REPORT OF SURVEY FOR ELECTRIC POWER RESOURCES IN ARGENTINA (RIO MENDOZA)

MARCH 1964

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO, JAPAN

C o n t e n t s

Appendix

To

Report of Survey for Electric Power Resources in Argentina (Rio Mendoza)

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1. Present Status of Available Data

Extensive sets of data obtained through site investigation are required in establishing any development plan. Most important among such are the followings:-

a) Temperature, Precipitation, Humidity

b) River run-off records

c) Geological characteristics

d) Detailed topographical map of the area

e) General data on industries.

For the Province of Mendoza, data regarding (a), (b) and (c) are available in good order. As for the geological data, part of them forms records from actual survey. A topographic map at 1/100,000 (contour: 50 m) has been prepared by the Argentine Army, and in 1962 an aerophotograph over the whole Province of Mendoza has been completed. (Nagative film at 1/50,000 scale)

Accordingly, necessary data here would, to a satisfactory degree, be complete if survey should be conducted for the depth of river-bed rock and its geological feature, and for the weathering of geographical features in both of the river-bank areas, and further if the compilation of aerophotographs should be carried out to make a detailed topographic map. However, as it is, this country may well be counted as one among those few countries now on the way to development in which is available a fairly large amount of data as maintained in good order.

2. Effects of Development

The development plan is to construct along the river basin six power plants with the total maximum generating capacity of 486,000 KW and the total annual energy generation of 2,499,000,000 KWH, and at the same time to utilize the discharged water from the plants for irrigation, sanitary and industrial water services. The development would, no doubt, make great contribution to the progress of various industries in Mendoza Province and its neighboring Provinces as well.

2.1 Electric Power

At present, Mendoza Province and San Juan Province together have the electric facilities with the generating capacity of 158,000 KW and the annual energy generation of 492,000,000 KWH or 560 KWH per head of population. To this would be added, according to this plan, the generating capacity of 486,000 KW and the annual energy generation of 2,499,000,000 KWH, thus making the per-head generation about 2,370 KWH around 1975 when the planned development would have been completed.

Both of Tupungato Power Plant with the generating capacity of 72,000 KW and Mendoza NO.3 Power Plant with that of 186,000 KW are designed to be of an 8-hour peak operation. This electric power available at the peak-load time would play a very significant role in the supply system, as demand increases in the future with the increase of population and the development of industries. In case it becomes necessary to supply still more electric power in the future, the base load would be borne by the remaining hydro-power plants of 228,000 KW in total generating capacity planned in the report, together with some termal-power plants that would probably be constructed at such a time. The peaking load would be borne by the power plants provided with the two large reservoirs mentioned above. An operation of this type would result in the most effective supply of electric power to the consumers.

The estimated construction cost of the plan amounts to US$ 2,341,000,000 in total, consisting of those for generating, transmitting and transforming facilities plus the reserve fund involved. This means the construction cost per KW and that per KWH on the secondary side of the receiving-end substation to be US$488 and US¢9.3 respectively, with the generating cost at US¢1.04 per KWH.

Further, with the cost for distribution facilities, distribution loss and other expenses involved taken into account, the selling electric rate is assumed to be US¢1.46 per KWH. Comparing this with those as of 1959 in other countries:-

U. S. A.	US¢1.69	Japan	US¢1.47
France	¢1.79	W. Germany	¢2.38
Switzerland	¢1.54	Great Britain	¢1.78
Canada	¢1.09		

The rate under consideration is seen to be lower than any in other countries except Canada.

The currently-effective electric rates in Mendoza Province are at US¢4 per KWH for domestic use and US¢2.3 for quantity-consumptive industries, the over-all average rate being considered as US¢3. The low-enough electric rate as a result of Río-Mendoza development would, therefore, encourage development of industries in this district by giving them a cheap and advantageous basic energy.

Moreover, as the discharged water would be utilized for irrigation, sanitary and industrial water services, the power generation cost could be partly reimbursed by the beneficiaries in proportion of the benefits they would receive in effect. In this case, it costs only US¢0.82.

2.2 Agriculture

Since there is available at present along Rio Mendoza no storage reservoir to regulate and effectively utilize its river run-off for irrigation purpose, the river water in flood season, is allowed to have its own way to no useful effect, while in drought season, the shortage of irrigation water prevents satisfactory agricultural activity. The plantation land of 85,000 ha surrounds Mendoza City, and throughout the area good irrigation water-ways have been developed. Of the plantation land, 52,000 ha is occupied with vineyards and the remaining area includes various fruit gardens and meadows. If the problem of water shortage could be solved for the land, the land would turn into the vineyards and vegetable fields with better and greater productivity.

It is planned for this purpose that storage reservoirs are to be constructed at Tupungato and Uspallata (Mendoza No.3 Power Plant Reservoir) with effective capacities of 130,000,000 m^3 and 650,000,000 m^3 respectively, totaling 780,000,000 m^3. The total effective capacity could regulate and equalize the river run-off for 10 years at least, so that the irrigation water may be maintained at any time at any quantity as needed. Assuming that the kinds of crops and their individual plantation areas should remain unchaged, the effect of these reservoirs might be considered to be as stated below.

According to the data of Irrigation Agency of Mendoza Province for reference, if the necessary irrigation water should be secured for the 52,000 ha of vineyards, the production would increase at least by 9 quintal (41.4 kg) per hectare annually. Priced at US$5.50 per quintal, the annual increase of the production is:

52,000 ha x 9 quintal x US$5.50 = US$2,574,000

In addition, there may be an expected increase of productivity, priced at US$22.00 per hectare, in regard to various fruit gardens and meadows for the remaining 32,000 ha:

32,000 ha x US$22.00 = US$704,000

The total increase of productivity thus amounts to US$3,278,000 for the 85,000 ha plantation land. This may show one of the large effects of the irrigation.

2.3 Sanitary Water and Industrial Water Services

At present, the sanitary and industrial water of 46,000,000 m^3 is used in a year, 93% of which is served for domestic use (including uses at hotels, shops and public organizations)

In this plan, it is considered that the industrial water consumption should show a sharp increase due to the new establishment or expansion of various factories in connection with the expected increase of electric power available in the future. The quantity to be used per day would then be regarded as 5 m^3/s; that is, 155,000,000 m^3 a year. The new possible supply would be 105,000,000 m^3 of the total necessity. Assuming the unit rate per m^3 of water at intake to be US¢3, the new increase of use would amount in terms of money to US$3,150,000 per year.

2.4 Industry and Others

With the cheap electric power supply available and the rich industrial water service secured, a remarkable industrial developments can certainly be expected, particularly, in the field of electric metallurgy to exploit the undeveloped mineral resources, and of chemical industry (utilizing lime stone, salt, petroleum; all rich in the neighboring districts).

3. Study on Construction Cost

The storage reservoirs in this plan are to be utilized, through their regulation of the river run-off, not merely for generating electric power, but for securing the necessary quantity of water for irrigation, sanitary and industrial water services. The full benefit from the effect of constructing these reservoirs shared, is such that it is not reasonable to have the electric power industry alone bear all the cost of their construction. The usual practice in many countries of the world in such a case is that the construction cost should be shared and borne by each of the beneficiaries in proportion to the benefit he would enjoy from the effect of the construction concerned.

The benefit per year would be calculated, as already stated, to be US$3,278,000 for agricultural concerns and US$3,150,000 for sanitary and industrial water services. The total increase in income would then be US$ 3,150,000 for a year. If the reservoir construction cost is assumed to be ten times this amount or 10 years' increase and is borne by the beneficiaries, the other construction cost to be paid by the electric power industry would be as follows:-

Generating Capacity	486,000 KW	
Annual Energy Generation	2,499,000,000 KWH	
Transmission Loss	150,000,000 KWH	(About 6% estimated)
Energy on receiving-end substation Secondary-side	2,339,000,000 KWH	
Construction Cost at generating end	US$221,547,000	
Construction Cost of Transmission Lines & Transformer Substations	15,900,000	
Total:	US$237,447,000	..... (1)
Amount to be paid by Irrigation Beneficiaries	US$32,780,000	
Amount to be paid by Sanitary & Industrial water services Beneficiaries	31,500,000	
Total:	US$64,280,000	..... (2)

Accordingly, the construction cost to be paid by power generation side:

(1) - (2), US$173,167,000

Construction Cost per KW	US$357
Construction Cost per KWH	¢7.4
Unit Price of Power Generation	¢0.82

(on the secondary side of transformer in the receiving-end substation)

On the other hand, should no cost happen to be reimbursed by the beneficiaries:

Construction Cost per KW	US$488
Construction Cost per KWH	¢9.3
Unit Price of Power Generation	¢1.04

(on the secondary side of transformer in the receiving-end substation)

This will show: if the whole construction cost should be borne by the power generation side alone, the unit price of power generation would be higher by 27%, which would bring about the rise of the electric charge for general domestic consumption and industrial use. This would be sure to adversely affect the development of the expected industrialization.

4. Comparison with Construction of Thermal-Power Plant

The development plan is aiming at the integral utilization of the rich flow of Rio Mendoza for the multi-purposes of supplying electric power, irrigation water, and sanitary and industrial water services. The production of electric energy out of the river is not the only purpose of the plan. For this reason, it would be absurd to try to compare the hydro-power plants of this plan with any thermal power plants in scale the same as the former, in terms of the resulting electric rates, etc. to choose one category of plants as the more advantageous of the two in generating electric power. However, here a comparison is tried only for reference, assuming other things being equal.

The thermal power plant to be constructed is assumed to be one of exclusively heavy-oil burning which utilizes the petroleum richly produced in the neighboring districts of Mendoza City. (There are oil refineries operating in the suburbs of the City) With the station load factor at 65%, the power plant capacity would be at 450,000 KW. Should the construction be carried out as divided, for instance, in three periods so as to meet progressively the expected power requirement the increase of plant capacity in each period would stand at 150,000 KW.

The construction cost per KW of a 150,000 KW-class exclusively-heavy-oil-burning thermal-power plant (thermal efficiency: 37%) now being constructed in Japan is US$215. If this figure is applied to the case of Mendoza City:-

Generating Capacity	150,000 KW
Load Factor	65%
Annual Energy Generation	855,000,000 KWH
Construction Cost	US$32,250,000
Unit Power Generation Cost at Sending End	US¢0.83

The unit price of hydro-power generation, as stated before, is calculated to be US¢0.82 at sending end when part of the construction cost is borne by the beneficiaries, and US¢1.04 when no cost is borne by them. The electricity rate that would result from the hydro generation with part of the construction cost borne by the beneficiaries, proves to be almost the same as that which would result from the above mentioned thermal generation. It may be concluded therefore that the construction of the hydro-power plant utilizing the river run-off should by far be the more advantageous, as it allows not only electricity generation but multi-purpose utility of the river run-off, to the efficient and effective utilization of natural resources.

- END -

I. Purpose and Development of Survey

In early 1963, the Government of Argentina requested the Government of Japan to carry out a basic survey for the development of Rio Mendoza, Mendoza Province. The Overseas Technical Cooperation Agency, therefore, conducted a basic survey of Rio Mendoza in regard to the development of electric power resources during the period from late February to early June, 1963. Preceding to this, in April 1962, a general preliminary survey for electric power resources development had been carried out, and a selection of the sites best suitable for Japanese technical cooperation in basic surveys for the electric power resources development in Argentina had been made, by the mission led by Mr. T. Nakamura, managing director of the Overseas Electrical Industry Survey Institute, Inc. (Refer to the Preliminary Report on the Investigation of Electric Power Resources in Argentina 1962, Overseas Electrical Industry Survey Institute, Inc., Tokyo, Japan: IV Conclusions 3, Gist of Basic Investigation of Rio Mendoza.)

Mutual Understanding on the Proposed Basic Survey on the Development of Hydro-Electric Power Resources on the Rio Mendoza.

At their conference at Takarazuka, Osaka-fu, Japan on the third of December, 1962, Jose H. Monserrat, President of Agua y Energia Electrica of Argentina (hereinafter referred to as "the AYEE") and Tatsugoro Nakamura, Managing Director of Overseas Electrical Industry Survey Institute, Inc., of Japan (hereinafter referred to as "the Institute") reached the below stated mutual understanding:

1. The river on which the proposed basic survey is to be conducted and the organization that is to conduct said survey.

The river Mendoza is to be the river on which the proposed basic survey shall be carried out based on the report entitled "Preliminary Report on the

Investigation of Electric Power Resources in Argentina, August, 1962", that had been prepared to summarize the findings of the preliminary survey for the development of electric power resources in Argentina conducted by the Institute in April, 1962.

The proposed basic survey is to be conducted by the Institute with the cooperation of the AYEE.

2. <u>Principal Items of the Works of the Basic Survey</u>

As stated in the above mentioned "Preliminary Report on the Investigation of Electric Power Resources in Argentina, August, 1962", the principal items of the proposed survey are to be as stated below;

(1) To carry out leveling, triangulation and astronomical observation (including establishment of bench-marks, markers and/or survey stations relevant to these works) so as to prepare for the work of taking the aerial photographs;

(2) To take the aerial photographs over the areas under survey, including development of the negatives;

(3) To carry out geological study by boring;

(4) To prepare air-maps from the aerial photographs obtained;

(5) To carry out provisional surveys as to the availability of aggregates and other dam construction materials required;

(6) To carry out topographical surveys on the selected dam sites and on other sites other plant structures;

(7) To carry out investigation on power demands, on irrigation projects and on industrialization plans.

3. <u>Allocation of the Principal Items of the Basic Survey between the AYEE and the Institute.</u>

Of the seven principal items of the basic survey, the AYEE and the Institute shall each undertake the work as allocated below:

(A) Works allocated to the Institute

The Institute is to carry out the works of the above stated principal items (1), (3), (4), (5), (6) and (7) at its own expense, availing itself of the subsidy granted by the Government of Japan.

In carrying out the work mentioned above, the Institute is to divide the work in two phases as follows:

In the first phase, items (1), (4), (5) and (7) shall be carried out. In the second phase, items (3) and (6) shall be carried out based on the result of the work of the first phase. Other surveys supplementary to the first phase survey, if any, with respect to items (1), (5) and (7) shall be conducted concurrently.

(The second phase of the work regarding item (1) above shall be conducted on the part of the river that lies between Cacheuta dam site and the confluence of the Mendoza and the Rio Blanco upstream from said dam site.)

(B) Works allocated to AYEE

Keeping step with above mentioned first phase of the work that is to be undertaken by the Institute, AYEE is to carry out the work of Item (2) above at its expense. In other words, AYEE is (1) to have the aerial photographs (on the scale of 1:40,000 or thereabout) taken over the survey areas designated by the Institute, and (2) have thus obtained negative films of aerial photographs developed, and (3) have one copy of thus developed negative films made and (4) have those two copies of films delivered to the Japanese survey team, all at AYEE's expense.

(C) Works in which AYEE is to cooperate with Japanese Survey Team.

AYEE is to cooperate with the Institute, when the Institute undertakes the above stated first phase of survey work, as prescribed below:

(a) AYEE is to provide, on its own expense, the 6-member Japanese survey team with space for its office work and with appropriate board and dwellings as long as the team stays in Argentina.

In case no existing dwelling facility is available for this purpose, AYEE is to provide the Japanese team with new ones.

(b) The Institute estimates that the first phase of the work requires a period of about three months to complete. Throughout this 3-month period; AYEE is to furnish, free of charge, the Japanese team with the following items:

Transportation Facilities

One waggon,

Three jeeps complete with drivers and fuel, inclusive of repairs and insurances, etc.

In case other forms of transportation facilities become necessary for carrying out the required work (for instance, boats complete with men to run them, inclusive of fuel, repairs and insurances, etc.), such transportation facilities as required.

Man Power

About ten hands everyday to assist in survey work, complete with wages, allowances, insurances and other fringe benefits, if any, inclusive of their dwelling quarters.

AYEE staff-members

At least two AYEE staff-members (one as surveyor and the others as liaison agent) are to be despatched to the Japanese survey team, complete with salaries, allowances, insurances and other fringe benefits, if any, inclusive of their dwellings.

(c) AYEE is to arrange so that the Japanese survey team is permitted to import devices, instruments, tools and machinery necessary for conducting the survey work free of whatever sort or nature of charges. The team is also to enjoy the same sort of priviledge in taking those devices, instruments, tools and machinery out of Argentina at the completion of the work.

(d) AYEE is to offer the Japanese survey team every assistance and convenience when the team desires to procure in Argentina materials and consumables necessary for conducting the survey work.

(e) AYEE is to arrange so that Argentine Government grants each of the Japanese survey team members courtesy visa at his entrance to Argentina.

4. <u>Presentation of Survey Report</u>

After completing the first-phase survey work in Argentina, the Japanese survey team is to prepare a survey report based on the topographical maps obtained by means of air-mapping from the aerial photographs mentioned previously. Copies of this survey report shall be submitted to the Government of Argentina, AYEE and the Government of Japan.

The second phase of the work shall be conducted based on this report on the first-phase of work. On completion of the second phase survey work, the Institute is to prepare the final report on the development of hydro-electric power resources of the Rio Mendoza and is to submit copies of this final report to the Government of Argentina, AYEE and the Government of Japan.

5. <u>Other provisions</u>

Agreement in detail between AYEE and Institute for carrying out the second phase of work is to be reached, previous to the commencement of said second phase of the work, between the parties concerned by taking into consideration the results of the first phase of the work.

- Quotation Ended -

Last but not least, the Japanese Survey Team wishes to express its heartfelt gratitude to the following gentlemen for their kindest cooperation rendered to it in Argentina:

Ing. Edmundo R. Gellon

AYEE
Ing. J. H. Monserrat

Ing. F. V. Torreguitar

Ing. A. L. Grandi

Ing. Carlos Herrero

Ing. P. F. Kraan

Ing. Amerigo Premat

Ing. Santiago Curelli

Ing. J. C. Maruyama

Dr. Alejandro Anibal Palma

Dr. Vallejo

II. Summary of Report

The basic survey of Rio Mendoza was originally to be carried out in two phases. In the first phase, the compilation of a detailed topographic map on Rio Mendoza was planned in order to work out an outline general development plan, and to select the sites where construction work should earliest be started. The topographic map should have been compiled, based on the aerophotographs of Rio Mendoza together with the results of the ground survey conducted for scribing the aerophotographs, both of which were to be delivered from the Argentine Government. The second survey was scheduled to follow the first one in order to make site investigation including topographic, geological and other necessary surveys of the dam sites at the points selected in the first survey as those where construction should earliest be started, and thus prepare a feasibility report for the parts surveyed.

However, even at this moment at which this report has been completed, no negative films of the aerophotographs are as yet furnished by Argentina, notwithstanding the Japanese request made for them several times. Therefore, the topographic map for Rio Mendoza, most fundamental in establishing the plan, could not be compiled. The plan itself could not be worked out with the accuracy expected at the beginning. As, however, the survey this time has revealed the river gradients partly in concrete terms, the following development plan has been tentatively worked out, with irrigation and power generation in mind, referring to the existing topographic map at 1/100,000 scale.

The resulting conclusion arrived at by the Survey Team is that, to supply the dire shortage of electric power at present in Mendoza Province, preparation should immediately be set to for the construction of two hydro-power plants with the total generating capacity of 66,000 KW and the total available annual energy generation of 443×10^6 KWH at Punta de Vacas, upstream of Rio Mendoza. It is very important to construct a large reservoir to secure the irrigation water and regulate the current flow. Furthermore, the reservoir is significant to the development of power generation as well. However, the construction of a dam for such purpose could only be effected after preparatory survey of several years at least, while, on the other hand, the present dire power shortage could not allow such a long period of time to wait. It may consequently be recommended as of most advantage for solving the present problems about the irrigation water and power shortage, that the two power stations should first be constructed at any rate, and that at the same time the preparation should be started for the construction of a large reservoir at other planned site, making the best of the experiences and knowledge obtained in constructing the two stations mentioned above.

We wish to add that the construction of the recommended two power plants would cause no unfavorable influence on the quantity of downstream irrigation water.

If the power supply for Mendoza Province and its neighboring areas should happen to be the only aim of the plan, it would be more advantageous to construct a thermal-power station utilizing the petroleum now richly available around Mendoza City. Since, however, the main purpose of the report lies in the integral development of Rio Mendoza, the power plants in this plan are considered all as ones of hydro-power.

III. Development Plan

The main purpose of the development on Rio Mendoza is to secure the irrigation water for the plantations surrounding Mendoza City, sanitary water, industrial water supply, as well as to supply electric energy. It is therefore deliberated in this plan to construct a reservoir which can perfectly regulate the current flow of Rio Mendoza for a long period, and to utilize its stored water for irrigation, sanitary and industrial water supply etc., and meanwhile to generate hydroelectric power.

1. Data Resulting from Investigation

1-1, Data Resulting from Survey

The data that have resulted from leveling and triangulation are shown in Table 1 and Table 2. The locations of the stations are indicated by pinning on the photographs. For convenience, these locations are approximately illustrated in Drawing No.2.

Table 1 ' Leveling Data - (1)

Name of River: Rio Tupungato

Level Point	Elevation
BM-T.V.C.	2418.677
T-12	2386.416
T-11	2409.094
T-10	2435.786
T-9	2464.103
T-8	2491.328
BM-T-3	2526.047
T-7	2562.772
T-6	2591.370
T-5	2611.500
T-4	2641.797
T-3	2664.634
T-2	2677.610
T-1	2684.136
BM T-2	2690.571
T-a'	2695.243
T-b	2714.562
T-c	2735.535
T-d	2751.474
T-e	2767.025
T-f	2778.501
T-h	2806.292
BM T-1	2781.219
T- -1'	2783.544
T- -2'	2831.306
T'-1	2753.558
T'-2	2804.083

Name of River: Rio Cuevas

Level Point	Elevation
BM-T.V.C.	2418.677
C-11	2404.290
C-10	2421.742
C-9	2510.337
C-8	2524.235
C-7	2565.146
C-2	2591.619
C-6	2583.821
C-5	2611.511
C-4	2621.810
C-3	2666.133
C-2	2688.110
C-1	2690.234
BM-C	2724.416
C-1'	2726.371
C-2'	2751.303
C-3'	2788.505
C-4'	2845.478
C-5'	2822.625

Name of River: Rio Vacas

Level Point	Elevation
BM-X	2384.024
BM·V-6	2397.672
V-8'	2402.669
V-7'	2491.112
V-6'	2515.951
BM·V-4	2617.996
V-4'	2662.003
BM·V-3	2859.330
V-2'	2930.927
V-1'	3074.084

Name of River: Rio Mendoze

Level Point	Elevation
BM·X	2384.024
M-1	2348.754
(BM·M-1)	2359.954
M-2	2364.738
M-3	2366.151
M-4	2292.350
M-5	2304.467
M-6	2299.486
M-7	2279.982
M-8	2284.897

Table 1 Leveling Data - (2)

Name of River: Rio Vacas

Level Point	Elevation
T·P-V	3092.916
BM·V-2	3114.502
BM-T.V.C.	2418.677
TP-V	3092.916
V-2	3123.629
V-4	3153.103
V-5	3172.949
BM·V-1	3180.949

Name of River: Rio Mendoza

Level Point	Elevation
M-10	2238.637
M-11	2172.896
M-12	2157.262
M-14	2131.989
M-24	2017.944
M-26	1956.238
M-18	2128.212
M-27	2100.130
M-28	2075.338
M-29	2128.820
M-30	2173.056
A'-9'	1939.621
A'-8'	1896.321
PF(6)	1878.910
A'-7'	1874.683
A'-6'	1880.276
A'-5'	1868.405
A'-4'	1853.001
A'-3'	1834.218
A'-2'	1879.580
PF(2)	1880.917
PF(1)	1894.292
TP-11	1881.187
TP-9	1881.381
TP-8	1872.241
TP-7	1860.976

Name of River: Rio Mendoza

Level Point	Elevation
M-9	2254.193
M-10	2238.637
M-16	2221.104
M-15	2174.811
M-17	2161.656
M-18	2128.212
M-19	2130.772
M-20	2147.647
M-21	2095.994
M-22	2031.455
M-23	1998.727
M-24	2017.944
M-25	1997.476
A'-9' (BM·M-6)	1939.621
BM·Y	1738.491
TP·A	1738.856
A-1	1759.850
A-2	1785.575
A-3	1797.806
A-4	1865.498
A-5	1886.311
A-6	1934.416
A-6"	1865.701
BM-Y	1738.491
P-1	1724.011
F-2	1710.489
P-3	1698.954
P-4	1681.792
P-1	1680.471
P-5	1662.412
P-6	1643.264
P-3	1637.106
P-7	1626.316
P-9	1574.862
BM·P	1563.345
P-10	1524.414
P-12	1509.461
P-13	1492.127
P-14	1463.099

Table 2 Leveling Data - (3)

Name of River: Rio Mendoza

Level Point	Elevation
TP-6	1852.179
TP-2	1777.050
TP-A	1738.856
N-1 (BM·N-1)	1384.186
N-2	1339.171
N-3	1329.362
N-4	1322.809
N-5	1305.141
N-6	1288.445
N-7 (BM·N-2)	1299.799
N-8 (GM·N-3)	1264.102
N-9	1250.776
N-10	1241.982
N-11	1229.275
N-12	1209.429
N-13	1193.355
N-14	1200.976
N-15	1187.636
N-16	1072.344
N-17	1159.492
N-18	1112.878
BM·N-1	1384.186
P'-1	1423.016
P'-2	1463.933
P'-3	1518.704
P'-4 (BM·P-1)	1596.742

Name of River: Rio Mendoza

Level Point	Elevation
P-15	1440.988
P-16	1414.833
P-17	1389.693
P-18	1390.283
P-19	1375.503
BM·N-1	1384.186
Q-1	1348.282
Q-2	1335.757
Q-3 (BM-Q-1)	1425.753

Table 2 Triangulation Data - (1)

Triangulation Point	X	Y
	m	m
Extremo S.O.	+ 70,000.00	+ 60,000.00
U-3	67,715.26	58,429.25
5	65,919.35	53,579.12
6	64,947.82	48,829.71
7	57,519.08	45,096.87
8	53,124.61	43,264.53
9	49,548.01	40,919.71
10	45,779.43	37,663.95
11	43,237.28	32,568.03
12	41,840.68	31,564.78
13	40,799.43	29,680.68
14	39,830.30	27,515.91
P.V. 2	36,115.53	23,706.40
P.V. 1	35,165.04	23,648.42
P.V. 1 (defl.)	35,065.15	23,610.77
C-1	36,340.16	20,544.01
2	37,413.71	18,377.36
3	38,104.46	15,483.04
4	38,846.58	12,495.77
5	39,190.61	8,545.20
6	39,082.02	7,302.36
7	40,568.38	6,825.21
P.V. 2	36,115.53	23,706.40
V-8	37,729.35	24,459.46
7	40,353.78	21,838.59
6	41,201.83	21,957.20
5	42,814.26	20,975.26
4	45,326.78	20,432.38
3	47,379.87	19,392.57
2	50,598.44	18,120.41
1	57,154.68	15,009.42
P.V. 1	35,165.04	23,648.42
T-10	27,394.07	24,604.45
9	25,586.88	24,658.71
8	24,786.12	24,222.34
7	23,194.83	24,435.86
6	22,504.81	24,687.43
5	20,003.63	24,392.35
4	16,138.96	25,276.41
3	10,204.60	24,093.57

Table 2 Triangulation Data - (2)

Triangulation Point	X	Y
	m	m
T-3 (Defl.)	+ 10,267.75	+ 24,055.92
2	8,238.31	25,400.08
1	5,553.80	19,443.54
U-3	67,715.26	58,429.25
2	59,977.09	58,249.60
U-2 (Defl.)	59,993.04	58,176.78
1	57,738.50	61,634.02
P-1	54,823.88	63,201.36
2	53,067.55	63,901.87
3	51,312.83	64,718.26
4	48,367.93	64,995.97
5	44,977.36	65,249.37
6	44,163.47	64,988.58
7	44,698.05	65,683.67
8	44,135.37	67,006.63
9	42,425.62	68,405.40
10	40,765.49	70,494.82
11	37,540.43	70,987.44
12	33,587.94	71,355.55
13	33,298.75	73,517.01
14	32,055.17	75,215.15
15	29,530.04	77,656.46
16	28,678.42	79,526.93
17	26,168.10	82,472.41
18	25,455.43	84,125.24
19	22,407.14	86,136.76
20	20,642.91	87,292.41
21	20,118.30	88,199.28
22	20,786.76	91,205.34
23	21,581.34	95,080.82
P-24	17,238.44	94,519.04
U- 4	65,682.50	61,378.94
PA	29,712.46	80,435.07
PB	26,190.50	72,703.41
PC	31,611.21	80,448.94
PD	17,665.98	89,005.08

1-2, Outline of Geological Features

1-2-1, Outline of Geological Features

Both banks of Rio Mendoza show rather steep slopes, and the rock-bed is exposed in the ground. On the river-bed is extended the bed load for a wide range of areas, so that the so-called flat-bottom valley is shaped at many places. Generally, few covering materials could be found on the rock-bed, and the exposures of the rock-bed are recognized as comparatively new. Many different geological features can be found, distributed along the Rio Mendoza basin. The geological composition has been forcedly disturbed three times by the past earth crust movements, and the aspects appear very complicated.

A brief explanation of the main geological components is as follows:- (See Drawing No.3)

Graywacke: Can be observed in Rio Tupungato and almost all parts of the survey area. Especially, widely distributed in Uspallata and its upstreams. The graywacke is regarded as that to be compared with the Mississippian of the Paleozoic era, and generally grey-color and very solid. Many are found in lump shapes with the strata indistinct, but some in phyllitic condition.

Granite: Distributed along Rio Tupungata upstream, Rio Vacas downstream, Cerro Negro and its downstream and Cacheuta. The rock faces are full of variety showing from dioritic to porphyritic and so forth. The granite found in Rio Tupungato area would be considered as one griding into at a time after the mississippian of the Paleozoic era.

Porphyry, Porphyrite: Generally found in any place. Especially, widely distributed in the up-and-downstream of Uspallata. Many would have penetrated into the present places during the period from the end of the Paleozoic era through the Mesozoic era. All are very solid and in many colors such as grey, pink, etc. Remarkable development of the joint is often observed.

Volcanic Rock, Pyroclastic Rock: The rhyorite, dacite, tuff breccia are richly distributed. The formation for the most part would belong to the Paleozoic era, Permian and Cenozoic period. Most of the tuffs here are advanced in age of formation and are generally hard.

Moraine, Alluvium, Detritus: Along Rio Mendoza, main stream and its branches, the moraine is distributed often on large scales. The alluvium is found in all the parts of the river-bed, consisting of sand and pebble, and is often seen to form gravel terraces 10-30 m high. Its thick accumulation ranges throughout the river-bed, and the thickest pile would be as high as some 50 m. The detritus is accumulated in fan shape from top to bottom on the depressed area of both the river banks. Most of the them consist of the debris of outcrop rocks, and sand or clay is seldom interspersed among them.

1-2-2 Particular Geological Characteristics

Due to the wide river-bed and the thick accumulation of sand and pebbles, there are along Rio Mendoza few places whose topographic and geological features are suitable and promising for dam construction. Stated as follows is the brief conclusion on the geological features in regard to the points, topographically and geologically, advantageous to dam construction upon the bed rock.

(1) Rio Tupungato

No.1 Site: Located at the border line between granite and graywacke formation, and the left-bank section is granite for the most part, with graywacke distributed at its higher elevation. As for the right-bank section there exist the granite part which forms its upstream-side half and the graywacke part which occupies its downstream-side half. On the river-bed section is an accumulation of sand and pebbles, and the bed-rock is considered to be granite. The outcrop in the left bank shows the developed joint of N20°-45°, E60°-80°W, along which from the left bank all the way downstream to the river-bed there exists a fractured zone 1-2 m wide. The weathering of the fractured zone is considered to be slight. In the granite, the existence of pegmatite is observed.

No.2 Site: The bed rock here consists of graywacke. In the right-bank section is seen a fractured zone 5 m wide, at N20°E80°E (estimated). It is presumed that there exists in the downstream-side half of this section a rather large fault-fractured zone at around N60°E. The left-bank section is remarkable for its many cracks streaked in the N-S direction, with detritus distributed up to comparatively high positions. Gravel has been piled up on the river-bed, but its thickness above bed rock is deemed to be relatively small.

No.3 Site: Consists largely of graywacke, with gravel detritus rather widely distributed.

(2) Rio Cuevas

The main geological features in the area consist of rhyorite and tuff granite. In the neighborhood of Inca Hotel, up-stream of the river, the distribution of conglomerate is observed. On the river-bed, gravel is generally distributed.

(3) Rio Vacas

No.4 Site: The graywacke in the river-bed is in an exposed and phyllitic condition. The right-bank section on its downstreamside is bounded by granite, and in the higher places of the left-bank section volcanic rocks (estimated) are distributed. Further, it is presumed that a fault should exist in the direction from the upstream side of the left-bank through the downstream side of the right-bank. Downstream of No.4 Site, the main feature is granite with graywacke interspersed, and with outcrops here and there of the bed-rock, which can provide a very promising dam site.

(4) Rio Mendoza (Punta de Vacas - Uspallata)

No.5 Site: Beginning from the upstream neighborhood of this site, the rock faces appear in rich variety: graywacke, porphyrite, dacite, dacitic pyroclastic rock exist, and several strikes of the dacitic porphyrite dike are penetrating. As a whole, a very complicated geological edifice is formed. Along the left-bank the bed rock is outcropped almost up to the river-bed, but along the right-bank the gravels have been accumulated rather thickly, forming gravel terraces. Downstream of No.5 Site, the main component feature consists of porphyrite and dacite, and the river-bed is covered with gravels as a whole.

(5) Rio Mendoza (Uspallata - Cacheuta)

No.6 Site: Mainly consists of quartz porphyry, and in the right bank a remarkable joint at N15°-25°W60°W has been developed but the rock quality is fairly good. On the river-bed the gravels are accumulated widely, and their depth above bed rock is estimated to be rather great.

No.7 Site: On the upper-stream side are distributed andesite, basalt and pyroclastic rock which are piled up in coordinate layers at NS60°W. Several strips of fractured zone at NS60°-80°W are found in the upstream-side half of the right-bank section, but along the downstream-side half is distributed graywacke which is outcropped as far as the neighborhood of the river-bed. Along the left-bank the gravel has accumulated 20 - 30 m high on the river-bed.

Downstream of Cerro Negro as far as Medie, there are comparatively many places where granite remains exposed down to the river-bed. The site, therefore, would be advantageous to the construction of dams. The granite is seen turned into masa or to form fractured zones in some parts of the right-bank on the lower reaches of the stream. Furthermore, same dikes of basalt (estimated) several meters wide are seen running here and there through the bank.

Around Desalte is seen mainly distributed the porphyrite but less gravel detritus. This would be suitable for a dam site.

1-2-3 Opinion Obtained from Field Investigation

Generally along the basin of Rio Mendoza, the gravels have been accumulated widely on the river-bed, and often piled up to the height of 20 - 30 m to form gravel terraces. The fact that gravels have been piled up very thickly (presumingly more than 30 m high), would limit the number of promising sites, where dams could be constructed on foundation rocks, to only a few. The foundation rock as a whole is good in quality, and even where fractured zones are formed, the degree of weathering (chiefly clayey change) is recognized very low.

Accordingly, the thickness of the river-bed gravel and its physical nature still remain to be studied first in a future investigation. In other words, further investigation should be conducted to see whether a selected site justifies excavation down to the bed-rock in order to construct dams thereon. The investigation is desired to include also studies of the permeability and solidification of the river-bed gravels, and of how to give basic treatment to the gravels for purposes of construction works.

2. Data for Plan

2-1 Topography

We have based our knowledge of the topography on the river gradients of Rio Tupungato, Rio Vacas, and those of part of Rio Cuevas, Rio Mendoza, which were clarified by the survey carried out this time, referring to the topographic map at 1/100,000 scale of the Instituto Geografico Militar. (See Drawing No.4 and No.5)

2-2 River Run-off

The data of Anuario Hidrologico, and the data of flow, 1958-1962, were used as references. According to these data, the river run-off of Rio Mendoza for the past ten years has been gradually reduced year by year. The data of river run-off of Rio Tupungato, Rio Cuevas, and Rio Vacas, at Punta de Vacas, are available as far back from 1949 but three years from 1952 to 1954. This report is based on these data from 1949 to 1962 covering 11 years. The data are shown in Drawing No.6.

2-3 Amount of Evaporation

According to the measurements which were made by Servicio Meteorologico Nacional in Mendoza City and Potrerillos, the annual amount of evaporation was 1,456.5 mm within Mendoza City and 1,285.3 mm in Potrerillos.

2-4 Sand Running-down

S.A.D.I.P. measured the volume of sediment loads on rivers. The measurement periods were not always continuous, but the results for annual sand running-down are recorded as follows:-

Rio Tupungato	1,591,000 m^3
Rio Cuevas	146,600 m^3
Rio Vacas	115,400 m^3
Rio Mendoza	3,178,500 m^3

As there is no good expedient to scour the inflowing sediment sand in a storage reservoir, assumption is made that the inflow sediments should come to be accumulated in the future as high as the lowest water level (L.W.L.). This sediment volume is calculated to be 190,000,000 m^3 at the Tupungato Dam (to be constructed directly downstream of the confluence of Rio Tupungato and Rio Chorillos) and 300,000,000 m^3 at the dam for Mendoza No.3 Power Station (to be built on the lower reach of Uspallata), totaling 490,000,000 m^3. This total amount would be equivalent to that of the sand and pebbles inflowing from the upper streams to accommodate in 100 years.

In case of the power stations provided with no reservoir, the intake gates are to be placed as high as possible, to serve the purpose to maintain high regulating storage capacity. Moreover, a sedimentation basin spacious enough for sedimentation of the inflowing sand will be installed as connected with the intake gates.

2-5 Estimated Discharge Required for Irrigation

In the period of the survey, no adequate data were available for the irrigation periods and the amounts of water for irrigation respectively required for various kinds of agricultural products. The reference data below have been quoted therefore from Agricultura Bajo Riego by Ing. J. A. Luque.

The relation between the irrigation period and the required discharge is shown in the Table 3 and Drawing No.9. The plantations for respective crops are estimated as follows:-

Grape	52,000 ha.
Various Fruits	8,000 "
Olive	16,000 "
Alfalfa	9,000 "
Total:	85,000 ha.

According to Drawing No.9, the annual volume required for irrigation covering the whole present cultivated area is estimated to amount to 680×10^6 m^3.

2-6 Estimated Discharge Required for Industrial and Sanitary Service

According to the data for 1960, of the total water consumption excepting irrigation water, 46×10^6 m^3, domestic water service supply occupied 93%, and 2% was used for the industrial purpose. The total water to be required in the future due to the development of industries in connection with the expected increase of electric power supply, as well as to the increase of population is estimated to reach 5 m^3/s (150×10^6 m^3).

2-7 Estimated Demand for Electric Power

The demand in anticipation for electric power was taken into consideration to cover the increase up to 1975. In Mendoza Province and its neighboring districts, there have been the new establishments of various industries consumptive of electricity in quantity, the expansion of YPF oil refineries, and

Table 3 Irrigation Water Volume & Its Period

For Crops Respectively

Kind	Period m/d - m/d	Water Required (m3/ha) period	No. of Days	Water Required (m3/ha) per day	Total m3/s
Grape 52,000 ha.	8/20 - 9/20	560	32	17.5	10.5
	9/21 - 10/22	500	32	15.6	9.4
	10/23 - 11/23	560	32	17.5	10.5
	11/24 - 12/25	690	32	21.6	13.0
	12/26 - 1/26	820	32	25.6	15.4
	1/27 - 2/27	1,060	32	33.2	20.0
	2/28 - 5/3	1,000	65	15.4	9.3
	5/16 - 7/15	820	31	26.4	15.9
Various Fruits 8,000 ha.	8/18 - 10/4	1,050	48	21.9	2.0
	10/5 - 11/21	1,060	48	22.1	2.1
	11/22 - 12/31	1,100	40	27.5	2.6
	1/1 - 2/17	1,190	48	24.8	2.3
	2/18 - 5/8	1,130	80	14.1	1.3
	5/9 - 7/15	980	68	14.4	1.3
Olive 16,000 ha.	9/19 - 11/5	440	48	9.2	1.7
	11/6 - 12/23	560	48	11.7	2.2
	12/24 - 2/9	690	48	14.4	2.7
	2/10 - 3/29	630	48	13.1	2.4
	3/30 - 6/9	500	72	7.0	1.2
	6/10 - 7/30	500	51	10.0	1.8
Alfalfa 9,000 ha.	9/11 - 10/12	1,060	32	33.2	3.5
	10/13 - 11/5	1,060	24	44.2	4.6
	11/6 - 11/29	1,190	24	49.6	5.2
	11/30 - 12/23	1,310	24	54.6	5.7
	12/24 - 1/16	1,370	24	57.2	6.0
	1/17 - 2/19	1,310	24	54.6	5.7
	2/20 - 3/21	1,190	40	29.8	3.1
	3/22 - 6/30	1,060	101	10.5	1.1

the construction of pumping station to suction the underground water for irrigation. This entails the rapid increasing demand for electric power. As a counter-measure to meet it, AYEE has completed the electric transmission line through San Rafael -Mendoza-San Juan, but has never been successful in satisfying the rising requirements. Under the current circumstances, AYEE keeps the regulated supply of electricity and the power shortage as of 1963 was recorded to be still 45,000 KW. A large control on power supply was carried out in the period from April through August recently.

With the past consumption records, the expected increase of population in the future, the expansion of industries, all put under deliberation, the rate of increase of electricity demand per classified consumption is estimated: Domestic Service 10%, Commercial 8%, Industrial 18%, Irrigation 15%, Transportation 2%, Public Organizations 5%, and other miscellaneous 7%. The annual demand for power is anticipated as shown in Table 4 and represented in Drawing No.7.

Table-17. <u>Estimated Demand For Electric Power</u>

Use / Year		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Domestic	10^6KWh	77.5	93.6	106.0	120.0	135.0	152.0	172.0	196.0	222.0	255.0	285.0	322.0	366.0
Commercial	"	45	48.6	52.5	56.7	61.2	66.0	71.2	76.7	82.2	88.7	95.6	103.2	111.5
Industrial	"	304	350	40.2	462	530	608	700	805	925	1,062	1,222	1,410	1,620
Public Light	"	6.3	6.5	6.8	7.1	7.3	7.7	8.0	8.4	8.8	9.2	9.6	10.0	10.5
Transportation	"	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.7	5.9	6.0
Public Org.	"	46	48.3	50.8	53.4	56.0	58.8	61.8	65	68.3	71.3	75.0	78.6	82.5
Other (civil)	"	14.7	15.7	16.8	17.9	19.2	20.5	21.9	23.4	25.0	26.8	28.7	30.7	32.8
Irrigation	"	40	46	52.8	60.7	70	80.5	92.5	106.2	122	140	161	185	213
Total	"	538.3	613.6	692.7	782.9	883.9	998.8	1,132.8	1,286.2	1,458.7	1,658.7	1,882.6	2,145.4	2,442.3
Population	10^3	893	920	945	970	1,000	1,025	1,055	1,090	1,120	1,150	1,187	1,221	1,260
Consumption per Head	KWh	92.5	101.8	112	123	135	148	163	180	198	218	240	264	290
Transmission Loss (12%)	10^6KWh	64.6	73.6	83.2	94.0	106	120	136	154	175	199	226	256	293
Total (Generating End)	"	602.9	687.2	775.9	876.9	989.9	1,118.8	1,268.8	1,440.2	1,633.9	1,857.7	2,108.6	2,401.4	2.735.3
Load Factor	%	55	57	58	60	62	63	64	65	65	65	65	65	65
Max. Generating Cap.	MW	125	138	153	167	183	203	227	253	287	327	370	422	480
Installed Capacity	"	144	158	176	192	211	234	261	291	330	376	426	485	552

3. Outline of Irrigation Plan

In order to insure supply of irrigation water for areas around Mendoza City, construction of storage reservoirs at the topographically-suitable sites on Rio Tupungato and Uspallata is planned. The reservoirs are intended to completely control and regulate the outflowing water for many years. The storage capacities of the reservoirs are calculated as follows:-

Reservoir	Tupungato	Uspallata	Total
Total storage (10^6 m^3)	320	950	1,270
Effective Storage (")	130	650	780

With the total effective capacity of 780 x 10^6 m^3 for the two reservoirs, the run-off could be regulated to a perfect average of run-off for the past 11 years. This is shown in Drawing No.8. With these reservoirs, it would become certainly possible to secure the irrigation water for 85,000 ha. area (shown in Drawing No.9) and the industrial and sanitary water supply of 5 m^3/s (shown in Table-5).

The above-listed storage capacities were calculated from the data based on the topographic map at 1/100,000 scale. If the storage capacities calculated on the basis of a topograph to be compiled on the aerophotographs should prove shortage of the above value, another storage reservoir would have to be built to cover the shortage. As such third reservoir site the Potrerillos Site would be a suitable one.

Table-5 Uspallata Reservoir Effluent Plan

Month	Average Effluent/month for 85,000 ha. (m^3/s)	Effluent for Industries (m^3/s) and Sanitary	Total (m^3/s)	Possible Effluent (for Power Generation) (m^3/s)
J	27.5	5	32.5	40.2
F	30	5	35	40.2
M	15.5	5	20.5	40.2
A	13	5	18	40.2
M	19.5	5	24.5	40.2
J	20	5	25	40.2
J	10	5	15	40.2
A	10	5	15	40.2
S	14	5	19	40.2
O	17.5	5	22.5	40.2
N	21	5	26	40.2
D	24.5	5	29.5	40.2

The present plantations are rather overestimated to be 85,000 ha., allowing a considerable extent of increase in the future. However, in case the more increase of demand might result from the expansion of plantations, increase of population, and development of industries, the effluent from Uspallata, by being reduced in the non-irrigation period and released more in the irrigation period, could insure full supply to these needs.

4. Power Generation Plan

Table 6 and Drawing No.10 show the power generation plan which will serve the purpose of producing electric power as well as assuring the water supplies for irrigation, industries, domestic use in the districts along the lower reaches of the rivers.

This aims at the perfect adjustment of water flow based on its records for the past eleven years from 1949 to 1962, and the utilization of heads of the rivers, for power generation. The explanatory in brief of the individual power plants is as follows:

Tupungato Power Plant:

About 15 km upstreams from Punta de Vacas and at the lower reach from the diversion point with Rio Chorillos, it is planned to construct over Rio Tupungato a hollow gravity dam, 95 m high and 440 m in the crest length, to make a reservoir accomodating the total storage of 320×10^6 m^3, and the effective capacity of 130×10^6 m^3. This reservoir should regulate the annual run-off at the Site, and on the other hand, the discharged water, 40 m^3/s at the maximum, would be led through the tunnel 7,500 m long, making the effective water head of 212 meters, into an underground power plant located near the confluent point of Rio Tupungato and Rio Blanco, where electric power will be generated at the maximum output of 72,000 KW and an annual enetrgy of 210×10^6 KWH. The power plant is of an 8-hour peak operation.

Vacas Power Plant:

An intake dam is to be built over Rio Vacas, 14 km upstreams from Punta de Vacas. From the dam, the discharged water, 4.5 m^3/s at the maximum, runs through the tunnel 9,500 m long, making the effective head of 415 m. The generating capacity would be 16,000 KW at the maximum, with the energy generation of 90.5×10^6 KWH per year. The plant is of a 12-hour peak operation.

Mendoza No.1 Power Plant:

An intake dam is to be constructed on the immediate lower reach from the confluent point of Rio Tupungato and Rio Blanco so as to regulate the discharge inflowing from the Tupungato dam, equalizing it from 40 m^3/s into 13.3 m^3/s and, at the same time, to intake the remaining run-off of about 6.7 m^3/s, making the total of 20 m^3/s.

The discharged water runs through the tunnel 7,800 m long into an intake dam which is constructed over Rio Cuevas about 3 km upstreams from Punta de Vacas, and put together with the intake discharge of 4 m^3/s at the maximum, runs further through the interior of an intake dam which is planned over Rio Vacas about 3 km upstreams from Punta de Vacas, where the discharge from the Vacas Power Plant is to be adjusted to 2 m^3/s at the maximum. The total discharge of 26 m^3/s is led for 5,000 meters by tunnel, to an underground power station to be constructed on Rio Mendoza about 5 km downstreams from Punta de Vacas.

The plant, with its effective water head 221 m high, would have the maximum output of 50,000 KW and the annual energy generation of 328 x 10^6 KWH.

Mendoza No.2 Power Plant

The discharged water from the Mendoza No.1 Power Plant would, at its tailrace, be immediately taken in through the tunnel 35,000 m. long, making out the effective head of 347 meters, to be utilized for electricity generation. The maximum output is 76,000 KW and the annual energy generation 515 x 10^6 KWH.

Mendoza No.3 Power Plant

A rockfill dam, 135 m high and 444 m in crest length, is to be constructed over Tio Mendoza about 5 km downstreams from the Uspallata railroad station, to provide a reservoir with the total storage of 950 x 10^6 m^3 and the effective capacity of 650 x 10^6 m^3. The total effective capacity of this reservoir combined with that of the Tupungato Power Plant, 780 x 10^6 m^3, can regulate the flow to the equivalent of average run-off for the past 11 years. From this storage reservoir, the water, 120 m^3/s at the maximum, is taken in and led for the length of 10,000 meters by tunnel. Utilizing the resulting effective head of 183 m, electricity is produced at the maximum generating capacity of 186,000 KW and the annual energy generation of 542 x 10^6 KWH. The power plant performs an 8-hour peak operation.

Mendoza No.4 Power Plant

The discharge of 120 m^3/s from the Mendoza No.3 Power Plant is to be equalized into 40 m^3/s by means of the regulating reservoir to be constructed on Rio Mendoza around Cerro Negro. The equalized discharge is led through the tunnel 18,700 m long, to a power plant located near Potrerillos. The plant, with its effective water head 253 m high, would have the maximum generating capacity of 86,000 KW and the annual energy generation of 750 x 10^6 KWH.

This power generation plan would make available in total the generating capacity of [illegible]86,000 KW and the annual energy generation of 2,499 x 10^6 KWH.

Table-6. Outline of Power Generation Plan

		Tupungato	Vacas	Mendoza No. 1			" No. 2	" No. 3	" No. 4	Total
	Type of Power Generation	Dam and Run-of-river	Run-of-river	"			"	Dam and Run-of-river	Run-of-river	
Dam	Type	Hollowgravity	Concrete	No. A Concrete	No. B Concrete	No. C Concrete	-	Rockfill	Concrete	
	Height (m)	95	14	19	14.5	8	-	135	8	
	Crest Length (m)	440	53	240	204	50	-	444	90	
	Concrete Volume (10^3m^3)	1,160	6.3	68.5	22.3	4.2	-	-	14.2	
	Rock and Earth Volume (")	-	-	-	-	-	-	11,590	-	
Reservoir	H.W.L.	2,750	2,940	2,525	2,510	2,508	-	1,820	1,620	
	Draw Down (m)	20	2	5	-	2	-	40	5	
	Gross Storage Capacity (10^6m^3)	320	-	1.2	-	0.2	-	950	4	
	Effective Storage Capacity (")	130	0.1	1.0	-	0.15	-	650	2.5	
Tunnel	Type	Pressure	Non Pressure S=1/1,000	Non Pressure S=1/800	Non Pressure S=1/800	Non Pressure S=1/800	Non Pressure S=1/800	Pressure	Non Pressure S=1/1,000	
	Overall Length (m)	7,500	9,500	7,800	4,000	5,000	35,000	10,000	18,700	
	Diameter (m)	4.6	2	3.1	3.4	3.5	3.5	7.8	4.1	
Penstock	Total Length (m)	247	580			265	920	248	280	
	Diameter (m)	3.4	1.15			2.7	2.7	4.1 2.9	3.3 2.3	
	Pipe No.	1	1			1	1	2 4	1 2	
Power Plant	Standard Intake Elevation (m)	2,745	2,940			2,504.9	2,274	1,810	1,615	
	Standard Outlet Elevation (m)	2,525	2,510			2,274	1,880	1,620	1,340	
	Total Head (m)	220	430			230.9	394	190	275	
	Effective Head (m)	212	415.5			221	347	183	253.4	
	Max. Discharge (m^3/S)	40	4.5			26	26	120	40	
	Max. Generation Capacity (MW)	72	16			50	76	186	86	486
	Annual Power Generation (10^6KWh)	210	91			352	554	542	750	2,499
	Usable rate of Power Plant %	33	65			77	77	33	100	59

5. Transmission Plan

The electric transmission lines interconnecting all the abovementioned six power plants are to be constructed along the river:

Transmission Line	Transmission Capacity (MW)	Voltage (KV)	No. of Circuits	Total Circuit Length (KM)
From Tupungato Plant to Mendoza No.2 Plant	132	220	1	50
From Mendoza No.2 Plant to Mendoza City	486	220	2	100

6. Estimated Construction Cost

The proper estimation of the construction cost cannot be made unless, following the basic survey, the further survey has been completed to study the execution of construction works. Particularly, at this stage where there was no available detailed topographic map and no geological investigation was carried out, nothing but a very rough calculation could be expected.

The depth of dam foundation and the geological conditions of the areas through which the tunnels are planned to run are the decisive factors in determining the construction cost. But, both still remaining unknown, estimates on standard designs had to be employed this time for the calculation of the cost for constructing dams, tunnels and foundations of power plants.

Chief item unit prices are presumed as follows:-

Dam :	Earth Excavation	US\$1.5/m^3
	Rock Excavation	" 3.5/m^3
	Concrete	" 2.5/m^3
	Earth Banking	" 3/m^3
Tunnel:	Excavation	" 17/m^3
	Concrete	" 30/m^3

The thickness of the tunnel structure is made out to be 8% of the tunnel diameter, taking the value on the safe side because of unknown, surrounding geological conditions.

6-1. Estimate of Construction Costs at Generating End

Since there are as yet many indefinable factors involved in computing the construction cost, these factors as reflected in cost are allowed for as the reserve fund. The interest during construction is estimated as at 6.5% per annum for all the construction cost inclusive of the reserve fund. The estimated construction cost at generating end is as shown in Table-7.

Table-7 Estimate of Construction Cost at Generating End

(10^3 US$)

Power House / Item	Tupungato	Vacas	Mendoza No.1	Mendoza No.2	Mendoza No.3	Mendoza No.4	Total
Building	468	104	315	544	1,379	609	
Water-way	5,670	1,715	7,640	13,201	18,125	11,662	
Reservoir	30,474	-	-	-	28,780	-	
Machine & Equipment	3,136	930	2,208	4,715	7,315	3,185	
Construction Road	128	112	-	-	-	-	
Indemnity	-	-	60	-	8,400	-	
Overhead expenses	17,960	704	2,522	5,144	26,016	4,312	
Reserve fund	3,831	240	912	1,611	6,034	1,386	
Total Construction Cost	61,667	3,805	13,657	25,215	96,049	21,154	221,547

Note: The amount listed as overhead expenses includes temporary facilities, supervision expense, interest during construction.

6-2 Estimate of Construction Cost for Transmission Line and Transformer Substation

Construction cost of transmission line:

From Tupungato to Mendoza No.2 Power Plant	US$1,400,000.-
From Mendoza No.2 Power Plant to Mendoza City	$2,000,000.-

Construction cost of Transformer Substation:

Between Tupungato and Mendoza No.2 Power Plant	$2,200,000.-
From Mendoza No.2 Power Plant to Mendoza City	$8,100,000.-
Total:	US$15,900,000.-

IV. Conclusion

1. Further Survey to be Followed

This report represents the outline development plan for Rio Mendoza and all its basin, based on the basic survey for irrigation and electric power resources. In the basic survey, the general and brief geological survey only has been carried out in regard to the construction of dams, tunnels and power plants, but especially at the planned dam sites, the depth of river-bed and the quality of the rock foundation still remain to be known. Further, as there has not as yet been any detailed topographic map available, the report was obliged to deal with but a very rough and basic outline of the survey.

However, as concerns Rio Mendoza, fortunately, we have available its run-off data for the past 40 years. Therefore, in order to complete the more accurate plan for development, it is necessary to carry out further basic survey following this basic one to cover the problems as follows:-

(a) Compilation of Detailed Topographic Map Covering All the Length of Rio Mendoza

The aerophotographs to cover all the reaches of the rivers have been prepared, and utilizing the aerophotographs and other photos, the triangulation by pinning on them has been effected, together with the leveling, thanks to the basic survey carried out this time. It is therefore necessary that, utilizing all the data obtained, a topographic map at 1/10,000 scale at least should be made out as soon as possible.

(b) Execution of General Geological Survey

Investigation should be made for the general geological survey on the planned dam sites and the designated locations for the tunnels and power plants, as shown in Drawing No.5. Especially the survey on the depth of the alluvium, and its coefficient of infiltration bearing capacity.

(c) Investigation on the Construction Materials

(d) General Topographic Survey on the Site of Dams and Power Plants

(e) Planning of the future Irrigation and Industrialization

Dependent upon the results of the above survey, the development plan worked out this time may in part undergo changes such as those of dam site, etc.

2. Recommendations Resulting from the Survey

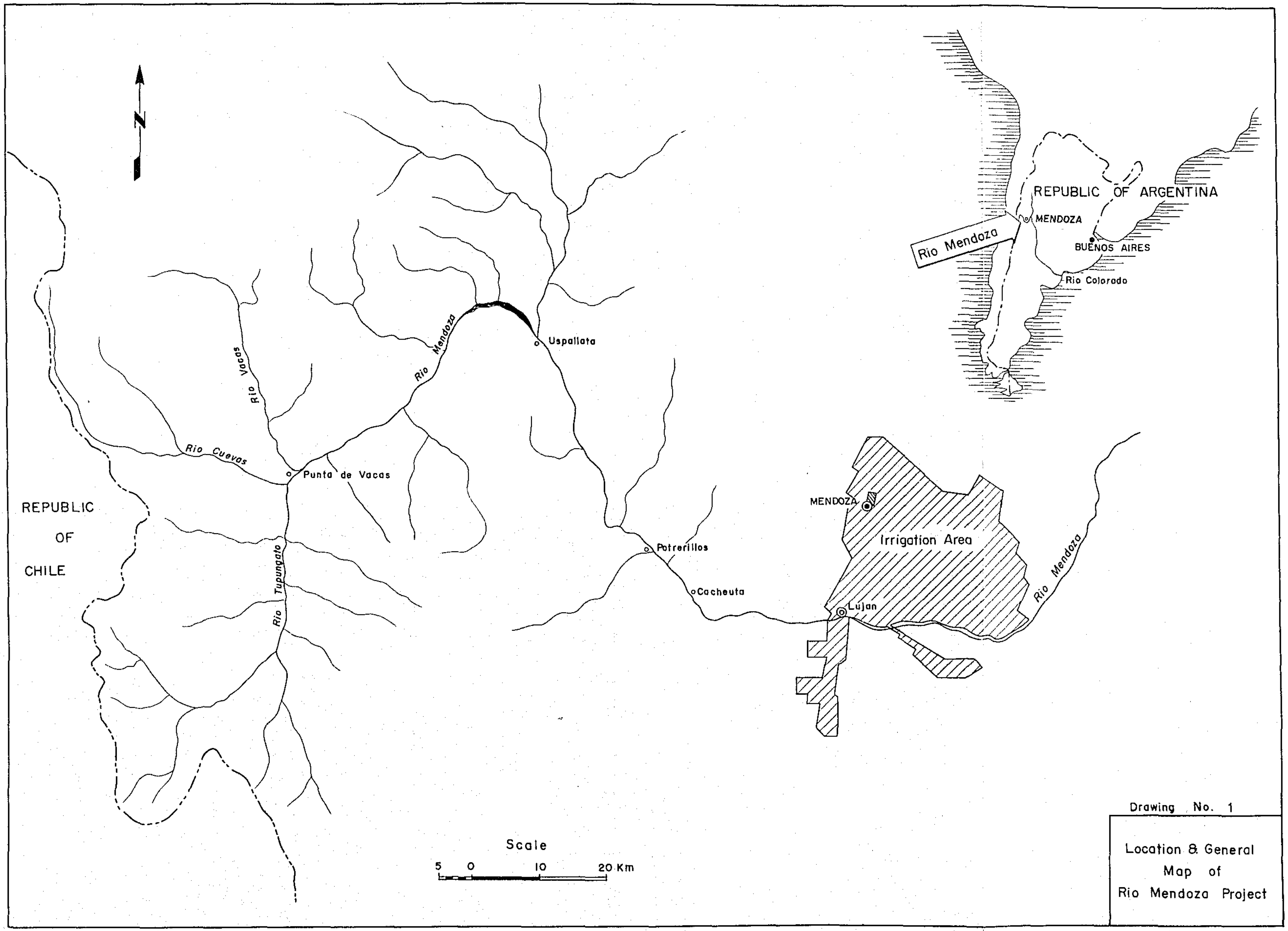
At present, Mendoza Province suffers the power shortage of 45,000 KW, and has to bring in force a large-scale restriction on power supply between May and August. This imposes a lot of inconveniences upon the citizens' life. It is therefore necessary to set to the construction as soon as possible of the two power plants, Vacas with the output of 16,000 KW and Mendoza No.1 of 50,000 KW, totaling 66,000 KW of the output and 440 x 10^6 KWH of the annual energy generation. In preparing for the construction, it is recommended to carry out an early survey on the items as follows:

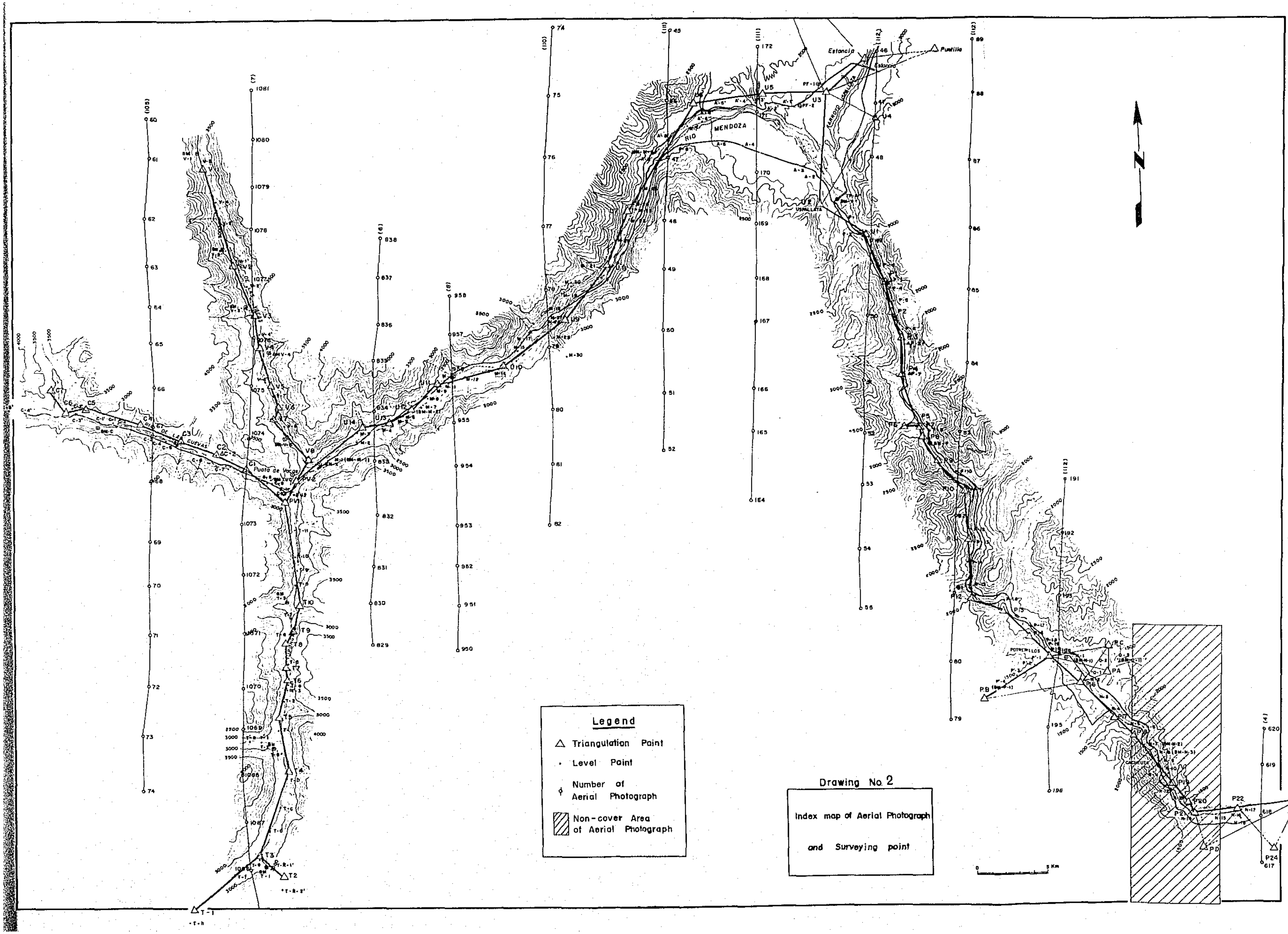
(a) Plane surveying of the area around the intake-dam sites and power plants.

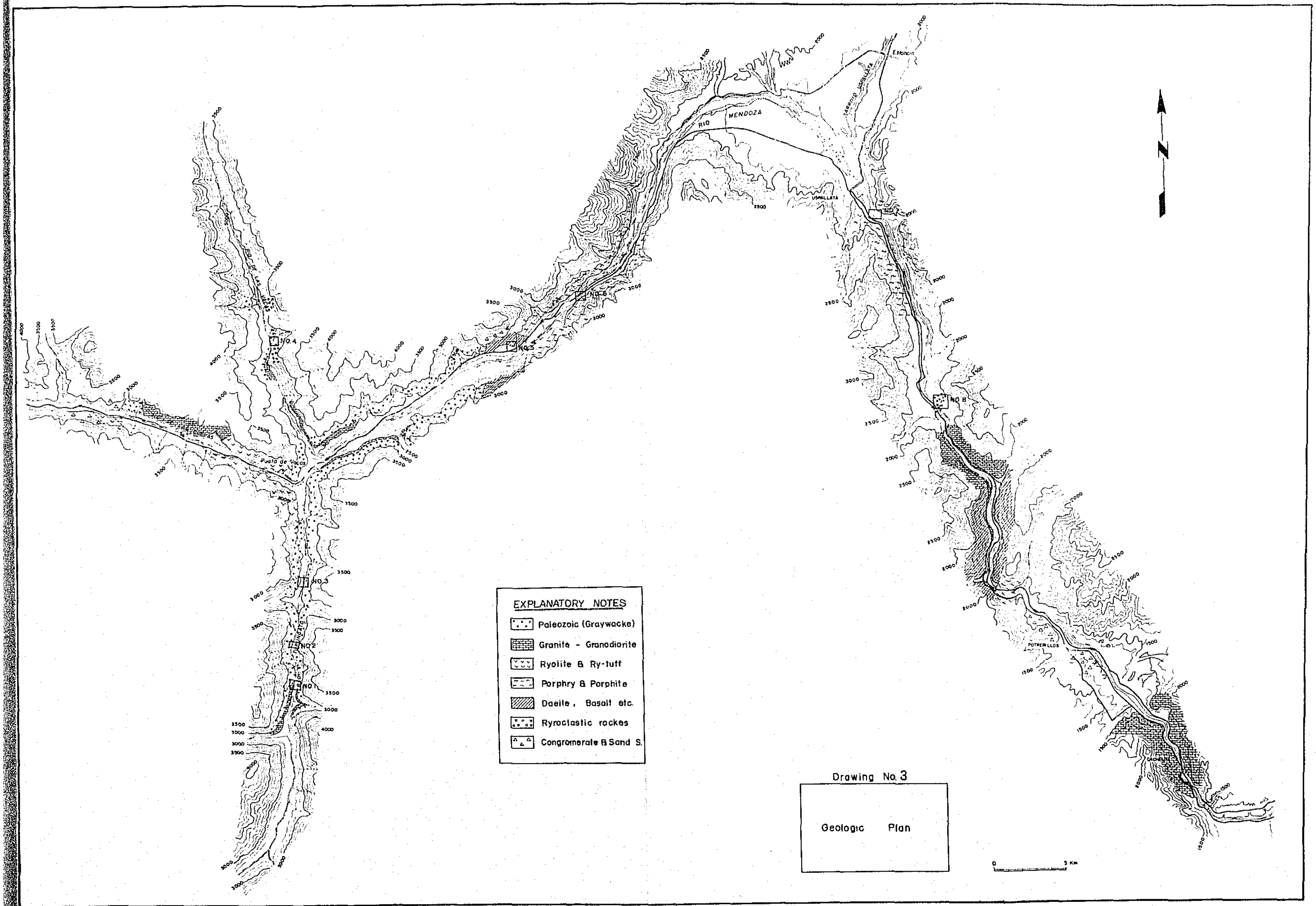
(b) Geological survey of the intake-dam sites and study on the depth of the allumium.

(c) Plan of the channel-running area which should be compiled by aerophotography. (Data for the compilation are available with the Japanese Survey Team.)

As a matter of course, there should be provided storage reservoirs which can regulate the run-off and secure the irrigation water. However, time allows no long preparatory investigation to select suitable dam sites for them so few at present. As the first thing to be done in future, the construction of the two power plants should be started, and abreast with the construction works, the satisfactory survey would be carried out for such reservoirs as above-mentioned. It is regarded as the most advantageous to materialize the plan in the way described herein for the purpose of solving the present power shortage and securing the irrigation water.

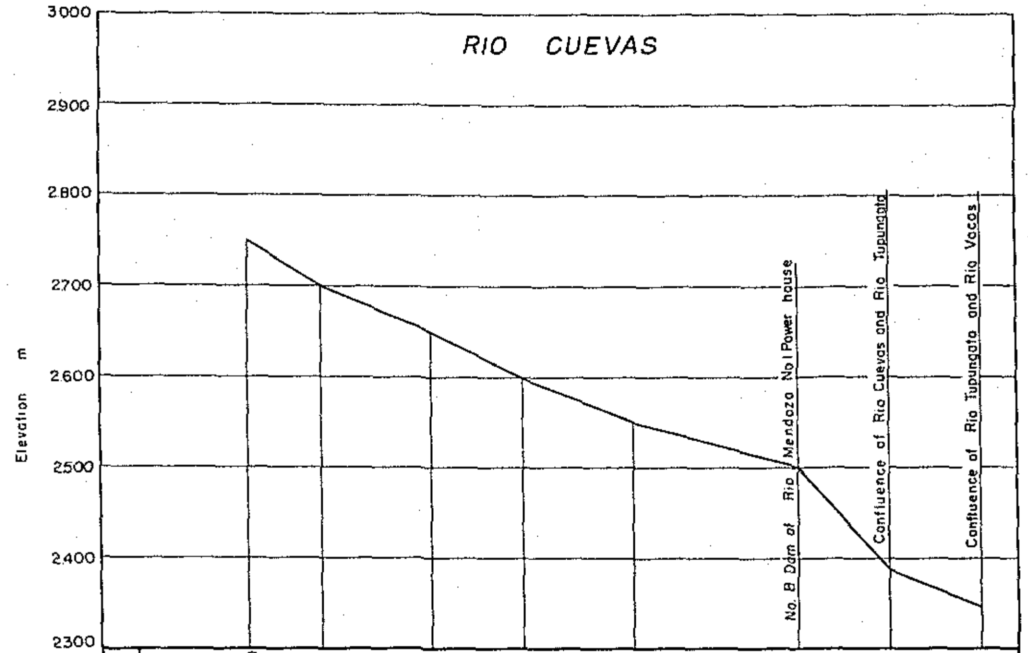

N
REPUBLIC OF CHILE
Rio Cuevas
Rio Vacas
Punta de Vacas
Rio Tupungato
Rio Mendoza
Uspallata
Potrerillos
Cacheuta
Lujan
MENDOZA
Irrigation Area
Rio Mendoza
Scale
5 0 10 20 Km
REPUBLIC OF ARGENTINA
MENDOZA
Rio Mendoza
BUENOS AIRES
Rio Colorado
Drawing No. 1
Location & General Map of Rio Mendoza Project


Legend
Triangulation Point
Level Point
Number of Aerial Photograph
Non-cover Area of Aerial Photograph
Drawing No. 2
Index map of Aerial Photograph and Surveying point
RIO MENDOZA
Puente de Vacas
RIO DE LAS CUEVAS
Uspallata
Estancia
Punilla
Potrerillos
Cacheuta
0
5 Km
N

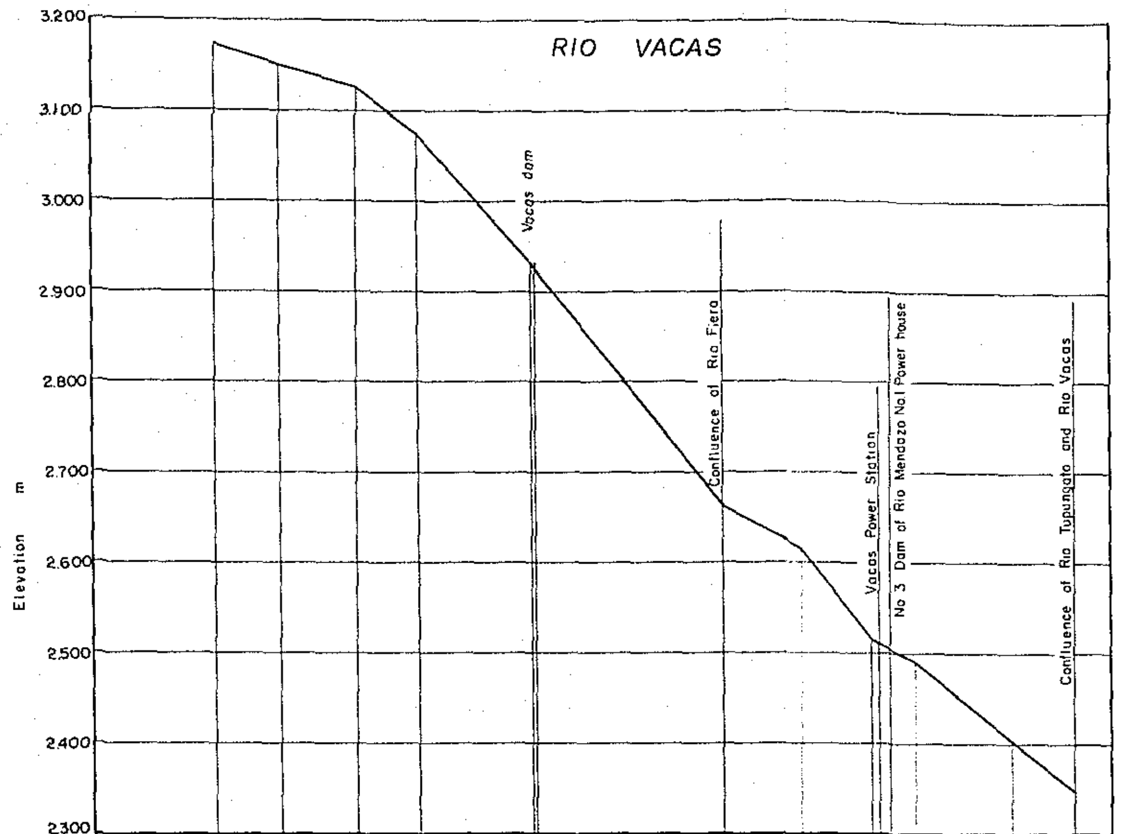


Drawing No. 3

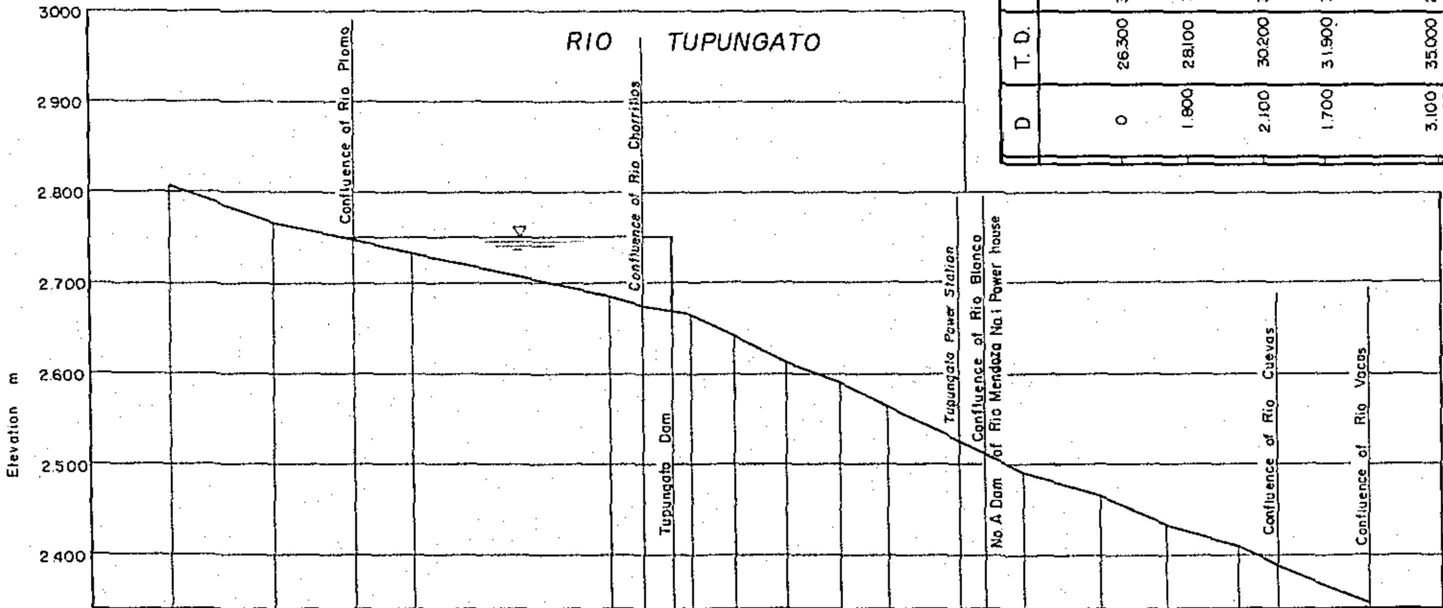
Geologic Plan



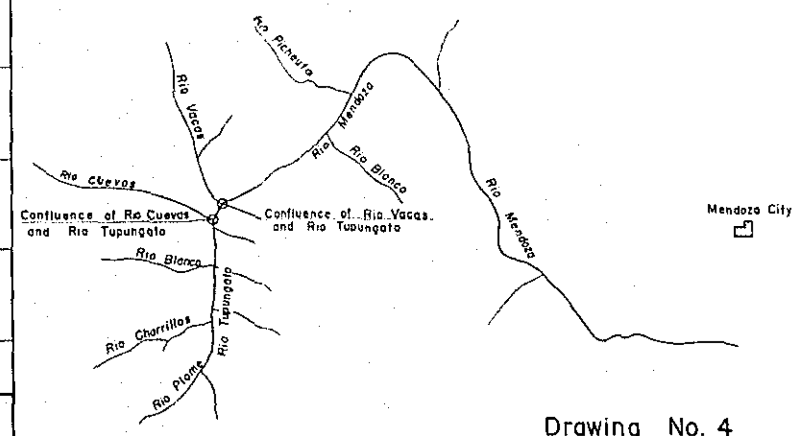
W.E	2.750.000	2.700.000	2.650.000	2.600.000	2.550.000	2.500.000	2.386.416	2.346.700
T.D	30000	32000	35000	37500	40500	45000	47500	50.000
D	0	2.000	3000	2.500	3000	4.500	4.500	2.500



W.E	3.172949	3.153103	3.123629	3.074084	2.930927 2.928000	2.662003	2.617996	2.515951 2.507500 2.502000	2.491112	2.402669	2.346700
T.D.	26300	28100	30200	31.900	35000 35.100	40200	42400	44400 44600 44900	45600	48300	50000
D	0	1.800	2.100	1.700	3.100 100	5.100	2.200	2.000 200 300	1.700	2.700	1.700



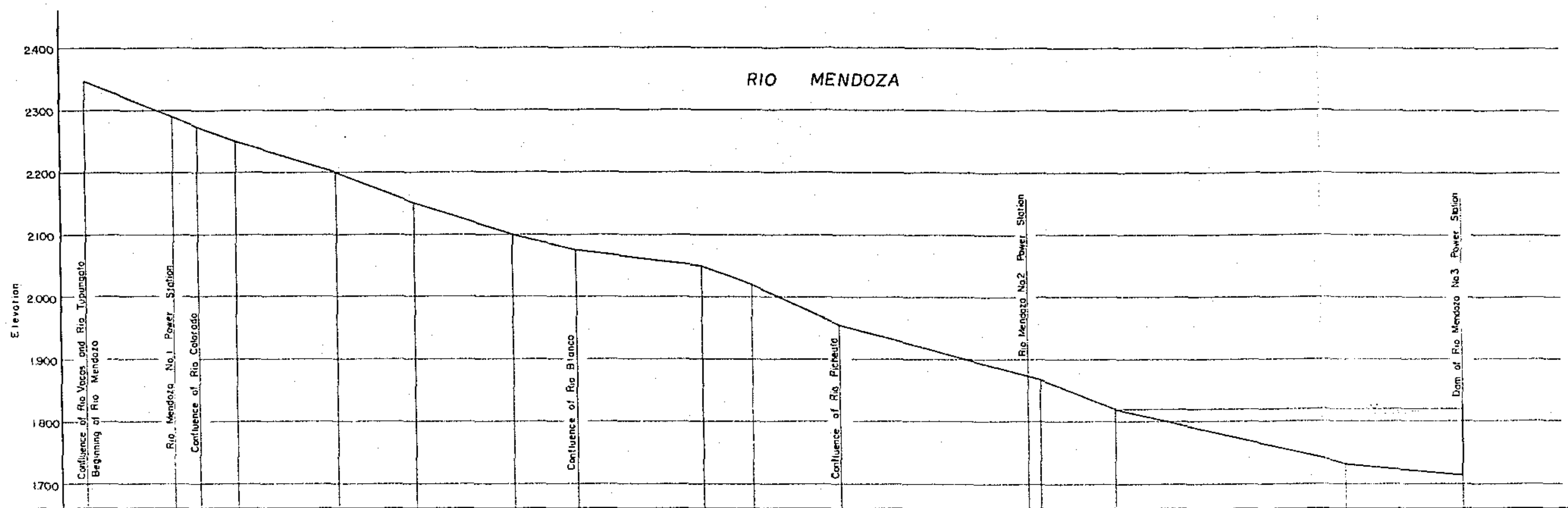
W.E	2806.792	2.767.025	2.751.474	2.735.535	2684.136	2677.610	2671.100	2664.634	2641.797	2611.500	2591.370	2562.772	2523.000	2510.125	2.491.328	2.464.103	2.435.786	2.409.094	2.386.416	2346.700
T.D	17200	20000	22200	23.800	29.200	30.100	30.900	31.400	32.600	34.000	35.500	36.800	38.800	39.500	40.500	42.600	44.400	46.400	47.500	50000
D	0	2.800	2200	1.600	5.400	900	800	500	1.200	1.400	1.500	1.300	2.000	0.700	1.000	2.100	1.800	2.000	1.100	2.500



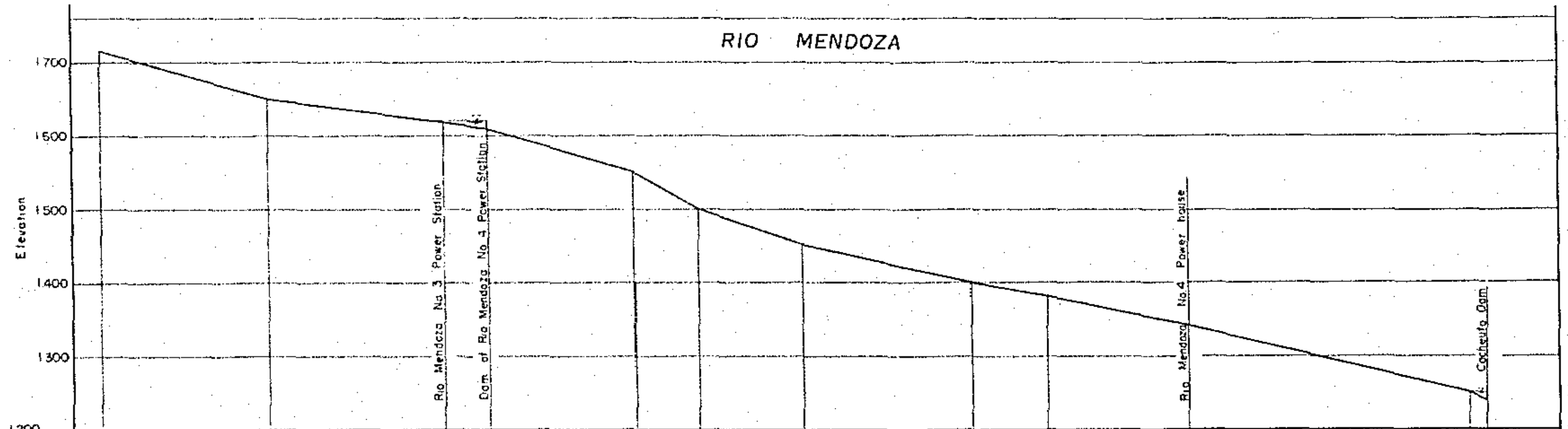
Note: Water Elevations of Rio Cuevas were reprinted from Instituto Geografico Militar Map Scale 1/100 000
Water Elevations of Rio Tupungato and Rio Vacas are actually Measured.

Drawing No. 4

Profile of the Rio Cuevas, Rio Vacas, Rio Tupungato.



W. E.	2.346.700	2.274.000	2.272.200	2.250.000	2.200.000	2.150.000	2.100.000	2.075.338	2.050.000	2.000.000	1.956.238	1.870.000	1.865.700	1.820.000	1.732.456		1.714.000
T. D.	50.000	53.000	54.500	56.000	60.000	63.100	67.000	69.500	74.500	76.500	80.000	87.500	88.000	91.000	100.200	102.200	105.000
D.	0	3.000	3.500	1.500	4.000	3.100	3.900	2.500	5.000	2.000	3.500	7.500	0.500	3.000	9.200	2.000	2.800



W. E.	1.714.000	1.650.000	1.620.000	1.608.000	1.550.000	1.500.000	1.450.000	1.400.000	1.380.447	1.339.182	1.250.000	1.230.500
T. D.	105.000	110.600	116.500	118.000	122.900	124.900	128.500	134.200	136.700	141.500	151.000	151.600
D.	2.800	5.600	5.900	1.500	4.900	2.000	3.600	5.700	2.500	4.800	9.500	0.600

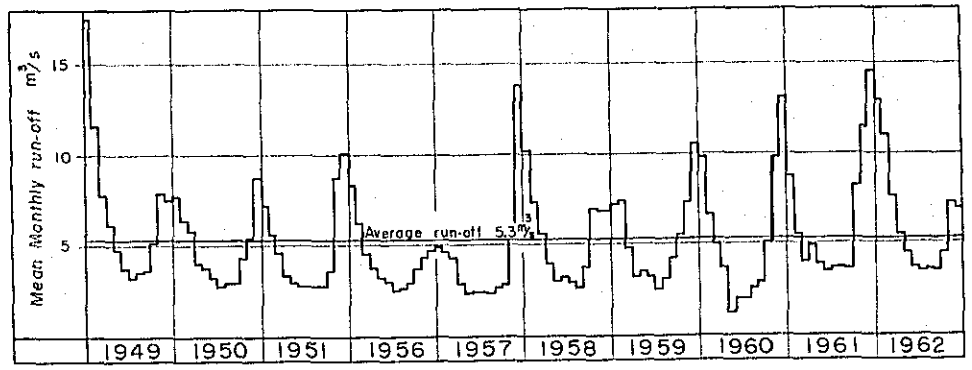
Note: Water Elevations of Rio Mendoza were reprinted from Institute Geografico Militar Map Scale 1/ 100,000

Drawing No. 5

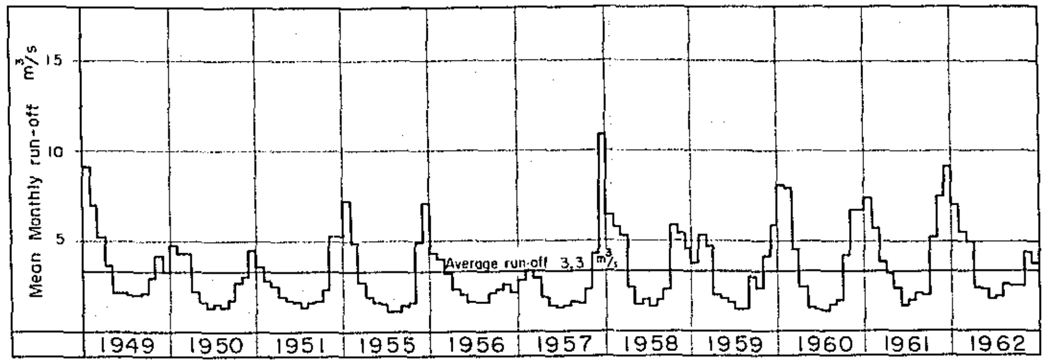
Potile of the

Main Rio Mendoza

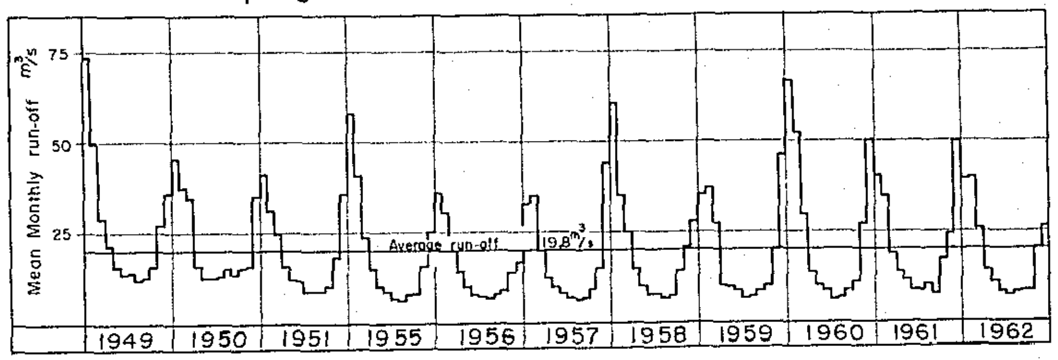
Rio Cuevas at punta de Vacas (C.A = 685 Km^2)



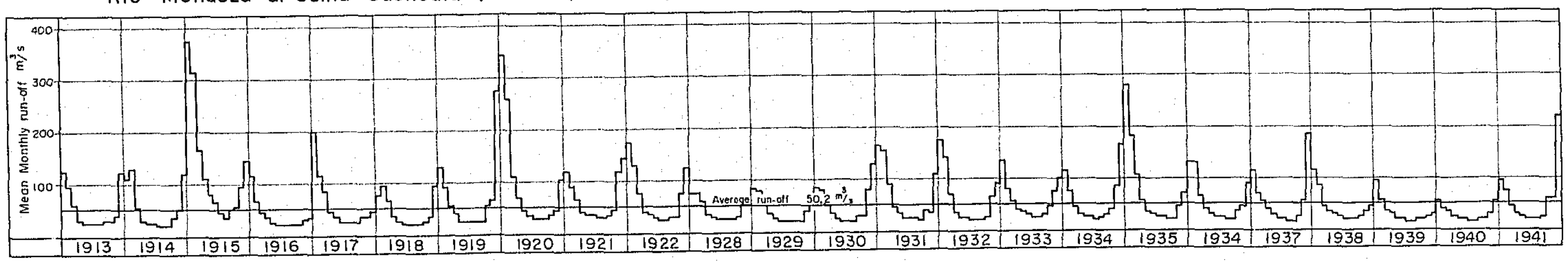
Rio Vacas at Punta de Vacas (C. A = 569 km^2)

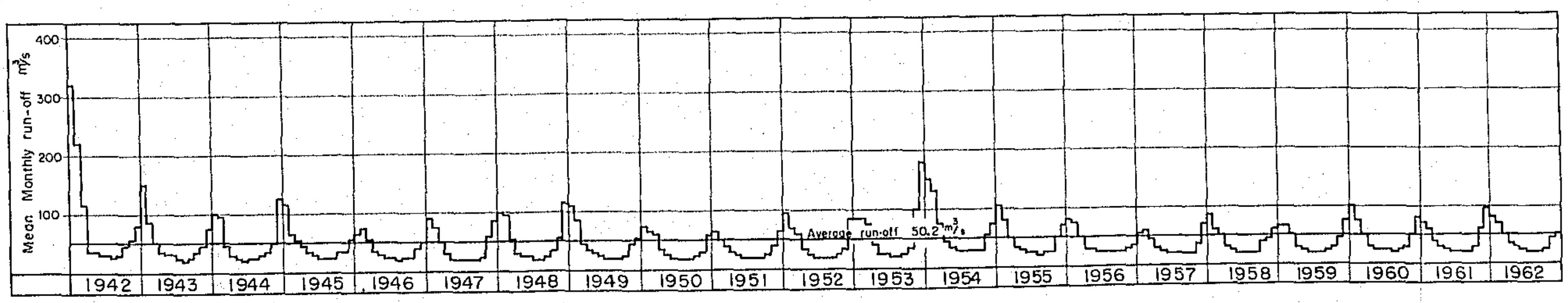


Rio Tupungato at Punta de Vacas (C.A = 1,801 km^2)



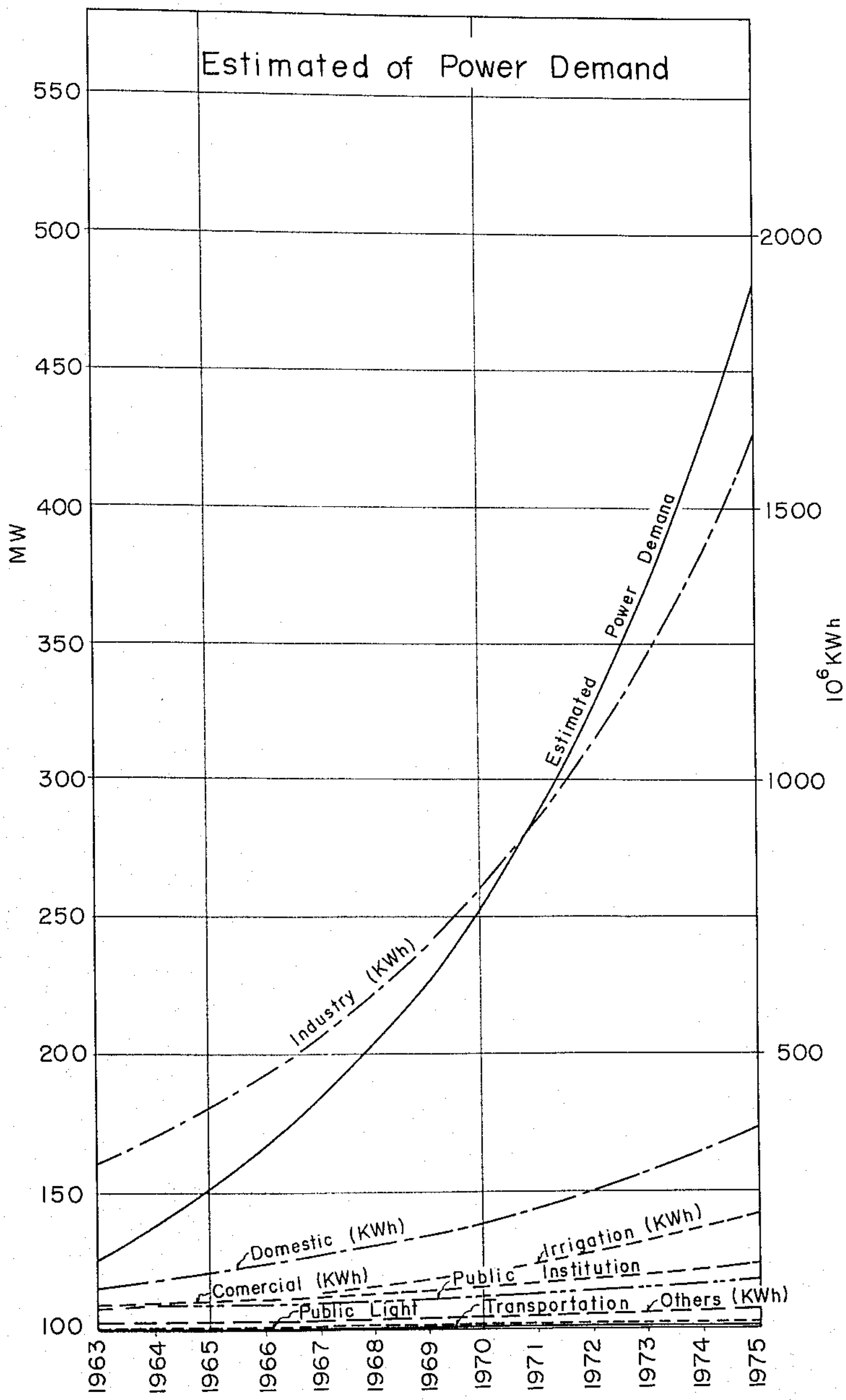
Rio Mendoza at Usina Cacheuta (C.A = 8,200 km^2)



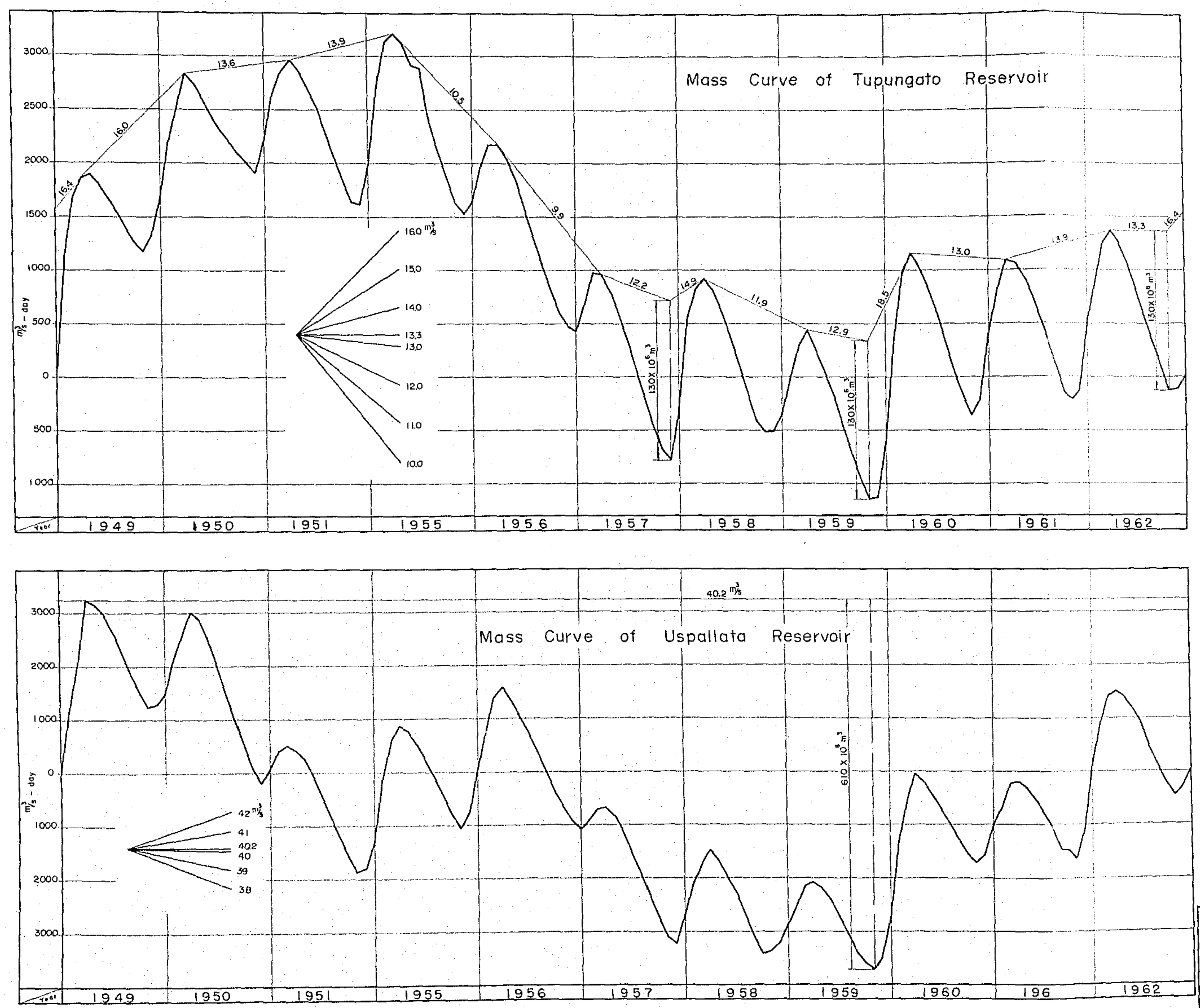


Drawing No. 6

Monthly Average Run-off
at Punta de Vacas
& Usina Cacheuta

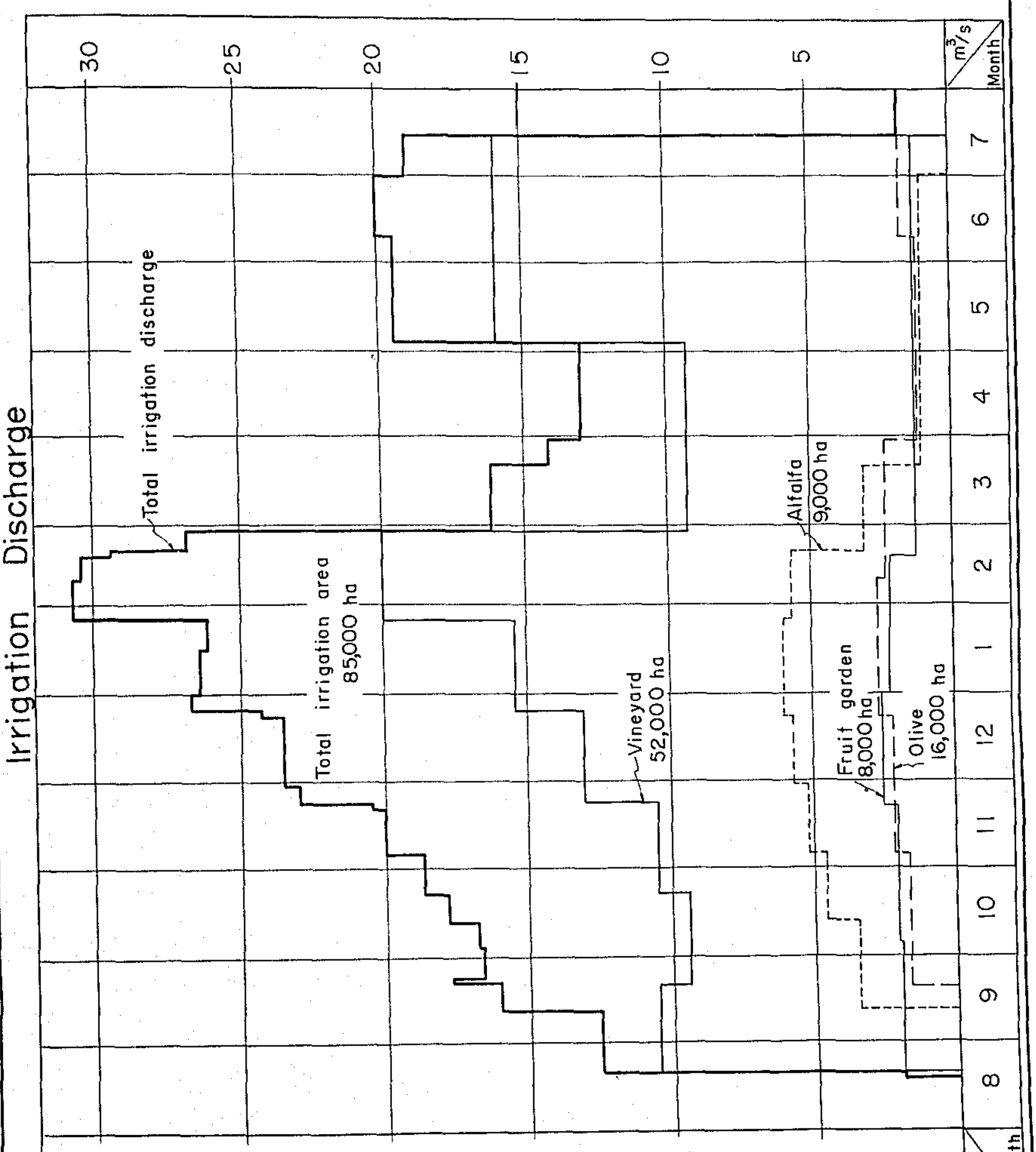

Estimated of Power Demand
MW
10^6 KWh
550
500
450
400
350
300
250
200
150
100
2000
1500
1000
500
Estimated Power Demand
Industry (KWh)
Domestic (KWh)
Irrigation (KWh)
Public Institution
Comercial (KWh)
Public Light
Transportation
Others (KWh)
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975

Drawing - (7)



Drawing No.

Mass Curve of Tupungato & Uspallata Reservoir


Irrigation Discharge
Total irrigation discharge
Total irrigation area 85,000 ha
Vineyard 52,000 ha
Alfalfa 9,000 ha
Fruit garden 8,000 ha
Olive 16,000 ha
m³/s
Month
30
25
20
15
10
5
8
9
10
11
12
1
2
3
4
5
6
7

Drawing-(9)

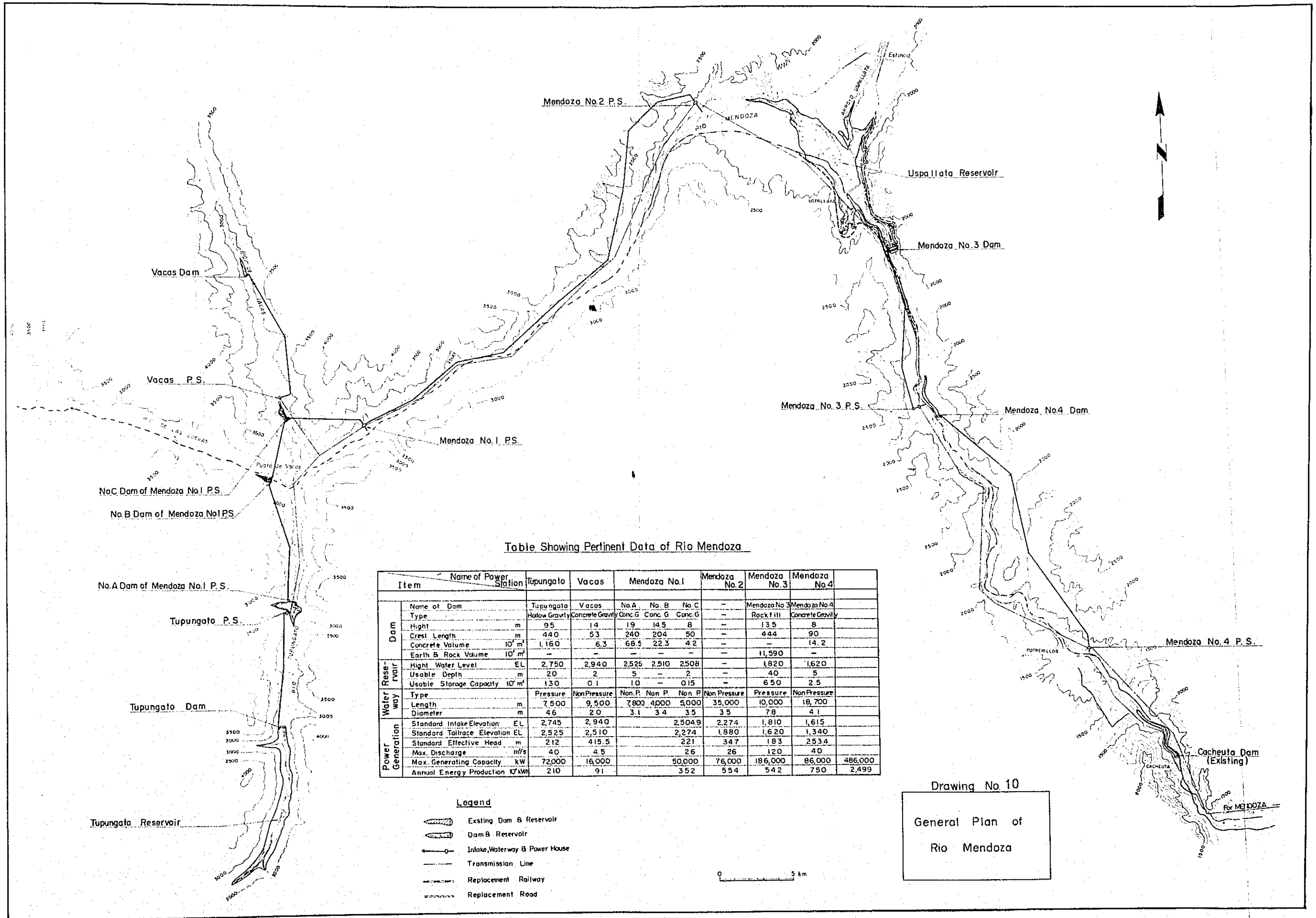


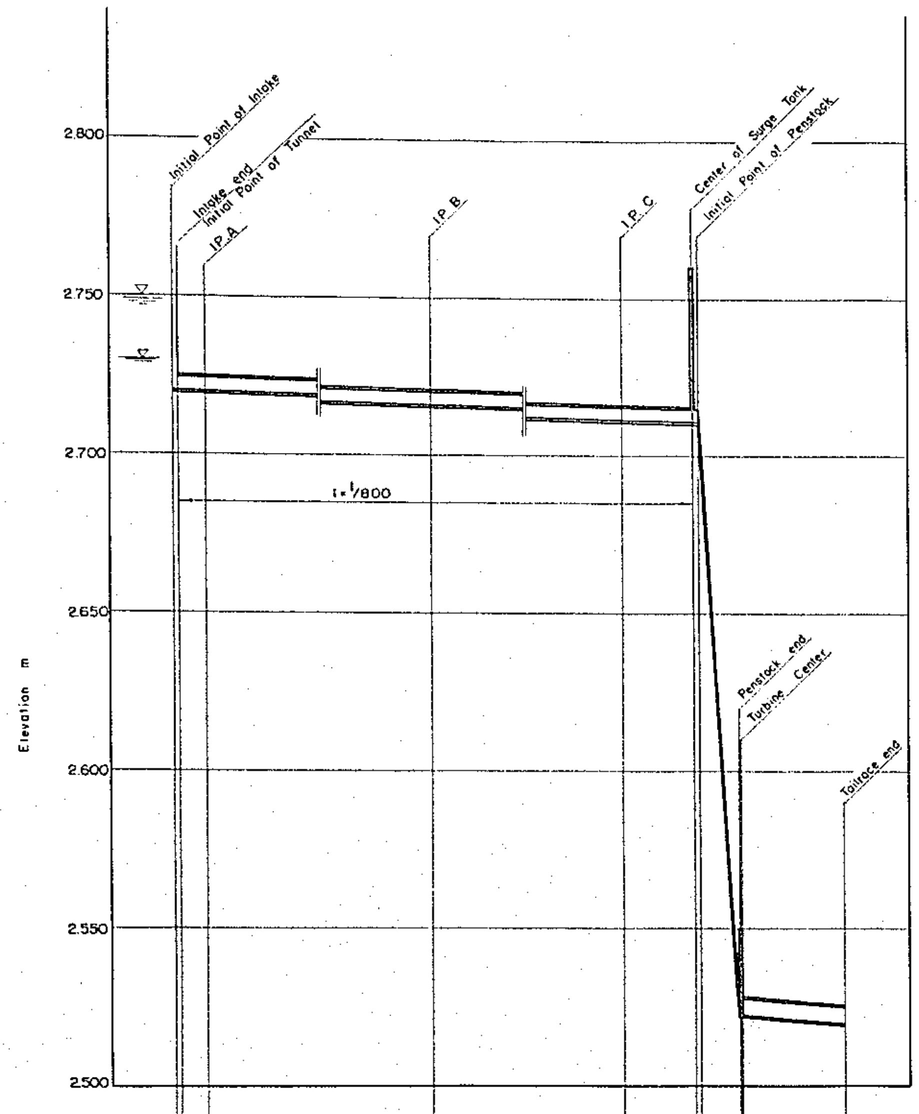
Table Showing Pertinent Data of Rio Mendoza

Item		Name of Power Station	Tupungato	Vacas	Mendoza No.1			Mendoza No.2	Mendoza No.3	Mendoza No.4	
Dam	Name of Dam		Tupungato	Vacas	No.A	No. B	No. C	–	Mendoza No 3	Mendoza No.4	
	Type		Hollow Gravity	Concrete Gravity	Conc. G	Conc. G	Conc. G	–	Rock fill	Concrete Gravity	
	Hight	m	95	14	19	14.5	8	–	135	8	
	Crest Length	m	440	53	240	204	50	–	444	90	
	Concrete Volume	$10^3 m^3$	1,160	6.3	68.5	22.3	4.2	–	–	14.2	
	Earth & Rock Volume	$10^3 m^3$	–	–	–	–	–	–	11,590	–	
Reservoir	Hight Water Level	EL	2,750	2,940	2,525	2,510	2,508	–	1,820	1,620	
	Usable Depth	m	20	2	5	–	2	–	40	5	
	Usable Storage Capacity	$10^6 m^3$	130	0.1	1.0	–	0.15	–	650	2.5	
Water way	Type		Pressure	Non Pressure	Non. P.	Non P.	Non P.	Non Pressure	Pressure	Non Pressure	
	Length	m	7,500	9,500	7,800	4,000	5,000	35,000	10,000	18,700	
	Diameter	m	4.6	2.0	3.1	3.4	3.5	3.5	7.8	4.1	
Power Generation	Standard Intake Elevation	EL	2,745	2,940			2,504.9	2,274	1,810	1,615	
	Standard Tailrace Elevation	EL	2,525	2,510			2,274	1,880	1,620	1,340	
	Standard Effective Head	m	212	415.5			221	347	183	253.4	
	Max. Discharge	m^3/s	40	4.5			26	26	120	40	
	Max. Generating Capacity	kW	72,000	16,000			50,000	76,000	186,000	86,000	486,000
	Annual Energy Production	$10^6 kWh$	210	91			352	554	542	750	2,499

Drawing No. 10

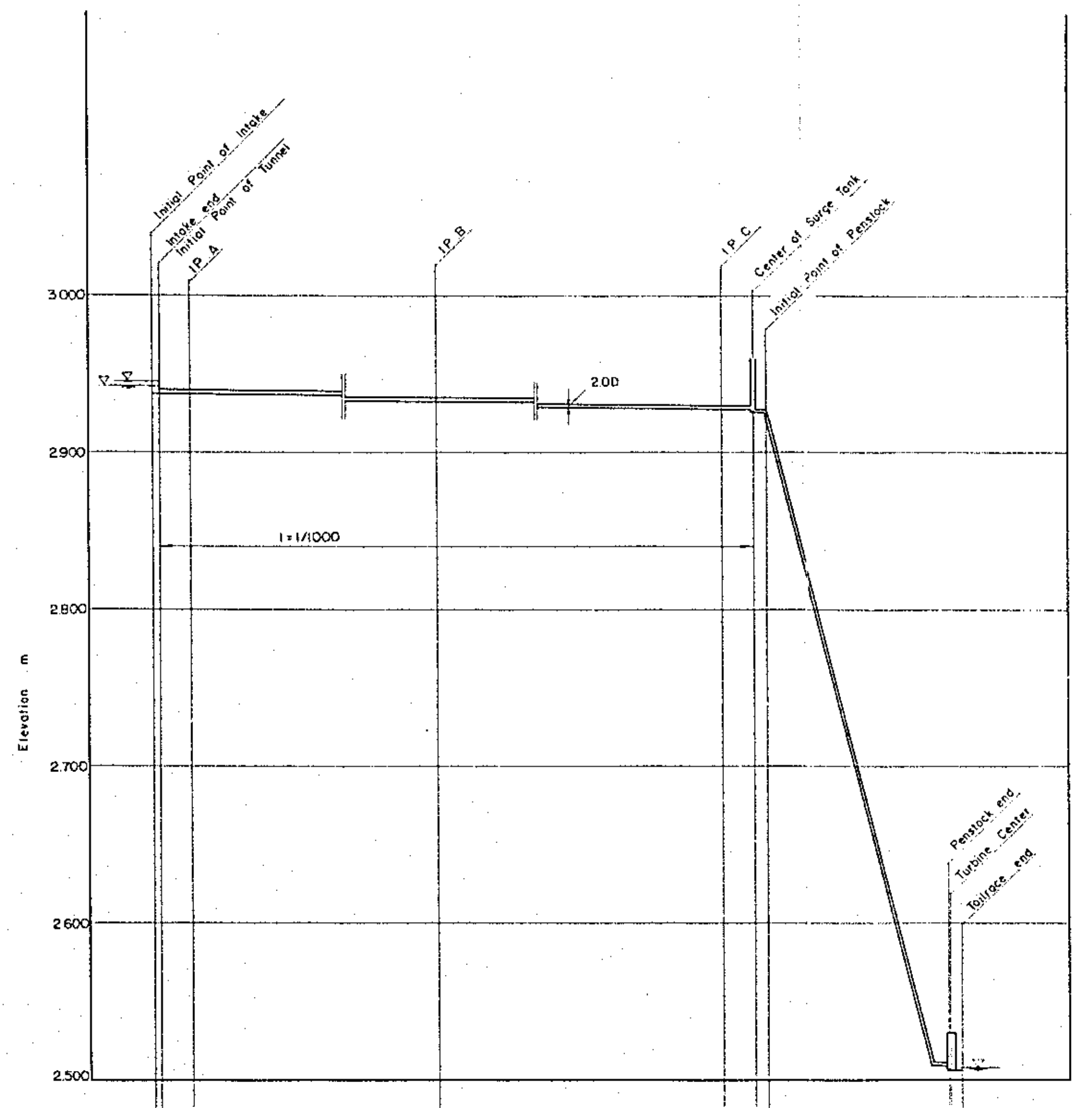
General Plan of Rio Mendoza

Tupungato P.S.



F. H.	2.720.000	2.719.967				2.710.500		2.525.000	2.525.000	2.519.350
G. H.	2.722.000	2.760.000	2.950.000	2.750.000	3100.000	2.770.000	2.740.000	2.680.000	2.675.000	2.550.000
T. DIS.	0	33.000		3.633.000	7.133.000	7.583.000	7.608.000	7.855.000	7.860.000	8.510.000
DIS.	0	33.000		3600.000	3500.000	450.000	25.000	247.000	5.000	650.000
I.P.			A	B	C					

Vacas P.S

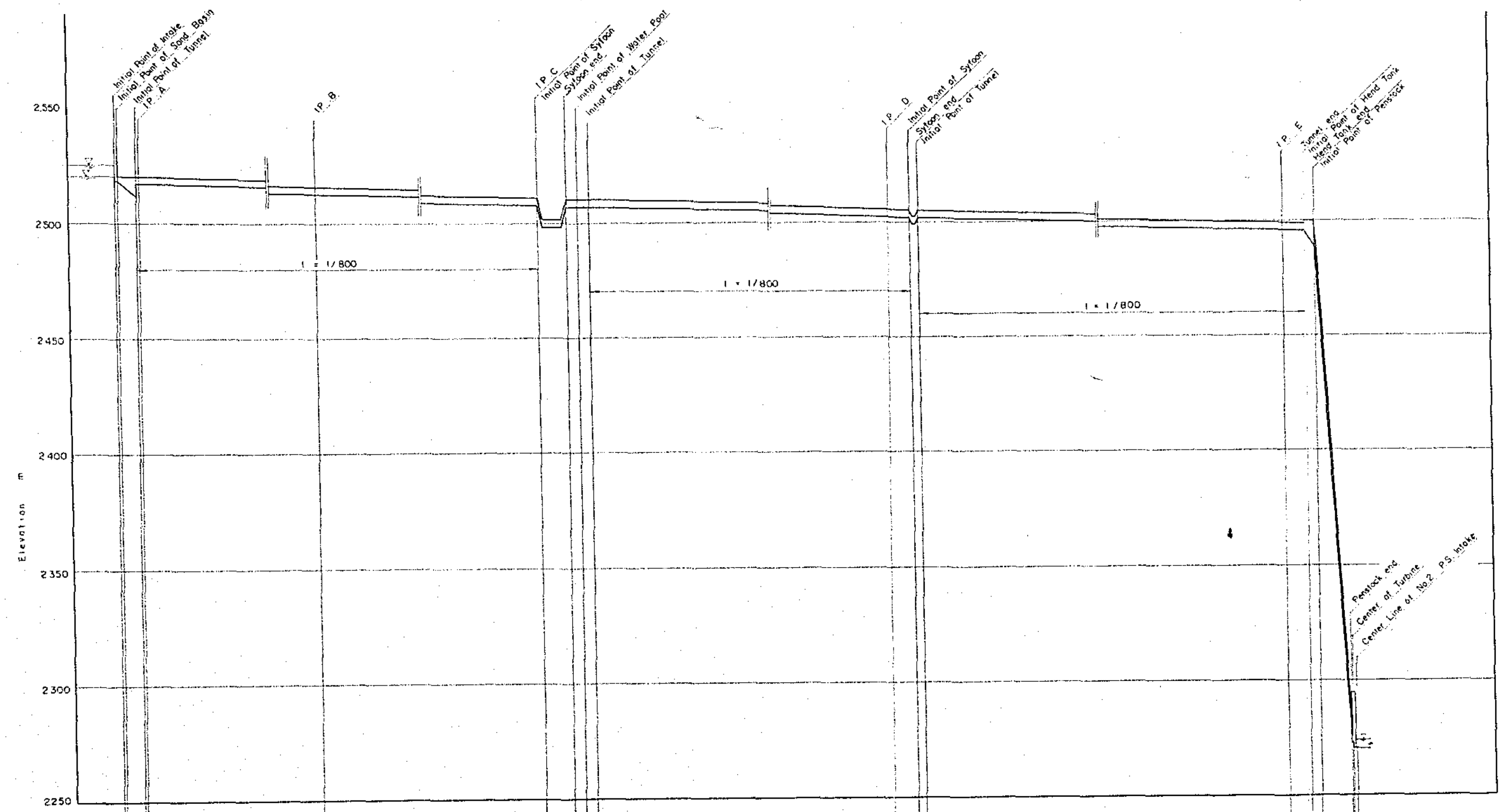


F. H.	2.937.000	2.937.000				2.927.500	2.925.500	2.509.500	2.510.000	2.506.000
G. H.	2.935.000	2.951.000	2.960.000	2.940.000	2.940.000	2.927.500	2.925.500	2.920.000	2.915.000	2.910.000
T. DIS.	0	21.500	121.500	5.021.500	9.421.500	9.521.500	9.560.500	10.140.500	10.145.500	10.180.500
DIS.	0	21.500	100.000	5.000.000	4.400.000	100.000	39.000	580.000	5.000	35.000
I.P.			A	B	C					

Drawing No 11

Tupungato P.S. & Vacas P.S.

Alignment Profile of Waterway

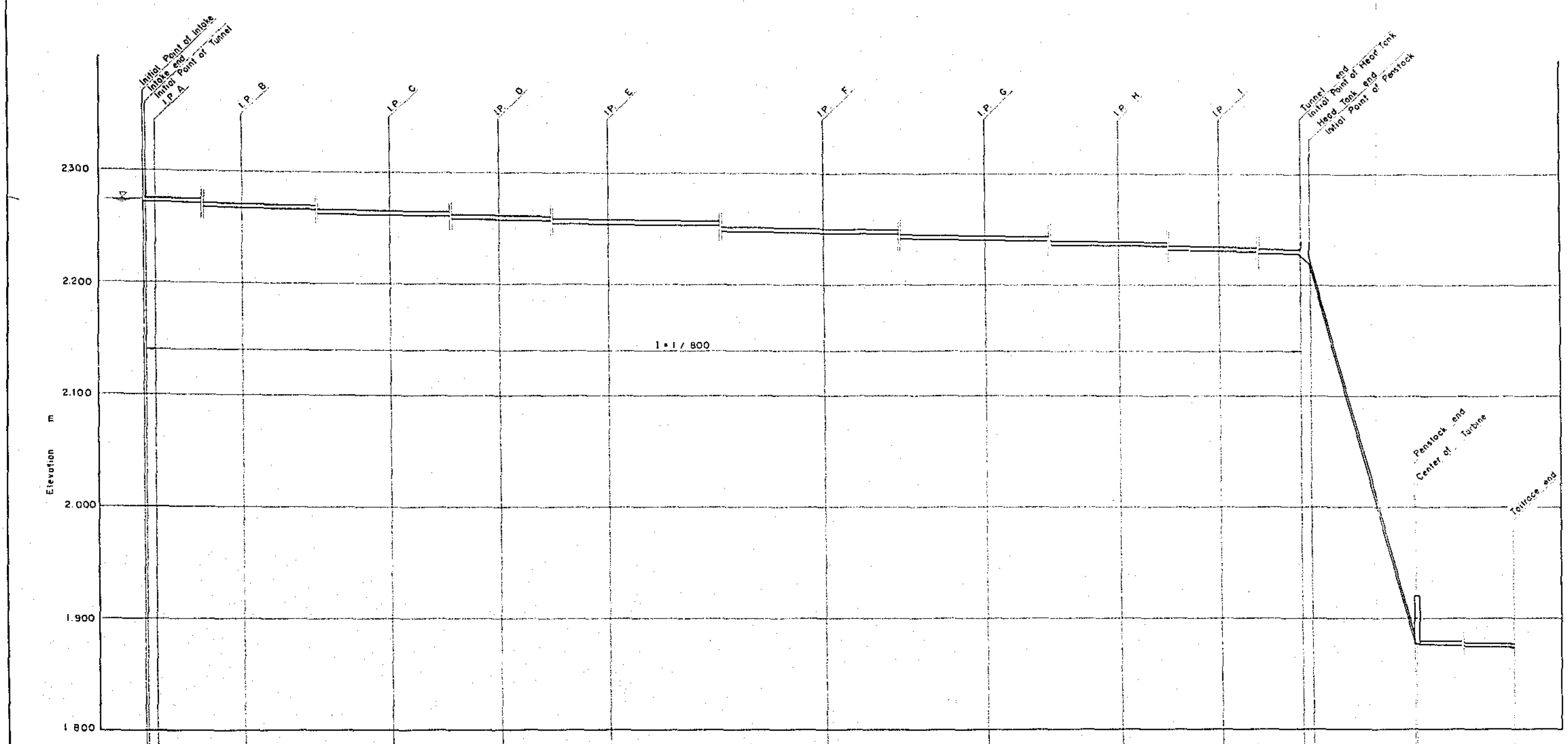


I.P.	DIS.	T. DIS.	G. H	F. H.
A	0	0	2519.000	2518.000
	20.000	20.000	2540.000	2518.000
	155.000	175.000	2530.000	2516.000
	20.000	195.000	2540.000	
B	3405.000	3600.000	2550.000	
C	4300.000	7900.000	2520.000	
	240.000	8140.000	2525.000	2507.000
	100.000	8240.000	2550.000	2506.790
	100.000	8340.000	2560.000	2506.690
D	3800.000	12140.000	2550.000	
	200.000	12340.000	2520.000	2501.690
	65.000	12405.000	2530.000	2501.600
E	4800.000	17205.000	2580.000	
	200.000	17405.000	2550.000	2495.350
	86.000	17491.000	2500.000	2490.000
	274.000	17765.000	2350.000	2274.000
	5.000	17770.000	2350.000	2274.000
	30.000	17800.000	2340.000	2270.750

Drawing No. 12

Mendoza No.1 P.S.

Alignment Profile of Waterway

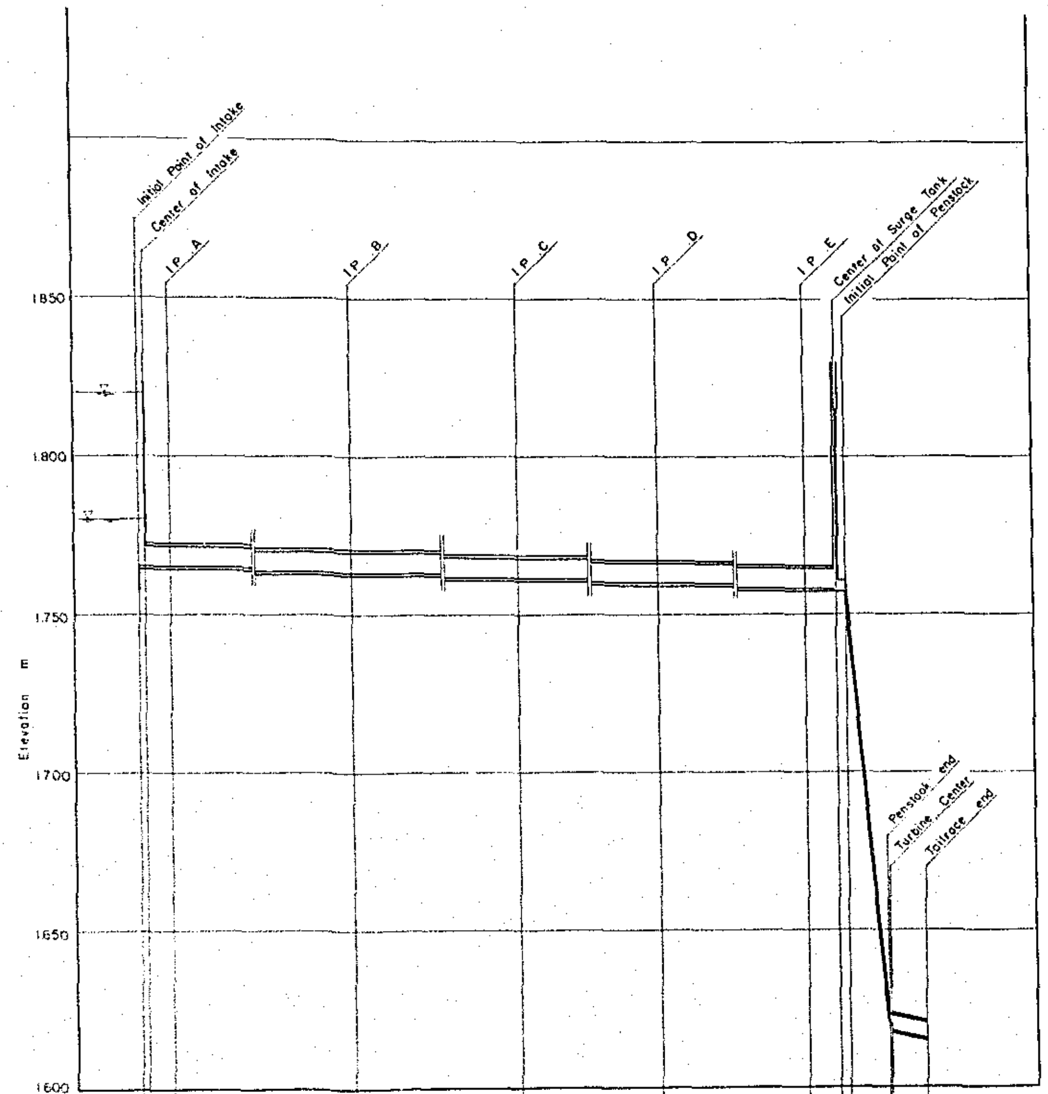


I.P.	DIS.	T. DIS.	G. H.	F. H.
A	0 20000 300000	0 20.000 320000	2350000 2.350000 2.300000	2.271000 2.271000
B	3.200.000	3.520000	2.280000	
C	4.300 000	7.820000	2.280000	
D	3200.000	11.020000	2.270000	
E	3.200.000	14.220000	2 270 000	
F	6400.000	20.620000	2.260000	
G	4.800.000	25.420000	2 260 000	
H	4000.000	29420000	2 250000	
I	3000.000	32 420000	2.240000	
	2400 000 85 000	34.820000 34.905.000	2.250000 2.225000	2227900 2220600
	920000 5000	35.825000 35 830000	1.890000 1.885000	1.880000 1 880000
	1500.000	37 330000	1.880000	1874.500

Drawing No. 13

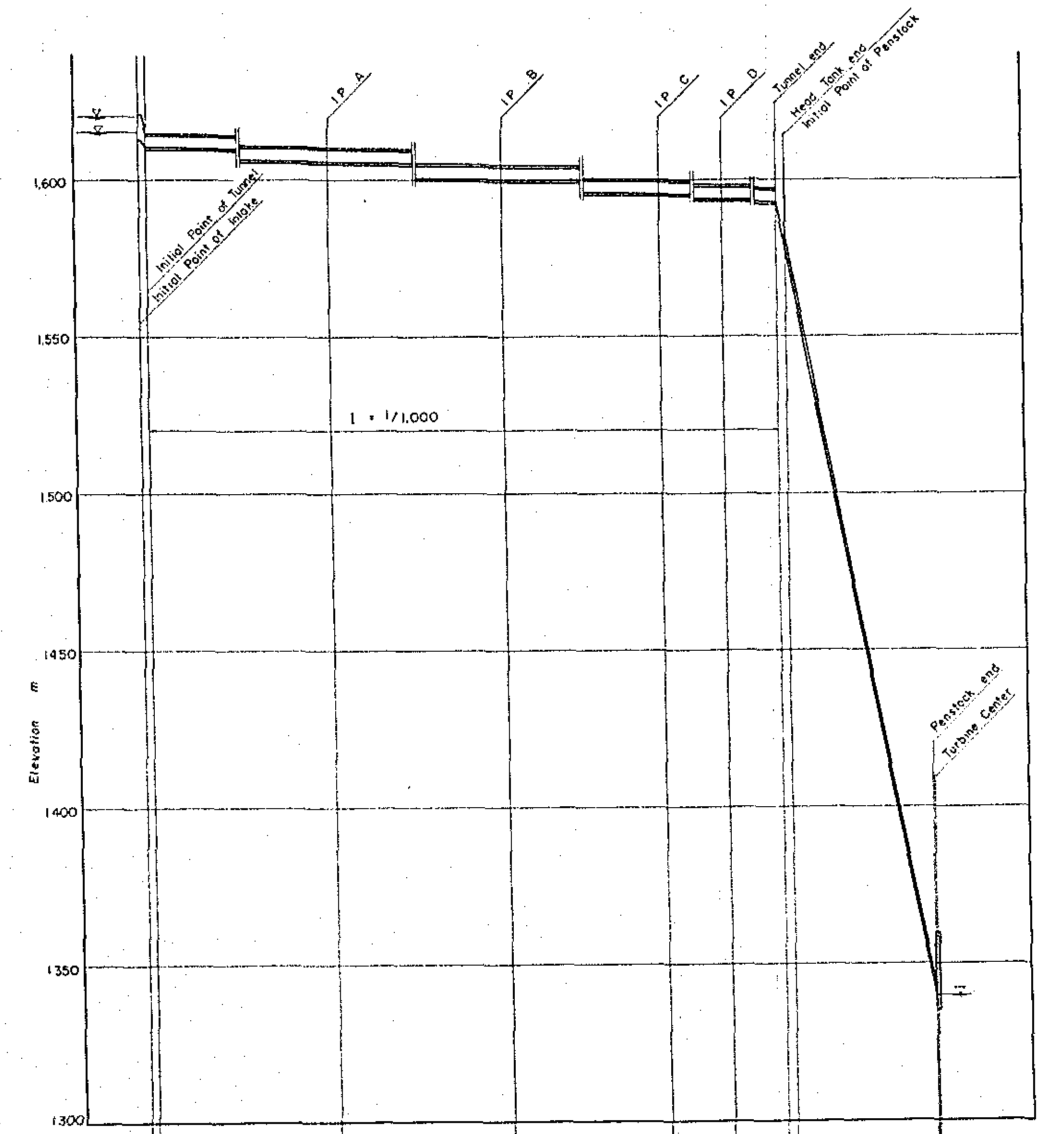
Mendoza No.2 P.S.
Alignment Profile
of Waterway

Mendoza No. 3 P.S.



I.P.	DIS	T DIS	G. H.	F. H.
	0	0	1,766000	1,765000
	45000	45000	1,830000	1,764955
A	150000	195000	1,900000	
B	2605000	2,800000	1,800000	
C	2,600000	5,400000	1,800000	
D	2,200000	7,600000	1,800000	
E	2,300000	9,900000	1,900000	
	200000	10,100000	1,850000	1,757200
	60000	10,160000	1,780000	1,757,140
	250000	10,410000	1,633000	1,621,000
	5000	10,415000	1,633000	1,621,000
	220000	10,635000	1,625000	1,615240

Mendoza No. 4 P.S.

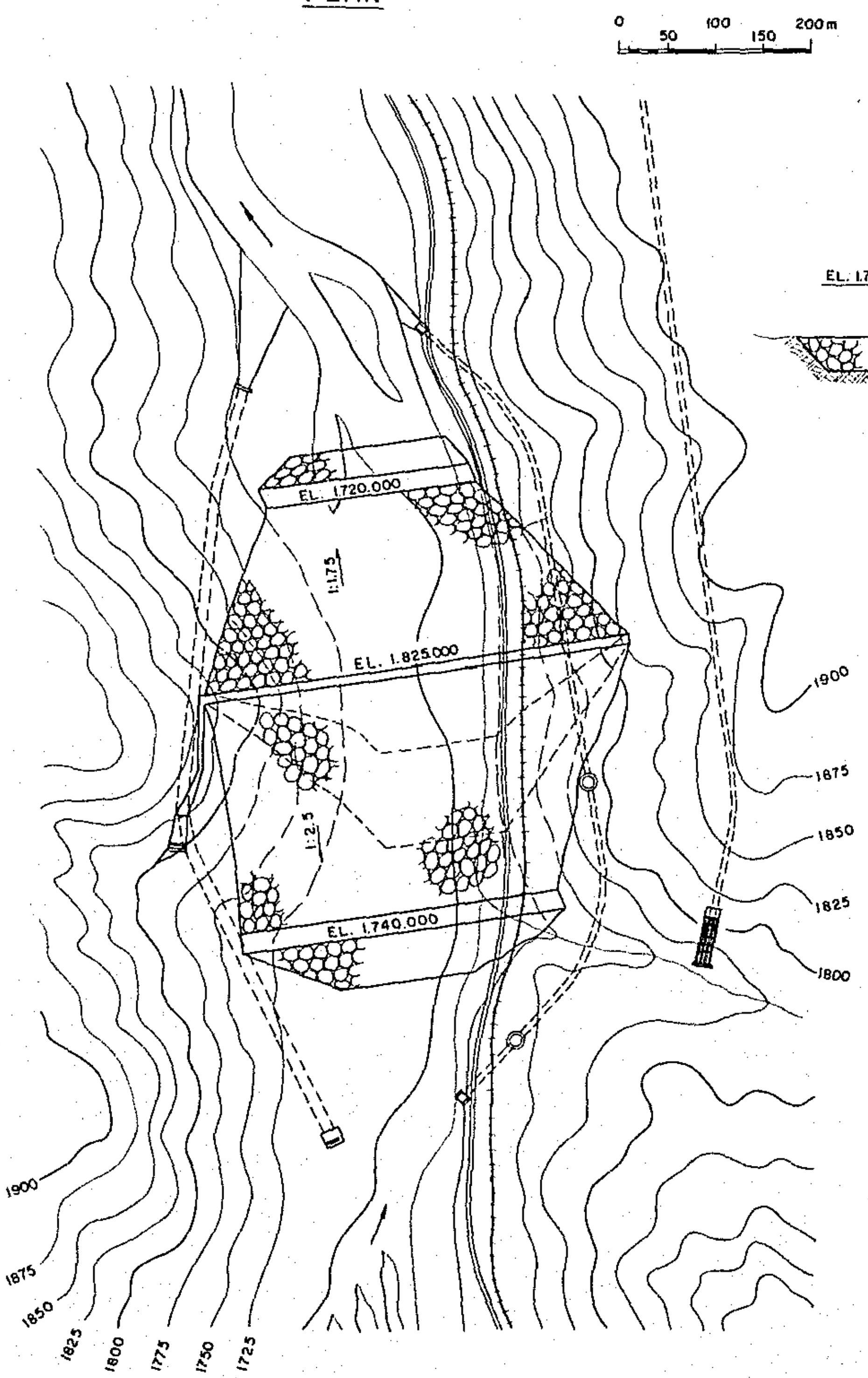


I.P.	DIS	T. DIS	G. H.	F. H.
	0	0	1,612,000	1,613,000
	52000	52000	1,650000	1,611,100
A	5,700000	5,752,000	1650000	
B	5,500000	11,252000	1650000	
C	5000000	16,252000	1,650000	
D	1500000	17,752,000	1,750000	
	1,000000	18,752,000	1,600000	1,592400
	60,000	18,812,000	1,580000	1,577400
	900,000	19,712,000	1,340000	1,340,000
	5000	19,717,000	1,340000	1,340000

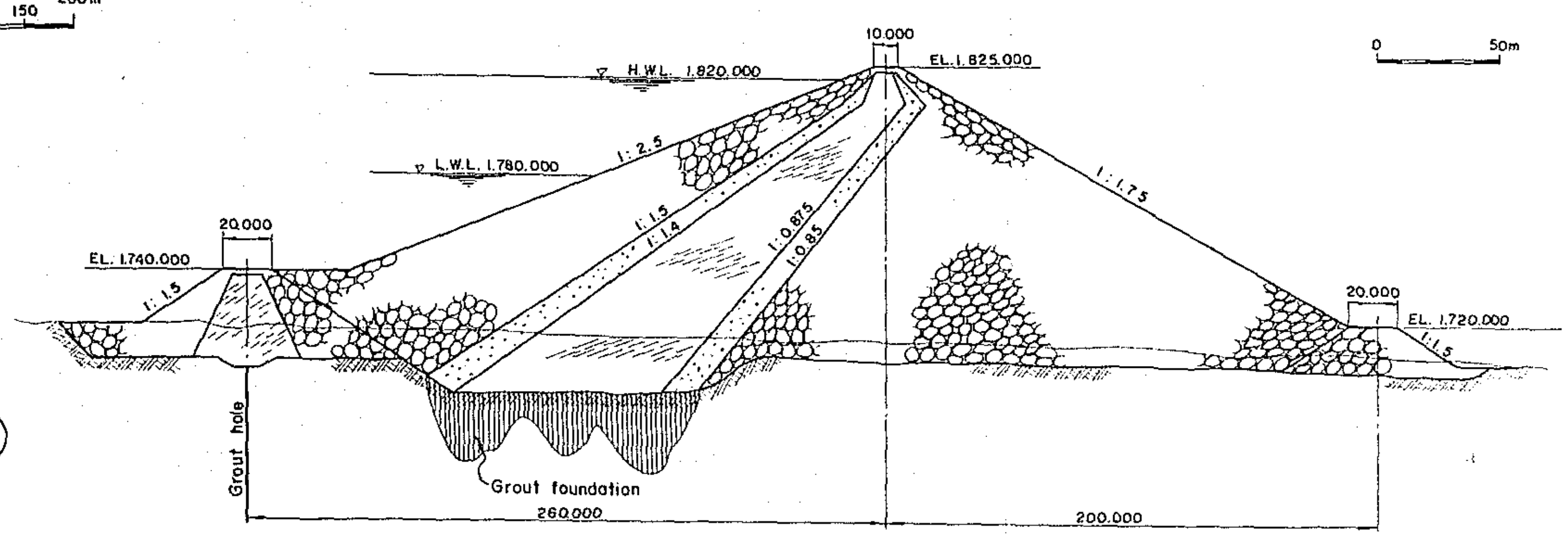
Drawing No. 14

Mendoza No. 3 & No. 4
P.S. Alignment Profile
of Waterway

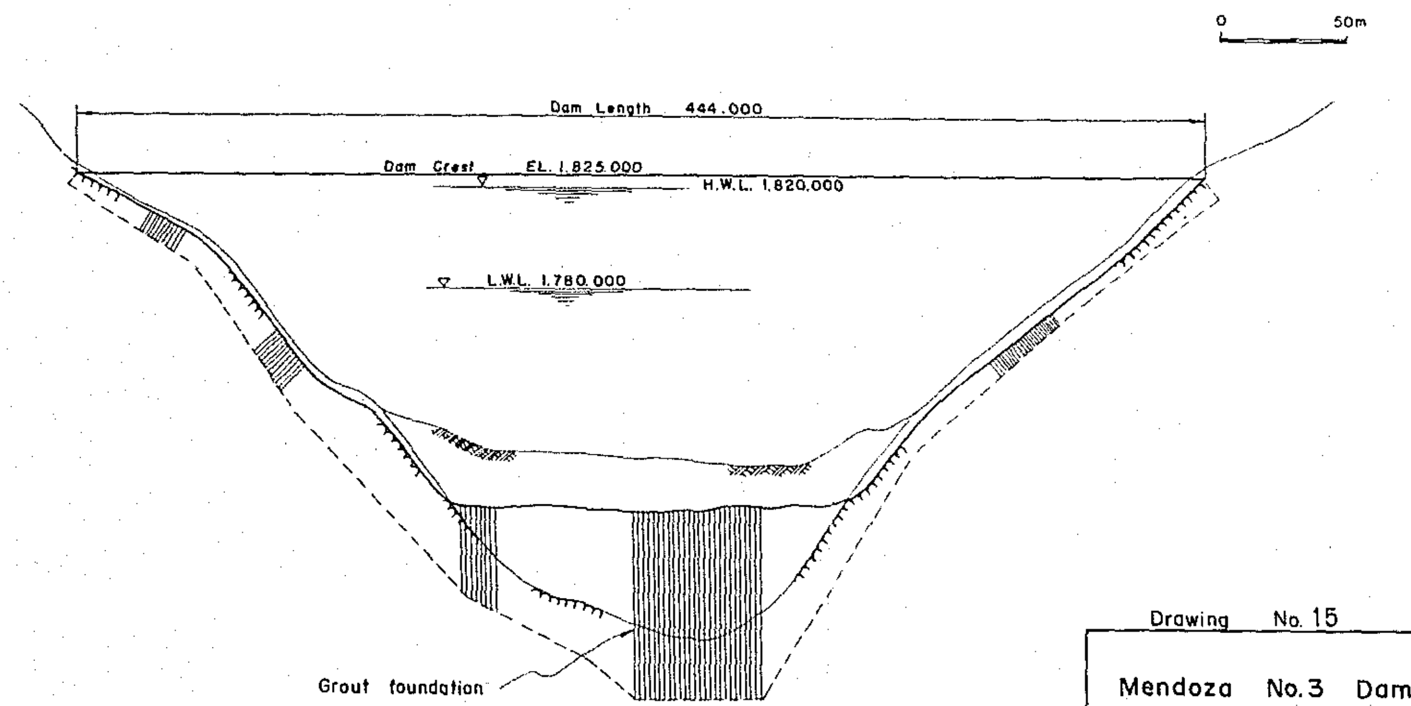
PLAN



TYPICAL CROSS SECTION



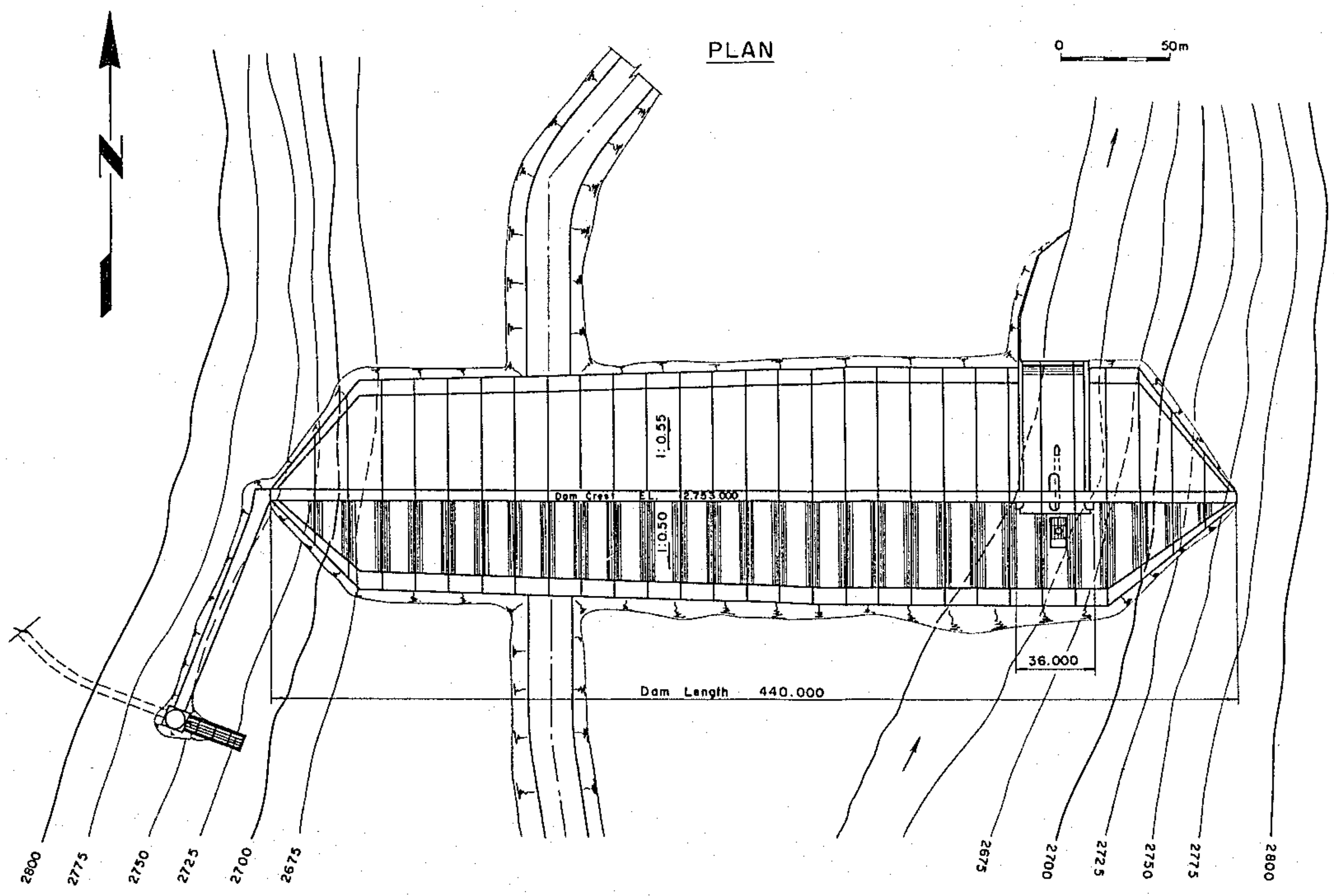
UPSTREAM ELEVATION



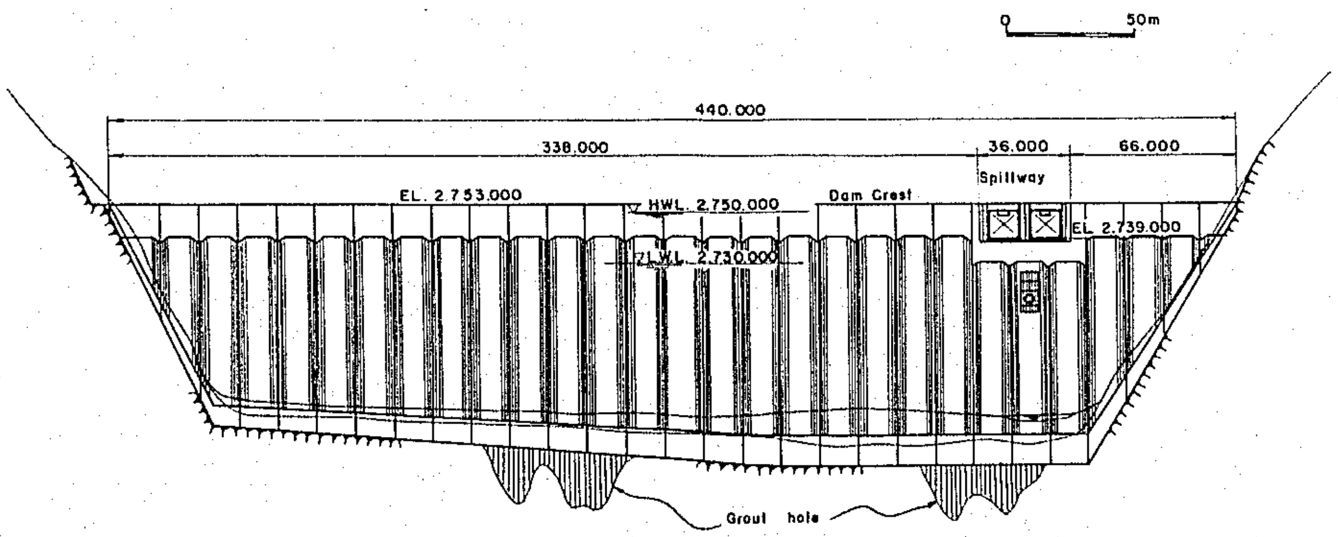
Drawing No. 15

Mendoza No. 3 Dam
General Plan, Section and Elevation

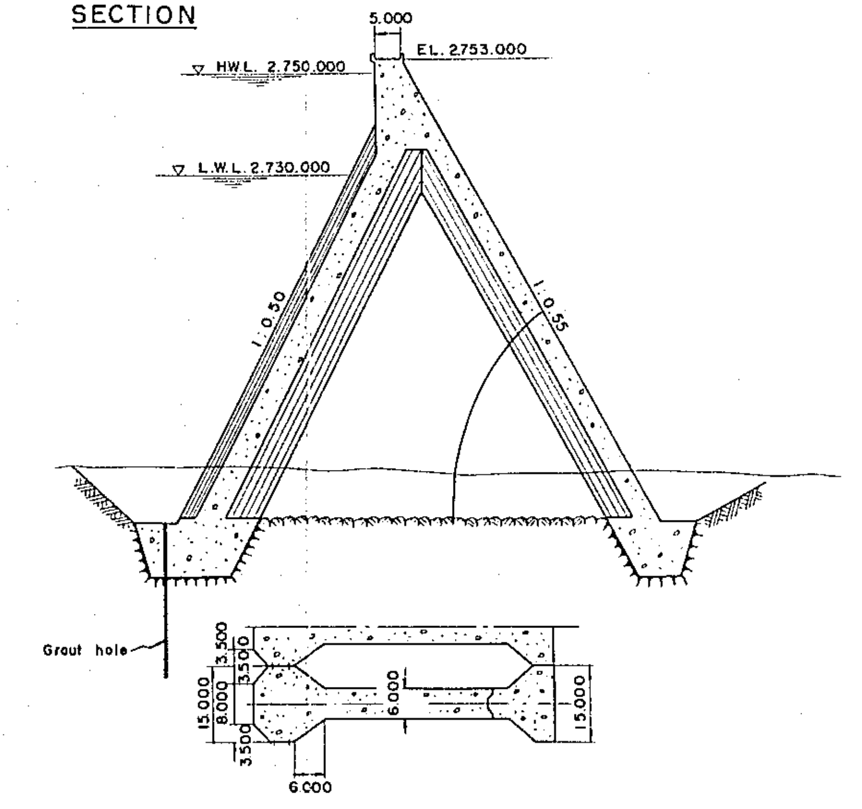
PLAN



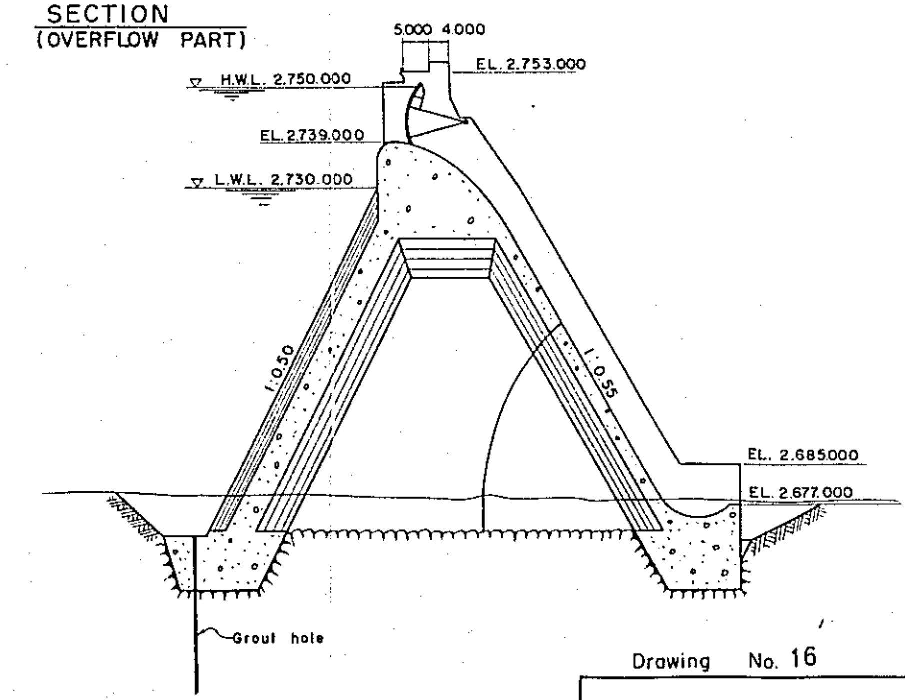
UPSTREAM ELEVATION



SECTION



SECTION
(OVERFLOW PART)



Drawing No. 16

Tupungato Dam
General Plan, Section
and Elevation