# FINAL REPORT

# VOLUME III SUPPORTING REPORT

# A. TOPOGRAPHIC SURVEY

**STUDY**
**ON**
**INTEGRATED WATER RESOURCES DEVELOPMENT**
**IN THE CAÑETE RIVER BASIN**
**IN**
**THE REPUBLIC OF PERU**

**FINAL REPORT**
**VOLUME III**
**SUPPORTING REPORT**

**A: Topographic Survey**

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# Chapter 1 Topographic Survey

## 1.1 Topography

The Cañete river is the second largest among the rivers which flow into the Pacific Ocean. Its length is approximately 230 km and catchment area is 6,189 $km^2$. The average slope of the basin is 29 %, whereas that of the rivers bed is 1/50. The steep mountainous and hilly areas occupy 95 %, and the flat areas only 5 %. In view of the physiographic characteristics, the basin is divided into three categories.

The lower reach extended from the river estuary to 70 km upstream (nearby San Jerónimo bridge) is occupied by Andean ridges, plain area and shore area. Andean ridges show hilly feature with slope inclined between 17.6 % and 57.7 % to the river channel. Some geodynamic phenomena occur on the slopes and along the tributaries. Plain area consists of fluvio-alluvial plains such as river terraces, alluvial cones, riverbanks, flood plains subject to inundation, etc. In this section, the width of the riverbed varies from 50 m to 200 m, and slope of the river ranges from 0.7 % (1/14) to 4.2 % (1/24). Riverbed gradient is steeper in the upper stream, whereas steep and gentle slope varies alternately in some section. Fairly large terraces situated in the both margins of the river are utilized for agricultural uplands. Shore area is distributed along the coastal zone and formed by marine erosion and sedimentation.

In the middle reach situated in 70 km to 170 km from the river estuary (nearby Huancaya village), continuous high mountain ranges and gouges with V-shaped deep valley are predominant. The height increases progressively from the west to the east and high lands become eroded steep and deep ravine in this reach. Major geodynamic phenomena such as slope failure, debris flows and unstable slope occur on the slopes and along the tributaries. Agricultural uplands are distributed in man-made stepped terraces on rather gentle slopes and alluvial cones. Generally, however, hillsides facing the river channel are very steep and eroded. The elevation difference between the riverbed and the top of the hills ranges from 500 m to 1,300 m.

The upper reach situated in 170 km to 230 km from the river estuary consists of alpine areas and glacial areas. Both areas range at an elevation higher than 4,000 m (elevation of the river rise, Ticliacocha lake, is approximately 5,800 m). Physiographically, the alpine area is formed by glacial and fluvio-glacial action showing U-shaped valley, cirque, swampy plain, glacial lakes, drumlins, etc. Moraine and fluvio-glacial deposits are main overlying sediments. This area occupies 58 % of the total surface basin. Slope of the riverbed largely vary ranging between 0.5 % and 100 % according to glacial erosion and sedimentation at the elevations from 4,000 m to 4,800 m. There are also some natural reservoirs created along the rivers, which were dammed up by the

sedimentation of glacial and fluvio-glacial deposits, talus deposit of collapsed weathered rocks and/or eroded limestone outcrops. Number of glacial lakes and reservoirs is 447, and the total surface area is estimated at approximately 4 $km^2$, which contribute to store and regulate river water in the basin. Extensive livestock is practiced in gently sloped lands and river valley. Farming is practiced sporadically on man-made terraces.

## 1.2 Topographic Maps

(1) Existing maps in the Study Area

Scale 1 : 25,000 topographic maps with 25 m contour lines, prepared by the Ministry of Agriculture between 1973 and 1979, cover the whole Study Area. Scale 1: 10,000 and 1: 5,000 maps are available at partial area along the coast and along agricultural land in branch rivers.

(2) Maps prepared in the Study

For the purpose of the Study, scale 1: 5,000 topographic maps with 5 m contour lines were prepared along 1) the alternative canal route in the coast side and at 2) five candidate dam sites including 3 storage dam sites and 2 intake dam sites.

1) Maps for the alternative coastal canal route cover area of 130 $km^2$ (35 sheets) along the route, produced with aerial photographs of scale 1 : 20,000 which were shot in this Study stage.
2) Maps at the dam sites cover total 21 $km^2$ (9 sheets) including the reservoir area of Auco, Calchota and San Jerónimo storages dams and Zuniga (for mountain side canal) and Socsi (for coast side canal) intake dams, produced with the existing aerial photographs of scale 1: 14,000 (in low level coast) to 1: 31,000 (in high level mountain area).

# Chapter 2 Topographic Survey

## 2.1 Aerial Photo Mapping

### (1) Monumentation and Aerial Signalization

Monumentation and Aerial Signalization works for 1: 5,000 mapping were carried out at 24 points (23 points were newly established) in the total area of approximately 125 $km^2$. The location map of the ground control points are shown in Figure 1, and Coordinates of Control Points are shown in Table 1. Field inspection for monument installation and aerial signalization was conducted for 13 points through the instruction of the JICA Peru office.

**Work Items and Productions**

| Work Items | Productions |
|---|---|
| Description of points | 1 set with terrestrial photos |

### (2) Aerial Photography and Mapping

Acquisition of a scale of 1: 25,000 B&W aerial photographs were carried out in the area shown in Flight Plan Map, Figure 2 along coast side route and Figure 3 along mountain side route, and the total flight distance of approximately 126.5 km and 176.6 km, receptively. Survey results are as follows:

**Aerial Photography along Coast Side Route**

| Work Items | Descriptions |
|---|---|
| Total Flight Course | 10 courses |
| Total Flight Distance | 177 km |
| Total Photographs | 106 pcs |

**Aerial Photography along Mountain Side Route**

| Course | Photo number | Flight distance (km) |
|---|---|---|
| 1 | 11 | 23.0 |
| 2 | 9 | 18.4 |
| 3 | 9 | 18.4 |
| 4 | 12 | 25.3 |
| 5 | 8 | 16.1 |
| 6A | 11 | 23.0 |
| 6B | 7 | 13.8 |
| Total | 67 | 138.0 |

**Survey Results**

| Work Items | Coast Route | Mountain Route |
|---|---|---|
| Aerial Photography | | |
| Photo-Processing | | |
| a) Contacts prints | 3 set (318 pieces) | 3 set (201 pieces) |
| b) Dia-positives | 1 set (106 pieces) | 1 set (67 pieces) |
| c) Enlargement by 2 times | 1 set (106 pieces) | 1 set (67 pieces) |
| d) Photo index map | 1 set | 1 set |
| Daily report and flight report | 1 set | 1 set |
| Quality control sheet | 1 set | 1 set |
| Camera calibration certificate | 1 set | 1 set |

## 2.2 Topographic Mapping for Canals

Topographic mapping of scale 1:5,000 was carried out succeeding photogrammetric work. The work items are as follows:

**Coastal Mapping Areas**

| Work Items | Quantity |
|---|---|
| Monumentation and aerial signalization | 28 stations* |
| GPS control survey | 30 stations |
| 3rd order levelling | approx. 110 km |
| Minor order leveling | approx. 30 km |
| Field classification | 130 $km^2$ |
| Aerial triangulation | 96 locations |
| Stereo plotting (1:5,000) | 130 $km^2$ |
| Editing (1:5,000) | 130 $km^2$ |
| Drawings (1:1,5,000) | 130 $km^2$ (35 sheets x 2 sets) |

*: 27 control points were monumented and signalized. Owing to no permission of landowner, the C.P.No.2 was not monumented. C.P.No.2 was pricked afterward.

## 2.3 Topographic Mapping for Dams

For the mapping work, existing aerial photograph of PETT project was utilized. The scale of PETT project photograph was 1: 15,000. Aerial triangulation adjustment was transferred from existing photograph of former PETT project. The parts that were not clear in the photograph were classified in the field. The mapping areas are as follows:

## Mapping Areas

| Mapping Sites | Areas |
|---|---|
| Socsi | 1.0 $km^2$ |
| Zuniga - San Jeronimo | 10.0 $km^2$ |
| Santo Domingo - Calachota | 4.5 $km^2$ |
| Auco | 5.5 $km^2$ |
| Total | 21.0 $km^2$ |

## Survey Results

| Work Items | Productions |
|---|---|
| Existing Aerial Photograph | 47 photographs |
| Index Photograph | 1 set (2 photographs) |
| Transference of existing aerial triangulation data | 28 models |
| Field Classification | 21 $km^2$ |
| Supplementary Survey | 0.2 $km^2$ |
| Plotting and Editing | 21 $km^2$ |
| Drawing | 21 $km^2$ (9 sheets x 2 sets) |

# TABLES

## Table 1 Coordinates of Control Points

| No. | North (km) | East (km) | Measured Distance | Calculated Distance | Difference |
|---|---|---|---|---|---|
| CPM-01 | 8,610.60 | 328.00 | | | |
| CPM-02 | 8,601.10 | 330.90 | 9.80 | 9.93 | -0.13 |
| CPM-03 | 8,591.10 | 334.50 | 10.60 | 10.63 | -0.03 |
| CPM-04 | 8,593.00 | 336.10 | 2.50 | 2.48 | 0.02 |
| CPM-05 | 8,592.30 | 340.00 | 4.00 | 3.96 | 0.04 |
| CPM-06 | 8,585.10 | 342.60 | 7.60 | 7.66 | -0.06 |
| CPM-07 | 8,585.30 | 345.60 | 3.00 | 3.01 | -0.01 |
| CPM-08 | 8,582.40 | 350.50 | 5.70 | 5.69 | 0.01 |
| CPM-09 | 8,583.60 | 354.80 | 4.50 | 4.46 | 0.04 |
| CPM-10 | 8,581.40 | 354.70 | 2.30 | 2.20 | 0.10 |
| CPM-11 | 8,577.50 | 355.70 | 4.00 | 4.03 | -0.03 |
| CPM-12 | 8,569.80 | 361.60 | 9.70 | 9.70 | 0.00 |
| CPM-13 | 8,566.20 | 361.20 | 3.60 | 3.62 | -0.02 |
| CPM-14 | 8,564.10 | 360.00 | 2.40 | 2.42 | -0.02 |
| CPM-15 | 8,565.50 | 370.50 | 10.50 | 10.59 | -0.09 |
| CPM-16 | 8,562.80 | 370.90 | 2.90 | 2.73 | 0.17 |
| CPM-17 | 8,566.40 | 375.00 | 5.50 | 5.46 | 0.04 |
| CPM-18 | 8,564.20 | 374.60 | 2.30 | 2.24 | 0.06 |
| CPM-19 | 8,572.00 | 378.00 | 8.60 | 8.51 | 0.09 |
| CPM-20 | 8,570.60 | 379.60 | 2.20 | 2.13 | 0.07 |
| CPM-21 | 8,576.00 | 383.80 | 6.90 | 6.84 | 0.06 |
| CPM-22 | 8,581.00 | 387.90 | 6.50 | 6.47 | 0.03 |
| CPM-23 | 8,579.30 | 389.70 | 2.50 | 2.48 | 0.02 |

CPM means Control Point Mountain route.

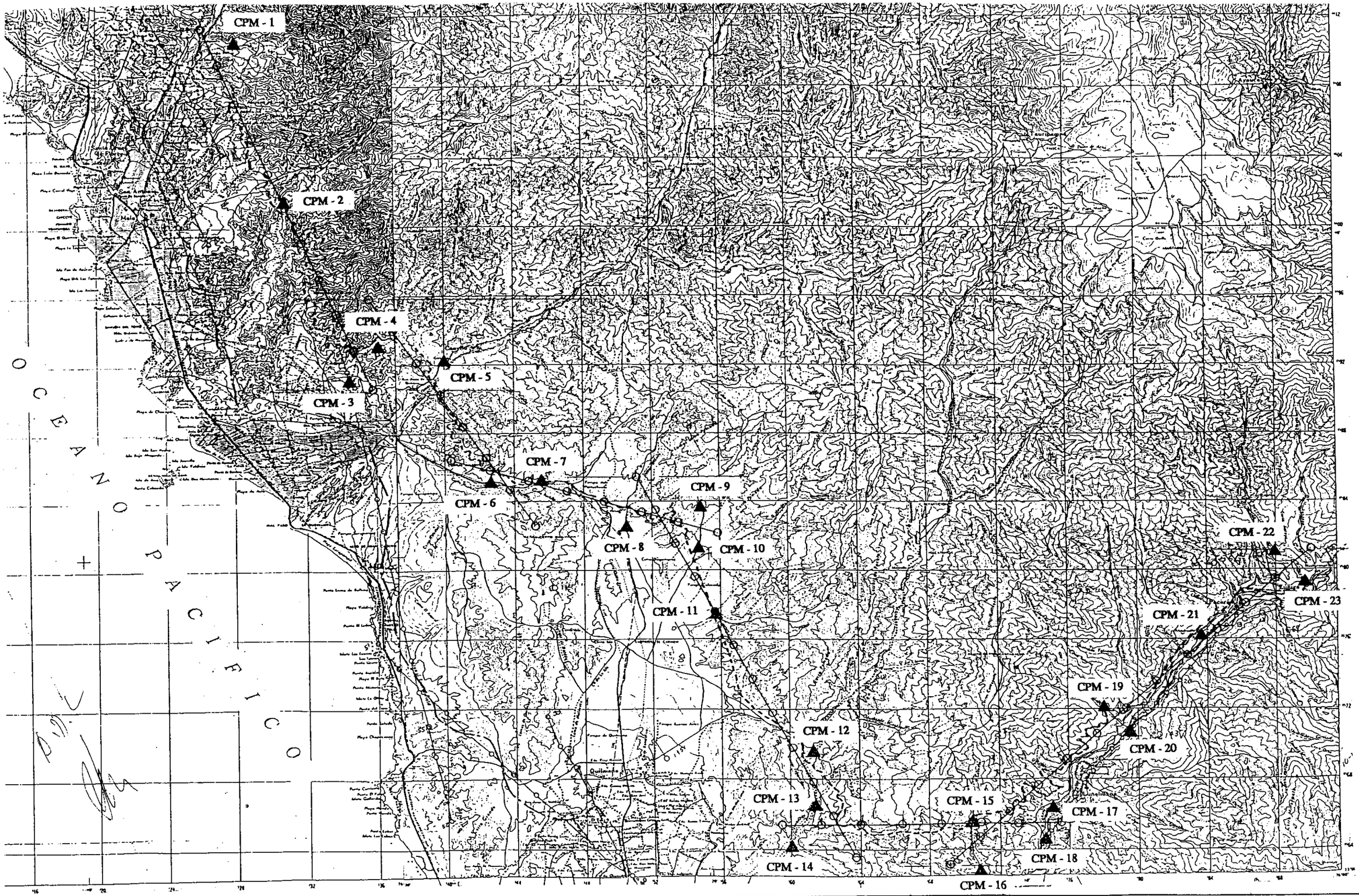
Measured Distance is the distance from the previous point which is measured on the map.

Calculated Distance is the distance from the previous point calculated with their coordinates.

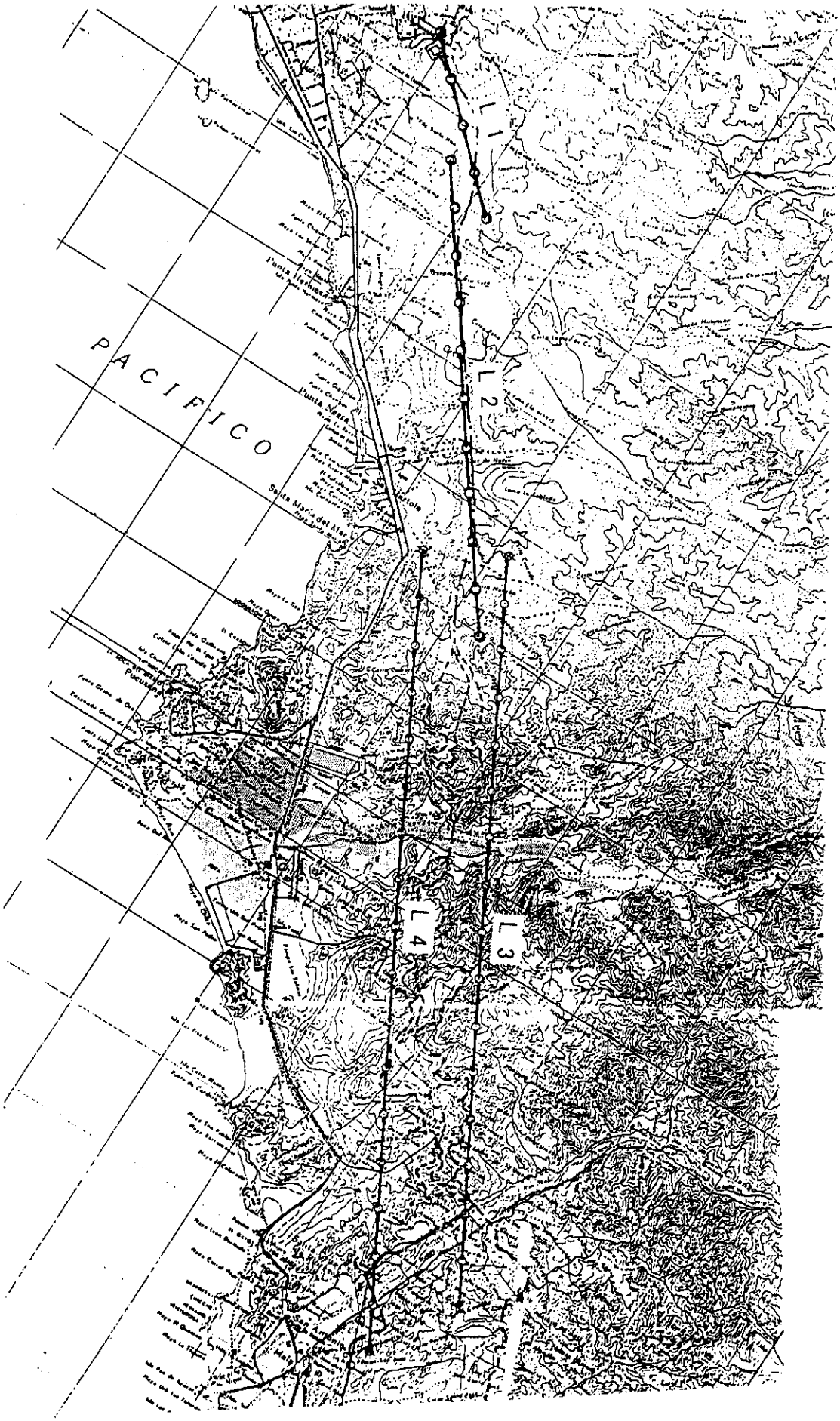
Difference is the difference between Measured Distance and Calculated Distance.

This is the reconfirmation of measuring.

# FIGURES




| | |
|---|---|
| STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT<br>IN<br>THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU<br>JAPAN INTERNATIONAL COOPERATION AGENCY | Figure 1 Control Points and Aerial Signalization |




| | |
|---|---|
| STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT<br>IN<br>THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU<br>JAPAN INTERNATIONAL COOPERATION AGENCY | **Figure 2 Flight Route Map (Coast Side Route) (1/3)** |

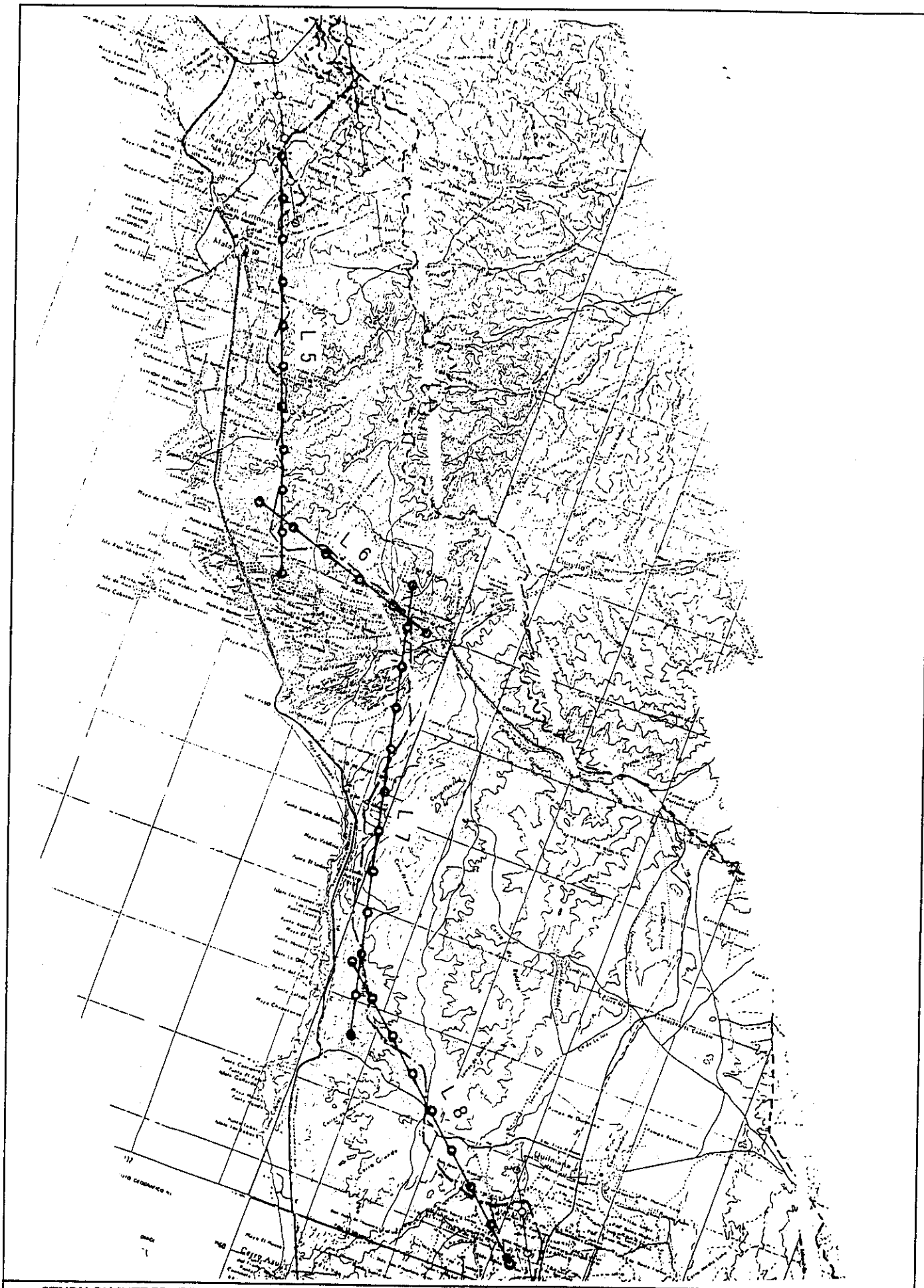



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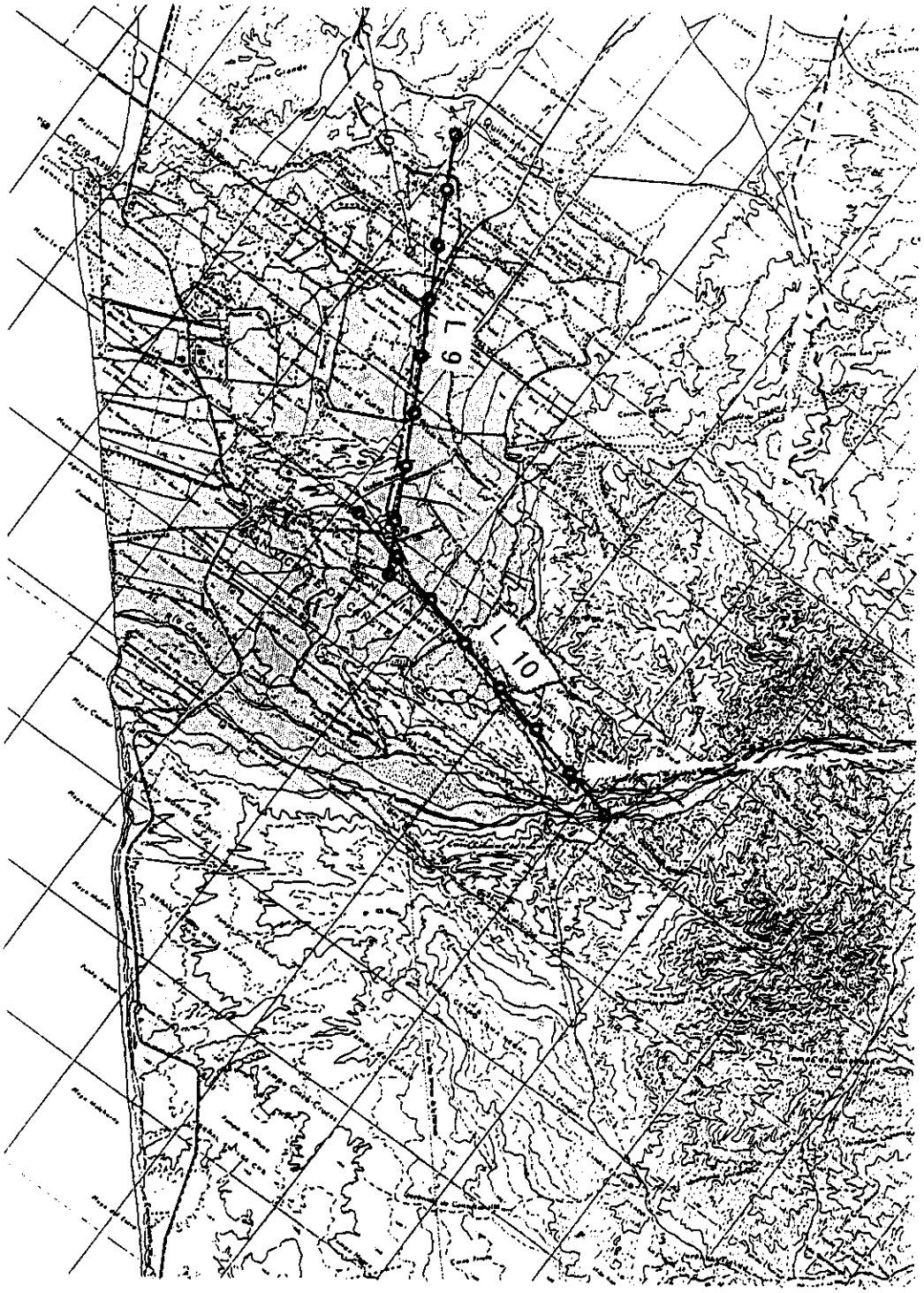
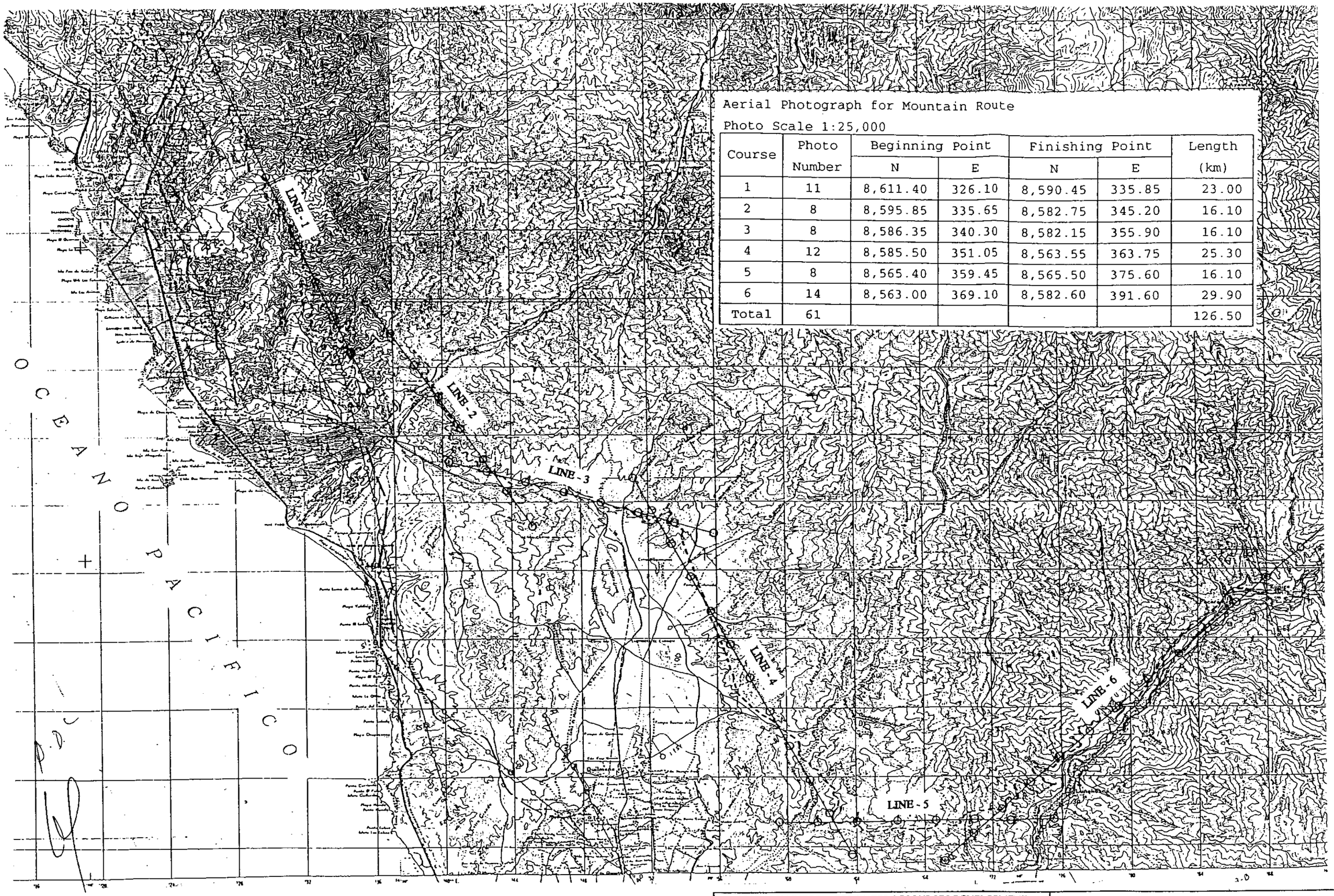
**Figure 2 Flight Route Map (Coast Side Route) (2/3)**




| STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT IN THE CANETE RIVER BASIN IN THE REPUBLIC OF PERU | Figure 2 Flight Route Map (Coast Side Route) (3/3) |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




Aerial Photograph for Mountain Route

Photo Scale 1:25,000

| Course | Photo Number | Beginning Point | | Finishing Point | | Length |
|---|---|---|---|---|---|---|
| | | N | E | N | E | (km) |
| 1 | 11 | 8,611.40 | 326.10 | 8,590.45 | 335.85 | 23.00 |
| 2 | 8 | 8,595.85 | 335.65 | 8,582.75 | 345.20 | 16.10 |
| 3 | 8 | 8,586.35 | 340.30 | 8,582.15 | 355.90 | 16.10 |
| 4 | 12 | 8,585.50 | 351.05 | 8,563.55 | 363.75 | 25.30 |
| 5 | 8 | 8,565.40 | 359.45 | 8,565.50 | 375.60 | 16.10 |
| 6 | 14 | 8,563.00 | 369.10 | 8,582.60 | 391.60 | 29.90 |
| Total | 61 | | | | | 126.50 |

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Figure 3 Flight Route Map
(Mountain Side Route)