



Cooperation Project to carry out a technical and economic study for improved utilization of the hydrological resources of the Maipo River Basin.

Aim of the Project

The Project aims to obtain the cooperation of the British Government, Ministry of Overseas Development, to carry out a study of the hydrological resources of the Maipo River Basin, located in the Province of Santiago; as indicated on the attached map; and a technical and economic study for the optimum utilization of these resources.

The Maipo River system comprises the rivers Maipo, Mapocho, Colina, Lampa, Puangue, and Angostura, and at present provides water supplies for the domestic needs of approximately 2.4 million inhabitants, the irrigation of approximately 225,000 hectares of agricultural land, the generation of hydro-electric power, and the demands of certain important industrial activities.

The studies are to be divided into three main phases as described below; interim reports will be submitted for the first and second phases and a final report on completion of the third phase. The Consultants will provide adequate opportunity to discuss the findings and proposals in each phase with the authorities concerned as the work proceeds, and one month will be allowed for consultation on the final report in draft before completion.

PHASE I - Evaluation of the water resources and analysis of present usage

(a) Evaluation of the resources

(i) The Consultants will study all available maps, plans, climatological and hydrological data, stream flow and well records, previous reports, population and other statistics relating to the Maipo basin area, as defined above.

(ii) Establish or evaluate from the records, the available surface water resources for each component of the catchment area, allowing for the effects of infiltration, run-off, groundwater storage, and depletion and losses from evaporation, etc.

(iii) Study the general geology of the area with particular reference to water-bearing formations, groundwater movement, and occurrence of mineral salts, and estimate the extent, location, and quality of underground water supplies available.

\* (to follow)

(b) Analysis of the present usage

- (i) The Consultants will make an analysis and establish from the records the quantities of water at present used in each sector - domestic and sanitary, agricultural, hydro-electric power, industrial, and mining, etc.
- (ii) Estimate the deficiencies or excesses of water which may exist in each sector, and determine the sectors in which water is used inefficiently, lost, or polluted, indicating the reasons in each case.

(c) First Interim Report

The Consultants will prepare an Interim Report in Spanish and English presenting the above data and information in a suitable concise form for reference in proceeding with development studies.

PHASE II - Proposals and Suggestions for the optimum exploitation of the overall hydrological resources of the Maipo basin, and programme for development

- (a) Under this Phase, taking as a basis the evaluation of water resources prepared under Phase I, the Consultants will determine the actual water requirements for each sector, proposing in general terms the regulation and basic distribution of supplies. The aim will be to secure the optimum overall development of the hydrological resources of the Maipo basin, and to programme this development with due regard to priorities, and in collaboration with the various authorities concerned.

The requirements of this development will comprise the following:-

(i) Water for domestic and sanitary purposes

Provision for the anticipated population of the area in the next fifty years. The investigations should include the sources, location, and capacities of existing and proposed supply installations for the principal centres of population, the approximate areas covered, and populations served.

Reservoir storage requirements should be determined, and for new storage the location, topography, geology, and principal features of the proposed dam and reservoir with descriptions of available construction materials.

In the case of well supplies, the location, depth, and approximate capacity of the wells should be given, with estimated drawdown, water quality, and means of aquifer recharge.

(ii) Supplies for agriculture

Water requirements for the existing irrigated area and for new proposed developments in the zones of Colina-Batuco and Curacavi-Casablanca, and other possible areas, based on cropping patterns recommended after investigations covering soil surveys, land classification, and drainage conditions, and with due regard to national needs and markets.

The total irrigable area included in the project is approximately 260,000 hectares of which about 200,000 are existing and the remainder new.

Reservoir storage requirements to be determined, based on studies correlated to domestic and power requirements. For new storage the capacity, location, topography, geology, and principal features of proposed dam(s) and reservoir(s), with descriptions of available construction materials.

Preliminary location and outline design for head-works; available construction materials.

Preliminary layout for integrated canal system, covering existing and new areas. Studies to determine extent to which underground water is available and can be economically developed for irrigation; definition of areas to be served, location, depth, and capacity of wells, water quality, estimated draw-down, and means of aquifer recharge.

The proposals for agricultural development are to include, in addition to the above :-

- Provision for drainage and land improvement, and for on-farm preparations.
- Agricultural credits and farm loans.
- Agricultural advisory services.
- Infrastructure improvements.
- Organisation and Management.

(iii) Water for hydro-electric power

Requirements for existing installations and potential future development of hydro-power in the Maipo basin, based on studies correlated to domestic and irrigation water requirements, and in consultation with ENDESA and other electricity authorities.

Particulars of existing generating plants, and proposed locations and capacities of new plants.

Reservoir storage requirements based on above studies. Capacity, location, topography, geology, and principal features of dam and reservoir (if required), with descriptions of available materials.

(iv) Water for Industrial Purposes

Requirements for existing industrial plants and for new industries proposed or recommended in the Maipo area.

Location and particulars of existing plants using industrial supplies, nature of effluents.

Location and particulars of new plants proposed, anticipated programme for development, water consumption, nature of effluents.

Studies to determine the availability of supplies correlated to domestic, irrigation, and power requirements, and with due regard to priorities, in consultation with CORFO and other departments concerned.

(v) Water for Mining

Provision and investigations on a similar basis <sup>50</sup>/<sub>80</sub> that for industries.

(b) Programme of economic-social development

The Consultants will prepare a programme of economic-social development for the Maipo Irrigation Project area, to be developed in parallel with the water resources programme, and covering the proposals for hospitals, schools, and housing in conformity with ODEPLAN requirements.

(c) Second Interim Report

The Consultants will prepare a Second Interim Report in Spanish and English presenting the proposals and suggestions for the optimum utilization of the hydrological resources of the Maipo basin and economic-social programme, in a suitable and concise form for proceeding with the economic assessment.

PHASE III - Economic assessment of the proposed development programme for the Irrigation Project area

(a) Under this final phase the Consultants will :-

(i) Estimate the approximate financial requirements in local and foreign currencies for implementing the proposed programme for the Irrigation Project area as defined in Phase II(a)(ii) above, both for capital and annual expenditures, and including hospitals, educational, and housing programmes.

(ii) Prepare estimates of annual benefits to landowners, gross and net revenues which may be expected to accrue from the development, with schedule of proposed taxes, water rates, etc., to be collected.

(iii) Carry out a study of the economic soundness of the development in suitable form to serve as a basis for obtaining finance from an International Credit Agency.

(iv) Assess the National Economic Benefits accruing from the development, including the gains or savings in foreign exchange.

(b) Final Report

The Consultants will prepare a Final Report in Spanish and English incorporating the two interim reports prepared under Phases I and II and the estimates of cost and economic assessment under Phase III.

British Government Cooperation

The British Government through the Ministry of Overseas Development will engage, at its own expense, the services of a firm of Consulting Engineers to carry out the studies described in the agreement.

The Chilean Government will provide free of cost the items listed in the appendix attached hereto including the cost of all subsistence expenses of the personnel in Chile.

## APPENDIX

### Items and Services to be provided by Chilean Government.

- 1) Subsistence expenses for Staff and Specialists engaged on the project in Chile.
- 2) Offices, secretary, office equipment, and materials.
- 3) Transport necessary for carrying out the work.
- 4) Borings, trial pits, laboratory tests as required by the Consultants.
- 5) Any labour required by the Consultants for the investigations.
- 6) The Services of Chilean Engineers and Specialists required by the Consultants.
- 7) Survey equipment required by the Consultants.
- 8) Aerial photographs and maps of the area covered by the investigations.

Geologist

TERMS OF REFERENCE.

1. Examine and interpret all existing maps, information and records relating to the existing geology of the Maipo area.
2. Prepare from existing information and in collaboration with the project Hydro-geologist a brief report with geological map(s) on the general geology of the Maipo Valley area to a scale of 1:100,000 identifying the principal formations and structures, with at least two cross sections illustrating the general sequences and main features. The report should include comments on the history of seismic and volcanic activity in or near the area.
3. A more detailed report on the geology of the areas under consideration for location of storage reservoirs, with maps to a scale of 1:25,000, with particular reference to water-tightness of the proposed reservoir areas, and any special features such as the stability of the reservoir sides, major faults, potential seepage paths, proximity to active volcanoes, etc.
4. Finally a detailed report on each of the proposed dam sites with maps to a scale of 1:1,000, and at least one cross section of the valley at each site. The reports should cover the geological sequences at the sites, and characteristics of the rocks with particular reference to the foundation strata, dip and strike, faults, shear zones, liability to underground seepage, stability of the valley sides, seismic activity, and any other noteworthy features.  
The reports should also include recommendations for any further geological investigations considered necessary to prove or amplify the preliminary findings.
5. The reports maps and sections should be prepared in draft form as soon as possible after completion of the field work, to enable the Engineers to discuss and develop their proposals. Maps and drawings will be completed to final form for the project report by the Consultants and checked by the Geologist.

Hydro-Geologist

TERMS OF REFERENCE

The project aims to study the hydrological resources of the Maipo River Basin and to propose measures to obtain optimum utilization of those resources. To that end the hydrogeologist is required, inter alia:-

1. To examine all available geological maps and records, existing reports, well records, and other relevant information pertaining to the area with particular reference to water bearing formations, groundwater movements, and occurrence of mineral salts, and estimate the extent, location, and quality of underground water supplies available.
2. To prepare a list of all wells in the area including lithology, depth and diameter of borehole, ground level, depth and extent of aquifer (which should be identified), maximum and average extraction rates with rest and drawdown levels, including seasonal variation, aquifer characteristics, chemical analysis of water, and any other relevant information. Existing information may have to be supplemented by personal enquiry.
3. To record (on a map to a scale of  $1/25,000$ ) the location, flow and water quality of all springs in the project area. (This information may already exist).
4. To identify and establish the geologic and hydraulic characteristics of all important aquifers in the project area, including where necessary the use of tracers to establish velocity of underground flow.
5. To co-operate with the project geologist in preparing from existing data the draft(s) of a geological map(s) of the area at a scale to be determined but not less than 1:100,000 showing all formation and structures identified lithologically within the area, and cross-sections at a suitable scale and related to the main map to illustrate the principal geological features of the area. In addition to draw up a hydrogeological map of the area at the same scale as above showing the main structures and the principle groundwater provinces of the area and the principle aquifers, and indicating areas of good groundwater potential, the map will show piezometric levels in the project area and indicate direction of groundwater flow. The maps will be prepared to a sufficient standard to enable a draughtsman to complete them and the hydrogeologist will examine and correct the proofs of the final drawings and cross-sections.  
To prepare or assist in the preparation in like manner of any further geological or hydrogeological maps that may be required.

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6. To establish the recharge mechanism of groundwater within the area and evaluate from existing climatological and meteorological data and /or seasonal variation of piezometric levels of groundwater within the area, or other suitable means, the mean annual recharge to groundwater within the respective groundwater provinces of the area. Draw up, in conjunction with R.P.T. engineering staff, the water balance for each part of the area and the area as a whole. Establish the optimum development of groundwater within the respective groundwater provinces with particular reference to the metropolitan area of Gtr. Santiago, and other areas scheduled for such development.
7. To examine the phenomenon of recuperation in the rivers of the area, and in particular the Rio Maipo near Chinihue, with a view to establishing the source of recuperation (by geochemical or other means) and possible future variations in recuperation due to groundwater exploitation and increased use of surface and groundwater for irrigation, industrial, and domestic purposes.
8. To study the implications of possible pollution of groundwater due to overpumping in the metropolitan area of Santiago and the lack of adequate sewage treatment facilities.
9. To comment upon or advise R.P.T. staff on all aspects relating to groundwater, or development of groundwater, that may arise during the investigations or as a result of proposals made by the project team. To read and comment upon the aspects of the reports submitted by R.P.T. related to groundwater or groundwater development.
10. To prepare and submit to R.P.T. a report summarising the investigations into groundwater as detailed above and describing the hydrogeology of the project area in qualitative and quantitative terms. The report which is to form part of the main report for the overall development of the water resources of the Maipo basin should contain proposals for groundwater development in the area for industrial, agricultural or domestic purposes and indicate as far as possible the location, type, depth, size, capacity and estimated drawdown of all wells proposed with characteristics of the aquifer developed, lithology, water quality, and means of aquifer recharge. Where definitive information may be lacking the report should contain proposals for further investigation with full details of location, depth, and capacity of proposed exploratory wells and aquifer to be exploited (with lithology) and all relevant information that may be of use to the persons conducting such investigations. Draft sections of the report, or on principal zones or projects should be submitted as early as possible in order to allow early study of such zones or projects by the engineers and the Chilean government in considering overall development.
11. To advise on the feasibility of draining by tube well, areas subject to water logging and to provide approximate aquifer parameters and other information to enable R.P.T. staff to make an engineering assessment of such a project.

