudinal profiling and cross sectioning at the upper dam site was carried out along 22 courses of traverse, totaling 23 courses of traverse including the dam axis, separated by 25m or 50m pitch, from 500m upstream of the dam axis to 500m downstream of the dam axis.

The width of the cross-sectional lines is 300m at the left bank and 300m at the left bank with a total extension of 13.8 km. Cross sectioning is carried out throughout a distance of 1.0 km extending from 500m upstream of the dam aixs to 500m downstream of the dam axis.

At the lower dam site longitudinal profiling and cross sectioning are carried out along 10 courses of traverse, totaling 11 courses of traverse including the dam axis, separated by 25m pitch or 50m pitch, from 200m up-stream of the dam axis to 200m downstream of the dam axis with a total dis-tance of 3.850 km. (Figure 4.1, 2).

The true altitude was determined by carrying out a direct leveling survey from Jalantut approximately 60 km downstream of the dam site where the national bench mark of Malaysia is located. A concrete bench mark is established at the lower dam site and used as a reference.

The upper dam site has no road and accordingly a direct leveling sur-vey is impossible. Direct leveling was therefore carried out at the cont-rol point for plotting (NNSS master station) and a control point for plott-ing (NNSS master station) and a control point for plotting (NNSS slave sta-tion) was also established on the upper dam axis.

Field work was carried out by referring to the provisional altitude. Then, the true altitude of the NNSS point located on the upper dam axis was determined after completion of aerial triangulation and that altitude was considered absolute.

4.2 Execution of the Longitudinal Profiling and Cross Sectioning

The geological investigation group and the design group carried out preliminary investigations followed by determination of the provisional dam axes, prior to longitudinal profiling. Then, longitudinal profiling was carried out at the upper and lower dam sites successively, around the aforementioned provisional dam axes.

However, it was impossible to draw courses of traverse parallel and perpendicular to the dam axis because the topographical conditions in the environs of the dam site were different to those initially planned. Traversing was therefore carried out along the river and the initially planned configuration was modified slightly in order to determine the most adequate longitudinal and transversal directions matching the topography of the dam site.

Furthermore, emphasis was put on the vicinity of the dam axis and the survey was made as thorough as possible around the axis, by extending the cross-sectional line, reducing the interval between courses of traverse, etc.

At the upper dam site the courses of traverse were planned with an initial length of 300m both on the left bank and the right bank. However, during execution of the longitudinal profiling and cross sectioning, the length of the nine courses of traverse located immedaitely upstream and immediately downstream of the dam axis was extended by 50m, to 300m on the left bank and 350m on the right bank. Furthermore, several intermediate courses of traverse were inserted at strategic points and their extension was shortened at places of secondary importance.

Altitudes were determined by establishing provisional bench marks on the provisional dam axis at the vicinity of the river bed and carrying out direct leveling along the various courses of traverse. (The conversion to absolute altitude was carried out after the return of the survey team to Japan.)

At the lower dam site the interval between courses of traverse was reduced in the environs of the dam axis in order to reduce the survey area.

To determine altitude, indirect leveling was carried out from the K.B.M. (left bank bench mark located on the dam axis) determined by direct leveling and a provisional bench mark was established on the right bank on the dam axis. Then, direct leveling was carried out from the aforementioned provisional bench mark, along the various courses of survey. (Table 4.4 ∿ 28)

Equipment and instruments used;

- Boat	3 units
- Chain saw	4 units
- Optical rangefinder (Hewlett Packard 3800)	1 unit
- Theodolite (Wild T2)	1 unit
- Theodolite (Tocon TL-10)	2 untis
- Level (Sokkisha B-2)	2 untis
- Steel tape	50m
- Estrone tape	100m

5. TRAVERSE SURVEY

5. TRAVERSE SURVEY

5.1 Plan for Excecution of Traverse Survey Work

A round trip traverse survey between the observation points determined in 1981 by satellite Doppler survey, i.e., the master point (environs of the lower dam site) and slave point SS-3 (environs of the upper dam site) was planned this year, clarifying with the purpose of further clarifying the relative position of the two dams. As for the observation, solar observation was planned at the master point and at slave point SS-3.

5.2 Execution of Traverse Survey

A traverse survey was carried out along the Sg. Tekai River, from the master point to salve point SS-3 located at the vicinity of the upper dam site (Figure 5.1). The traverse points from the upper dam site to the master point were roughly selected on the aerial photographs taken in 1981. Then, the traverse survey was carried out after a detailed selection of the traverse points in the field. Considerable time and manpower was required to carry out the traverse survey along the river because of dense weed and shrubs.

The traverse survey work was often interrupted in September by the frequent rain, but was concluded on schedule.

The equipment, instruments and results of the traversing survey were as follows.

- Equipment and instruments used

Observation of angles:	Theodolite (WILD T2)
Electronic distance meter:	K&E Auto Ranger S

5. Traverse Survey

- Specifications of traversing survey

  Observation of angles:

  - Sets of observations: 2 sets
  - Observation error at each station: 10"
  - Double angle error: 20"

- Solar observation

  - Sets of observations: 5 sets
  - Standard deviation of observations: 20"

- Results of traversing survey

  (1) Results of two-way traversing observation

  - closure error in angle: 47"
  - Closure error in coordinates: N = 0.69m
    E = 0.89m

  (2) When coordinates of master station and slave station SS-2 were given

  - Clsoure error in angle: 47"
  - Closure error in coordinates: N = -2.31m
    E = +3.52m

  (3) Standard deviation of solar observation

  - Master station: 13.7"
  - Slave station SS-3: 8.6"

6. TOPOGRAPHIC SURVEY

6. TOPOGRAPHIC SURVEY

6.1 Plan for Execution of Topographic Survey

A topographic survey was carried out at the sites listed below, as planned during the preliminary investigation stage and a 1:500 topographical map was prepared for use at the detailed design stage.

- Upper dam site (0.95 km^2)
- Upper dam quarry site and borrow site (0.65 km^2)
- Lower dam site (0.25 km^2)
- Lower dam quarry site (0.25 km^2)

The bench mark to be used as a reference for surveying was not the one established in 1981 at the lower dam site, and a new one was established at the upper damk site instead. Thus, a provisional altitude was initially attributed during the survey of the upper dam site, and then converted to the correct altitude after completion of the leveling survey.
For compass reckoning the survey was carried out by referring to magnetic north, and the true north grid was inserted after obtaining the traversing survey results.

6.2 Execution of the Topographic Survey

1) Upper site

The upper site, including the dam site, features steep topography with outcrops in some places. Furthermore, the upper site is gloomy and the view is obstructed by dense tropical jungle. An additional negative factor is the heat and humidity. The only means of transportation available for access to the upper site is the fluvial navigation boat and work conditions were unpleasant with most of the surveying being carried out on foot. Nevertheless, the topographical surveying was concluded on schedule. (Figure 6.1 ∿ 11).

2) Lower site

The lower site has a rather steep dam site, but generally speaking the topography is gentle compared with the upper site. Topographical surveying at the lower site was concluded ahead of schedule because the survey area was small and both boat and jeep were used for transportation. (Figure 6.12 ∿ 15)

3) Location of boring holes and test pits

The latitudes, longitudes, XY coordinates and altitudes of the boring holes and test pits are indicated in Table 6.1.

Equipment and instruments used to carry out the topographical survey are listed below.

* * * * * * *

APPENDIX
METHOD OF NNSS

1. EXPLANATION OF GEODETIC METHOD BY NNSS

NNSS is the abbreviation used for the U.S. Navy Navigation Satellite System. Satellite transmissions (400 MHz and 150 MHz) of orbit position and time every two minutes, together with accurate measurement of doppler variations of the received carriers, are utilized in computing precise latitude, longitude and height.

The elliptic motion between the earth and the satellite, in accordance with a Kepler law, can be represented and restricted by six elements. Three elements represent the elliptic motion of the satellite orbit, and the other three elements represent the position of the orbits between the earth and the satellite.

The following elements are used in the NNSS calculation. The satellite position at any time, in the space coordinate with the earth at the origin, can be represented. Values used to correlate the elliptic motion of the satellite orbit are:

a. long-radius
b. eccentricity
c. pass time at the nearest point

Values used to correlate the position of the ellipst of the orbits between the earth and satellite are:

d. lifting cross point longitude
e. inclined angle in relation to the equator
f. variable nearest point

The frequency of radio waves transmitted from the satellite are altered by the "doppler effect." The frequency increases when the satellite approaches the receiving station decreases when the satellite is going away. When the satellite is in a position closest to the receiving station, the receiving frequency and the transmitting frequency are identical in theory.

Appendix

Utilizing the doppler effect, changes in satellite position can be computed every two minutes.

Thus, a single hyper bolid can be fixed for the three-dimensional space coordiante, and the receiving station is on this hyper bolid. A minimum of three hyper bolids can be fixed for the receiving position. This is the satellite doppler positioning (geodetic) system.

2. LONGITUDE, LATITUDE, ELEVATION

The elements of the elliptic body adopted in the NNSS method are those defined in "WGS-72" and the satellite orbit follows this body.

long-radius (a) = 6378135m

1/f (eccentricity) = 298.260

However, the elements of the elliptic body adopted in Malaysia are the "Modified Everest (Malayan Revised Triangulation)."

long-radius (a) = 6377304m

1/f (eccentricity) = 300.8017

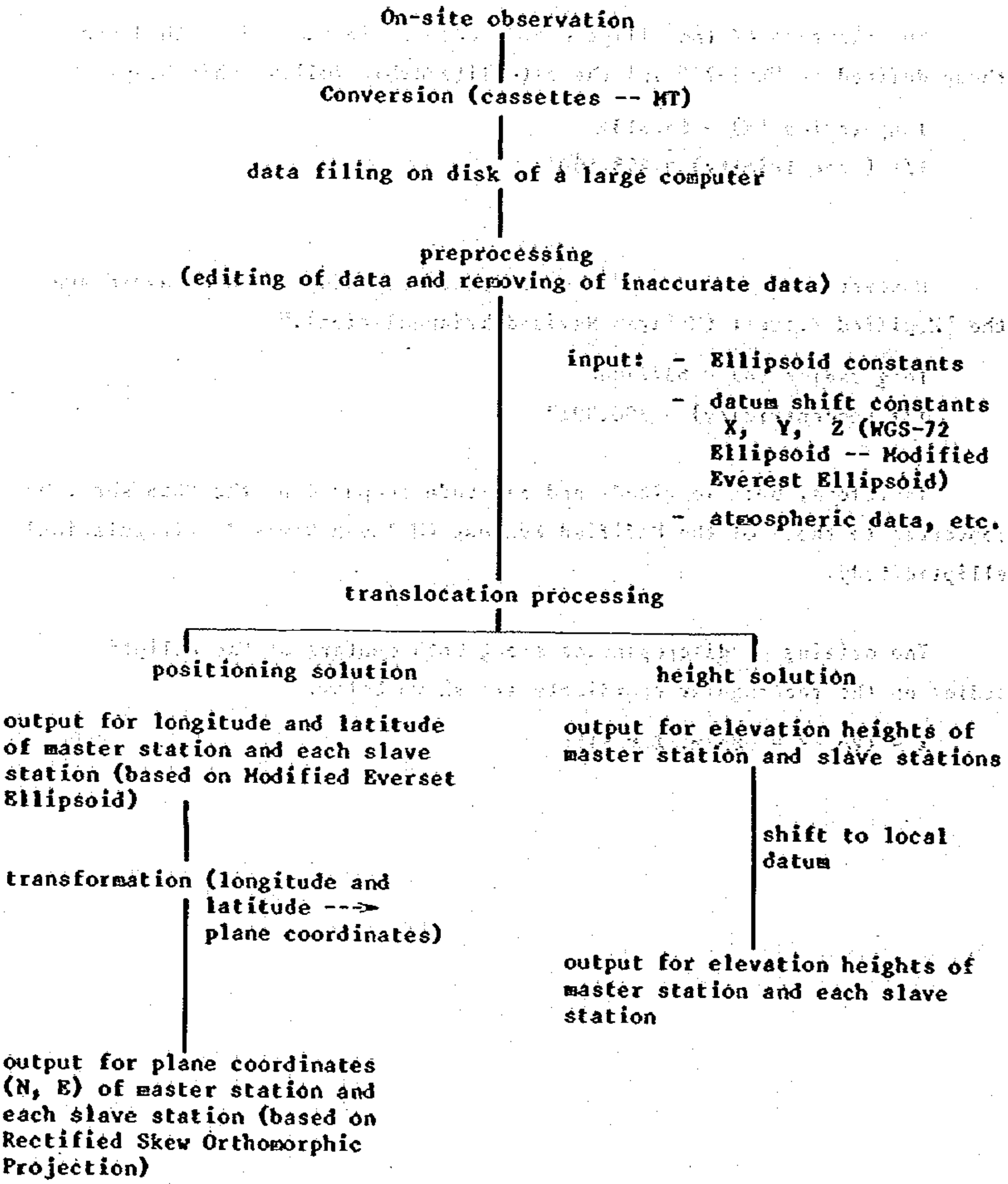
Therefore, both longitude and latitude computed by the NNSS shall be converted to those of the Modified Everest (Malayan Revised Triangulation) elliptic body.

The origins of discrepancies among both centers of the elliptic bodies on the rectangular coordiante are shown below.

X = 12m, Y = -857m, Z = -15m

Appendix

Flow Chart of Computation of Satellite Doppler Survey Data



The calculation method for coordinates is indicated as follows.

Point positioning method	Observation carried out independently at the necessary position of the coordinate.
Translocation method	Observation carried out concurrently at the necessary plural positions of the coordinate, and the coordinates of slave stations correlated with the master station retaining the interaction of stations.

Measurement procedures:

1. Foundamental coordinate was established at the master station using the point positioning method.

2. Each slave station correlated to the master station using the translocation method.

   Remarks: The elevation of the master station was correlated with the Malaysia National Bench Mark using direct leveling.

Computation is shown on the next page.

TABLES

List of Tables

Table 1.1 List of work carried out each year

PRELIMINARY INVESTIGATION STAGE (1981)	DETAILED INVESTIGATION STAGE (1982)
1. Aerial Photography Aerial photographs covering the lower dam site, upper dam site and the lower reservoir area were taken. Number of flight courses: 4 Number of photos: 72 Scale of photos: 1:20,000 Aerial camera: Wild RC-10 (focal length: 152.89 mm)	1. Aerial Photography None
2. Ground Control Survey A ground control survey was carried out for photogrammetric mapping covering the areas of the lower dam site, the upper dam site and the lower reservoir. Control points were established by means of a Satellite Doppler Positioning Survey. Aerial signals were established on these points prior to aerial photographing. Number of points: 9 (1 master station) (8 slave stations) Instrument used: JMR-3 Method of observation: Translocation Survey System	2. Ground Control Survey A ground control survey was carried out for photographic mapping covering the upper reservoir area. Control points were established by means of a Satellite Doppler Positioning Survey. These control points were indicated on the aerial photographs. Number of points: 5 (1 master station) (4 slave stations) Instrument used: JMR-3 and JMR-4 Method of observation: Translocation Survey System

PRELIMINARY INVESTIGATION STAGE (1981)	DETAILED INVESTIGATION STAGE (1982)
3. Leveling Survey A leveling survey was carried out between one of the national bench marks near Jerantutrailway station and the lower dam site. One original bench mark and one reference bench mark were established on the left bank of the lower dam site. Length of leveling: approx. 60 km	3. Leveling Survey Leveling was carried out between the bench mark established in 1981 at the lower dam site and th upper dam site, and two bench marks were established on each bank of the upper dam site. Length of leveling: 22 km
4. Longitudinal Profiling and Cross Sectioning Longitudinal profiling and cross sectioning were carried out at each site at the dam as follows: Lower dam site: - Longitudinal profiling: 400m - Cross sectioning: 3,900m Upper dam site: - Longitudinal profiling: 1,000m - Cross sectioning: 14,600m	4. Longitudinal Profiling and Cross Sectioning None
5. Traverse Survey None	5. Traverse Survey Traversing was carried out from the lower dam site to the upper dam site in order to define the relative position of the lower dam site and the upper dam site which had been fixed by means of the Satellite Doppler Positioning Survey carried out in 1981.

PRELIMINARY INVESTIGATION STAGE (1981)	DETAILED INVESTIGATION STAGE (1982)
6. Topographic Survey None	**6. Topographic Survey** A topographic survey was carried out in order to produce 1:500 scale maps covering both dam sites. Area covered: - Lower dam site: 0.5 km^2 - Upper dam site: 1.6 km^2 Mapping scale: 1:500 Contour intervals: 1m
7. Photogrammetric Mapping Aerial triangulation work and aerial mapping work were carried out. 1:500 scale maps covering each dam site and 1:10,000 scale maps covering the lower reservoir area were produced. Number of models: 64 models Mapping area: - 1:10,000 scale: 131 km^2 - 1: 5,000 scale: 15 km^2 Contour interval: 5m	**7. Photogrammetric Mapping** Aerial triangulation work and mapping work are presently being carried out. 1:10,000 scale maps covering the upper reservoir area will be completed by the middle of February 1983. For this work, 1:25,000 scale aerial photographs taken in 1966 are being used. Number of models: 110 models Mapping scale: 1:10,000 Mapping area: 300 km^2 Contour interval: 10m

Table 1.2

MESSRS.

SCHEDULE OF SITE INVESTIGATION (1981)

SHEET ____ OF ____

NO.

DATE

DIV.

CHECKED BY

PROJECT: CONTRACT NO.

TEKAI HYDRO ELECTRIC POWER DEVELOPMENT PROJECT, FEASIBILITY STUDY

ITEM	June	July	August	September	October
1. Direct Levelling					
(Jerantut KBM+167,582)					
Lower Dam Site)					
2. Cross Sectioning and					
Longitudinal Profilling					
- Upper Dam Site					
- Lower Dam Site					
3. Satelite Doppler (NNSS)		SS-7,8,6,1,5			
- Target Installation		SS-4,2,MS	SS-3		
		MS MS MS	MS MS MS	MS MS	
- Measurement of NNSS		SS-7 SS-8 SS-6	SS-5 SS-3 SS-2	SS-1 SS-4	
4. Aerial Photography					

NOTE.

|——| : Site Work

|– – –| : Preparation and Office Work

MS : Master Station (NNSS)

SS-1 : Slave Station No.1

SHEET ______ OF ______

Table 1.3

SCHEDULE OF SITE INVESTIGATION

MESSRS. ______

NO. | DATE | DIV. | CHECKED BY

PROJECT: CONTRACT NO. ______

TEKAI HYDRO ELECTRIC POWER DEVEROPMENT PROJECT, FEASIBILITY STUDY

ITEM	May	June	July	August	September	Octorber	
1. Direct Levelling							
(LOwer Dam Site							
Upper Dam Site)							
2. Satelite Doppler (NNSS)							
- Measurement of NNSS			MS SS-9	MS SS-11 MS SS-12 MS SS-10			
3. Traverse Survey							
4. Topographic Survey							

NOTE:

——— : Site Work

— — — : Preparation and Office Work

MS : Master Station (NNSS)

SS-1 : Slave Station

Table 3.1 TABLE FOR COORDINATES AND ELEVATION HEIGHT OF SATELLITE DOPPLER SUREY STATIONS

STN NO.	LATITUDE			LONGITUDE			COORDINATES		HEIGHT (ON THE PEG)
	DEG	MIN	SEC	DEG	MIN	SEC	NORTHING (M)	EASTING (M)	
MS	4	14	47.595	102	24	24.712	469648.950	490314.373	68.49
SS-1	4	15	50.747	102	28	38.789	471576.040	498150.328	390.69
SS-2	4	10	33.331	102	33	42.916	461815.002	507512.656	83.60
SS-3	4	11	0.230	102	31	48.958	462645.443	503999.877	188.03
SS-4	4	10	50.344	102	29	56.063	462347.037	500518.670	74.91
SS-5	4	11	12.255	102	28	24.541	463024.198	497697.923	73.33
SS-6	4	12	14.074	102	27	26.239	464925.440	495903.348	62.82
SS-7	4	14	47.216	102	22	25.678	469643.329	486644.646	55.36
SS-8	4	20	8.334	102	24	0.791	479500.004	489592.943	59.43
SS-9	4	22	58.419	102	24	7.621	484723.031	489811.929	77.68
SS-10	4	25	41.724	102	27	15.264	489729.048	495603.577	74.72
SS-11	4	5	56.019	102	39	53.347	453282.224	518922.281	128.37
SS-12	4	12	18.506	102	39	36.123	465029.216	518406.678	172.74

Table 6.1 Location of Bench Marks

	No.	N	E	LONGITUDE	LATITUDE	ELEVATION
UPPER TEKAI	UBM-1	462991.00	503932.00	102 31 46.739	4 11 11.443	105.839
	UBM-2	462981.00	503937.00	102 31 46.902	4 11 11.119	105.111
	UBM-3	462811.00	503911.00	102 31 46.066	4 11 5.604	98.436
	UBM-4	462809.00	503874.00	102 31 44.866	4 11 5.537	96.174
	UCR	463009.00	504142.00	102 31 53.549	4 11 12.037	154.153
	UCL	462670.00	504007.00	102 31 49.187	4 11 1.035	114.020
LOWER TEKAI	BH	469138.00	492056.00	102 25 21.230	4 14 31.053	111.748
	BMJK1	469355.00	492051.00	102 25 21.057	4 14 38.092	92.928
	BMJK2	469146.00	492049.00	102 25 21.003	4 14 31.313	109.022

UPPER TEKAI LOCATION OF BORE-HOLE AND TEST-PIT

No.	N	E	LONGITUDE	LATITUDE	ELEVATION
U-1	462719.00	504045.00	102 31 50.417	4 11 2.626	159.46
2	462797.00	504091.00	102 31 51.905	4 11 5.158	100.13
3	462869.00	504131.00	102 31 53.199	4 11 7.495	72.69
4	462914.00	504155.00	102 31 53.975	4 11 8.956	99.35
5	463003.00	504204.00	102 31 55.560	4 11 11.845	150.13
UD-1	462787.00	504268.00	102 31 57.647	4 11 4.842	75.83
2	462774.00	504161.00	102 31 54.177	4 11 4.416	76.81
3	462838.00	504188.00	102 31 55.049	4 11 6.493	74.55
4	462697.00	504018.00	102 31 49.542	4 11 1.911	173.37
5	462790.00	504055.00	102 31 50.738	4 11 4.929	114.02
6	462833.00	504072.00	102 31 51.287	4 11 6.325	75.07
7	462917.00	504106.00	102 31 52.386	4 11 9.051	86.92
8	462988.00	504134.00	102 31 53.291	4 11 11.355	138.96
9	462915.00	503841.00	102 31 43.791	4 11 8.973	72.00
10	462666.00	504319.00	102 31 59.306	4 11 0.920	96.12
11	462789.00	504240.00	102 31 56.738	4 11 4.906	126.00
12	462720.00	503820.00	102 31 43.119	4 11 2.648	94.00
13	462739.00	503743.00	102 31 40.621	4 11 3.260	96.66
14	462734.00	503898.00	102 31 45.648	4 11 3.106	109.68
15	462785.00	503773.00	102 31 41.592	4 11 4.754	93.27
.16	463046.00	504188.00	102 31 55.039	4 11 13.239	72.42
17	463007.00	503841.00	102 31 43.787	4 11 11.957	102.32
18	462901.00	503780.00	102 31 41.813	4 11 8.516	74.67

No.	N	E	LONGITUDE	LATITUDE	ELEVATION
UQ-1	462882.00	503476.00	102 31 31.954	4 11 7.886	132.56
2	463244.00	503237.00	102 31 24.185	4 11 19.615	164.31
3	463453.00	503103.00	102 31 19.829	4 11 26.388	234.87
4	463070.00	503213.00	102 31 23.415	4 11 13.971	121.32
5	463360.00	503015.00	102 31 16.979	4 11 23.367	195.05
UB-1	462746.00	504862.00	102 32 16.914	4 11 3.541	164.61
2	462831.00	504805.00	102 32 15.062	4 11 6.295	149.59
3	462966.00	504770.00	102 32 13.920	4 11 10.672	127.79
4	462698.00	504712.00	102 32 12.052	4 11 1.977	135.47
5	462836.00	504616.00	102 32 8.931	4 11 6.448	77.25
6	462954.00	504532.00	102 32 6.201	4 11 10.271	107.10
P-1	462738.00	504835.00	102 32 16.039	4 11 3.280	170.24
2	462711.00	504750.00	102 32 13.283	4 11 2.400	144.65
3	462914.00	504848.00	102 32 16.452	4 11 8.989	141.83
4	462881.00	504744.00	102 32 13.081	4 11 7.914	134.70
5	462984.00	504836.00	103 32 16.060	4 11 11.259	112.56
6	462955.00	504721.00	102 32 12.331	4 11 10.313	120.54
7	463062.00	504846.00	102 32 16.380	4 11 13.789	93.05
8	463031.00	504750.00	102 32 13.268	4 11 12.779	101.86
9	463016.00	504704.00	102 32 11.777	4 11 12.290	105.61
10	462785.00	503139.00	102 31 21.029	4 11 4.723	87.08
11	462746.00	503083.00	102 31 19.214	4 11 3.456	84.18
12	462885.00	503118.00	102 31 20.343	4 11 7.966	113.93
13	462807.00	503072.00	102 31 18.854	4 11 5.434	84.82

Tables

No.	N	E	LONGITUDE	LATITUDE	ELEVATION
Q-14	462954.00	503039.00	102 31 17.777	4 11 10.200	112.92
15	462893.00	502946.00	102 31 14.764	4 11 8.217	92.71
16	463094.00	502977.00	102 31 15.759	4 11 14.738	140.36
17	463046.00	502913.00	102 31 13.686	4 11 13.178	132.15

LOWER TEKAI

No.	N	E	LONGITUDE	LATITUDE	ELEVATION
L-1	469151.00	492049.00	102 25 21.003	4 14 31.475	109.42
2	469236.00	492050.00	102 25 21.031	4 14 34.232	55.13
3	469302.00	492051.00	102 25 21.060	4 14 56.373	72.60
4	469374.00	492052.00	102 25 21.088	4 14 38.708	98.22
LD-1	469243.00	492117.00	102 25 23.204	4 14 34.462	55.28
2	469082.00	492048.00	102 25 20.974	4 14 29.237	126.09
3	469200.00	492047.00	102 25 20.935	4 14 33.064	63.79
4	469276.00	492052.00	102 25 21.093	4 14 35.530	59.40
5	469337.00	492051.00	102 25 21.058	4 14 37.508	87.77
6	469415.00	492053.00	102 25 21.119	4 14 40.038	114.40
7	469310.00	492002.00	102 25 19.470	4 14 30.630	64.34
8	469311.00	491970.00	102 25 18.432	4 14 36.661	59.31
9	469271.00	491956.00	102 25 17.980	4 14 35.362	54.80
10	469342.00	491884.00	102 25 15.641	4 14 37.662	57.50
11	469349.00	492129.00	102 25 23.587	4 14 37.901	78.95
12	469425.00	491944.00	102 25 17.583	4 14 40.357	88.52
13	469412.00	491847.00	102 25 14.437	4 14 39.930	76.17
LQ-1	470038.00	491894.00	102 25 15.929	4 15 0.238	124.69
2	469959.00	491983.00	102 25 18.820	4 14 57.680	139.40
3	469983.00	491845.00	102 25 14.342	4 14 58.452	97.43
4	469885.00	491921.00	102 25 16.813	4 14 55.277	107.72
5	469899.00	492054.00	102 25 21.126	4 14 55.738	107.63
6	470012.00	492026.00	102 25 20.212	4 14 59.402	103.49