Report on Topographic Mapping Project for Musoma Area, Republic of Tanzania

(Second Year)

(Part I) Field Operations
- Levelling (Second-order levelling)
- Eccentric Pricking
- Field Identification Work

(Part II) Survey Work Conducted in Japan
- Aerial Triangulation
- Compilation Work

March 1975

Japan International Cooperation Agency

Location Map of Project Area

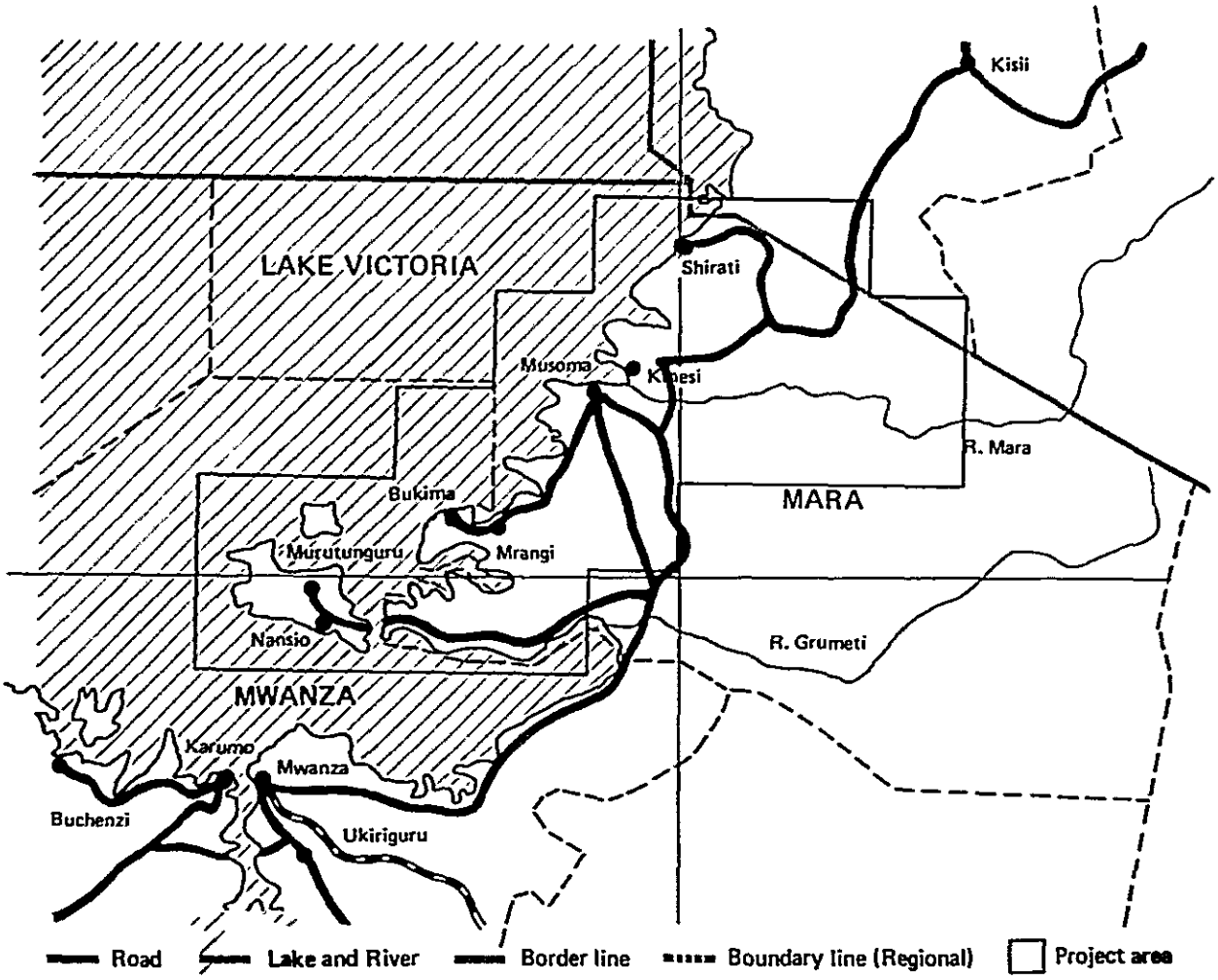
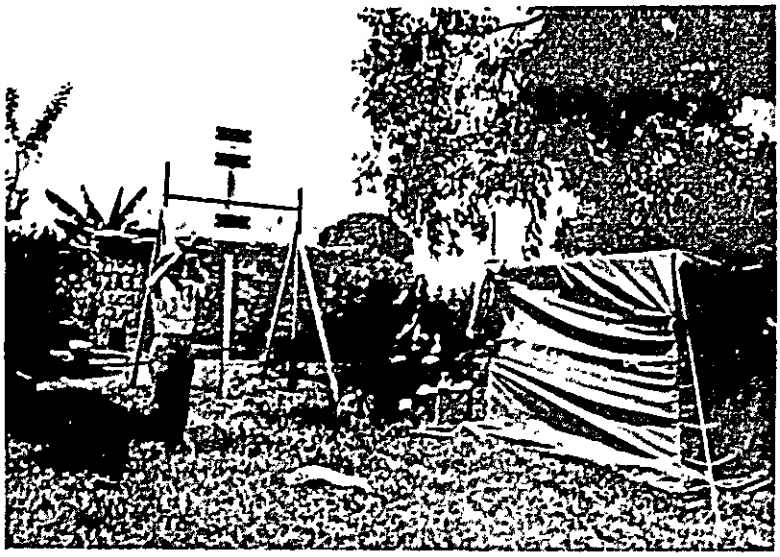


Photo point survey



Cross-water levelling

Second-order levelling

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogan, President
Japan International Cooperation Agency

The Report on the Second Year Survey Work of the Musoma Area of Tanzania Topographic Mapping Project, carried out from F.Y. 1973 in compliance with your request, is herein submitted to you.

In this report are clarified the contents of Second Year Survey Works (levelling, eccentric pricking, field identification, aerial triangulation, and plotting). I feel confident that the results of the survey techniques conducted by the despatched survey group during the said period will largely contribute to future development plans for the Musoma Area and to improvement of the Tanzania survey techniques.

I hereby express my heartfelt gratitude to Mr. J. Daniel, Director of the Survey & Mapping Division, Ministry of Land, Housing & Urban Development of the Republic of Tanzania, the Division personnel, the officials of the Japanese Embassy in Tanzania, and the Japan Overseas Cooperation Volunteers who cooperated with us during the field survey period and in drawing up this report. At the same time, I hope that the third year (final year) survey projects will be conducted without delay.

March 1975

Juhei Kobayashi

Juhei Kobayashi
Leader, Topographical Mapping Group of the Musoma Area, TANZANIA
International Engineering Consultants Association

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Part II

(Part I)

Field Operations

Levelling (Second-order levelling)

Eccentric Pricking

Field Identification Work

1. SUMMARY OF FIELD OPERATIONS

1.1 Objective

Implementation of the field survey (Phase II) scheduled as the second-year activity of the map preparation project for the Musoma Area of Tanzania (scale: 1:50,000), a project which has been initiated in 1973 as a technical co-operation program between Japan and the Republic of Tanzania.

1.2 Project Area

Approximately 12,730km²

1.3 Period

From: June 13, 1974
To: November 1, 1974
(Covers from date of the advance party's departure from Japan to date of the last element's return to Japan inclusive.)

1.4 Work Classification and Workload

a. Second-order levelling	
(1) Recovery of first-order bench marks	30km
(2) Establishment of second-order bench marks	98 points
(3) Second-order levelling observations and calculations	704km
(4) Differential survey of station markers	4 points
(5) Observations of water level (Lake Victoria)	3 sites
(6) Observations for closure of tide gauge (Lake Victoria)	1 site
(7) Cross-water levelling	1 site
b. Photo point survey	
(1) Photo point survey	9 points
(2) Pricking and eccentric observations	73 points
(3) Observations of magnetic declination	41 points
c. Field identification	Approx. 12,730km²

1.5 Weather Condition During Survey Period

	Jun	Jul	Aug	Sep	Oct	Nov	Total	%
Fair	9	19.5	25	18	25	1	97.5	68.7
Cloudy	9	8.5	3.5	8	4	0	33	23.2
Rain	0	3	2.5	4	2	0	11.5	8.1
Total	18	31	31	30	31	1	142	100.0

1.6 Conditions of Project Area

a. Understanding of local inhabitants toward the topographic mapping project
Since this was the second-year activity, the residents of Musoma City have generally displayed better understanding toward the project compared with last year. However, once out of Musoma, owing to poor dissemination of the project's objective and scope, the survey party was often questioned by inhabitants as to the purpose and nature of the survey. Nevertheless, upon learning the objective and importance of the

survey, they voluntarily provided necessary information to the survey party.
To assure safety of the surveying members while surveying the Tanzania-Kenya border, a request for escort service was made to the local Tanzanian authority, which was refused on the grounds that such a service was deemed unnecessary. Therefore, accompanied only by locally hired field assistants, the survey party executed a survey along the border area. Since some of the survey party members spoke Swahili, no trouble worth reporting occurred, although the survey party experienced difficulties communicating in Swahili with local tribesmen since they did not understand that tongue.

b. Surveying inside Kenya
Concerning survey activities to be executed inside the Kenyan territory, prior agreement had been reached between the two governments concerned, and the Kenyan Government was informed in advance of the survey party's exact date and place of entry into Kenya. However, owing to poor communications between the central and the local immigration authorities, the entry process was somewhat delayed. The survey party thereafter encountered absolutely no difficulty, and all aspects of the survey work were accomplished as scheduled, supported by excellent assistance rendered by the local Kenyan authority.

c. Co-operation rendered by local Tanzanian Government Agencies
Local administrative offices, the police, post office, and so on located in the Musoma Area voluntarily provided much information necessary for surveying activities, thereby contributing to the successful accomplishment of the project. The project area was under a military alert owing to a tense international situation, but the alert neither imposed a problem regarding surveying work nor restricted daily activity of the survey party members.

d. Hiring of field assistants
Assisted by local government agencies, the survey party had no difficulties in hiring local inhabitants as field assistants.

e. Construction of Ujamaa villages
In conformity with the national policy of Tanzania, large-scaled construction of Ujamaa villages was underway in the project area. Some 300 Ujamaa villages have already been constructed since 1973 and more are projected to be constructed in the coming years. These Ujamaa villages, nonexistant when the aerial photographs were taken in 1973, imposed a problem, adding a heavy burden to this year's survey. Since data on newly constructed Ujamaa villages were not available, the survey party made a field investigation to determine the actual status of these Ujamaa villages, and information on them was properly recorded. At the same time, abandoned houses were eliminated from the previous data as much as possible.

f. Electric and telephone facilities
At present, a thermo-power station located in Musoma City supplies electricity only to the main sector of the city. However, the service area is expected to soon be expanded to the Tarime and Butiyama areas. Telephone service is open between Musoma and Mwanza and Musoma and Butiyama, while installation of telephone lines to Tarime is being contemplated. Telephone calls to Dar es Salaam are made via Mwanza, but it is difficult to get through owing to frequent interruptions or bad connections.

g. Road conditions

Owing to the late arrival of the dry season in 1974, all road surfaces were heavily damaged by rain streaming over roads, causing many accidents from overturned land cruisers. Further, inadequate road repair work after the dry season arrived made it difficult to drive, not to speak of the suffocating heavy dust. In general, the project area has a relatively dense road network, but not many roads are passable.

h. Procurement of supplies and materials

Provisions and daily necessities were locally available at Musoma, whereas certain articles were difficult to obtain at outlying sub-camps. The Base Camp in Musoma had a more than adequate water supply, but sub-camps encountered a water problem. Although all sub-camps were established in areas where water service was available, the survey party members had to haul water to the camp sites, creating a great inconvenience. Particulary, at Migori, Kenya, members prepared potable water by boiling and filtering water from an artesian well.

Gasoline—an essential item for accomplishing field surveys—rose 30% in price compared with last year and was often sold out. Since procurement of gasoline at sub-camp sites was rather difficult, operational vehicles always carried a reserve drum of gasoline. The majority of spare parts required for vehicle maintenance were not available at Musoma; consequently, when these parts were not readily available even at Mwanza, they were purchased at Arusha, Dar es Salaam, or Nairobi.

i. Operational assistance

At the outset of the survey, by order of the Director, Tanzanian Survey Division, Mr. Mchatta, Technical Advisor to the Survey Division, accompanied the main survey party from the day of its departure from Dar es Salaam on June 22nd until July 6th. While in Musoma, in addition to participating in detailed planning of the survey work and co-ordinating the views of surveyers, Mr. Mchatta acted as a mediator in negotiating with local Tanzanian government officials as well as local civilian leaders. In Musoma City, Mr. Sikukuu, Chief of the Survey Division Musoma Branch, rendered all possible assistance to the Survey party—as he did last year. He wholeheartedly assisted the survey party in many aspects, advising the survey party on administrative matters incidental to hiring field assistants, co-ordinating opinions and views, rendering service in obtaining necessary reference data, negotiating the survey party's entry into Kenya, renting boats from the regional government, and communicating with the Survey Division Head Office in Dar es Salaam.

2. PREPARATION FOR SURVEY WORK

2.1 Encampment

Upon arriving at Musoma on June 20th, the advance party immediately commenced work for establishing the Base Camp at the same location as last year. Necessary preparations such as cutting grass to clear the camp site had been completed by Mr. Sikukuu in advance. The advance party, for the time being, erected enough tents to support their own activities and commenced camp life from June 21st. Also, for receiving incoming mail from Japan, P.O. Box 399 Musoma was re-rented from July 29th.

2.2 Hiring of Field Assistants

A total of 32 field assistants were hired, one from Dar es Salaam and 31 from Musoma. Field assistants included interpreters and guides. On July 1st, at the Base Camp, a labor contract was concluded in the presence of Mr. Sikukuu. Those field assistants who worked until June 30 were all hired on a temporary basis.

2.3 Organization of Survey Teams

The field survey party was first divided into the second-order levelling group, eccentric pricking group, and photo field identification group according to the work functions. Each group was then divided into teams as follows:

Second-order Levelling Group

- Team 1: Kiyoshi Yoshioka, Hideo Yoshida
- Team 2: Ryoichi Kawakami, Takeyoshi Masuda
- Team 3: Masuo Iijima, Takeyoshi Ikoda
- Team 4: Takamichi Fukuoka, Seiichiro Nishiyama

Photo Field Identification

- Team 1: Toshiyuki Harada, Takashi Oguri
- Team 2: Eiji Shibata, Fumio Yamaguchi
- Team 3: Minoru Arai, Hiromutsu Oka
- Team 4: Masami Yamamoto

Eccentric Pricking Group

- Team 1: Takashi Aoki, Isao Inoue, Hiroshi Kodama

2.4 Flight Survey

On June 25th and 26th, employing a Cessana plane belonging to Tim Air, which flew Mr. Wakui, Survey supervisor, and the Main Camp members from Dar es Salaam, Mr. Wakui and the Photo Field Identification Group members conducted reconnaissance of areas which denied physical entry such as an extended marshy area located in the upper reaches of the River Mara. The reconnaissance flight was conducted twice for approximately two and a half hours, with flight altitudes ranging from 300 to 400 meters. This reconnaissance flight was extremely helpful in determining the present status of terrain features,roads, vegetation, and so forth as well as in comprehending the progress of Ujamaa village construction commenced in 1973 and the status of collective migration effected by various villages.

3. SECOND-ORDER LEVELLING

3.1 Reconnaissance of Levelling Routes

Since the second-order levelling routes were surveyed prior to terminating the first-year project, and these routes as well as the total route distance of 680km had already been acknowledged by the Government of Tanzania, only those roads passable during the dry season were surveyed this year.

3.2 Selection of Levelling Points

While giving due consideration to preservability, accessibility, and detectibility of bench marks, levelling points were selected along the levelling routes at 10km intervals and at intersections, and at prominent locations within cities and villages. As a result, the mean

distance between two levelling points became 7.2km, with total levelling points numbering 98. In selecting levelling points, Mr. Mchatta, Technical Advisor to the Survey Division, explained the wishes of the Tanzanian Government as well as provided necessary instructions. The levelling point net is provided in Appendix 1.
The system of the Tanzanian Government Survey Division was followed in naming the levelling points. These terms included the name of the nearest first-order levelling route, category of levelling point, and serial number.
For instance—

H/57A/2/1

where,

H/57A ..... First-order levelling route number
2 ..... second order
1 ..... serial number

3.3 Monumentation

The monuments were established based on specifications prescribed by the Survey Division, and monuments in normal terrains were established at 91 points and monuments in rocky terrains were established at seven points.
Concrete beacons with countersunk metal tacks were employed as monuments in normal terrains. For monuments in rocky terrains, holes were chiseled in the rock, into which metal tacks were directly cemented. Sectional drawings and plans of the two types of monuments are provided in Appendixes 2 and 3.

3.4 *Observations*

Employing a CARL ZEISS N:2 and its attachment staff, reciprocal observations were conducted. Also, atmospheric temperature was observed both at levelling points and fixed points. The observed values were entered in the field notebook either by the recorder or the observer, and the observation final result table was tabulated at the Base Camp. A field check of entries was conducted twice by the supervisor and a person other than those making entries.
For accomplishing the levelling work, five sub-camps were established within the survey area.

3.5 Field Calculation

By effecting temperature correction of the staff and orthometric correction of the observed values through field calculation, it was determined that both the reciprocal observation error and the circulatory closure error were within the allowable limits. The final observation results were calculated in Japan by an electronic computer.

3.6 Cross-water Levelling

Cross-water levelling was conducted between Kisoria in the Musoma Area and Ukerewe Island, a distance covering approximately 4km. Selection of cross-water levelling points and monumentation were performed under the guidance of Mr. Wakui, Survey Supervisor. Monumentation was conducted in the manner similar to monumentation of the second-order bench marks. After considering various factors such as preservability of the bench marks, the levelling point on Ukerewe Island was established on top of a rock located on the side of the ferryboat waiting room. One

auxiliary levelling point was also established.
Employing a WILD N3, 10 sets of simultaneous observations were conducted from both shores (Kisoria and Ukerewe Island), these 10 sets of simultaneous observations constituting half a group. One full group of observations was obtained by combining this half group with another half group of observations conducted at isochronal times (1300 hours was used as a basis for establishing the isochronal time). Twelve groups of observations were made in three days, mutually switching observers and equipment on both shores at noon.
Observed results and subsequent calculation figures were entered in the prescribed field notebook, which were inspected twice by the observer and the supervisor on the spot. For switching observers and equipment, a boat leased by the Musoma Regional Commissioner was used.

3.7 Simplified Tide Observations and Closure of Existing Tide Gauge

Simplified tide observations were conducted at three stations around the clock at one-hour intervals for two days. A mean value of tide was obtained by calculating the results of 48 observations made in two days. The simplified tide stations were closed on the nearest second-order bench mark.
The existing tide gauge located in Musoma was closed on the first-order bench mark H/57C/14 by employing a WILD N3.
The average water level of Lake Victoria was obtained by computing values obtained through observations at three simplified tide stations; observations conducted from September 23rd through 25th.

3.8 Levelling Observations of Station Markers

Of the four traverse points used for closing levelling station markers, two of them (5-ST-2 and 11-ST-2) were closed on the second order levelling route by direct means, whereas closure of the remaining two traverse points (5-ST-7 and 13-ST-4) were effected from the nearest second-order bench mark, using the same observatory method and restrictions applied to conducting second-order levelling. Appendix 4 provides a comparison table of direct levelling and indirect levelling values.

3.9 Recovery of First-order Bench Marks

Nine first-order bench marks, to be used as the given points in the 1974 survey work, were inspected to determine secular changes of their physical features and abnormalities. As a result, they all were determined to be in satisfactory condition. Appendix 5 provides a comparison of the observed elevation (by 2nd-order levelling) and the adjusted elevation (1st-order levelling).

3.10 Pricking

To assist in subsequent aerial triangulation and plotting work, the first-order levelling points and the second-order levelling routes were pricked on the double-enlarged aerial photographs. For the second-order levelling routes, pricking was effected every 2km. The elevations of pricking points were also calculated. Only those levelling points and levelling routes of which locations were clearly identifiable and which were situated in less accidented areas were pricked.
For calculating elevation of pricking points, observed values of the second-order levelling were used.

4. ECCENTRIC PRICKING (ECCENTRIC PRICKING AND ESTABLISHMENT OF ADDITIONAL PHOTO POINTS)

4.1 Selection of Pricking Points

Eccentric pricking points were selected from among planimetric features clearly interpretable as well as identifiable on aerial photographs. Pricked were those signals which were clearly identifiable on aerial photographs plus those triangulation points of which locations were actually confirmed through field identification work while comparing with the aerial photographs. A total of 73 triangulation point prickings and eccentric prickings, 13 more than the scheduled 60 points, were conducted. Initially, plotting was to be conducted by obtaining data on the adjoining area located southeast of the project area, surveyed by Finmap (a Finnish survey firm). However, since the Finmap data was not available, a total of 13 points—9 points inside the Kenyan territory, two control points established by Finmap, and two photo points—were added (see the survey network provided in Appendix 6). More than two points including one auxiliary point were pricked for eccentric pricking. By consulting aerial photographs, clearly identifiable planimetric features were selected as the photo points.

4.2 Observations

Three different methods of observations—depending upon the eccentric distances—were employed in observing each eccentric pricking point. To conduct eccentric pricking observations, the Pricking Team established six sub-camps within the project area.

- For those eccentric pricking points having less than 35m eccentric distances, a plane-table and a steel tape were employed. Eccentric distances were measured three times with a steel tape. Eccentric directions and relative elevations were observed by an Alidate two and three times respectively. After completing the required numbers of observations, their mean averages were computed.
- For those pricking points having eccentric distances of 25 to 100m, the WILD T3 and a steel tape were employed. Eccentric distances were measured in three pairs with the steel tape; and eccentric directions and relative elevations were observed with the WILD T3 in two pairs and three pairs forward respectively.
- For those pricking points having eccentric distances of 100m or greater, the WILD T3 and a tellurometer MRA 101 were employed. Eccentric distances were measured in two sets (40 fine readings) both backward and forward (one set consists of two coarse readings and ten fine readings).
  Also, atmospheric temperature observations were conducted concurrently to effect temperature correction of the observed values. Employing the WILD T3, eccentric directions were observed in two pairs and relative elevations were observed in two pairs both backward and forward.
- Observations of photo points were conducted in a manner identical to that of the 1973 survey.

The observed results were entered in the prescribed field notebook by the recorder, and field inspection of the entries was conducted in the manner similar to levelling work. Compilation of the observation record sheets and calculation were conducted at the Base Camp, inspected twice, and then shipped to Japan.

4.3 Rough Calculation in Field

Rough field calculation was conducted by applying temporary co-ordinates of the second-order traverse points and the photo points obtained during the 1973 survey.

5. PHOTO FIELD IDENTIFICATION

5.1 Preliminary Survey

Following establishment of the Base Camp, to complete the preliminary survey work started in Japan, the Photo Field Identification Group conducted preliminary survey in the field, adding newly obtained data in the field.

5.2 Consolidation of Views Prior to Commencing Survey

From June 22nd to July 6th, Mr. Mchatta remained in Musoma to co-ordinate activities with the survey party members. Prior to commencing the photo field survey work, acting in behalf of the Director of the Tanzanian Survey Division, he co-ordinated views of both sides—the Tanzanian Survey Division and the Japanese Survey Party—on various matters related to field identification work including survey particulars and items to be entered on the maps. Later on, after selecting a terrain feature typical of the project area, Mr. Mchatta and members of the Photo Field Survey Group conducted a two-day joint field identification survey to co-ordinate views, survey standards, and so on. Teams under the Photo Field Identification Group, each team consisting of one interpreter (Japanese), one surveyor (Japanese), one guide, and one field assistant, conducted surveys of their assigned sectors.

5.3 Field Identification

As already mentioned, large-scale construction of Ujamaa villages has been underway in the project area since 1973. On the other hand, as the construction progressed, old villages were gradually razed or evacuated. To bring data up to date, following the field survey, those razed villages shown on the aerial photographs were deleted and newly constructed Ujamaa villages were properly recorded. According to Tanzanian sources, more than 300 villages in the Musoma Area alone were to be removed in 1973 and 1974. Since the field survey entailed covering a vast area of 12,730km^2, the project area was divided into six districts, and a sub-camp was established in each district, with the exception of the Musoma District. Boats were leased from the Regional Commissioners of Musoma and Mwanza to transport the survey team and equipment to Ukerewe Island.

5.4 Arrangements

Using uniform diagrams, symbols, and annotations, all observed data were properly arranged and entered on the photographs. Since only three linguist surveyors were assigned to the entire Photo Field Identification Group, a four-day rotation system was adopted. Under this rotation system, three of the four teams went out in the field daily, while one team remained at the camp site to put the observed data in order. Each team, in turn, remained at the camp site every fourth day to consolidate and to correlate the observed data. Also, one day a week was set aside as a general arrangement day to consolidate views, entry method, and so forth with all teams participating.

5.5 Collection of Data

In parallel with the field work, attempts were made to collect data necessary for the field identification work and plotting work from local government agencies, but attempts were fruitless, resulting in only few data of some value being collected.

6. OPERATIONS INSIDE KENYA

Upon arriving at Dar es Salaam, the advance party held a meeting with Mr. Daniel, Director, Tanzanian Survey Division. At this meeting, a plan to enter Kenya on August 1st to conduct reconnaisance and pricking work was outlined for him. Also, Mr. Daniel was requested to take necessary action to acquire entry permits as well as control point data from Kenya.

On July 25th, Mr. Mchatta personally made a trip to Nairobi, consulted with the Director of the Kenya Survey Division on both requests made by the advance party, and returned to the Musoma Base Camp with a permit authorising the survey members to conduct a survey inside Kenya and to record the control point data. Mr. Buso, Deputy Leader of the Survey party, and Mr. Iijima immediately held a meeting with Mr. Sikukuu to make final arrangements for a survey inside Kenya. On the morning of August 2nd, a 12-man survey group, comprised of Mr. Buso, Mr. Iijima, a seven-man field identification team, and the three-man pricking team departed for Kenya from Musoma. At 1100 hours, the group arrived at Sirari and started the entry process. However, the group's entry into Kenya was refused by Kenyan Immigration authorities on the grounds that the Immigration Office was not in receipt of instructions to let them enter the country and that the permit produced by the survey group was not considered an official entry permit. The survey group explained to the immigration officials the nature, extent, and significance of the survey to be conducted inside Kenya and persistently demanded approval of their entry. Meanwhile, the Kenya local Immigration Office attempted to contact Nairobi by radio, but communication was not possible. Compelled by unavoidable circumstances, the survey group reluctantly discontinued negotiations at 1630 hours and returned to Tarime. Fearing that the waiting period at Tarime might be prolonged, the survey group established a sub-camp in Tarime, hastely obtained data on the Tarime District, and commenced survey work. At the same time, Mr. Sikukuu was requested to negotiate with the Kenya authorities for the survey group's entry into Kenya. Mr. Sikukuu personally made a trip to Kenya to negotiate with the Kenya Government authorities concerned, and permission for the survey group's entry into Kenya was granted on August 10th. On the morning of August 12th, the survey group departed for Kenya, but their entry was again rejected by local Kenyan immigration authorities owing to poor communications between the Kenyan Central Government and the local Immigration Office. At 1400 hours on the same day, the survey group was finally permitted to enter Kenya. Upon entering the Kenyan territory, the survey group immediately established a sub-camp at a location designated by the Chief, Kenyan Survey Division Migori Branch, and commenced operations from the next day (13th). Despite the many difficulties encountered before entering Kenya, the survey work inside Kenya was conducted at appreciably fast speed owing to all-out co-operation rendered by the Kenya Government, completing the entire phases of survey on August 22nd, ahead of the scheduled date.

On the morning of August 13th, the day after their entry into Kenya, Survey Party Deputy Leader Buso and Mr. Iijima paid a courtesy call on the local Kenyan Government administrative agency in Migori and later held a meeting with the Chief, Kenyan Survey Division Migori Branch, to coodinate survey activities to be conducted inside Kenya. In the afternoon of the same day, they left for Nairobi, paying courtesy calls on the Kenyan Survey Division Head Office and the Japanese Embassy. They received necessary data from the Director, Kenyan Survey Division, and returned to the Migori sub-camp on the 15th.

7. CALCULATION AND EDITING

7.1 Precise Calculations of Traversing

Precise calculations of traverse points surveyed during the 1973 survey were effected by applying the results of the differential levelling conducted this year (1974). For elevations of first-order triangulation points, both previously measured elevations and newly measured elevations were listed together with annotations indicating the year calculations were effected. Adjustment computation of traverse points was conducted in two stages--program TR51 for Stage I and program TR52 for Stage II.

7.2 Computation of Photo Points

Using calculated results of second-order traverse points, photo points were computed by applying the same programs employed for traverse points.

7.3 Calculation of Eccentric Pricking Points

Final results of eccentric pricking points were computed through applying the final results of second-order traverse points and photo points.

7.4 Second-order Levelling

Results of the first-order levelling conducted from Seronera to Bunda during the 1973 survey produced a 1.95m difference at F.B.M. Bunda. Through a fact-finding investigation conducted by the Tanzanian Survey Bureau, an error of 1.171m was determined, and a new elevation was given to F.B.M. Sernera by the Tanzanian Government. Based on the new elevation, data on first-order levelling conducted during the 1973 survey were re-computed, resulting in a difference of only 0.78 at F.B.M. Bunda. This discrepancy is believed to have been caused by a difference in tide levels of the tide stations involved.

Adjustment computation of the second-order levelling conducted this year was effected by recomputing the results of the first-order levelling points (surveyed by Finland) with Tanga as the datum and using these recomputed results as the given points. Thus, the Tanga height became the common datum for all elevations in the project area. Datum reduction was effected per instructions of the Tanzanian Government.

7.5 Description of Survey Points

Second-order levelling points were described by referring to the results of field identification work and appropriate aerial photographs. A description of second-order traverse points was also completed by entering the final results of second-order traverse points obtained during the 1974 survey.

7.6 Editing of Photo Field Identification Results

Upon returning to Japan, the Photo Field Identification Group re-inspected all entries made on photographs.

8. PASCO'S VIEW ON THE THIRD YEAR SURVEY

Matters requiring serious consideration in conducting the 1975 field supplementary survey and inspection work are as follows:

8.1 Operational Matters

a. In reference to administrative boundaries, it is presumed that those data to be received by PASCO some time this year will not provide sufficient information to permit an accurate delineation of boundary lines. Further, other than rivers, there are no topographic features that can be effectively used as reference points. Consequently, careful judgement by the Tanzanian Government may ultimately be required for determining the boundaries in many areas.
b. Boundaries for national parks, forest reserves, and wildlife parks (zoological parks) are considered to present problems similar to those described above.
c. For determining administrative designations, a unitary examination of records of the appropriate regional government is desirable; however, an office maintaining such records does not exist in the regional government. Therefore, it will be necessary to conduct a survey at district-level government agencies or to conduct a field survey to determine the exact administrative designations, which entails the approval of your government.
d. Correct spellings of place names shall be ultimately determined by your government.
e. It is necessary to conduct a survey of newly established Ujamaa villages and roads leading to these villages, those areas showing large-scaled increases in the number of houses, and those villages requiring elimination from existing data owing to recent migration or evacuation.
f. Matters to be given priority during the 1975 survey
   Transfer or establishment of signs or permanent buildings requiring annotations
   Data on newly established telephone facilities
   Pertinence of road classification
   Pertinence of vegetation classification
   Data on newly built wells

8.2 Matters to be Discussed With Tanzanian Survey Division

a. Approval on matters related to boundaries and place names as mentioned above.
b. Reception and disposition of data on adjoining areas.
c. Magnitude of magnetic declination to be indicated on each map.
d. Criteria for line weight and the size of symbols, items required for drafting.
e. A procedure for editing and approving map orginals.
f. Approval of colour and printing paper.

8.3 Organisation

Because of the nature of the 1975 survey, both surveyors with an excellent command of Swahili and auto mechanics are indispensable to successful accomplishment of the survey.

8.4 Vehicle Maintenance

The past two years' experience revealed that land cruisers put in an average of 50,000km during one survey period, and their rate of impairment is great owing to poor road conditions. Wear-and-tear or damaged parts had been completely replaced before terminating the 1974 survey, but it is still necessary to perform overall maintenance and inspection at the outset of the 1975 survey. Compared with the 1974 operation, an increased replacement of parts is anticipated in 1975.

8.5 Matters to be Investigated Prior to Formulating a Plan

a. Rate of price advance (general merchandise)
b. Price of petrol and supply/demand relations
c. Official wage standard of workers
d. Availability of vehicle parts which were not obtainable in Tanzania or Kenya during the 1974 survey.

(Part II)

Survey Work Conducted in Japan

Aerial Triangulation

Compilation Work

1. SUMMARY OF SURVEY WORK CONDUCTED IN JAPAN

1.1 Objective

Implementation of Phase II survey work in Japan planned as the second-year activity of the topographic mapping project for the Musoma Area, Republic of Tanzania, a project initiated in 1973 as a technical co-operation program between the Republic of Tanzania and Japan.

1.2 Area

Approximately 12,730km²

1.3 Period.

From: November 1, 1974
To: March 10, 1975

1.4 Work Classification and Workload

a. Aerial triangulation
   (1) No. of models 579
b. Compilation
   (1) No. of sheets compiled 5.5 shts. actual (6 shts. aggregate)
   (2) No. of models compiled 130 models

2. AERIAL TRIANGULATION

2.1 Work Specifications and Equipment Used

a. Photo scale	1:50,000
b. Aerial camera	RC-10 with superwide-angle lens
c. Focus distance	87.95mm
d. Contact prints and positive films made for aerial triangulation	
e. No. of strips	50 (including trunk course)
f. No. of models	579
g. Necessary field-confirmed control points and level points	
h. Equipment used	Pricking device
	Stereocomparator
	Electronic computer, TOSBAC 3400 Model 41

Employing the above-mentioned equipment, materials, and data, block aerial triangulation was effected by using aerial photographs taken with the superwide-angle lens aerial camera. See Appendix 9 for areas of triangulation effected.

2.2 Work Plan and Method

An analytical method was employed. Giving due consideration to the distribution of control points, the project area was divided into five blocks, and block adjustment computation was effected for each block. Computer programs employed for aerial triangulation included spherical surface correction, light reflection correction, and focus distance correction. The number of strips constituting each block is indicated in par. B-7.

2.3 Selection of Pass Points and Tie Points

Pass points and tie points were accurately pricked on contact prints and positive films to avoid impeding subsequent work. Pricked positions on contact prints were circled in red ink, with the pricking positions located at the exact center. For positive films, pass points were circled with a red pencil and tie points with a blue pencil, with pricked points located at the exact center.

2.4 Designations of Pass Points and Tie Points

Regarding the designations of pass points and tie points, a pass point located in the immediate vicinity of a photograph principal point was designated as point "b". For those strips running in the east-west direction, pass points located on the north half of photographs were designated as point "a" and those pass points on the south half of photographs were designated as point "c". For those strips running in the north-south direction, pass points located on the east half of photographs were designated as point "a" and those pass points on the west half of photographs were designated as point "c". For pass points of incomplete photographs (photographs containing the lake), letters other than "a", "b", and "c" were used (for instance "e" and "f").

As for designations of tie points, a serial number was added to the strip number of a one-way strip, and the letter "T" was suffixed to the last digit. For every two models on one side of a strip, two or more tie points at even intervals were established.

2.5 Measurement of Photo Co-ordinates

Employing a stereocomparater, index points, control points (including level points), pass points, tie points, specially designated points, and the water level of Lake Victoria (to be used as a reference for elevation) were measured. Based on measured data, work was conducted in the order of internal orientation, relative orientation, and successive relative orientation, and re-measurement were effected on those points which exceeded the values prescribed in the specifications.

2.6 Computation for Transformation of Geodetic Co-ordinates

Geodetic co-ordinates under the block system were transformed by using all control points (including level points) within the same block. For effecting transformation of geodetic co-ordinates, a simple or quadratic conformal representation transformation equation was employed for horizontal positions and a simple, quadratic, or cubic equation was employed for correcting elevations.

2.7 Adjustment Computation

Adjustment computation of each block was conducted in the order of Block 1, 2, 3, 5, and 4. Using the points pricked on contact prints and positive films of Block 3 and Block 5 plus the field survey control points, adjustment computation of Block 4 was effected, thus completing the computation process.

Classification of block	Strip No.	Transfer strip No. for work	Photo No.	No. of models	No. of models within block
Block 1	7B	67	1 ~ 4	3	
	6A	66	6 ~ 9	3	6
Block 2	5A	65	2 ~ 5	3	
	4A	64	1 ~ 9	8	
	3A	63	1 ~ 9	8	
	3	73	4 ~ 5	1	
	2A	62	5 ~ 10	5	
	J	90	1 ~ 7	6	31
Block 3	10 (left side)	10	2 ~ 12	10	
	9 (left side)	9	4 ~ 13	9	
	8A	8	6 ~ 19	13	
	7 (left side)	7	7 ~ 20	13	
	6	6	2 ~ 21	19	
	5	5	1 ~ 23	22	
	4	4	2 ~ 21	19	
	3	3	11 ~ 26	15	
	2	2	5 ~ 15	10	
	A	81	2 ~ 11	9	
	B (left side)	82	3 ~ 7	4	
	B (right side)	92	8 ~ 11	3	
	C	83	1 ~ 18	17	
	D (left side)	84	1 ~ 18	17	
	H (left side)	88	2 ~ 8	6	
	H (right side)	98	9 ~ 24	15	
	11 (left side)	11	2 ~ 11	9	210
Block 4	18	18	1 ~ 6	5	
	17	17	1 ~ 14	13	
	16	16	1 ~ 17	16	
	15 (right side)	35	5 ~ 19	14	
	14 (right side)	34	5 ~ 28	23	
	13A (right side)	33	7 ~ 11	4	
	13	53	1 ~ 21	20	
	12A (right side)	32	8 ~ 24	16	
	12	52	1 ~ 5	4	
	11 (right side)	31	10 ~ 29	19	
	10 (right side)	30	11 ~ 32	21	
	9 (right side)	29	12 ~ 32	20	

Classification of block	Strip No.	Transfer strip No. for work	Photo No.	No. of models	No. of models within block
	8A (right side)	28	18 ~ 31	13	
	8	48	3 ~ 15	12	
	7 (right side)	27	19 ~ 30	11	
	E	85	1 ~ 23	22	
	F	86	1 ~ 18	17	
	G	87	1 ~ 15	14	
	I	89	1 ~ 24	23	
	15 (left side)	15	2 ~ 6	4	
	14 (left side)	14	1 ~ 6	6	
	13A (left side)	13	2 ~ 8	6	
	12A (left side)	12	3 ~ 9	6	
	HA	95	5 ~ 20	15	
	D	99	17 ~ 25	8	332
	Total No. of strips 50				Total No. of models 579

3. COMPILATION

3.1 Preparation for Work

After carefully examining the expansion ratio, a 120cm x 80cm Teijin Mat (#500) was selected as the bases for plotting and the compilation editing manuscript. After aligning the plotting base and the compilation editing base (one laid upon the other), neatline corners, control points, eccentric points, pass points, and tie points were plotted concurrently, using a co-ordinatograph. Plotted positions were marked with red chalk to avoid impeding subsequent work. 120cm x 80cm UNIPER #150 overlay sheets (made in Japan) were used for plotting the elevation points.

3.2 Plotting Work

The East Africa Tri-country Common Specifications (scale 1:50,000) was used for compilation work. Giving due consideration to the subsequent compilation editing process, five colours were used for red for delineating topographic features—roads and buildings; purple for water and swampy areas; black for intermediate contour lines; brown for index contour lines; green for land classification boundaries, distorted surface areas, bare rocks, scattered rocks, and so on.

Upon completion of ground orientation, essential elements of orientation and other data were entered on the orientation record sheet. Allowing the maximum of a 0.4mm horizontal error (measured on the sheet) and a 5m error in elevation as stipulated in the plotting regulations, the accuracy of all models was checked, and all points were determined to be within tolerable limits. All bench marks were plotted on the plotting sheet, used for checking curves. All spot elevation points were measured

and checked prior to detail plotting on the elevation point overlay. Since topographic data on Kenya was not available, the typing process was deferred until editing of the compilation manuscript to be conducted later.

3.3 Compilation Editing Work

After laying a compilation editing sheet on top of the plotting sheet, roads, buildings, land classification boundaries, water areas, and so on were delineated in accordance with East Africa Tri-country Common Specifications. Necessary data were delineated in three colours: black for two-lane highways, water ares, buildings, and curves; red for main roads, ordinary roads, and foot paths; green for land classification boundaries. Since the East Africa Tri-country Common Specifications provided no symbol for bench marks (first-order and second-order levelling), they were denoted by the terms "spot" and "height." However, this posed a problem in that distinction between machine-measured and actually measured elevation values became impossible. This problem shall be solved by effecting a supplementary survey after discussing the matter with Tanzanian Government representatives. Boundaries of regions, districts, national parks, and so on have not been delineated on the compilation editing manuscript owing to nonavailability of the necessary data. Swamp boundaries, not normally indicated, were indicated as one of the land classification boundaries to assist in subsequent scribing work. The minimum area for indicating vegetation boundaries was established at 5mm x 5mm on the sheet, and any vegetation covering an area less than that were inclusively indicated.

3.4 Matters Demanding Special Attention for Accuracy Control

During the preparation, plotting, and compilation editing process, the person(s) responsible for each process heeded the following points:

a. Preparation for compilation work

   All plotted control points, pass points, tie points, neatline corners, and so on were checked against respective survey results to determine whether plotting errors were less than 0.2mm on the sheet.

b. Compilation

   Plotted features were checked with the plotting equipment to determine whether or not they were delineated exactly as shown on field identification photographs, and whether or not contour lines and elevation values were within the required accuracy.

c. Compilation editing

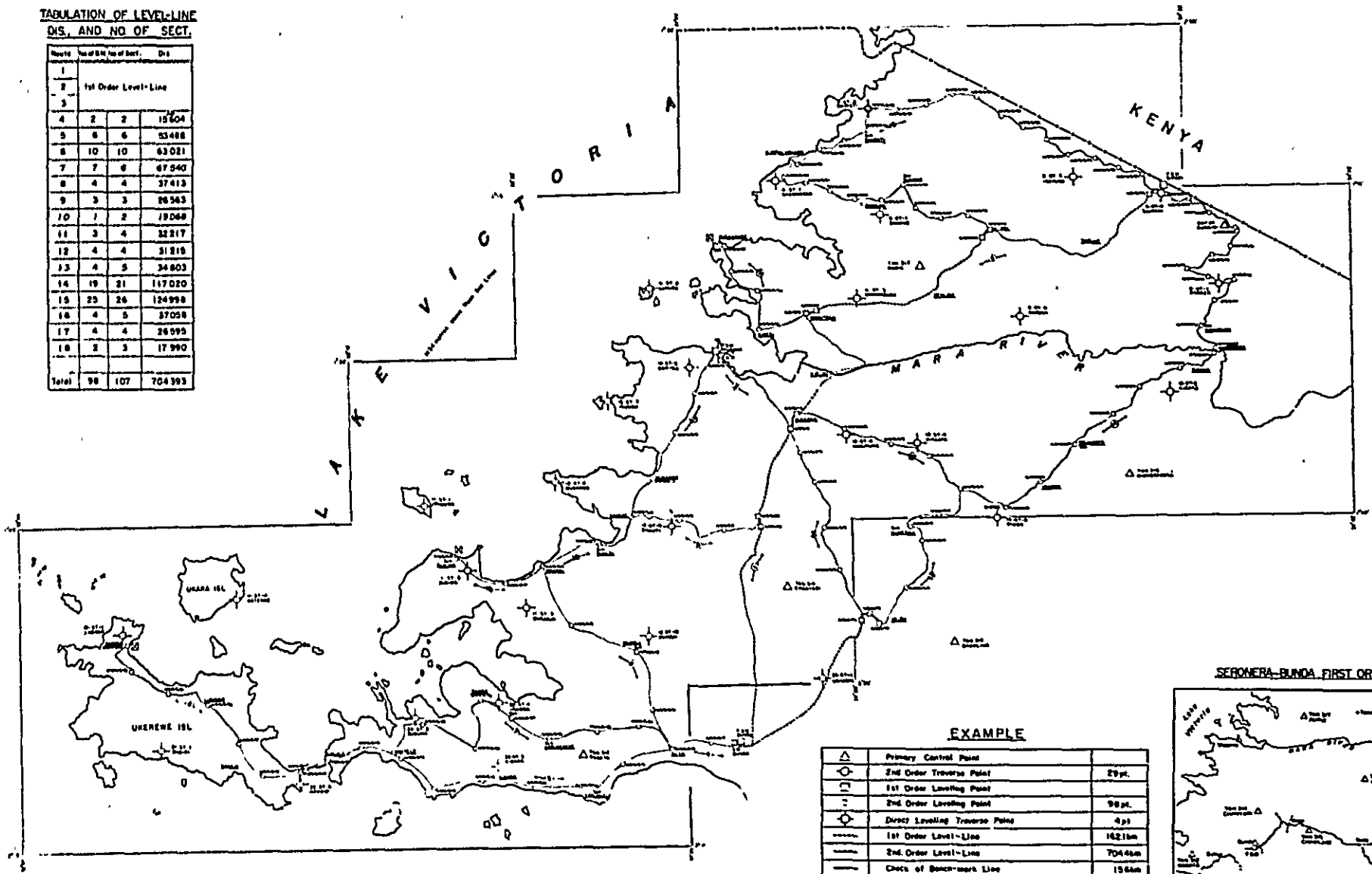
   The compilation editing manuscript was checked against the plotting sheet as to whether or not all necessary data had been properly delineated. It was also checked against the field identification photographs to determine whether or not all data were accurately transcribed on the manuscript. Further, an accurate representation of data as prescribed in the specifications, proportionment of elevation points to curve lines, and any discrepancies between the plotting sheet and the compilation editing manuscript were throughly checked to ensure overall accuracy.

Diagram 1 MUSOMA

SCAL 1:750,000

TABULATION OF LEVEL-LINE DIS. AND NO OF SECT.

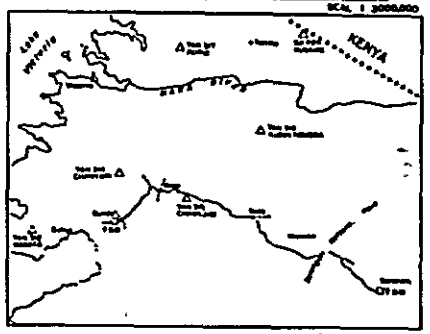
Route	No of B.M	No of Sect.	Dis
1			
2	1st Order Level-Line		
3			
4	2	2	15604
5	6	6	53488
6	10	10	63021
7	7	8	67540
8	4	4	37413
9	3	3	26563
10	1	2	19068
11	3	4	32217
12	4	4	31215
13	4	5	34603
14	19	21	117020
15	25	26	124998
16	4	5	37058
17	4	4	26095
18	2	3	17990
Total	98	107	704393



EXAMPLE

△	Primary Control Point	
◇	2nd Order Traverse Point	29pt.
□	1st Order Levelling Point	
·	2nd Order Levelling Point	98pt.
◇	Direct Levelling Traverse Point	4pt
———	1st Order Level-Line	1621km
———	2nd Order Level-Line	704.4km
———	Check of Bench-mark Line	156km
▭	Overseas Levelling	
⊠	Temporary Tide Observation Station	4place
①——	Route Number	

SERONERA-BUNDA FIRST ORDER LEVEL-LINE

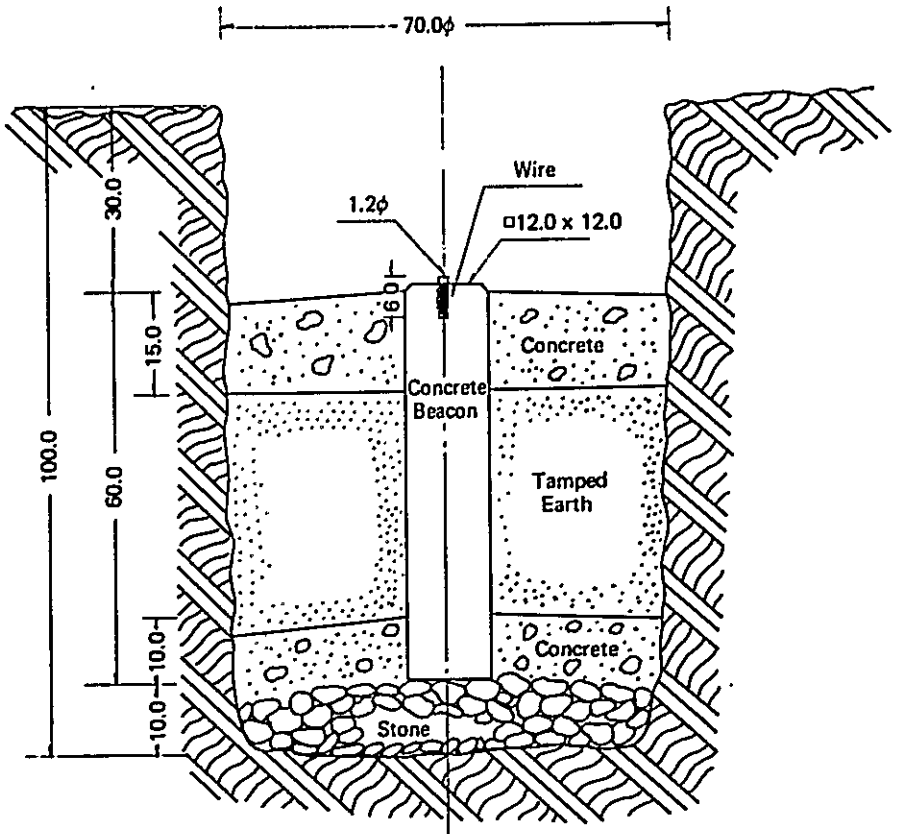


Observed on 1973

Diagram 2
MONUMENT IN

SCAL 1:100 UNIT: CM

Normal Terrain



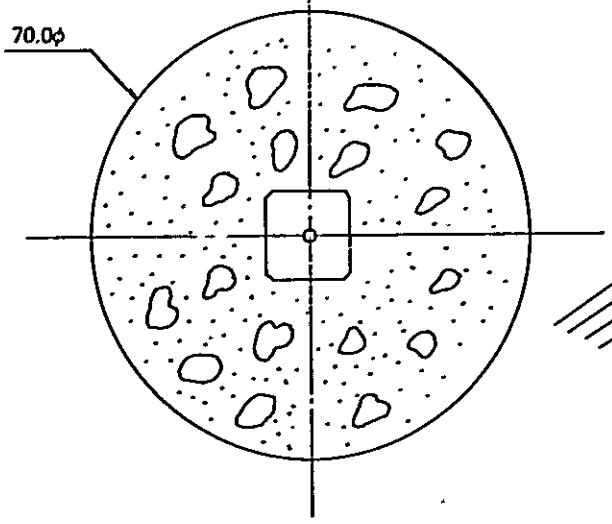


Diagram 3

Rocky Terrain

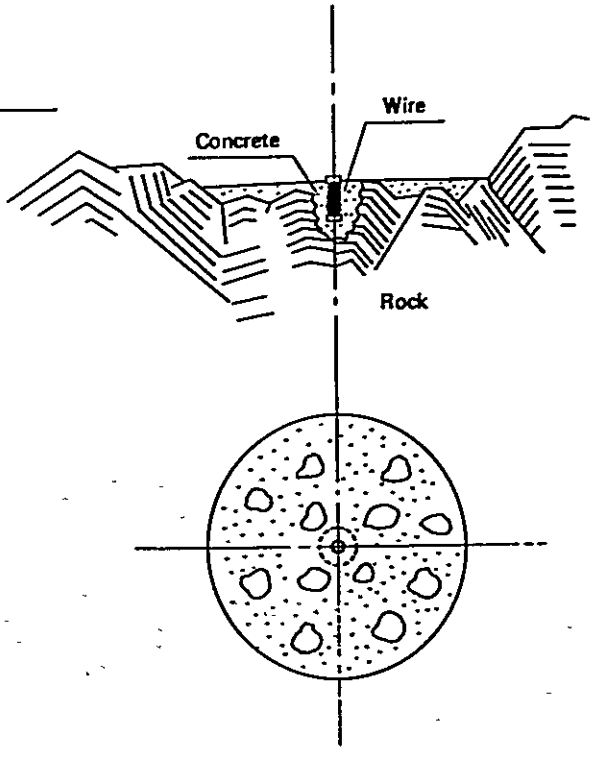


Diagram 4

Difference of direct levelling and indirect levelling

Station	Direct levelling (Given height of levelling point) m	Indirect levelling (Given height of primary point) m	Difference m
5 - ST - 2	1,177.145	1,176.44	+0.70
6 - ST - 1	1,656.842	1,656.88	−0.04
11 - ST - 2	1,169.905	1,169.03	+0.87
13 - ST - 4	1,176.850	1,175.49	+0.36

Diagram 5

Result of second-order levelling observation to check first-order levelling point

Station		Dist.	Adjusted elevation (By 1st. order)	Observed elevation (By 2nd. order)	Diff.	Allowable error $\pm 12\text{mm}\sqrt{S\ \text{km}}$
From	To	km	m	m	mm	mm
F.B.M. BUNDA	S.M. BUNDA	0.016	1,235.073	1,235.073	0	1
H/57A/22	H/57A/23	1.755	1,266.118	1,266.129	−11	16
H/57B/1A	H/57C/2	1.794	1,266.8560	1,266.8593	−3.3	16
H/57B/21	H/57B/22	1.194	1,177.646	1,177.643	+3	13
H/57B/45	H/57B/46	1.731	1,230.827	1,230.829	−2	16
H/60A/80	H/60A/79	2.155	1,444.692	1,444.691	+1	18
H/60A/79	H/60A/78	2.213	1,474.143	1,474.145	−2	18
F.B.M. SIRARI	H/57B/70	2.682	1,636.216	1,636.218	−2	20
F.B.M. MUSOMA	H/57C/14	2.090	1,136.791	1,136.793	−2	17

Diagram 6 MUSOMA AREA OBSERVATION MAP

1:750,000

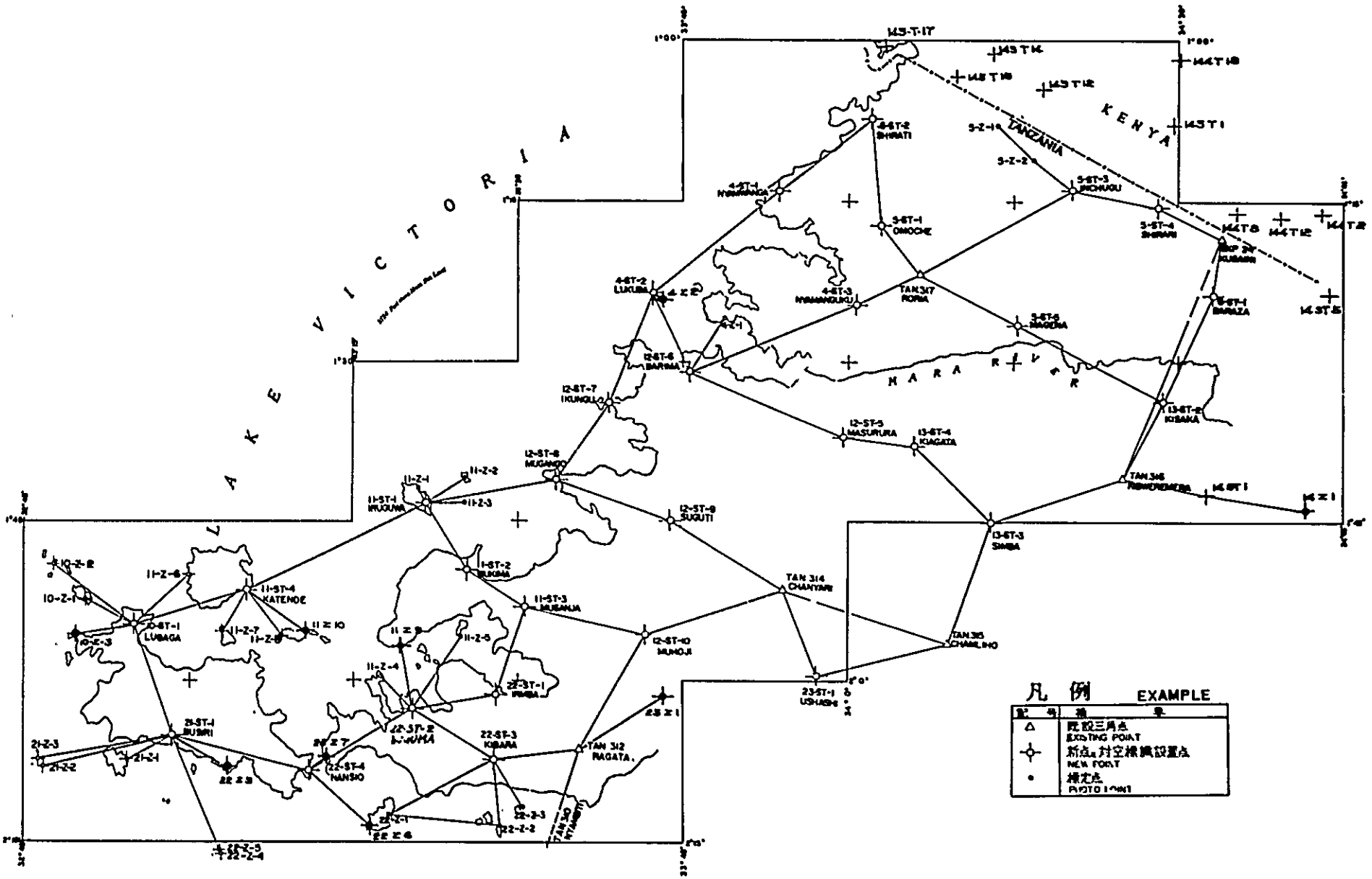


Diagram 7
Table of levelling accuracy

Second-order levelling

No.	Route No.	Dist. km	Closure error mm	Allowable error mm
1	5,7	121.0	+41	82
2	9,11	58.8	−33	57
3	4, 8, 9, 10	98.6	+ 8	74
4	16	37.1	− 7	45
5	12, 13	86.8	−31	60
6	12, 14	148.2	+27	91
7	15	126.0	+12	83

$\pm 7.5\text{mm}\sqrt{S}$ (S:km)

Cross-water levelling M.S.E. ±2.3mm

Allowable error M.S.E. ±9.3mm $\pm 5\text{mm}\sqrt{S}$ (S:km)

Diagram 8
M.S.E. of observed difference (all routes)

Route No.	Dist. km	M.S.E. mm	No. of sect.	Freq. of diff. +	−	0	Remarks
4	15.604	1.34	2	1	1	0	Observer
5	53.488	2.30	6	6	0	0	I.E.C.A.
6	63.021	2.01	10	6	2	2	K. Yoshioka H. Yoshida
7	67.540	1.77	8	4	4	0	R. Kawakami T. Masuda
8	37.413	2.70	4	4	0	0	M. Iijima T. Ikota
9	26.563	2.01	3	3	0	0	T. Fukuoka S. Nishiyama
10	19.068	2.67	2	2	0	0	Instrument
11	32.217	1.41	4	1	3	0	CARL ZEISS Ni2
12	31.215	2.50	4	4	0	0	No. 54021 No. 86307
13	34.603	1.41	5	5	0	0	No. 86320 No. 86360
14	117.020	1.47	21	12	8	1	Rod for CARL ZEISS
15	124.998	1.73	26	17	9	0	No. 1A, B No. 4A, B
16	37.058	1.80	5	2	3	0	No. 8347, 8348 No. 8338, 8349
17	26.595	1.75	4	3	1	0	
18	17.990	2.16	3	2	1	0	Observation Period
Total	704.393		107	72	32	3	

6 July 1974
25 Sept. 1974

(All Routes) M.S.E. = ±1.85mm

Number of Sections
107

$m = 1$ $\quad m = \pm\sqrt{\frac{1}{4n}\left(\frac{\mu^2}{D}\right)}$

n: Number of Sections
D: Distance
μ: Difference of readings between forward and backward runnings

Diagram 9 MUSOMA AREA, TANZANIA