2.1.6 Outer water level of planning standard

Under this project, the Yacyreta Dam would be constructed at a point about 25 km, upstream the Parana River from Ayolas. At a point about 85 km downstream, the Ita Ibate Dam was to built to control water level and ultimately to accommodate the navigation of 2,000-ton-class vessels, according to Yacyreta Pablic Corporation's plans.

The designed drainage canal would be constructed in between the Ita Ibate Dam and the Yacyreta Dam, the designed water level for the former dam was to be used as a outer water level of planning standard.

In this case, the Parana River's rate of flow would be integral to rainfall probability, and with a 1/10 year probability of 30,000 $m^3/s$, the water level would be determined. Because of the effects of the Ita Ibate Dam, the water level would be elevated from the present level -- 59.3 m above the sea at the estuary of the Yacyreta River and 65.5 m at the mouth of the Atinguy River.

Therefore, the drainage from the survey areas certainly would be influenced by the Parana River's water height, wherein drainage simulation tests should be launched.

## 2.2 Topography, Geology and Soils

### 2.2.1 Topography

This survey area is adjacent to the Yacyreta Dam and located along the northern part of the Parana River in the southern part of Paraguay.

North and east sides of this survey area are the hilly land through which the National Road No. 1 runs almost along the ridge. Elevation of the peak in this hilly land is 180 m, to which the hilly land with the elevation of 150 to 100 m is continued. Topography suddenly changes at the elevation of 100 to 90 m on this hilly land, and a flat swamp zone is formed in the land lower than 90 m in elevation. At the elevation of 70 to 60 m, the land comes to the Parana River at the south side of the survey area, along which slightly high natural levees are formed. West side of the survey area continues to the Great Ñeembucú Swamp, a flat land, and the project area of the survey area has the platter-like topography where the ponding occurs at all times.

There are seven rivers flowing into the project area, and water flowed into the project area is temporarily stored there, thereby forming a ponding zone.

Rivers which drain water from the project area are mainly the Atinguy River and the Yabebyry River but also there are the Yaguary River, a small river, and artificial drainage canals, all of which pour into the Parana River.

West side of the ponding zone in the project area is separated by a gravel road between San Ignacio and Yabebyry, but swamp zones at the east and west sides are connected to each other at several points, and the direction of water flow varies depending upon the water level in the Great Neembucú swamp at the west side. There is a sandy earth zone, a flat gently sloped land, along the Parana River but this zone becomes lower than the area along rivers as the zone approaches to the central portion where a large swamp zone is extended from east to west away from the Parana River.

### 2.2.2 Geology

(1) Geology of Paraguay

Paraguay has no sea, its total area is about 407,000 $km^2$, and it is in the southwestern part of South American Plain with the south latitude

of 19° to 28° and the west longitude of 54° to 63°.

Paraguay lies between the Andes mountain range and Brazil and its geology is not uniform as same as the general geology in South America. The Paraguay River flowing almost through the center of Paraguay divides the national land into two parts; Parana Basin and Chaco Basin.
Fig. 2-2-1 shows the geological distribution map based on geological ages and Table 2-2-1 shows the stratigraphy of rocks.

With respect to the geology of Paraguay, the western part of the Paraguay River belongs to Quaternary strata, the strata of the last half of Jurassic period is located in the form of a strip at the central part, east of the Paraguay River, the strata of Permian period, Carboniferous period and Silurian period are distributed at the western side of the central part, and the strata of the first half of Cretaceous period are distributed at the eastern side along the boundary between Brazil and Argentina.

As shown in Fig. 2-2-1, in the survey area, the strata of Quaternary period are diminant mainly in Misiones Department at the southern part of the country with basalt as base rock, and the strata of Jurassic period are distributed in the remaining area.

1) The strata of Quaternary period are formed with the alluvial deposit, which consist of extremely fine grains mostly with grey to white color. They are mostly formed near small rivers and the surrounding areas or plains.

New deposits of the Quaternary period contain thickly deposited clay, sand and gravel and also, at certain parts, gypsum.

Soils are mostly the clay, silt and fine and medium grained sand, and the groundwater level is relatively high. According to the geological data of Yacyreta Agency, the stratum of basalt is present about 10 to 50 m thick below the Quaternary stratum.

2) In the last half of Jurassic period, there is the formation of red clayey sandstone with a low consistency which runs in parallel to each other.

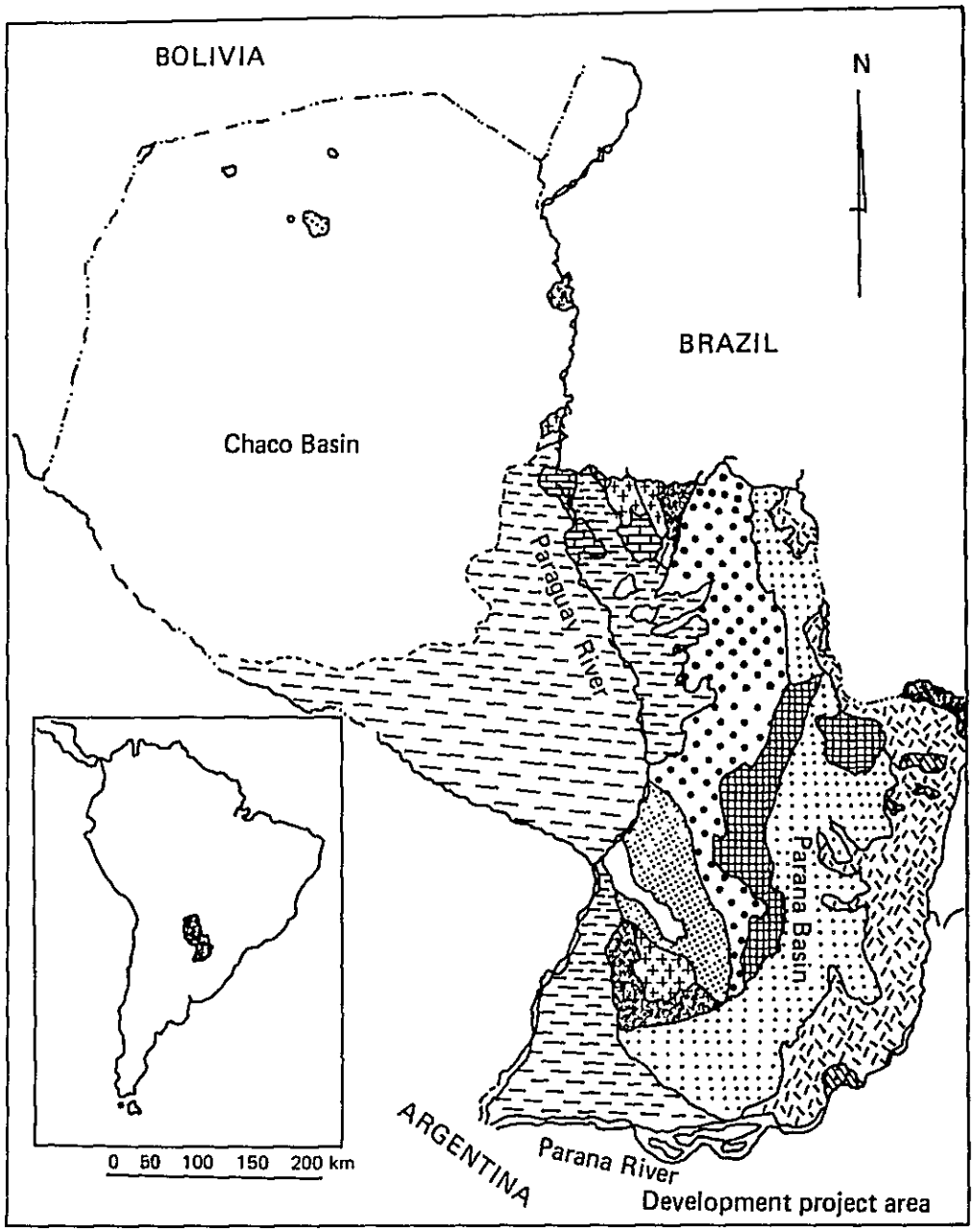



Fig. 2-2-1 Soil Map of Paraguay

Table 2-2-1 Field Exploration for Stratigraphy of Rocks

| Era | Period | Epoch | Stratum | Petrologic composition (by naked eye) |
|---|---|---|---|---|
| Cenozoic | Quaternary | | | Mechanical alluvial and colluuvial deposit |
| | Tertiary | | San Antonio | Red sandstone resulted from rivers, no variation |
| | | | Nemby | Groups of olivine basalt, olivine and nepheline (half-saturated) |
| | | | Chaco | Caly and silt containing all or one of rock salts, gypsum and hard gypsum |
| Mesozoic | Cretaceous | | Acaray | Fine grained continental sandstone |
| | | | Sapucai | Alkali rocks such as esecsite, shonkinite, phonolite |
| | | | Alto Parana | Exposed soleite basalt |
| | Last half of Jurassic | | Misiones | Red continental sandstone resulted from aeolian mudstone |
| Palaeo-zoic | Permian | Ybytyruzu | Panetey | Siliceous shale containing marl, siltstone and lime |
| | | | Independencia | Medium or coarse grained sandstone |
| | Carboniferous | Cerro Cora | | Mechanical deposit resulted from glaciers and siliceous shale containing siltstone and lime |
| | First half of Silurian | Itacurubi | Arenisca Cariy Lutita Vargas Pena Arenisca e Ayala | Micaceous sandstone, and sandstone containing fossils |
| | | Caacupe | Arenisca Tobati Arenisca Cerro Jha Conglom, Paraguari | Basal conglomerate, granitic sandstone, sugar-like sandstone |
| | Cambrian | Itapugumi | | Calcareous calcite, marl, lutite |
| Precam-brian | | Villa Florida | Caapucu | Granite, porphyry, rhyolite |
| | | | San Miguel | Porphyry, gneiss, mica schist |

(2) Results of test pitting near the survey area

(data from Yacyreta Public Corporation)

This survey was performed by the mechanical boring for a distance of 38.6 km along the old road between Ayolas and Santiago starting from Ayolas and a point about 6.1 km east of the Atinguy River to Santiago. (Refer to Appendix for this data.)

1) Eastern part of the Atinguy River (P7 to P11)

This survey was performed on a route passing through a flat plain or swamp zone at the eastern part of the Atinguy River. The upper layer is the deposit of coarse, medium and fine grained silty sand starting from the ground surface. Lower layer comprises basalt starting from a depth of about 10 m but the depth of rock layer will hardly affect the excavation of drainage canal.

2) From Ayolas to Santiago (P15 to P32)

P15 to P19 were surveyed along the Anã Cua River, a tributary of the Parana River, and the upper layer is covered with sand. P15 and near Ayolas, basalt is present at a depth of 21.6 m which is considerably deep but, at P16, the basalt is present at a depth of 9.6 m below the ground surface and suddenly drops near the river bed.

Basalt is distributed at the elevation of 60 m from P16 to P32 in Santiago but is 10 m lower at P30. Normally, the basalt is distributed at the elevation of 60 m and its depth is greater than 10 m below the ground surface and thus the basalt will not disturb the excavation of canals. However, at P17 of Estero Cmaguary, the ground surface rises and also the elevation of the basalt layer rises to 66 m so that it may be necessary to anticipate the appearance of basalt there on the route of drainage canals.

3) Consideration

Generally there is the formation of clay, silt and sand about 10 m thick, and the layer of basalt seems to be present below the formation. Thus, for the excavation of irrigation canals and drainage canals and slope protection, the work should be carried out basing upon the physical properties of each layer of sand, silt and clay, that is, the results of specific gravity test, grain size analysis, permeability test and penetration test. Also, for planning of structures, it seems to be

difficult to support them directly by the basalt layer which is deeper than 10 m below the ground surface in view of the construction costs and therefore it may be necessary to consider the use of friction piles or footings for the structures.

(3) Base rock survey in the survey area

1) Survey method

Hearing was held with counterpart and local residents and also the base rock was surveyed in areas where the base rock was presently exposed. Hand auger of 5.0 m was used as tool of survey, and the range of base rock within a distance of 100 to 300 m in the surrounding area was predicted. This was performed to verify that the base rock will not complicated with the planning routes of irrigation canals and drainage canals. Particular areas surveyed were the area between Santa Ana and former airport, the basin of the Atinguy River and the downstream of the Yabebyry River.

2) Base rock survey between Santa Ana and former airport

Refer to the plan of Fig. 2-2-2 and the sectional view of base rock As shown in these drawings, it will be known that the sandstone and basalt are exposed as a series of base rock zones between the Santa Ana Farm and former airport. That is, starting from the basalt zone exposed at the northern part of Puesto Uno, the plateau with the elevation of 80 m class continuing from the south to north was surveyed and the range of existence of the basalt zone was almost confirmed.

① At the A-point, the west side of an exposed portion of the base rock was dug, and the rock was confirmed at a depth of 0.85 m. Digging was also performed at the peak of the western plateau but no rock was detected at the depth of 4.0 m. Then, at a distance of 100 m to the east, the base rock was confirmed at a depth of about 0.4 m.

On the northeastern plateau, boulders and rocks were confirmed at a depth of 0.40 to 0.80 m.

② At the B-point, the base rock was surveyed northeastwards from the point of exposed sandstone, and no base rock was detected to a depth of 5.30 m at the peak of plateau. It was told that the base rock was found at a depth of 10 m in the wells of farms on the plateau. There was a swamp at a distance of 50 m to the east, and the range of existence of the base rock seems to be very narrow there.

③ At the C-point, local residents informed us of some boulders and then the digging was performed. Base rock was detected there at a

depth of 0.50 to 1.80 m. Rocks were found around this plateau, and the presence of rocks near the ground surface was confirmed at the east side of the plateau.

④ At the D-point, there was no exposed rock so that a bore hole was made at the peak of plateau to a depth of 5.0 m but no rock was detected. Local residents informed us of a place where boulders were seen, ground was digging there and hard objects were detected at a depth of 0.3 to 1.0 m, and then top soil was removed with scoop and a layer of cobble was found. There may be a layer of sandstone below the cobble.

⑤ At the E-point, ground was surveyed northwest of the exposed rock, the presence of rock was confirmed in the range of 250 m, and the digging was performed near a swamp at the east side and the base rock was detected at a depth of 1.5 m.

⑥ At the F-point, the rock was confirmed at a depth of 2.90 m and 2.30 m on the NE-SW line south of Santa Clara stock farm and its vicinity. Also, in the vicinity of Santa Clara stock farm, the area where boulders were present was found by a guidance of the manager of this stock farm, and this area was found to be the base rock zone.

⑦ G-point is in a former airport in the south of road, Ayolas-Yabebyry, the digging was performed near a pond which was partially a former quarry, and the rock layer was detected at a depth of 0.5 to 1.8 m. From this, it was confirmed that there was the base rock on the plateau in the range of about 15 km from the northwest of Santa Ana to the former airport.

⑧ H-point is on the plateau 800 m north of Santa Ana, and the owner of the stock farm told us that an area of about 500 m square on the plateau was a rock mountain.

⑨ The manager of the stock farm also told us that there was the base rock on the plateau which was connected from the A-point to the northern part.

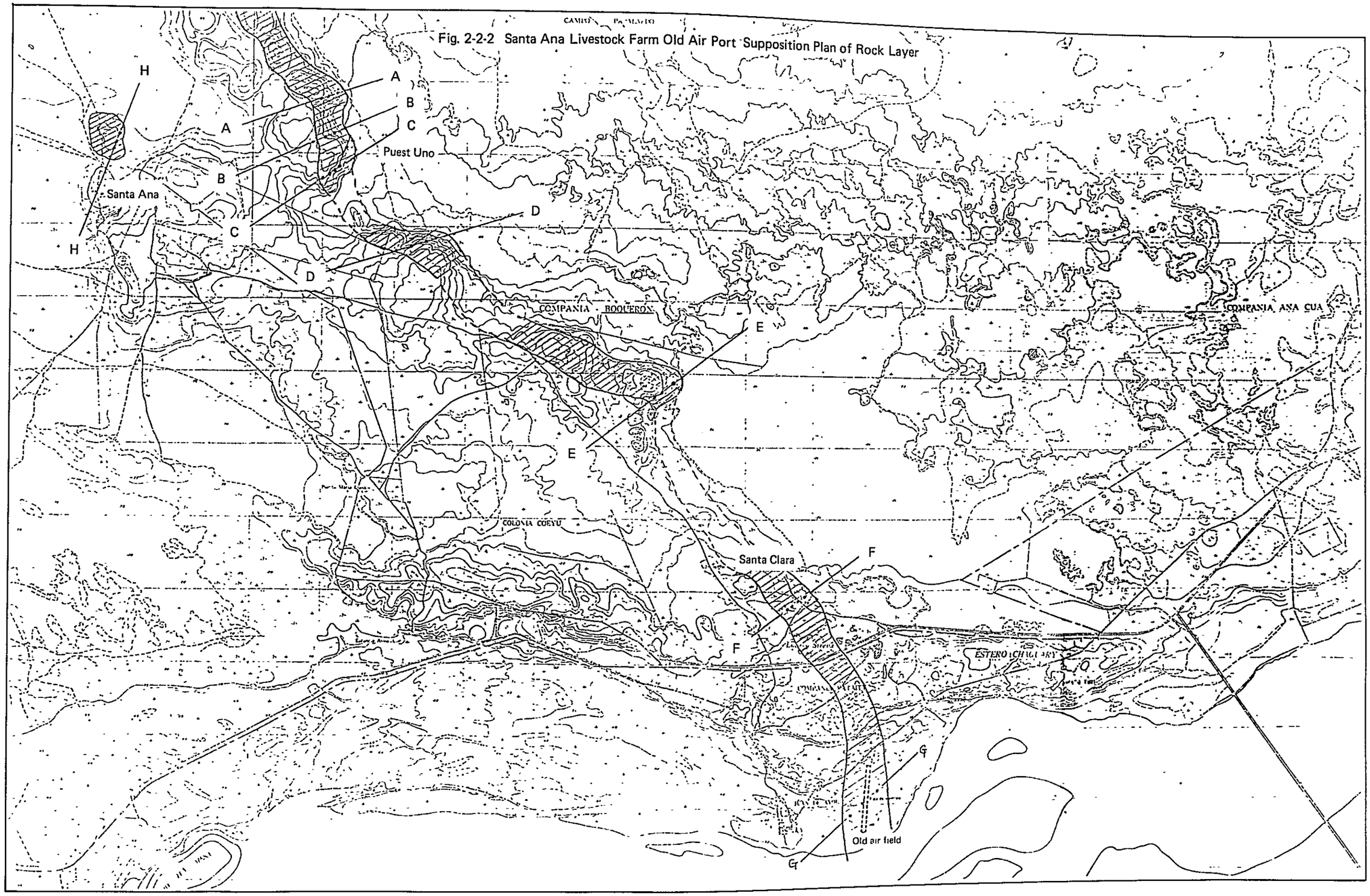
3) Consideration:

From this survey, it has been confirmed that there is a layer of basalt or sandstone with a width of 300 m exposed on or underground close to the ground surface on the plateau at an elevation of 80 m in the range of about 15 km from the Santa Ana stock farm to the former airport. However, the base rock seems to exist deeply underground in plains and swamp zones between plateaus and thus it was unable to confirm the presence of the base rock there. Borings will be necessary in future for the confirmation.

From the results of survey of outcrop performed this time, the basalt is hard but the sandstone is somewhat weak. If the sandstone is used as gravel for roads, the degree of compaction may be maintained to a certain degree in an early stage but, after the use for a long time, the road surface is likely to be weakened as a result of the crushing by vehicles and absorption of moisture due to rain, both of which occur alternately. However, if water is properly drained from the road bed and road surface, then the roads may be long utilized to a certain degree.

Since mostly the gravel pavement is used in this country where the construction materials are in short supply, it may be necessary to utilize these rocks to the greatest degree and therefore the lithology test and the estimation of usable amount should be performed in future.

Fig. 2-2-2 Santa Ana Livestock Farm Old Air Port Supposition Plan of Rock Layer



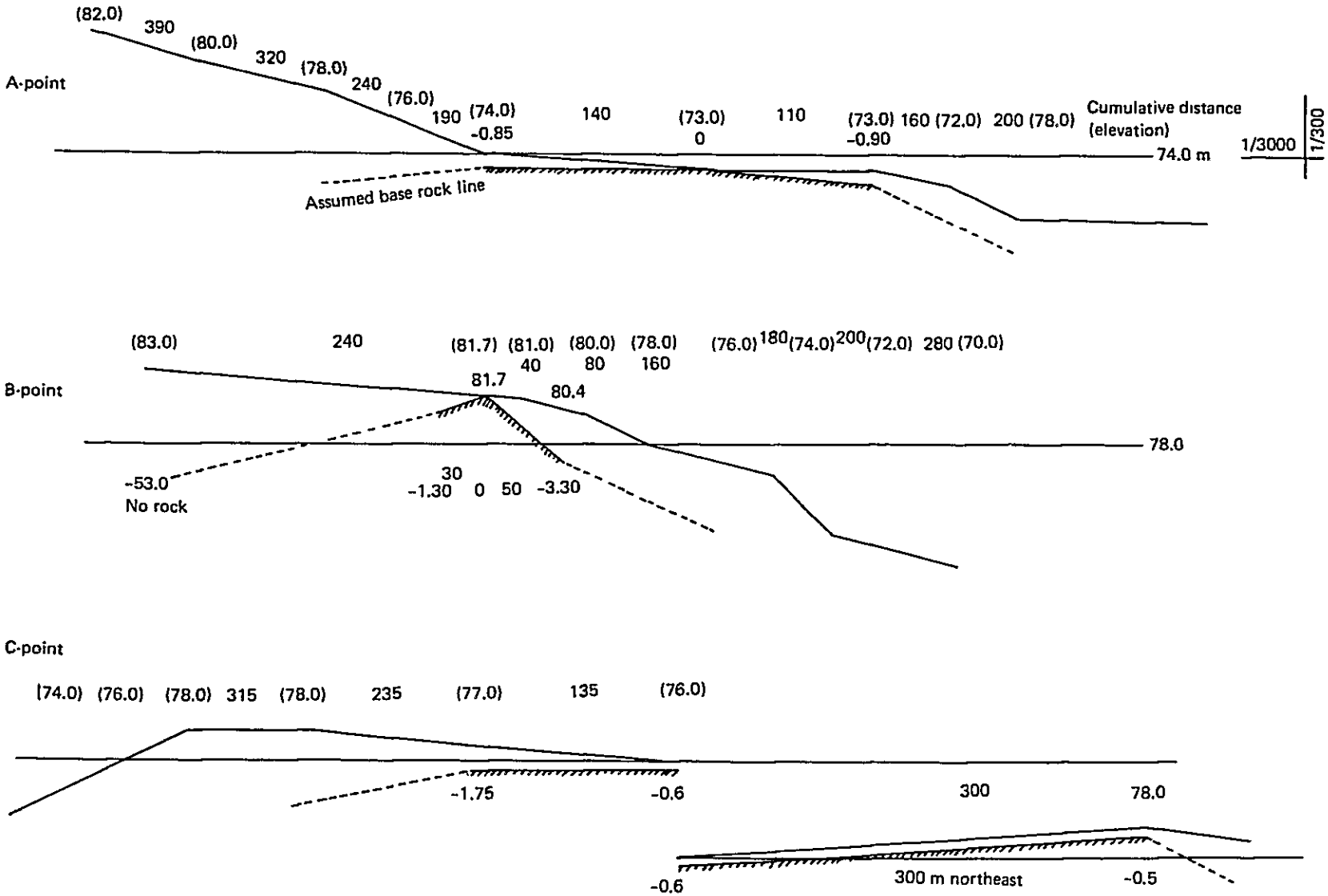



Fig. 2-2-3 Assumed Base Rock Section between Santa Ana Stock Farm and Previous Airport

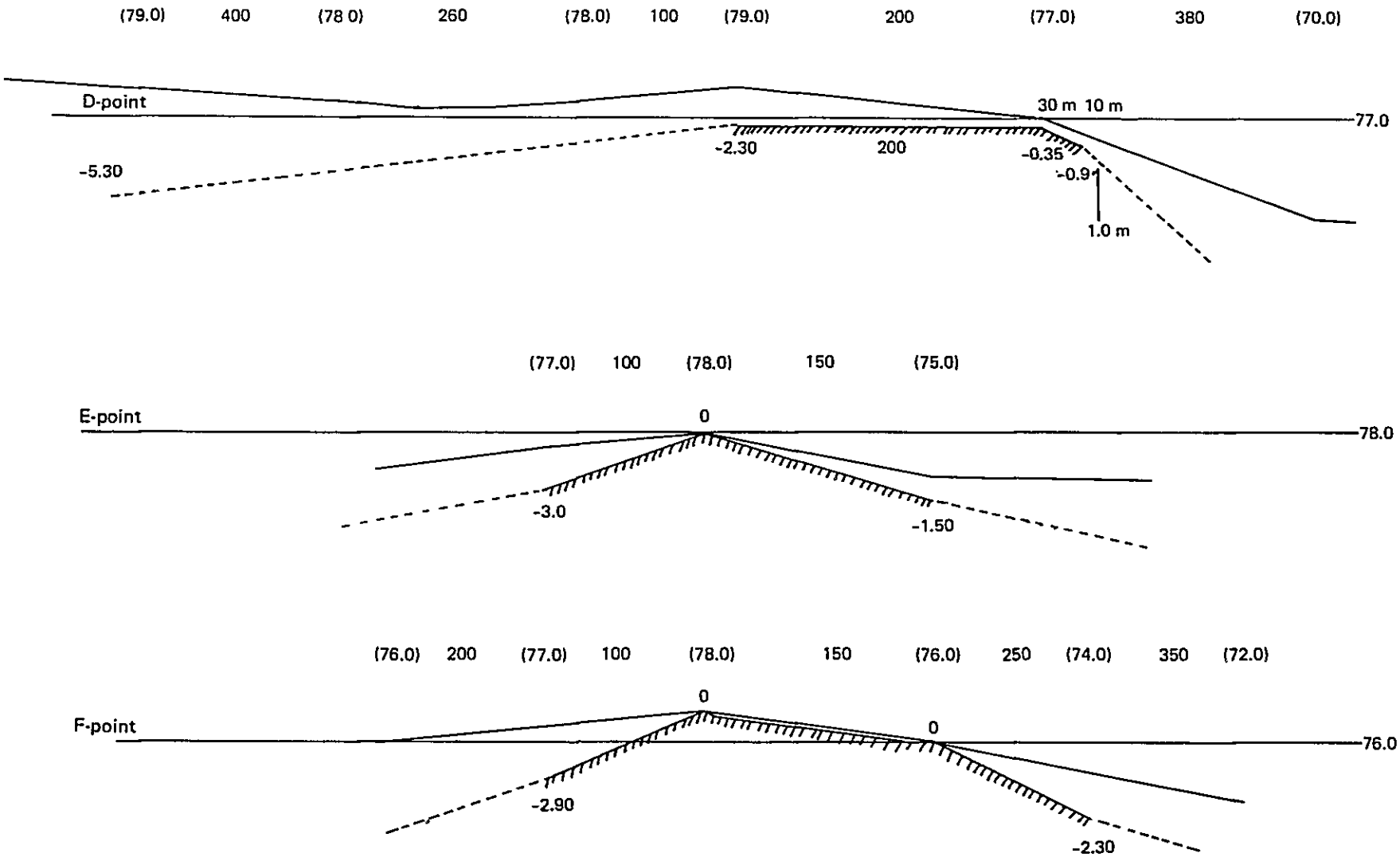



Fig. 2-2-3 Assumed Base Rock Section between Santa Ana Stock Farm and Previous Airport (cont')

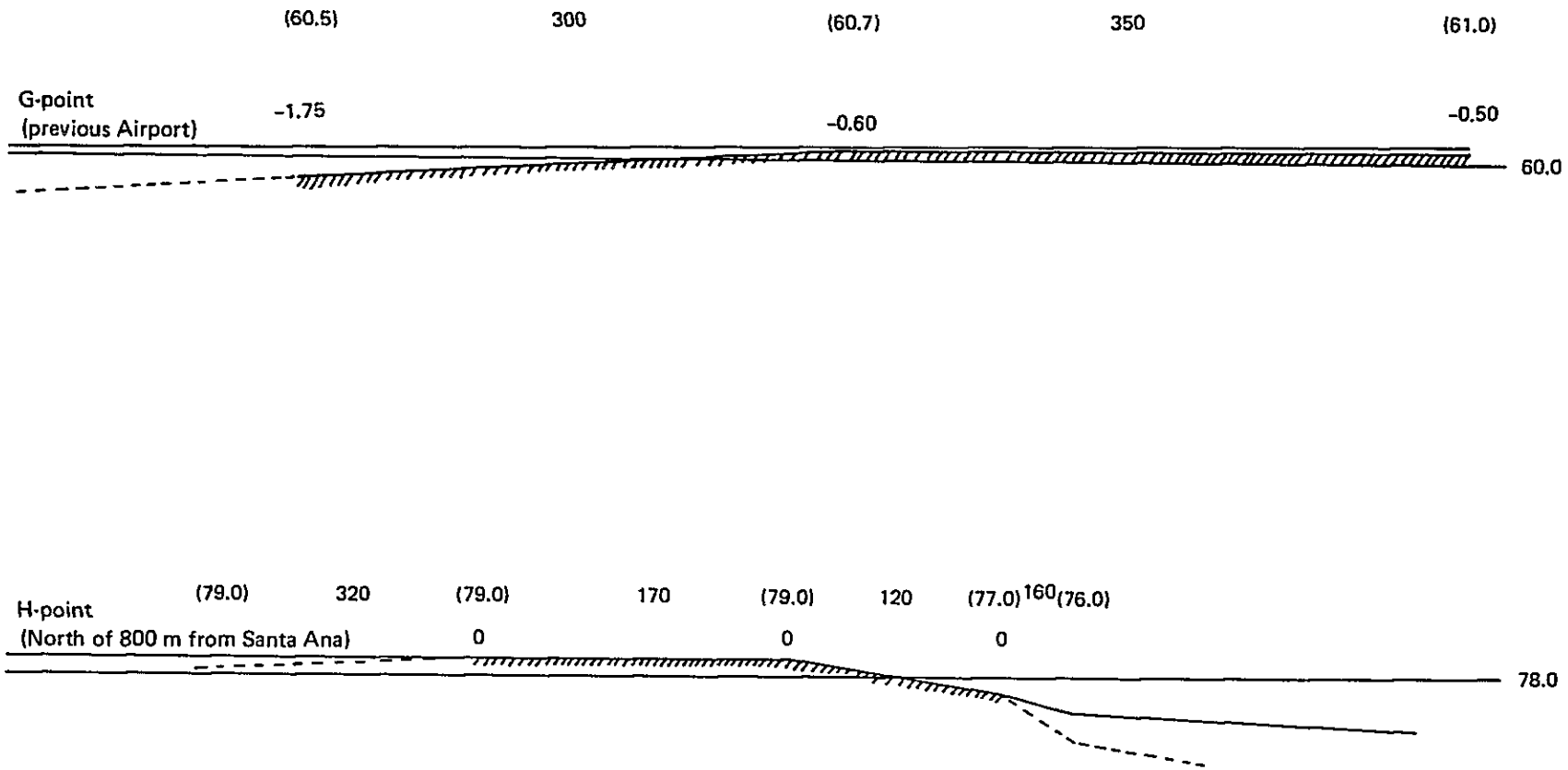
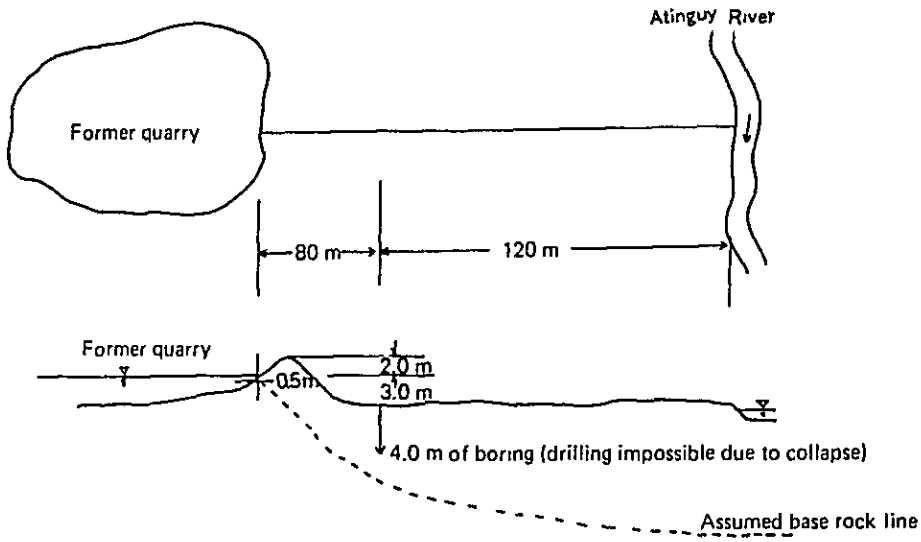



Fig. 2-2-3 Assumed Base Rock Section between Santa Ana Stock Farm and Previous Airport (cont')

At ⑰ and [2] close to the northern hilly land, silty clay is present to a depth of 5.0 m and the presence of sand layer below the silty clay is expected. But there is no rock in this area.

At ⑪, [5], ㊴, ㉙ and ㉑ along the middle reach, a layer containing sand is present from the depth of about 1.0 m, fine or medium grained sand is present from a depth of 1.5 m to 3.0 m and the digging was impossible at certain places but there is no layer of base rock. Point ㊴ was dug between De Cabyal Cantera (quarry) and the Atinguy River.

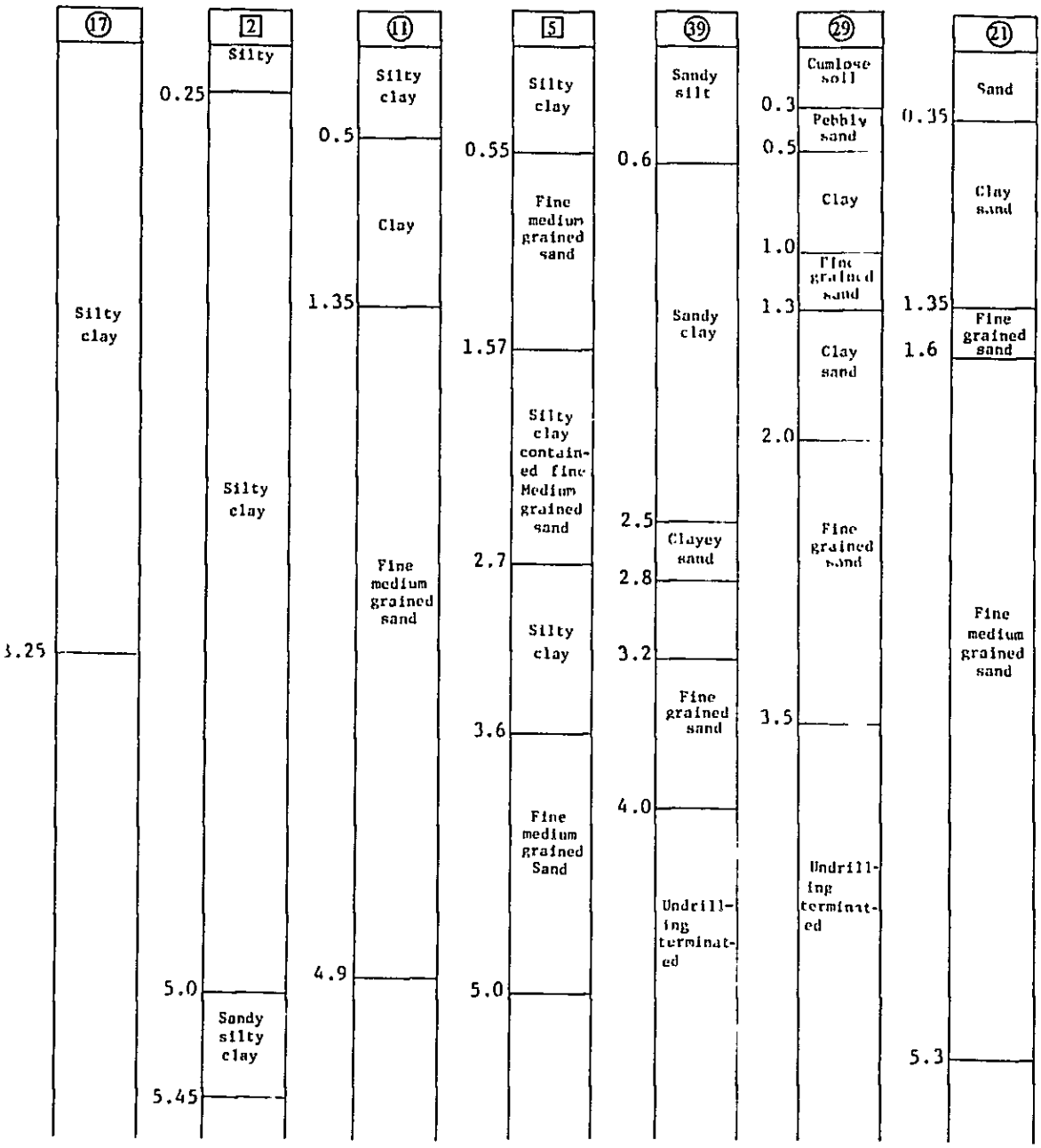



As shown above, the quarry is at a distance of 200 m from the Atinguy River. Boring was performed at a distance of 80 m from the quarry to a depth of 4.0 m below the ground surface. Clay and sand formations were there but the wall of bore hole was collapsed due to groundwater and fine sand near the bottom so that it was not possible to confirm the base rock. Since the base rock was seen at a depth of 0.5 m from the water surface in the former quarry, the detection of the rock was anticipated at 80 m point. The base rock is considered to exist there at a depth greather than 4.0 m. Sand layer was also found along

(4) Results of base rock survey in the basin of the Atinguy River

① Results of Survey

As shown in the Fig. 2-2-4, borings were performed by field exploration with hand auger at ten points of ⑰, ⑪, ㊴, ㉙, ㉑, [2], [5], Ⓐ, Ⓑ and Ⓒ along the Atinguy River.
Boring logs are indicated below.



the Atinguy River but no rock was found.

At (B) and (C) points, bore holes were made with hand auger but collapsed at a depth of less than 1.0 m due to groundwater and fine sand and the digging was not possible thereafter.

These bore holes were made at places where river canal considerably meandered. There were 3.0 to 5.0 m high river banks consisting of sand layer and clay and also there were many trees standing in with clay of the steeply sloped banks but no rock layer was seen there. However, the manager of Joruge stock farm told us that there were several boulders with a diameter of 0.3 to 0.5 m near Paso Ita (place where there is the water source of the Atinguy River) at (A) point and a base rock was seen at the bottom of river about 1.5 m below the water surface though the area of the recognizable rock was small.

(2) Consideration

From the above, a small recognizable base rock is present only in the water source in the basin of the Atinguy River, and there is no rock layer in other places including the basin at the east side of the former quarry.

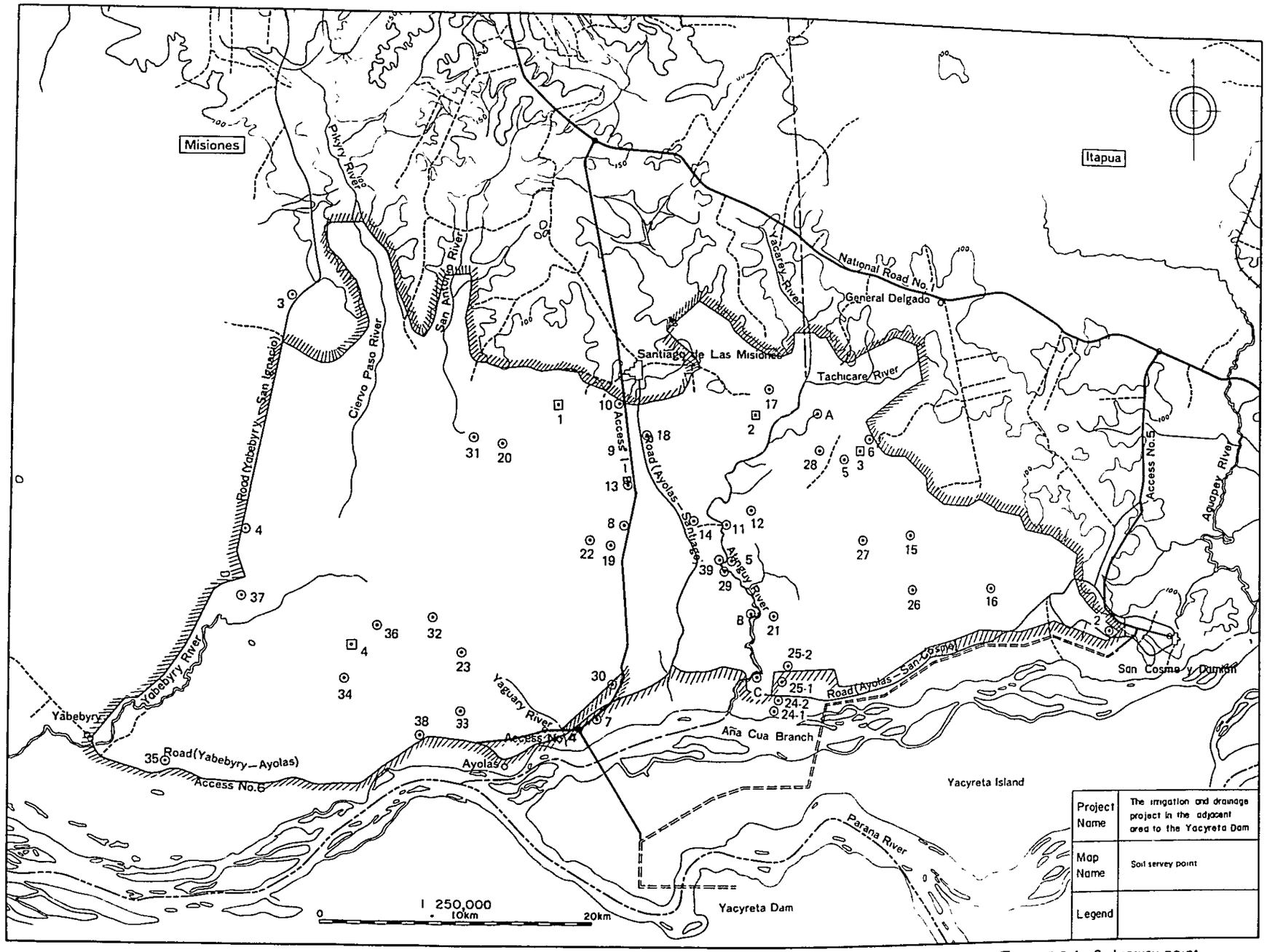



Fig 2-2-4 Soil servey point

(5) Results of base rock survey in the basin of the Yabebyry River

This basin is planning to be surveyed in the next fiscal year but was surveyed this time since a straight cliff was found at a bend 100 m downstream of the road between Ayolas and Yabebyry. In consequence, the cliff consists of sandy clay and clay and no rock layer was found.

2.2.3 Soil property

(1) Outline of survey area

Soils in the survey area can be roughly classified into San Cosme layer (consisting of continental sand, red fine sand and cumlose soil) at the east side, Serra Geral layer (basalt as parent rock) at the central part, and alluvium at the west side. Thickness of top soil is considered to be relatively small or 10 to 15 m, and the outcrop of basalt and former quarrys were seen. Also, a fault was recognized from the northwest to southeast near the proposed water intake point. Groundwater level in the survey area is normally high and fluctuates considerably by season. Also, salt was recognized in groundwater but a further survey will be necessary.

(2) Method of geotechnical investigation

Areas near the expected routes of irrigation canals and drainage canals were mainly selected for the survey and the survey was performed with auger boring.

For the irrigation canals, the employment of earth-filled canals was expected and thus the water leak and compaction problems were the most anticipated. Therefore, the standard penetration test, specific gravity test, grain size analysis, consistency test, compaction test, permeability test and shear test were performed in order to use the results as basic data for structural planning of the proposed structures.

For the drainage canals, the presence of base rock was surveyed with hand auger at the narrow places which became the bottlenecks of running water in both the Atinguy and the Yabebyry Rivers (no mechanical boring was performed this time).

(3) Results of survey by hand auger

Auger boring was performed at 39 points. Whole area was divided into 8 parts and surveyed.

1) Eastern part

① & ② survey points

These are located at the foot of a mountain and a flat land on the route of the trunk irrigation canal, and silt and clay layer was recognized up to a depth of 3.0 to 4.0 m at each point. Upper layer was a silt layer or former paddy field so that organic matters were contained. Groundwater level was 0.9 m.

2) Eastern part of the Atinguy River (south and north sides of the road between Ayolas and San Cosme)

㉑, ㉔-1, ㉔-2, ㉕-1, and ㉕-2 survey points ㉔-1 and ㉔-2 are at the south side of the road and in a swamp zone near the Parana River. A considerably thick clay layer was found at ㉔-1 and a fine-grained layer at ㉔-2, and bore holes were collapsed at a depth of 2.0 m since groundwater was contained. Groundwater level was 0.3 to 0.6 m.

㉑, ㉕-1 and ㉕-2 are at the north side of the road and in a plain of natural grass land and swamp zone. Rainfall from the northern hilly land flows down partly into the Atinguy River and the swamp zone. Because of this, there was a silt and clay layer, and ㉕-1 was collapsed due to groundwater and fine sand layer and the digging became impossible thereafter. Groundwater level was 0.5 to 1.0 m.

3) Eastern, central & northern parts of the Atinguy River

⑤, ⑥, ⑫, ⑮, ⑯, ㉖, ㉗ & ㉘ survey points

This is a flat land into which rainfall flows directly from the hilly zone in the northern and northeastern parts, and its project area is a large inundation zone. ⑤, ⑥ and ㉘ are close to the foot of a mountain and at the southwestern part of Laurel stock farm, and hard sandy layers were seen at a depth of 3.0 to 5.0 m and thus drilling with hand auger was not possible. Therefore, for the excavation of irrigation and drainage canals, the filling and compaction

works and water leak must be carefully handled. Groundwater level was 0.5 to 2.0 m.

4) Basin of the Atingay River

⑪ , ⑭ , ⑰ , ㉙ and ㊴ survey points

The Atinguy River meanders through a flat land and natural levees are formed by forests in the vicinity of the river. Since there is Cabyal quarry (basalt) in the basin of the Atinguy River, the presence of base rock was predicted in the nearby area but it was not confirmed ( ㊴ point). At ⑭ located next to the old road between Ayolas and Santiago, a hard sandy layer was seen at a depth of 3.6 but the digging with auger was not possible thereafter. Basalt layer was not confirmed. At ⑪ and ㉙ , a sand layer was recognized to a depth of almost 5.0 m but no base rock was recognized. Groundwater level was 2.65 m at ⑭ but 0.5 to 0.8 m at other points. This layer was covered with silt and clay at each point.

5) Along Access 1-B road

⑧ , ⑨ , ⑩ , ⑬ , ⑲ , ㉒ , ⑦ and ㉚ survey points

This road runs in the south-north direction through a flat land, and nearby area was excavated to obtain earth required for the road construction and thus many swamp and inundation zones were recognized there. Mainly the sand and some clay were contained in the layer and the groundwater level was 0.70 to 1.30 m, so that the wall of bore hole was collapsed and the digging became impossible thereafter.

⑩ point was at the foot of northern hilly land, and a silt layer was recognized there but became hard as the depth of digging increased and thus the digging was discontinued.

6) Central and southern parts between Access 1-B Road and Yabebyry-San Ignacio Road

㉓ , ㉜ , ㉝ , ㉞ , ㊱ , ㊳ and ㉟ survey points

This is a zone containing a swamp at the southwestern part of the survey area, and its hilly zone running through a part of Santa Ana stock farm from the northwest to southeast is the rock and outcrop zone

of basalt and sandstone. The range of presence of these rocks was described in the foregoing paragraph. In the earth layer, silt and clay were deposited but the bore holes were collapsed due to groundwater and the digging became impossible thereafter. Groundwater level was 0.15 to 1.5 m.

7) Along road between Yabebyry and San Ignacio

③, ④ and ㊲ survey points

The Great Ñeembucú Swamp is located at the west side of this road, and water flowing from the northern hilly land normally flows to the west side because of the road bridge. However, this water sometimes flows from the west to east depending upon the rainfall, and the east side of road is always inundation. Because of this, the groundwater level is low or 0.2 to 0.4 m also at ③, ④ and ㊲ points. Soil was silt or sand and the digging became impossible because of groundwater.

8) Central and northern zone between Access 1-B and Yabebyry-San Ignacio

⑳ and ㉛ survey points

This zone is generally inundated thereby forming a swamp zone due to the rainfall directly flowing from the northern hilly land and is accessible only by riding a horse. Sand or clay layer was present there and the groundwater level was 0.4 m.

9) Consideration:

Auger borings were performed at 39 survey points in eight parts subdivided as described before.

Generally, alternate layers of sand-silt and clay formations were confirmed at every survey point, and top soil was normally cumlose soil or sandy earth containing some organic matters between 0 m and 0.3 m.

For the sand layer (fine grained sand) containing groundwater below the top soil, the digging was not possible due to the collapse of wall of bore hole at several points. Groundwater was recognized at all survey points, and its level was usually from 0.2 m to 2.0 m and, near the swamp zones, was from 0.2 m to 0.5 m. Because of this, the construction work should be carried out by referring to the results of

soil test and taking into account of the presence of groundwater level.

(3)-1) Soil survey points

In the northeastern part of the Atinguy River, hard sand layer is seen in some area and the digging with auger is not possible, and this seems to be a deposit of hard rock close to sandstone. Depth of hard layer is 1.0 to 3.0 m and this layer should be taken into account for filling and excavation of irrigation and drainage canals.

(4) Results of soil test in laboratory

1) Method of survey

A total of 5 survey stations were selected; 3 stations near the trunk irrigation canal planned at the foot of hilly lands in northern part and 2 stations near the drainage canal of western swamp zone and basin of the Atinguy River.

Survey was conducted by boring with hand auger to a depth of 5.0 m, samples were taken at the points where the soils changed, soil test was performed for the samples, and then standard penetration test and field permeability test were performed.

2) Contents of test

Borings with hand auger (5.0 m) for irrigation water (No. 1, No. 2 & No. 3)

① Standard penetration test

② Field permeability test

③ Soil test

(a) Specific gravity
(b) Mechanical analysis of soil
(c) Consistency
(d) Compaction test
(e) Permeability test for compacted soil
(f) Direct shear test

For drainage canal (No. 4 and No. 5)

① Standard penetration test

② Soil test

(a) Specific gravity

(b) Grain size analysis

(c) Consistency

3) Results of soil test

① No. 1 station, 1.5 km southwest of Romero Cué Farm

Boring was performed for the design route of the trunk irrigation canal, and clayey soil classified into A7-5 of the soil classification was found at this station. Mean specific gravity was 2.57, mean LL of consistency was 45.0% with 15.0% of PL and 25.0 of PI so that medium average viscosity was recognized. Maximum dry density was 1,735 kg/$m^3$ and optimum water content was 12.9%. Coefficient of permeability was $1.2\times10^{-5}$ cm/sec which is normal for a cohesive soil.

In the standard penetration test, N-value of 7 to 40 was found, which means a hardness higher than the medium.

With respect to the earth to be used for the open canal type irrigation canal at No. 1 station, the filled portion will be required to be fully compacted and its face of slope to be properly protected.

② No. 2 station, 2.0 km south of San Juan Farm

This station is on the route of irrigation canal at the foot of hilly land in northern part, and its soil is classified into the cohesive soil of A7-6. A layer 3 m thick of cohesive soil was recognized at this station, and more than 90% of the amount of this soil passed a 0.005 mm sieve. Its LL was 60% in average, PL was 20% and PI was 40, which indicates a strong cohesive soil. Coefficient of permeability was found to be $1.8\times10^{-6}$ cm/sec in laboratory test.

N-value was 3 up to the depth of 3.5 m and thus this soil must be handled as soft clay. If this soil is used for open canal (cutting) or filling, it should be displaced or a special slope protection measure should be taken. Groundwater level was high or 0.25 cm.

③ No. 3 station, 3.5 km west of San Jorge Farm

This station is on the route of trunk irrigation canal. Soil at this station is a cohesive soil classified into A6 and A7 with LL of 30% in average, PL of 15% and PI of 18. Also, mean specific gravity of 2.60, maximum dry density of 1,760 kg/cm$^3$, optimum water content of 12.5%, coefficient of permeability of $8\times10^{-4}$ cm/sec in laboratory, and coefficient of permeability of $2.1\times10^{-5}$ cm/sec in field test.

N-value was 9 to 30 which means a hard soil and thus slope protection will not be required. However, since its coefficient of permeability is low if it is used for filling of irrigation canal, the use of this soil must be carefully studied before the work.

④ No. 4 station, 2.5 km northwest of Santa Ana Farm

This station is on the route of trunk drainage canal planned in the western part of the survey area. Soil classification of the layer at this station is A6, and a silty soil is present below this layer. Consistency is 30.0% in LL in average, 14.0% in PL and 15 in PI. Maximum dry density of 1,800 kg/m$^3$, optimum water content of 12.1% and coefficient of permeability of $1.1\times10^{-4}$ in field were found.

N-value was 6 to 13, which means the medium hardness of soil, and thus this soil can be utilized in an ordinary manner for the construction work.

⑤ No. 5 station, 30 km upstream of river mouth in the basin of the Atinguy River

The Atinguy River is planned to be used as the trunk drainage canal in the east of Access No. 1 Road. And the results of soil exploration in this basin will be used for detecting the base rock and also for the work of trunk drainage canal by widening the river. Because of this, survey station was selected in an area of the basin where the river considerably meanders. Soil class of the layer at this station was A2-4, specific gravity was 2.5 in average, and consistency was mostly NP.

Value of compaction test was 1,355 kg/m$^3$ which is light compared to 1,700 kg/m$^3$ at other stations and the optimum water content was large or 28.8% so that this soil must be carefully handled.

According to the results of standard penetration test, N-value was 6 to a depth of 2.0 m and thus this soil was hard, but the penetration test was also performed at a depth of 3 m during which a penetration of 0.5 m was recorded by one blow. For the construction work, its bearing capacity should be considered to be zero and the boring to a deeper part should be performed for further verification.

4) Consideration:

Soil is mostly cohesive soil with the maximum dry density of 1,700 to 1,800 kg/cm$^3$, optimum water content of 12.1 to 14.7%, coefficient of permeability of $1.2\times10^{-5}$ mm/sec in laboratory and of $2\times10^{-4}$ mm/sec in field, and the medium hardness value of standard penetration test. Stations ①, ② and ③ are on the site of route for irrigation canal and the slope protection must be considered for the filling work for the irrigation canal. N-value of the standard penetration test was low or 3.0 and thus this must be taken into account when building structures.

At the station ③, the coefficient of permeability was low or $8\times10^{-4}$ mm/sec and Regosols Layer, a soft sand layer, was recognized at a point about 1.0 km away from the station in the soil exploration so that the use of earth taken from other borrow areas or the similar means should be considered during filling works.

At the stations ④ and ⑤ on the route of drainage canal, anticipated problems will be the presence of base rock during excavation of open canal, water leak and foundation ground for structures. Base rocks found up to now are located only in the area between Santa Ana and former airport and, for the use of these rocks, the lithology test and estimation of usable amount of these rocks should be performed. At the station ⑤, the maximum dry density of 1,355 kg/m$^3$ was obtained and this was lower than those at other stations, and its optimum water content was large or 28.8%. N-value obtained in penetration test was low in lower layers. River improvement and widening plan is made for the Atinguy River in this area and thus a further soil test should be conducted in this basin in future.

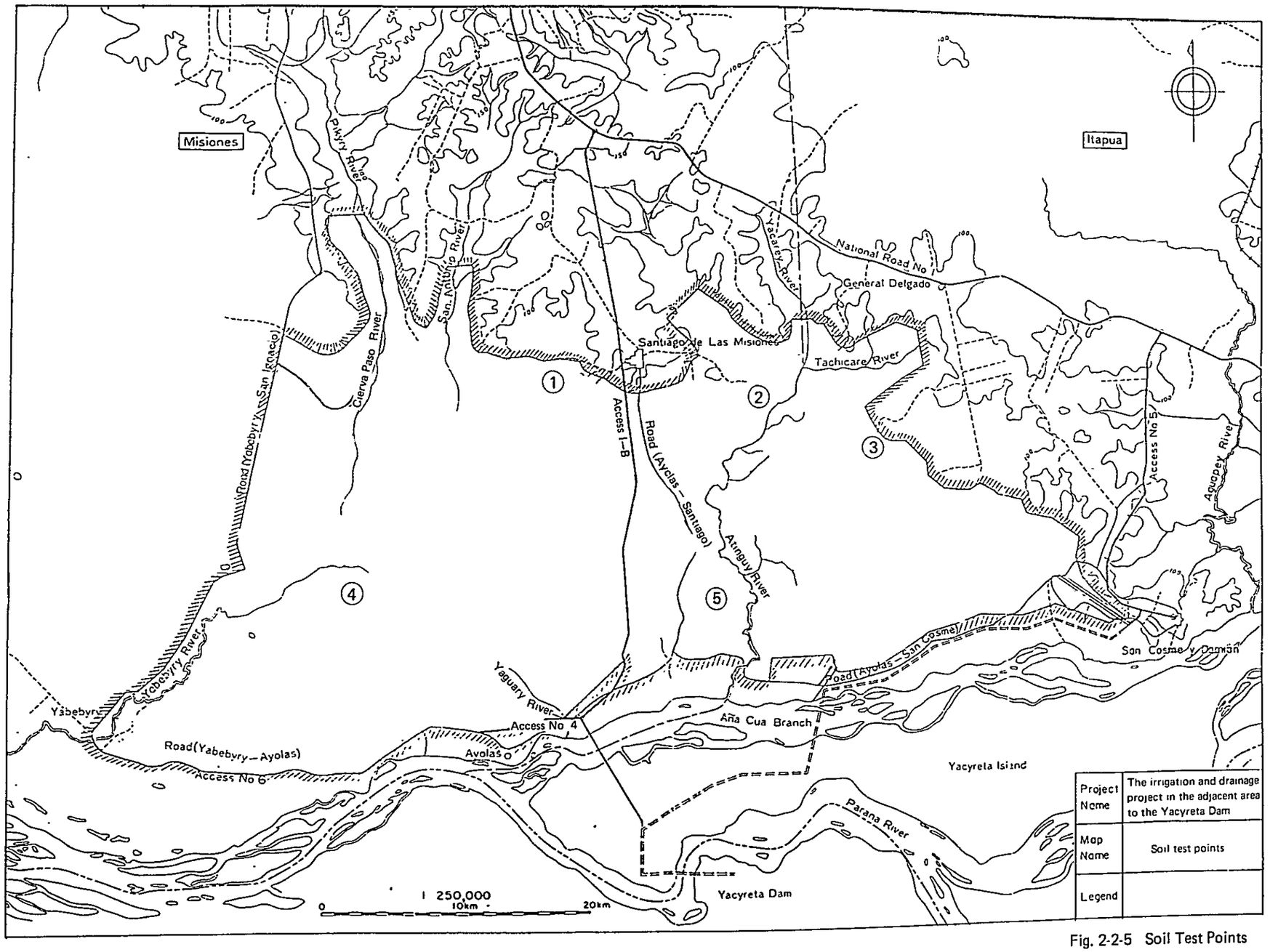



Fig. 2-2-5 Soil Test Points

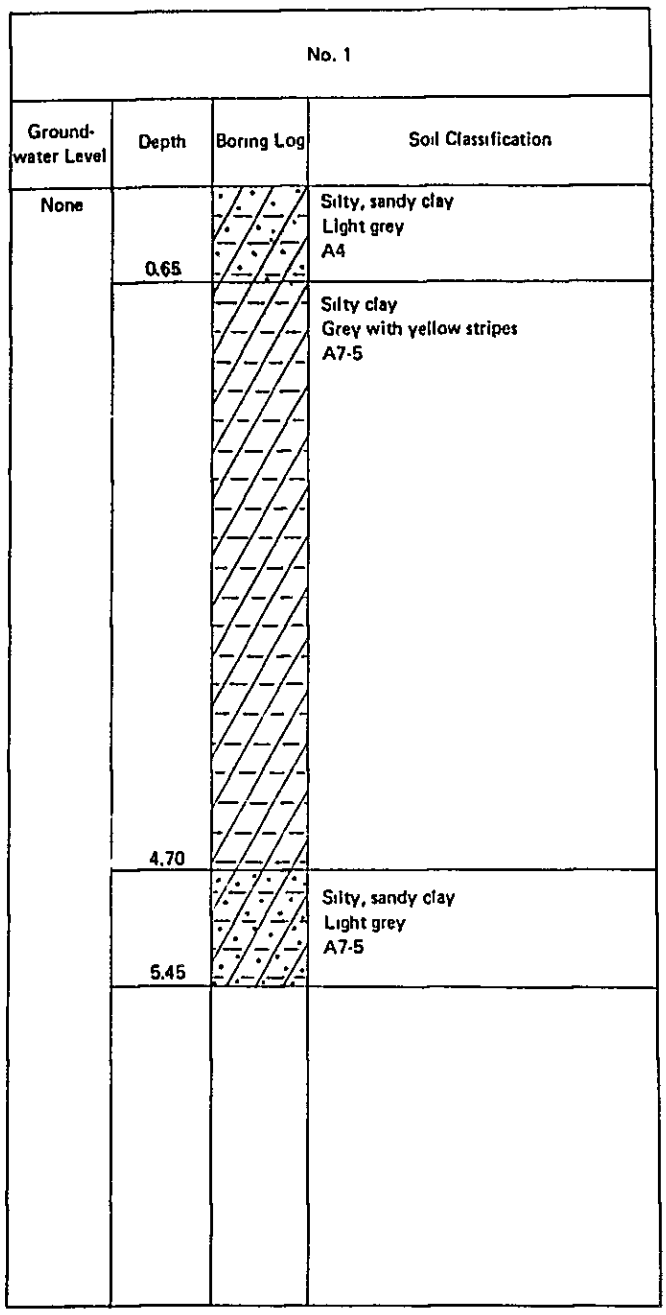



Fig. 2-2-6 Map of Soil Explanation Area

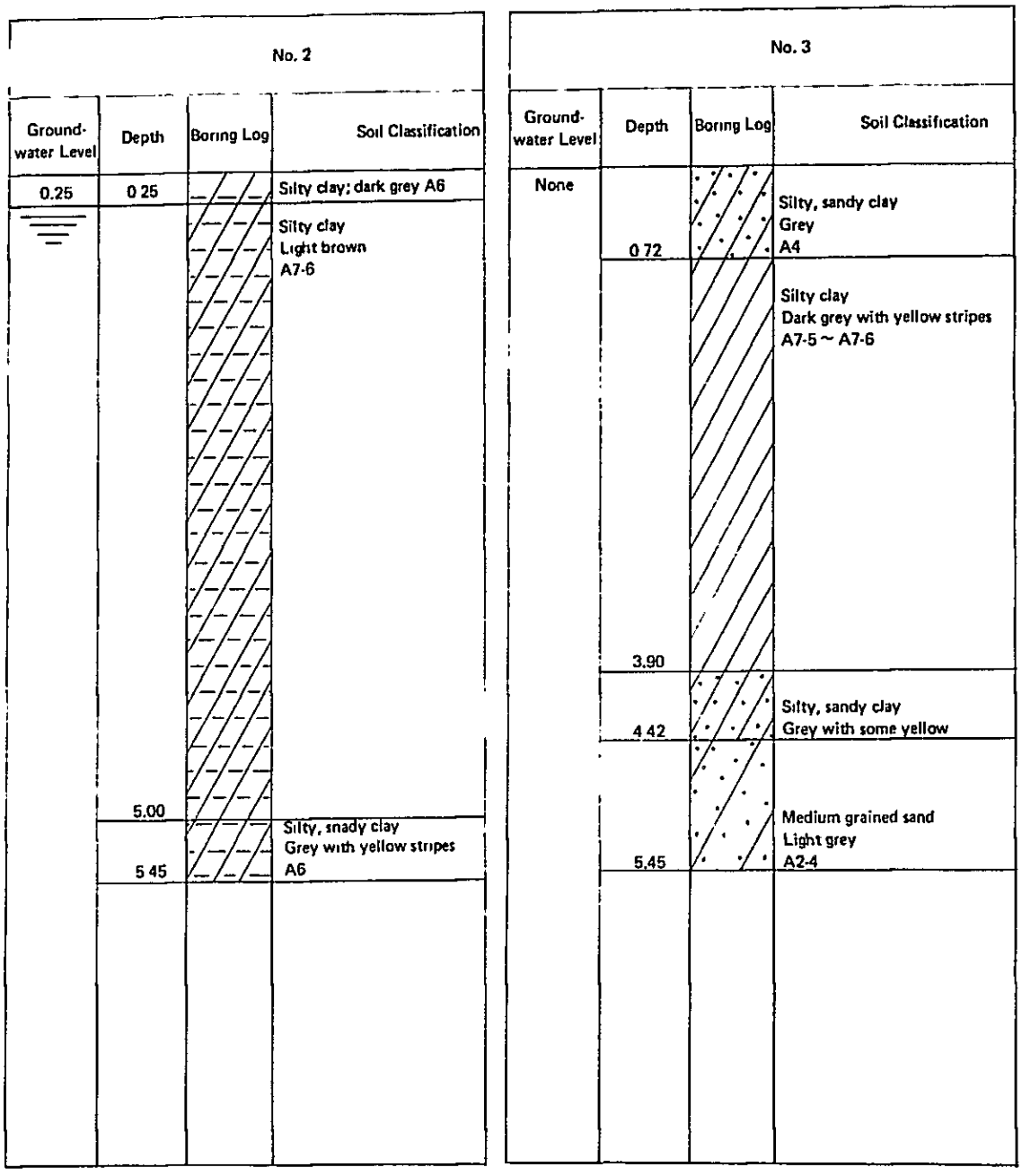



Fig. 2-2-6 Map of Soil Explanation Area (cont')

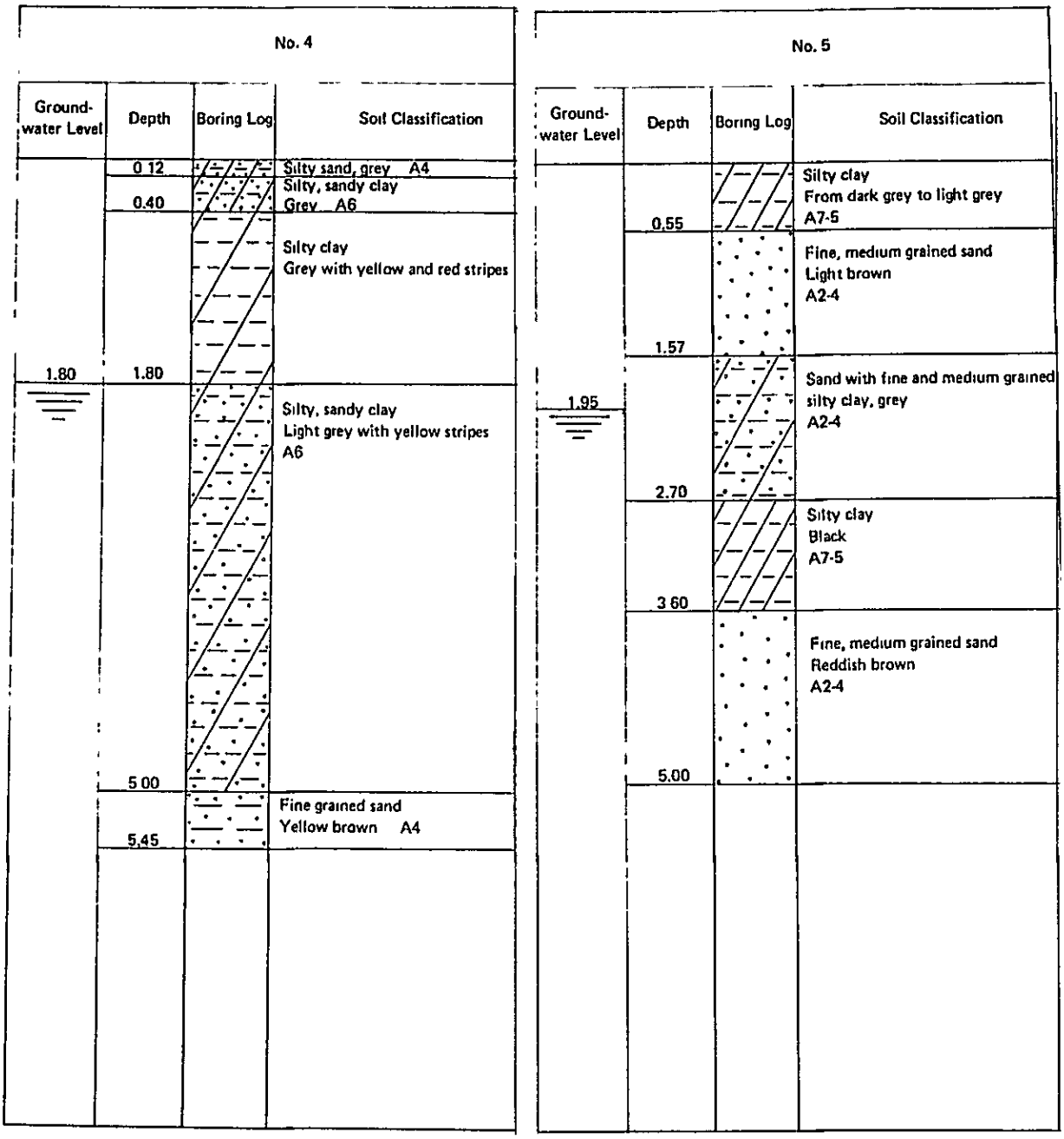



Fig. 2-2-6 Map of Soil Explanation Area (cont')

Table 2-2-2 Soils Test Result Deta

| Boring No. | Sample No. | Drilling depth (m) | Survey area | Percent finer in mechanical analysis (%) | | | Consistency | | | | Soil classification | Specific gravity | Compaction | | Permeability test (mm/sec) | | Standard penetration test, N-value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | #10 | #40 | #200 | L.L | P.L | P.I | G.I | A-classification method | | Maximum dry density (kg/m³) | Optimum moisture content (%) | Laboratory test | Field test | 1.0 m | 2.0 m | 3.0 m | 5.0 m |
| 1 | 0 | 0.00∿0.65 | Romero Cué Farm (1.5 km south-west) | 99.8 | 94.6 | 65.1 | 17.7 | 10.3 | 7.4 | 8 | A 4 | 2.47 | 1,735 | 12.9 | $1.2\times10^{5}$ | | | | | |
| | 1 | 1.00∿1.45 | | 100.0 | 96.3 | 77.9 | 46.2 | 18.7 | 27.5 | 16 | A 7-5 | 2.55 | | | | | 7 | | | |
| | 2 | 2.00∿2.45 | | 99.9 | 94.7 | 70.0 | 35.1 | 14.4 | 20.7 | 12 | A 7-6 | 2.64 | | | | | | 9 | | |
| | 3 | 3.00∿3.45 | | 99.8 | 94.3 | 90.0 | 45.6 | 16.9 | 28.7 | 17 | A 7-6 | 2.64 | | | | | | | 12 | |
| | 5 | 5.00∿5.45 | | 99.9 | 95.8 | 81.4 | 46.3 | 20.7 | 25.6 | 16 | A 7-6 | | | | | | | | | 39 |
| 2 | 0 | 0.10∿0.40 | San Juan Farm (2.0 km south) | 99.6 | 96.6 | 67.2 | 29.5 | 16.6 | 12.9 | 10 | A 6 | 2.47 | 1,705 | 14.7 | $1.8\times10^{-6}$ | $2.5\times10^{-4}$ | | | | |
| | 1 | 1.00∿1.45 | | 99.8 | 98.6 | 91.9 | 62.6 | 23.4 | 39.2 | 20 | A 7-6 | | | | | | 3 | | | |
| | 2 | 2.00∿2.45 | | 100.0 | 98.6 | 88.8 | 57.0 | 20.4 | 36.6 | 19 | A 7-6 | 2.58 | | | | | | 3 | | |
| | 3 | 3,00∿3.45 | | 99.9 | 99.0 | 93.7 | 79.3 | 21.5 | 57.8 | 20 | A 7-6 | | | | | | | | 3 | |
| | 5 | 5.00∿5.45 | | 99.9 | 98.6 | 50.6 | 36.2 | 16.0 | 20.2 | 13 | A 6 | | | | | | | | | 14 |
| 3 | 0.0 | 0.00∿0.46 | San Jorge Farm (3.5 km west) | 99.9 | 96.5 | 64.5 | 21.9 | 12.0 | 9.9 | 8 | A 4 | | 1,760 | 12.5 | $8\times10^{-4}$ | $2.1\times10^{-5}$ | | | | |
| | 0 | 0.46∿0.72 | | 99.6 | 95.6 | 62.2 | 16.6 | 8.2 | 8.4 | 8 | A 4 | 2.53 | | | | | | | | |
| | 1 | 1.00∿1.46 | | 99.9 | 97.4 | 74.1 | 39.7 | 17.3 | 22.4 | 13 | A 6 | 2.58 | | | | | 9 | | | |
| | 2 | 2.00∿2.45 | | 100.0 | 97.8 | 78.2 | 51.2 | 21.1 | 30.1 | 18 | A 7-6 | 2.70 | | | | | | 11 | | |
| | 3 | 3.00∿3.45 | | 99.9 | 97.5 | 73.3 | 47.1 | 17.4 | 29.7 | 19 | A 7-5 | 2.66 | | | | | | | 10 | |
| | 5 | 5.00∿5.45 | | 99.6 | 88.7 | 15.1 | 19.2 | 12.9 | 6.3 | 0 | A 2-4 | 2.63 | | | | | | | | 30 |
| 4 | 0 | 0.00 | Santa Ana Farm (2.5 km north-west) | 100.0 | 98.2 | 54.5 | 23.5 | 14.6 | 8.9 | 8 | A 4 | 2.62 | 1,800 | 12.1 | | $1.1\times10^{-4}$ | | | | |
| | 1 | 0.12∿0.75 | | 93.7 | 89.1 | 49.7 | 25.2 | 11.6 | 13.6 | 12 | A 6 | | | | | | | | | |
| | 2 | 1.00∿1.45 | | 99.3 | 96.6 | 70.4 | 30.9 | 17.7 | 13.2 | 10 | A 6 | | | | | | 6 | | | |
| | 3 | 1.60 | | 99.6 | 96.2 | 67.0 | 37.5 | 14.8 | 22.7 | 14 | A 6 | 2.62 | | | | | | 7 | | |
| | 4 | 2.00∿2.45 | | 99.8 | 97.1 | 57.1 | 35.6 | 12.5 | 23.1 | 3 | A 6 | | | | | | | | 10 | |
| | 5 | 3.00∿3.45 | | 99.0 | 96.9 | 69.0 | 34.8 | 14.9 | 19.9 | 12 | A 6 | | | | | | | | | 13 |
| | 6 | 5.00∿5.45 | | 98.4 | 94.1 | 44.8 | 19.5 | 12.8 | 6.7 | 8 | A 4 | | | | | | | | | |
| 5 | 0 | 0.50 | River basin of Atinguy River (30 km upstream of river mouth) | 91.0 | 85.7 | 72.0 | 51.6 | 34.5 | 17.1 | 14 | A 7-5 | 2.50 | 1,355 | 28.8 | | | | | | |
| | 1 | 0.80 | | 99.8 | 98.1 | 15.3 | NP | NP | NP | 0 | A 2-4 | | | | | | | | | |
| | 2 | 1.50 | | 100.0 | 88.2 | 27.9 | 17.6 | 11.9 | 5.7 | 0 | A 2-4 | 2.58 | | | | | 6 | | | |
| | 3 | 1.00∿1.45 | | 99.9 | 99.1 | 9.5 | NP | NP | NP | 0 | A 2-4 | | | | | | | 6 | | |
| | 4 | 2.00∿2.45 | | 100.0 | 89.6 | 25.4 | 18.6 | 13.3 | 5.3 | 0 | A 2-4 | | | | | | | | 1 | |
| | 5 | 3.00∿3.45 | | 100.0 | 96.6 | 82.3 | 46.8 | 25.0 | 21.8 | 14 | A 7-5 | 2.47 | | | | | | | | |
| | 6 | 4.00 | | 99.9 | 80.6 | 5.8 | NP | NP | NP | 0 | A 2-4 | | | | | | | | | |
| | 7 | 5.00 | | 98.6 | 50.4 | 3.5 | NP | NP | NP | 0 | A 2-4 | | | | | | | | | |

## 2.3 Soil

### 2.3.1 Preliminary maps and soil survey

It is very difficult to prepare soil map by mean of soil survey carried out on the survey area over 150,000 ha. In this year, preliminary maps, therefore were prepared regarding soil classification of the area by reflections and aerial photos from the view of Landsat. (Details are described in Appendix).

On the base of preliminary maps, representative points by each soil types were selected, and field survey was carried out, then soils classified in preliminary maps were verified.

In addition to verification of preliminary map, field soil survey and sample collection mentioned later were carried out in the field survey, and physical and chemical analysis of the collected samples were ask to Agricultural research center (CRIA) and Soil Course, department of agriculture, Asuncion University, then on the base the results relation between soil and crop cultivation is examined.

### 2.3.2 Classification and distribution of soils

Classification and distribution of soils in preliminary map are shown in Fig. 2-3-1. Soil was divided roughly by FAO/UNESCO classification standard,further divided in detail by difference of organic matter and soil texture of surface soil, then classified into total 18 types. The soil properties by types and the results of survey on soil profile are as follows.

(1) Coarse textured Regosols

This soil distributes over natural levee and back swamp of Parana river, Atinguy river, Yabebyry river, particularly micro relief more than the surrounding area. This composing material, different from fine textured Regosols, is sandy deposit carried by flooding of Parana River. For vegetation, many forests are found here and there. It is because that micro relief drains better than the surrounding area. In addition, this soil is used for natural grassland and upland field.

For soil profile, thin layer 0∿5 cm containing humus is found, and definite specialization for stratigraph is not found. For sandy soil of low viscosity containing many coarse sand, the surface soil is yellowish brown and the compactness is rather high as scale of hardness shown 15 mm.

Layers under 30 cm is yellowish orange color, and hardness is lower than surface soil under moderate wet condition. Humus content is about half of surface soil.

(2) Fine textured Regosols

This soil distributing over gentle and steep slope area of hill land of northern survey area is different from coarse textured Regosols, and it is formed out of breakdown soil carried from the northern hill land as the basic material. For grain size accumulation, this soil is finer than coarse textured Regosols and has high water holding capacity. The vegetation is mostly natural grassland, upland field and forest.

According to results of survey on soil profile, layer accumulated by humus is about 10 cm rather thicker than coarse textured Regosols. Definite specialization of stratigraph is not found, however, mottle is found under 50 cm. Soil color is brown 7.5 YR 4/3, and soil compactness is high as 24 mm between 0 and 30 cm below ground level, 21 cm under 30 cm and viscosity is getting higher as layer is lower. Groundwater level is rather high, about 1 m below ground level.

(3) Coarse textured Gleysols

This soil distributes over fen surrounding micro relief near Parana river among fens in survey area, lowland in natural levee, abandoned river channel etc. It exists adjacent to coarse textured Regosols, and the ground water level is constantly around ground surface or this soil area is often under flooding condition. This might be originally sandy soil, however, it is supposed that incompletely resolves organic matters remain and cover ground surface as ground water level is high, then impermeable layer is being formed out of secondary accumulation of clay carried from the adjacent highland.

According to results of survey on soil profile, specialization into surface soil and subsoil is in progress, surface soil is glayish brown color and subsoil is dark brown color. For soil texture, surface, soil is sandy loam and subsoil is sandy clay loam. Mottle is found in subsoil 50 cm below ground level, and it is definite gley mottle. As ground water level is high, wetting rate increases and hardness decreases in lower horizon.

Surface soil contains humus more than subsoil, and plant root longer than 50 cm was discovered.

Vegetation in this soil is mostly marshy native pasture.

(4) Fine textures gleysols

This soil distributes over valley bottom plain and the following gentle slopped fan plain of earth accumulation. Parent material is breakdown soil carried from hill land like fine textured Gelysols, and finer than coarse textured Gleysoil. Ground water level is generally high and there is no flooded area. For vegetation in this soil area, most part is used for grassland and partly for paddy field.

In this soil, gley layer appears within 50 cm deep compared with coarse textured gleysols, and exists under reduced condition. For soil color, surface soil is grayish brown and subsoil is brown. The soil viscosity is higher than other soils, and the subsoil has high viscosity. The soil is rather soft as hardness of all layers is within 20 mm, it is supposed because the soil is under wetting and soil texture is sandy clay loam.

(5) Planosols

This soil distributes mainly over the northeastern survey area, and it is typical soil in back fen from topographycal viewpoint. Specialization of the stratigraph is advanced more than Regosols, and B horizon shows high compactness and forms impermeable layer because of aquatic resultant. Namely it forms pan and is used for paddy field as viscosity and water holding capacity of the soil are high. Second layer of surface soil (A2 layer) is found to be dissolved white color as this pan is aquatic resultant.

According to results of field survey on soil profile, humus layer is thin, the soil texture of the following surface soil is loam and the subsoil is humus, and they are generally high viscosity soil. For mottle, gley mottle is found in the subsoil here and there. Both surface soil and subsoil show high compactness, more than 20 mm. Particularly, the surface soil shows more than 30 mm in certain places. Difference of humus content between the surface soil and subsoil is large, it is supposed because of feature of Planosols.

(6) Humic Planosols

This soils distributes over vast central back fen. Large part of this area is flooded and few micro relief is found. Resolution of organic matters is not advanced and humus layer is accumulated because of flooding and high ground water level.

For soil texture, this soil is rather sandier than Planosols, and it is shows aquatic resultant as impermeable layer is being formed although pan is not perfectly formed. For soil color, the surface soil is dark brown and the subsoil is yellowish brown. Mottle and formation of gleysols are found in the subsoil. Viscosity of the soil is lower than Planosols because of sandy soil, and the hardness is extremely low such as 12 mm for subsoil and 22 mm for surface soil because of influence of grand water.

(7) Acrysols

This is a light reddish yellow colored residual soil spreading on strong weathered layer of sandystone and basalt which are distributing over the northern hill land of survey area. For vegetation and land use of the soil, original forest is used for upland field and grassland here and there.

For soil, movement and accumulation of clay from surface soil to B layer by podzolization are found, therefore, it shown high viscosity and high water holding capacity. Both surface soil and subsoil are reddish brown color and show rather high hardness, over 20 cm.

(8) Fluvisols

This soil distributes over river side of Parana River, and development of stratigraph is not found because it is subject to erosion and sedimentary action by flooding.

This soil is disregarded in this consideration because it does not distribute over this survey area.

2.3.3 Soil survey

To survey soil profile and collect soil sample, last year testing pit (trial pit) survey was carried out at 22 points in the area. This year, testing pit (trial pit) survey was carried out at 38 points representing the soil (Fig. 2-3-2) including 22 points selected last year to verify soil


Fig. 2-3-1 Soil Map

classification map prepared by above mentioned preliminary survey. Moreover, to examine distribution range, of soil, trial boring survey was carried out and the distribution range was confirmed. For testing pit survey, it was carried out by 1 m deep and samples by each layers were collected. For trial boring survey, soil was confirmed by 50 cm deep by boring stick.

As 3 same type samples are omitted in the collected 60 soil samples including last year's soil samples, soil physical and chemical analysis on 57 samples were carried out.

2.3.4 Soil analysis

Physical and chemical characters of soil analyzed are shown in Appendix.

The characters are classified by soil types and physical and chemical features of soil are shown in Table 2-3-1.

Soil analysis is performed by the following items and relation between the features and planted crops is described as follows.

(1) pH ($H_2O$)

This figure showing nature of soil, such as acidity, neutrality (7.0) and alkali, vitally affects characters and action of matters contained in the soil, and influence action of soil bacteria and growth of plant. Generally neutrality or nearly neutrality soil is suitable for growth of plant.

(2) Degree of electrical conductivity

This degree is measured to know salinity in soil solution. Plant growth hindrance by over-saline is mainly caused by absorption interference of nourishment water of plant roots by increase of ordinary soil osmotic pressure, except by specific harmful content.

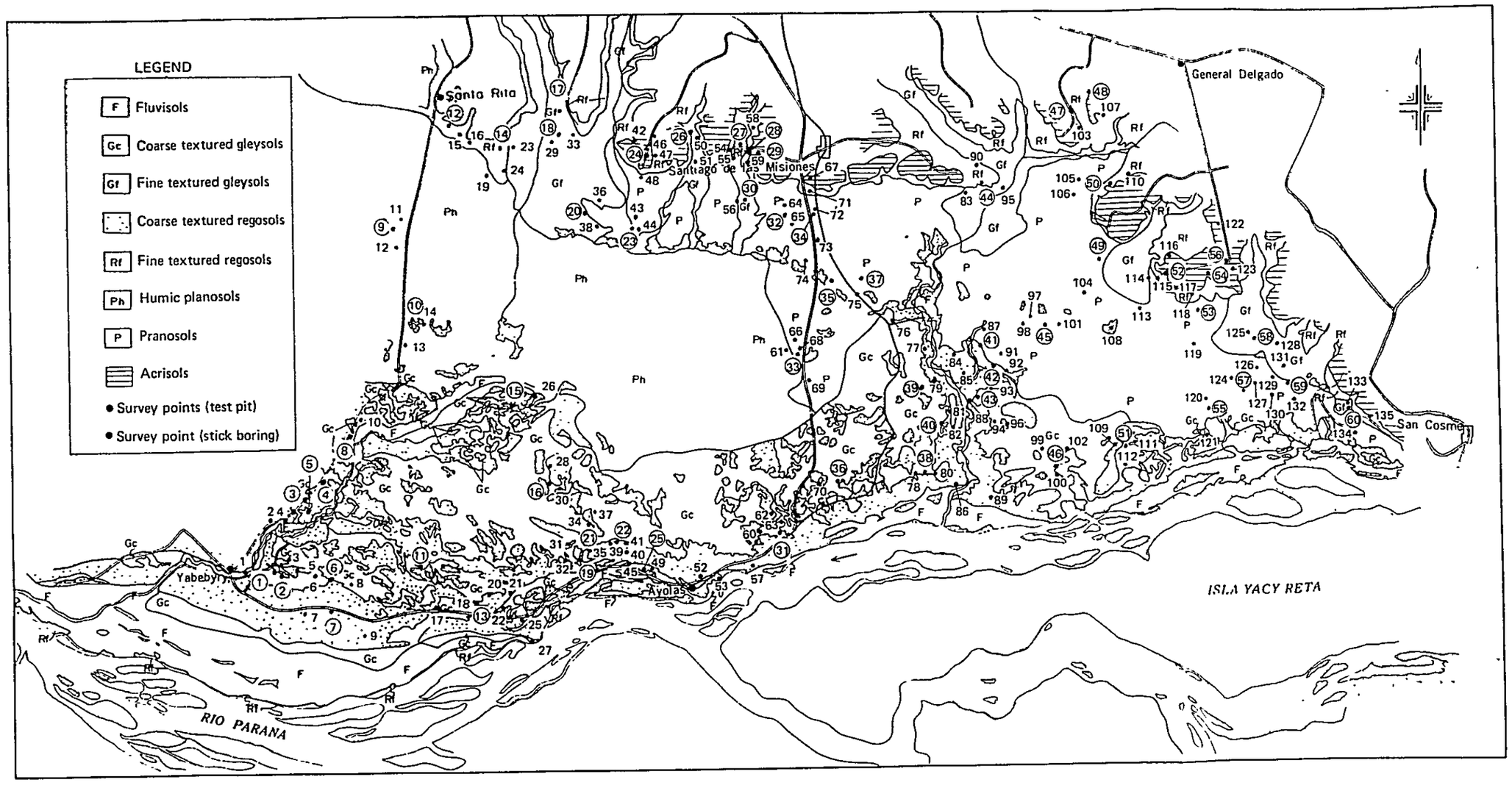



Fig. 2-3-2 Soil Survey Point Map

(3) Exchangeable base

This indicates base capacity existing in soil. Particularly nitrogen,phosphorus, potassium and calcium often run off in soil, and these 4 elements should exist in good balance for rich soil. Exchangeable base of soil should be examined together with acid degree. As these cations are dissociating to some extent and tend to change to other cations, they are termed exchangeable base.

(4) Cation exchange capacity

Maximum cation rate which soil is able to exchange is termed cation exchange capacity. Soil with large cation exchange capacity can absorb and hold more fertilizer ingredient. Soil shows more acid according as exchange capacity is occupied by more hydrogen ions, and more alkaline according as by more cations.

(5) Degree of base saturation

This indicate percentage of cation exchange capacity occupied by cation in soil. Soil becomes acidity according as usually degree of base saturation is lower, on the contrary soil becomes alkali according as it come nearer 100%.

(6) Coefficient of phosphatic absorption

This indicates amount of phosphatic acid absorbed by soil in mg, in case phosphate is contained in soil 100g. Soil with large coefficient of phosphatic absorption shows large phosphatic absorption, and more phosphatic fertilizer is required for plant cropping.

(7) Exchangeable Aluminium

Aluminium is held on the surface of soil particles as exchangeable condition, and degree of base saturation and pH both are usually low in case where exchangeable aluminium content in soil is large. Therefore, large exchangeable aluminium content often causes acid disturbing, and it is improved by application of lime. In case where pH is 6.0 or more, exchangeable Aluminium becomes unexchangeable because it is absorbed into soil.

## Table 2-3-1 Characteristic of Soil Classification

| | | Soil color | Mottle | Iron | Moisture | Viscosity | Compactness | Humus (%) | pH (H2O) | pH (KCl) | Degree of electrical conductivity (mmho/cm) | ex. Ca (me/100g) | ex. Mg (me/100g) | ex. K (me/100g) | ex. Na (me/100g) | Al (me/100g) | CEC (me/100g) | Degree of base saturation (%) | Coefficient of phosphoric acid absorption | Effective phosphorus | Effective phosphorus L (%) | Effective phosphorus Si (%) | Effective phosphorus Si (%) | (Name of) soil texture Japan | (Name of) soil texture USDA | Apparent specific gravity (g/cc) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Fertility Type | Surface soil | 10YR 6/3 | | - | Dry | Weak | L | 0.29 | 5.1 | 4.0 | 0.07 | 2.0 (72.9) | 0.81 (16.3) | 0.06 (2.8) | 0.1 (3.1) | 0.8 | 5.6 | 64 | | 3 | 18.0 | 16.4 | 65.6 | SCL | SL | 1.51 | |
| | Subsoil | " | 6/4 | - | - | Half wet (over 1m) | Weak | L | 0.29 | 5.1 | 4.0 | 0.7 | 2.0 (72.9) | 0.81 (16.3) | 0.06 (2.8) | 0.1 (3.1) | 0.8 | 5.6 | 64 | | 3 | 18.0 | 16.4 | 65.6 | SCL | SL | 1.51 | |
| Fine textured Regosols | Surface soil | 7.5YR 4/3 | - | - | Half wet | Medium | 24 | 0.61 | 4.9 | 3.8 | 0.0 | 2.5 (90.1) | 0.75 (15.1) | 0.06 (2.8) | 0.0 (0.0) | 0.8 | 22.7 | 15 | 585 | 1 | 24.5 | 29.9 | 45.6 | CL | L | 1.43 | Soil profile 3, analysis 3 |
| | Subsoil | " | " | Faint | - | Wet (about 1m) | Medium | 21 | 0.42 | 5.6 | 4.1 | 0.04 | 2.8 (78.5) | 0.96 (19.4) | 0.04 (1.9) | 1.2 (37.2) | 1.7 | 16.3 | 31 | | 1 | 34.3 | 21.0 | 44.7 | LiC | CL | | |
| Coarse textured Gleysols | Surface soil | 7.5YR 4/2 | - | - | Half wet | Weak | 21 | 0.67 | 4.7 | 3.6 | 0.0 | 2.6 (72.9) | 0.82 (16.5) | 0.06 (2.8) | 0.0 (0.0) | 1.4 | 7.4 | 47 | 650 | 2 | 17.9 | 23.6 | 58.5 | CL | SC | 1.34 | Soil profile 12, analysis 12 |
| | Subsoil | " | 5/3 | Faint | C | Very wet (within 1m) | Weak | 18 | 0.38 | 4.8 | 3.6 | 0.0 | 2.7 (75.7) | 0.86 (17.3) | 0.06 (2.8) | 0.0 (0.0) | 2.1 | 9.9 | 37 | | 1 | 22.2 | 20.7 | 57.0 | CL | SCL | | |
| Fine textured Gleysols | Surface soil | 7.5YR 4/2 | - | - | Wet | Medium | 19 | 0.98 | 4.7 | 3.5 | 0.0 | 2.8 (78.5) | 0.80 (16.1) | 0.09 (4.2) | 0.0 (0.0) | 1.5 | 15.0 | 23 | 325 | 3 | 25.9 | 26.9 | 47.2 | LiC | SCL | 0.99 | Soil profile 12, analysis 12 |
| | Subsoil | 10YR 5/2 | Contained | C | Very wet (within 1m) | Strong | 18 | 0.50 | 4.7 | 3.3 | 0.0 | 2.9 (81.3) | 0.90 (18.1) | 0.06 (2.8) | 0.0 (0.0) | 3.4 | 14.8 | 26 | | 1 | 36.5 | 23.2 | 40.3 | LiC | CL | | |
| Planosols | Surface soil | 7.5YR 4/2 | - | - | Half wet | Medium | 24 | 0.73 | 4.7 | 3.6 | 0.05 | 2.7 (75.7) | 0.84 (16.9) | 0.08 (3.8) | 0.05 (1.4) | 1.6 | 12.2 | 30 | 640 | 2 | 23.1 | 28.0 | 48.9 | CL | L | 1.38 1.71 | Soil profile 15, analysis 15 |
| | Subsoil | " | 5/2 | Contained | C | Wet (about 1m) | Medium | 22 | 0.33 | 4.8 | 3.5 | 0.01 | 2.8 (78.5) | 0.88 (17.7) | 0.05 (2.4) | 0.07 (2.2) | 3.4 | 11.9 | 32 | | 1 | 31.9 | 20.2 | 47.9 | LiC | SCL | | |
| Humic Planosols | Surface soil | 7.5YR 3/1 | - | - | Wet | Weak | 22 | 1.08 | 5.0 | 3.7 | 0.0 | 2.8 (78.5) | 0.83 (16.7) | 0.07 (3.3) | 0.0 (0.0) | 0.8 | 13.3 | 26 | 630 | 3 | 21.1 | 23.5 | 55.4 | CL | SCL | 1.40 | Soil profile 2, analysis 2 |
| | Subsoil | 10YR 4/3 | Faint | C | Very wet (about 50cm) | Weak | 12 | 0.21 | 5.7 | 4.2 | 0.3 | 2.8 (78.5) | 0.84 (16.9) | 0.04 (1.9) | 0.5 (15.5) | 0.3 | 10.1 | 41 | | 2 | 31.1 | 11.9 | 57.0 | SC | SCL | | |
| Acrysols | Surface soil | 5YR 4/4 | - | - | Half wet | Medium | 22 | 0.86 | 5.2 | 4.1 | 0.01 | 2.7 (75.7) | 0.84 (16.9) | 0.13 (6.1) | 0.02 (0.6 | 0.4 | 10.4 | 35 | 540 | 1 | 29.2 | 27.3 | 43.5 | LiC | CL | 1.66 | Soil profile 4, analysis 4 |
| | Subsoil | 2.5YR 5/8 | - | - | Half wet (over 1m) | Strong | 20 | 0.49 | 5.3 | 4.1 | 0.0 | 2.9 (81.3) | 0.95 (19.2) | 0.12 (5.7 | 0.1 (3.1 | 0.7 | 10.6 | 38 | | 1 | 36.7 | 22.9 | 40.4 | LiC | CL | | |
| Fluvisols | Surface soil | 10YR 7/3 | - | - | Half wet | Non | Very low | None | | | | | | | | | | | | | | | | | SL | | Test pit 3 |
| | Subsoil | " | " | - | - | Wet | " | " | " | | | | | | | | | | | | | | | | SL | | |

Notes: 1. Surface soil 0 ~ 30 cm, subsoil 30 ~ 100 cm 2. Low column of exchangeable base is indicated in oxide mg/100g.

## Table 2-3-2 Area by Soil Classification

| | Coarse textured Regosols | Fine textured Regosols | Coarse textured Gleysols | Fine textured Gleysols | Planosols | Humic Planosols | Acrysols | Fluvisols | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ha) | 21,650 | 7,450 | 31,725 | 15,975 | 38,500 | 32,875 | 1,325 | 2,975 | 152,475 |
| % | 14.2% | 4.9 | 20.8 | 10.5 | 25.3 | 21.6 | 0.9 | 2.0 | 100.0 |

Note: Fluvisols distributes over river land of Atinguy river and Yabebry river in survey area.

### 2.3.5 Physical and chemical properties of soil

According to results of soil analysis, physical and chemical properties by soil types are as follows.

(1) Coarse textured Regosols

For pH, surface soil and subsoil both show weak acidity as 5.1. For exchangeable base, a little calcium, kalium and natrium, and large magnesium are contained. This tendency is shown in not only coarse textured Regosols, but also soil all over this survey area. As coefficient of phosphatic absorption is small as 125 and available phosphatic is a little, it is required to apply phosphatic acid in crop cultivation.

(2) Fine textured Regosols

Difference of pH between subsoil and surface soil is extremely large as 4.9 for surface soil and 5.6 for subsoil. Both soils show acidity. There are 2 cases why soils show acidity, one existance of exchangeable Aluminium and another that exchangeable base is leached by much rain. Soil is considerably acidities by rain as this survey area is a high rain area as annual average rainfall 1,600 mm and pH of surface soil is lower than subsoil.

Compared with other soils, more exchangeable base exists in subsoil. And this soil show the largest cation exchange capacity in this survey area as 22.7 me/100 g for surface soil and 16.3 me/100 g, and large fertilizer holding capacity. As coefficient of phosphatic absorption is 585, fertilization effect of phosphatic acid is high. However, it is required to apply phosphatic acid in crop cultivation as content of available phosphatic acid is small.

(3) Coarse textured Gleysols

This soil shows low acidity over all layers as pH is 4.7 for surface soil and 4.8 for subsoil, and it is a gleyzied soil which leached by vertical motion of groundwater and rainfall. Exchangeable base shows tendency same to other soil types, but magnesium content is a little larger than others. For cation exchange capacity, subsoil shows larger capacity than surface soil, and this soil has effective fertilizer holding capacity for cultivation of crop with wide root area.

As degree of base saturation is 47% for surface soil and 37% for subsoil, this soil is nutritious compared with other aligotrophic soils. Coefficient of phosphatic absorption is 650, and application effect of phosphoric acid can be expected.

(4) Fine textured Gleysols

For property of gleysols in this survey area, acidity is weak like coarse textured gleysols. It is supposed that acidification by rainfall and vertical motion of ground water is caused by reasons same to coarse textured Gleysols and accumulation of humus is a one the causes of acidification.

For exchangeable base, this soil shows similar tendency to other soils, however, it has large enough fertilizer holding capacity among soils in this survey area. Coefficient of phosphatic absorption is 325, and application effect of fertilizer is large. However, application of phosphatic acid is favorable, as available phosphatic acid content is small.

(5) Planosols

For pH, this soil shows strong acidity as 4.7 ∿ 4.8. For exchangeable base, this is abundant in magnesium like other soils, and short in calcium, natrium and kalium. It is supposed that this soil has rather large fertilizer capacity as cation exchange capacity is about 12 me/100 g, standard capacity in this survey area, and degree of base saturation is about 30%. Coefficient of phosphatic absorption is small as 640.

(6) Humic planosols

Considerable difference of physical and chemical properties between this soil and planosols is not observed. However, humus content in the surface soil and planosols is not observed. However, humus content in the surface soil is extremely large and soil texture is sandy humus and viscous soil.

(7) Acrysols

This soil shows weak acidity as 5.2 ∿ 5.3 for pH, and it is short a little in calcium among exchangeable bases, however, suitable for almost all crops cultivation because of cation exchange capacity (10.5 me/100g), degree of base saturation (about 37%) and coefficient of phosphatic absorption (540).

2.3.6 Soil improvement

Soil improvement is to improve original physical and chemical properties and microbial properties of the soil to fertilize the soil and to raise productivity of crops. Usually, typical physical and chemical properties requiring soil improvement are acidity and degree of phosphatic absorption of soil. Moreover application of organic fertilizer, green manuer cultivation etc. are performed to improve physical properties of the soil.

Short of phosphatic acid in soil considerably affect growth of crops, and phosphatic absorption capacity varies with types of soil. Therefore, phosphatic fertilizer is few used for crops in the form of available phosphatic acid although it is applied much, in case where the soil shows large phosphatic absorption capacity. Generally, in case where coefficient of phosphatic acid is over 1,000, soil improvement is needed as it is said that more application of phosphatic acid is required for farming stage. As coefficient of phosphatic absorption is under 700 in this survey area and fertilization effect of phosphatic acid is enoughly expected, and special soil improvement is not required.

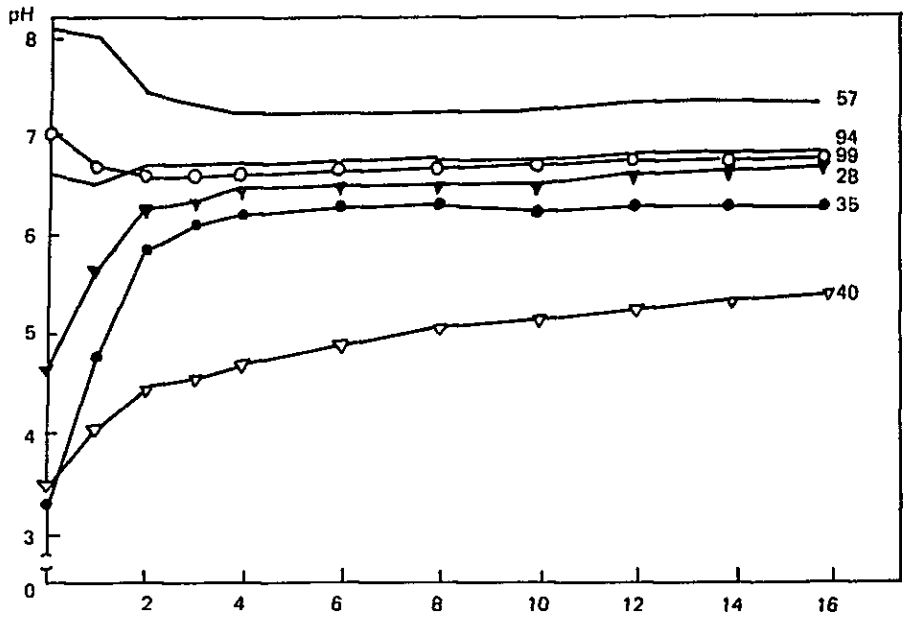
Green manuer cultivation is described as below for acid improvement and physical improvement.

(1) As pH of soil is one of the important properties of soil, chemical conditions and solubility of soil and physiology of plant root and micro organism vary with acidity of soil.

For example, phosphatic acid which is vital nourishment for plant becomes the form of phosphatic Aluminium in acid condition, and the solubility is extremely small. However, it becomes the form of phosphatic calcium in neutral condition and alkaline condition, and the solubility is large.

Moreover, as growth and acts of micro-organism are often restricted under acid condition, functions such as organic dissolution, nitrogen fixation etc. deteriorates.

As mentioned above, in case where usually acidity of soil is low (pH is small), growth of crop is often hindered. On the base of test data and experiments, optimum pH and allowable range of pH for crop cultivation by crops are determined (Table 2-3-3). According to these,




| *Soil No* | *Texture* | *pH* | *O.M. %* | *Fe %* | *Mn %* |
|---|---|---|---|---|---|
| 28 | Clay | 4.9 | 2.9 | 4.70 | 0 08 |
| 35 | Clay | 3 4 | 6 6 | 2 60 | 0.01 |
| 40 | Clay | 3.8 | 7.2 | 0.08 | 0.00 |
| 57 | Clay loam | 8 7 | 2.2 | 0 63 | 0 07 |
| 94 | Clay | 6 7 | 2 6 | 0 96 | 0.09 |
| 99 | Clay loam | 7 7 | 4 8 | 1.55 | 0.08 |

Source F N Ponnauperuma
Physicochemical Properties of Submerged Soil
Food and Fertilizer Technology Center, ASPAC
Taypei

Fig. 2-3-3 Kinetics of the Solution pH of Six Submerged Soils

Table 2-3-3 Allowable to Optimum Ranges of pH by Crop

| Name | pH | |
|---|---|---|
| | Allowable range | Optimum range |
| Watermelon | ② 5.0 ∿ 6.8<br>③ 5.0 ∿ 7.0 | |
| Pumpkin | | |
| Strawberry | | |
| Pepper | 6.0 ∿ 6.5 | ③ 6.0 ∿ 6.5 |
| Cucumber | ② 5.7 ∿ 7.2 | |
| Tomato | ① 5.2 ∿ 6.7 | ① Acidic close to neutral<br>② 6.2 ∿ 7.2 |
| Eggplant | ① Except strong acid of alkaline | ③ Slight acidic to neutral |
| Melons | ② 6.0 ∿ 6.8 | |
| Sweet corn | ③ 5.5 ∿ 8.0 | |
| Cabbage | ② 5.5 | Slight acidic to neutral |
| Chinese cabbage | ② Slight acidic or alkaline | |
| Tsukena | | |
| Seri | | |
| Onion | ③ 6.3 ∿ 7.8 | |
| Sweet potato | ① 6.1 ∿ 7.7 | ② Neutral to slightly acidic |
| Irish potato | ② 4.5 ∿ 7.0<br>① 5.0 ∿ 5.3 | ② 5.0 ∿ 6.0 |
| Japanese radish | Relatively strong against acidity | ② 5.8 ∿ 6.8 |
| Desheen | ③ 4.0 ∿ 9.1<br>② 4.1 ∿ 9.1 | |

| Name | pH | |
|---|---|---|
| | Allowable range | Optimum range |
| Fig | | ⑤ 7.2 ∿ 7.6 |
| Pears | | ⑤ 5.0 ∿ 7.4<br>④ About 5.0 |

Table 2-3-3 Allowable to Optimum Ranges of pH by Crop (Cont')

| Name | pH | |
|---|---|---|
| | Allowable range | Optimum range |
| Carrot | ① 5.3 ~ 7.0 | ② 6.0 ∿ 6.6 |
| Chinese yam | ② 5.3 ∿ | |
| Turnip | ③ 5.2 ∿ 6.8 | ③ 7.4 ∿ 7.6<br>② 5.2 ∿ 6.8 |
| Ginger | | |
| Edible lily | ② 5.0 ∿ 6.3 | ② 5.7 ∿ 6.3 |
| Hanegi | ③ 6.8 ∿ 7.2<br>② 5.7 ∿ 7.4 | ① 5.8 ∿ 7.4 |
| Chibou | | |
| Chinese chive | ② Abhoring acidic soil | |
| Garlic | | ② 5.5 ∿ 6.0 |
| Hop | | ① 7.0 ∿ 7.8 |
| Wheat | | ① 6.0 ∿ 7.0 |
| Soybean | ① 4.0 ∿ 7.0 | ① 6.0 ∿ 6.5 |
| Small beans | ① Weak to acidity | |
| Italian ryegrass | ⑥ 6.0 ∿ 6.5 | |
| Sorghum | ⑥ 6.0 ∿ 6.5 | |
| Dentocorn | ① Acidic - alkaline<br>⑥ 5.5 ∿ 6.0<br>① 5.0 ∿ 8.0 | |
| Tree paeony | | |
| Chinese paeony | | |
| Lily | | |
| Tulip | | |
| Chrysanthemum | | |
| Pea | ② Neutral or slightly alkaline<br>6.1 ∿ | |
| Broad | | |
| Snap bean | ③ 4.9 ∿<br>① 5.3 ∿ 6.3 | ③ 5.3 6.3 |
| Grapes | | ⑤ Muscat 7.3 ∿ 7.7<br>⑤ Delauare 5.0 ∿ 7.5 |

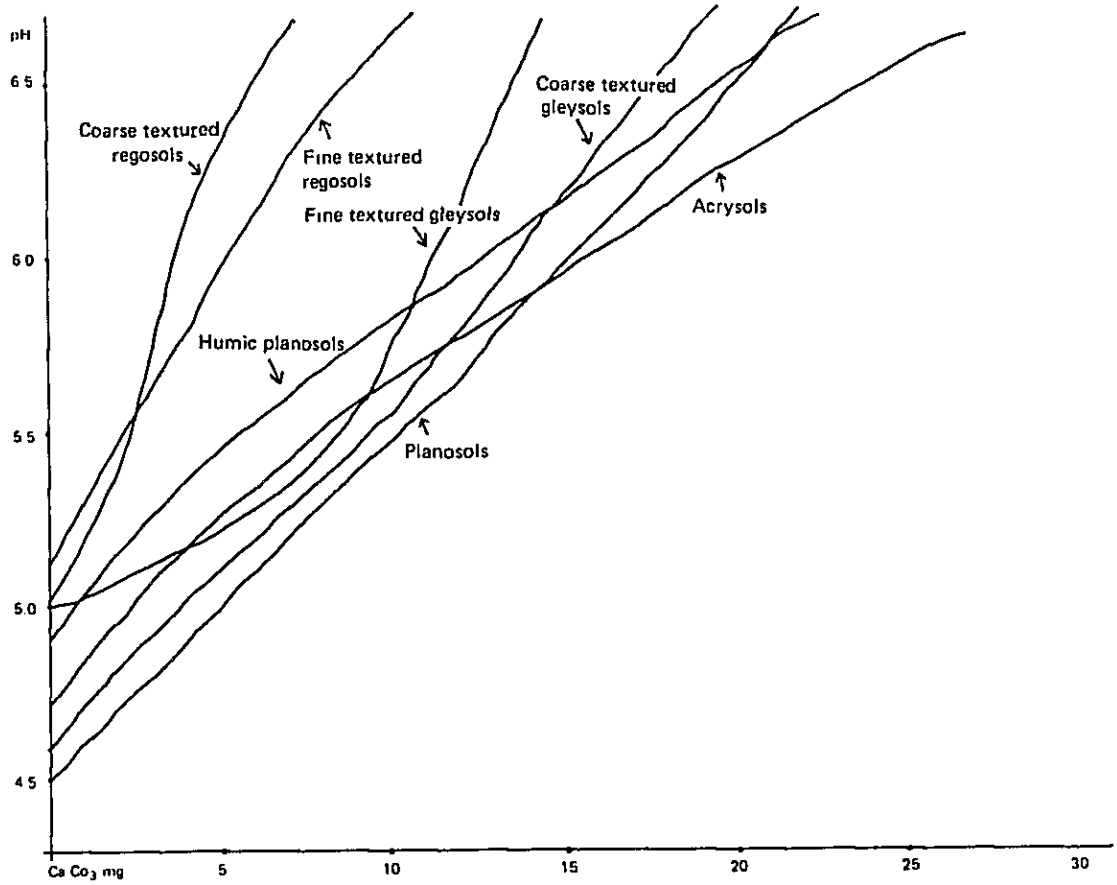



Fig. 2-3-4 Buffer Curve

Acidic Improvement Table

| | Present condition pH | Apparent specific gravity g/cc | Application amount (t/ha) | | |
|---|---|---|---|---|---|
| | | | pH 5.5 | pH 6.0 | pH 6.5 |
| Coarse-textured regosols | 5.0 | 1.46 | 0.6 | 1.0 | 1.4 |
| Fine-textured regosols | 5.1 | 1.41 | 0.4 | 1.2 | 1.7 |
| Coarse-textured gleysols | 4.6 | 1.41 | 1.9 | 2.9 | 3.9 |
| Fine-textured gleysols | 5.0 | 0.99 | 1.3 | 1.9 | 2.2 |
| Planosols | 4.5 | 1.41 | 2.3 | 3.6 | 5.0 |
| Humic planosols | 4.9 | 1.40 | 1.5 | 3.0 | 4.8 |
| Acrysols | 4.7 | 1.66 | 2.0 | 4.1 | 6.6 |

Amount of calcium carbonate required to improve soil pH to pH 6.0 and pH 6.5 at 15 cm deep is calculated by this buffer curve, which is shown in Table 2-3-4.

According to this table, regosols which is relatively sandy soil needs a little calcium carbonate to reach target pH, which acrysols which is viscous soil needs much calcium carbonate. Gleysols and planosols show in-between property. To reach target pH 6.0, calcium carbonate from 1.0 t/ha for coarse textured regosols to 4.1 t/ha for acrysols is required, however, crops which are relatively resistant to acidity shall be cultivated in acrysols and planosols to reduce required application amount.

(2) Green manure cultivation

This survey area has much annual rainfall, about 1,600 mm, and the rainfall intensity. Therefore, for soil conservation, in upland field, application of organic fertilizer and green manure cultivation are performed, and physical property of soil is improved, then it is expected to raise soil fertility.

Organic fertilizer, particularly compost is preferably applied. However, green manure cultivation shall be introduced, because the area is too large and compost production is difficult as livestock farming is performed by mainly grazing.

As large carbonic rate matters among green manuer componets particularly coarse fiber, lignin, etc. are kept in soil for long time, they should be first introduced for hot places like this area. For this purpose, Gramineae (Gramineous) green oats, green rye are preferable. Moreover, leguminous plants such as green soybean, lupin, white Dutch clover, alfalfa, etc. show high fertilization effect as they fix the nitrogen of the air, and therefore they are preferably introduced.

as soil over pH 6.0 is included in allowable range of pH for almost all crops cultivation except certain crops, they can be cultivated. Moreover, soil pH 6.0 is in the optimum range of pH for soybean and wheat which will be introduced in this survey area as key crop, therefore target of acid improvement of soil is determined to be pH 6.0.

Paddy rice, however, is resistant to acidity and the soil has been neutralized by inundation except sulfate soil (Fig. 2-3-3). Therefore, acid improvement of soil is performed only for upland field, not for paddy field.

To improve acidity of soil, usually calcium carbonated or quick line are applied. Buffer curve is used to determine amount of calcium carbonate required to raise soil pH to target pH. Fig. 2-3-4 shows the buffer curve by types of soil obtained by experiment.

## 2.4 Irrigation

### 2.4.1 Utilization of existing irrigation facilities

(1) Rice crop

In the project area, there exists about 4,500 ha of paddy fields including their remains. Among them, the comparatively large-scaled farm is the Bolf farm which is located in the eastern part of the area and is continuing rice cropping for about 40 years. The source of irrigation water of this farm is the small rivers flowing out from the hilly part and the Parana River. Pumping station is provided along the shores of the Parana River. The water from the small rivers is mainly used as the irrigation water and the pumping machine is used only when the spell of drought continues and the runout from the hilly part becomes extremely small. Moreover, the irrigation canal system consists of the irrigation canal which conducts water to the paddy fields from the pumping station and the irrigation canal which performs damming of small rivers and conducts water to the paddy fields. When the pumping station is not operated, the small rivers are dammed and flown down to the irrigation canal from the pumping station. Moreover, when the water level of the small rivers drop, a portable small-sized pumping machine is also used. (See Fig. 2-4-1)

The farmland proprietor and the responsible management person have actively adopted the rice crop techniques of advanced nations Urguay and and Argentin etc., and practically all of the farm work of the area under crop (about 350 ha) are performed by large-sized machinery systems. Moreover, the water management work also includes the effective use of rainfall, extermination of noxious insects by irrigation water, etc., and it is performed considerably delicately. The irrigation method is a storage and continuous flowing irrigation method performed by contour levee.

All other rice crop farmers are small in size. Their source of irrigation water are small rivers, etc., that flow into the area. Water intake is made by providing a simple weir in the upstream part and irrigation is performed. Moreover, the expansion of rice crop has become difficult because the outlet works are not completely furnished and the discharge of small rivers is not stable.

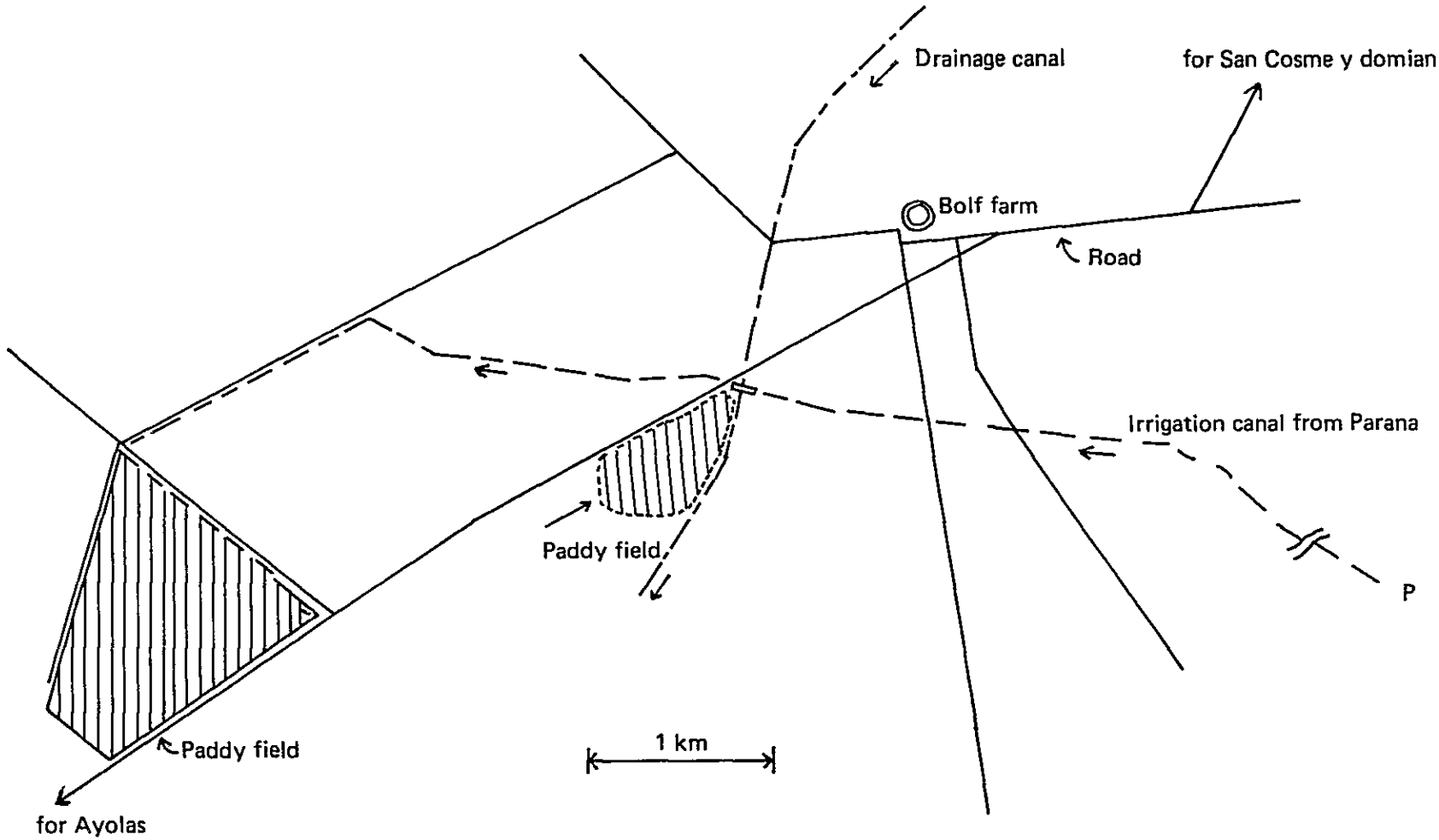



Fig. 2-4-1 Irrigation and Drainage Canal in the Bolf Farm

(2) Upland crops

Practically all of the project area is of low flatland and is utilized only as a wild grassland and no large-scaled upland crops can be seen. We find only the planting of maize, cotton, etc., in the land cleared by burning on the natural levee along the Parana River but there are no irrigation facilities.

2.4.2 Paddy field water requirement in depth

The daily water requirement in depth of a paddy field is the total of the potential evapotranspiration and the vertical and horizontal percolations.

The "N Type Water Requirement Measuring Apparatus" was installed at the paddy field (the soil is planosols) of the Bolf farm which was within the project area in December, 1983 and observations have been continued under the schedule of up to April, 1984. Since the said observation is not yet completed and the same type of observation data is not available in Paraguay, studies are made based on presently procured observation data.

Table 2-4-1 is the observation data. According to this, the daily water requirement in depth exists in the range of 5 mm/day to 11 mm/day and it is 8.3 mm/day in average. The vertical percolation exists in the range of 1 mm/day to 3 mm/day. The potential evapotranspiration receives the influence of meteorological conditions (temperature, sunshine, wind, etc.) and the growth condition of rice, and the percolation amount receives the influence of the soil permeability and the surrounding groundwater level.

Since the observation period is short and it corresponds to the initial period in the growth stage, there is the possibility that the potential evapotranspiration will become more greater in the future.

Detailed analysis will be performed after observation completion, however, the designed potential evapotranspiration will be calculated as shown in Chapter 5-1 Irrigation. Moreover, since the period when the groundwater level becomes fixed and the water level are unknown, the maximum value (3 mm/day) was to be adopted among the observation data for this time and the value will be revised based on the future observation results.

Table 2-4-1 Daily Water Requirement in Depth

| Date | Daily water requirement in depth | | | Ground-water level | Plant height | Temperature | Water temperature | Soil temperature | Weather |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 1 - 2 | | | | | | |
| | m/m | m/m | m/m | GL- m | cm | °C | °C | °C | |
| Dec. 14 | | Start | | 0.65 | 30 | 35.0 | 38.5 | 36.5 | Fine |
| Dec. 15 | (4.0 | 1.0 | 3.0) | 0.69 | 30 | 29.0 | 30.0 | 28.0 | " |
| Dec. 16 | 9.0 | - | 9.0 | 0.72 | 30 | 27.4 | 30.5 | 28.5 | " |
| Dec. 17 | 9.0 | - | 9.0 | 0.85 | 30.3 | 27.0 | 29.0 | 28.0 | Fine/cloudy |
| Dec. 18 | 5.0 | - | 5.0 | 0.75 | 30.3 | 28.5 | 27.0 | 27.5 | " |
| Dec. 19 | 7.0 | 1.0 | 6.0 | 0.76 | 30.5 | 23.0 | 25.0 | 26.5 | Cloudy/fine rain |
| Dec. 20 | 8.0 | - | 8.0 | 0.73 | 30.5 | 28.5 | 30.0 | 27.0 | Fine |
| Dec. 21 | | - | | 0.74 | 30.5 | 29.0 | 30.2 | 28.5 | " |
| Dec. 22 | 8.0 | 1.0 | 7.0 | 0.76 | 30.5 | 24.5 | 24.6 | 26.0 | " |
| Dec. 23 | 9.0 | 2.0 | 7.0 | 0.78 | 30.5 | 31.5 | 26.5 | 26.0 | " |
| Dec. 24 | 8.0 | 1.0 | 7.0 | 0.80 | 30.5 | 31.0 | 25.4 | 26.0 | " |
| Dec. 25 | 9.0 | 1.0 | 8.0 | 0.82 | 30.5 | 30.5 | 27.0 | 26.5 | " |
| Dec. 26 | 8.0 | 1.0 | 7.0 | 0.83 | 35.0 | 30.0 | 26.5 | 26.0 | " |
| Dec. 27 | | 3.0 | | 0.85 | 35.0 | 29.0 | 28.0 | 28.0 | " |
| Dec. 28 | 11.0 | - | 11.0 | 0.88 | 35.0 | 28.0 | 26.5 | 27.5 | " |
| Dec. 29 | 7.0 | 1.0 | 8.0 | 0.90 | 35.0 | 30.0 | 30.5 | 29.0 | " |
| Dec. 30 | 10.0 | 2.0 | 8.0 | 0.91 | 42.0 | 30.0 | 27.5 | 28.0 | " |
| Dec. 31 | 8.0 | 3.0 | 5.0 | 0.93 | | 30.0 | 28.0 | 28.0 | Cloudy |
| Average | 8.0 | 1 - 3 | 7.5 | | | 29.0 | 28.3 | 27.9 | |

1 Evaporation rate + Percolation rate

2 Percolation rate

3 1 - 2 = Evapotranspilation rate

Variety: Blue bell (Cropping period 120 days)

Seeding: Nov. 6

Ovseration time: 9:00 of every day.

2.4.3 Leakage amount of existing irrigation canal

The investigation results of the leakage amount in the irrigation canal of the Bolf farm is as shown in Table 2-4-2. The irrigation canal is an unlined canal and it possesses a filled up levee utilizing the excavated soil. The side surfaces and bottom part of the irrigation canal is of a comparatively soft viscous soil and is trampled by horses and cows. It is considered that a portion of this soft viscous soil has flown in from the hilly areas and settled here. The leakage amount is made 10 mm/day from the investigation results and the leakage degree in the designed irrigation canal is studied. Now when the maximum water intake quantity is made 108 $m^3/s$, the water depth is made 2.0 m and the canal bottom width is made 100 m, the discharge per canal unit width is about 1.08 $m^3/sec/m$ (V = 0.54 m/sec). On the other hand, the leakage amount per unit area is 10 mm/1,000/86,400 = $1.157 \times 10^{-7}$ $m^3/sec/m^2$ . If discharge is made Qo when time (t) equals 0 and the discharge is made q when t = 1 second, the discharge (Q) after the elapse of n seconds is represented as follows:

$$Q = Qo - nq$$

Now when Qo = 1.08 $m^3/sec/m$, V = 0.54 m/sec and q = $1.157 \times 10^{-7} \times (1.0 \times 0.54) = 6.248 \times 10^{-8}$ $m^3/sec$, and the flowing distance is made 100 km, it becomes as follows:

$$Q = Qo - nq = 1.08 - (100 \times 1{,}000/0.54) \times 6.248 \times 10^{-8} = 1.068 \text{ m}^3/\text{sec/m}$$

In this case the rate of leakage becomes as follows:

$$(Qo - Q)/Qo \times 100 = (1.08 - 1.068)/1.08 \times 100 = 1.1\%$$

Table 2-4-2 Investigation Leakage Amount Existing Irrigation Canal

| Part | Leaking rate | Remarks |
|---|---|---|
| | mm/d | |
| Side face | 1.9 ~ 13 | Surface of clayey soil |
| " | 76 ~ 1200 | In case where surface clayey soil is removed. |
| Bottom face | 2 ~ 10 | Surface of clayey soil |

Since the designed irrigation canal is an unlined canal, it is considered of adopting the earth lining construction method for the measure against leakages. According to the results of the soil test, the permeability coefficient of a portion of the soil indicate that of the $1 \times 10^{-4}$ cm/sec class and the rate of leakage in this case becomes as follows:

$$q = 1 \times 10^{-4} \times 10^{-2} \times (1.0 \times 0.54) = 5.4 \times 10^{-7} \text{ m}^3/\text{sec}$$

$$Q = Qo - nq = 1.08 - (100 \times 1{,}000/0.54) \times 5.4 \times 10^{-7} =$$
$$1.08 - 0.1 = 0.98$$

$$(Qo - Q)/Qo \times 100 = (1.08 - 0.98)/1.08 \times 100 = 9.3\%$$

2.4.4 Soil physical properties

Sample of the soil in the area was collected in a 100 cc sample cylinder and its physical properties were measured by using the "Physical Property Measuring Device". The results of this measurement is shown in Table 2-4-3. The calculated value of the available moisture amount was 16 to 24% by Planosols, 12 to 27% by Regosols and about 20% by Acrisols.

2.4.5 Intake rate

For performing study of the irrigation method, an intake rate investigation which indicated the infiltration strength of the soil was performed. The drawing of the investigation sites is shown in Fig. 2-4-2 and the investigation result is shown in Table 2-4-4. It could be considered that the surface irrigation and the storage irrigation were suitable for the irrigation method as the infiltration strength was small with the exception of a portion of the Regosols soil. However, it is necessary to study the irrigation discharge upon taking into consideration the risk of soil erosion.

Details of the intake rate investigation is shown in the Appendix.

## Table 2-4-3 Soil Physical Properties

| Soil | Depth | G | S | Volume Ratio PF = 1.5 | | | Wp | AM | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | SV | AV | MV | | | |
| | cm | | | % | % | % | % | % | |
| Regosols (Re-f) | 7.5 | 2.65 | 1.68 | 63.3 | 12.5 | 23.6 | 7.8 | 15.8 | Ea. Bolf. Pasturage. Red sandy soil |
| | 22.5 | 2.65 | 1.63 | 61.7 | 19.9 | 18.4 | 5.9 | 12.5 | |
| Regosols (Re-c) | 7.5 | 2.65 | 1.56 | 58.8 | 10.2 | 31.0 | 10.5 | 20.5 | Ea. Pordon Ropez. Pasturage |
| | 22.5 | 2.65 | 1.62 | 61.3 | 13.7 | 25.0 | 8.3 | 16.7 | |
| Regosols | 7.5 | 2.6 | 1.31 | 50.3 | 8.5 | 41.2 | 14.3 | 26.9 | Left bank of A' Aeingy near the road. Pasturage |
| | 22.5 | 2.6 | 1.41 | 54.2 | 6.8 | 39.0 | 13.5 | 25.5 | |

G. Specific gravity assumed

S: Apparent - specific gravity

Sv: Ratio of soil volume

Av: Ratio of air volume

Hv: Ratio of Moisture volume

Wp: Wilting point $Wp = 0.238Fc^{1.102}$ (FC = HV (PF=1.5))

AM: Available moisture AM = Wp - Fc

Fc: Field capacity (PF = 1.5)

## Table 2-4-3 Soil Physical Properties (Cont')

| Soil | Depth | G | S | Volume Ratio Saturated | | AM | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | SV | MV | | |
| | cm | | g/cm$^3$ | % | % | % | |
| Planosols | 7.5 | 2.6 | 1.49 | 57.1 | 42.9 | 21.5 | Ea. Blof. Paddy field after seeding |
| " | 12.5 | 2.6 | 1.53 | 58.9 | 41.1 | 20.6 | |
| " | 17.5 | 2.6 | 1.69 | 64.9 | 35.1 | 17.8 | |
| " | 22.5 | 2.6 | 1.75 | 67.4 | 32.6 | 16.3 | |
| Planosols | 7.5 | 2.6 | 1.47 | 56.7 | 43.3 | 21.7 | Pasturage near the Access Road (22.5 km point) |
| " | 22.5 | 2.6 | 1.35 | 52.0 | 48.0 | 24.0 | |
| Acrisols | 7.5 | 2.65 | 1.51 | 57.1 | 42.9 | 21.5 | Bare field caltivated near the Access Road (20.2 km point) |
| " | 22.5 | 2.65 | 1.65 | 62.1 | 37.9 | 19.0 | |

G: Specific gravity assumed

S: Apparent - specific graviey

Sv: Ratio of soil volume

Hv: Ratio of moisture volume

AM: Available moisture AM = 1/2 Hv (saturated)

Table 2-4-4 Intake Rate

| Point No. | Soil | $D = CT^n$ C | $D = CT^n$ N | $I = KT^m$ K | $I = KT^m$ M | IB mm/hr | Remarks |
|---|---|---|---|---|---|---|---|
| ①- 1 | Planosols | 1.30 | 0.50 | 39.0 | -0.50 | 2.3 | Ea. Bolf Paddy-field before seeding |
| 2 | | 0.94 | 0.50 | 28.2 | -0.50 | 1.6 | |
| 3 | | 0.50 | 0.57 | 17.1 | -0.43 | 1.6 | |
| ②- 1 | Planosols | 1.60 | 0.56 | 53.8 | -0.44 | 4.6 | Ea. Bolf Paddyfield not cultivated. |
| 2 | | 0.68 | 0.69 | 28.2 | -0.31 | 5.8 | |
| 3 | | 0.68 | 0.89 | 36.3 | -0.11 | 22.9 | |
| ③- 1 | Planosols | 0.81 | 0.40 | 19.4 | -0.60 | 0.6 | Ea. Sarandy. swamp |
| 2 | | 0.60 | 0.52 | 18.7 | -0.48 | 1.2 | |
| ④- 1 | Regosols | 0.26 | 0.37 | 5.8 | -0.63 | 0.1 | Ea. Pablo Mora on the small hill in the swamp. |
| 2 | | 0.34 | 0.43 | 8.8 | -0.57 | 0.3 | |
| 3 | | 3.00 | 0.23 | 41.4 | -0.77 | 0.4 | |
| ⑤- 1 | Regosols | 0.77 | 0.94 | 43.4 | -0.06 | 35.0 | Paddyfield not cultivated this yeat. |
| 2 | | 0.94 | 0.70 | 39.5 | -0.30 | 8.3 | |
| ⑥- 1 | Regosols | 1.46 | 0.41 | 35.9 | -0.59 | 1.1 | Puesta lomita |
| 2 | | 1.23 | 0.42 | 31.0 | -0.58 | 1.0 | Paddyfield not cultivated this year |
| 3 | | 0.11 | 0.97 | 6.4 | -0.03 | 5.9 | |
| ⑦- 1 | Regosols | 11.6 | 0.89 | 619.4 | -0.11 | 390.7 | Orchard (Orange) |
| 2 | | 10.8 | 0.85 | 550.8 | -0.14 | 280.5 | |

D: Cumulative intake (mm)

I: Intake rate (mm/hr)

T: Minutes

K: Coefficient K = 60 cm

c, n: Coefficients calculated

M: Coefficient M = n - 1

$I_B = 60\ cn\ \{600(1 - n)\}^{n-1}$ (mm/hr)

$I_B$: Basic intake rate

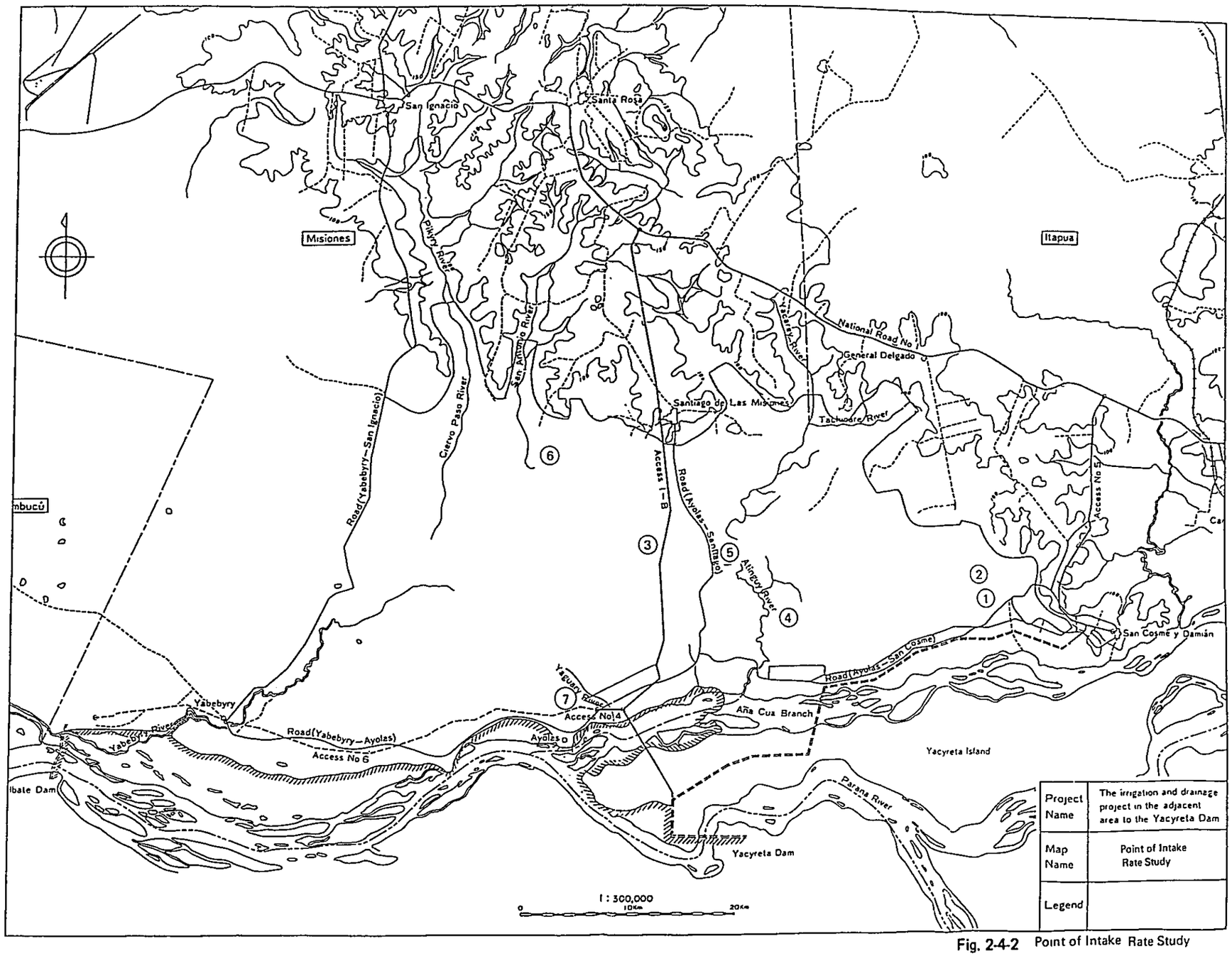



Fig. 2-4-2 Point of Intake Rate Study

(6) Water quality of irrigation water, surface water and groundwater

Water of the Parana River which becomes the irrigation water, the surface water ponded in the area and the groundwater from the well in the area were collected and the PH and EC were measured by the Glass Electrode Method. The measured results are shown in Tables 2-4-5 and 2-4-6 and the collection places are shown in Fig. 2-4-3. Moreover, the investigation results by the Yacyreta Public Corporation is shown in the Appendix.

The PH and EC values of the Parana River has no problems when used as irrigation water. When continuously observing the PH of the surface water from the northern part in the area (upstream part) to the southern part in the area (downstream part) (See No. ⑦ → ⑧, ⑪ → ⑫ → ⑬, ⑱ → ⑲ of Fig. 2-4-3), the value of PH has been slightly improved. With the exception of a portion, the PH of groundwater shows a weak acidity from neutrality and it has become of a higher value than the PH obtained by the soil investigation result. (See Chapter 2-3 "Soil") The groundwater indicating acidity are found in the northern part of the area (③, ④, ⑯) and the southwest part of the area (⑰) and this can be considered as the influence of parent materials. Groundwater indicating from neutrality to weak alkalinity exists in parts which can be considered as traces of natural levee (②, ⑤, ⑧) and EC also indicates a great value.

From the above-mentioned facts, it can be considered that a leaching action by irrigation water can be expected on the PH of a large majority of the soil in the area. It is necessary to promote further studies in the future on portions where both the groundwater and surface soil indicate acidity and on portions indicating a weak alkalinity and a comparatively large EC value.

Table 2-4-5 Water Quality of Surface Flow

| No. | PH | Water temperture at measuring time | EC | Water temperture at measuring time | Remarks |
|---|---|---|---|---|---|
| | | | µs/cm | | |
| ① | 6.5 | 25.0 | 37 | 25.0 | Irrigation water of Bolf from M |
| ② | 5.8 | 26.0 | 21 | 26.0 | Drainage canal of Bordor L |
| ③ | 6.5 | 22.0 | 22 | 22.0 | A° Atingy at Listro |
| ④ | 6.3 | 22.0 | 19 | 22.0 | A° Atingy near Ea. Fanstina |
| ⑤ | 6.8 | 23.0 | 24 | 23.0 | A° Atingy at the Bridge |
| ⑥ | 6.1 | 23.0 | 29 | 23.0 | Canal in the Swamp |
| ⑦ | 5.3 | 25.0 | 21 | 25.0 | Puesto Losi |
| ⑧ | 5.6 | 23.0 | 24 | 23.0 | Swamp near Sarandy |
| ⑨ | 6.3 | 24.0 | 28 | 24.0 | A° Ingua |
| ⑩ | 6.6 | 20.0 | 26 | 20.0 | Puesto lonita irrigation water |
| ⑪ | 5.3 | 22.0 | 32 | 27.0 | Puesto San R |
| ⑫ | 6.1 | 30.0 | 45 | 30 | Swamp |
| ⑬ | 6.7 | 22.0 | 55 | 22.0 | A° Yaguary near Route A |
| ⑭ | 6.1 | 21.0 | 14 | 21.0 | Swamp |
| ⑮ | 7.3 | 20.0 | 116 | 20.0 | Swamp |
| ⑯ | 6.3 | 20.0 | 105 | 22.0 | Swamp |
| ⑰ | 6.2 | 24.0 | 26 | 24.0 | Swamp |
| ⑱ | 6.2 | 21.0 | 19 | 21.0 | A° Yabebyry |
| ⑲ | 5.7 | 25.0 | 20 | 22.0 | Swamp |
| ⑳ | 6.7 | 24.0 | 23 | 24.0 | A° Yabebyry |
| ㉑ | 7.1 | 22.0 | 43 | 22.0 | Rio Parana at the Bridge |

Measuring method: Glass electrode method

Table 2-4-6 Water Quality of Well

| No. | PH | Water temperture at measuring time | EC | Water temperture at measuring time | Remarks |
|---|---|---|---|---|---|
| | | °C | µs/cm | °C | |
| ① | 6.7 | 25.0 | 37 | 25.0 | Ea. Bolf |
| ② | 7.6 | 19.0 | 258 | 19.0 | Puesto Cerrito |
| ③ | 5.4 | 22.0 | 301 | 22.0 | Ea. Caapucũ (listro) |
| ④ | 5.3 | 23.0 | 19 | 23.0 | Santiag |
| ⑤ | 7.0 | 22.0 | 1,452 | 23.0 | Casa que esta Cerca de Route |
| ⑥ | 6.7 | 25.0 | 310 | 25.0 | Cantera |
| ⑦ | 6.8 | 22.0 | 380 | 22.0 | Ea. Fanstina |
| ⑧ | 8.0 | 20.0 | 2,170 | 20.0 | Puesti lomita |
| ⑨ | 7.3 | 24.0 | 784 | 24.0 | Santa Tomasa |
| ⑩ | 6.9 | 21.0 | 271 | 21.0 | Ra Ley |
| ⑪ | 6.6 | 21.0 | 84 | 21.0 | Colonia Coeyu |
| ⑫ | 6.6 | 21.0 | 97 | 21.0 | Colonia Coeyu (Escuela) |
| ⑬ | 5.3 | 24.0 | 200 | 24.0 | Casa questa Cerca de Routa |
| ⑭ | 6.0 | 20.0 | 29 | 20.0 | Augar hole |
| ⑮ | 6.0 | 22.0 | 19 | 22.0 | " |
| ⑯ | 5.4 | 20.0 | 52 | 20.0 | " |
| ⑰ | 4.3 | 20.0 | 2,520 | 20.0 | " |

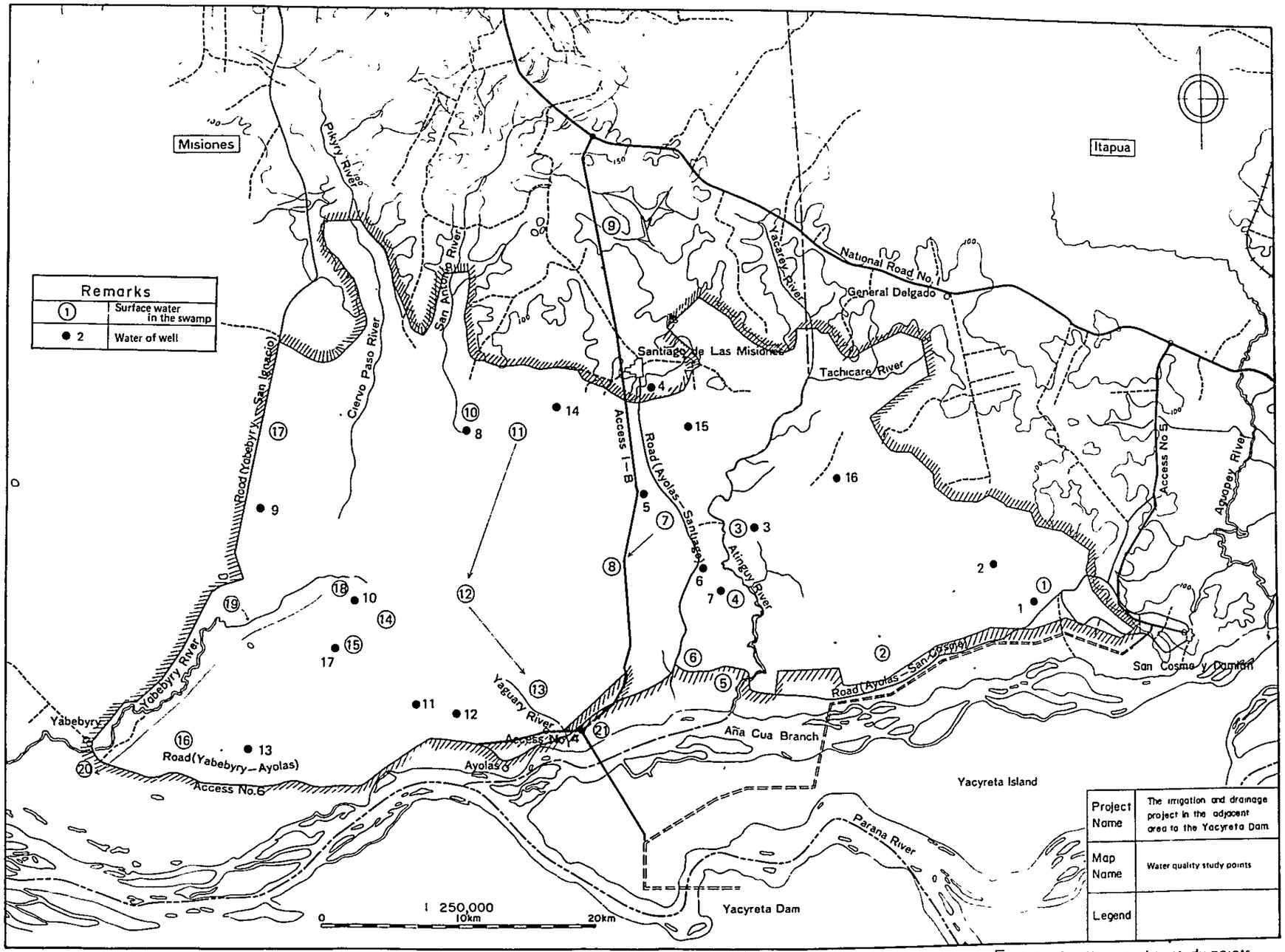



Fig 2-4-3 Water quality study points

## 2.5 Surveying

### 2.5.1 Zero-point setting levelling for autographic water level gage and tuff water gage

The zero-point levelling was made because of the need to link the zero points of an autographic water level gages and a staff water gages at the standard elevation.

(1) Staff water gage levelling

A staff water gage levelling was made last year for five points along Access 1-B and one point in between Ayolas and San Cosme. This year, similar surveying were made for five points in between Yabebyry and San Ignacio, one point in La Ré along the mid-stream of the Yabebyry River and one point in Listro along the mid-stream of the Atinguy River. (Refer to Table 2-5-1)

Fig. 2-5-1 and in Appendix Fig. 2-5-1 are the planimetric map for comparative geographic positions and a sketch map, respectively.

Table 2-5-1 Staff Water Gage Levelling

| Staff water gage number | Control point | | B.M. Elevation | Staff water gage zero elevation |
|---|---|---|---|---|
| | Number | Elevation | | |
| | | m | m | m |
| 1 | RN 51 | 75,139 | 76,456 | 74,276 |
| 2 | Closed conduit | 74,716 | 74,716 | 73,149 |
| 3 | Closed conduit | 74,708 | 74,708 | 72,555 |
| 4 | RN 2 | 75,145 | 74,265 | 72,034 |
| 5 | High column | 73,758 | 73,758 | 66,567 |
| 6 | 13/7 | 75,268 | 75,268 | 73,883 |
| 7 | C.M.T. 13B | 72,441 | 71,936 | 70,111 |
| 8 | C.M.T. 12B | 70,801 | 71,463 | 69,551 |
| 9 | C.M.T. 12B | 70,801 | 71,355 | 69,985 |
| 10 | C.M.T. 12B | 70,801 | 71,232 | 69,782 |
| 11 | C.M.T. 11D | 71,202 | 71,230 | 69,295 |
| 12 | C.M.T. 11D | 71,202 | 70,625 | 67,670 |
| 13 | C.M.T. 4B | 72,212 | 74,419 | 68,641 |

(2) Autographic water level gage levelling

We set the B.M. for Yabebyry last year, and made an autographic water level gage levelling for not only Yabebyry, but also Caje Cue, Arroyo Ingua and Atinguy, this year. (Refer to Table 2-5-2)

Fig. 2-5-1 and in appendix Fig. 2-5-2 are the planimetric map for comparative geographic positions and a sketch map, respectively.

Table 2-5-2 Autographic Water Level Gage Levelling

| Position of autographic water level gage | Control point | | B.M. elevation | Autographic water level gage zero elevation |
|---|---|---|---|---|
| | Number | Elevation | | |
| | | m | m | m |
| Arroyo Ingua | R.N. 13 | 108,280 | 107,539 | 101,583 |
| Caje Cue | C.M.T. 15-D | 153,840 | 103,562 | 99,850 |
| Yabebyry | C.M.T. 10-B | 66,287 | 66,306 | 59,951 |
| Atinguy | | | 68,966 | 60,828 |

Note: As to Atinguy, we obtained the data on autographic water level gage zero elevation from E.B.Y., and calculated the B.M. elevation through levelling operations based on the elevation of the existing water level gage. (Refer to in appendix Table 2-5-1)

2.5.2 Control point survey

In this project, we employed the triangulation and control points set by E.B.Y. Last year, we collected data on the 39 control points of a dam on the Parana River's right bank. (Refer to Table 5-45 in the appendix of the last year's report)

This year, we additionally obtained data on Access 1-B, Access No. 5 and the basic traverse network control points of the dam. (Refer to in appendix Tables 2-5-2, 2-5-3, 2-5-4 and 2-5-5, as well as attached maps)

2.5.3 Longitudinal and cross levelling for drainage rivers

The two rivers, the Atinguy and the Yabebyry, run through the project areas, which drain the water from the hinterland and rainfall in this area downstream. The two rivers also run onangentle grade and extremely meandering.

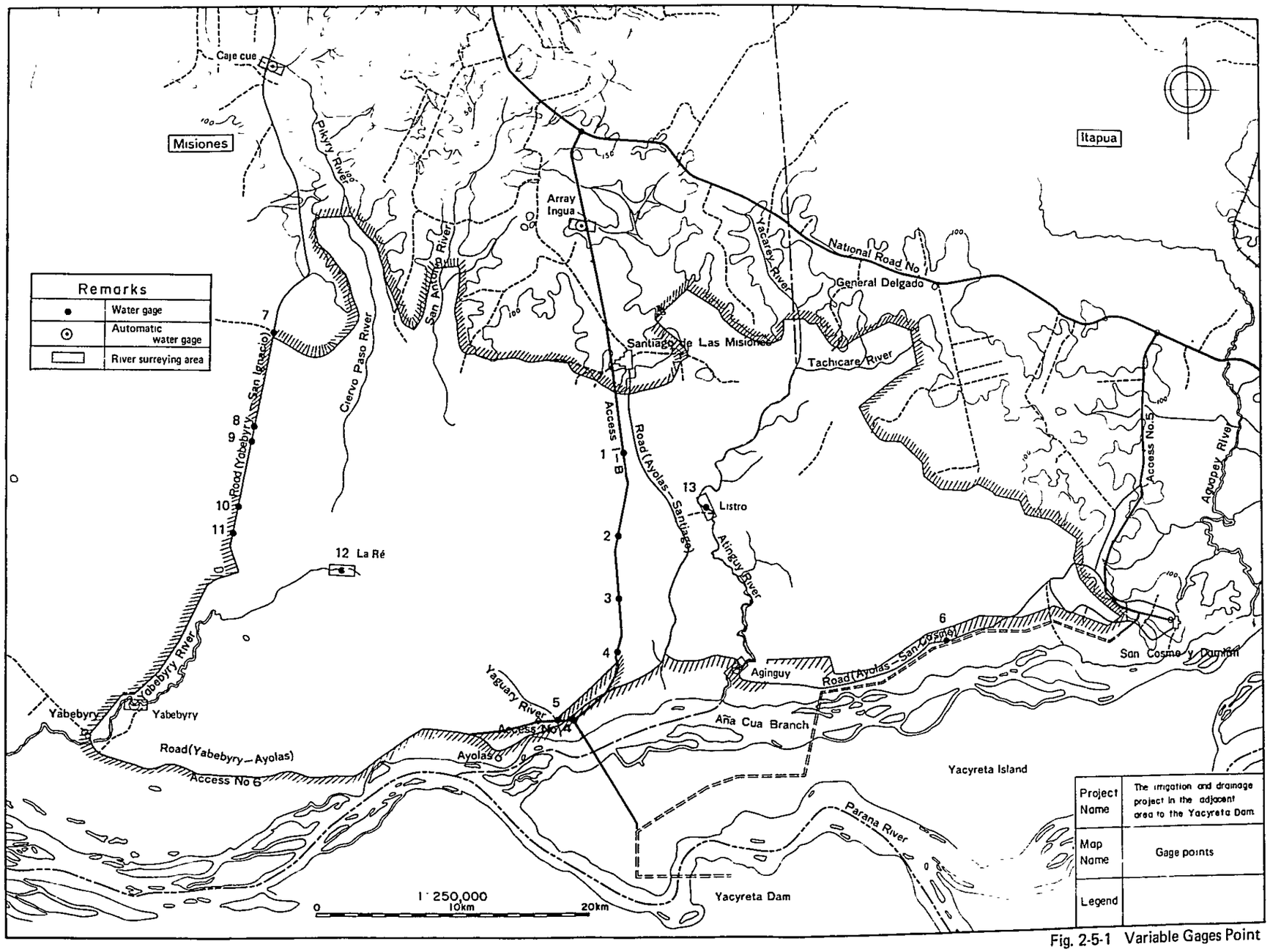



Fig. 2-5-1 Variable Gages Point

Table 2-5-3 Summary of River Surveying

| Point of levelling | Survey point | Distance | Riverbed elevation (deepest point) | Water surface elevation | Riverbed slope | Water surface slope | Riverbed slope | Water surface slope |
|---|---|---|---|---|---|---|---|---|
| | | m | m | m | | | | |
| Atinguy (Point of autographic water level gage) | No. 900 | 900 | 61,955 | 64,235 | 1/2,300 | 1/6,000 | 1/2,100 | 1/2,700 |
| | No. 0 | 900 | 61,379 | 63,949 | | | | |
| | No.-900 | 16,500 | 61,165 | 63,935 | | | | |
| Listro (Point of staff water gage) | No. 1000 | 1,000 | 69,208 | 70,078 | 1/930 | 1/2,000 | | |
| | No. 0 | 1,000 | 67,624 | 69,654 | | | | |
| | No.-1000 | | 67,061 | 69,111 | | | | |
| Arroyo Ingua (Point of autographic water level gage) | No. 1000 | 1,000 | 104,556 | 105,381 | 1/680 | 1/590 | | |
| | No. 0 | 1,000 | 102,412 | 103,112 | | | | |
| | No.-1000 | | 101,599 | 102,013 | | | | |
| Caje Cue (Point of autographic water level gage) | No. 1000 | 1,000 | 103,199 | 103,749 | 1/530 | 1/540 | | |
| | No. 0 | 1,000 | 100,778 | 101,298 | | | | |
| | No.-1000 | | 99,391 | 100,061 | | | | |
| Yabebyry (Point of autographic water level gage) | No. 1000 | 1,000 | 60,266 | 61,566 | 1/1,400 | 1/7,500 | 1/2,900 | 1/3,400 |
| | No. 0 | 1,000 | 60,493 | 61,393 | | | | |
| | No.-1000 | 24,700 | 58,838 | 61,298 | | | | |
| La Ré (Point of staff water gage) | No. 1000 | 1,000 | 67,297 | 68,487 | 1/2,200 | 1/3,200 | | |
| | No. 0 | 1,000 | 66,974 | 67,984 | | | | |
| | No.-1000 | | 66,367 | 67,857 | | | | |

These prove an apparent major cause of the areas' inundation. For these reasons, we made both longitudinal and cross levellings.

Levelling was made at the downstream point where an autographic water level gage was located and at Listro of the mid-stream point for the Atinguy River, while for the Yabebyry River, the downstream point an autographic water level gage site - and the mid-stream point La Ré were selected as levelling points.

In addition to those four points, similar points were set Caje Cue and Arroyo Ingua, the sites along the river running into the target areas from the hiterland, where an autographic water level gage was installed.

We cannot get very accurate results because of only one control point in each levelling point but can obtain the movements of the riverbed and water surface changing with the meander. Therefore, as regard to the scope of measurement, a longitudinal levelling was made on each 1 km of upward and downward the river from the control point concerned. A cross levelling, meanwhile, was to cover from the flow center to the periphery of flood. Results are shown in Table 2-5-3.

The planimetric map for comparative geographic positions is given in Fig. 2-5-1, while the cross and longitudinal maps can be found in a group of attached drawings.

2.5.4 Estuary survey for the Atinguy and Yabebyry River

(1) The Atinguy Estuary

For about 1.8 km downstream from its concrete bridge (point of autographic water level gage installation), the Atinguy River is 30∿40 m wide and the areas in the neighborhood is covered with forests elevated by 1.5 ∿ 2 m from the surface of water. From these areas downstream to the estuary for about 2 km, sparsely forested natural plains spread on both sides of the river, constituting à flood periphery for Parana. The river, constituting a flood periphery for Parana. The riverbed is rocky, which rules out the possibility that the bed might have been eroded by the current.

This river is about 2 m below the water surface at the deepest point near the estuary, the width being 40 ∿ 50 m and opening wider toward the estuary. At points close to the estuary, the Atinguy is about 81 m wide and the current runs at a right angle with the Parana River.

Fig. 2-5-2 shows the planimetric map for the periphery of the estuary, and the cross and longitudinal sections of the estuary are given in Fig. 2-5-3 and Fig. 2-5-4, respectively. Table 2-5-4 indicates the results of our survey made on December 7, 1983.

Table 2-5-4 Results of the Surveying (near the estuary of the Atinguy River)

| Point of survey | Simple distance | Additional distance | Riverbed elevation | Water surface elevation | Riverbed slope | Water surface slope |
|---|---|---|---|---|---|---|
| No. 0 | 0 m | 0 m | 61,379 m | 63,100 m | | |
| No.-500 | 500 | 500 | 61,220 | 63,117 | | |
| No.-900 | 400 | 900 | 61,165 | 63,104 | 1/6,500 | 1/57,000 |
| No.-2,573 | 1,673 | 2,573 | | 63,030 | | |
| No.-3,848 | 1,275 | 3,848 | 60,783 | 63,033 | | |

These results indicate that the riverbed has a slope, but the water surface slope is negligible near the Atinguy's estuary, which undeniably is affected by the Parana River's water level.

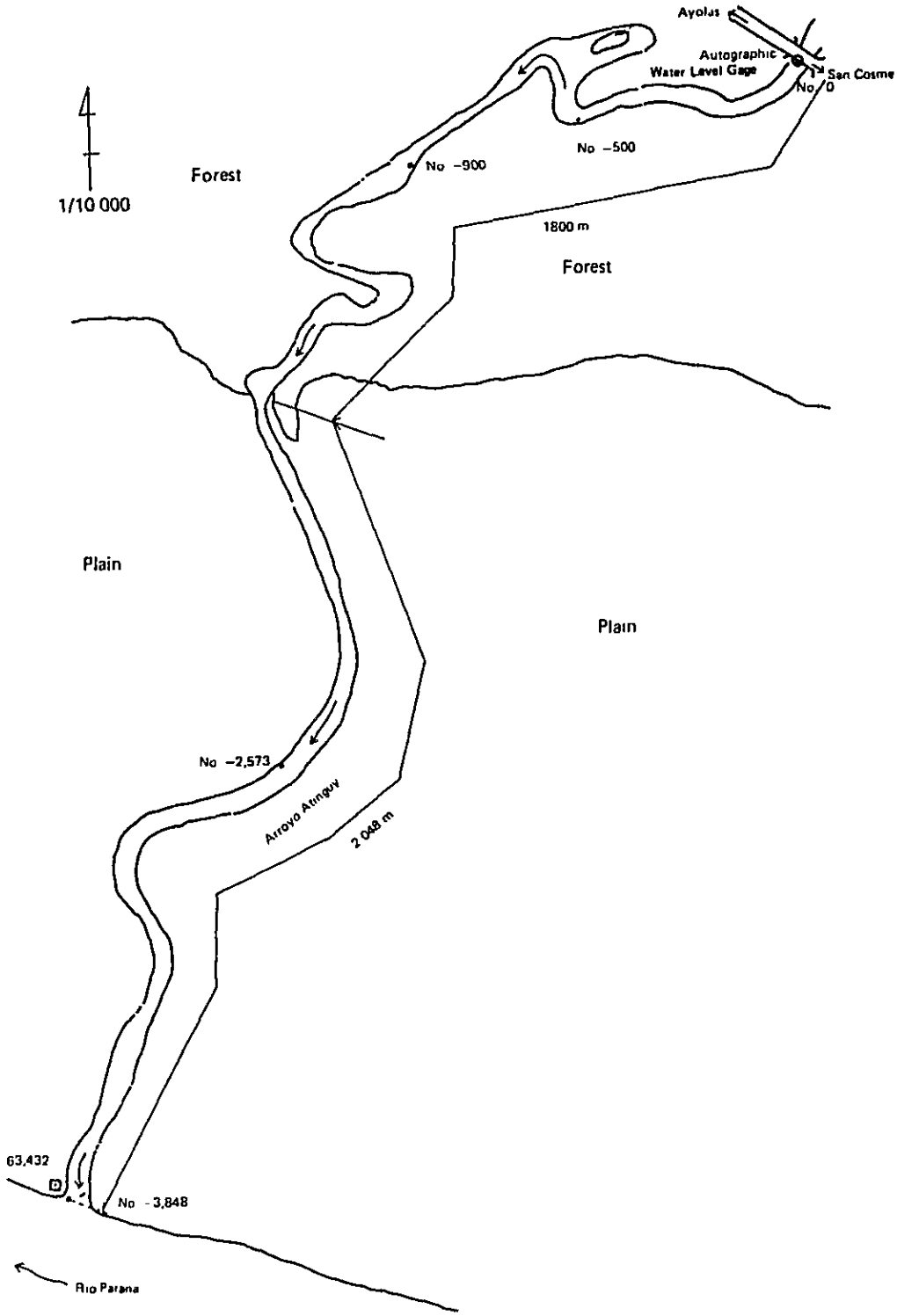



Fig. 2-5-2 Planimetric Map for the Atinguy River's Estuary

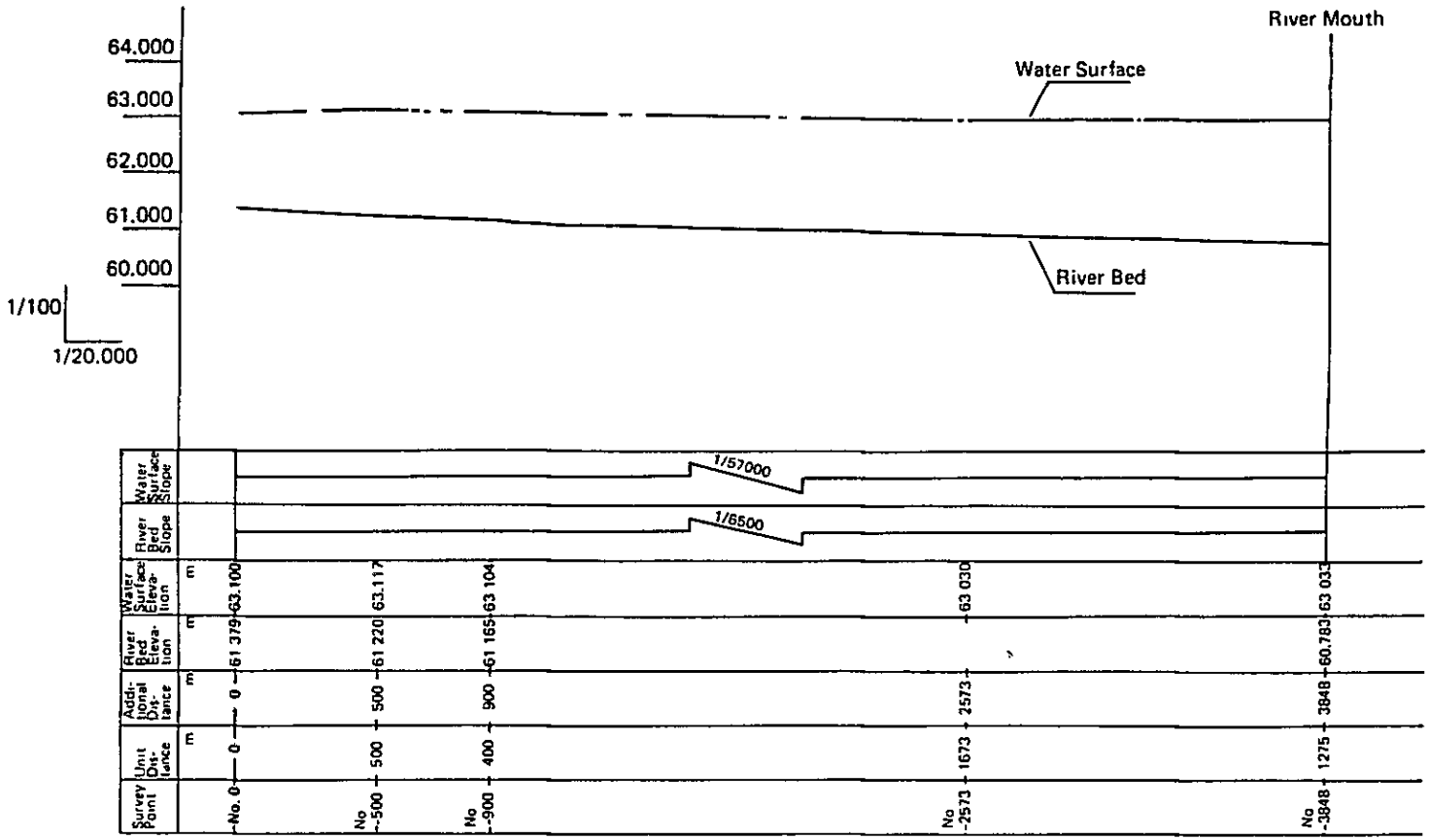



Fig. 2-5-3 Longitudinal Section of the Atinguy River's Estuary

S = 1:400

No. –3848



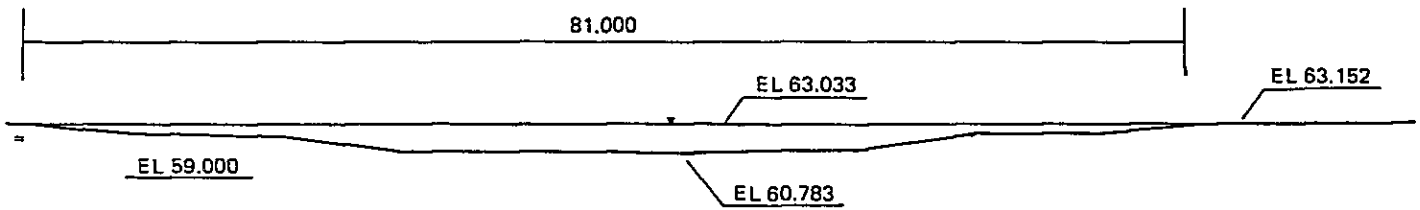



Fig. 2-5-4 Cross-Section of the Atinguy River's Estuary

(2) The Yabebyry Estuary

For about 8 km from its autographic water level gage installation point to a wooden bridge on the outskirts of Yabebyry, the Yabebyry River is about 30 m wide, and the areas in the neighborhood are wild plains, constituting a flood periphery in the case of inundation and then natural banks are along the river. For about 13 km down the river from this bridge, it is 30 ∿40 m across, and the periphery is thickly forested land.

From these areas down to the Parana River, the difference of elevation is virtually non-existent with an equal level of water surface. A swampy zone also spreads at points of low water level.

The Yabebyry River characteristically has many meandering points and its riverbed is sandy with a high-water channel or major bed expanding for 200 ∿ 300 m.

At a point 27 km downstream from the water level gage installation site near the estuary we levelled in the latest survey, the elevation of water surface stood at 56 m, almost equal to the water level of the Parana River, and the warer used to flow to join that river. Therefore, we could not locate the estuary of the Yabebyry River accurately. Since the normal high-water level of Ita Ibate Dam was elevated by 59 m, the Yabebyry River's mouth was to be moved by about 10 km up the river from that point.

Fig. 2-5-5 indicates the planimetric map for the Yabebyry's estuary, and the estuary's longitudinal section and survey results are given in Fig. 2-5-6 and Table 2-5-5, respectively. (The survey made on December 12 1983)

Table 2-5-5 Survey Results for the Yabebyry River's Estuary

| Point of survey | Simple distance | Additional distance | Water surface elevation | Water surface slope | |
|---|---|---|---|---|---|
| | m | m | m | | |
| No. 0 | 0 | 0 | 61,204 | 1/6,500 | 1/5,200 |
| No. 19,000 | 19,000 | 19,000 | 58,285 | 1/3,600 | |
| No. 27,000 | 8,000 | 27,000 | 56,034 | | |

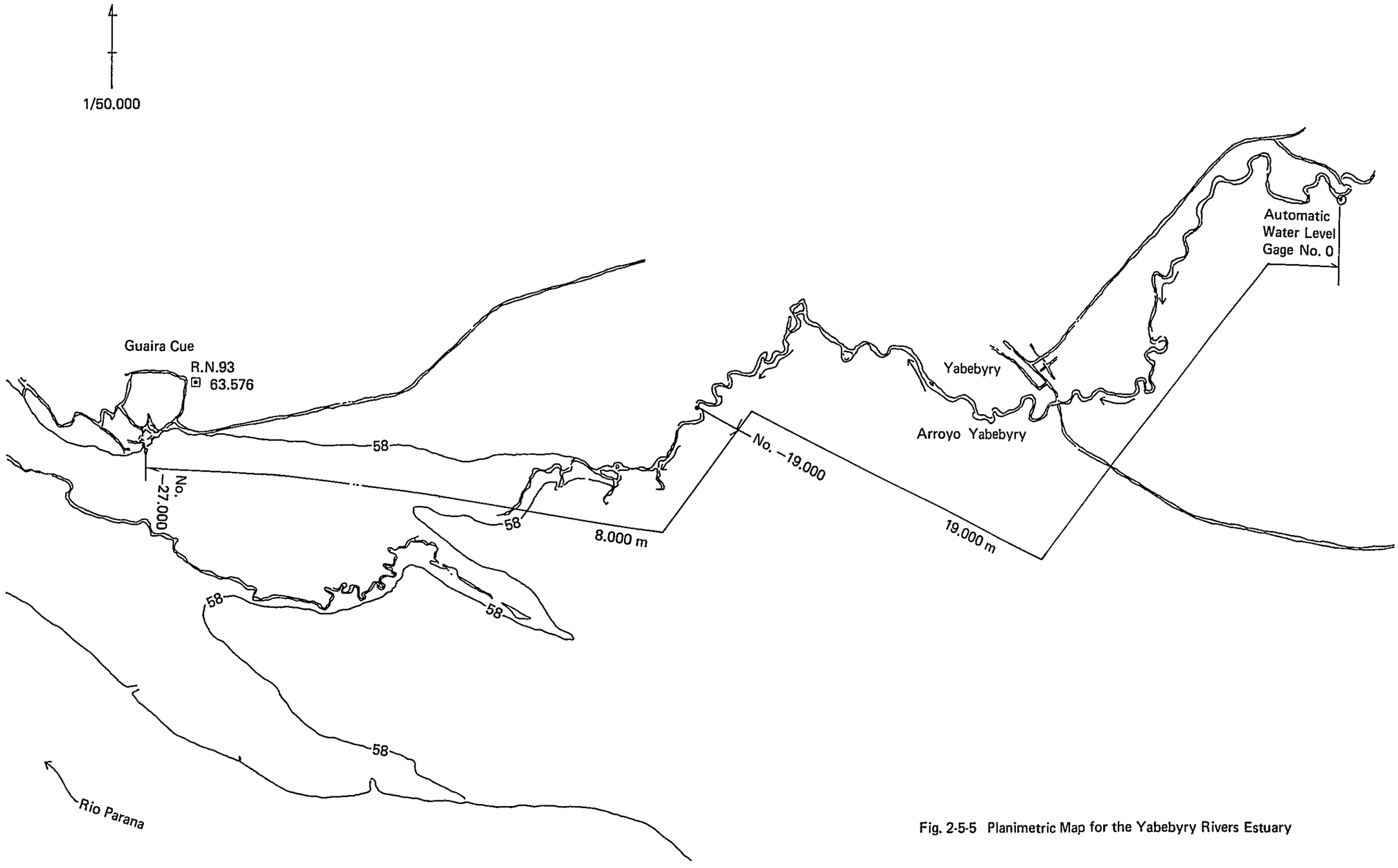



Fig. 2-5-5 Planimetric Map for the Yabebyry Rivers Estuary

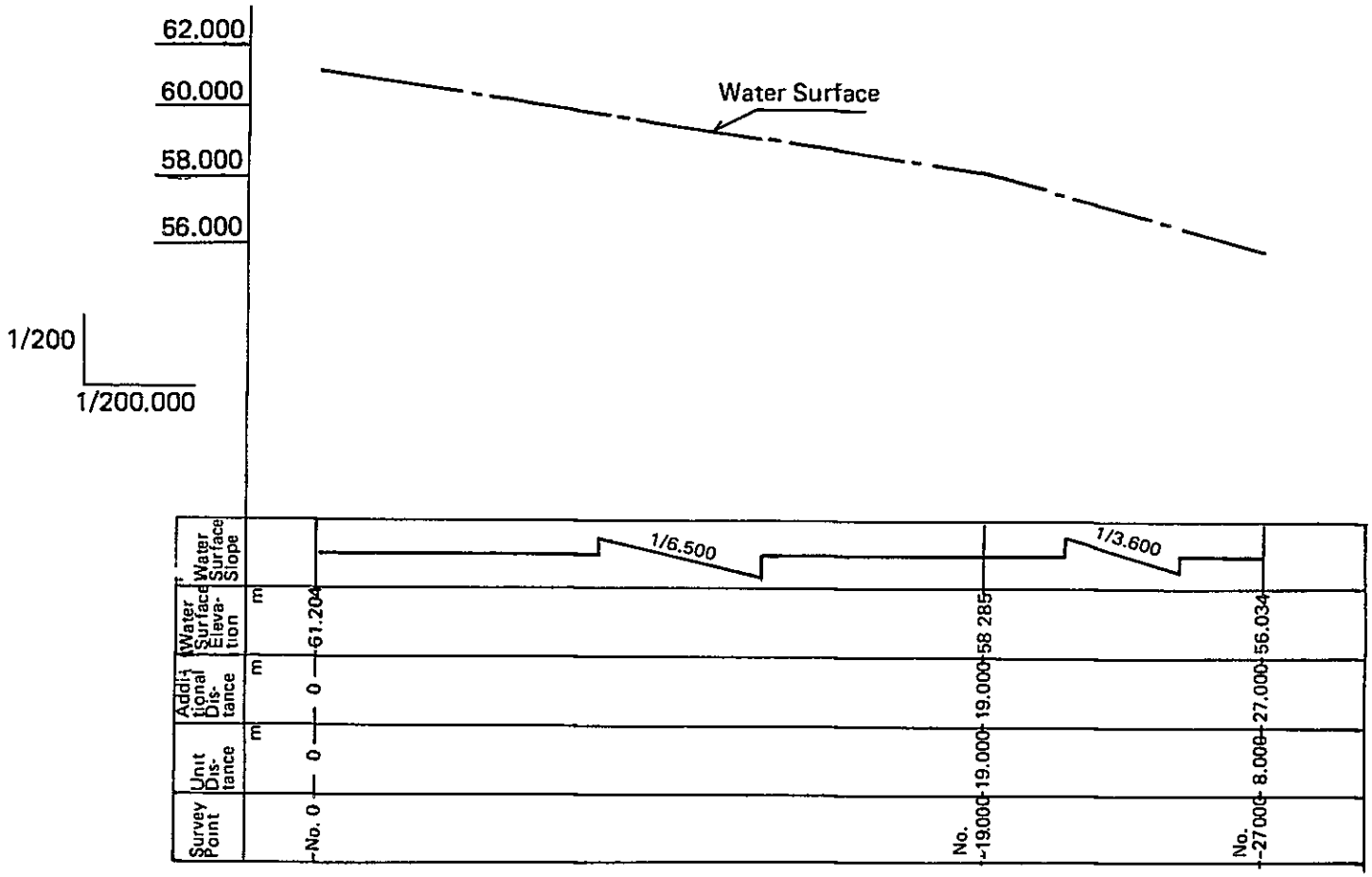



Fig. 2-5-6 Longitudinal Section of the Yabebyry River's Estuary

## 2.6 Land Utilization

### 2.6.1 Present topography

(1) Outline of topography in the survey area

Survey for fiscal year 1983 was performed basing upon the topographic maps (scale of 1/50,000 and interval of contour lines of 10 m) issued by Instituto Geografico Militar). However, the accuracy of elevation of these maps was inadequate in carrying out the understructure improvement project so that topographic maps with 2 m interval of elevation were prepared basing upon the aerial photographs taken in 1972 and then it was determined to carry out the survey plan using these maps.

Topography of the survey area will be outlined below. Parana River adjacent to the survey area gently meanders in the direction of west-south-west and forms many bars such as Yacyreta Island and Taravera Island. Parana River becomes narrow near San Cosme located at the eastern end of the survey area, and forms a large swamp zone at the right bank side due to great inundations with its peak point located near San Cosme. In the northern part 20 to 25 km away from the Parana River, there is a gentle hilly land whose base rock is sandstone and basalt.

Basing upon these topographic maps, aerial photographs and the results of field survey, the present topography can be classified as shown in Table 2-6-1.

With respect to typical topographic classes in the survey area, in the gentle alluvial fan and foot (15%) of hilly area continuing from northern hilly land drain conditions are good and land is well utilized. Also, hinterland marsh and ups within the marsh where the natural grass grows will occupy almost 76% of the total area of the survey area.

Table 2-6-1 Table Showing Current Topographic Classification

| Class | Area | Percentage |
|---|---|---|
| | ha | % |
| Hills | 1,275 | 0.8 |
| Shallow valleys in hills | 0 | 0 |
| Colluvial slopes | 9,950 | 6.5 |
| Alluvial cones | 100 | 0.1 |
| Valley bottom plains | 4,750 | 3.1 |
| Gentle alluvial fans | 11,400 | 7.5 |
| Natural levees | 6,225 | 4.1 |
| Back swamp | 91,900 | 60.3 |
| Slightly elevated land in back swamp (higher) | 2,675 | 1.8 |
| Slightly elevated land in back swamp (lower) | 20,675 | 13.6 |
| Abandoned river channels | 250 | 0.2 |
| Lowland along the rivers | 3,000 | 2.0 |
| Shoal and sand dune | 25 | 0.0 |
| Rivers & springs | 75 | 0.0 |
| Total | 152,300 | 100 |

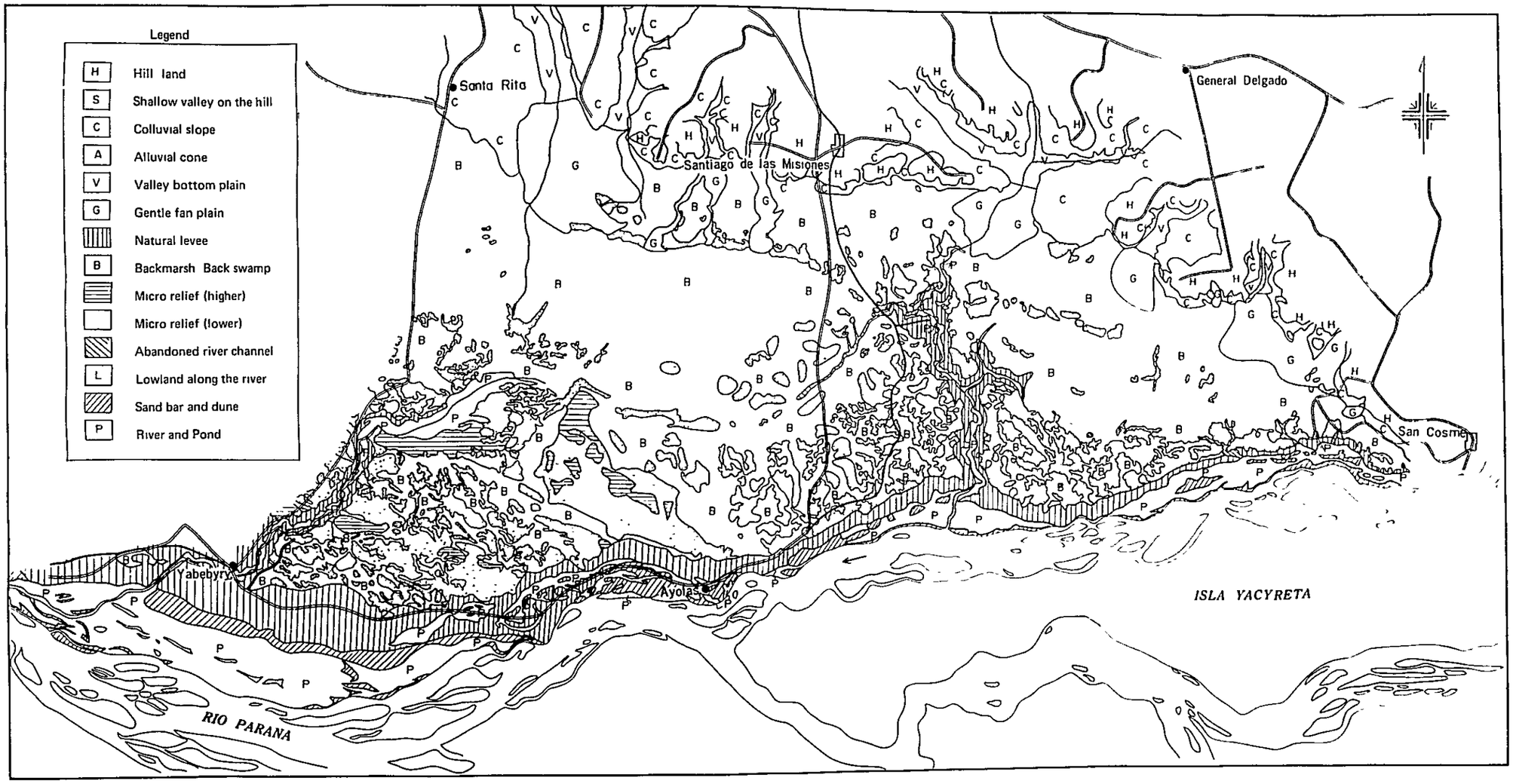



Fig. 2-6-1 Geomorphological Map

1) Hilly land

This is an area at the elevation higher than 90 m located in eastern and northern parts of the survey area. Base rocks in the hilly are sandstone, basalt and muddy sandstone and are considerably weathered.

This land has a gentle terrain and is utilized as vegetable fields and villages.

2) Shallow valleys in hilly land

These are the outstanding hollows located in the hilly land. These are mostly marshes but sometimes ponds. It is distributed only in a small area and located only on the hilly land in the northeastern part of the survey area.

3) Deposit at the foot of hilly area

This is a deposit terrain resulted from the crawling and washing by rain at the foot of slope of the hilly land. Surface layer is formed by the weathered earth of relatively fine grain. This deposit is well distributed along the hilly land in the northeastern part.

4) Alluvial cone

This is seen at the foot of hilly land and similar to the deposit at the foot of hilly area but is often located in a relatively new area in steep alluvial fan. This is seen only at the foot of hilly land in northeastern part.

5) Flat land at the bottom of valley

This is a flat land which is affected by the alluvial action of rivers by which hilly land will be dissected. This flat land has hilly lands at both sides of it while the gentle alluvial fan stated below has no such hilly lands. This flat land is distributed in the northern and northwestern parts of the survey area.

6) Gentle alluvial fan

This fan continues to the flat land at the bottom of valley and sediment flow from the upstream area is deposited in this fan. It consists of muddy deposit and its groundwater level is high.

7) Natural levees

This natural levee consists of sandy deposit of river bank and

large-scale natural levees continue along the Parana River. Levees of this kind also are distributed in the form of narrow strip along the downstream portions of Atinguy River and Yabebyry River running through the survey area. Low land along river which is stated later is located inside of and below the natural levee. Its elevation is almost equal to that of the hinterland marsh. Forests are well developed on the natural levees in many cases.

8) Hinterland marsh

This is flat land of marsh type located behind the high portions such as natural levees. This marsh is relative dry near the hilly land but the marsh at the west center side of the survey area is always inundated.

9) High portion in hinterland marsh (higher)

Among the high portions (ups) scattered in the form of islands in the hinterland marsh, the portions which are obviously higher than the natural levees and also several meters higher than marshes in surrounding areas are classified as high portions (higher). They are distributed only in the northwestern portion of downtown of Ayalas and at the left bank side of Yabebyry River. Surface layer of the high portion consists of sandy earth.

10) High portion in hinterland marsh (lower)

This high portion has the smaller difference in elevation from the marsh compared to the high portion (higher) stated above. This portion is considered to be formed as a result of the flooding of Parana River and its tributaries and repetition of erosion and redeposition. This high portion normally consists of sandy soil and its grain tends to become coarser as the difference in elevation from the marsh becomes larger.

11) Old river channels

Former rivers which still maintain previous shapes are classified as old river channels.

Among the low lands along rivers (stated later) which are located along the present rivers, the low lands which will be easily flooded with its shape changed easily during an increase of water in rivers are

excluded from the old river channels. These channels are seen only between the natural levees west of Ayolas.

12) Low lands along rivers

These are the low lands distributed in the form of strip along rivers, which will be easily inundated by the running water from rivers. These are the swamp zone consisting of sandy and muddy deposit and not suited to the growth of trees.

13) Sand bar and sand bank

Among the high portions (ups) seen in the low lands stated previously, those which have the lower elevations compared to the natural levees are classified into sand bar and sand bank. These were formed by rivers or wind and more sandy soils are contained compared to the low lands in river bed.

Generally, trees are fixed and sand bar and bank are stabilized by these trees but there is a high potential of being inundated in view of the relative height.

(2) Drainage situations in survey area

In order to grasp the drainage situations within the survey area, data from LANDSAT was analyzed and the change in the drainage situations by season was analyzed. The results of analysis are shown in the maps of overhead flooding inundation of Figure 2-6-2.

1) Overhead flooding situations in rainy season

In the rainy seasons of February 1976 and December 1978, large-scale overhead flooding zones are recognized in the middle reaches of Atinguy River and Yabebyry River during rainy seasons. From these topographic maps, it will be known that these zones have gentler slopes and considerably lower than the northern hilly land.

2) Overhead flooding situation in dry season

In the dry seasons of July 1976 and August 1978, the overhead flooding zones and marsh zones are distributed from the downtown of Ayolas to the northwestern part. And also, a significant overhead flooding zone is recognized in the eastern part of Atinguy River. On a topographic map, these zones are located far from rivers and coincide with the

hinterland marsh with a gentle slope or the hollow type low flat land.

3) Change in drequency of ponding

In order to grasp the outline of ponding zones, the map of change in frequency of ponding of Figure 2-6-3 was prepared from ponding maps in various seasons.

Significant ponding zones are recognized in the hollow northwest of the downtown of Ayolas, in an area north of the hollow, in an area west of Access 1-B Road and in a central area east of Atinguy River.

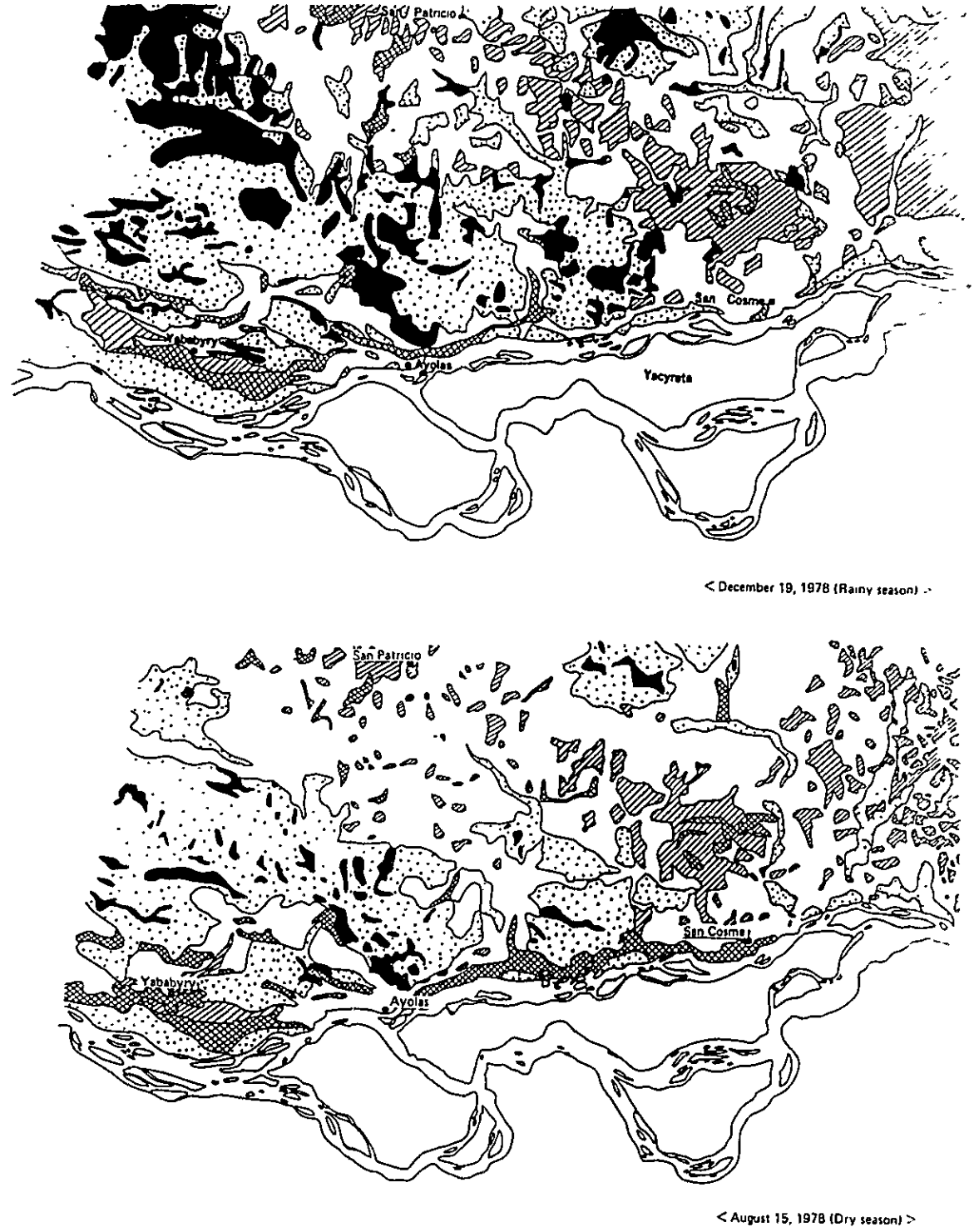



Fig. 2-6-2 Land Flooding Inundation Map 1 (Scale: 1:500,000)

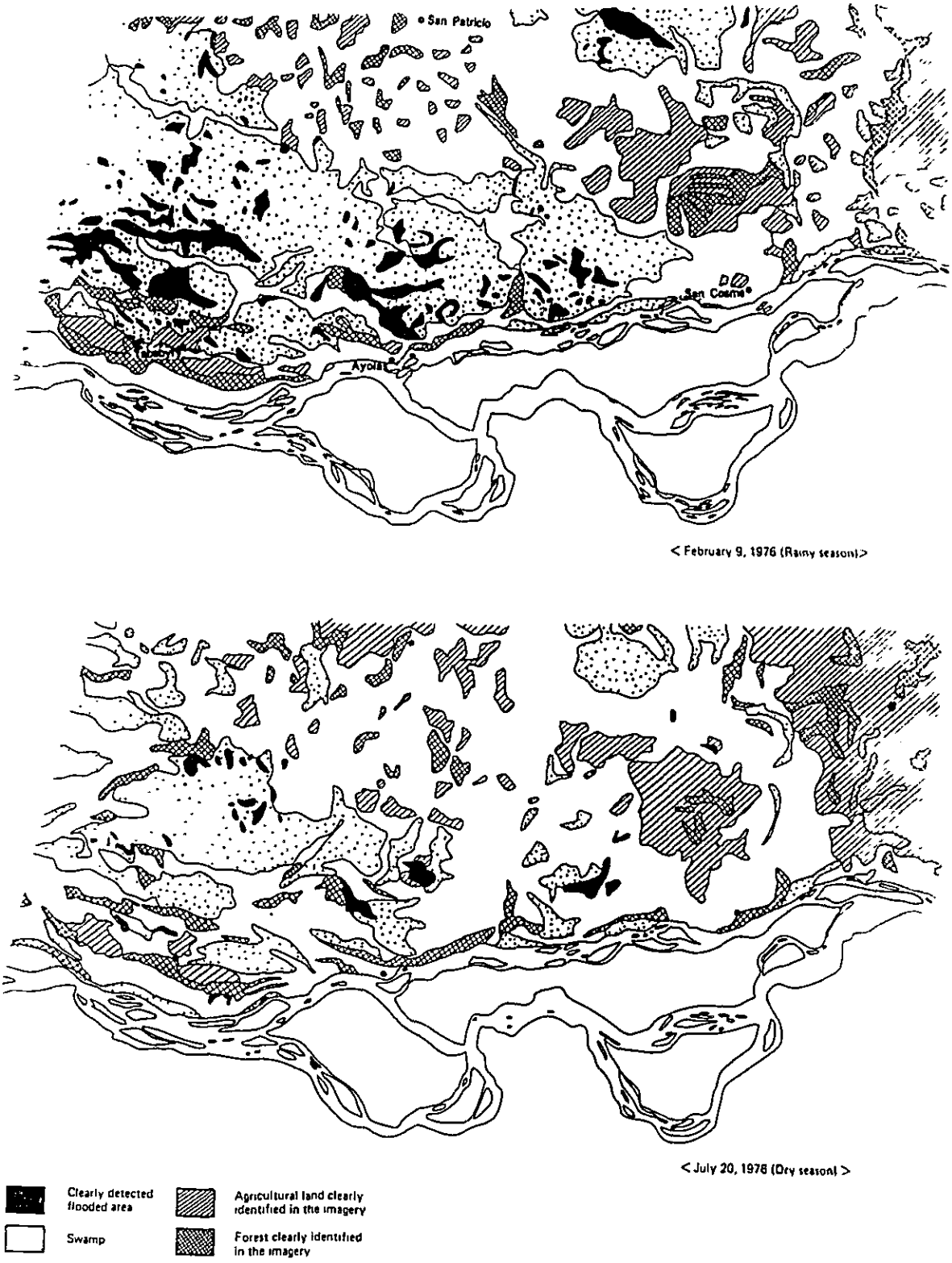



Fig. 2-6-2 Land Flooding Inundation Map 2 (Scale: 1:500,000)

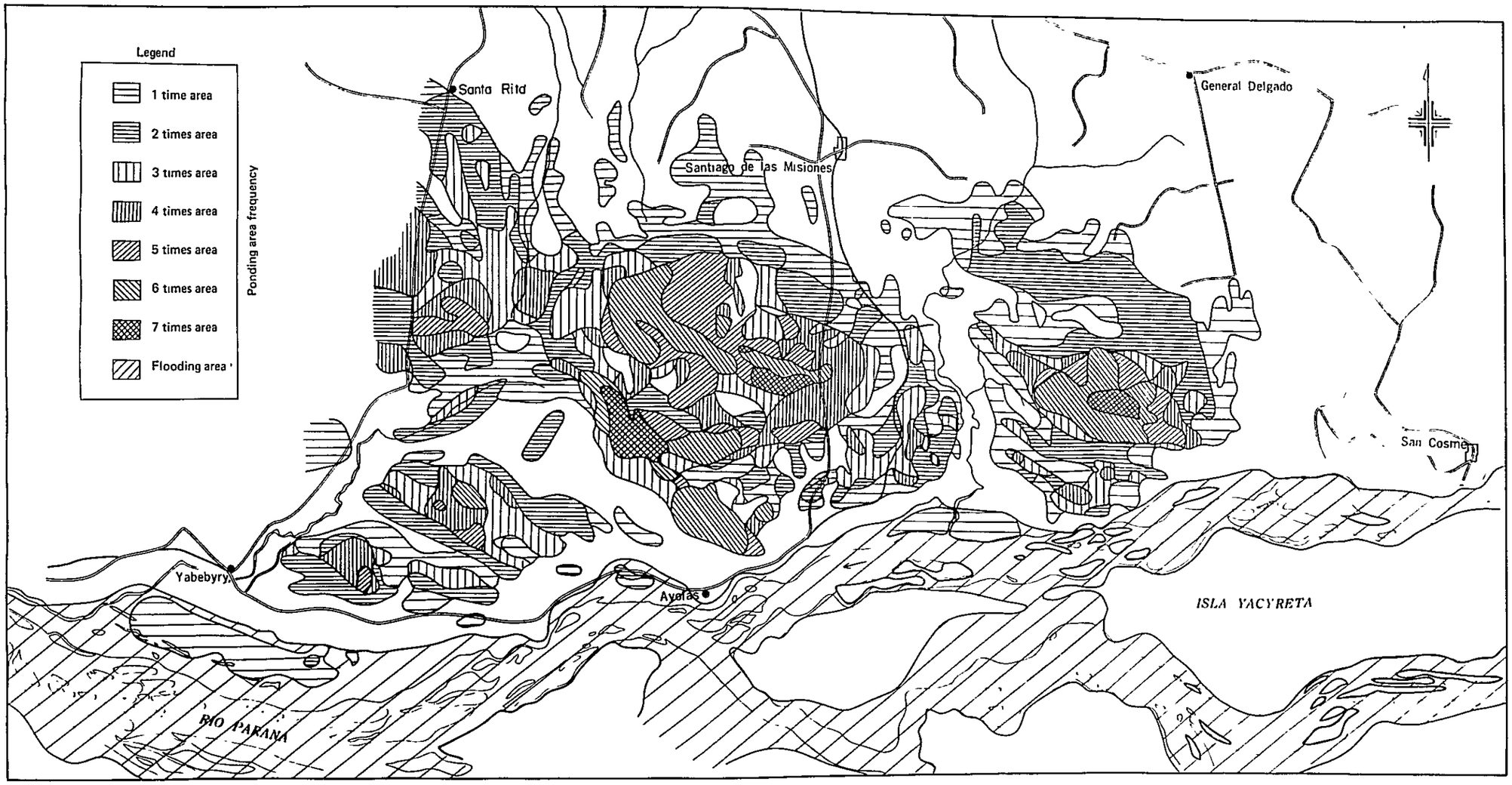



Fig. 2-6-3 1:250,000-scale Ponding Area Frequency Map

### 2.6.2 Present situations of vegetation

As already stated, most portion of the survey area is the swamp zone which changes greatly by the dry and wet conditions, where there are no standing trees and the ground is covered with natural grass.

On the natural grass land, grass suited to the dry land will grow in hilly area or high portion of land while the grass suited to wet land will mainly grow in the hinterland marsh, so that the drying conditions in a particular zone can be known from the vegetation.

Forests are well developed on the natural levees along Parana River and its tributaries such as Atinguy River and Yabebyry River while small forests are distributed in high portions scattered in the hinterland marsh, and these forests mostly comprise low trees. However, the forests on the northern hilly land mainly comprise high trees.

(1) Vegatation in forests

1) Forests on natural levees

Forests about 200 m to 1,500 m wide are well developed along the natural levees in Parana River and in lower reaches of Atinguy River and Yabebyry River. However, tall trees are mostly low, and Guaviyu (12 m high) similar to crape myrtle, Cuvupay similar to silk tree and Aguai are densely grown (30 to 5o trees per 100 $m^2$) but valuable trees are hardly seen. Grasses are mostly Kariwata and grow only in limited areas.

2) Small grouped forests in marsh

In the range of 12 to 13 km from Parana River, small grouped forests with the scale of 5 to 200 ha are scattered. These forests are located in island-like high portions (ups) which are 1 to 2 m higher than surrounding marsh and no standing trees are seen in the marshes. Density of trees is about 20 trees per 100 $m^2$.

3) Forests in hilly land

Mainly high trees grow in hilly land and the proportion of small trees is small, and the density of trees is small or 17 trees per 100 $m^2$. Results of tree survey in the typical points are shown in Figure 2-6-5.

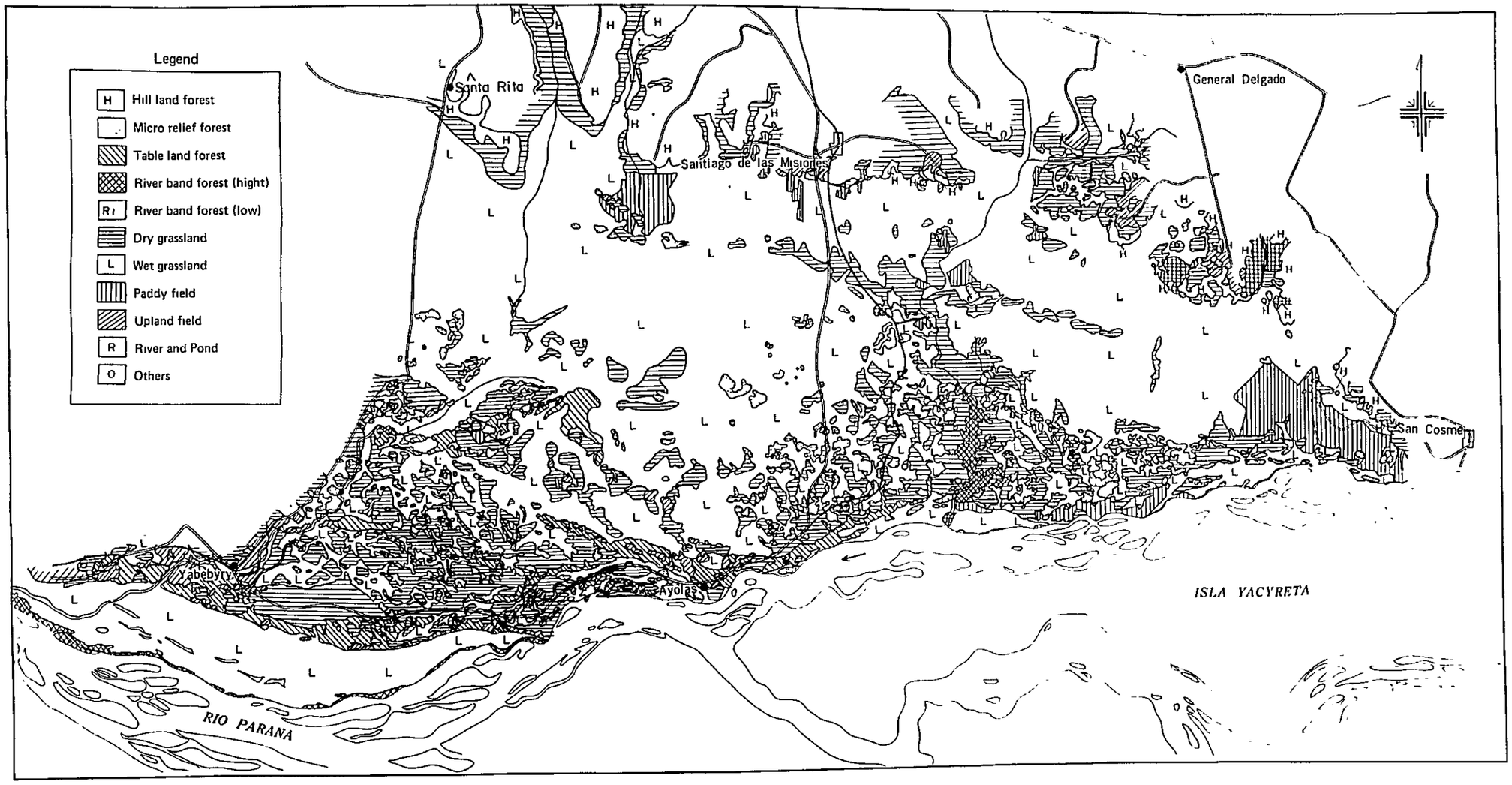
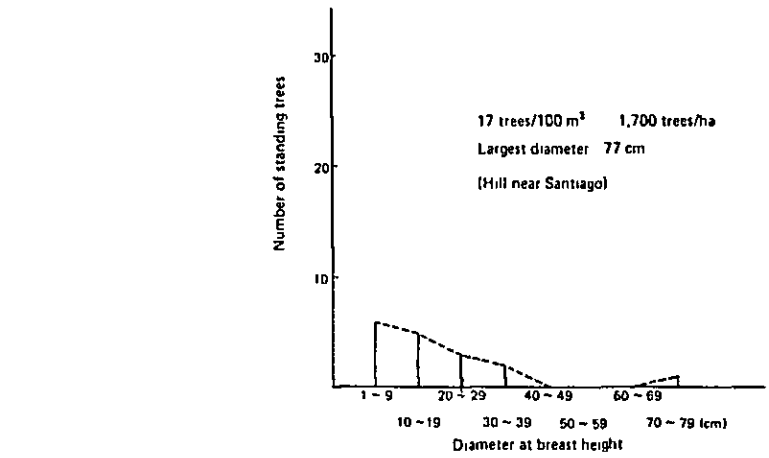
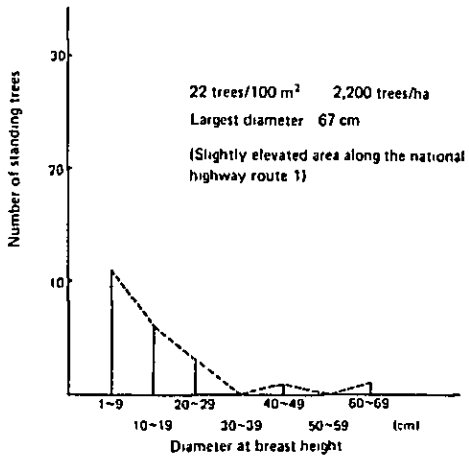
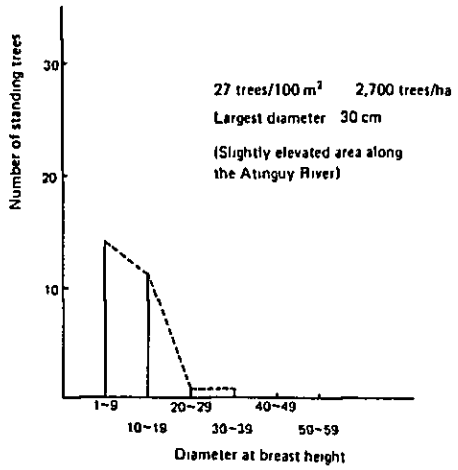
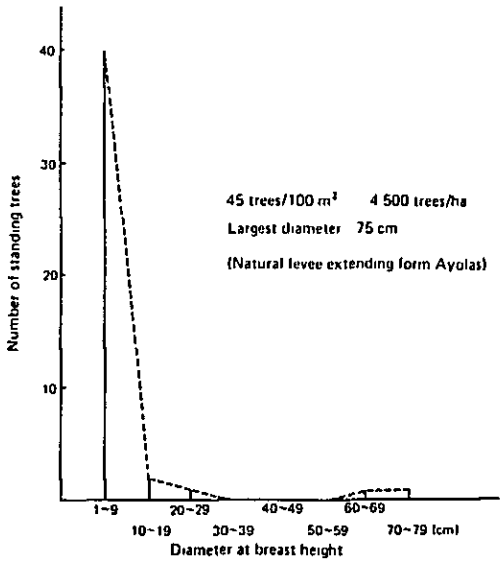



Fig. 2-6-4 Vegetation Map



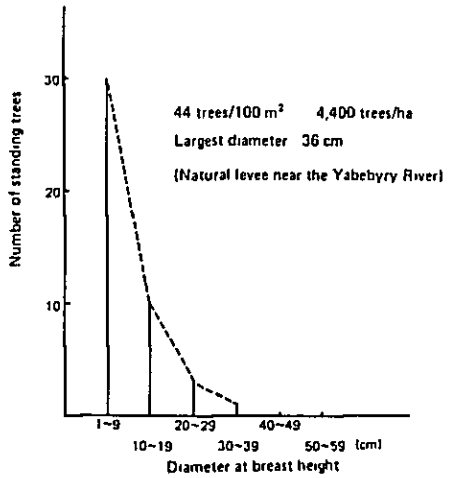




Fig. 2-6-5 The Relationship between the Diameter at Breast Height and Number of standing Trees in Different Physical Environment

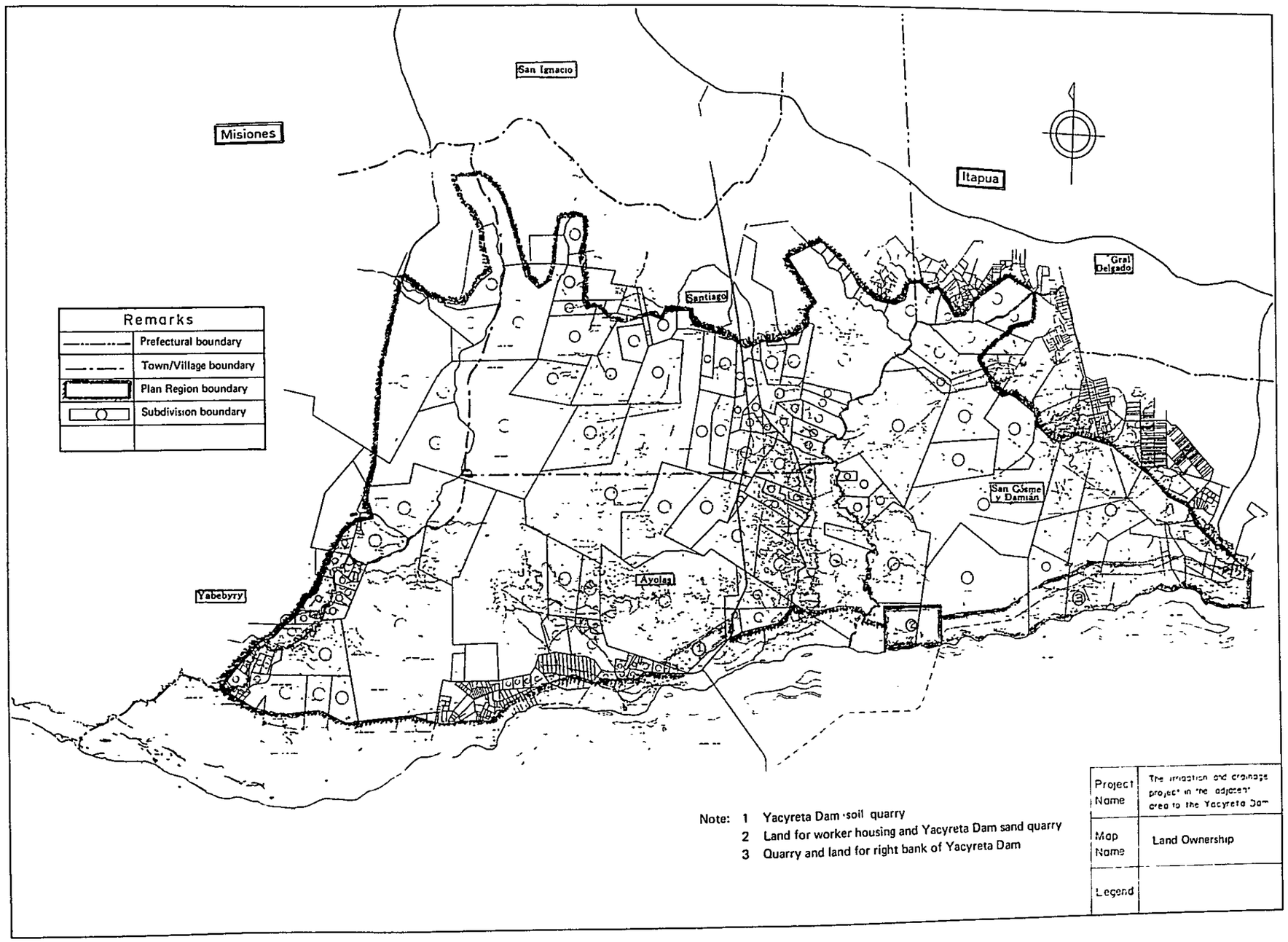



Fig. 2-6-6 Land Ownership Map

(2) Vegetation of natural grass in dry land

As typical natural grass, Past (Cabayú) is widely distributed. Espartillo similar to weeping lovegrass is not eaten after growing big cows. cows and Typychá Moriti, a shrub about 1 m high, is not eaten by cows. Therefore, these shrubs grow in groups so that pasturing power is decreased. Farmers burn fields in dry season in order to eliminate these shrubs and weeds and to rejuvenate grass land. No standing trees are seen in these grasslands probably because of the burning of fields.

(3) Vegetation of natural grass in marsh

As same as dry land, Pasto Cabayú is dominant in marsh. Capii Jhový, which is a natural grass for stock, grows in marsh. This grass is also not eaten after growing big by cows and becomes a stub, resulting in a decrease in pasturing power.

When the marsh becomes poor and ponding occurs at all times aquatic plants become dominant. Long grasses such as Pili and Agua Rupa grow in groups and water surface is covered with floating weeds such as Aguape Purúa and Aguape Guazu.

2.6.3 Present situations of land possession

In succession to the survey in fiscal year 1983, the survey of the land possession was carried out basing upon the data prepared by the Ministry of Finance, E.B.Y. and Farming Village Welfare Bureau. Outline of the land possession is as shown in Table 2-6-2.

Table 2-6-2 Situation of Land Possession in Survey Area

| Class | Area | | Number of farmers' houses | | Remarks |
|---|---|---|---|---|---|
| | Quantity | % | Quantity | % | |
| ha ha<br>0 ∿ 5 | ha | | houses | | |
| 6 ∿ 10 | 3,490 | 2 | 174 | 52 | |
| 11 ∿ 50 | 495 | 0 | 13 | 4 | |
| 51 ∿ 200 | 4,975 | 3 | 47 | 14 | |
| 201 ∿ 1,000 | 23,140 | 14 | 52 | 16 | |
| 1,001 | 135,320 | 81 | 46 | 14 | |
| Total | 167,420 | 100 | 332 | 100 | |

Note: This areas are included outside of survey area.

(1) Land for settlement

Lands for settlement are seen along Ayolas-Yabebyry Road west of the downtown of Ayolas, and part of the lands is located within the survey area.

Area assigned for one household is 20 ha, 30 ha or 40 ha, and a farm of 2 to 3 ha is cultivated by the field burning method. Mainly cassava, corn and fruit trees are raised as foods and cotton and sugar canes for sales but a large portion of marsh is not being utilized.

(2) Lands for E.B.Y.

1) Land for dam body

E.B.Y. is planning to use a range of .1 km from the axis of dam at right bank to the outer side as land at right bank of Yacyreta Dam. E.B.Y. is planning to use these lands as borrow areas at the right bank of Yacyreta Dam and also as lands for catch canal outside the dam.

2) Land for downtown

At the north side adjacent to the downtown of Ayolas, 500 ha of land is planned as housing area for offices, engineers and laborers working for the construction of Yacyreta Dam. And construction of public facilities and permanent houses is already completed in an area of 300 ha.

E.B.Y. originally planned to build temporary houses for laborers in the remaining land but the site for laborers' houses (about 800 houses) was changed to the land for borrow area at the east side of Atinguy River.

3) Material stock yard

700 ha at the north side of the intersection between Access 1-B Road and the road to Yacyreta Island is planned as land for borrow area and material stock yard.

4) Land for farmers

For residents living along Parana River and in Yacyreta Island which will be sunk under water as a result of construction of dam reservoir, E.B.Y. is planning to give compensation money and settlement land to these residents. Hearing is presently being held with the residents and no detailed plan has been made up to now.

### 2.6.4 Present situations of land utilization

Survey area is in the large swamp zone located along the Parana River, where the natural grass grow without standing trees except forests in certain parts.

In order to survey the situations of land utilization in the survey area, the land utilization map was prepared basing upon the results of reading of aerial photographs, digital image analysis of LANDSAT data, and field survey. Outline of the survey is shown in Figure 2-6-7.

Present situations of land utilization within the survey area were classified by using this land utilization map and indicated in Table 2-6-3 "Present Land Utilization and Land Areas".

Table 2-6-3 Present Land Use and Land Areas

| Class | Area | % | Remarks |
|---|---|---|---|
| | ha | | |
| Natural grasslands (dry) | 26,000 | 17.1 | |
| Natural grasslands (damp) | 83,300 | 54.7 | |
| Artivicial grasslands | 100 | 0.1 | |
| Upland fields | 1,100 | 0.7 | |
| Paddy fields | 4,500 | 2.9 | |
| Natural forests | 8,000 | 5.3 | |
| Artificial forests | 0 | 0 | |
| Swamps | 29,200 | 19.2 | |
| Rivers & ponds | 100 | 0 | |
| Others | 0 | 0 | |
| Total | 152,300 | 100 | |

Most land in the survey area is currently being used as coarse pastures (72%) which utilize the natural grass. Considerably a large area of wet land is located within these pastures and the rate of land utilization in these pastures (pasturing power) is low.

Among the hinterland marsh, about 20% of the whole is a marsh which is considerably ponded, and thus the effects of improved drainage by the development project are waited for.

Natural forests scattered in the hilly lands and high portions (ups) in the survey area have low trees and bushes, and valuable trees are hard to find. There are 4,500 ha of paddy fields but the area of actually used paddy fields is less than that since the cyclic system is employed for the paddy fields and pastures.


Fig. 2-6-7 Land use Map

(1) Natural grassland

Natural grassland, which is about 72% of the whole in area, is utilized for coarse pastures, and only 17% of the whole is dry land which can be efficiently utilized. The remaining natural grassland is always subjected to the danger of ponding and its rate of utilization is low.

(2) Artificial grassland

Some aggressive farmers developed the improved grassland (Pangora, Sudan grass, star grass, etc.) for securing coarse fodder in winter and finish fattening before shipping beef cattle but the area of the improved grassland is very small.

(3) Vegetable farms

Forests on the natural levees along Parana River south of the survey area were developed by field burning method and cassava, corn and others are being raised. These farms are small and scattered in many places.

(4) Paddy fields

In Bolf Farm east of the survey area, paddy fields of about 3,500 ha are concentrated. Irrigation water from the main stream of Parana River is pumped up and paddy rice is raised.

In the gently sloped lands (1/300 to 1/1,500 approximately) in the middle reach of Atinguy River, near Santiago and lower reach of Santiago River, the irrigation water from the hilly lands is being utilized by the gravity flow.

Farmers improve the drainage from fields by the reclamation and also improve the pasturing power by rejuvenating the grasslands.

(5) Natural forests

Natural forests in the survey area are the forests on hilly lands, forests for preventing disaster along rivers and small grouped forests in marsh. Valuable trees are almost none and these forests are poorly utilized. (Refer to the environmental conservation.)

(6) Artificial forests

Artificial forests of pines and eucalyptuses are seen on the northern hilly lands outside the survey area but hardly seen within the survey area.

(7) Marshes

As already stated previously, the marsh in this area always changes by season and weather. Marshes distributed in the hollows and middle reaches of Atinguy River and Yabebyry River are partly utilized for pasturing and the rate of utilization is low.

(8) Rivers and ponds

In the Parana River adjacent to the survey area, various kinds of fishes are seen such as Dorado similar to a large salmon, Surubyy (grows to a size of 1.5 m) which looks like a half-blood of eel and sturgeon, large eel (Pacu, Pati) and a sort of piranha (Maguruyu), and many half-farmers/half-fishermen catch these fishes to make living.

Also, Taruvy which looks like a snakehead is seen in ponded areas and tributaries within the survey area and is caught as food.

## 2.7 Outline of Livestock Industry in Paraguay

### 2.7.1 Origin of livestock farming

The origin of livestock farming in Paraguay dates away back to 1553. At that time seven cows and five oxen were introduced.

In 1568 Felipe de Caceres introduced additional 4,000 head of cattle and later on played a role of a kind of distributing center including the export of alive cattle to Chili and Argentine.

In the Francia age in the 1840's it is said that about tow million cattles were raised. Thus, cattle introduced in the colonial age has been raised with selection under the natural environment resulting in the formation of the original breed currently called "Ganado Criollo". Ganado Criollo is raised widely in Paraguay and the basin of River La Prata.

In this century European breeding stocks such as Hereford, Short horn and Aberdeen-Angus were imported to improve the traditional cattle.

Furthermore, the introduction of the Zebu stocks, Brahman and Nellore in the 1940's has lead to hybridization with the native breeds.

According to data by the Ministry of Agriculture and Livestock, since the 1950's the introduction of breeding stock from foreign countries has been encouraged in order to hasten the improvement of species in a full scale.

### 2.7.2 Number of cattle and poultry

Paraguay covers a wide flat area of 407,000 $km^2$. Livestock farming centering around a herbivorous animal, beef cattle, is the nucleus of her industry to make efficient use of the national land with little population. The total number of cattle and poultry is shown in the following table.

Table 2-7-1 Number of Farm Animals Bred

Unit: 1,000 EAM Censo

| Animal | 1975 | 1976 | 1977 | 1978 | 1979 | 1981 |
|---|---|---|---|---|---|---|
| Cattle | 5,043.3 | 5,567.7 | 5,799.9 | 5,809.5 | 5,203.3 | 6,341.4 |
| Pigs | 974.8 | 1,102.0 | 1,173.6 | 1,201.4 | 1,272.7 | 1,003.1 |
| Horses | 324.7 | 325.4 | 325.8 | 327.5 | 328.8 | |
| Sheep | 366.3 | 370.4 | 374.1 | 403.2 | 423.0 | Not totalled |
| Goats | 107.8 | 108.3 | 113.2 | 120.3 | 125.6 | |
| Chickens | 9,013.8 | 9,346.7 | 10,141.2 | 11,350.8 | 12,471.1 | |

With regard to cattle in spite of some 10% fall in 1979 compared with the previous year the number is steadily increasing, as shown in the table above.

The 1981/1975 ratio is 125.7%.

2.7.3 Improvement of livestock

Paraguay is a sparsely populated country with an average population density of 7.8 persons/$km^2$, and the total number of cattle amounts to 6.34 millions, namely two/person. Thus, cattle of twice the number of the total population is raised in such the wide land in the subtropical region for production. The area is largely covered by natural grassland, where the genera Paspalum, Axonophus, Andropagon and Cynodon are dominant and the palatability of cattle is relatively good. Some experimental finding by an agricultural experiment station indicates that the dry matter production/ha reaches 5 tons. Under such the environmental condition the improvement of livestock has been attempted in trial and error based on a hybrid of the same blood with a Zebu species called Criollo by introducing breeding stocks in each age.

Currently much effort has been put on the creation of new cattle which can be raised even in extensive management in natural grassland, can deal with the seasonal change in grazing capacity, and has resistance against pioplasma and hot weather.

Cattles introduced for these purposes include European species such as Hereford, Aberdeen Angus, Charolais and Limousin, while Nellore, Gir, Guzerat, Indo-Brazilian, Santa Gertrudis and Brahman have been introduced from Brazil and Argentine. However, the situation is no better than trial and error.

Table 2-7-2 Cattle Sales Results for the Ministry of Agriculture and Livestock Barrenito Ranch (from Annjal Statistics of S.T.I.C.A.)

(1954 ~ 1980)

| Class / Year | For breeding | | | For slaughtering | | | |
|---|---|---|---|---|---|---|---|
| | Bulls | Cows | Total | Bulls | Cows | Total | Sales total |
| | (head) | (head) | (head) | (head) | (head) | (head) | (head) |
| 1954 | 68 | - | 68 | 299 | 777 | 1,076 | 1,144 |
| 1955 | 502 | - | 502 | 656 | 723 | 1,379 | 1,881 |
| 1956 | 169 | - | 169 | 403 | 4 | 407 | 576 |
| 1957 | 216 | - | 216 | 58 | 69 | 127 | 343 |
| 1958 | 333 | - | 333 | 200 | 470 | 670 | 1,003 |
| 1959 | 65 | - | 65 | 519 | 301 | 820 | 885 |
| 1960 | 183 | - | 183 | 651 | 737 | 1,388 | 1,571 |
| 1961 | 433 | - | 433 | 400 | 249 | 649 | 1,082 |
| 1962 | 254 | - | 254 | 50 | 259 | 309 | 563 |
| 1963 | 151 | - | 151 | 500 | 644 | 1,144 | 1,295 |
| 1964 | 174 | 2,119 | 2,293 | 500 | - | 500 | 2,793 |
| 1965 | 250 | - | 250 | 110 | 116 | 226 | 476 |
| 1966 | 265 | - | 265 | 170 | 207 | 377 | 642 |
| 1967 | 170 | - | 170 | 10 | 9 | 19 | 189 |
| 1968 | 168 | 53 | 221 | - | - | - | 221 |
| 1969 | 293 | 10 | 303 | 70 | - | 70 | 373 |
| 1970 | 372 | - | 372 | 100 | 30 | 130 | 502 |
| 1971 | 531 | - | 531 | 185 | 90 | 275 | 806 |
| 1972 | 443 | 100 | 543 | 132 | 10 | 142 | 685 |
| 1973 | 453 | 160 | 613 | 99 | 100 | 199 | 812 |
| 1974 | 513 | 368 | 881 | 226 | 250 | 476 | 1,357 |
| 1975 | 419 | 290 | 709 | 61 | 131 | 192 | 901 |
| 1976 | 365 | 421 | 786 | 122 | 100 | 222 | 1,008 |
| 1977 | 371 | 347 | 718 | 171 | 145 | 316 | 1,034 |
| 1978 | 411 | 301 | 712 | 130 | 49 | 179 | 891 |
| 1979 | 370 | 505 | 875 | 258 | 9 | 267 | 1,142 |
| 1980 | 430 | 176 | 606 | 8 | 9 | 17 | 623 |
| Total | 8,372 | 4,850 | 13,222 | 6,098 | 5,488 | 11,576 | 24,798 |

The table above shows the actual record of breeding stocks production and distribution within the nation at the Barrerito Experimental Stock Farm by year. Barrerito is raising 7,000 head of beef cattle including Nellore, Brahman, Santa Gertrudis for breeding stock production.

Meanwhile, the Center of Artificial Insemination (Centro de Inseminacion Artificial) is grazing 15 breeding stocks in the improved pasture throughout a year, and producing taklet semeu by gathering sperm twice a week to sell to large scale stock farms. The selling record and prices are shown in Table

The selling record of the taklet semeu indicates that the Nellore and Brahman species, which are sold most widely, share approx. 34% and 30% of the total, respectively, although preference differs according to nicking with cow, vigor of spermatozoon, form and disposition of breeding stocks and others. The selling prices are dependent on the disposition of individual, and divided into four grades by every 50 Gs up to the highest price of 300 Gs according to the supply-demand relation, disposition and

Table 2-7-3 Seamen Sales for Farm Livestock Artificial Fertilization Center According to Year (1974 ∿ 1981)
(from Livestock Development Plan Annual Statistics)

| Breed \ Year | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | Sub-Total | 1981 (Jan.∿Jun.) | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Brahman | 21,305 | 18,808 | 16,326 | 21,450 | 27,555 | 25,365 | 27,753 | 158,562 | 2,300 | 160,862 |
| Nelore | 15,243 | 17,897 | 25,890 | 25,772 | 30,270 | 24,691 | 37,290 | 177,053 | 5,673 | 182,726 |
| Sta. Gertrudis | 4,880 | 5,683 | 4,835 | 7,977 | 9,430 | 5,783 | 9,248 | 47,836 | 3,092 | 50,928 |
| Fleckvieh (1) | - | 1,085 | 3,710 | 5,842 | 7,262 | 8,082 | 3,265 | 29,246 | 139 | 29,385 |
| A. Angus | 970 | 1,635 | 4,375 | 3,500 | 2,985 | 2,905 | 7,423 | 23,793 | 201 | 23,994 |
| Charolais | 2,966 | 3,035 | 4,662 | 4,122 | 6,366 | 5,620 | 4,145 | 30,916 | 355 | 31,271 |
| Limousin (2) | - | - | 1,890 | 3,360 | 1,655 | 2,740 | 655 | 10,300 | 151 | 10,451 |
| Chianina | 7,079 | 5,955 | 5,019 | 2,482 | 3,345 | 1,750 | 380 | 26,010 | 50 | 26,060 |
| Holande | 495 | 774 | 1,060 | 2,235 | 1,680 | 1,723 | 1,497 | 9,464 | 1,374 | 10,838 |
| Pardo Suizo | 559 | 622 | 480 | 655 | 595 | 820 | 985 | 4,716 | 91 | 4,807 |
| Hereford (3) | - | - | - | 520 | 510 | 659 | 700 | 2,389 | 50 | 2,439 |
| Jersey (4) | 571 | 115 | - | - | - | 160 | 76 | 922 | 136 | 1,058 |
| Normando (5) | - | - | - | - | - | - | 5,000 | 5,000 | - | 5,000 |
| Sinmetal (6) | - | - | - | - | - | - | - | - | 2 | 2 |
| Total | 54,068 | 55,609 | 68,247 | 77,915 | 91,653 | 80,298 | 98,417 | 526,207 | 13,614 | 539,821 |

Notes: (1) Fleckvier sales begun from 1975.
(2) Limousin sales begun from 1976.
(3) Hereford sales begun from 1977.
(4) Jerseysales begun in 1974 and 1975 and terminated in 1978.
(5) Normando sales for 1980.
(6) Sinmental sales begun from 1981.

Table 2-7-4 Value of Sales by Livestock Artificial Insemination Center (1981)

| Breed | | Country of production | Value of sales (Garani) |
|---|---|---|---|
| Nelore | No. 2441 | Brasil | 300 |
| " | " 2599 | " | 250 |
| " | " 495 (Mocho) | Paraguay | 250 |
| " | " 5050 | Brasil | 300 |
| Brahaman | No. 689 | U. S. A. | 300 |
| " | " 213 | Paraguay | 300 |
| " | " 78 | " | 250 |
| " | " 876 | U. S. A. | 300 |
| " | " 801 | " | 300 |
| " | " 174 | " | 300 |
| " | " 210 | Argentina | 250 |
| Sta. Gertrudis | No. 102 | Paraguay | 250 |
| " | " 110 | U. S. A. | 300 |
| " | " 255 | Paraguay | 250 |
| " | " 04 | " | 250 |
| " | " 041 | " | 200 |
| A. Angus | No. 2737 | U. S. A. | 300 |
| " | " 896 | " | 250 |
| " | " 1583 | Argentina | 250 |
| Chianina | No. 1 | Italia | 200 |
| " | " 2 | " | 200 |
| Fleckvieh | No. 45B | Argentina | 250 |
| " | " 45 | " | 250 |
| Simental | No. 2237 | Suiza | 300 |
| Limousin | No. 14 | Argentina | 250 |
| Charolais | No. 96 | " | 250 |
| Hereford | No. X239 | " | 200 |
| Pardo Suizo | No. 215 | " | 200 |
| " | " 7418 | Suiza | 300 |
| Holando | No. 733 | U. S. A. | 200 |
| " | " 792 | " | 200 |
| " | " 296 | Uruguay | 200 |
| " | " 1741 | U. S. A. | 300 |
| Jersy | No. 600 | Uruguay | 150 |

Note: These prices were effective for June 23, 1981.

properties of semeu.

2.7.4 Breeding of cattle

Breeding of beef cattle in Paraguay is performed by natural mating. In general, one breeding stocks is alloted to a group of 30 to 40 cows, but the allocation varies according to a variety of factors such as paddock division (fence wire is higher) and herder.

Cattle herd management systems can be roughly grouped as follows:

① All cattle is managed as a group.
② Fattening cattle is managed separately.
③ Stock cattle and cows for rearing are managed separately.
④ Cows, bulls, fattening cows and steers are managed separately.

Thus, the management systems vary from a very primitive extensive method to a method in which a herd of cattle is managed separately by different purposes for rearing.

Improved breeding stock with a more than 3/4 blood amount is getting more popular as bull for breeding, which indicates the desire of the Paraguayan Government for improving cattle. On the other hand, cows calve every two years resulting in low productivity because of their peculiar biological cycle; since the grazing capacity drops sharply in winter, the sexual cycle enters in hibernation with rare estrus, and with the recovery of nutrition from spring to summer and with an increasing weight estrus comes back leading to a breeding season.

An illustration of the breeding system in Paraguay is shown in the figure below. The renewal and improvement of cattle has been performed from generation to generation by using improved cattle of the top layer and F1 (hybrid) of the improved cattle with the shift to a lower layer.

Generally, productivity at beef cattle stock farms is rather low; 40 ∿ 45% in the Oriental, while 45 ∿ 50% in the Occidental in terms of delivery rate. These values are much lower compared with those in Argentine and Uruguay.

Unless calving every other year owing to the low grazing capacity, as pointed out before, is solved, much difficulty will still be there. In addition, the accident rate of calf until the weaning period is high

mainly because of scours, vermination and pneumonia.

Accident rate of calf until the weaning period

..... Approx. 15%

Accident rate of fattening cattle until consignment

..... Approx. 5%

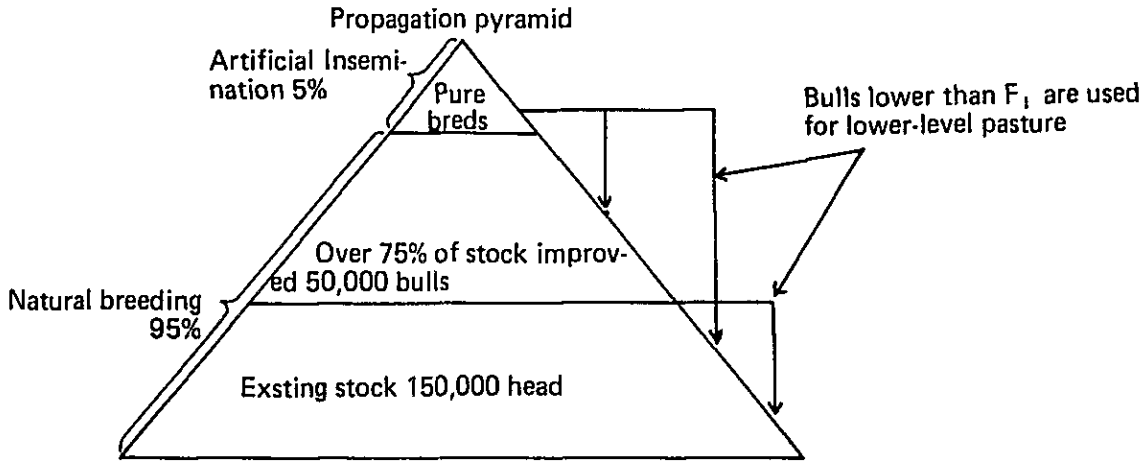



Fig. 2-7-1 Breeding Illustration

## 2.8 Food Demand and Supply of Paraguayan People

As shown in Table 2-8-1, the plan of food supply for 1980 has been set up by the studying group of Agriculture and livestock farming Dept. in Paraguay.

This Table reveals that the foods people consumed most in volume have been starchs (potatoes) followed by fruits, cereals and meats. In seeing the contents in details by category, it is made clear that corns are the most consumed foods in the category of cereals (Table 2-8-2), with the domestic production amounting to approx. 367,000 t. The breakdown of demand for corns is devided into the exports (14,000 t.), livestock feeds and others excluding foods (188,000 t.) and food for people (165,000 t.). As long as wheat is concerned, the greater portion is imported as it's domestic production is confined to 34,000 t. equivalent to 23% of the total supply. Regarding the rice, the domestic production amounts to 62,000 t. of which 2,000 t. is exported, 3,000 t. being a natural decrease and 55,000 t. is the total food consumption.

Talking about the starchs, manjoca is consumed most in volume accounting for 86% of the total demand of starchs. In addition, 30% of the total food consumption is occupied by manjoca. All the manjocas are domestically produced and amount to 1.97 million t. in volume. 857,000 t. of manjocas are consumed for livestock feed and 735,000 t. are just for food. 100,000 t. of sweet potatoes and 15,000 t. of potatoes are consumed, and 6,000 t. are imported out of them.

The most consumed beans in volume are porotto beans whose production amounts to 61,000 t.. 20% of them is exported and 38,000 t. are consumed domestically. The other beans are peanuts and green peas. Soybeans is ranked second next to manjoca in terms of domestic production though the consumption as food is small. Soybeans production amounts to 445,000 t., of which 73% is exported, 14% used for oil expression, a little bit decreased in seed, and the remaining 12,000 t. is consumed as food.

All the vegetables except onion are self-supported and 17% of tomato production is exported.

All the fruits are self-supported as well as the vegetables. Oranges (239,000 t.), banana (149,000 t.) and watermelon (129,000 t.)

occupies approx. 80% of all the fruits. Regarding the grapefruits and pine-apples, 5 to 10% of production is exported respectively though they are very small in quantity. Exported grapefruits amount to 1,400 t., pine-apples to 1,890 t..

Of all the meats beef is most produced and consumed in volume. Beef is followed by pork Beef/pork and their kidneys occupies 96% of the meats in total in terms of volume. Especially, beef and it's kidney amount to approx. 70% of the meats. Although they keep almost the same level concerning consumed foods, 10% of produced beef is exported.

With regards to milk and milk products 139,000 t. is produced and 6,000 t. is imported. 41% of milk production amounting to 133,000 t. is forwarded to the processed materials such as butter and cheese.

Eggs are self-supported as a whole. Regarding oils and fats approx. 7% of soybean oil and mixed oil productions is respectively exported.

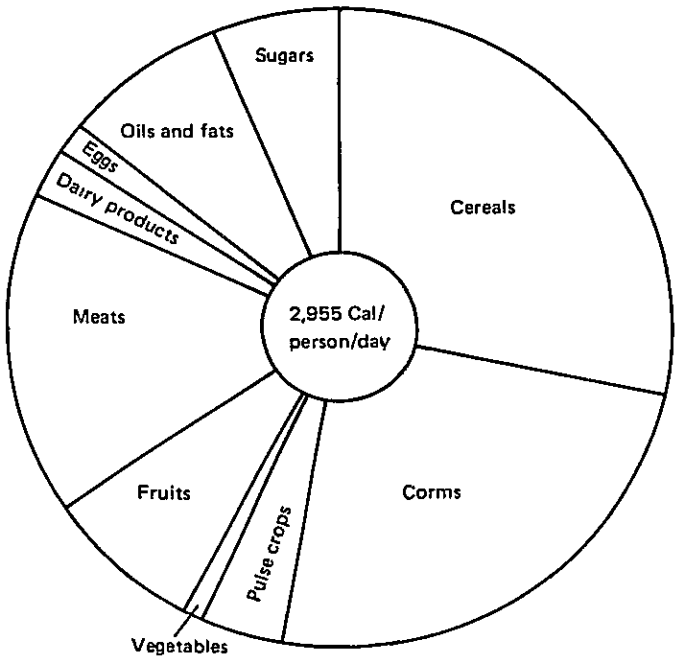
Sugar production amounts to 72,000 t., of which less than 24% is exported. The other products to be exported are coffee, matê and rum.

Table 2-8-1 List of Supply and Demand of Foods (1980)

(Unit: ton)

| Item | Supply | | | | Other purpose | | | | Consumption food | | Consumption amount per capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production amount | Import amount | Export amount | Total supply | Seed | Liverstock feed | Processing resources | Natural decrease | Total food | Net food | Consumption amount/ capita/year | Consumption amount/ capita/day |
| | | | | | | | | | | | g | g |
| Cereals | 463,452 | 113,693 | 15,805 | 561,340 | 10,106 | 146,730 | - | 42,843 | 361,661 | 254,850 | 83,200 | 227.9 |
| Corms | 2,116,820 | 6,100 | 6,700 | 2,116,220 | 1,797 | 863,817 | | 400,227 | 850,379 | 503,150 | 164,300 | 440.2 |
| Pulse crops | 529,600 | - | 336,286 | 193,314 | 26,430 | - | 67,771 | 35,160 | 63,953 | 60,500 | 19,730 | 51.1 |
| Vegetables | 95,610 | 3,540 | 3,490 | 95,660 | 240 | - | - | 7,409 | 88,011 | 78,468 | 21,730 | 65.2 |
| Fruits | 663,951 | - | 3,290 | 660,661 | - | - | - | 115,050 | 545,611 | 401,354 | 131,500 | 258.2 |
| Meats(Carcass) | 235,424 | - | 16,676 | 218,748 | - | - | - | 14,960 | 203,788 | 203,788 | 116,625 | 188.5 |
| Dairy products | 139,084 | 5,952 | - | 145,036 | - | - | 54,605 | - | 90,431 | 90,431 | 29,540 | 80.9 |
| Eggs | 32,245 | - | - | 32,245 | - | - | - | - | 32,245 | 32,245 | 10,530 | 26.9 |
| Oils and fats | 34,369 | - | 2,366 | 31,903 | - | - | - | - | 32,003 | 32,003 | 7,100 | 28.6 |
| Sugars | 72,585 | - | 17,069 | 55,516 | - | - | - | - | 55,516 | 55,516 | 18,670 | 51.2 |
| Non-alcoholic drinks | 72,026 | - | 5,733 | 66,293 | - | - | - | - | 66,293 | 66,293 | 21,650 | 59.3 |
| Alcoholic drinks | 61,694 | 1,000 | 1,555 | 61,139 | - | - | - | - | 61,139 | 61,139 | 19,970 | 51.7 |
| Total | 4,516,860 | 130,285 | 408,970 | 4,238,175 | 38,573 | 1,013,547 | 122,376 | 615,649 | 2,451,035 | 1,839,737 | 647,545 | 1,587.7 |

Rate of Calorie Intake Classify in Paraguay
(1977 ~ 1982 year average)




Rate of Calorie Intake Classify in Japan
(1980)

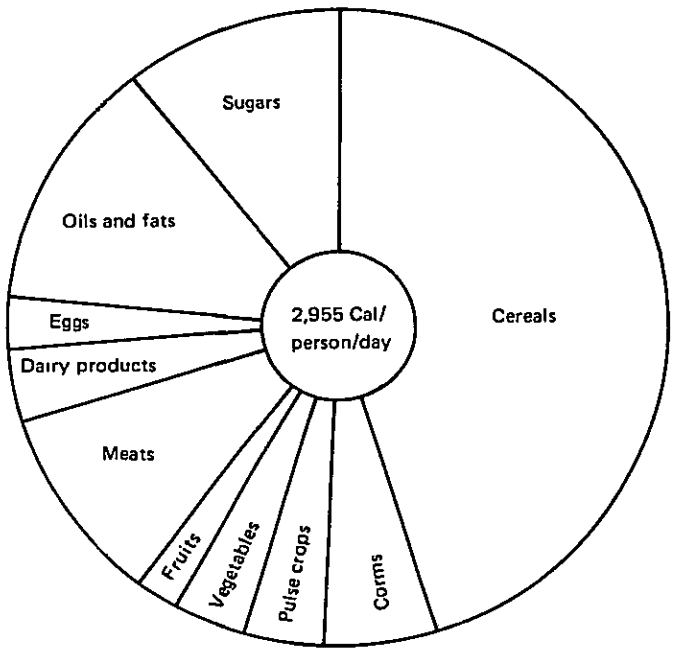



Fig. 2-8-1

Table 2-8-2 List of Food Supply and Demand 1982 (Unit: ton)

| Item | Supply | | | | Seed, feed, processing purpose | | | | Consumption food amount | | Net food amount/person | | User's rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production amount | Import amount | Export amount | Total supply amount | Seed | Live-stock feed | Process-sing resource | Natural decrease | Total food amount | Net food amount | Consumption amount/ capita/year | Consumption amount/ capita/day | |
| | | | | | | | | | | | g | g | % |
| Cereals | 463,452 | 113,693 | 15,805 | 561,340 | 10,106 | 146,730 | - | 42,843 | 361,661 | 254,850 | 83,200 | 227.9 | - |
| Wheat | 34,444 | 113,693 | - | 148,137 | 3,298 | - | - | 2,849 | 141,990 | 104,363 | 34,100 | 93.4 | 73.5 |
| Rice | 62,188 | - | 1,595 | 60,593 | 2,518 | - | - | 3,314 | 54,761 | 35,050 | 11,400 | 31.2 | 34.0 |
| Maize | 366,820 | - | 14,210 | 352,610 | 4,290 | 146,730 | - | 36,680 | 164,910 | 115,437 | 37,700 | 103.3 | 70.0 |
| Corms | 2,116,820 | 6,100 | 6,700 | 2,116,220 | 1,797 | 863,817 | - | 400,227 | 850,379 | 503,150 | 164,300 | 440.2 | - |
| Cassava | 1,970,100 | - | - | 1,970,100 | | 857,117 | - | 378,224 | 734,759 | 404,117 | 132,000 | 351.6 | 55.0 |
| Potato | 12,720 | 6,100 | - | 18,820 | 1,797 | - | - | 1,903 | 15,120 | 13,608 | 4,400 | 12.2 | 90.0 |
| Sweet poteto | 134,000 | - | 6,700 | 127,300 | - | 6,700 | - | 20,100 | 100,500 | 85,425 | 27,900 | 76.4 | 85.0 |
| Pulse crops | 529,600 | - | 336,286 | 193,314 | 26,430 | - | 67,771 | 35,160 | 63,953 | 60,500 | 19,730 | 54.1 | - |
| Pea | 3,900 | - | - | 3,900 | 328 | - | - | 381 | 3,191 | 3,191 | 1,040 | 2.9 | - |
| Poroto beans | 60,800 | - | 12,173 | 48,627 | 2,160 | - | - | 8,192 | 38,275 | 38,275 | 12,500 | 34.2 | - |
| Peanut | 19,900 | - | - | 19,900 | 1,692 | - | 3,691 | 3,005 | 11,512 | 8,057 | 2,600 | 7.2 | 70.0 |
| Soybean | 445,000 | - | 324,113 | 120,887 | 22,250 | - | 64,080 | 23,582 | 10,975 | 10,975 | 3,590 | 9.8 | - |
| Vegetables | 95,610 | 3,540 | 3,490 | 95,660 | 240 | - | - | 7,409 | 88,011 | 78,468 | 24,730 | 65.2 | - |
| Onion | 26,670 | 3,540 | - | 30,210 | - | - | - | 2,990 | 27,220 | 24,498 | 8,000 | 21.9 | 90.0 |
| Garlic | 960 | - | - | 960 | - | - | - | 29 | 691 | 670 | 220 | 0.6 | 97.0 |
| Pumpkin | 23,400 | - | - | 23,400 | - | - | - | 1,160 | 22,240 | 17,790 | 5,810 | 15.9 | 80.0 |
| Tomato | 19,870 | - | 3,490 | 16,380 | - | - | - | 1,990 | 14,390 | 14,390 | 4,700 | 12.9 | - |
| Other vegetables | 24,710 | - | - | 24,710 | - | - | - | 1,240 | 23,470 | 21,120 | 6,000 | 13.9 | 90.0 |
| Fruits | 663,751 | - | 3,290 | 660,661 | - | - | - | 115,050 | 545,611 | 401,354 | 131,500 | 258.2 | - |
| Avocado | 2,900 | - | - | 2,900 | - | - | - | 500 | 2,400 | 1,440 | 500 | 1.4 | 60.0 |
| Banana | 148,830 | - | - | 148,830 | - | - | - | 28,110 | 120,720 | 96,576 | 31,500 | 36.4 | 80.0 |
| Japanese apricot | 1,390 | - | - | 1,390 | - | - | - | 70 | 1,320 | 1,120 | 400 | 1.1 | 85.0 |
| Peach | 1,980 | - | - | 1,980 | - | - | - | 100 | 1,880 | 1,600 | 500 | 1.4 | 85.0 |
| Strawberry | 600 | - | - | 600 | - | - | - | 30 | 570 | 570 | 200 | 0.5 | - |
| Lemon | 1,030 | - | - | 1,030 | - | - | - | 60 | 970 | 870 | 300 | 0.8 | 90.0 |

| Item | Supply | | | | Seed, feed, processing purpose | | | | Consumption food amount | | Net food amount/person | | User's rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production amount | Import amount | Export amount | Total supply amount | Seed | Live-stock feed | Process-sing resource | Natural decrease | Total food amount | Net food amount | Consumption amount/ capita/year | Consumption amount/ capita/day | |
| | | | | | | | | | | | g | g | % |
| (Fruits Cont'd.) | | | | | | | | | | | | | |
| Lemon (real) | 1,000 | - | - | 1,000 | - | - | - | 50 | 950 | 855 | 300 | 0.8 | 90.0 |
| Lemon (sutil) | 6,170 | - | - | 6,170 | - | - | - | 620 | 5,550 | 4,995 | 1,600 | 4.4 | 90.0 |
| Mango | 11,550 | - | - | 11,550 | - | - | - | 1,730 | 9,820 | 3,928 | 1,300 | 3.6 | 40.0 |
| Mamon | 2,240 | - | - | 2,240 | - | - | - | 110 | 2,130 | 1,700 | 600 | 1.6 | 80.0 |
| Melon | 19,490 | - | - | 19,490 | - | - | - | 1,900 | 17,590 | 12,310 | 4,000 | 11.0 | 70.0 |
| Apple and pear | 731 | - | - | 731 | - | - | - | - | 731 | 658 | 200 | 0.5 | 90.0 |
| Mandarin | 36,800 | - | - | 36,800 | - | - | - | 3,700 | 33,100 | 29,790 | 9,700 | 26.6 | 90.0 |
| Orange | 239,030 | - | - | 239,030 | - | - | - | 44,820 | 194,210 | 135,050 | 44,400 | 121.6 | 70.0 |
| Grapefruit | 31,000 | - | 1,400 | 29,600 | - | - | - | 5,200 | 24,400 | 16,800 | 5,600 | 15.3 | 70.0 |
| Pineapple | 14,370 | - | 1,890 | 12,480 | - | - | - | 1,380 | 11,100 | 8,912 | 2,900 | 7.9 | 80.0 |
| Water melon | 129,500 | - | - | 129,500 | - | - | - | 25,900 | 103,600 | 72,500 | 23,700 | 64.9 | 70.0 |
| Grape | 15,340 | - | - | 15,340 | - | - | - | 770 | 14,570 | 11,660 | 3,800 | 10.4 | 80.0 |
| Meats | 235,424 | - | 16,676 | 218,748 | - | - | - | 14,960 | 203,788 | 203,788 | 116,625 | 188.5 | - |
| Beef (Carcass) | 144,745 | - | 14,960 | 129,785 | - | - | - | 14,960 | 114,825 | 114,825 | 87,500 | 102.7 | - |
| Mutton (Carcass) | 2,096 | - | - | 2,096 | - | - | - | - | 2,096 | 2,096 | 685 | 1.9 | - |
| Goat meat (Carcass) | 246 | - | - | 246 | - | - | - | - | 246 | 246 | 80 | 0.2 | - |
| Pork (Carcass) | 64,134 | - | - | 64,134 | - | - | - | - | 64,134 | 64,134 | 20,950 | 57.4 | - |
| Horse meat (Carcass) | 207 | - | - | 207 | - | - | - | - | 207 | 207 | 60 | 0.2 | - |
| Chiken | 3,494 | - | - | 3,494 | - | - | - | - | 3,494 | 3,494 | 1,140 | 3.2 | - |
| Fish | 2,150 | - | - | 2,150 | - | - | - | - | 2,150 | 2,150 | 780 | 1.9 | - |
| Horse internal organ | 16,214 | - | 1,716 | 14,498 | - | - | - | - | 14,498 | 14,498 | 4,730 | 19.0 | - |
| Pork internal organ | 2,138 | - | - | 2,138 | - | - | - | - | 2,138 | 2,138 | 700 | 2.0 | - |
| Milk, dairy products | 139,084 | 5,952 | - | 145,036 | - | - | 54,605 | - | 90,431 | 90,431 | 29,540 | 80.9 | - |
| Milk | 133,163 | 5,952 | - | 139,115 | - | - | 54,605 | - | 84,510 | 84,510 | 27,600 | 75.6 | - |
| Cheese | 5,590 | - | - | 5,590 | - | - | - | - | 5,590 | 5,590 | 1,830 | 5.0 | - |
| Butter | 331 | - | - | 331 | - | - | - | - | 331 | 331 | 110 | 0.3 | - |

| Item | Supply | | | | Seed, feed, processing purpose | | | | Consumption food amount | | Net food amount/person | | User's rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Production amount | Import amount | Export amount | Total supply amount | Seed | Live-stock feed | Process-sing resource | Natural decrease | Total food amount | Net food amount | Consumption amount/ capita/year | Consumption amount/ capita/day | |
| | | | | | | | | | | | g | g | % |
| Eggs | 32,245 | - | - | 32,245 | - | - | - | - | 32,245 | 32,245 | 10,530 | 26.9 | |
| Hen egg | 32,245 | - | - | 32,245 | - | - | - | - | 32,245 | 32,245 | 10,530 | 26.9 | |
| Oils and fats | 34,369 | - | 2,366 | 32,003 | - | - | - | - | 32,003 | 32,003 | 10,520 | 28.6 | |
| Lard | 14,625 | - | - | 14,625 | - | - | - | - | 14,625 | 14,625 | 4,780 | 13.1 | |
| Cotton oil | 2,803 | - | - | 2,803 | - | - | - | - | 2,803 | 2,803 | 980 | 2.5 | |
| Soybean oil | 2,359 | - | 859 | 1,500 | - | - | - | - | 1,500 | 1,500 | 490 | 1.3 | |
| Peanut oil | 1,439 | - | - | 1,439 | - | - | - | - | 1,439 | 1,439 | 470 | 1.3 | |
| Mixed oil | 13,143 | - | 1,507 | 11,636 | - | - | - | - | 11,636 | 11,636 | 380 | 10.4 | |
| Sugars | 72,585 | - | 17,069 | 55,516 | - | - | - | - | 55,516 | 55,516 | 18,670 | 51.2 | |
| Sugar | 72,027 | - | 17,069 | 54,958 | - | - | - | - | 54,958 | 54,958 | 18,490 | 50.7 | |
| Honey | 558 | - | - | 558 | - | - | - | - | 558 | 558 | 180 | 0.5 | |
| Non alcoholic drinks | 72,026 | - | 5,733 | 66,293 | - | - | - | - | 66,293 | 66,293 | 21,650 | 59.3 | |
| Coffee | 8,326 | - | 3,733 | 4,593 | - | - | - | - | 4,593 | 4,593 | 1,500 | 4.1 | |
| Aerated water | 42,103 | - | - | 42,103 | - | - | - | - | 42,103 | 42,103 | 13,750 | 37.7 | |
| Mate | 21,597 | - | 2,000 | 19,597 | - | - | - | - | 19,597 | 19,597 | 6,400 | 17.5 | |
| Alcoholic drinks | 61,694 | 1,000 | 1,555 | 61,139 | - | - | - | - | 61,139 | 61,139 | 19,770 | 54.7 | |
| Rum | 14,722 | - | 1,555 | 13,167 | - | - | - | - | 13,167 | 13,167 | 4,300 | 11.8 | |
| Beer | 38,338 | - | - | 38,338 | - | - | - | - | 38,338 | 38,338 | 12,520 | 34.3 | |
| Wine | 8,634 | 1,000 | - | 9,634 | - | - | - | - | 9,634 | 9,634 | 3,150 | 8.6 | |
| Total | 4,516,860 | 130,285 | 408,970 | 4,238,175 | 38,573 | 1,010,547 | 122,376 | 615,649 | 2,451,030 | 1,839,737 | 647,545 | 1,587.7 | |

Note 1. Of all the materials to be processed, peanuts and soybeans are used as the materials to be expressed for producing oil. Milk is used as the materials of ice-cream and milk sweets as well as cheese and butter.

2. This statistics are made by Statistics Section of the Ministry of Agriculture and Livestock who collected and arranged as much data as possible. However, there can be inaccurate data depending upon a part.
Absence of figures by category concerning vegetables makes the computation of nutritive elements insufficient.
Sugar is not classified into sugar and syrup and cakes are not surveyed. Although honey is somehow exported, exported volume is not excluded.



Data

1. This statistics were made by the study group consisting of AMILCAR B. GODOY MARTINEZ DONNA HAUSER M.S. as well as Agronomist Eng. PEDRO GONZALEZ, DONNA HAUSER M.S. and RODOLFO DUARTE who belong to the Statistics Section of the Ministry of Agriculture and Livestock in the Republic of Paraguay.
They computed the nutritive intake of Paraguayan people by estimating the table of food demand and supply/year collected since 1968, and made the statistics from statistical data by which they forecast the food consumption level of the people for 1977 and 1982 based upon the Latin American Nutrition level and the table of nutrition elements.

2. According to U.N. method the first line of 'Supply' must be filled with 'Stock'. However, in this country the production statistics are not available and, in addition, distribution and inventory statistics are not produced. Therefore, the blank for 'stock' is not set up.

## 2.9 Production of Main Crops and Trend of Their Markets

### 2.9.1 Rice

More than one hundred years have already passed since the paddy rice culture was started in Paraguay. In 1980 the growing area has increased to 24,000 hectares including the area in both Itapua and Misiones provinces (both are surveyed this time) which accounts for approximately 70% of all the growing area of wet paddy in the country and the amount of production have reached 54,000 t. (Refer Table 2-9-1)

The upland rice culture was commenced by Brazilian immigrants living in the border area from the latter part of 1960, and the growing area amounts to 14,000 hectares with the production of 19,000 t in 1980.

In the last 5 years the average rates of paddy rice in both the total paddy area and the total production have been approximately 65% and 75% respectively.

Paddy rice is overwhelmingly superior in terms of production a hectare. In the last 10 years wet paddy production shows approximately 2,300 kg/ha, upland rice showing 1,400 kg/ha. During the same period of time the production of both wet and upland rice sustains a satisfactory growth.

Production slowed in 1978 due to drought damage, and in 1979 due to the reduced area of upland rice. (Fefer figure 2-9-1) As any change can not be seen in production a hectare in last 10 years, a increase in the amount of production is attributable to a increase in the planted area. Most of rice produced is consumed in the domestic market (in 1978 700 t of rice was imported according to the actual records.). The average per capita annual consumption of rice is calculated as about 21 kg for the last 5 years, which exceeds by 60% and 16% respectively compared with 13 kg consumed between 1967 and 1970, and 18 kg consumed between 1971 and 1975. Although a growth in rice consumption has slowed down in recent years, it is seemingly on the increase yet.

Rice prices for the last 10 years are shown in the Table 2-9-2. The average producer's price of rice (unhulled rice) is calculated as 28 Gs/kg for the last 3 years (1979 ∿ 1981), which is 1.75 times as many as 16 Gs averaged between 1972 and 1974. At the same time the average retail price of polished rice in Asuncion is 85 Gs/kg for the last 3 years,

Table 2-9-1 Transition of Rice (unhauled rice) Production in Paraguay

(Total of paddy Rice and Upland Rice )

| Item | Year | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paddy rice | Area (1,000 ha) | 7.2 | 9.0 | 13.2 | 11.6 | 15.4 | 16.2 | 15.8 | 16.2 | 17.3 | 17.1 | 18.3 | 20.7 | 22.0 | 24.1 |
| | Production volume(1,000 t) | 18.1 | 20.8 | 30.2 | 35.0 | 33.3 | 35.5 | 34.0 | 38.9 | 44.0 | 40.6 | 45.6 | 43.4 | 47.4 | 53.9 |
| | Yield par unit area (t/ha) | 2.5 | 2.3 | 2.3 | 3.0 | 2.2 | 2.2 | 2.2 | 2.4 | 2.6 | 2.4 | 2.5 | 2.1 | 2.2 | 2.2 |
| Upland rice | Area (1,000 ha) | | | | 3.5 | 6.2 | 5.5 | 5.7 | 6.7 | 7.3 | 11.5 | 15.3 | 11.1 | 8.1 | 14.2 |
| | Production volume(1,000t) | | | | 5.2 | 5.5 | 8.2 | 7.7 | 11.8 | 11.7 | 16.1 | 23.1 | 14.8 | 9.5 | 18.8 |
| | Yield par unit area (t/ha) | | | | 1.5 | 0.9 | 1.5 | 1.4 | 1.8 | 1.6 | 1.4 | 1.5 | 1.3 | 1.2 | 1.3 |
| Total | Area(1,000 ha) | 7.2 | 9.0 | 13.2 | 15.1 | 21.6 | 21.7 | 21.5 | 22.9 | 24.6 | 28.6 | 33.6 | 31.8 | 30.1 | 38.3 |
| | Production volume(1,000t) | 18.1 | 20.8 | 30.2 | 40.2 | 38.8 | 43.7 | 41.7 | 50.7 | 55.9 | 56.7 | 68.7 | 58.2 | 56.9 | 72.7 |
| | Yield par unit area (t/ha) | 2.5 | 2.3 | 2.3 | 2.7 | 1.8 | 2.0 | 1.9 | 2.2 | 2.3 | 2.0 | 2.0 | 1.8 | 1.9 | 1.9 |
| Population (1,000 person) | | 2,116 | 2,169 | 2,227 | 2,290 | 2.359 | 2,433 | 2,513 | 2,598 | 2,686 | 2,779 | 2,873 | 2,970 | 3,068 | 3,168 |
| Per capita consumption(kg/person) | | 9 | 10 | 14 | 18 | 16 | 18 | 17 | 20 | 21 | 20 | 24 | 20 | 19 | 23 |

Source: M.A.G. statistical data

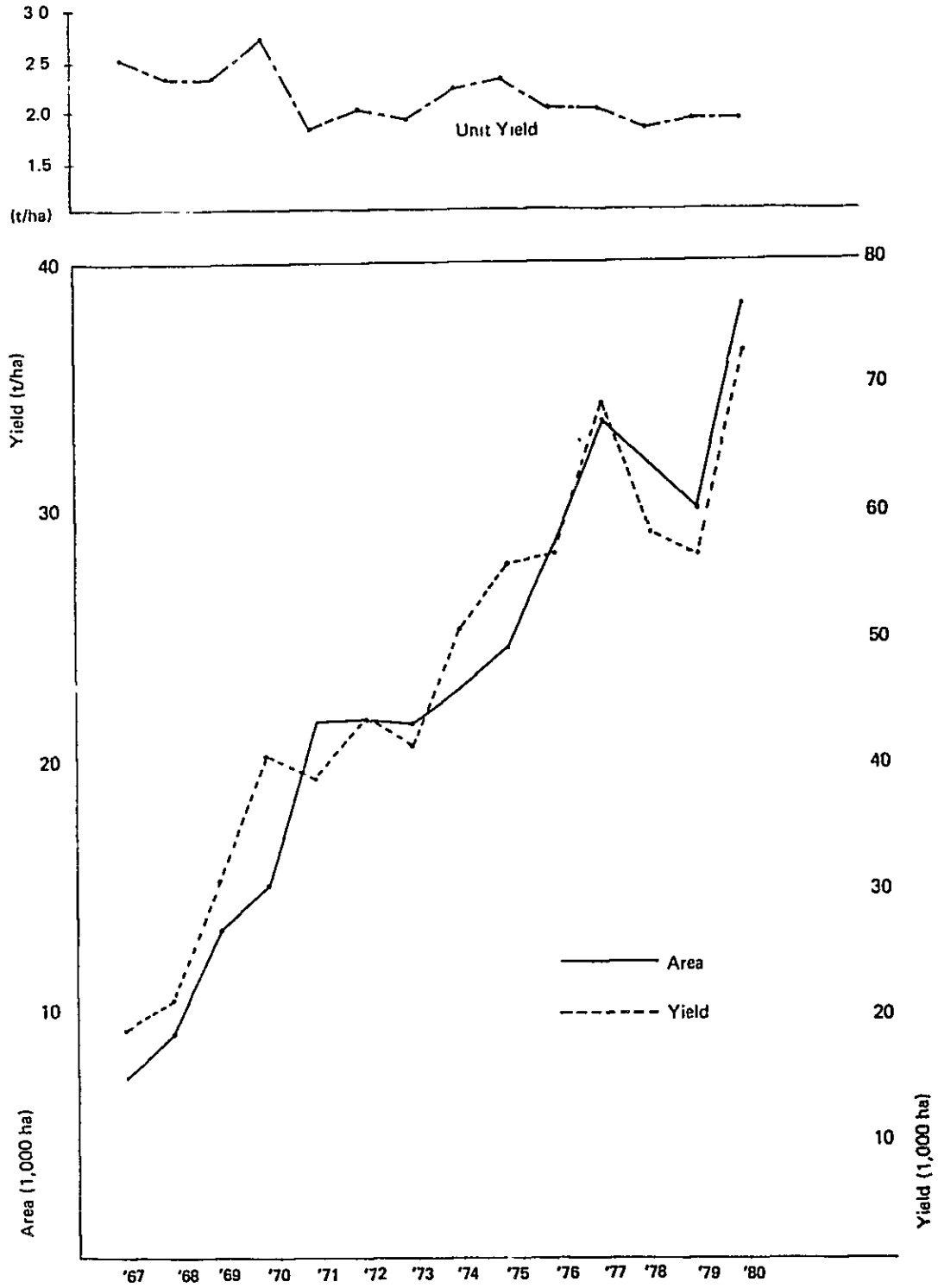



Fig. 2-9-1 Transition of Rice (unhauled rice) Production in Paraguay (Total of Paddy Rice and Upland Rice)

which is 2.02 times as many as 42 Gs averaged for the 3 years (1972 ∿ 1974). The market price in Asuncion has continued to be approximately 3 times as many as the producer's price.

Regarding the domestic distribution of rice, as shown in figure 2-9-2, most of rice are usually transported from the producers to the rice mills where rice is polished, and sold to the consumers by way of wholesalers and retailers. Some of rice is packed into small packages and is passed from the rice mills to the wholesalers for sale, and some are transported from the rice mills to the retailers directly without packaging.

On the other hand some of large-scale farmland proprietors are engaged in all the processes from rice-polishing to retailing.

The rice for exportation is collected to the exporters by way of either producers and brokers or rice mills. However, the amount to be exported is still limited.

Rice is exported by way of ecporters on the basis of orders received from importers in another country in the same way as conducted for soybean. Accordingly, any direct relationship with the Government can not be seen in such export of rice. Although 7.5% of assessed export price (usually lower than FOB price) is collected as export tax by the Government, rice being exported by way of agricultural cooperative associations is free of tax. Chile is the most demanding country of rice exported from Paraguay.

Although a national project of rice production has not yet been set up, a promotion program of rice production is being prepared by the Government in 1983 for the purpose of improving the technologies for rice culture and extensive the more effective methods.

Table 2-9-2 Trend of Rice Price

(Unit: Gs/kg)

| | Producer's price (unhulled rice) | Market price in Asuncion (polished rice) | Remarks |
|---|---|---|---|
| 1972 | 11 | 31 | |
| 1973 | 15 | 41 | |
| 1974 | 22 | 53 | |
| 1975 | 20 | 55 | |
| 1976 | 18 | 55 | |
| 1977 | 18 | 55 | |
| 1978 | 22 | 71 | |
| 1979 | 27 | 82 | |
| 1980 | 27 | 82 | |
| 1981 | 30 | 90 | |
| Average price for 3 years between 1979 ∿ 1981 / Average price for 3 years between 1972 ∿ 1974 | 28/16 = 1.75 | 85/42 = 2.03 | |

Source: M.A.G. Statistical data

Fig. 2-9-2 Distribution Channel of Rice