C3 Estimate of Exploitable Groundwater in Major Cities

C3.1 Field Reconnaissance and Data Collection

In the course of the field investigation for this study, the field survey was conducted for collection of detailed data and information to estimate the exploitable groundwater in service areas of the Water Districts in the selected major cities. The results of the studies or investigations on groundwater availability which were carried out by LWUA for the areas of ex-MWSS, Metro Cebu WD, Davao City WD and Metro Iloilo WD were collected during the field investigation. The field reconnaissance surveys were conducted for four major cities for which no data were available at the LWUA's office in Manila. The activities in and data and information collected for those cities are as below.

(1) Baguio City in Province of Benguet

- Data Collection: Location of existing water source, pumping rate of existing wells, spring discharge, well structures and their construction records
- Site Survey: Confirmation of locations and facilities of reservoir, location of existing deep wells and springs, confirmation of the overall topographical and the geological conditions

(2) Angeles City in Province of Pampanga

- Data Collection: Location and pumping rate of existing wells, well structures, log data and construction records and water quality data
- Site Survey: Confirmation of locations of existing deep wells as well as topographical and geological conditions

(3) Bacolod City in Province of Negros Occidental

- Data Collection: Location and pumping rate of existing wells, well structures, log data and construction records, locations and discharge of springs and water quality data
- Site Survey: Confirmation of locations of existing deep wells and springs, yield mechanism of spring water and topographical and geological conditions

(4) Cagayan De Oro City in Province of Misamis Oriental

- Data Collection: Location and pumping rate of existing wells, well structures, log data and construction records, locations and discharge of springs and water quality data
- Site Survey: Confirmation of locations of existing deep wells and topographical and geological conditions

C3.2 Baguio City Water District

C3.2.1 Topography

Baguio City is located in the top of Cordillera Central Mountains, stretching from south to north in the north Luzon Island. The city area slopes down steeply to the east and west.

The elevation of the city area ranges from about 1,300 m to 1,600 m. The populated areas are distributed in a fairly small flat area and low lands with elevations of 1,300 m to 1,400 m, surrounded by comparatively high mountains. The highly elevated portion of the city area form the western watershed of the Aguno River basin which extends almost from north to south. Its elevation ranges from 1,300 m to 1,600 m. Beyond the watershed, the small

tributaries of the Agno River flow down with very steep river bed slopes.

On the other hand, in the western part, the small and fairly flat lands are scattered. The difference of these topographic conditions in the eastern and western parts of the city area is considered to reflect the geological structure of monoclinic as stated in the succeeding Subsection C3.2.2.

C3.2.2 Geology

The geology of the city area is mainly formed by the Tertiary formations of Miocene age, which are classified into i) Klondyke formation, ii) Kennon formation, iii) Zigzag formation, iv) Black mountain andesite porphyry and v) Diorite. Of these, the Klondyke, Kennon and Zigzag formations consist of sediment formations, while other two formations of the Black mountain andesite porphyry and Diorite are composed of intrusive rocks. The former has a possibility for the groundwater development in view of the water bearing formations, but the latter is difficult to construct and drill deepwell because of hard rocks.

The Kennon formation is made up of limestone consisting of massive rocks with large fissures or much porous at places. The groundwater flows into the fissures or water courses in the limestone area. Therefore, the drilling hole needs to encounter the water course to develop groundwater. The distribution of the geology is shown in Figure C-13. The characteristics and features of the geology is shown in Table C-9. Geological section of A-A' line in Figure C-13 is illustrated in Figure C-14.

The aforesaid formations are explained below:

(1) Zigzag Formation

This formation is the youngest age of the three sediment formations. The formation is distributed in western side of the Baguio City, consisting of well compacted and poorly sorted conglomerate. This formation may have the monoclinic geological structure dipped to the west.

(2) Kennon Limestone

This limestone is distributed in the northwestern and the western areas of the city, forming the hills with steep slope. The limestone area is covered by the weathered tera rossa soils on the ground surface of red or yellow brown color. The limestone near the KM 8 reservoir provided at an elevation of 1,550 m is observed to be much porous, but those in the lowland area of 1,260 m in elevation near the Puyat farm is massive with many fissures. The different features of these rocks may result from the different sediment conditions for long geological terms. It appears that the total thickness of these rocks in 200 m or more.

(3) Klondyke Formation

The formation is a sediment in the late Miocene, Tertiary age and the oldest one of the three sediment formations. The formation is mainly made up of lava flows, breccia, pyroclastics and normal clastic sediments. The formation is distributed in the east half side of the city area. As mentioned in the foregoing Subsection C3.2.1, the watershed of the Agno River basin extends from north to south in the eastern part of the city. In the western area of the city, the small flat lands are distributed. This topography may be considered to reflect the geological structure of a monoclinic dipped to the west.

(4) Black Mountain Andesite Porphyry

This rocks are distributed on both sides of Kennon road aligned in the south of Baguio City. The rocks with hard faces are observed to be dipped to the west. It may be the basement rocks of the Baguio mountain.

(5) Diorite

This rocks are scattered in small areas of the eastern area of the city. The rocks are considered to be intrusive rocks of the Miocene, Tertiary age.

C3.2.3 Groundwater Condition

In the Baguio City area, a total of 37 deepwells and one spring are operated by Baguio City WD (BWD). The location of these groundwater sources is shown in Figure C-13. The main features of deepwell and their monthly production records are summarized in Tables C-10 and C-11, respectively.

These wells are classified into two categories in accordance with the completion year, namely sixteen (16) old wells completed between 1954 and 1982 and twenty (20) new wells completed between 1985 and 1996. The existing wells sometimes have the plural adjacent wells which are called by the same name but different number. The new wells had been often constructed within 10 m from the existing wells, since the old well could not tap water due to the lowering of groundwater level. Thus, the new deeper well had been drilled near the old well.

The depth of the wells ranges from 60 m to 220 m. The total daily groundwater production is estimated to be 33,228 m^3/day. The average daily production rate per one well ranges from 143 to 7,638 m^3/day and their average is 949 m^3/day. According to the UNDP-LWUA report (Baguio-La Trinidad Pilot Area, 1994), there were several free-flowing wells near Cathedral in the past. The artesian conditions of aquifer have disappeared by the lowering of groundwater table due to excessive withdrawal of groundwater to serve the increased population. Now, the artesian aquifer is in water table condition. In addition, the heavy corn depression occurs in the central part of Baguio City.

As a result of the field observation, the wells located near the watershed have the tendency to show small pumping rate, while the high production is recorded by the one located near the valleys. This phenomenon is considered to be attributable to the mechanism of groundwater recharge.

C3.2.4 Groundwater Development Potential

In the previous UNDP's study, the groundwater recharge was examined using the monthly rainfall data and estimated evapotranspiration. As a result, the groundwater recharge was estimated to correspond to a ratio of 8 % of annual rainfall. The UNDP had investigated the groundwater recharges in different catchment areas including that in La Trinidad City. The study applies the ratio of 8 % to annual rainfall in order to estimate the groundwater recharge in the Baguio City area.

As aforesaid, Baguio City spreads over the moderately sloped area at the top of Cordillera Central Mountains. Hence, the groundwater potential of the city area is higher than those of

other steep slope areas. The groundwater recharge is calculated for each of the promising geological formation areas as follows:

The recharge area:	1) Klondyke formation;	25.40 km^2
	2) Kennon formation;	14.26 km^2
	3) Zig Zag formation;	10.49 km^2

The average rainfall for ten years of 1984 to 1994 was derived to be 3,600 mm/year. The potential groundwater recharge is calculated as below:

The recharge rate:	1) Klondyke formation;	20,086 m^3/day
	2) Kennon formation;	11,248 m^3/day
	3) Zig Zag formation;	8,277 m^3/day
	Total	39,611 m^3/day

The potential groundwater recharge derived to be close to the present total groundwater production of 33,228 m^3/day. Considering the groundwater withdrawal of private sector, it is estimated that the remnant potential for groundwater development would be comeratively small.

On the other hand, the existing wells are mostly located along the small valleys or near the streams. Besides, those wells are provided along the flowing direction of groundwater. Hence, it is considered that at the wells the surface water would infiltrate easily into the underground. Provided that new wells are built at the places with the same conditions with existing wells, some additional development can be expected. The quality of groundwater at the existing sources is almost within the permitted limits of the Philippine National Standard for Drinking Water in 1994 (PNSDW).

C3.3 Angeles City Water District

C3.3.1 Topography

Angeles City is located in the northwestern part of Pampanga Province. In the west side, the active volcano, namely Mt. Pinatubo with an elevation of 1,780 m, which erupted in the year 1991 with the production of much lahar (volcanic ash and pumice), is located. In the east side, Mount Arayat with an elevation of 984 m which is an old volcano, borders the catchment area.

The city area is located on the alluvial fan formed by the Bamban River flowing from west to east in the northern part of the area. Beside, the Pasig Porac Rivers flow from west to east in the southern part of the area. The area moderately slopes from west to east with a slope gradient of 9/100. These rivers continuously have carried a large quantity of lahar to the downstream reach during rainy season, causing damages to houses and paddy field. Even in the present time, the discharge of lahar still continues. The topographic condition of the city area is shown in Figure C-15.

The city area is about 60.3 km^2 and is located adjacent to Mabalacat Municipality including Dau town in the east direction. The ground surface in the city area is covered by the lahar with a thickness of less than one meter.

C3.3.2 Geology

The city area is covered by the volcanic sediments brought about by eruption of Mt. Pinatubo and Mt. Arayat volcanoes, of Quaternary age, Cenozoic era. The sediments consists of volcanic ash, sand and breccia and clay altered from tuff.

C3.3.3 Groundwater Condition

In Angeles City, there are twenty (20) wells supply thereto for the municipal water in the city area. The locations of the existing wells are shown in Figure C-15. The main features of these wells are listed in Table C-12 and their production rates are in Table C-13.

The depths of the wells is in arrange of 81 m to 200 m. The geological section along sectional line of A-A' in Figure C-15 is shown in Figure C-16. The columnar sections of these wells indicate that the geology is made up of volcanic sediments of sand and breccia, and clay altered from tuff. As a result of analysis on the geological structures, the formations were distributed with the moderate slope in the direction from Mt. Pinatubo to Central Luzon Plain. The formations are considered to be divided into two aquifers with different depths: i) shallow aquifer (named as A aquifer in this report) with depths of 10 m to 100 m, ii) deep aquifer (named as B aquifer) with depths of 110 m to more than 200 m.

The geological components of both aquifers are not so different. These aquifers are isolated by the clay formation with sand and gravel and/or silt formation with a thickness of more than about 15 m which acts as an aquiclude. Therefore, groundwater including both aquifers is in artesian condition. In addition, the static water levels of both aquifers are different due to the degrees of artesian condition:

1) A aquifer with the water level of about 5 m to about 7 m
2) B aquifer with the water level of 14 m to 16 m.

C3.3.4 Groundwater Development Potential

As mentioned in the foregoing Subsection C3.3.3, the formations are distributed with the moderate slopes which are declined in the direction from west to east. Therefore, groundwater also flows in the directions from west to east in both aquifers of A and B. The flow directions are estimated to accord with the topography.

Based on the monitoring data of existing wells, the hydraulic gradient was estimated to be 0.95 %. As a result of the analysis of pumping test data, the transmissibility is derived to be $T=8.03 \times 10^{-3}$ m^2/sec as an average value of C-3 and C-5 wells in A aquifer, which it comes to $T=8.03 \times 10^{-3}$ m^2/sec in case of C-6 well in B aquifer. On the other hand, the average thickness of aquifer portion is considered to be 39 m in A aquifer and 44 m in B aquifer.

The width of groundwater flow in the city area is measured to be 5.5 km on the topographic map. The total flux of groundwater was calculated by Darcy's formula appling the hydraulic gradient under aquifer conditions as mentioned above. As a result of the calculation, the total flux of groundwater is estimated to be 362,500 m^3/day in A aquifer, and 13,600 m^3/day in B aquifer. A total of groundwater runoff is derived to be 376,100 m^3/day.

The present withdrawal of groundwater from existing wells for water supply is 33,334 m^3/day. This amount is equivalent to 8.9 % of total groundwater runoff estimated above. This extraction amount is considered to be small even if that of the private sector is counted. From the examination, it is judged that the city area has fairly large potential for groundwater development.

According to the existing data of water quality analysis on limited items, the groundwater quality is within the permitted range of the PNSDW. However, as the analysis data was in the very limited parameters and the future development area is located in the mountain foot of active volcano, the water quality shall be investigated in more detail.

C3.4 Metro Iloilo Water District

C3.4.1 Topography

Iloilo City is located in a wide plain, facing to Iloilo Strait in the east and south side. The plain was formed by the Jaro and the Iloilo Rivers and the tributaries. Many tributaries drain the low lands in the coastal area, forming a delta. The plain has the elevation ranging from 40 m to 0 m. These rivers flow down through the hilly land with the elevation of 220 m to 100 m, which spreads in the northwesern area of the city. The hilly land is dissected highly.

C3.4.2 Geology

The area is divided into two topographies, namely hill and wide alluvial plain. The hills are made up of Tertiary formations such as Tarao Formation consisting of sandstone or clayey sandstone. On the other hand, the alluvial plain has the sediments consisting of sand, gravel, siltstone and clay. The thickness thereof reaches 315 m in Manduriao near the seashore.

C3.4.3 Groundwater Condition

According to report on Water Supply Feasibility Study which was prepared by C. Lotti & Associate Consulting Engineers (1980), the area along seashore line has salt water intrusion phenomenon regardless the depth. The phenomenon is caused by the overpumping of groundwater in the city area. In addition, the plain has brine water, probably originated by fossil water in inland areas near Alimodian Municipality and Santa Barbara Municipality. The brine water is possibly originated in the deeper stratums. The distribution area of the saline water is shown by the line of the values of more than EC 1,000 ms/cm in Figure C-17.

The geological cross section developed using the data in the report is shown in Figure C-18. The aquifer is distributed in the depth of 46 m to 115 m and with a thickness of about 40 m in the San Miguel test well. It is composed of sand and gravel. The aquifer extends with a moderate slope in the east direction and become shallower in the direction with the depth from 12 m to 15 m. The baseline of the aquifer obtained by the electric resistivity prospecting is also indicated in Figure C-17. The aquifer is considered most thick in formation thickness and is developed in the San Jose. Groundwater in the aquifer is in the artesian condition. The water quality in this area is within the permitted range of the PNSDW.

At present, there were seven (7) wells in the water supply area. The well structures have the

depth of 94 m to 122 m to withdraw groundwater from the same aquifer. The total production rate is estimated at 552.1 m^3/day and the average production rate at 79 m^3/day/well.

C3.4.4 Groundwater Development Potential

SWECO-LWUA has carried out the study on future water resources development potential in Metro Iloilo Water District and has worked out the master plan covering the period from 1995 to 2030. The study estimates the total recoverable groundwater recharge in the three (3) river basins of Tigum, Aganon and Sibalom at 218,824 m^3/day. The report describes that the intensive withdrawal for future groundwater development will cause the larger risk of the salt water intrusion in the flat plain area near the seashore. Therefore, it is recommended the wells in the inland area which is more than 6 km to 9 km distant from seashore in the further groundwater development in order to avoid salt water intrusion.

In addition to the salt water intrusion, groundwater quality may be affected by leaching of mineral through faults and fissures in deep sediments. Furthermore, the previous report indicates that iron content is sometimes above permissible limit of 0.3 mg/liter in some wells. Likewise, the high calcium content is indicated therein. Therefore, the well locations for future development need to be determined based on the further study on water quality.

C3.5 Bacolod City Water District

C3.5.1 Topography

Bacolod City is located in the northeastern area of Negros Occidental Island and isolated by the Guimaras Strait from Panay Island. The city area includes the mountain slope of Mt. Mandalagan with an elevation of 1,879 m which is non-active volcano formed in the Pliocene-Quaternary age. The erupted materials are accumulated on the mountain foot forming the moderate and wide sloped area in the western part of the mountain. They might by carried near the city area.

Some rivers originate from the top of the mountain and empties into Guimaras Strait. The slope has a lot of small undulation which reflects the flowing directions of lava and erupted materials. On the slope, there are several springs with a wide range of discharges in a height of more than 300 m. The mountain slope is used to cultivate sugar cane. On the other hand, the city spreads on the flat and low land with a width of about 3 km along the seashore.

C3.5.2 Geology

According to the field observation, the mountain slope is mostly covered by the volcanic ash including the accumulated iron component and loam (weathered ash). Besides, the pyroclastic flow is sometimes observed at several places. The flat area near the seashore, where Bacolod City Proper is located therein, is made up of lava, tuff, volcanic ash and breccia of volcanic eruptions. The alluvial sediments are considered to be distributed only in the limited areas along the rivers.

The majority of existing wells are mainly distributed in the elevation of 90 m to 50 m for well field. The location of the wells is shown in Figure C-19. The geological section in A-A' line in Figure C-19 is shown in Figure C-20.

C3.5.3 Groundwater Condition

The total number of sources from which groundwater is being extracted at present are nineteen (19) deepwells and two spring fields as summarized in Table C-16. The total production rate is counted to be 43,813 m^3/day as shown in Table C-17. The average rate per well is 1,950 m^3/day. Considering the well locations, the aquifers are horizontally distributed with a fairly width in the moderately sloped lands. The volcanic topography formed by the old volcano with the moderate slope is made up of stratified volcanic sediments such as tuff, sand, gravel, lava and loam (weathered tuff). The groundwater flows homogeneously downstream through porous zones of these volcanic sediments.

In the field investigation on the other hand, large-scale springs were observed in the area of ground elevation higher than 700 m. According to the field observation, it appeared that after groundwater took the special water course in the volcanic sediments such as soft tuff and breccia formation it came out to the ground surface as springs.

C3.5.4 Groundwater Development Potential

The available pumping test records measured by the modified Jacob method were used to analyze the exploitable groundwater. As a result, the average T value was derived to be about 160 m^2/day. The modified Jacob equation is expressed as follows:

$$s = (0.183\ Q)/T \log (2.25Tt/r^2S)$$

Where,
- s: drawdown
- Q: discharge
- T: transmissivity
- r: radius
- S: storage coefficient

Result of Analysis of Pumping Test Data

Well No.	*Transmissivity (T); m^2/day*
18	156.9
20	158.6
Average	*157.8*

Assuming that groundwater uniformly and downstream flows into the volcanic sediments along the land slope under the condition of obtained average transmissivity values, the groundwater flux is estimated by Darcy's formula. In addition, the possible development depth of aquifer is taken within those of the existing wells (about 200 m). The value of hydraulic gradient is calculated using static water levels at the time of well construction, because the recent data are not available. The value is in a range of 0.037 to 0.033. As the development area of groundwater in the water district is limited only in the city area, the width of the aquifer in the right-angled direction against the groundwater flow is measured to be 14.5 km. The groundwater flux is calculated to be about 84,700 m^3/day.

The present withdrawal of groundwater for water supply corresponds to 47.7 % of groundwater flux. It is considered that further development of groundwater in the area would

not have the adverse influence on the present environmental circumstance, since the mountain foot area is mostly utilized for cultivation and forest. Therefore, further development will be possible and the amount will be roughly estimated at about 14,662 m^3/day. The total amount of the future and present groundwater withdrawal is calculated at 55,055 m^3/day, which is equivalent to 65 % of total groundwater flux.

On the other hand, the total discharge of the springs is reported to be 10,300 m^3/day in the ADB's report (1997). The present total intake discharge of those springs is 3,420 m^3/day, while it is estimated that spring water of 2,760 m^3/day will be exploited through the future development. Hence, the sum of the present and future withdrawal of spring water comes to 6,180 m^3/day, which is equivalent to 60 % of total exploited amount of spring water. From the above examination, the sum of development potential of groundwater and spring is estimated at 33,880 m^3/day.

The existing wells were concentrated in north and central portions of the mountain slope with the elevation of 90 m to 50 m. The southern area with the same elevation is still in the undeveloped condition. Therefore, the future development of groundwater is recommended to be conducted in the southern area. The future development amount of groundwater of 27,000 m^3/day corresponds to new construction of about 13 wells on the assumption that the new wells can have the average production rate of existing wells of 1,950 m^3/day/well. On the other hand, the future groundwater development needs to be conducted with the monitoring of water quality in the existing wells which are located in the seashore area in order to avoid the salt water intrusion. If further development is necessary, it is recommended that the deeper aquifer or surface water be planned to be developed to cope with the future demand.

The groundwater quality in the existing wells and springs utilized for municipal water supply is almost within the permitted range of the PNSDW. However, some wells are reported to have slightly higher iron and manganese contents than the permitted upper limits of the PNSDW. Therefore, the well location and its depth need to be determined based on further groundwater survey or the removal facilities of those chemical will have to be properly designed to be installed if newly constructed wells in the future are likely to be affected by the water quality issue.

C3.6 Cagayan De Oro City Water District

C3.6.1 Topography

Cagayan De Oro City, a capital of Misamis Oriental Province, is located in the north central of Mindanao Island and faces to the Bohol Sea. The city is divided into two portions by the Cagayan De Oro River which flows from south to north. The city is located in the small alluvial plain which has been formed by the river. The hinterland surrounding the alluvial plain is occupied by hill-top terrace with a vast area and its elevation ranges from 100 m to 150 m. The top of the terrace is formed by the fairly smooth flat land and it is surrounded by steep cliffs.

There exists the vast mountainous area in the eastern part of the city, which is dissected by many small streams. The elevation ranges from 400 m to 500 m. The mountainous area is

made up of limestone. The hilly terrace and sloped areas are continuously distributed near the seashore with high elevation. The alluvial plain is extended with long and narrow belt in the eastern direction along the seashore. Furthermore, another alluvial plain with fairly wide areas is located along the Iponon River.

C3.6.2 Geology

Giologically, the area is formed by six (6) different formations which distribute in the city and the periphery areas. Those formations are composed of: i) alluvial sediments of Holocene and Quaternary, ii) Cagayan Terrace gravel of Pleistocene to Holocene and Quaternary, iii) Bukidonon Formation of late Pliocene of Tertiary to Pleistocene of Quaternary, iv) Indahag Limestone of early to late Pliocene of Tertiary, v) Opol Formation of Miocene of Tertiary, vi) Schist of Mesozoic era. The geological map for the city area is shown in Figure C-17. Each formation has the following features:

(1) alluvial sediments

Alluvial sediments are deposited in the narrow areas along the Cagayan De Oro River and the wide area along the Iponon River, extending to the east of the city. The formation consists of silt, sand and gravel, and boulders.

(2) Cagayan Terrace Gravel

The Cagayan Terrace gravel formation is distributed on both sides of the Cagayan De Oro River, forming hilly areas with the height difference of 100 m to 150 m between the top of the terrace and river bank. The formation has numerous boulders in the basement of the terrace, consisting of gravel, sandstone and shale.

(3) Bukidnon Formation

The formation is mainly distributed in the eastern part of the city and in the hinterland of the Cagayan Terrace Gravel formation. It forms hilly area with high elevation of 250 m to 300 m as well as a fairly flat top area. The geology consists mainly of tuffaceous sandstone, agglomerate, pebbly sandstone and conglomerate.

(4) Indang Limestone

The limestone is mainly distributed in the southern part of the city for wide area. The formation is made up of coral rubbles and sandy limestone.

(5) Opol Formation

The formation is mainly distributed in the west side of the Iponon River beyond the city area. The formation is composed of the conglomerate, pebbly sandstone, agglomerate and tuff.

(6) Schist

The formation is distributed in the mountainous area to the east of the city. The mountainous area with an elevation of about 500 m is fairly dissected.

C3.6.3 Groundwater Condition

The existing water sources for water supply in Cagayan De Oro City consist of nineteen (19) deep wells and one (1) spring. Of all the existing wells, nine (9) wells are provided distributed in the narrow alluvial sediment area along the Cagayan De Oro River. Three (3)

wells lie in the alluvial plain along the Iponon River and four (4) wells in the small plain situated in the east of Barangay Bago. The location of existing wells is shown in Figure C-17, while the main features of the said deepwells is listed in Table C-22.

The nine (9) existing along the Cagayan De Oro River produce a large quantity of groundwater because of tapping a superior aquifer which is called as Macasanding formation. The groundwater production rate per well ranges from about 5,000 to 8,000 m^3/day with the average rate of 7,100 m^3/day. The well depths range between 150 m to 255 m. In the past, the groundwater spout out with high pressure as soon as the drilled bore hole penetrated to the aquifer. Besides, it was very hard to plug the wells due to the pressure. However, it seems that the pressure will be lowered with the increase of amount of gourndwater because of much withdrawn. The detailed thickness and distribution of the Macasanding formation are unknown. The formation layer consisting of sand and gravel with overlying impervious layers of sandy clay is distributed in the depth of about 200 m to 230 m below the ground level. The aquifer is founded to be distributed in the alluvial area along the Cagayan De Oro River.

The other three (3) wells located in the alluvial plain along the Iponan River also produce a large quantity of groundwater ranging from 2,700 m^3/day to 5,000 m^3/day. These wells have the depth of 190 m to 123 m.

In Barangay Bago area, out of four wells, only one well produces the significantly large discharge of 9,600 m^3/day, while the production rate of other three wells is limited to the range of 90 m^3/day to 2,800 m^3/day.

In the alluvial plain with a narrow belt extending along the seashore in the east direction of the city, the salt water intrusion takes place in some deep wells.

C3.6.4 Groundwater Development Potential

As mentioned above, the distributions of the Macasanding aquifer and the correspondent formation are unknown. However, the aquifer is considered to be distributed over the entire area of the alluvial plain spreading along the Cagayan De Oro River. The groundwater development potential was estimated based on the existing pumping test data as shown below:

Transmissivity Values of Existing Wells (extracted from Macasanding Aquifer)

Well No.	Transmissivity; m^2/day	Test Data	Analysis
17	3,191	Time Drawdown Test Data	s-r curve
20	5,059	Time Drawdown Test Data	s-t curve
	3,264	Recovery Test Data	s'-t curve
Average	3,838	-	-

The groundwater flux flowing in the aquifer was estimated by using the pumping test data for new wells which were constructed in 1997.

The groundwater in the aquifer is considered to flow downstream along the river course. The width of aquifer in the direction with right angle to the flowing direction is estimated to be about 3,500 m. In addition, the hydraulic gradient of existing wells was estimated to be

approximately 0.7 %. The groundwater flux flowing downstream was estimated using the Darcy's formula.

The groundwater flux was roughly estimated at 94,031 m^3/day. The present withdrawal of groundwater totals 86,367 m^3/day. The withdrawal corresponds to about 90 % of the exploitable groundwater flux and it is considered to be the maximum limit of groundwater development potential. Therefore, further groundwater development of the Macasandig Formation is not recommended.

The other alluvial areas have already been allocated for construction of several wells. Considering the spacing distance among the wells, area is not recommended to avoid the mutual interference among the wells in withdrawing groundwater, the further groundwater development in the unless no other deep aquifer is newly found. In addition, there was a Malasag Spring in which the discharge was not so large. The groundwater quality is generally in a good condition.

Part – C

Tables

Table C-1 ESTIMATION OF GROUNDWATER RECHARGE BY WATER RESOURCES REGION

WRR	Area km^2	Mean Rainfall (mm/year)	Estimated Storage (mm/year)	Estimated Storage (MCM/year)	Estimated Inflow Gross (MCM/year)	Estimated Inflow Net (MCM/year)
I	14,103	2,878	4,620	66,528	4,144	2,072
II	37,986	2,082	11,850	170,640	7,186	3,592
III	23,546	1,832	54,700	787,680	7,186	3,592
IV	47,475	1,250	37,000	532,800	8,137	4,068
V	17,631	1,750	8,625	124,200	4,130	2,065
VI	20,223	2,500	55,242	795,485	5,050	2,525
VII	14,952	1,277	2,053	29,563	2,235	1,111
VIII	21,532	2,800	8,400	120,960	5,712	2,856
IX	18,740	1,774	14,700	211,680	3,605	1,802
X	28,018	2,277	15,950	229,680	5,805	2,902
XI	24,224	2,645	12,635	181,944	6,525	3,262
XII	29,962	1,747	36,000	518,400	6,482	3,241
Total	293,393	2,124	24,680	3,769,560	66,197	33,088

Data Source: Groundwater in the Philippines (1980)

Table C-2 ESTIMATION OF GROUNDWATER RECHARGE BY RIVER BASIN

WRR	MRB	Area (km^2)	Mean Rainfall (mm/year)	GW Storage (MCM/year)	GW Recharge (MCM/year)
I	Laoag	3,694	2,500	17,732	797
	Abra	5,125	2,370	13,261	1,106
	Bauang-Amburayan	3,437	2,310	16,279	750
	sub-total	12,256		47,272	2,653
II	Abulog	4,415	2,712	17,085	1,197
	Chico	5,247	2,390	17,635	1,924
	Lower Cagayan	6,256	1,900	24,926	1,686
	Upper Cagayan	6,250	2,462	22,969	1,684
	Ilagan	4,464	2,451	25,469	1,723
	Magat	6,830	2,460	24,324	1,841
	sub-total	33,492		132,408	10,055
III	Agno	13,877	2,208	30,620	2,600
	Pampanga	14,465	2,067	77,140	3,300
	sub-total	28,342		117,760	5,900
IV	Quezon Province	10,106	2,264	33,500	900
	Laguna Lake	5,078	2,148	15,000	1,000
	Taal Lake	3,942	2,026	8,200	540
	Palawan Island	14,896	2,058	3,900	1,230
	Mindoro, Romblon, Marinduque	12,560	2,129	5,775	1,880
	sub-total	46,582		45,875	5,550
V	Albay-Sorsogon	3,777	2,846	9,150	779
	Bicol	10,058	3,037	11,496	2,074
	Masbate	4,048	2,692	1,803	531
	sub-total	17,883		22,449	3,384
VI	Aklan	2,420	3,803		1,598
	Bago-Binalbagan	4,526	2,965	12,426	575
	Ilog-Hilabangan	5,520	2,640		1,463
	Jalaur	1,827	2,356		434
	Panay	2,182	2,865		580
	Sibalom-Guimbal	2,800	3,068		368
	sub-total	19,275		12,426	5,018
VII	Bohol	4,117	2,175		207
	Cebu	5,088	2,321		77
	Negros Oriental	5,694	2,280		236
	sub-total	14,899		0	520
VIII	Leyte	8,003	2,900	17,407	1,714
	Samar	13,492	3,085	29,207	2,876
	sub-total	21,495		46,614	4,590
IX	Mapangi-Dipolog	6,646	2,457		305
	Sibuguey-Ingin	1,211	2,583	3,775	146
	Siocon-Quipit-Taguite-Tumaga	9,540	2,099		204
	sub-total	17,397		3,775	655
X	Agusan	14,507	2,759	8,191	2,867
	Misamis Oriental	8,750	2,552	19,912	2,877
	sub-total	23,257		28,103	5,744
XI	Davao Oriental	9,012	2,746	3,292	2,197
	Tagum-Libuganon	7,901	2,476	5,812	859
	South Cotabato	6,945	2,317	9,689	512
	sub-total	23,858		18,793	3,568
XII	Agus	5,686	2,997	1,726	555
	Mindanao-Allah	13,219	2,552	25,455	1,108
	Pulangui	16,306	2,573		795
	sub-total	35,211		27,181	2,458
Grand Total		293,947		502,656	50,095

Data Source: Frame Work Plan (1979 to 1983), UNDP-NWRC

Table C-3 ESTIMATION OF GROUNDWATER POTENTIAL

WRR	Total Area (km^2)	Area for Groundwater Availability S/D (km^2)	Dp (km^2)	Dif. (km^2)	Estimated GW Storage S/D (MCM)	Dp (MCM)	total (MCM)	Estimated Recharge (MCM/yaer)
I	14,103	1,737	6,939	5,427	8,787	25,396	34,183	2,072
II	37,986	5,433	18,694	13,860	32,054	103,719	135,773	3,592
III	23,546	9,225	4,589	9,731	141,505	33,449	174,954	2,592
IV	47,475	6,564	11,900	29,011	60,793	78,585	139,378	4,068
V	17,631	1,999	6,011	9,622	17,689	36,612	54,301	2,065
VI	20,223	2,825	5,854	11,544	24,094	34,154	58,248	2,525
VII	14,952	1,137	10,494	3,321	10,141	58,649	68,790	1,111
VIII	21,532	813	17,323	3,397	8,870	105,086	113,956	2,856
IX	18,740	1,257	10,621	6,863	10,520	51,002	61,522	1,827
X	28,018	3,305	14,836	9,878	26,690	69,636	96,326	2,766
XI	24,224	2,532	14,927	6,765	22,946	100,437	123,383	3,293
XII	29,962	7,459	12,148	10,355	93,129	68,953	162,082	2,787
Total	298,393	44,285	134,336	119,772	457,218	765,678	1,222,896	31,554

Notes: 1 the areas for Groundwater Availability were measured on each map by the planimeter.
Groundwater Storage ws estimated based on the average depth of wells and area of each category.

2 S/D: Shallow and deep well area.
Dp: Deep well area.
Dif: Difficult area for groundwater development.

Table C-4 GROUNDWATER POTENTIAL BY PROVINCE

WRR	ID	Province	Base Data: Area (km^2)	Base Data: Precipitation (mm/year)	Availability: S/D area (km^2)	Availability: Dp area (km^2)	Availability: Df area (km^2)	Storage: S/D-S (15%) (MCM)	Storage: Dp-S (10%) (MCM)	Storage: total (MCM)	Recharge (Inflow) (MCM)
1	1	Abra	3,975.6	2,690	431.3	1,640.8	1,890.5	2,201	5,885	8,085	535
1	2	*Benguet*	2,655.4	3,314	167.3	2,445.9	312.2	829	7,697	8,526	491
1	3	Ilocos Norte	3,399.3	2,721	568.9	1,375.7	1,454.7	2,818	4,935	7,753	471
1	4	Ilocos Sur	2,579.9	2,658	301.6	937.6	1,340.7	1,494	3,363	4,857	343
1	5	La Union	1,493.1	2,515	254.8	839.3	399.0	1,262	3,011	4,273	188
			14,103.3	2,878	1,736.9	6,939.3	5,427.1	8,603	24,891	33,495	2,029
2	6	Batanes	209.3	2,576	39.8	39.5	*150.0*	129	241	370	27
2	7	Cagayan	8,664.1	2,502	1,555.4	5,301.2	1,507.5	12,054	32,385	44,439	1,084
2	8	Ifugao	2,507.8	1,616	143.8	1,476.2	887.8	934	9,018	9,952	203
2	9	Isabela	10,817.2	2,109	1,987.9	4,512.3	4,317.0	12,915	27,566	40,480	1,141
2	10	Kalinga-Apayao	6,729.5	1,829	1,024.4	3,016.6	2,688.5	6,655	18,429	25,084	615
2	11	Mountain Province	2,097.3	1,665	181.7	1,113.9	801.7	1,180	6,805	7,985	175
2	12	Nueva Vizcaya	3,903.9	1,908	142.9	1,827.5	1,933.5	928	11,164	12,093	372
2	13	Quirino	3,057.2	2,209	76.7	1,406.5	1,574.0	498	8,592	9,091	338
			37,956.3	2,042	5,432.6	18,693.7	13,860.0	35,293	114,200	149,493	3,954
3	14	Bataan	1,373.0	2,041	111.8	48.3	1,212.9	1,427	293	1,720	140
3	15	Bulacan	2,625.0	2,469	1,340.8	820.8	454.4	17,226	4,977	22,203	316
3	16	Nueva Ecija	5,331.3	1,738	3,627.2	702.1	1,002.0	46,290	4,258	50,548	463
3	17	Pampanga	2,180.7	1,692	1,598.9	176.5	405.3	20,405	1,070	21,475	184
3	18	Pangasinan	5,367.9	1,691	918.5	1,867.8	2,581.6	11,722	11,326	23,048	454
3	19	Tarlac	2,933.4	1,504	829.6	341.4	1,779.4	10,587	2,088	12,676	222
3	20	Zambales	3,714.4	2,029	789.5	629.4	2,295.5	10,076	3,817	13,892	327
			23,545.7	1,832	9,225.3	4,589.3	9,731.1	117,733	27,829	145,563	2,157
4	21	Aurora	3,239.6	2,429	256.5	159.8	2,793.3	2,709	1,077	3,787	303
4	22	Batangas	3,166.0	1,453	796.5	1,327.7	1,041.8	7,532	8,951	16,483	239
4	23	Cavite	1,205.4	1,526	645.9	408.3	61.2	6,108	3,360	9,467	92
4	24	Laguna	1,756.6	1,608	373.8	502.1	880.7	3,535	3,355	6,920	141
4	25	Marinduque	959.2	1,601	133.2	110.1	715.9	1,260	742	2,002	77
4	26	Metro Manila	636.0	1,631	222.9	369.2	43.9	2,108	2,489	4,597	52
4	27	Occidental Mindoro	5,879.8	1,660	1,298.8	765.5	3,815.5	12,282	5,161	17,443	488
4	28	Oriental Mindoro	4,364.7	1,734	1,077.3	471.4	2,816.0	10,157	3,178	13,365	378
4	29	Palawan	14,896.3	1,576	868.5	1,343.6	12,654.2	8,496	9,059	17,555	1,174
4	30	Quezon	8,706.6	2,079	627.9	5,820.4	2,258.3	5,937	39,241	45,179	905
4	31	Rizal	1,308.9	1,835	178.2	283.2	847.5	1,655	1,909	3,594	120
4	32	Romblon	1,355.9	1,527	24.3	249.1	1,082.5	230	1,679	1,909	104
			47,435.0	1,750	6,563.8	11,900.4	29,010.8	62,068	80,233	142,300	4,154
5	33	Albay	2,552.6	2,296	270.7	1,215.2	1,066.7	2,400	7,415	9,815	293
5	34	Camarines Norte	2,111.7	3,358	255.6	771.3	1,084.8	2,532	4,706	7,239	355
5	35	Camarines Sur	5,266.6	2,091	621.9	1,625.6	3,019.1	5,514	9,919	15,434	551
5	36	Catanduanes	1,511.5	2,631	55.3	186.3	1,269.9	490	1,137	1,627	202
5	37	Masbate	4,047.3	2,139	196.9	1,729.3	2,121.1	1,746	10,552	12,298	433
5	38	Sorsogon	2,141.4	2,207	568.1	482.9	1,090.4	5,037	2,917	7,954	236
			17,631.1	2,347	1,998.5	6,010.6	9,622.0	17,720	35,677	54,397	2,069
6	39	Aklan	1,817.9	1,962	262.3	646.1	909.5	2,239	3,711	5,950	178
6	40	Antique	2,522.0	2,325	191.7	973.5	1,356.8	1,637	5,591	7,228	293
6	41	Capiz	2,633.2	2,572	437.6	1,122.2	1,073.4	3,736	6,445	10,181	339
6	42	Guimaras	604.6	2,277	58.3	94.6	451.7	498	543	1,041	69
6	43	Iloilo	4,719.4	2,357	1,463.0	1,363.0	1,893.4	12,491	7,828	20,319	556
6	44	Negros Occidental	7,926.1	2,757	412.3	1,654.4	5,859.4	3,520	9,501	13,022	1,093
			20,223.2	2,500	2,825.2	5,853.80	11,544.2	24,121	33,619	57,740	2,528
7	45	Bohol	4,317.4	1,277	380.5	3,280.9	456.0	3,406	18,399	21,805	263
7	46	Cebu	5,088.4	1,585	203.5	4,266.0	618.9	1,821	23,924	25,745	403
7	47	Negros Oriental	5,402.3	1,573	536.1	2,645.1	2,221.1	4,798	14,834	19,632	425
7	48	Siquijor	343.5	1,383	16.8	302.2	24.5	150	1,695	1,845	24
			14,951.6	1,491	1,136.90	10,494.20	3,320.50	10,176	58,852	69,028	1,115
8	49	Biliran	555.5	2,804	5.1	347.8	202.6	59	2,227	2,286	78
8	50	Eastern Samar	4,339.6	3,172	153.8	2,059.6	2,126.2	1,772	13,189	14,959	688
8	51	Leyte	5,712.8	2,282	255.6	5,417.1	40.1	2,944	34,686	37,630	652
8	52	Northern Samar	3,498.0	3,366	119.9	3,208.1	170.0	1,381	20,541	21,923	589
8	53	Southern Leyte	1,734.8	2,192	76.7	1,633.3	24.8	884	10,458	11,342	190
8	54	Western Samar	5,691.2	2,874	201.6	4,656.7	832.9	2,322	29,817	32,139	818
			21,531.9	2,800	812.70	17,322.60	3,396.60	9,362	110,917	120,278	3,015
9	55	Basilan	1,206.1	1,641	84.4	814.2	307.5	642	3,557	4,199	99
9	56	Sulu	1,562.7	1,758	166.2	1,146.3	250.2	1,265	5,007	6,272	137
9	57	Tawi-Tawi	1,087.4	1,830	118.7	392.3	576.4	901	1,714	2,617	100
9	58	Zamboanga del Norte	6,665.2	1,893	191.9	2,961.9	2,911.4	1,461	12,938	14,399	574
9	59	Zamboanga del Sur	8,818.9	1,705	695.5	5,306.3	2,817.1	5,294	23,178	28,473	752
			18,740.3	1,774	1,256.7	10,621.0	6,862.6	9,566	46,393	55,960	1,662
10	60	Agusan del Norte	2,590.3	2,304	787.0	1,603.7	194.6	7,314	8,706	16,020	298
10	61	Agusan del Sur	8,965.5	2,495	1,055.8	7,641.3	268.4	9,812	41,355	51,166	1,118
10	62	Bukidnon	7,970.8	2,318	259.1	2,441.5	5,270.2	2,408	13,213	15,621	924
10	63	Camiguin	229.8	1,937	49.8	33.7	146.3	463	182	645	22
10	64	Misamis Occidental	1,939.3	1,670	97.5	273.3	1,568.5	906	1,479	2,385	162
10	65	*Misamis Oriental*	3,970.1	1,535	127.1	1,846.5	1,596.5	1,481	9,993	11,474	274
10	66	Surigao del Norte	2,752.2	2,842	928.2	900.7	833.3	8,626	5,362	13,988	391
			28,018.0	2,277	3,304.50	14,835.70	9,877.8	30,709	80,291	111,000	3,190
11	67	Davao del Norte	8,129.8	2,545	416.4	5,964.7	1,748.7	3,661	39,056	42,717	1,035
11	68	Davao del Sur	6,377.6	2,104	1,349.2	3,282.5	1,745.9	11,852	21,493	33,355	671
11	69	Davao Oriental	5,164.5	2,489	164.9	2,508.9	2,490.7	1,450	16,428	17,878	643
11	70	Surigao del Sur	4,552.2	3,259	601.7	3,171.0	779.5	5,290	20,763	26,053	856
			24,224.1	2,645	2,532.20	14,927.10	6,764.80	22,262	97,740	120,002	3,204
12	71	Lanao del Norte	2,945.9	1,949	334.0	343.5	2,268.4	3,914	1,831	5,745	287
12	72	Lanao del Sur	2,905.6	1,752	97.1	68.1	2,740.4	1,138	363	1,501	255
12	73	Maguindanao	4,848.6	1,449	2,621.2	1,803.9	423.5	30,717	9,615	40,332	351
12	74	North Cotabato	6,529.9	1,955	1,471.3	3,209.6	1,849.0	17,241	17,107	34,348	639
12	75	Sarangani	3,723.4	1,777	1,812.7	1,313.1	597.6	21,243	6,999	28,241	331
12	76	South Cotabato	3,745.4	1,904	549.4	2,293.6	901.4	6,438	12,230	18,668	357
12	77	Sultan Kudarat	5,263.4	1,513	573.7	3,115.4	1,574.3	6,723	16,605	23,328	398
			29,962.2	1,747	7,459.37	12,148.20	10,354.63	87,415	64,749	152,163	2,617
		Nation Total	*298,393.7*	*2,324*	*44,284.7*	*134,335.9*	*119,772.1*	*435,029*	*776,391*	*1,211,419*	*31,604*

Notes

1 Availability of Groundwater

- S/D area : area of the Quaternary Formation (shallow and deep well area)
- Dp area : area of the Tertiary Formation (deep well area)
- Df are : other area

2 Storage

- S/D-S : S/D area x Average Well Depth (GIS) x porous ratio (15%)
- Dp-S : Dp area x Average Well Depth (GIS) x porous ratio (10%)

3 Recharge (Inflow)

5% of the precipitation volume

Table C-5 LAND USE AREA FOR GROUNDWATER RECHARGE

WRR	ID	Base Data Province	Area (km^2)	Land Use Area (km^2) Agriculture (km^2)	Grass/Shruland (km^2)	Woodland (km^2)	Wetland (km^2)	Miscellaneous (km^2)	Rechargeable Land Ratio (%)
1	1 Abra		3,975.6	251.4	2,255.5	1,314.9	-	153.8	96.1%
1	2 Benguet		2,655.4	319.4	1,362.4	899.1	-	74.4	97.2%
1	3 Ilocos Norte		3,399.3	740.7	1,549.5	930.1	0.5	178.5	94.7%
1	4 Ilocos Sur		2,579.9	660.3	1,459.4	256.7	4.5	199.1	92.1%
1	5 La Union		1,493.1	354.6	896.4	115.2	10.8	116.1	91.5%
			14,103.3	2,326.5	7,523.1	3,516.0	15.8	721.9	94.8%
2	6 Batanes		209.3	40.8	41.7	28.9	90.4	7.6	53.2%
2	7 Cagayan		8,664.1	2,066.1	1,910.7	4,450.6	21.0	215.7	97.3%
2	8 Ifugao		2,507.8	251.9	1,530.2	693.7	-	32.0	98.7%
2	9 Isabela		10,817.2	3,466.9	2,430.3	4,283.2	-	636.9	94.1%
2	10 Kalinga-Apayao		6,729.5	948.2	2,174.0	3,479.7	-	127.6	98.1%
2	11 Mountain Province		2,097.3	194.8	896.0	965.4	-	41.1	98.0%
2	12 Nueva Vizcaya		3,903.9	719.7	1,249.2	1,838.6	-	96.4	97.5%
2	13 Quirino		3,057.2	248.3	789.7	1,966.2	-	53.1	98.3%
			37,986.3	7,936.6	11,021.9	17,706.1	111.4	1,210.3	96.5%
3	14 Bataan		1,373.0	229.4	794.9	258.0	43.3	47.4	93.4%
3	15 Bulacan		2,625.0	829.7	451.8	827.0	208.0	308.4	80.3%
3	16 Nueva Ecija		5,331.3	2,447.8	1,687.0	847.5	28.3	320.7	93.5%
3	17 Pampanga		2,180.7	1,044.5	195.3	158.9	423.5	358.5	64.1%
3	18 Pangasinan		5,367.9	2,466.6	2,105.3	307.7	174.1	314.2	90.9%
3	19 Tarlac		2,953.4	1,328.8	819.8	524.7	3.4	276.8	90.5%
3	20 Zambales		3,714.4	423.4	2,108.2	992.4	32.2	153.3	95.0%
			23,545.7	8,770.1	8,162.5	3,921.2	912.8	1,779.2	88.6%
4	21 Aurora		3,239.6	399.0	269.4	2,442.3	19.4	109.6	96.0%
4	22 Batangas		3,166.0	2,023.4	825.0	188.7	24.4	104.6	95.9%
4	23 Cavite		1,205.4	714.0	367.0	4.0	8.3	112.1	90.0%
4	24 Laguna		1,756.6	970.2	382.8	258.5	1.5	143.6	91.7%
4	25 Marinduque		959.2	350.8	397.4	148.4	45.5	17.1	93.5%
4	26 Metro Manila		636.0	-	-	-	-	636.0	0.0%
4	27 Occidental Mindoro		5,879.8	1,235.9	2,118.8	2,202.1	66.6	256.3	94.5%
4	28 Oriental Mindoro		4,361.7	1,543.9	885.6	1,614.5	83.7	233.3	92.7%
4	29 Palawan		14,896.3	1,542.5	3,829.7	7,932.5	700.5	891.1	89.3%
4	30 Quezon		8,706.6	3,289.9	2,059.2	2,752.7	300.2	304.6	93.1%
4	31 Rizal		1,308.9	236.3	674.1	163.9	14.6	220.0	82.1%
4	32 Romblon		1,355.9	486.7	421.4	417.8	14.6	15.4	97.8%
			47,475.0	12,792.6	12,230.3	18,125.4	1,279.2	3,047.4	90.9%
5	33 Albay		2,552.6	1,370.1	807.3	228.6	27.3	119.3	94.3%
5	34 Camarines Norte		2,111.7	1,265.8	462.7	275.1	76.8	31.2	94.9%
5	35 Camarines Sur		5,266.6	2,754.5	1,509.9	706.2	119.0	177.1	94.4%
5	36 Catanduanes		1,511.5	468.8	602.8	383.9	25.9	30.1	96.3%
5	37 Masbate		4,047.3	2,706.6	1,110.3	11.4	172.6	46.4	94.6%
5	38 Sorsogon		2,141.4	1,423.6	342.8	269.3	72.2	33.5	95.1%
			17,631.1	9,989.3	4,835.9	1,874.5	493.7	437.6	94.7%
6	39 Aklan		1,817.9	542.3	608.1	490.0	122.4	46.1	90.7%
6	40 Antique		2,522.0	679.0	1,229.2	523.5	11.4	78.9	96.4%
6	41 Capiz		2,633.2	947.6	1,076.0	349.4	236.4	23.9	90.1%
6	42 Guimaras		604.6	326.0	252.1	-	20.6	5.9	95.6%
6	43 Iloilo		4,719.4	2,424.6	1,649.9	284.5	189.1	171.3	92.4%
6	44 Negros Occidental		7,926.1	4,599.5	2,218.2	686.6	235.7	186.2	94.7%
			20,223.2	9,519.0	7,033.4	2,342.9	815.6	512.3	93.4%
7	45 Bohol		4,117.4	1,848.8	1,565.1	390.0	223.6	89.9	92.4%
7	46 Cebu		5,088.4	2,255.2	2,499.2	101.6	95.9	136.5	95.4%
7	47 Negros Oriental		5,402.3	2,363.8	2,642.9	297.1	49.8	48.7	98.2%
7	48 Siquijor		343.5	171.3	153.1	16.4	0.7	2.0	99.2%
			14,951.6	6,639.1	6,860.3	805.2	369.9	277.1	95.7%
8	49 Biliran		555.5	266.8	226.4	50.7	5.1	6.5	97.9%
8	50 Eastern Samar		4,339.6	1,624.3	1,284.1	1,306.9	86.0	38.4	97.1%
8	51 Leyte		5,712.8	3,258.5	1,655.6	452.1	169.5	142.3	94.5%
8	52 Northern Samar		3,498.0	1,994.2	347.6	1,012.6	110.7	32.8	95.9%
8	53 Southern Leyte		1,734.8	905.1	525.6	256.1	8.3	39.7	97.2%
8	54 Western Samar		5,691.2	1,580.9	1,628.8	2,290.9	161.4	29.3	96.7%
			21,531.9	9,629.8	5,668.1	5,404.3	540.8	289.0	96.1%
9	55 Basilan		1,206.1	832.6	135.2	122.0	85.2	28.3	90.6%
9	56 Sulu		1,562.7	907.9	372.0	24.9	234.8	18.0	83.8%
9	57 Tawi-Tawi		1,087.4	323.2	310.0	253.4	191.3	9.5	81.5%
9	58 Zamboanga del Norte		6,065.2	1,945.2	2,476.6	1,585.6	35.2	22.5	99.0%
9	59 Zamboanga del Sur		8,818.9	3,658.0	3,116.1	1,404.8	574.6	65.4	92.7%
			18,740.3	7,666.9	6,417.9	3,390.7	1,121.1	143.6	93.3%
10	60 Agusan del Norte		2,590.3	703.7	450.4	1,293.8	46.4	96.1	94.5%
10	61 Agusan del Sur		8,965.5	1,458.4	1,598.1	5,681.8	454.3	72.8	94.1%
10	62 Bukidnon		7,970.8	2,591.5	2,960.9	2,381.0	-	34.4	99.6%
10	63 Camiguin		229.8	133.3	42.6	48.2	0.4	5.3	97.5%
10	64 Misamis Occidental		1,939.3	1,189.3	333.4	322.8	45.6	48.1	95.2%
10	65 Misamis Oriental		3,570.1	1,742.9	1,116.6	652.8	8.5	49.4	98.4%
10	66 Surigao del Norte		2,752.2	859.9	428.0	1,131.6	172.4	160.2	87.9%
			28,018.0	8,381.9	6,930.0	11,511.9	727.8	466.4	95.7%
11	67 Davao del Norte		8,129.8	2,340.3	3,872.4	1,864.6	21.4	31.1	99.4%
11	68 Davao del Sur		6,377.6	2,840.1	2,476.4	1,110.1	36.6	214.4	96.1%
11	69 Davao Oriental		5,164.5	1,593.0	1,472.7	1,999.3	26.7	72.9	98.1%
11	70 Surigao del Sur		4,552.2	795.3	701.5	2,939.6	64.5	51.2	97.5%
			24,224.1	7,568.7	8,223.0	7,913.7	149.1	369.6	97.9%
12	71 Lanao del Norte		2,945.9	653.9	1,149.4	815.0	74.1	253.4	88.9%
12	72 Lanao del Sur		2,905.6	720.1	622.2	1,397.8	18.9	46.6	97.7%
12	73 Maguindanao		4,848.6	1,525.6	1,772.1	700.2	694.4	156.3	82.5%
12	74 North Cotabato		6,529.9	2,416.2	2,910.5	884.4	271.5	47.4	95.1%
12	75 Sarangani		3,723.4	1,420.5	1,175.4	1,002.1	3.4	112.0	96.8%
12	76 South Cotabato		3,745.4	1,510.1	1,162.0	950.0	4.2	119.2	96.7%
12	77 Sultan Kudarat		5,263.4	1,489.4	2,031.2	1,574.0	45.9	122.8	96.8%
			29,962.2	9,785.8	10,872.7	7,328.5	1,112.4	862.7	93.4%
		Nation Total	*298,392.7*	*101,006.4*	*95,779.1*	*83,880.3*	*7,649.6*	*10,117.2*	*94.0%*

Notes

1 Land Use Area : categorized and surveied by the NWRB since 1993 until 1995
2 Rechargeable Land Ratio : total area ratio of Agriculture, Grass Shruland and Woodland

Table C-6 ADDITIONAL GROUNDWATER RECHARGE BY IRRIGATION WATER (1/2)

WRR	ID	Province	Base Data: Irrigable Area (km^2)	Present: Irrigated (km^2)	2000: Irrigated (km^2)	2000: Add. Rech. (MCM/year)	2005: Irrigated (km^2)	2005: Add. Rech. (MCM/year)	2010: Irrigated (km^2)	2010: Add. Rech. (MCM/year)
1	1	Abra	167.4	129.3	149.6	4.8	167.4	9.0	167.4	9.0
1	2	Benguet	83.4	107.8	107.8	-	107.8	-	107.8	-
1	3	Ilocos Norte	406.6	376.3	435.5	14.0	406.6	28.5	406.6	28.5
1	4	Ilocos Sur	300.3	175.3	202.9	6.5	239.2	15.1	246.8	16.9
1	5	La Union	169.9	153.3	169.9	3.9	169.9	3.9	169.9	3.9
			1,217.6	942.0	1,065.7	29.3	1,180.9	56.5	1,158.5	58.3
2	6	Batanes	0.0	0.3	0.3	-	0.3	-	0.3	-
2	7	Cagayan	1,472.8	494.0	571.7	18.4	674.0	42.6	695.3	47.6
2	8	Ifugao	193.1	71.2	82.4	2.6	97.1	6.1	100.2	6.9
2	9	Isabela	2,528.7	1,209.2	1,399.5	45.0	1,649.9	104.2	1702.1	116.6
2	10	Kalinga-Apayao	476.6	210.9	244.1	7.9	287.8	18.2	296.9	20.3
2	11	Mountain Province	75.0	79.4	79.4	-	79.4	-	79.4	-
2	12	Nueva Vizcaya	485.2	242.2	280.3	9.0	330.5	20.9	341.0	23.4
2	13	Quirino	279.7	45.4	52.5	1.7	61.9	3.9	63.9	4.4
			5,472.1	2,352.6	2,710.2	84.6	3,159.9	195.9	3,279.1	219.1
3	14	Bataan	185.2	78.2	90.5	2.9	106.7	6.7	110.1	7.5
3	15	Bulacan	519.7	357.0	413.2	13.3	483.1	30.8	502.5	34.4
3	16	Nueva Ecija	2,086.4	1,201.5	1,390.6	44.7	1,639.4	103.6	1691.3	115.8
3	17	Pampanga	573.7	430.4	498.1	16.0	573.7	33.9	573.7	33.9
3	18	Pangasinan	1,805.0	984.0	1,138.8	36.6	1,342.6	84.8	1385.1	94.9
3	19	Tarlac	1,145.3	397.3	459.8	14.8	542.1	34.2	559.3	38.3
3	20	Zambales	382.0	144.2	166.9	5.4	196.9	12.4	203.0	13.9
			6,627.3	3,592.6	4,157.9	133.7	4,888.4	306.5	5,025.0	338.8
4	21	Aurora	166.3	118.5	137.1	4.4	161.6	10.2	166.3	11.3
4	22	Batangas	92.6	37.5	43.4	1.4	51.2	3.2	52.8	3.6
4	23	Cavite	237.6	134.1	155.2	5.0	183.0	11.6	188.8	12.9
4	24	Laguna	225.1	149.2	172.7	5.6	203.6	12.9	210.0	14.4
4	25	Marinduque	21.9	10.2	11.8	0.4	13.9	0.9	14.3	1.0
4	26	Metro Manila	0.0	0.0	0.0	-	0.0	-	0.0	-
4	27	Occidental Mindoro	561.7	223.7	258.9	8.3	305.2	19.3	314.9	21.6
4	28	Oriental Mindoro	567.1	203.1	235.1	7.6	277.2	17.5	285.0	19.6
4	29	Palawan	356.1	143.6	166.2	5.3	195.9	12.4	202.1	13.9
4	30	Quezon	278.5	147.4	170.6	5.5	201.1	12.7	207.5	14.2
4	31	Rizal	93.3	33.1	38.3	1.2	45.2	2.9	46.6	3.2
4	32	Romblon	55.7	20.0	23.1	0.7	27.2	1.7	28.1	1.9
			2,635.9	1,220.4	1,412.4	45.4	1,665.1	105.2	1,713.4	117.6
5	33	Albay	546.2	338.5	391.8	12.6	461.9	29.2	476.5	32.6
5	34	Camarines Norte	225.9	60.8	70.4	2.3	83.0	5.3	85.6	5.9
5	35	Camarines Sur	1,237.0	560.5	648.7	20.9	764.8	48.3	789.0	54.0
5	36	Catanduanes	37.7	18.9	21.9	0.7	25.8	1.6	26.6	1.8
5	37	Masbate	198.8	46.3	53.6	1.7	63.2	4.0	65.2	4.5
5	38	Sorsogon	151.0	100.8	116.7	3.8	137.6	8.7	142.0	9.7
			2,396.6	1,325.8	1,303.1	41.9	1,536.3	97.1	1,584.9	108.6
6	39	Aklan	105.1	74.4	86.1	2.8	101.5	6.4	104.7	7.2
6	40	Antique	240.2	143.1	165.6	5.3	195.2	12.3	201.4	13.8
6	41	Capiz	156.7	42.3	48.7	1.6	57.4	3.6	59.2	4.0
6	42	Guimaras	89.3	42.4	49.1	1.6	57.9	3.7	59.7	4.1
6	43	Iloilo	662.5	315.4	365.0	11.7	430.3	27.2	443.9	30.4
6	44	Negros Occidental	738.9	376.3	204.0	6.6	240.5	15.2	248.1	17.0
			1,972.5	793.7	918.5	29.5	1,082.8	68.4	1,117.0	76.5
7	45	Bohol	300.9	107.5	124.4	4.0	146.7	9.3	151.3	10.4
7	46	Cebu	58.6	36.1	41.8	1.3	49.3	3.1	50.9	3.5
7	47	Negros Oriental	137.9	76.3	88.3	2.8	104.1	6.6	107.4	7.4
7	48	Siquijor	10.0	5.5	6.4	0.2	7.5	0.5	7.7	0.5
			507.4	225.4	260.9	8.4	307.6	19.4	317.3	21.7
8	49	Biliran	42.1	29.1	33.7	1.1	39.7	2.5	41.0	2.8
8	50	Eastern Samar	40.7	23.3	27.0	0.9	31.8	2.0	32.8	2.2
8	51	Leyte	514.1	354.8	410.6	13.2	484.1	30.6	499.4	34.2
8	52	Northern Samar	108.6	30.6	35.4	1.1	41.7	2.6	43.0	2.9
8	53	Southern Leyte	56.9	53.6	56.9	0.8	56.9	0.8	56.9	0.8
8	54	Western Samar	81.4	16.9	19.6	0.6	23.1	1.5	23.8	1.6
			843.8	508.3	583.2	17.7	677.3	40.0	696.9	44.6
9	55	Basilan	4.2	1.9	2.2	0.1	2.6	0.2	2.7	0.2
9	56	Sulu	0.0	1.5	1.5	-	1.5	-	1.5	-
9	57	Tawi-Tawi	0.0	0.1	0.1	-	0.1	-	0.1	-
9	58	Zamboanga del Norte	323.1	58.0	67.1	2.2	79.1	5.0	81.6	5.6
9	59	Zamboanga del Sur	437.7	284.0	328.7	10.6	387.5	24.5	399.8	27.4
			765.0	345.5	399.6	12.8	470.8	29.6	485.7	33.2
10	60	Agusan del Norte	524.9	96.6	111.8	3.6	131.8	8.3	136.0	9.3
10	61	Agusan del Sur	564.5	135.8	157.2	5.1	185.3	11.7	191.2	13.1
10	62	Bukidnon	873.0	291.1	336.9	10.8	397.2	25.1	409.8	28.1
10	63	Camiguin	14.1	2.8	3.2	0.1	3.8	0.2	3.9	0.3
10	64	Misamis Occidental	125.9	24.8	28.7	0.9	33.8	2.1	34.9	2.4
10	65	Misamis Oriental	64.4	61.3	61.4	0.7	64.4	0.7	64.4	0.7
10	66	Surigao del Norte	130.7	65.3	75.6	2.4	89.1	5.6	91.9	6.3
			2,301.5	677.7	777.8	23.7	905.4	53.9	932.1	60.2
11	67	Davao del Norte	955.6	312.6	361.8	11.6	426.5	26.9	440.0	30.1
11	68	Davao del Sur	213.2	130.7	151.3	4.9	178.4	11.3	184.0	12.6
11	69	Davao Oriental	177.7	43.3	50.1	1.6	59.1	3.7	61.0	4.2
11	70	Surigao del Sur	402.9	70.3	81.4	2.6	96.0	6.1	99.0	6.8
			1,779.4	556.9	644.6	20.7	760.0	48.0	784.0	53.7
12	71	Lanao del Norte	125.6	143.6	143.6	-	143.6	-	143.6	-
12	72	Lanao del Sur	471.9	39.3	45.5	1.5	53.9	3.5	55.5	3.8
12	73	Maguindanao	1,093.1	140.8	163.0	5.3	192.2	12.2	198.3	13.6
12	74	North Cotabato	1,413.6	313.5	362.8	11.7	427.7	27.0	441.2	30.2
12	75	Sarangani	119.6	73.3	84.8	2.7	100.0	6.3	103.2	7.1
12	76	South Cotabato	1,003.5	267.4	309.5	10.0	364.9	23.1	376.4	25.8
12	77	Sultan Kudarat	518.7	298.6	345.6	11.1	407.4	25.7	420.3	28.8
			4,744	1,277	1,455	42	1,690	98	1,739	109
		Nation Total	*31,263*	*13,617*	*15,689*	*499*	*18,345*	*1,118*	*18,866*	*1,241*

Table C-6 ADDITIONAL GROUNDWATER RECHARGE BY IRRIGATION WATER (2/2)

WRR	ID	Province	Base Data: Irrigable Area (km²)	Present: Irrigated (km²)	2015: Irrigated (km²)	2015: Add. Rech. (MCM/year)	2020: Irrigated (km²)	2020: Add. Rech. (MCM/year)	2025: Irrigated (km²)	2025: Add. Rech. (MCM/year)
1	1	Abra	167.4	129.3	167.4	9.0	167.4	9.0	167.4	9.0
1	2	Benguet	83.4	107.8	107.8	-	107.8	-	107.8	-
1	3	Ilocos Norte	496.6	376.3	496.6	28.5	496.6	28.5	496.6	28.5
1	4	Ilocos Sur	300.3	175.3	246.8	16.9	262.4	20.6	300.3	29.6
1	5	La Union	169.9	153.3	169.9	3.9	169.9	3.9	169.9	3.9
			1,217.6	942.0	1,188.5	58.3	1,204.1	62.0	1,242.0	71.0
2	6	Batanes	0.0	0.3	0.3	-	0.3	-	0.3	-
2	7	Cagayan	1,472.8	494.0	695.3	47.6	739.2	58.0	851.5	84.6
2	8	Ifugao	194.1	71.2	100.2	6.9	106.5	8.3	122.7	12.2
2	9	Isabela	2,528.7	1,209.2	1702.1	116.6	1809.6	142.0	2,084.6	207.0
2	10	Kalinga-Apayao	406.6	210.9	296.9	20.3	315.7	24.8	363.6	36.1
2	11	Mountain Province	75.0	79.4	79.4	-	79.4	-	79.4	-
2	12	Nueva Vizcaya	455.2	242.2	341.0	23.4	362.5	28.5	417.6	41.5
2	13	Quirino	239.7	45.4	63.9	4.4	67.9	5.3	78.2	7.8
			5,472.4	2,352.6	3,279.1	219.1	3,451.1	266.9	3,997.9	389.1
3	14	Bataan	115.2	78.2	110.1	7.5	115.2	8.8	115.2	8.8
3	15	Bulacan	519.7	357.0	502.5	34.4	519.7	39.5	519.7	38.5
3	16	Nueva Ecija	2,056.4	1,201.5	1691.3	115.8	1798.2	141.1	2,071.3	205.7
3	17	Pampanga	573.7	430.4	573.7	33.9	573.7	33.9	573.7	33.9
3	18	Pangasinan	1,855.0	984.0	1385.1	94.9	1472.6	115.6	1,696.2	168.4
3	19	Tarlac	1,145.3	397.3	559.3	38.3	594.6	46.7	684.9	68.0
3	20	Zambales	382.0	144.2	203.0	13.9	215.8	16.9	248.6	24.7
			6,627.3	3,592.6	5,025.0	338.8	5,289.8	401.4	5,909.6	548.0
4	21	Aurora	166.3	118.5	166.3	11.3	166.3	11.3	166.3	11.3
4	22	Batangas	92.6	37.5	52.8	3.6	56.1	4.4	64.6	6.4
4	23	Cavite	237.6	134.1	188.8	12.9	200.7	15.8	231.2	23.0
4	24	Laguna	275.1	149.2	210.0	14.4	223.3	17.5	257.2	25.5
4	25	Marinduque	21.9	10.2	14.3	1.0	15.2	1.2	17.5	1.7
4	26	Metro Manila	0.0	0.0	0.0	-	0.0	-	0.0	-
4	27	Occidental Mindoro	561.7	223.7	314.9	21.6	334.8	26.3	385.6	38.3
4	28	Oriental Mindoro	567.1	203.1	286.0	19.6	304.1	23.9	350.3	34.8
4	29	Palawan	286.1	143.6	202.1	13.8	214.9	16.9	247.5	24.6
4	30	Quezon	278.5	147.4	207.5	14.2	220.6	17.3	254.1	25.2
4	31	Rizal	93.3	33.1	46.6	3.2	49.5	3.9	57.0	5.7
4	32	Romblon	55.2	20.0	28.1	1.9	29.9	2.3	34.4	3.4
			2,635.9	1,220.4	1,717.4	117.6	1,815.4	140.7	2,065.7	199.9
5	33	Albay	546.2	358.5	476.5	32.6	506.6	39.8	546.2	49.1
5	34	Camarines Norte	225.9	69.8	85.6	5.9	91.0	7.1	104.8	10.4
5	35	Camarines Sur	1,237.0	560.5	759.0	54.0	835.9	65.8	966.3	96.0
5	36	Catanduanes	37.7	18.9	26.6	1.8	28.3	2.2	32.6	3.2
5	37	Masbate	198.8	46.3	65.2	4.5	69.3	5.4	79.8	7.9
5	38	Sorsogon	151.0	100.8	142.0	9.7	151.0	11.9	151.0	11.9
			2,396.6	1,425.8	1,554.9	108.6	1,685.1	132.3	1,880.7	178.5
6	39	Aklan	105.1	74.4	104.7	7.2	105.1	7.3	105.1	7.3
6	40	Antique	240.2	143.1	201.4	13.8	214.1	16.8	240.2	23.0
6	41	Capiz	136.7	42.1	59.2	4.0	62.9	4.9	72.5	7.2
6	42	Guimaras	89.1	42.4	53.7	4.1	63.5	5.0	73.1	7.3
6	43	Iloilo	662.5	315.4	443.9	30.4	472.0	37.0	543.7	51.0
6	44	Negros Occidental	736.9	176.3	248.1	17.0	263.8	20.7	303.9	30.2
			1,972.5	793.7	1,117.0	76.5	1,181.4	91.7	1,338.5	128.9
7	45	Bohol	300.9	107.5	151.3	10.4	160.9	12.6	185.3	18.4
7	46	Cebu	58.6	36.1	50.9	3.5	54.1	4.3	58.6	5.3
7	47	Negros Oriental	137.9	76.3	107.4	7.4	114.2	9.0	133.5	13.1
7	48	Siquijor	10.0	5.5	7.7	0.5	8.2	0.6	9.4	0.9
			507.4	225.4	317.3	21.7	337.4	26.5	384.8	37.7
8	49	Biliran	42.1	29.1	41.0	2.8	42.1	3.1	42.1	3.1
8	50	Eastern Samar	40.7	23.3	32.8	2.2	34.9	2.7	40.2	4.0
8	51	Leyte	514.1	354.8	499.4	34.2	514.1	37.7	514.1	37.7
8	52	Northern Samar	108.6	30.6	43.0	2.9	45.7	3.6	52.6	5.2
8	53	Southern Leyte	56.9	53.6	56.9	0.8	56.9	0.8	56.9	0.8
8	54	Western Samar	81.4	16.9	23.8	1.6	25.3	2.0	29.1	2.9
			843.8	508.3	696.9	44.6	719.0	49.8	735.0	53.6
9	55	Basilan	4.2	1.9	2.7	0.2	2.9	0.2	3.3	0.3
9	56	Sulu	0.0	1.5	1.5	-	1.5	-	1.5	-
9	57	Tawi-Tawi	0.0	0.1	0.1	-	0.1	-	0.1	-
9	58	Zamboanga del Norte	323.1	58.0	81.6	5.6	86.8	6.8	100.0	9.9
9	59	Zamboanga del Sur	437.7	284.0	399.8	27.4	425.1	33.4	437.7	36.4
			765.0	345.5	485.7	33.2	516.4	40.4	542.6	46.6
10	60	Agusan del Norte	524.9	96.6	136.0	9.3	144.6	11.4	166.6	16.6
10	61	Agusan del Sur	564.5	135.8	191.2	13.1	203.3	16.0	234.2	23.3
10	62	Bukidnon	877.0	291.1	409.8	28.1	435.7	34.2	501.9	49.9
10	63	Camiguin	14.1	2.8	3.9	0.3	4.1	0.3	4.7	0.4
10	64	Misamis Occidental	125.9	24.8	34.9	2.4	37.1	2.9	42.7	4.2
10	65	Misamis Oriental	64.4	61.3	64.4	0.7	64.4	0.7	64.4	0.7
10	66	Surigao del Norte	130.7	65.3	91.9	6.3	97.7	7.7	112.5	11.2
			2,301.5	677.7	932.1	60.2	986.9	73.1	1,127.0	106.3
11	67	Davao del Norte	955.6	312.6	440.0	30.1	467.8	36.7	538.8	53.5
11	68	Davao del Sur	213.2	130.7	184.0	12.6	195.6	15.4	213.2	19.5
11	69	Davao Oriental	177.7	43.3	61.0	4.2	64.9	5.1	74.8	7.5
11	70	Surigao del Sur	402.9	70.3	99.0	6.8	105.3	8.3	121.3	12.1
			1,779.4	556.9	784.0	53.7	833.6	65.4	948.1	92.5
12	71	Lanao del Norte	125.6	143.6	143.6	-	143.6	-	143.6	-
12	72	Lanao del Sur	471.9	39.3	55.5	3.8	59.0	4.7	68.0	6.8
12	73	Maguindanao	1,091.1	140.8	198.3	13.6	210.8	16.6	242.8	24.1
12	74	North Cotabato	1,413.6	313.5	441.2	30.2	469.1	36.8	540.3	53.6
12	75	Sarangani	119.6	73.3	103.2	7.1	109.7	8.6	119.6	11.0
12	76	South Cotabato	1,003.8	267.4	376.4	25.8	400.2	31.4	461.0	45.8
12	77	Sultan Kudarat	518.7	298.6	420.3	28.8	446.9	35.1	514.8	51.1
			4,744	1,277	1,739	109	1,839	133	2,090	192
		Nation Total	*31,263*	*13,817*	*18,566*	*1,241*	*19,899*	*1,453*	*22,262*	*2,045*

Table C-7 REDUCED GROUNDWATER RECHARGE BY URBANIZATION (1/2)

WRR	ID	Province	Present		2000		2005		2010	
			Urban Pop. (Persons)	Misc. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)
1	1	Abra	41,741	133.8	46,228	16.5	51,295	35.2	55,900	52.2
1	2	Benguet	310,916	74.4	394,301	20.0	487,926	42.4	592,821	67.5
1	3	Ilocos Norte	137,556	178.5	151,214	17.7	163,437	33.6	174,595	48.6
1	4	Ilocos Sur	128,166	199.1	141,592	25.5	159,824	49.2	174,605	72.1
1	5	La Union	157,727	116.1	185,064	20.1	215,643	42.6	244,236	63.7
			776,106	721.9	921,399	99.9	1,078,125	203.0	1,242,558	304.1
2	6	Batanes	5,332	7.6	6,828	2.1	7,709	3.4	9,078	5.3
2	7	Cagayan	143,210	215.7	154,842	17.5	167,721	35.9	181,082	57.0
2	8	Isabela	15,857	32.0	19,624	7.6	22,391	13.2	25,301	19.1
2	9	Isabela	294,827	636.9	355,706	131.5	413,014	255.3	467,620	373.2
2	10	Kalinga Apayao	41,708	127.6	53,960	26.4	66,486	62.2	79,790	100.1
2	11	Mt. Province	6,015	41.1	6,323	2.1	6,978	6.6	7,705	13.6
2	12	Nueva Vizcaya	97,476	96.4	109,431	13.8	124,637	26.9	139,063	42.0
2	13	Quirino	32,649	53.1	38,238	9.1	45,343	20.6	52,583	32.4
			640,074	1,210.3	744,952	208.2	854,279	425.0	963,126	640.8
3	14	Bataan	345,501	47.4	402,143	7.8	466,757	16.6	527,274	24.9
3	15	Bulacan	1,452,560	308.4	1,681,671	48.6	2,000,213	116.3	2,332,664	186.9
3	16	Nueva Ecija	412,720	320.7	476,679	24.6	526,811	60.9	560,854	92.1
3	17	Pampanga	1,189,222	358.5	1,467,249	83.8	1,696,067	152.8	1,915,039	218.8
3	18	Pangasinan	910,599	314.2	1,078,241	57.8	1,271,658	124.4	1,472,368	193.8
3	19	Tarlac	273,343	226.8	324,943	52.2	378,679	106.7	430,533	159.2
3	20	Zambales	348,793	153.3	383,814	30.9	416,047	46.8	446,528	61.4
			4,932,729	1,729.2	5,814,040	305.8	6,755,632	624.4	7,694,270	937.1
4	21	Aurora	67,200	109.6	90,511	38.0	114,035	76.4	139,767	118.4
4	22	Batangas	830,955	104.6	1,006,567	22.1	1,185,191	44.6	1,341,211	64.7
4	23	Cavite	1,150,384	112.1	1,293,713	10.8	1,427,053	23.4	1,551,291	45.7
4	24	Laguna	1,345,659	143.6	1,679,905	35.7	2,105,089	81.0	2,539,840	127.4
4	25	Marinduque	27,988	17.1	30,852	1.7	33,415	3.3	35,604	4.7
4	26	Metro Manila	9,454,190	636.0	10,369,987	-	11,243,097	-	11,964,236	-
4	27	Occidental Mindoro	177,722	256.3	224,069	66.8	286,414	156.7	358,703	261.0
4	28	Oriental Mindoro	91,294	237.1	108,234	44.0	122,414	80.8	136,468	117.3
4	29	Palawan	229,937	891.1	290,350	234.1	368,590	537.3	462,400	900.9
4	30	Quezon	498,236	304.6	585,095	53.1	681,571	99.8	733,023	143.5
4	31	Rizal	1,257,384	220.0	1,493,956	41.4	1,801,645	95.2	2,142,016	154.8
4	32	Romblon	49,421	15.4	62,112	4.0	73,859	7.6	86,695	13.6
			15,210,370	3,047.4	17,235,351	551.7	19,422,373	1,206.3	21,604,758	1,949.9
5	33	Albay	262,391	119.3	298,201	16.3	337,093	34.0	373,360	50.5
5	34	Camarines Norte	118,134	31.2	136,996	5.0	155,318	9.8	173,879	14.7
5	35	Camarines Sur	501,417	173.1	613,678	39.6	719,464	77.0	832,519	116.9
5	36	Catanduanes	55,273	30.1	63,904	4.7	78,420	12.6	94,975	21.6
5	37	Masbate	131,426	46.4	141,901	3.7	152,848	7.6	163,315	11.3
5	38	Sorsogon	152,127	33.5	156,670	1.0	168,332	3.6	179,491	6.0
			1,220,768	437.6	1,411,350	70.3	1,611,273	144.5	1,817,539	221.0
6	39	Aklan	114,131	46.1	141,963	11.2	178,312	25.9	220,069	42.8
6	40	Antique	123,471	78.9	144,951	13.7	167,840	28.4	191,870	43.7
6	41	Capiz	206,078	23.9	263,339	6.6	334,471	14.9	417,222	24.5
6	42	Guimaras	47,553	5.9	61,181	1.7	71,959	3.0	83,262	4.5
6	43	Iloilo	657,844	171.3	848,738	49.7	997,644	88.5	1,149,966	128.1
6	44	Negros Occidental	1,209,809	186.2	1,402,944	29.7	1,603,737	60.6	1,786,146	88.7
			2,358,886	512.3	2,863,116	112.7	3,353,963	221.3	3,848,535	332.2
7	45	Bohol	251,595	89.9	328,063	27.3	410,294	56.7	504,805	90.5
7	46	Cebu	1,708,896	136.5	1,992,810	22.7	2,299,993	47.2	2,610,103	72.0
7	47	Negros Oriental	326,033	48.7	376,074	7.5	438,251	16.8	505,309	26.8
7	48	Siquijor	11,653	2.0	13,729	0.3	15,246	0.6	16,842	0.9
			2,298,177	277.1	2,710,671	57.8	3,163,784	121.3	3,637,059	190.2
8	49	Biliran	36,358	6.5	42,779	1.1	50,777	2.6	58,732	4.0
8	50	Eastern Samar	117,304	38.4	131,427	4.6	149,343	10.5	165,668	15.8
8	51	Leyte	518,367	142.3	611,500	25.6	726,142	57.0	840,201	88.3
8	52	Northern Samar	136,259	32.8	157,737	5.2	170,918	8.4	184,822	14.1
8	53	Southern Leyte	62,878	39.7	83,542	13.0	98,334	22.4	113,825	32.2
8	54	Western Samar	138,504	29.3	162,646	5.1	197,155	12.4	234,339	20.2
			1,009,760	289.0	1,189,631	54.6	1,392,669	113.2	1,607,587	174.7
9	55	Basilan	139,213	28.3	174,748	7.2	210,293	14.4	258,235	24.2
9	56	Sulu	146,385	18.0	186,548	5.0	224,623	9.6	264,541	14.6
9	57	Tawi-tawi	83,490	9.5	106,296	2.6	138,310	6.2	174,388	10.3
9	58	Zamboanga del Norte	143,351	22.5	164,267	3.3	189,867	7.3	214,222	11.1
9	59	Zamboanga del Sur	739,762	65.4	978,750	21.1	1,259,917	46.0	1,576,804	74.0
			1,252,201	143.6	1,610,709	39.2	2,023,010	83.6	2,488,193	134.1
10	60	Agusan del Norte	227,920	96.1	258,703	13.0	290,378	26.3	319,726	38.7
10	61	Agusan del Sur	124,053	72.8	152,345	16.6	189,805	38.6	232,807	63.8
10	62	Bukidnon	338,550	34.4	471,876	13.6	611,877	27.8	766,612	43.5
10	63	Camiguin	40,619	5.3	50,446	1.3	60,951	2.2	71,392	4.0
10	64	Misamis Occidental	139,986	43.1	166,712	9.2	197,120	19.6	229,395	30.7
10	65	Misamis Oriental	681,654	49.4	784,059	7.4	937,579	18.5	1,099,806	30.3
10	66	Surigao del Norte	172,018	160.2	203,627	29.4	227,492	51.7	249,374	72.8
			1,724,800	466.4	2,087,773	90.5	2,515,202	185.3	2,969,202	283.2
11	67	Davao del Norte	324,077	31.1	430,762	10.2	467,092	13.7	501,685	17.0
11	68	Davao del Sur	848,704	214.4	908,703	45.2	1,031,482	46.2	1,153,959	77.1
11	69	Davao Oriental	114,534	72.9	132,321	11.3	151,362	23.4	168,433	34.3
11	70	Surigao del Sur	203,588	51.2	248,717	11.4	297,052	23.5	348,263	36.4
			1,490,903	369.6	1,720,503	48.1	1,946,988	106.8	2,172,370	164.9
12	71	Lanao del Norte	241,992	253.4	291,880	95.5	392,666	216.0	507,109	352.8
12	72	Lanao del Sur	239,680	46.6	300,256	11.8	379,179	27.1	463,708	43.5
12	73	Maguindanao	235,859	156.3	349,584	41.8	421,639	82.6	499,453	126.6
12	74	North Cotabato	202,730	47.4	254,358	12.0	306,148	24.2	362,509	37.3
12	75	Sarangani	218,373	117.0	251,798	17.9	321,481	55.2	397,413	95.9
12	76	South Cotabato	451,412	119.2	519,466	15.0	663,149	55.9	821,555	91.7
12	77	Sultan Kudarat	209,640	122.8	250,255	23.8	303,477	55.0	359,931	88.1
			1,809,693	852.7	2,217,397	221	2,787,739	516	3,411,378	842
		Nation Total	34,724,465	10,117.2	40,526,898	1,860	46,905,033	3,951	53,456,575	6,174

Notes

1 Urban Pop.(Population) ; estimated by the NEDA based on 1995 *population census.*

2 Add.Mis.(Additional miscellaneous land) ; estimated from land use pattern, which is to vary by increase of urban population.

Table C-7 REDUCED GROUNDWATER RECHARGE BY URBANIZATION (2/2)

WRR	ID	Province	Present		2015		2020		2025	
			Urban Pop. (Persons)	Misc. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)	Urban Pop. (Persons)	Add.Mis. (km^2)
1	1	Abra	41,741	153.8	60,204	68.0	63,407	79.8	65,926	89.1
1	2	Benguet	310,916	74.4	707,817	95.0	828,612	123.9	956,136	154.4
1	3	Ilocos Norte	137,556	128.5	184,318	60.7	191,941	70.6	198,357	78.9
1	4	Ilocos Sur	128,166	199.1	156,325	90.3	194,344	102.8	199,655	111.5
1	5	La Union	157,727	316.1	270,370	82.9	292,654	99.4	308,332	110.9
			776,106	721.9	1,409,034	397.0	1,570,958	476.5	1,728,716	544.9
2	6	Batanes	5,332	7.6	9,591	6.1	10,589	7.5	11,593	8.9
2	7	Cagayan	143,210	215.7	193,308	75.4	203,729	91.1	211,495	102.8
2	8	Ifugao	15,857	32.0	27,824	24.2	30,091	28.8	32,045	32.7
2	9	Isabela	294,827	636.9	510,751	466.4	545,879	542.3	571,340	597.3
2	10	Kalinga-Apayao	44,708	122.6	93,080	138.1	165,693	174.1	118,310	210.1
2	11	Mt. Province	6,015	41.1	8,356	16.0	8,751	18.7	9,329	22.7
2	12	Nueva Vizcaya	97,476	96.4	154,254	56.1	167,109	68.8	177,415	79.0
2	13	Quirino	32,649	53.1	60,094	44.6	67,052	55.9	73,510	66.4
			640,074	1,210.3	1,057,258	826.9	1,138,854	987.2	1,205,037	1,119.9
3	14	Bataan	345,501	47.4	578,767	32.0	621,396	37.8	655,275	42.5
3	15	Bulacan	1,452,560	308.4	2,574,841	238.3	2,733,807	280.5	2,961,020	320.3
3	16	Nueva Ecija	442,720	320.7	607,437	119.3	637,864	141.3	662,345	159.1
3	17	Pampanga	1,189,222	358.5	2,120,435	280.7	2,304,040	336.4	2,472,304	386.8
3	18	Pangasinan	910,500	314.2	1,677,254	264.5	1,889,422	334.6	2,079,181	403.2
3	19	Tarlac	273,343	276.8	476,658	205.9	516,100	245.8	549,029	279.1
3	20	Zambales	318,793	153.3	472,459	73.9	495,814	84.8	515,062	94.4
			4,932,329	1,779.2	8,507,851	1,214.6	9,229,652	1,461.3	9,894,146	1,685.3
4	21	Aurora	67,200	109.6	169,590	167.0	200,305	217.1	232,029	268.9
4	22	Batangas	830,955	104.6	1,523,112	87.1	1,703,554	109.9	1,846,735	127.8
4	23	Cavite	1,150,384	112.1	1,925,045	70.7	2,199,839	96.8	2,456,090	121.2
4	24	Laguna	1,345,659	143.6	2,995,688	176.0	3,352,638	214.1	3,718,673	253.2
4	25	Marinduque	27,088	37.1	37,990	6.1	39,951	7.3	41,438	8.2
4	26	Metro Manila	9,454,190	636.0	12,525,987	-	12,954,059	-	13,272,876	-
4	27	Occidental Mindoro	177,722	256.3	444,417	384.6	538,922	520.9	614,477	629.8
4	28	Oriental Mindoro	91,294	233.1	150,774	154.5	164,324	159.7	178,294	226.0
4	29	Palawan	229,937	801.1	578,738	1,351.7	711,623	1,866.7	865,539	2,463.1
4	30	Quezon	408,236	304.6	812,161	491.9	887,624	238.0	963,275	284.3
4	31	Rizal	1,257,384	220.0	2,543,004	224.9	2,984,655	302.2	3,471,091	387.2
4	32	Romblon	49,421	35.4	101,402	16.2	117,050	24.1	132,735	26.0
			15,210,370	3,047.4	23,807,908	2,830.8	25,854,873	3,783.8	27,793,292	4,795.7
5	33	Albay	262,391	119.3	402,095	63.5	424,760	73.8	444,159	82.7
5	34	Camarines Norte	118,134	31.2	191,531	19.4	208,647	23.9	224,702	26.2
5	35	Camarines Sur	501,417	177.1	945,700	156.9	1,056,684	196.1	1,161,258	233.0
5	36	Catanduanes	55,273	30.1	113,275	31.6	134,758	43.3	151,120	52.2
5	37	Masbate	131,426	46.4	172,238	14.4	178,603	16.5	182,902	18.2
5	38	Sorsogon	152,827	33.5	189,772	8.3	197,352	10.0	201,670	10.9
			1,220,768	437.6	2,014,611	294.1	2,200,232	363.5	2,365,811	425.1
6	39	Aklan	114,131	46.1	266,630	61.5	315,790	81.4	367,476	102.2
6	40	Antique	123,471	78.9	216,081	59.2	240,535	74.8	264,483	90.1
6	41	Capiz	206,078	23.9	508,768	35.1	607,547	46.6	711,092	58.6
6	42	Guimaras	47,553	5.9	94,327	5.8	104,429	7.1	113,678	8.2
6	43	Iloilo	657,844	171.3	1,298,383	166.8	1,437,692	202.9	1,563,903	235.9
6	44	Negros Occidental	1,209,809	156.2	1,931,703	111.1	2,036,075	127.1	2,124,085	140.8
			2,358,886	532.3	4,315,892	439.5	4,741,469	539.9	5,145,622	635.9
7	45	Bohol	251,595	89.9	611,751	128.7	729,360	170.8	851,784	214.5
7	46	Cebu	1,708,896	136.5	2,901,391	95.2	3,169,556	116.7	3,362,907	132.1
7	47	Negros Oriental	326,033	48.7	574,030	37.1	642,086	47.2	709,883	57.4
7	48	Siquijor	11,653	2.0	18,517	1.1	19,764	1.4	21,047	1.6
			2,298,177	277.1	4,105,692	262.2	4,560,766	336.0	4,945,619	405.6
8	49	Biliran	36,358	6.5	63,372	5.6	75,552	7.1	84,246	8.6
8	50	Eastern Samar	117,394	38.4	179,562	20.3	191,451	24.2	199,579	26.9
8	51	Leyte	518,367	142.3	961,388	121.6	1,083,199	155.0	1,202,920	187.9
8	52	Northern Samar	135,259	32.8	216,063	19.2	235,106	23.8	245,939	26.4
8	53	Southern Leyte	62,878	39.7	128,889	41.7	144,120	51.3	158,958	60.7
8	54	Western Samar	138,504	29.3	275,042	28.8	315,654	38.1	350,263	44.7
			1,009,760	289.0	1,828,316	237.2	2,045,762	299.6	2,241,935	355.2
9	55	Basilan	139,213	28.3	303,061	53.3	343,205	41.4	374,391	47.7
9	56	Sulu	145,385	18.0	304,749	19.5	343,826	24.3	369,356	28.8
9	57	Tawi-tawi	83,490	9.5	210,206	14.4	245,772	18.4	276,494	21.9
9	58	Zamboanga del Norte	143,351	22.5	237,456	14.7	258,116	18.0	276,592	20.9
9	59	Zamboanga del Sur	739,762	65.4	1,919,418	104.2	2,258,753	136.9	2,554,323	160.3
			1,252,201	143.6	2,974,590	186.1	3,479,672	239.0	3,852,156	279.2
10	60	Agusan del Norte	227,920	96.1	345,012	49.4	365,011	57.8	379,614	64.0
10	61	Agusan del Sur	124,053	72.8	283,784	93.8	338,804	126.1	398,413	151.1
10	62	Bukidnon	338,550	34.4	927,906	59.9	1,084,269	75.8	1,222,569	89.9
10	63	Camiguin	40,619	5.3	80,306	5.2	86,102	6.0	89,985	6.5
10	64	Misamis Occidental	139,986	48.1	261,894	41.9	293,892	52.9	323,997	63.3
10	65	Misamis Oriental	681,654	49.4	1,265,589	42.3	1,393,368	51.6	1,439,745	54.9
10	66	Surigao del Norte	172,018	160.2	267,122	88.6	279,510	100.1	288,625	108.6
			1,724,800	466.4	3,431,604	381.1	3,840,956	470.3	4,142,978	548.2
11	67	Davao del Norte	324,077	31.1	562,547	22.9	618,257	28.2	672,941	33.5
11	68	Davao del Sur	848,704	214.4	1,244,297	99.9	1,318,280	118.6	1,373,518	132.6
11	69	Davao Oriental	314,534	72.9	179,994	41.6	158,180	46.8	194,019	50.6
11	70	Surigao del Sur	203,588	51.2	392,510	47.5	434,013	58.0	472,636	67.7
			1,490,903	369.6	2,379,348	212.0	2,558,730	251.7	2,713,114	284.3
12	71	Lanao del Norte	218,997	253.4	628,588	493.0	748,994	642.0	862,206	777.3
12	72	Lanao del Sur	239,680	46.6	542,633	58.9	609,533	71.9	658,157	81.3
12	73	Maguindanao	275,559	156.3	579,340	172.0	664,351	220.2	748,973	268.1
12	74	North Cotabato	202,730	47.4	418,127	50.3	473,714	63.3	527,455	75.9
12	75	Sarangani	218,373	117.0	469,896	134.7	544,782	174.8	608,897	209.2
12	76	South Cotabato	451,412	119.2	970,431	137.0	1,126,958	178.3	1,260,081	213.5
12	77	Sultan Kudarat	209,640	122.8	416,029	120.9	467,378	151.0	514,084	178.4
			1,809,691	862.7	4,025,053	1,122	4,635,200	1,502	5,179,853	1,804
		Nation Total	23,724,465	10,117.2	59,557,157	8,453	65,860,654	10,710	71,215,229	12,884

Notes

1 Urban Pop.(Population) ; estimated by the NEDA based on 1995 population census.

2 Add.Mis.(Additional miscellaneous land) ; estimated from land use pattern, which is to vary by increase of urban population.

Table C-8 GROUNDWATER RECHARGE FORECASTING BY PROVINCE

WRR	ID	Province	1995 (MCM/year)	2000 (MCM/year)	2005 (MCM/year)	2010 (MCM/year)	2015 (MCM/year)	2020 (MCM/year)	2025 (MCM/year)
1	1	Abra	535	537	539	537	535	533	532
1	2	Benguet	493	489	485	481	475	470	464
1	3	Ilocos Norte	471	483	495	493	491	490	488
1	4	Ilocos Sur	343	346	351	350	348	350	358
1	5	La Union	188	189	186	184	181	179	178
2	6	Batanes	27	27	27	26	26	26	26
2	7	Cagayan	1,084	1,100	1,122	1,124	1,122	1,130	1,156
2	8	Ifugao	203	205	208	208	208	209	212
2	9	Isabela	1,141	1,172	1,218	1,218	1,208	1,225	1,265
2	10	Kalinga Apayao	615	621	628	627	623	624	632
2	11	Mountain Province	175	174	174	174	173	173	173
2	12	Nueva Vizcaya	372	380	391	392	390	394	406
2	13	Quirino	338	338	339	338	337	337	338
3	14	Bataan	140	142	145	145	143	145	145
3	15	Bulacan	316	324	333	328	322	321	316
3	16	Nueva Ecija	463	506	562	571	569	592	655
3	17	Pampanga	184	193	205	200	195	190	186
3	18	Pangasinan	454	486	528	532	526	541	588
3	19	Tarlac	222	233	248	248	245	250	269
3	20	Zambales	372	379	385	385	383	385	392
4	21	Aurora	393	393	394	390	384	378	372
4	22	Batangas	230	230	230	229	227	226	227
4	23	Cavite	92	96	102	101	100	100	106
4	24	Laguna	141	141	148	145	141	142	146
4	25	Marinduque	77	77	77	77	77	77	78
4	26	Metro Manila	52	52	52	52	52	52	52
4	27	Occidental Mindoro	488	491	494	488	478	471	474
4	28	Oriental Mindoro	378	382	389	388	385	386	394
4	29	Palawan	1,074	1,161	1,144	1,117	1,081	1,044	1,004
4	30	Quezon	905	905	907	904	899	898	901
4	31	Rizal	120	118	114	109	103	96	90
4	32	Romblon	104	104	105	105	104	104	105
5	33	Albay	293	304	318	320	318	324	333
5	34	Camarines Norte	355	356	358	358	357	358	360
5	35	Camarines Sur	551	567	591	592	588	596	622
5	36	Catanduanes	202	202	202	201	199	198	198
5	37	Masbate	433	434	436	436	436	436	439
5	38	Sorsogon	236	240	245	245	245	247	247
6	39	Aklan	178	180	182	181	179	178	176
6	40	Antique	293	297	302	302	300	301	306
6	41	Capiz	339	339	340	340	338	338	338
6	42	Guimaras	69	70	72	72	72	73	75
6	43	Iloilo	556	562	573	571	567	569	582
6	44	Negros Occidental	1,093	1,095	1,099	1,097	1,094	1,096	1,103
7	45	Bohol	263	265	269	267	265	265	268
7	46	Cebu	403	403	403	401	399	398	398
7	47	Negros Oriental	425	427	430	430	429	430	433
7	48	Siquijor	24	24	24	24	24	24	25
8	49	Biliran	78	79	80	80	80	80	80
8	50	Eastern Samar	688	688	689	688	687	687	688
8	51	Leyte	652	662	676	676	672	672	668
8	52	Northern Samar	589	589	590	589	588	588	589
8	53	Southern Leyte	190	189	188	187	186	185	184
8	54	Western Samar	818	818	818	817	815	814	814
9	55	Basilan	99	98	98	97	96	96	95
9	56	Sulu	137	137	137	136	136	135	135
9	57	Tawi-Tawi	100	100	99	99	99	98	98
9	58	Zamboanga del Norte	574	576	578	579	578	579	582
9	59	Zamboanga del Sur	752	761	772	773	770	773	774
10	60	Agusan del Norte	298	301	304	303	302	303	308
10	61	Agusan del Sur	1,118	1,121	1,125	1,124	1,120	1,119	1,122
10	62	Bukidnon	924	933	946	947	945	949	963
10	63	Camiguin	22	22	22	22	22	22	22
10	64	Misamis Occidental	162	162	162	162	161	160	161
10	65	Misamis Oriental	274	274	273	272	271	271	271
10	66	Surigao del Norte	391	389	389	387	385	385	387
11	67	Davao del Norte	1,035	1,045	1,060	1,062	1,062	1,068	1,084
11	68	Davao del Sur	671	674	677	675	673	674	676
11	69	Davao Oriental	643	643	644	643	642	642	644
11	70	Surigao del Sur	856	856	857	856	853	853	855
12	71	Lanao del Norte	287	278	266	253	239	225	211
12	72	Lanao del Sur	255	255	256	255	253	253	254
12	73	Maguindanao	351	354	357	356	352	352	356
12	74	North Cotabato	633	649	663	665	664	669	685
12	75	Sarangani	331	332	332	329	326	324	323
12	76	South Cotabato	357	365	373	373	369	371	382
12	77	Sultan Kudarat	398	407	420	420	418	422	436

Table C-9 GEOLOGICAL FORMATION IN BAGUIO CITY AREA

Formation	Geological Age	Rock Sort	Geological Characteristics	Groundwater Condition
Klondyke Formation	Late Miocene, Tertiary, Cenozoic	Sediment	Lava flows, breccia, pyrocalstics and normal clastic sediments. The base at Kennon roads is bedded by polymictic conglomerate overlapped by pyroclastic lava, conglomerate, pebbles.	Generally and comparatevely larger potential for groundwater development.
Kennon Limestone	Middle Miocene, Tertiary, Cenozoic		Mainly massive with few andesite pebbles. The matrix is arenaceous and the small bioherm has off-reef faces. The formation is 200 m thick.	Groundwater flows into the limestone fissures. Therefore, it is very difficult to find the groundwater flowing course.
Zigzag Formation	Early to Middle Miocene, Tertiary & Cenozoic		Intercalated, thick to massive, well compacted and poorly sorted conglomerate, volcanic flows and waches	Generally poor potential for ground-water development. Comparatively small well yield.
Black Mountain Andesite Porphyry	Early Miocene (?), Tertiary, Cenozoic	Intrusive rock	Quartz diorite porphyry and later dacite porphyry	Generally poor potential for groundwater development
Diorite	Early Miocene (?), Tertiary, Cenozoic		porphyritic with hornblende	Generally poor potential for groundwater development

Source: Bureau of Mines and Geo-Sciences, DENR (1980)

Table C-10 EXISTING WELLS OPERATED BY BAGUIO CITY WATER DISTRICT

No.	Location	Constion year	Depth (m)	Diameter (m)	Screen (intake depth; below ground level) (m)
1	Amparo 3	1988	80.0	16"(0-65), 10"(65-80)	42-65, 65-80
2	Amparo 5	1992	93.0	14"(0-54), 10"(54-90)	57-63, 70-85
3	Camp 7-1	1982	220.0	16"(0-66), 10"(66-220)	74-77, 83-86, 101-104, 108-111, 116-119, 132-162-164, 170-176, 192-195, 197-209
4	Milo-2	1995	160.0	10"(0-138), 8"(138-160)	52-56, 72-76, 84-108, 114-138, 140-154
5	MRR-1	1968	73.0	10"(0-34), 8"(34-73)	40-52
6	Iabsan	1957	87.0	10"(0-87)	16-20, 27-32, 40-45, 60-68
7	City Camp	1992	100.0	10"(0-81), 8"(81-100)	51-70, 81-85, 87-89
8	Harrison-2	1995	74.0	10"(0-74)	35-41, 47-68
9	Market-2	1996	100.0	10"(0-100)	53-58, 63-76, 79-97
10	Hilltop	1985			
11	P. Burgos	1995	70.0	6"(0-47)	
12	Asin/Shangrilla	1990	115.0	10"(0-115)	40-46, 59-71, 77-110
13	Skating Rink	1954	69.3	8"(0-36.75), 6"(36.75-69.30)	47.7-56.8
14	Kisad	1962	152.0	8"(0-152)	30-50, 60-80, 85-104, 110-118, 121-138
15	Ramsey	1975	95.0	10"(0-30), 8"(30-85), 6"(85-95)	30-55, 60-70, 73-85
16	Riverwell	1979	100.0	12"(0-40), 10"(40-100)	46-60, 67-75, 79-87, 95-97
17	Athletic Bowl	1995	75.0	10"(0-75)	32-56, 59-71
18	Camp 8	1993	156.0	10"(0-60)	0-42, 42-44, 52-56
19	Cabinet Hill	1974	110.0	8"(0-66), 6"(66-110)	30-33, 36-40, 43-46, 50-53, 56-58, 62-66, 75-58-89, 95-101
20	Happy Glenn	1995	107.0	10"(0-107)	
21	Ambiong 1	1962	117.0	10"(0-55), 8"(55-95), 4"(95-117)	47-55, 60-92, 95-112
22	Ambiong 2	1989	100.0	12"(0-84), 10"(84-100)	12-21, 26-36, 40-59, 69-78, 84-100
23	Gibraltar	1968	60.0	10"(0-60)	25-45
24	Pacdal	1995	70.0	12"(0-59), 10"(59-70)	26-56, 59-67
25	Amsing	1969	66.0	8"(0-66)	30-60
26	Idisan	1996	156.0	10"(0-56), 6"(56-118), 4"(118-156)	56-118, 118-156
27	Evangelista	1982	100.0	10"(0-100)	63-93, 98-100
28	Wright Park	1994	105.0	10"(0-105)	51-69, 70-95
29	M. Roxas 1	1965	83.0	10"(0-83)	40-80
30	M. Roxas 2	1990	101.0	10"(0-101)	51-57, 61-70, 74-85, 87-99
31	Buyog	1979	154.0	10"(0-91), 6"(91-154)	42-56, 60-65, 74-79, 82-91, 105-108, 116-120, 51-63, 81-117
32	Teachers Camp	1991	128.0	10"(0-123)	
33	CBL	-	-	-	-
34	Guisad	1982	101.0	14"(0-67), 8"(67-101)	73-175
35	Ferguson	1996	110.0	10"(0-33), 6"(33-110)	33-110
36	Pinsao	1990	115.0	8"(0-115)	38-60, 64-84, 96-103
37	Easter	1954	80.0	6"(0-42), 4"(42-80)	42-80

Table C-11 PRODUCTION OF EXISTING WELLS OPERATED BY BAGUIO CITY WATER DISTRICT

No.	Location	Production Rate (m^3/day)												Average (m^3/day)
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1	Amparo 3	8,654	8,733	8,282	7,656	6,364	6,373	7,006	8,034	-	-	-	-	7,638
2	Amparo 5	-	-	1,658	1,580	1,289	1,290	1,336	1,440	-	-	-	-	1,432
3	Camp 7-1	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Milo-2	-	-	2,194	2,064	2,064	2,000	2,030	2,087	-	-	-	-	2,073
5	MRR-1	651	516	491	357	341	384	393	429	-	-	-	-	445
6	Iabsan	647	715	671	628	613	587	669	730	-	-	-	-	658
7	City Camp	604	537	478	446	416	451	466	607	-	-	-	-	501
8	Harrison-2	677	651	797	801	776	773	778	787	-	-	-	-	755
9	Market-2	1,026	986	1,037	998	1,007	1,071	1,080	1,070	-	-	-	-	1,035
10	Hilltop	475	475	327	327	327	327	435	545	-	-	-	-	405
11	P. Burgos	243	187	143	139	106	119	159	146	-	-	-	-	155
12	Asin/Shangrilla	170	160	106	82	82	171	176	261	-	-	-	-	151
13	Skating Rink	190	190	190	137	221	194	162	130	-	-	-	-	177
14	Kisad	492	492	492	195	170	426	385	524	-	-	-	-	397
15	Ramsey	1,413	1,279	1,394	1,332	1,315	1,034	1,262	1,376	-	-	-	-	1,301
16	Riverwell	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Athletic Bowl	548	548	548	468	531	447	442	293	-	-	-	-	478
18	Camp 8	2,756	2,756	2,453	2,452	2,489	2,431	2,074	2,506	-	-	-	-	2,490
19	Cabinet Hill	691	696	912	800	641	524	609	732	-	-	-	-	701
20	Happy Glenn	714	635	655	604	633	635	661	683	-	-	-	-	652
21	Ambiong 1	1,173	930	1,226	1,332	1,223	1,141	1,236	1,313	-	-	-	-	1,197
22	Ambiong 2	1,506	1,453	1,337	1,242	1,119	1,090	1,086	772	-	-	-	-	1,201
23	Gibraltar	345	345	343	352	391	436	442	480	-	-	-	-	392
24	Pacdal	327	308	359	407	406	414	849	673	-	-	-	-	468
25	Amsing	231	133	122	130	200	153	137	-	-	-	-	-	158
26	Idisan	1,032	1,067	1,203	1,242	1,227	1,276	1,223	1,267	-	-	-	-	1,192
27	Evangelista	161	181	137	101	99	176	-	-	-	-	-	-	143
28	Wright Park	-	232	220	139	200	378	257	246	-	-	-	-	239
29	M. Roxas 1	1,535	1,496	1,621	1,613	1,623	1,621	1,661	1,618	-	-	-	-	1,599
30	M. Roxas 2	1,433	1,420	1,396	1,140	996	983	1,121	1,333	-	-	-	-	1,228
31	Buyog	912	1,129	791	1,017	743	744	813	737	-	-	-	-	861
32	Teachers Camp	1,151	1,107	1,029	817	731	720	796	914	-	-	-	-	908
33	C B L	-	-	-	287	288	290	-	-	-	-	-	-	288
34	Guisad	301	301	270	275	193	471	483	411	-	-	-	-	338
35	Ferguson	613	539	605	527	549	613	625	622	-	-	-	-	586
36	Pinsao	649	616	692	682	693	705	715	712	-	-	-	-	683
37	Easter	-	-	301	304	308	309	304	303	-	-	-	-	305
	Total	31,319	30,815	34,479	32,674	30,378	30,758	31,873	33,784	-	-	-	-	33,228

Table C-12 EXISTING WELLS OPERATED BY ANGELES CITY WATER DISTRICT

Location	Constion year	Depth (m)	Diameter (m)	Screen (m)
Mabini	Before 1972	122.0	12"	
San Nicolas	Before 1972	93.0	6"	
Rizal	Before 1972			
Kuliat	Before 1972			
Sta. Teresita	Before 1972	110.0	10"	
Magalang	Before 1972	122.0	8"	
Pampang Road	Before 1972	81.0	8"	
Belen Homesite	1991	183.0	12"	
Mac Arthur	Before 1972	91.0	10"	
Lourdes NW	Before 1972	137.0	8"	
Old Pampang	1986	137.0	16"	
Bagong Bayan	1993	86.0	8"	dia.8" : 51.8-86.0
Town & Country	1993	200.0	8"	dia.8": 104.2-149.8, 174.6-188.0
Central #1	1996	100.0	12"	
Central #2	1996	200.0	8"	
Central #3	1996	100.0	12"	dia.10": 34-76
Central #4	1996	200.0	8"	
Central #5	1996	100.0	12"	dia.10": 41-83
Central #6	1996	200.0	10"	dia.8": 128-170, 182-194
Central #7	1996	100.0	12"	

Table C-13 PRODUCTION OF EXISTING WELLS OPERATED BY ANGELES CITY WATER DISTRICT

Location	Production (m^3/day)	Water Level (m) SWL	DWL	Remarks
Mabini	3,888	6.10	19.80	Operation hours (24 hrs)
San Nicolas	-	15.00	-	Non operational due to very old well.
Rizal	-	-	-	Non operational due to very old well.
Kuliat	-	-	-	Non operational due to very old well.
Sta. Teresita	-	8.38	-	Non operational
Magalang av.	2,938	5.03	22.32	Operation hours (24 hrs)
Pampang Road	1,498	7.08	17.41	Operation hours (14 hrs)
Belen Homesite	4,087	6.10	18.30	Operation hours (16 hrs)
Mac Arthur	-	7.33	12.11	Non operational
Lourdes NW	-	5.84	-	Non operational due to very old well.
Old Pampang	2,180	9.14	45.70	Operation hours (24 hrs)
Bagong Bayan	2,099	6.80	31.70	Operation hours (21 hrs)
Town & Country	2,043	15.00	33.50	Operation hours (16 hrs)
Central #1	3,456	6.00	23.00	Operation hours (24 hrs)
Central #2	1,728	14.00	35.00	Operation hours (24 hrs)
Central #3	4,320	5.00	22.00	Operation hours (24 hrs)
Central #4	2,160	15.00	30.50	Operation hours (24 hrs)
Central #5	-	6.00	-	Non operational
Central #6	1,555	16.00	40.00	Operation hours (24 hrs)
Central #7	1,382	7.00	25.00	Operation hours (24 hrs)
Total	33,334			

Table C-14 EXISTING WELLS OPERATED BY METRO ILOILO WATER DISTRICT

No.	Well No.	Depth (m)	Diameter (m)	Production Rate (m^3/day)
1	PS-1	103.0	14"(0-42.5), 10"(43-103)	96.1
2	PS-2	110.0	14"(0-41), 10"(41.5-110)	67.2
3	PS-3(A)	105.0	14"(0-66.7), 10"(67-105)	89.5
4	PS-7	122.0	8" & 10"	50.8
5	PS-8	-	12"	83.4
6	PS-9	101.0	12"	83.0
7	PS-10	94.0	12"	82.2

Table C-15 PRODUCTION OF EXISTING WELLS OPERATED BY METRO ILOILO WATER DISTRICT

No.	Well No.	Production Rate (m^3/day) in the year of 1996												Average
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(m^3/day)
1	PS-1	97.7	98.2	94.3	93.7	93.5	97.1	97.6	96	96	95.5	96	97.8	96.1
2	PS-2	-	59.5	56.8	58.7	64.6	70.8	72.4	74.4	67.4	74.4	68	72	67.2
3	PS-3 (A)	104.3	97.8	91	92.1	91.7	91.3	90.2	89.9	91.6	76.5	80.4	77.5	89.5
4	PS-7	57.8	58.9	60.8	50.9	47.1	40	49.7	52.8	57.3	54.4	39.9	39.6	50.8
5	PS-8	95	93	89.7	85.8	82.6	81.9	80.5	78	78.6	78.3	78.7	78.6	83.4
6	PS-9	101.5	100.8	98.5	95.6	95.9	88.9	90.3	84.6	77.6	63.4	54	44.9	83
7	PS-10	81.6	74.8	70.3	69.2	67.9	66.3	82.4	86.7	87.5	94.8	103.3	101.3	82.2
	Total	537.8	583	561.4	546	543.2	536.3	563.2	562.4	556	537.4	520.3	511.6	552.1

Table C-16 EXISTING SOURCES OPERATED BY BACOLOD CITY WATER DISTRICT

No.	Location	Constion year	Depth (m)	Diameter (m)	Screen (m)
1	Mabini	1955	112.7	16"(0-54.9), 10"(54.9-112.7)	57.9-62.5, 73.2-76.2, 85.3-88.4, 93.0-96.0, 103.6-105.2, 106.7-109.7
2	Paglaum	1962	-	-	-
3	Loygoy	1975	100.1	16"(0-60.0), 10"(60.0-100.1)	65.5-71.8, 80.1-83.5, 90.5-96.0
4	Loygoy	1976	111.0	16"(0-61.0), 10"(61.0-111.0)	67.1-70.1, 83.5-86.6, 69.6-90.8, 93.0-96.1, 101.5-103.0, 104.9-107.9
5	Loygoy	1976	147.2	16"(0-73.2), 10"(73.2-147.2)	79.6-81.1, 92.4-93.9, 96.7-98.2, 104.9-113.4, 137.8-143.9
6	Loygoy	1975	178.3	16"(0-76.2), 10"(76.2-178.3)	100.1-118.3, 123.5-138.0, 143.3-155.5, 160.0-176.2
7	Loygoy	1979	102.1	16"(0-76.2), 10"(76.2-102.1)	68.6-74.1, 75.9-80.5, 82.3-88.4, 91.5-96.0
8	Loygoy	1978	178.4	16"(0-76.2), 10"(76.2-178.4)	100.6-118.9, 123.4-138.7, 143.3-155.5, 160.0-175.3
9	Loygoy	1978	169.5	16"(0-68.6), 10"(68.6-169.5)	128.6-130.2, 131.7-133.2, 137.2-141.7, 143.3-148.1, 151.8-161.2, 164.9-166.4
10	Loygoy	1977	182.9	16"(0-76.2), 10"(76.2-182.9)	57.9-67.1, 80.2-87.5, 91.4-99.1, 105.2-113.9, 132.6-140.2, 149.4-152.4, 163.1-179.8
11	Espinos	1980	-	-	-
12	Mansilingan	1983	-	-	-
13	Villa Soledad	1990	200.9	12"(0-90.0), 8"(90.0-200.9)	49.5-55.5, 57.5-63.4, 69.4-75.2, 84.2-90.0, 97.0-100.0, 118.6-124.5, 127.5-136.3 145.5-168.2, 153.2-156.2, 163.2-166.1, 169.1-193.0
14	Vista Alegre	1990	198.0	12"(0-105.0), 8"(105.0-198.0)	60.0-63.0, 66.0-71.8, 78.9-84.7, 87.7-96.5, 117.0-122.8, 126.4-132.2, 141.3-150.0 156.1-161.9,167.9-192.0
15	Vista Alegre	1990	180.0	12"(0-96.5), 8"(96.5-180.0)	61.1-69.9, 75.3-87.0, 100.0-106.0, 113.0-122.0, 130.0-136.0, 142.0-145.0, 153.0-159.0, 162.0-180.0
16	Vista Alegre	1992	181.0	12"(0-115.0), 8"(115.0-181.0)	47.0-48.8, 52.9-58.8, 92.3-97.8, 101.2-104.1, 107.0-113.0, 123.0-126.0, 129.0-132.0 138.9-148.0, 154.0-160.0, 164.0-169.0, 175.0-178.0
17	Vista Alegre	1992	200.0	12"(0-106.0), 8"(106.0-169.0)	48-54, 57-63, 72-75, 78-81, 87-90, 94-97, 113-119, 127-133, 136-145, 148-154, 157-163
18	Capitol Sub.	1995	152.0	12"(0-90.0), 10"(90.0-152.0)	-
19	Vista Alegre	1997	160.0	12"(0-100.0), 8"(100.0-160.0)	-
20	Bocal Bocal SP	-	-		-
21	Boro Boro SP	-	-		-

Table C-17 PRODUCTION OF EXISTING SOURCES RECORDED BY BACOLOD CITY WATER DISTRICT

Location	Production (m^3/day)	Remarks
Mabini	1,311.0	Operation hours (23 hrs)
Paglaum	1,752.0	Operation hours (24 hrs)
Loygoy	1,992.0	Operation hours (24 hrs)
Loygoy	768.0	Operation hours (24 hrs)
Loygoy	1,440.0	Operation hours (24 hrs)
Loygoy	1,200.0	Operation hours (24 hrs)
Loygoy	1,196.0	Operation hours (23 hrs)
Loygoy	1,702.0	Operation hours (23 hrs)
Loygoy	1,840.0	Operation hours (23 hrs)
Loygoy	2,116.0	Operation hours (23 hrs)
Espinos	920.0	Operation hours (23 hrs)
Mansilingan	3,096.0	Operation hours (24 hrs)
Villa Soledad	2,304.0	Operation hours (24 hrs)
Vista Alegre	2,904.0	Operation hours (24 hrs)
Vista Alegre	2,496.0	Operation hours (24 hrs)
Vista Alegre	1,560.0	Operation hours (24 hrs)
Vista Alegre	3,624.0	Operation hours (24 hrs)
Capitol Sub.	2,712.0	Operation hours (24 hrs)
Vista Alegre	2,040.0	Operation hours (24 hrs)
Bocal Bocal Spring	4,800.0	Operation hours (24 hrs)
Boro Boro Spring	2,040.0	Operation hours (24 hrs)
Average	1,945.9	
	3,420.0	
Total	43,813.0	

Table C-18 EXISTING WELLS OPERATED BY CAGAYAN DE ORO CITY WATER DISTRICT

No.	Location	Constion year	Depth (m)	Diameter (m)	Screen (m)
1	PW#1	1975	255.2	16"(0-121.9), 10"(121.9-198.1), 8"(198.1-255.2)	230.5-255.22
2	PW#2	1976	226.2	16"(0-211.0), 10"(211.0-226.2)	210.97-226.21
3	PW#3A	1991	204.0	18"(0-89), 12"(89-204)	111-120, 126-132, 135-141, 144-150, 153-159, 165-174, 180-186, 189-198
4	PW#4	1975	210.9	16"(0-192.6), 10"(192.6-210.9)	192.6-210.9
5	PW#5	1976	75.6	12"(0-66.5), 10"(66.5-75.6)	66.46-75.6
6	PW#6	-	-	-	-
7	PW#7	1984	200.0	18"(0-66), 8"(66-200)	74-120, 133-142, 173-191
8	PW#8	1986	255.0	16"(0-73), 12"(73-255)	75-87, 90-96, 186-198, 204-210, 216-222, 228-240, 246-252
9	PW#9	1986	236.0	16"(0-68), 12"(68-236)	68-86, 113-119, 137-155, 161-179, 188-200, 206-212, 224-230
10	PW#10	1986	123.0	16"(0-41), 10"(41-123)	48-51, 53-63, 75-84, 87-90, 93-99, 105-111, 114-120
11	PW#11	1986	151.9	16"(0-55.8), 10"(55.8-151.9)	55.8-61.8, 67.9-73.9, 80.0-89.0, 91.5-94.5, 100.6-109.6, 115.8-121.8
					124.8-127.8, 133.9-142.9, 145.9-148.9
12	PW#12	1990	139.0	16"(0-50), 10"(50-139)	67-79, 87-93, 109-136
13	PW#14	1997	150.6	16"(0-58.7), 10"(58.7-150.4)	62.0-74.2, 77.2-83.3, 86.3-89.3, 96.3-99.4, 102.4-111.4, 112.4-115.5,
					117.5-126.6, 129.6-132.6, 138.6-144.6
14	PW#15	1994	104.3	16"(0-52.7), 10"(52.7-104.1)	59.0-62.0, 65.0-68.1, 71.1-77.1, 80.1-98.3
15	PW#16	1995	187.0	18"(0-66.7), 12"(66.7-187.0)	71.0-86.2, 88.2-94.2, 136.2-154.2, 157.2-169.3, 172.2-181.3

Table C-19 PRODUCTION OF EXISTING SOURCES OPERATED BY CAGAYAN DE ORO CITY WATER DISTRICT

No.	Production	Production Rate (m^3/day)												Average
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(m^3/day)
1	PW#1	8,044	8,654	-	6,745	7,198	8,347	8,468	8,301	8,424	8,343	-	-	8,058
2	PW#2	5,781	5,926	-	4,623	5,535	6,031	4,614	5,045	5,566	4,504	-	-	5,292
3	PW#3A	7,749	8,084	-	7,177	6,776	9,824	7,622	7,831	8,948	7,796	-	-	7,979
4	PW#4	5,904	6,301	-	6,186	6,598	6,084	5,396	4,977	5,006	7,979	-	-	6,048
5	PW#5	2,718	2,899	-	2,876	2,899	2,885	2,735	2,893	2,907	2,789	-	-	2,845
6	PW#6	-	-	-	-	-	60	120	-	-	-	-	-	90
7	PW#7	6,864	7,028	-	7,111	7,593	6,075	5,748	5,437	5,426	5,460	-	-	6,305
8	PW#8	8,556	7,168	-	7,273	7,660	7,747	7,359	6,835	7,018	7,642	-	-	7,473
9	PW#9	7,708	8,432	-	7,035	7,537	7,707	7,158	7,090	6,776	6,621	-	-	7,341
10	PW#10	4,487	4,302	-	3,361	3,885	4,084	4,518	4,265	4,316	4,315	-	-	4,170
11	PW#11	8,808	10,095	-	10,019	10,091	8,735	8,466	10,101	10,113	10,031	-	-	9,607
12	PW#12	2,867	3,258	-	3,098	3,265	2,328	2,254	2,376	2,448	2,447	-	-	2,705
13	PW#14	5,534	6,619	-	6,619	6,707	6,470	6,053	6,698	6,523	6,693	-	-	6,435
14	PW#15	3,910	5,370	-	6,285	6,588	3,750	4,866	5,059	4,758	4,641	-	-	5,025
15	PW#16	5,270	4,530	-	5,846	4,953	4,900	5,695	4,924	4,633	4,815	-	-	5,063
16	PW#17	under construction												-
17	PW#18	under construction												-
18	PW#19	under construction												-
19	PW#20	under construction												-
20	Malasag SP	382	382	-	398	398	398	398	398	398	398	-	-	395
	Total	84,583	89,049	-	84,652	87,683	85,426	81,469	82,231	83,260	84,475	0	0	84,829

Part – C

Figures

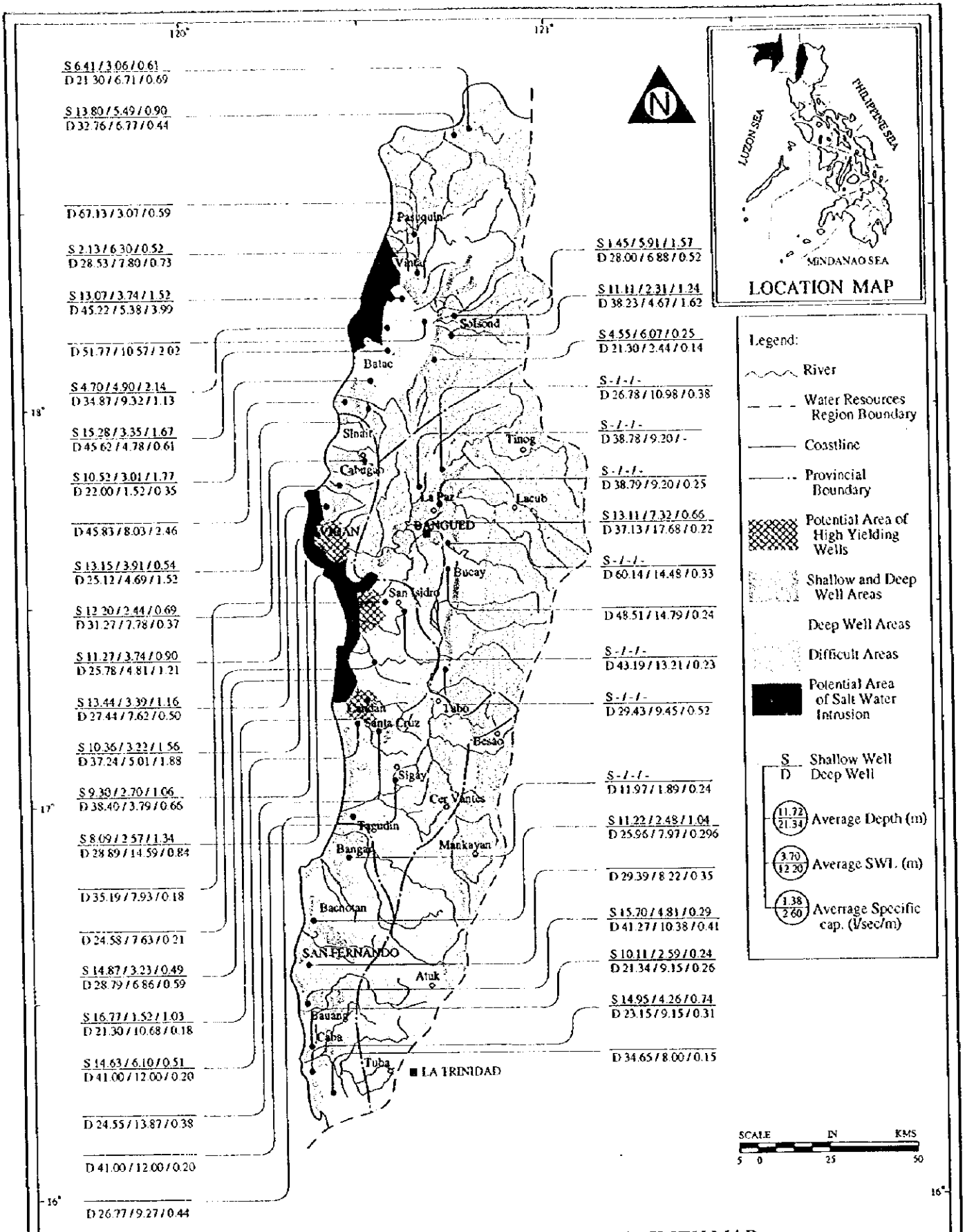

Figure C-1 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION I

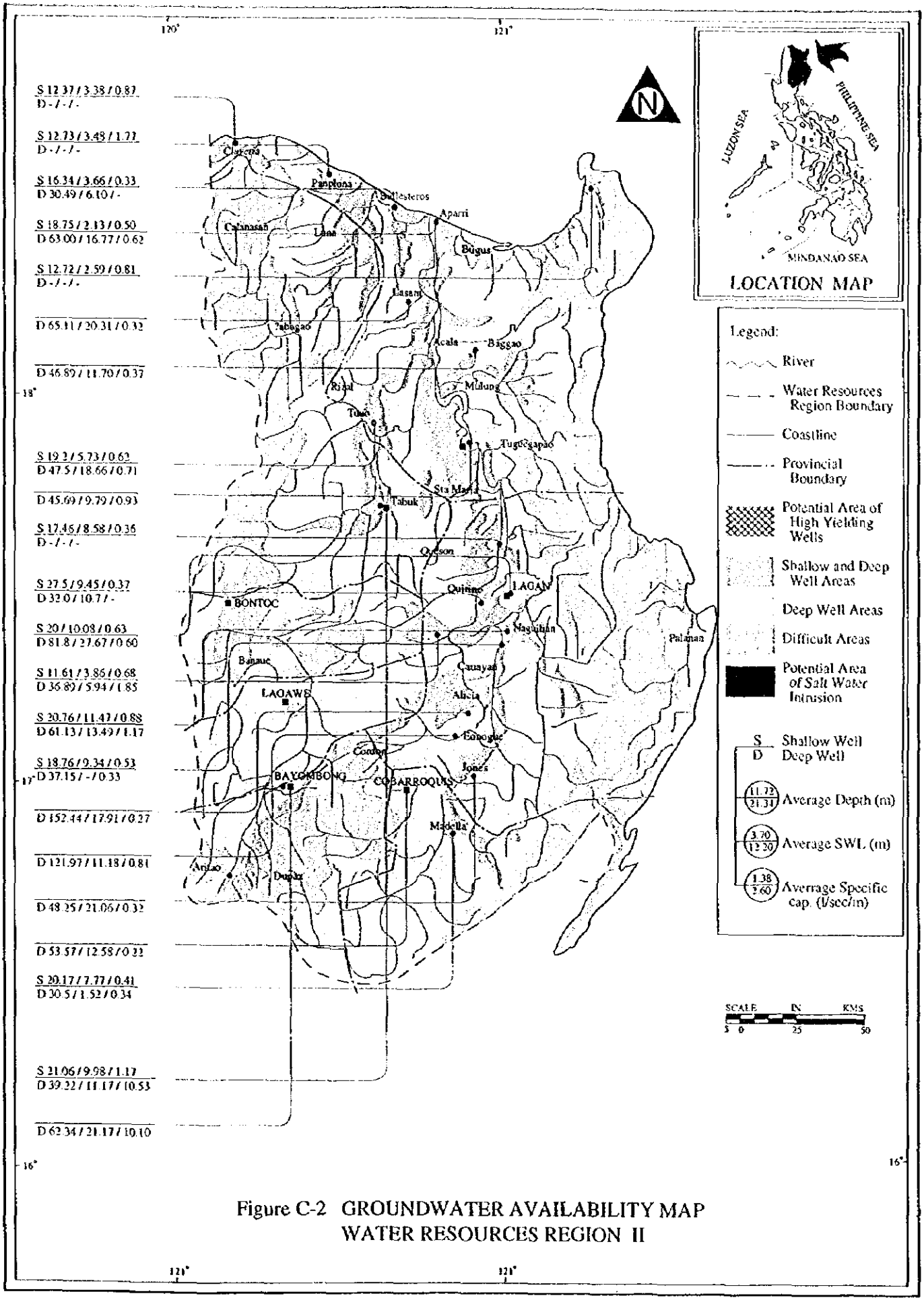

Figure C-2 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION II

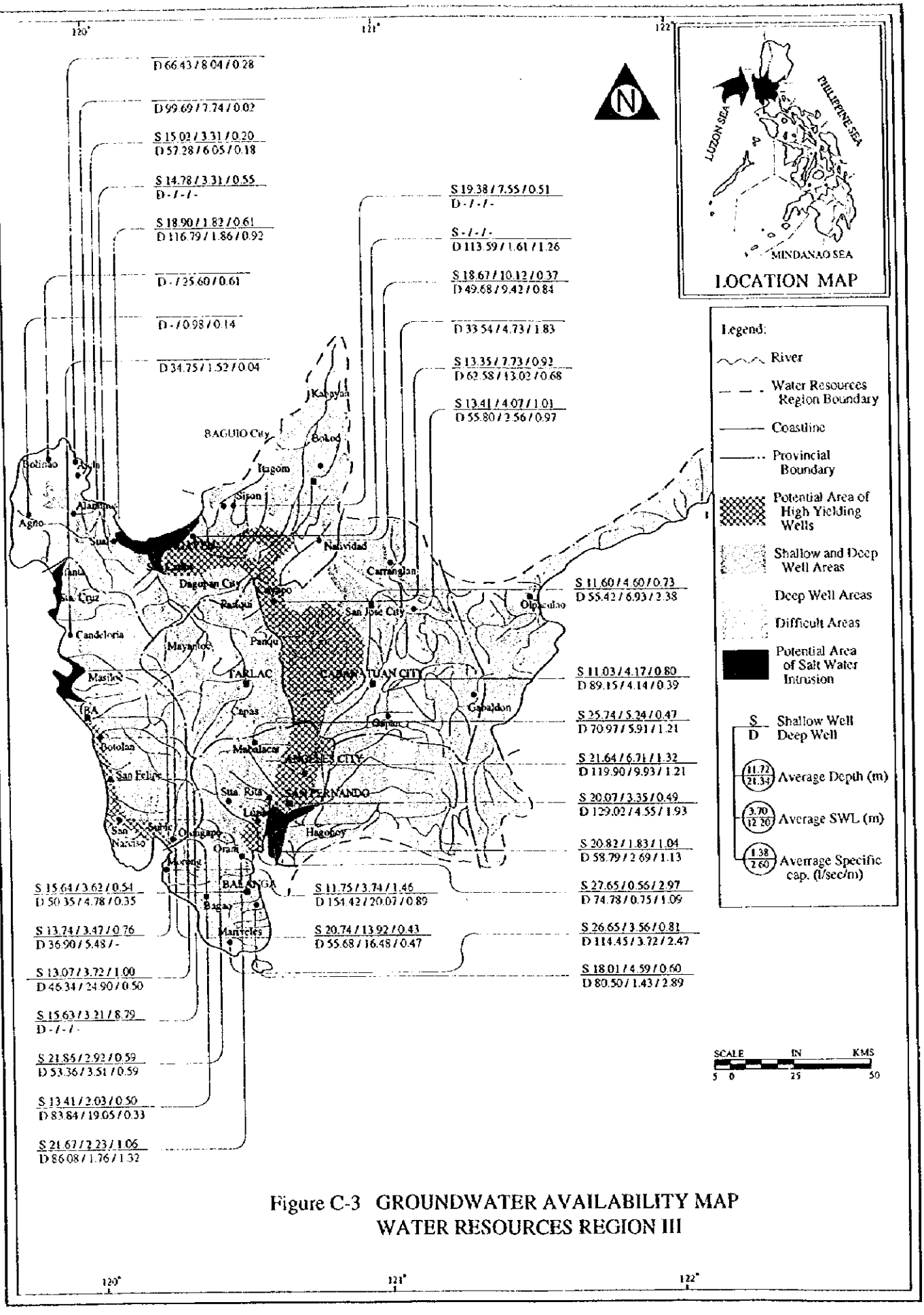

Figure C-3 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION III

GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION III

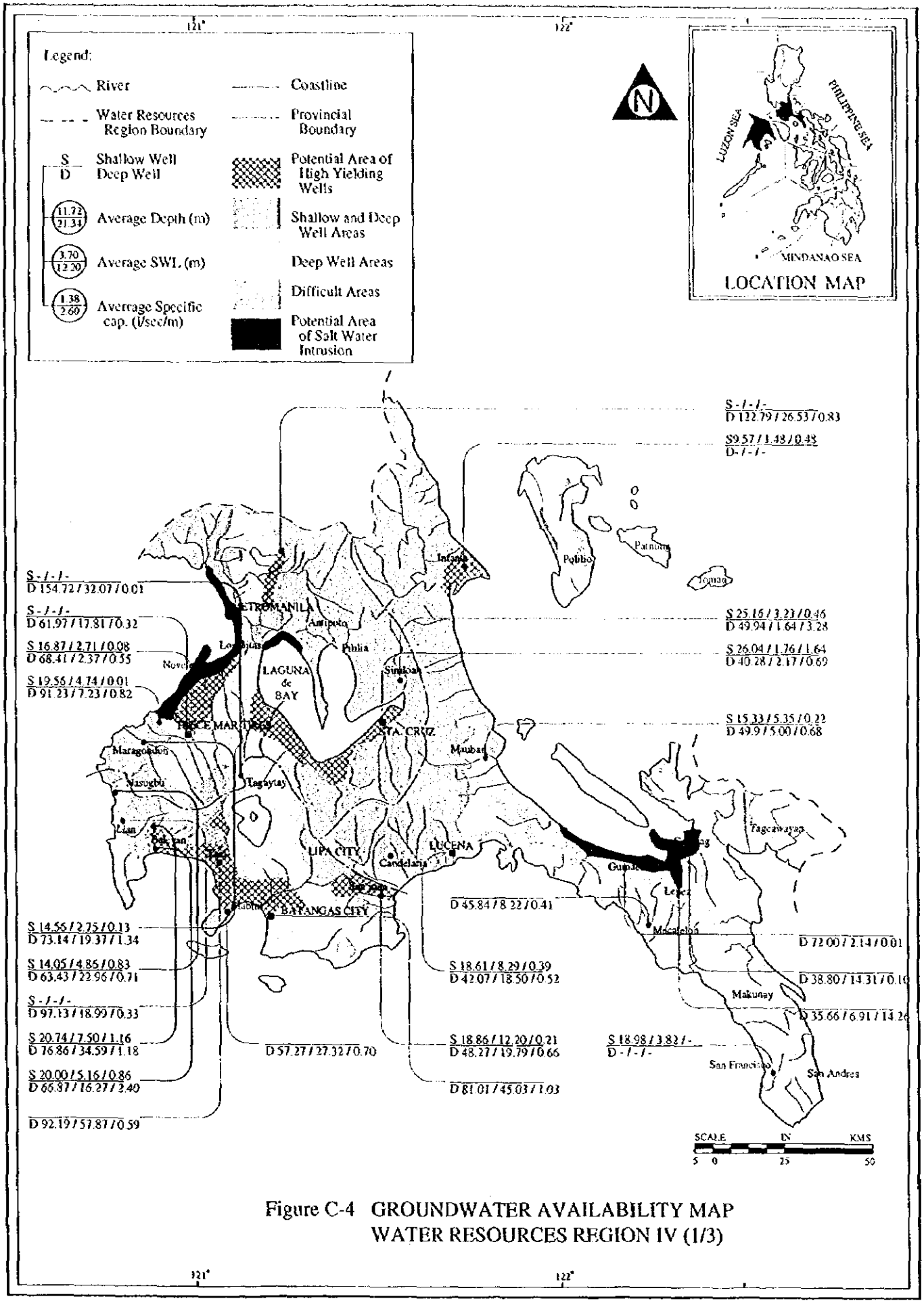

Figure C-4 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION IV (1/3)

GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION IV

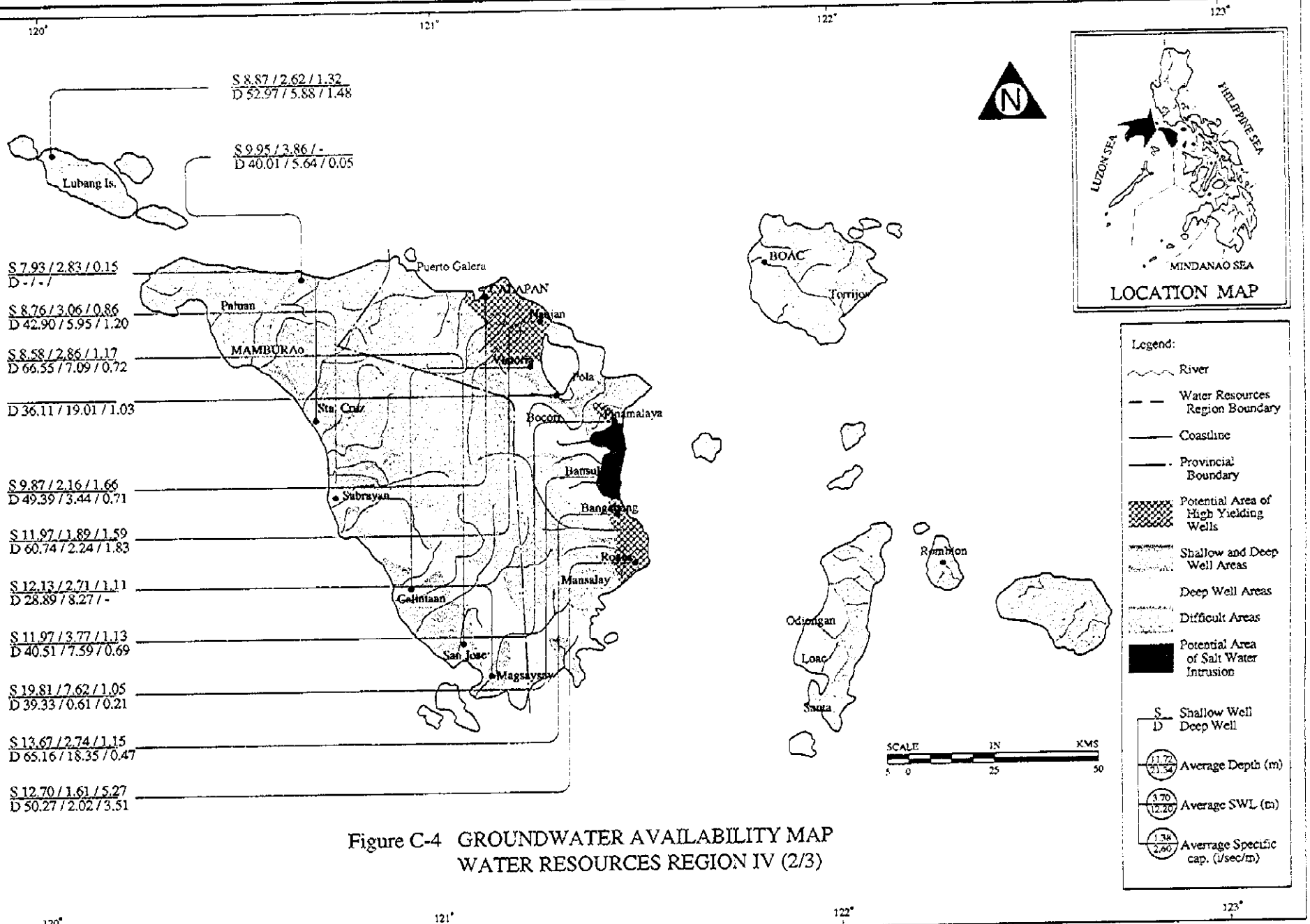

Figure C-4 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION IV (2/3)

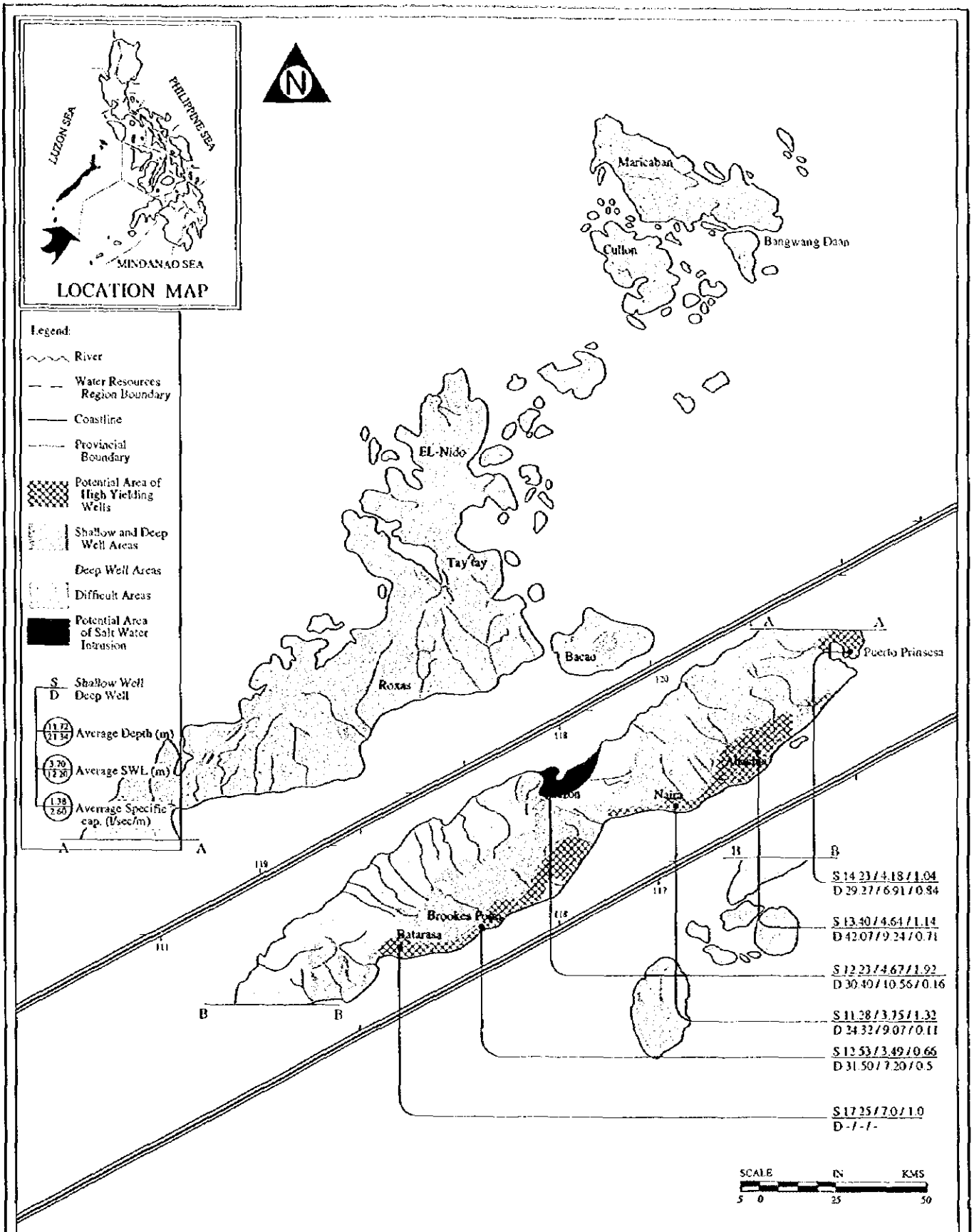

Figure C-4 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION IV (3/3)

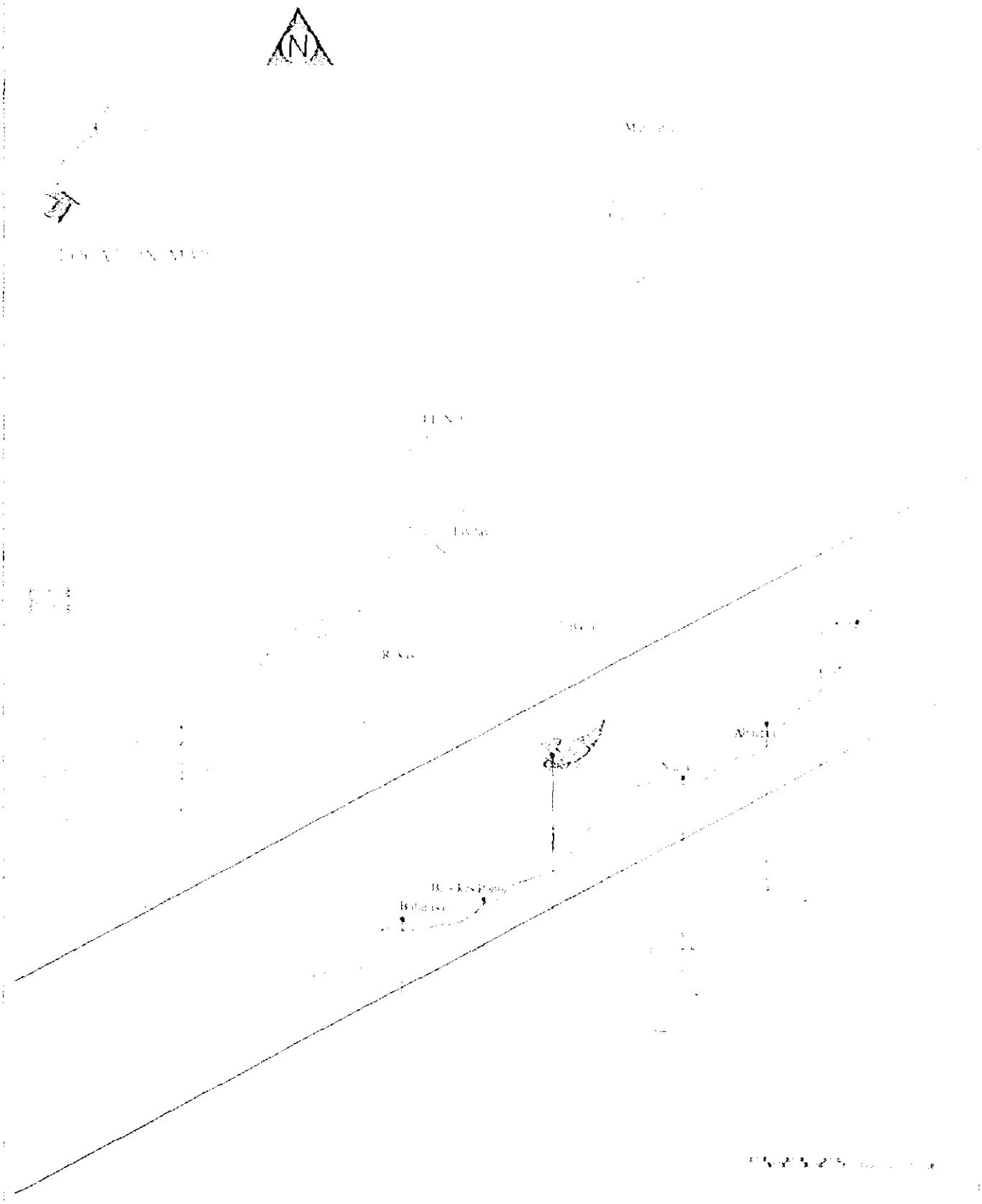

FIGURE C-1: GROUNDWATER VULNERABILITY MAP
WATER RESOURCES REGION [illegible]

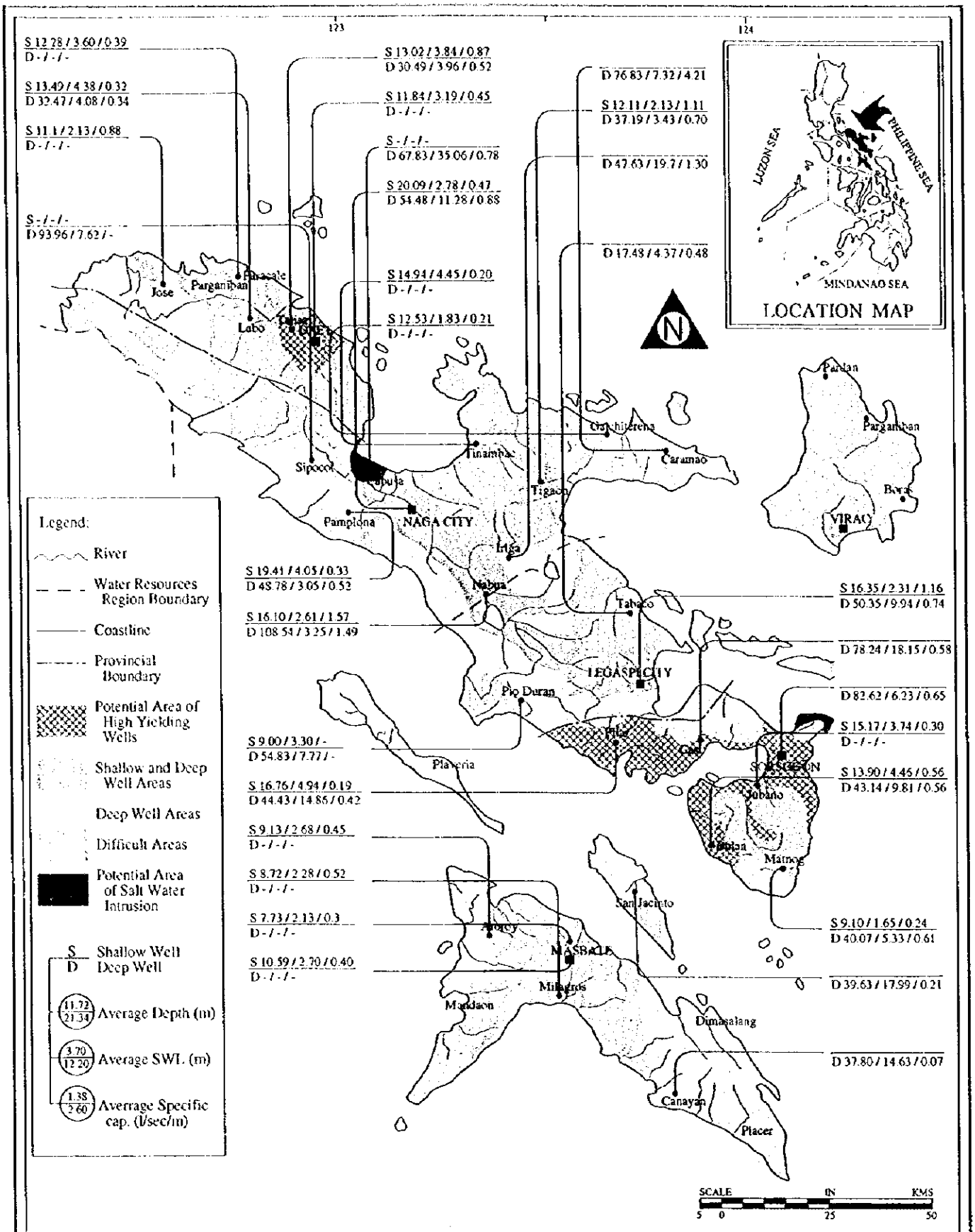

Figure C-5 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION V

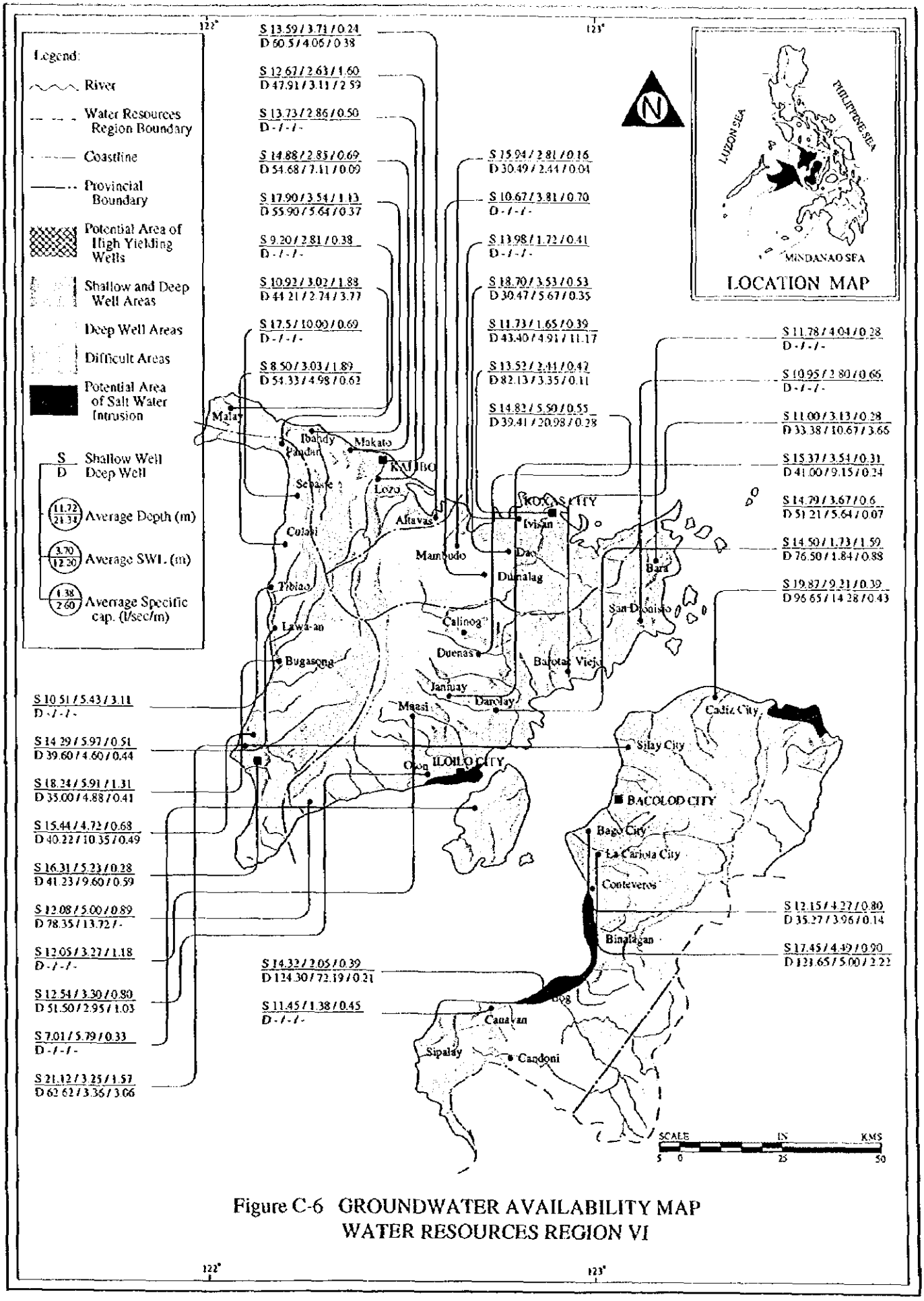

Figure C-6 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION VI

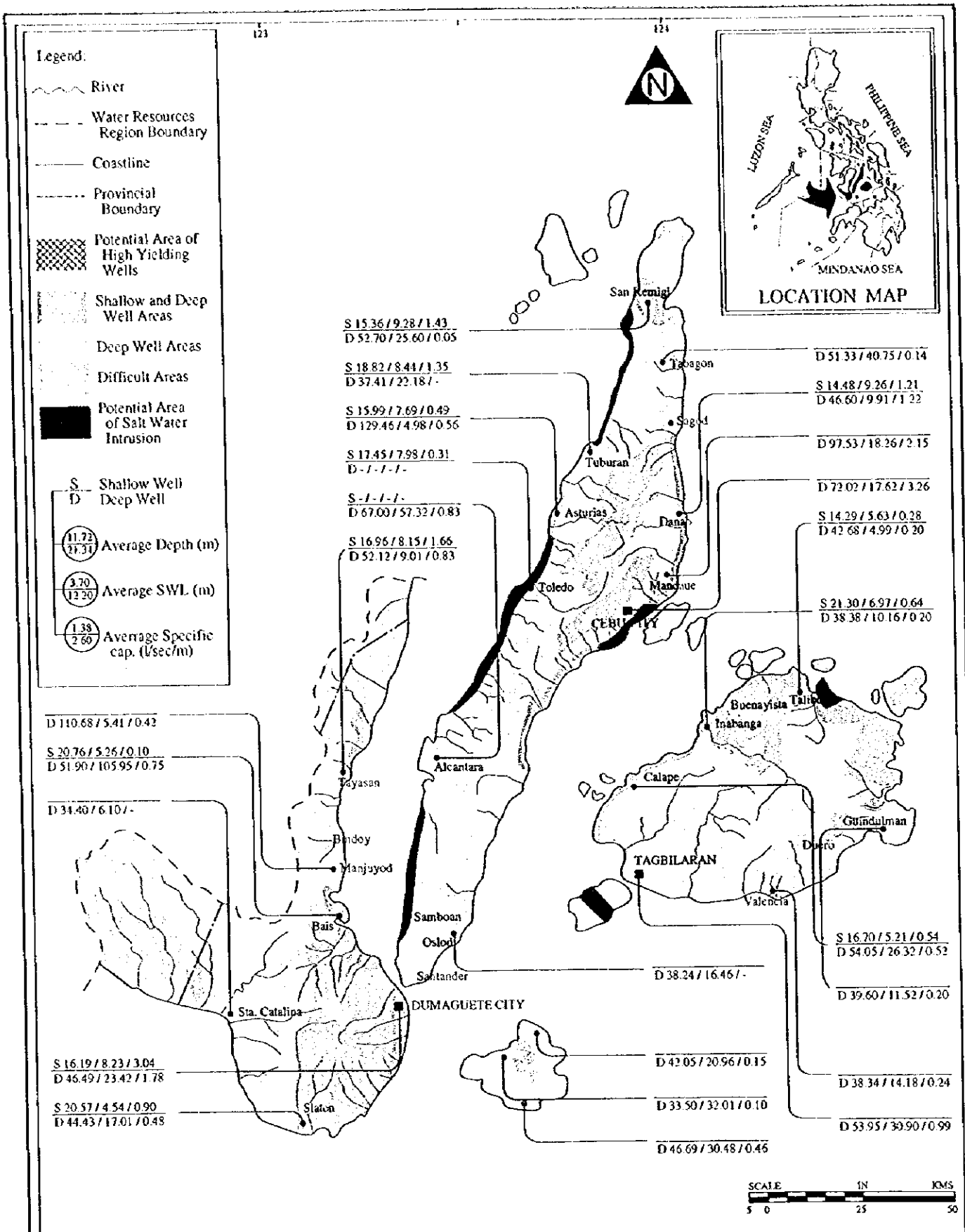

Figure C-7 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION VII

GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION VII

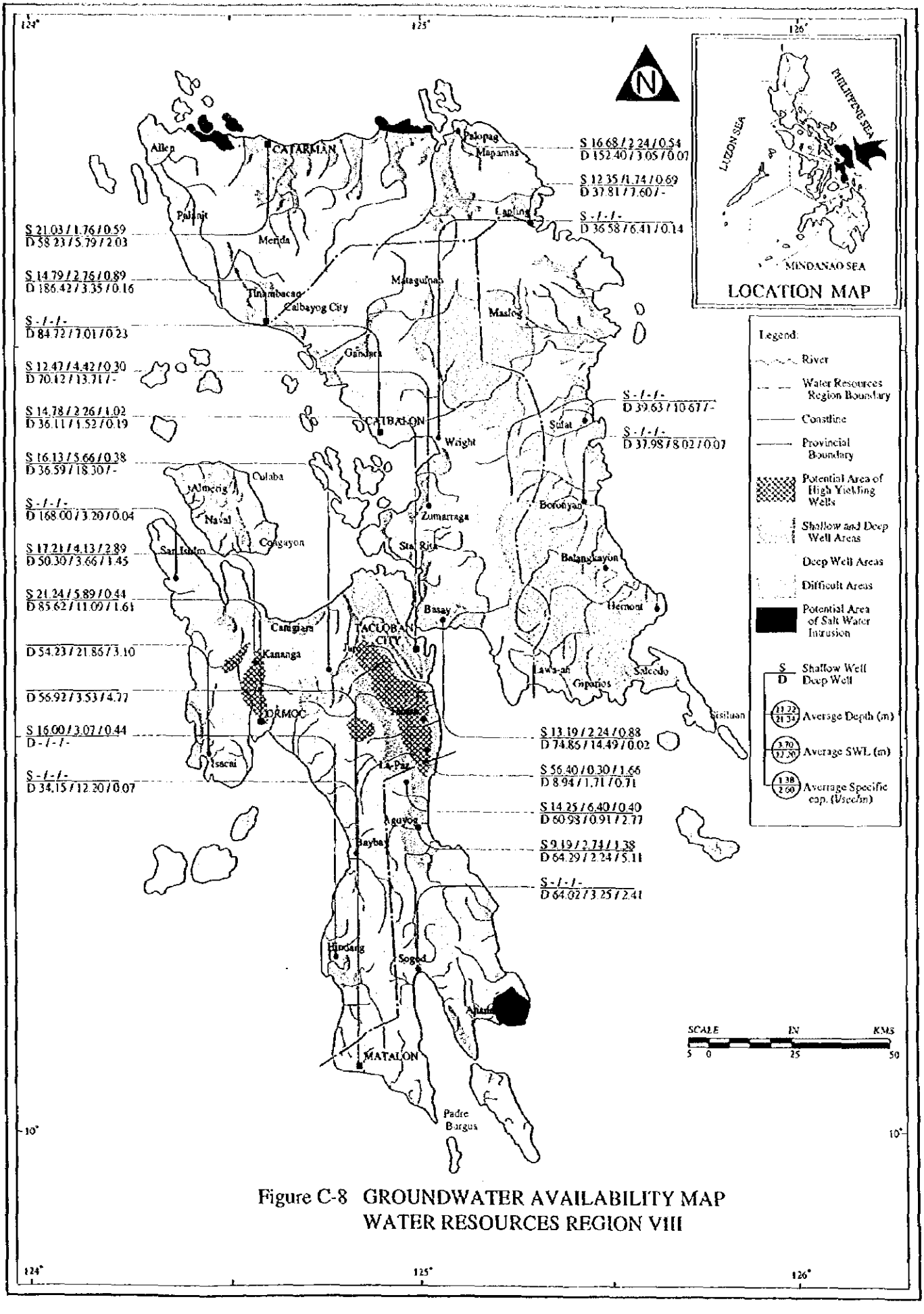

Figure C-8 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION VIII

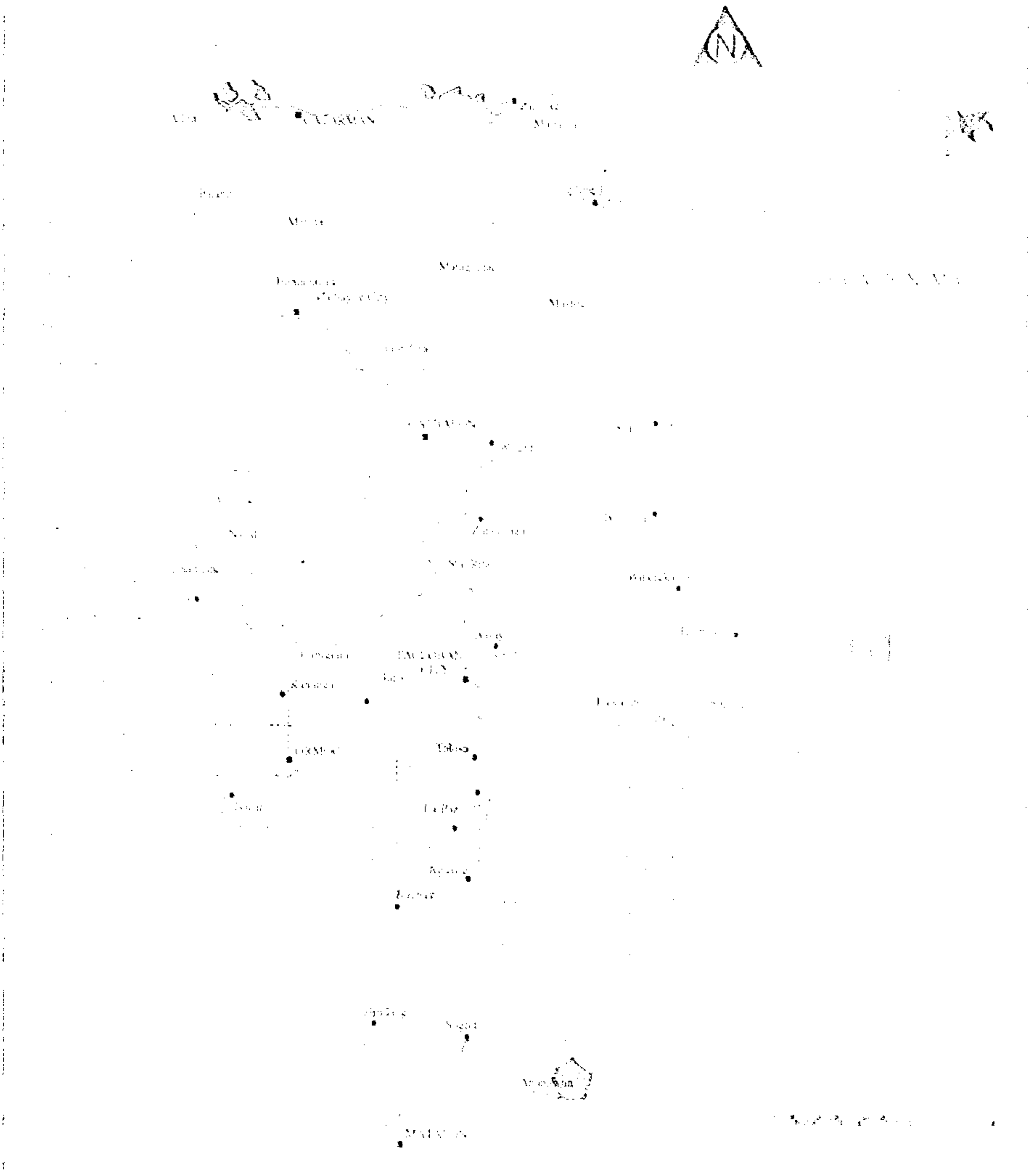

FIGURE C-5 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION VIII

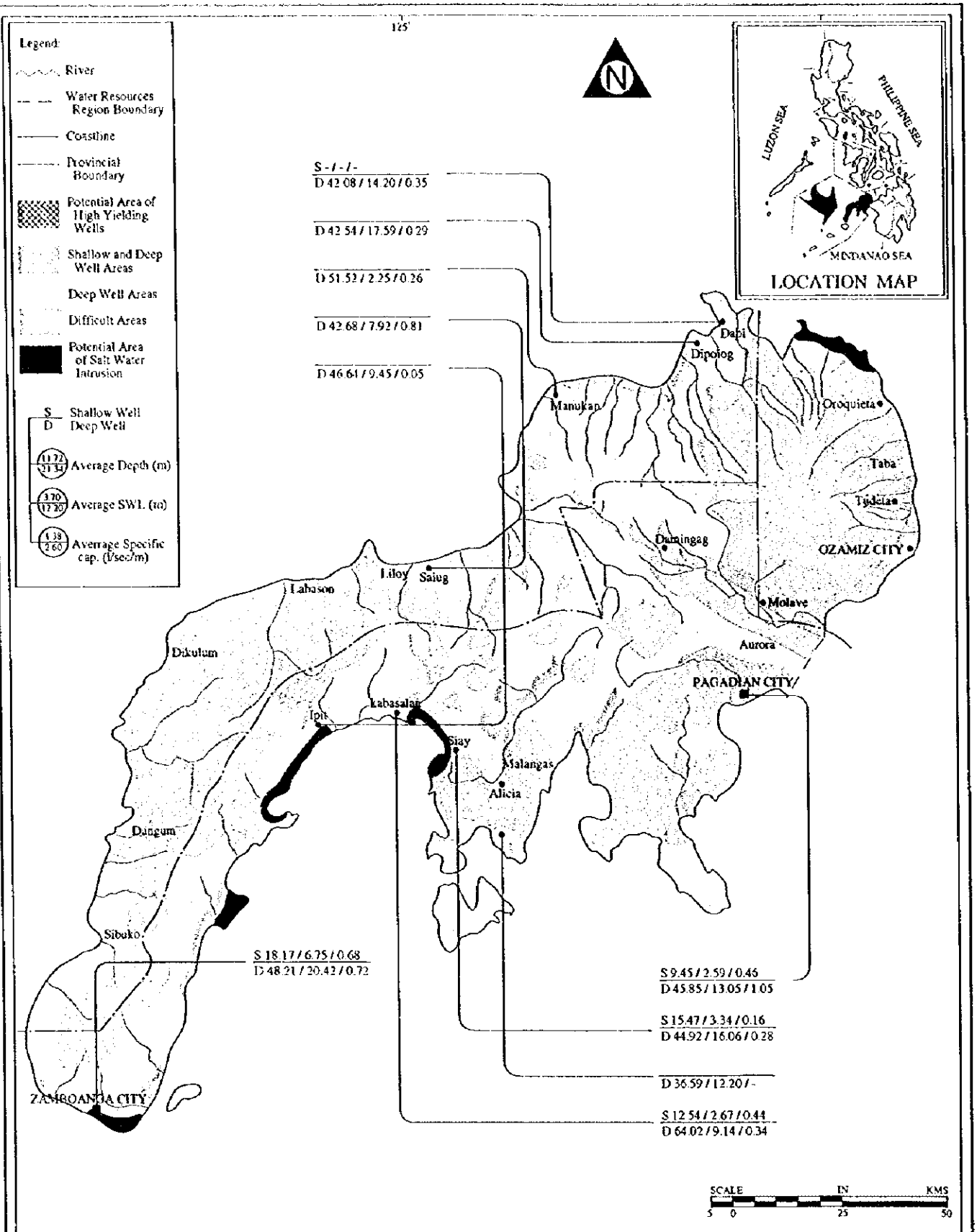

Figure C-9 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION IX

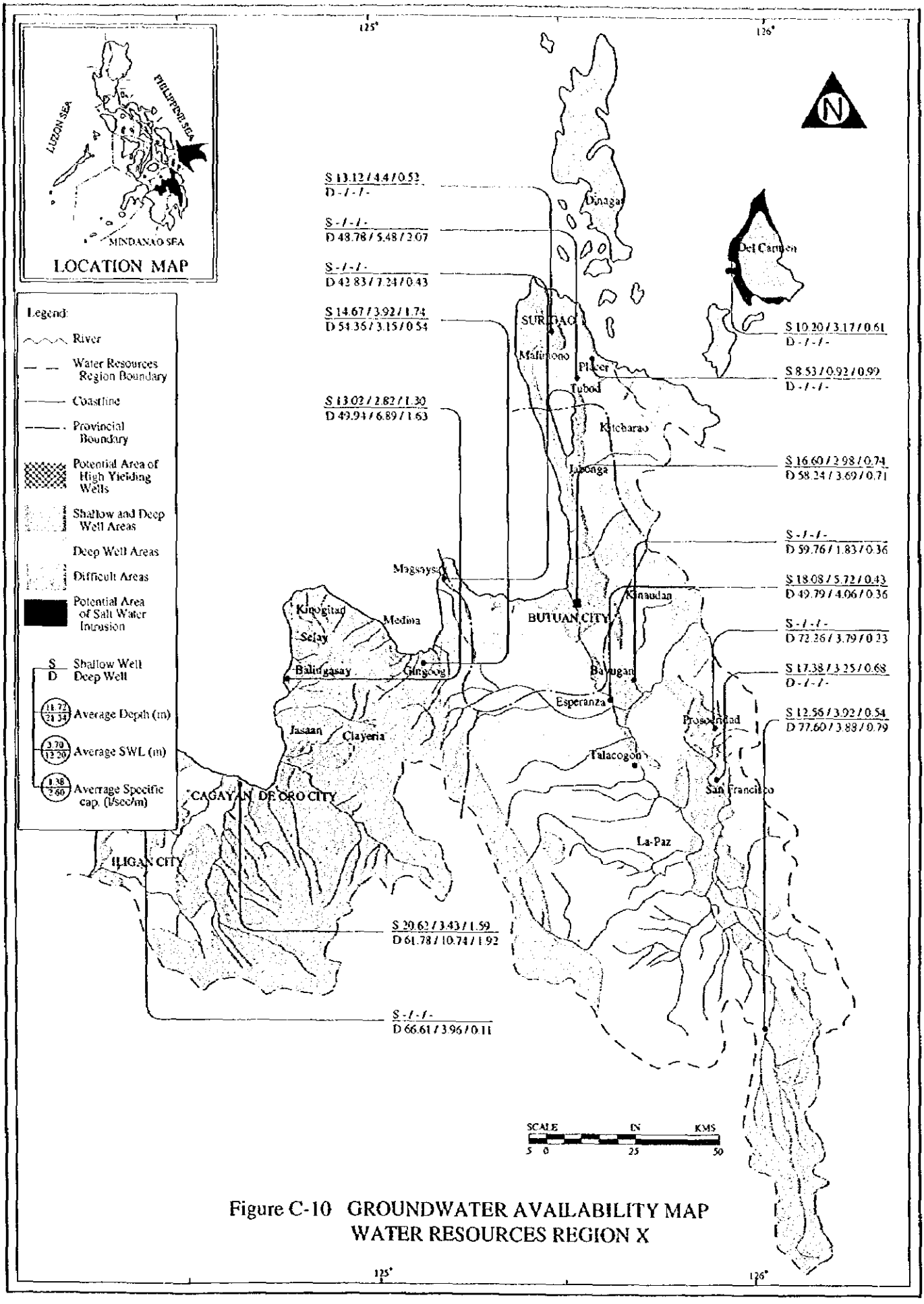

Figure C-10 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION X

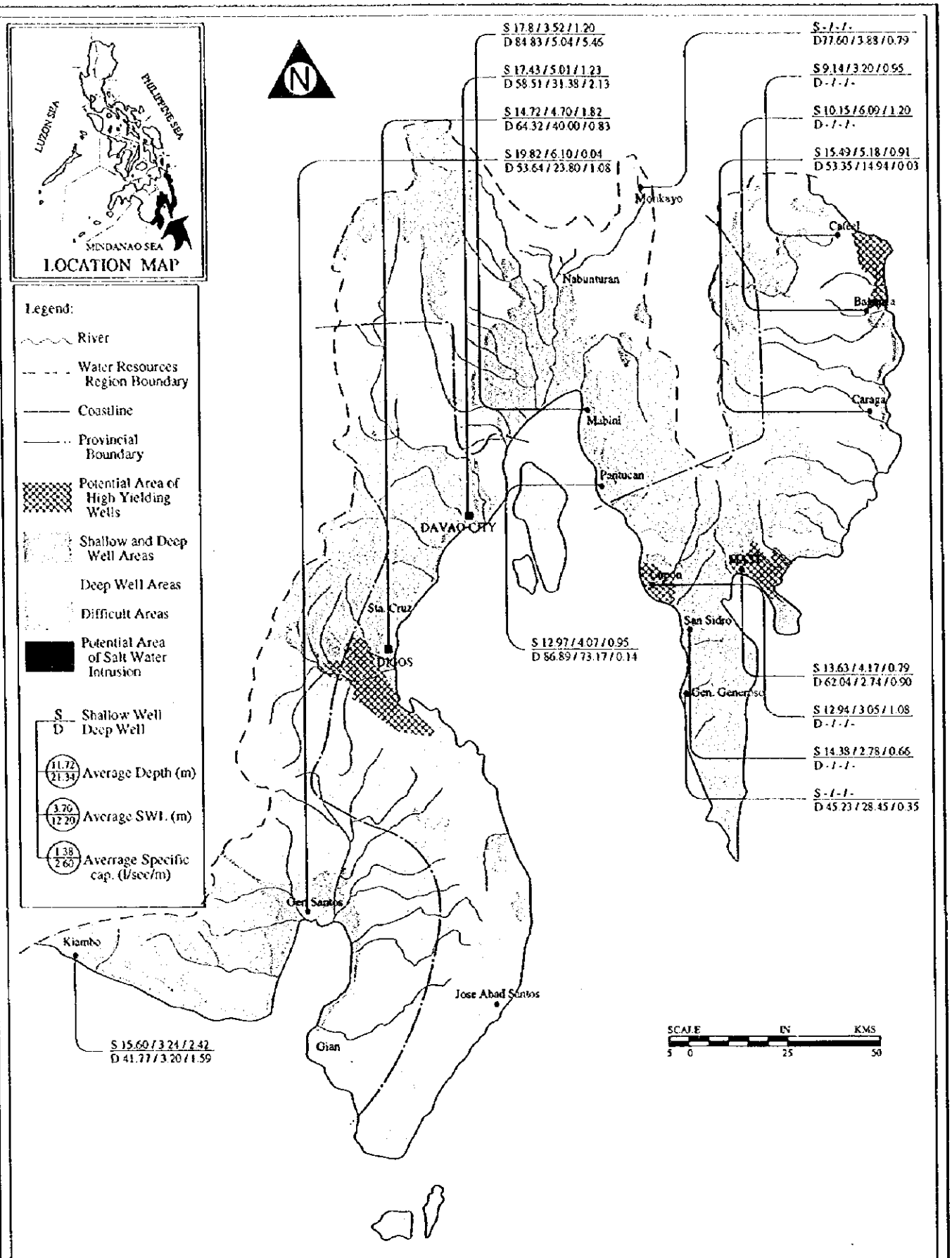

Figure C-11 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION XI

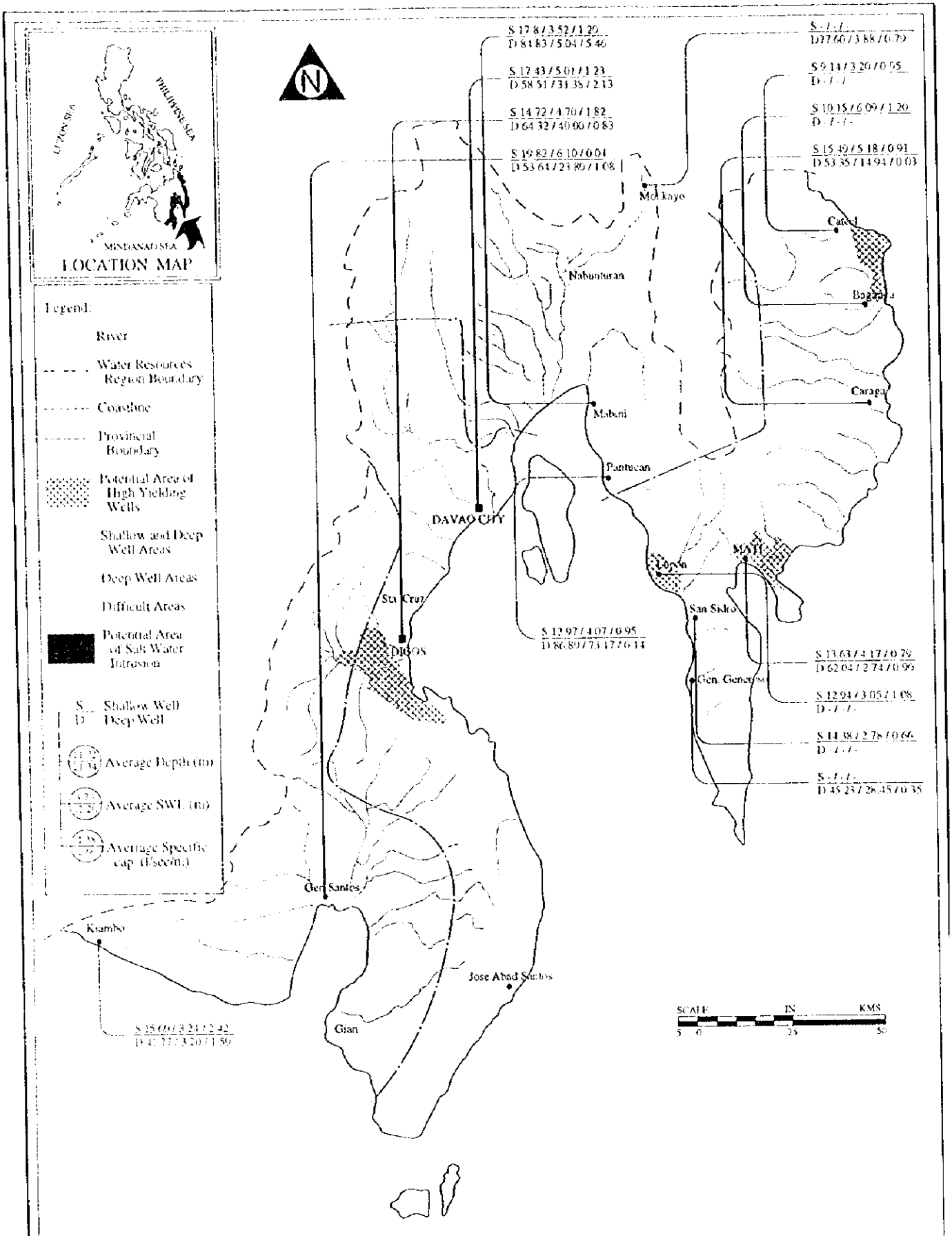

Figure C-11 GROUNDWATER AVAILABILITY MAP
WATER RESOURCES REGION XI

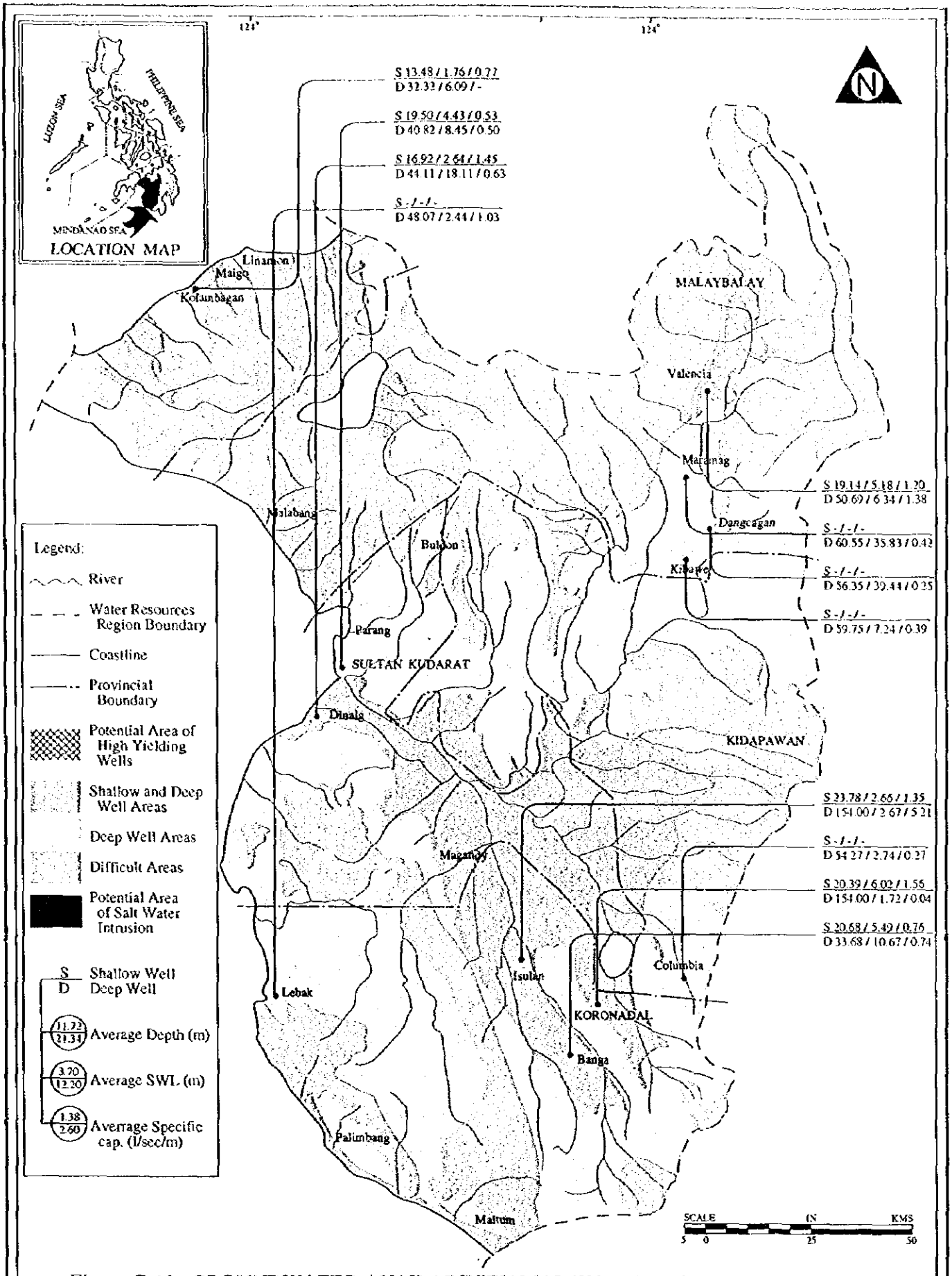

Figure C-12 GROUNDWATER AVAILABILITY MAP WATER RESOURCES REGION XII

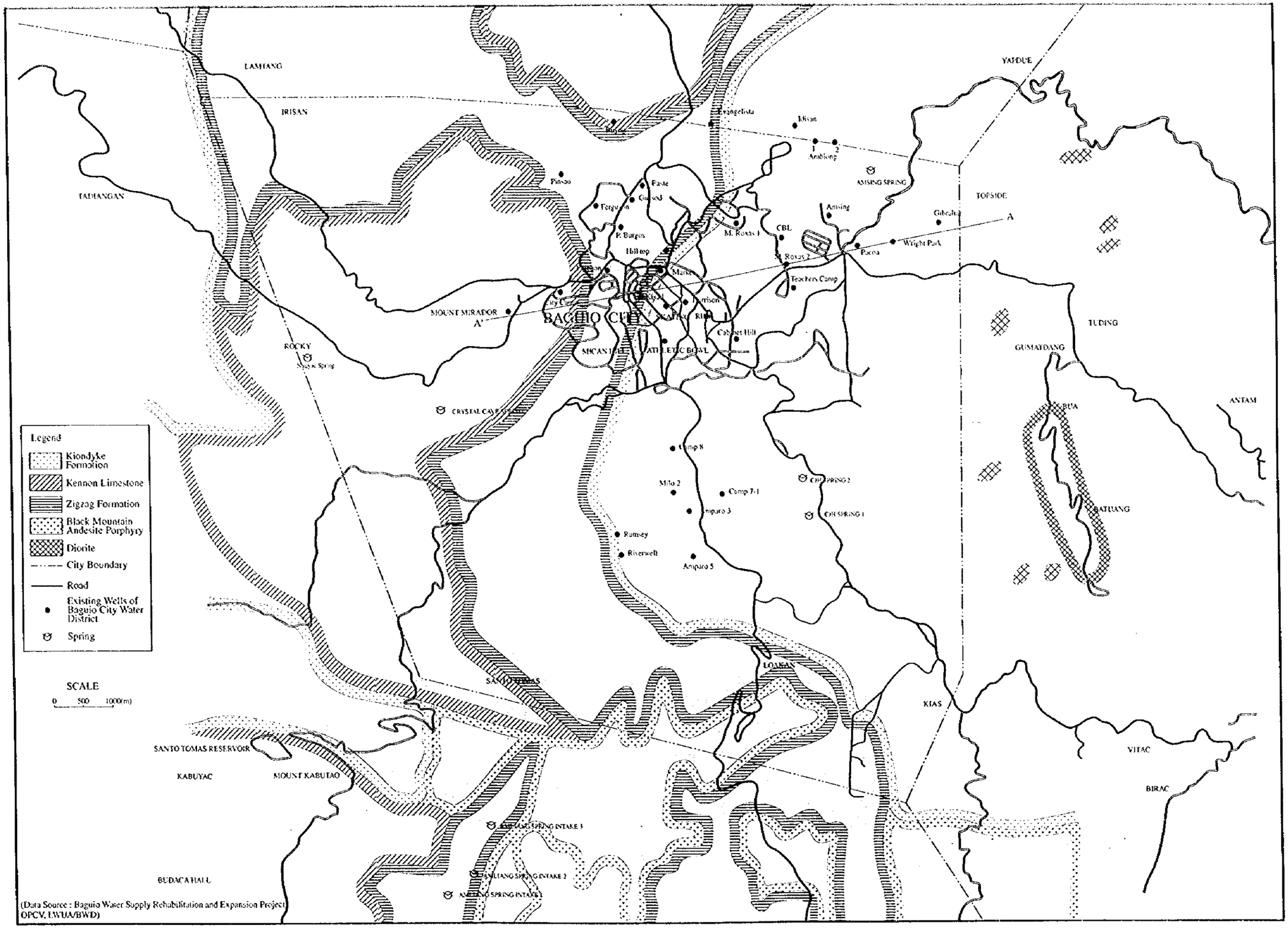

Figure C-13 LOCATION MAP OF EXISTING SOURCES FOR BAGUIO CITY WATER DISTRICT

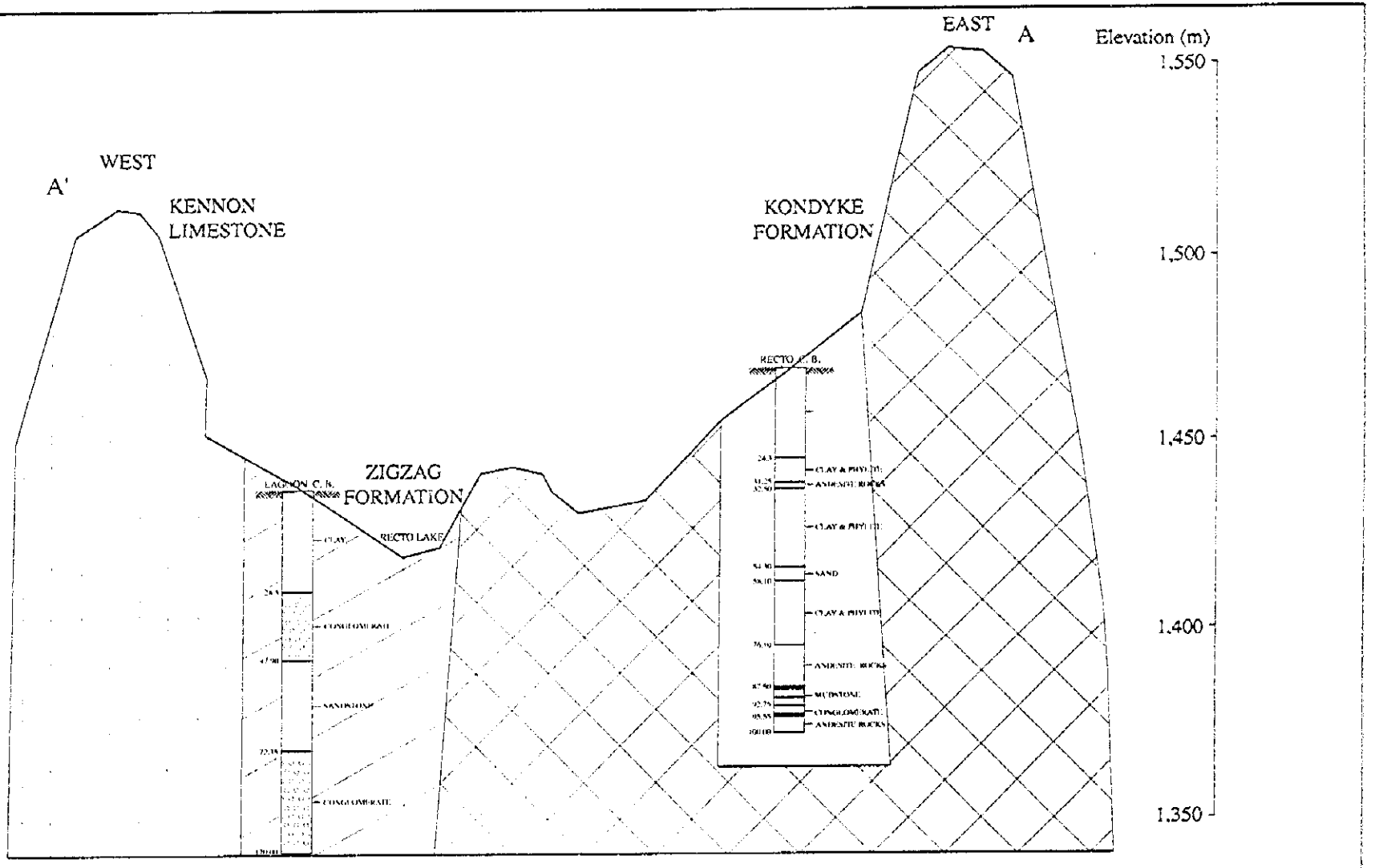

Figure C-14 GEOLOGICAL SECTION IN BAGUIO CITY AREA

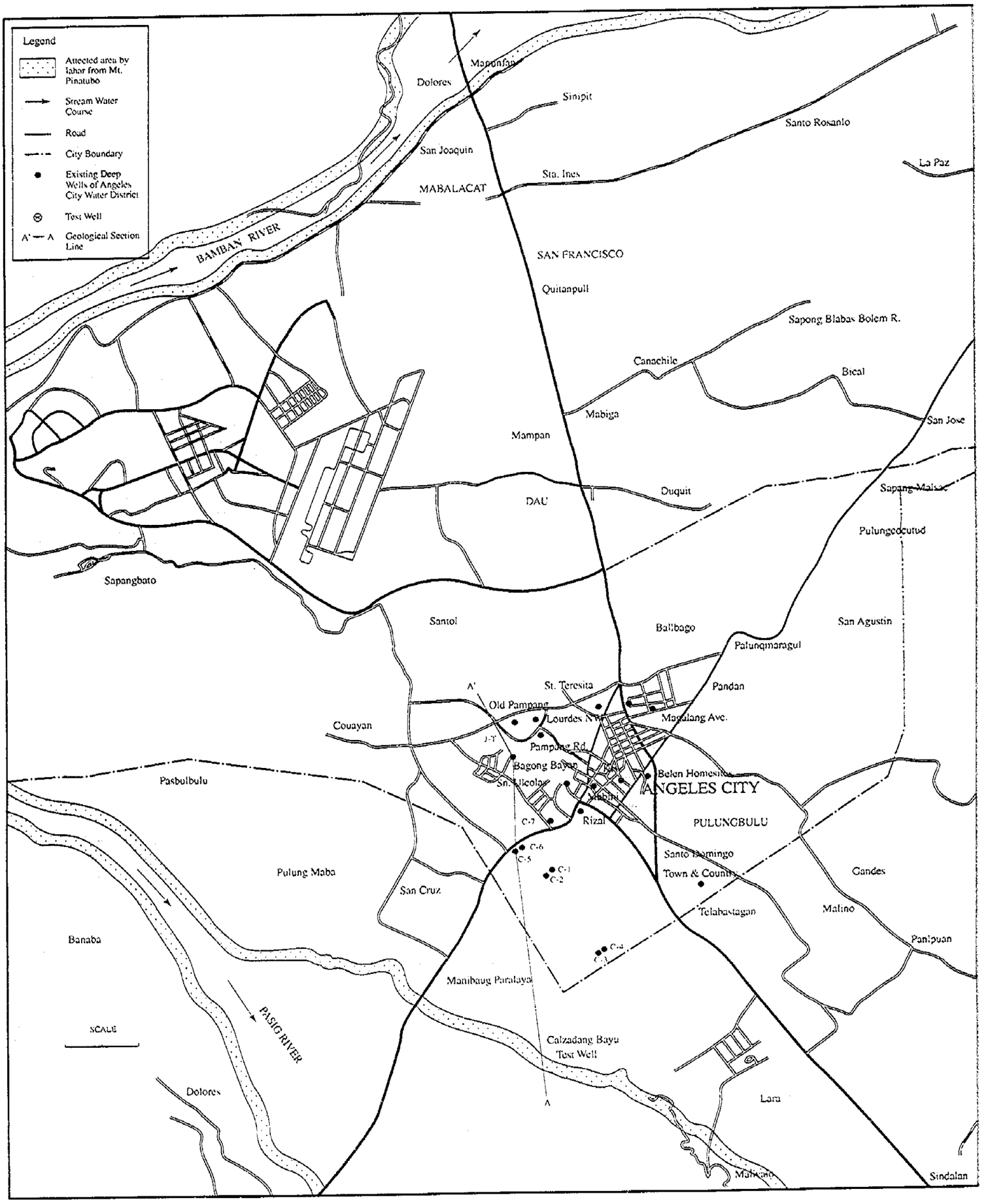

Figure C-15 LOCATION MAP OF EXISTING WELLS FOR ANGELES CITY WATER DISTRICT

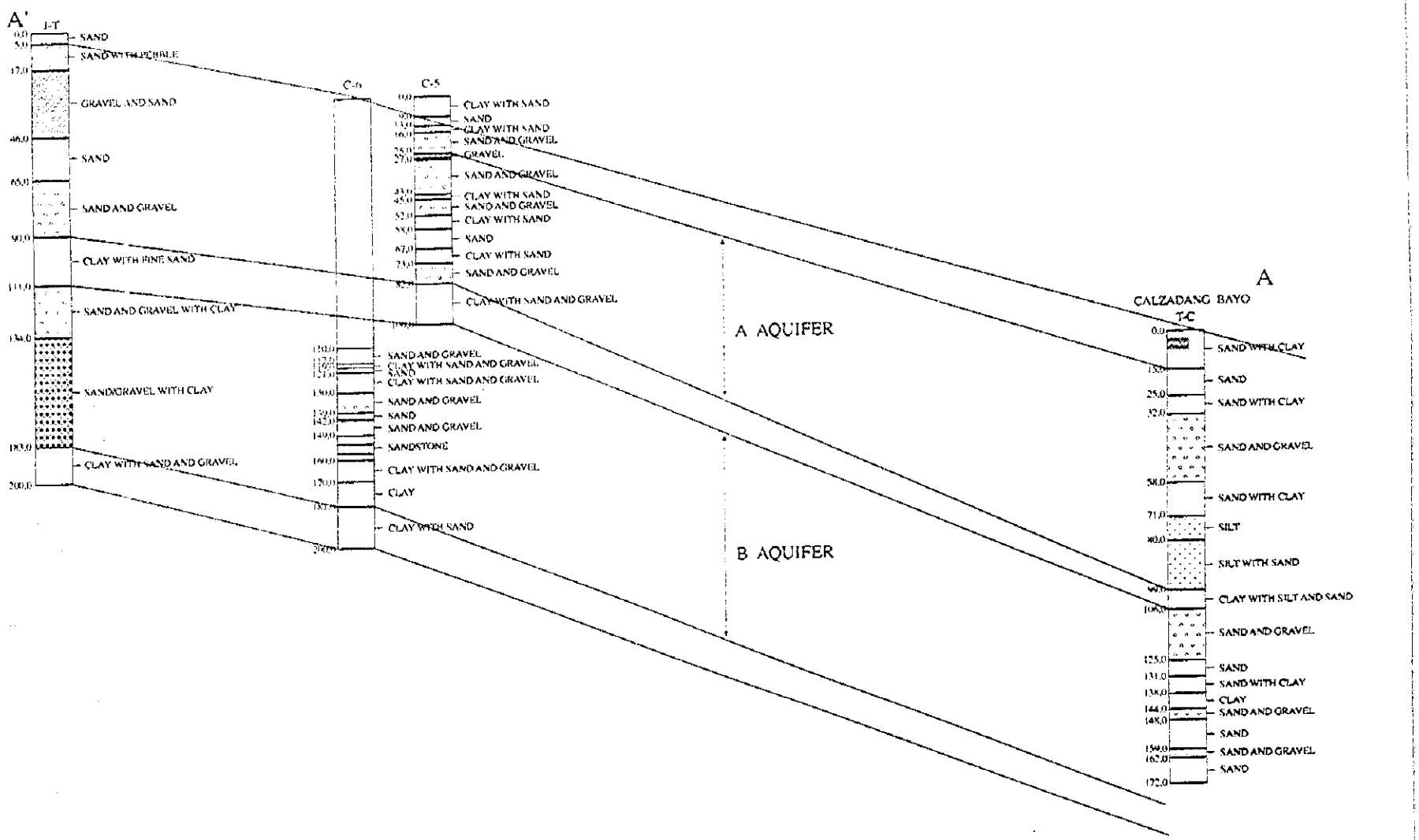

Figure C-16 GEOLOGICAL SECTION IN ANGELES CITY AREA

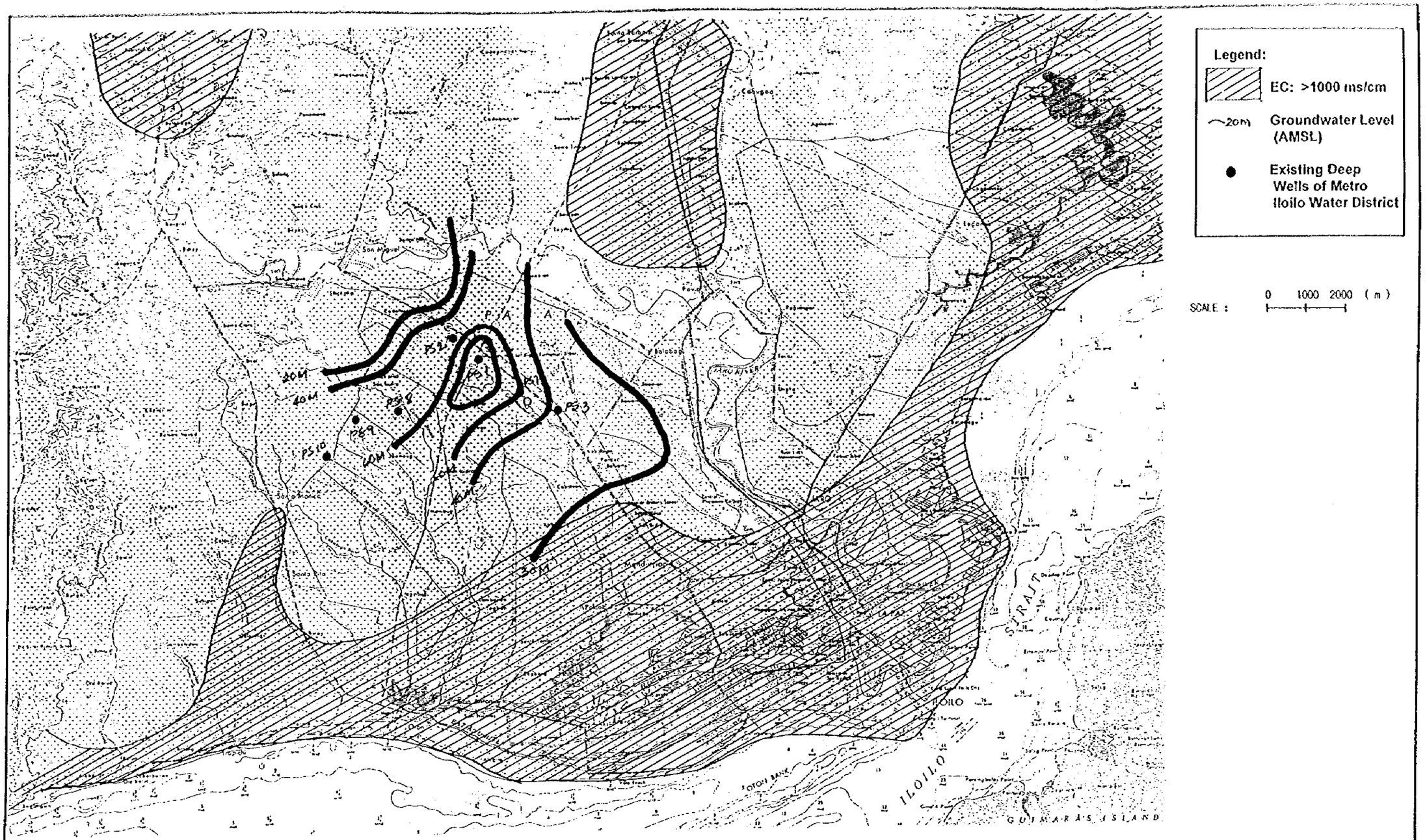

Figure C-17 LOCATION MAP OF EXISTING WELLS FOR METRO ILOILO WATER DISTRICT

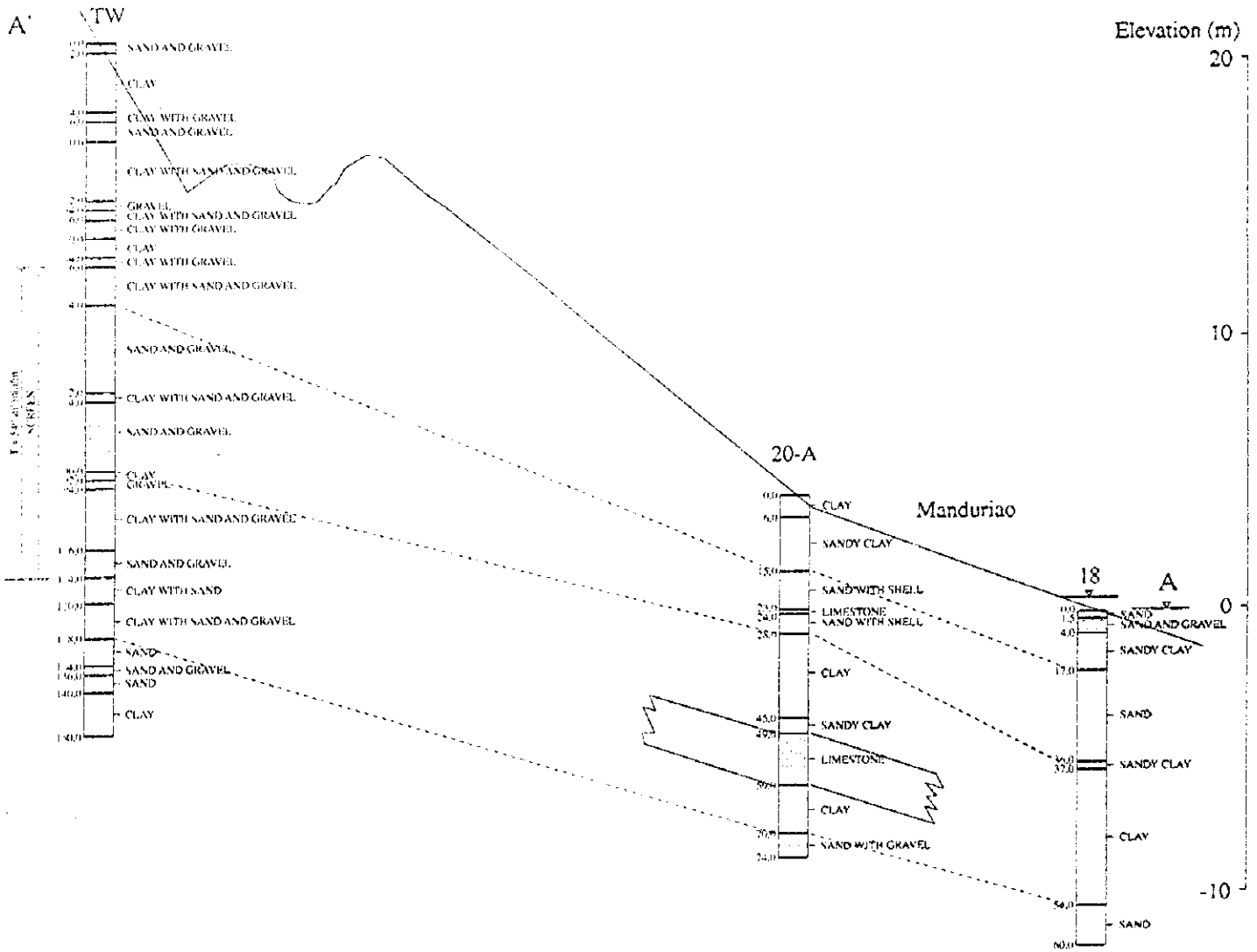

Figure C-18 GEOLOGICAL SECTION IN ILOILO CITY AREA

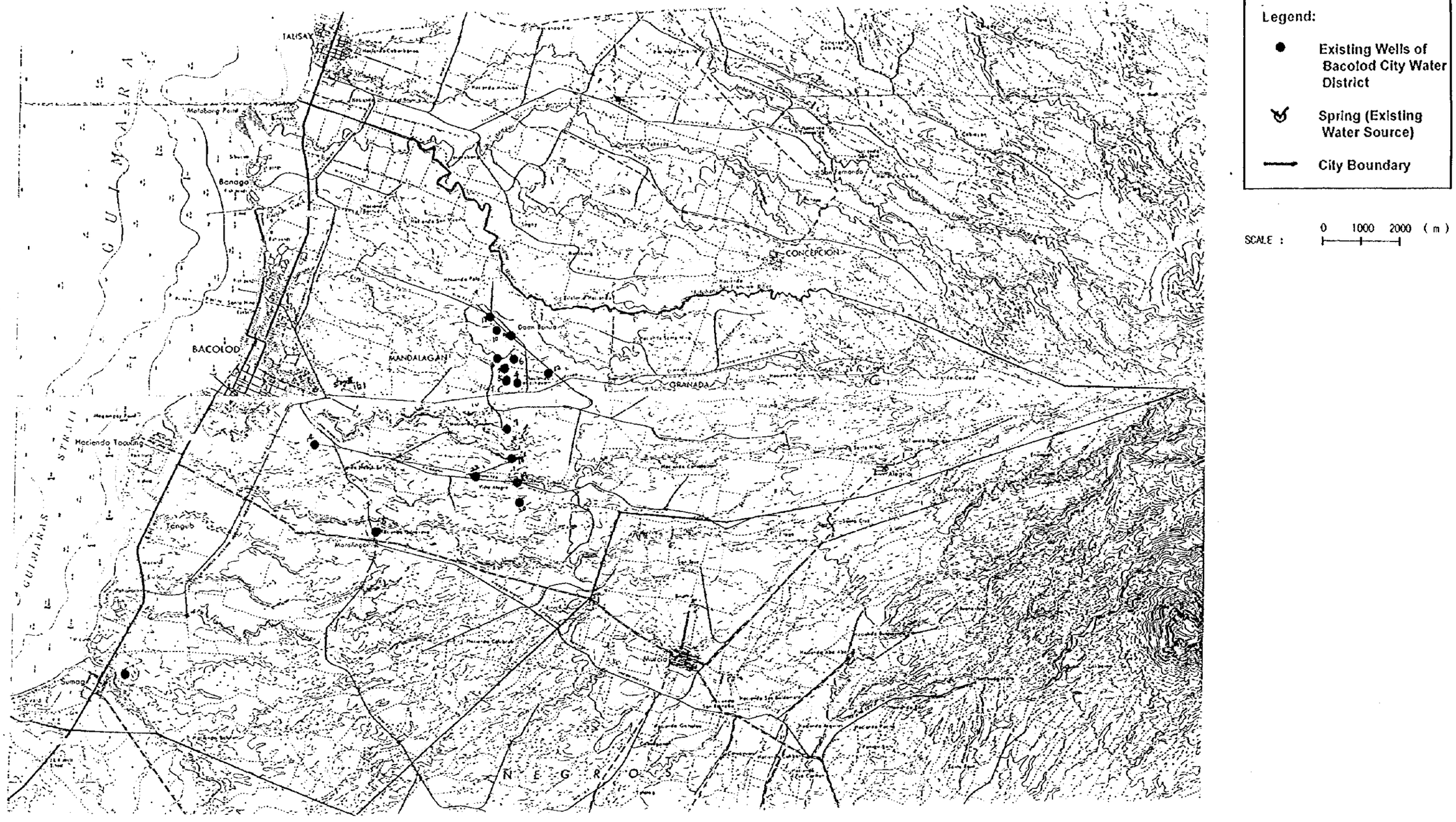

Figure C-19 LOCATION MAP OF EXISTING WELLS FOR BACOLOD CITY WATER DISTRICT

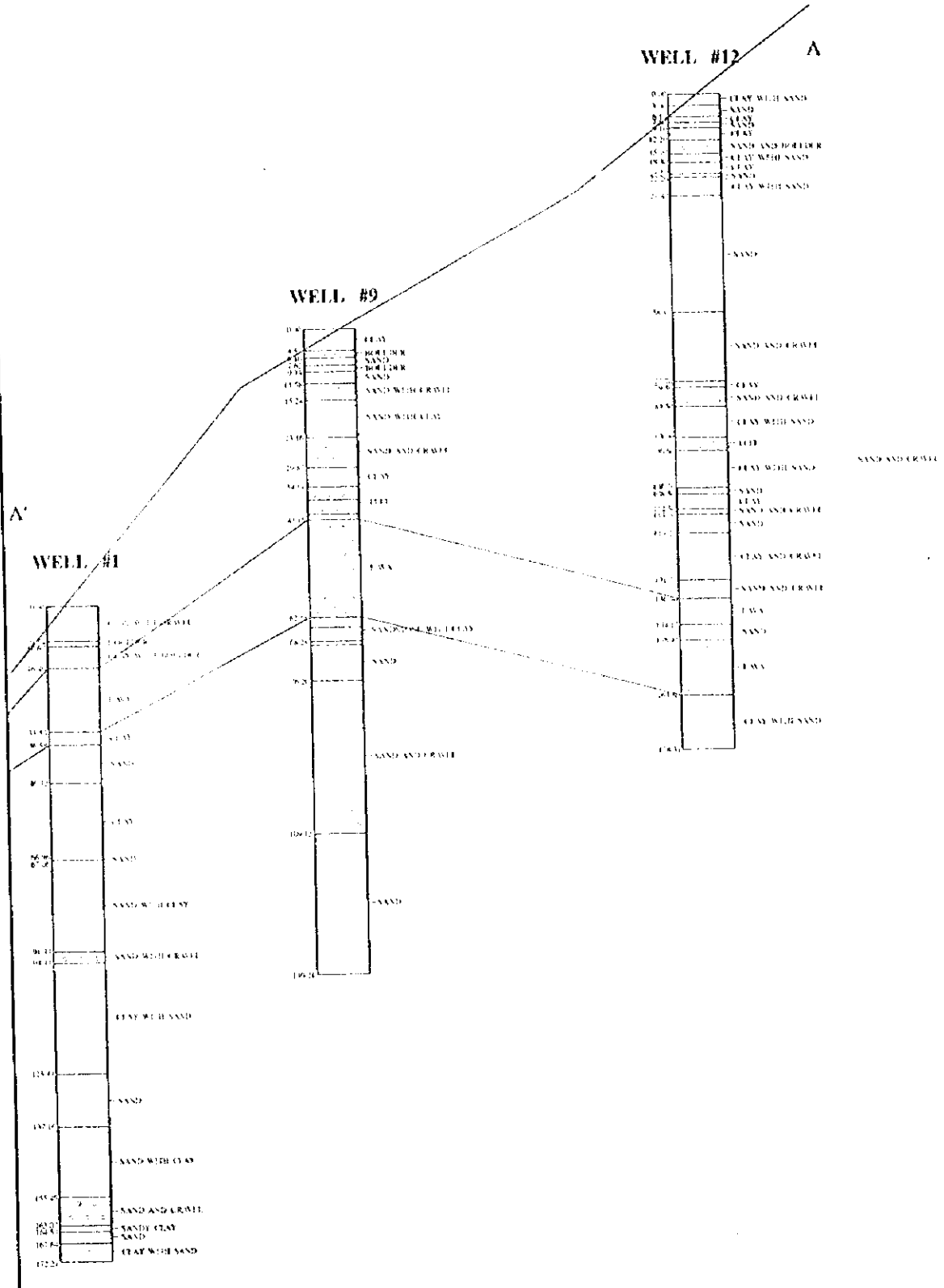

Figure C-20 GEOLOGICAL SECTION IN BACOLOD CITY AREA

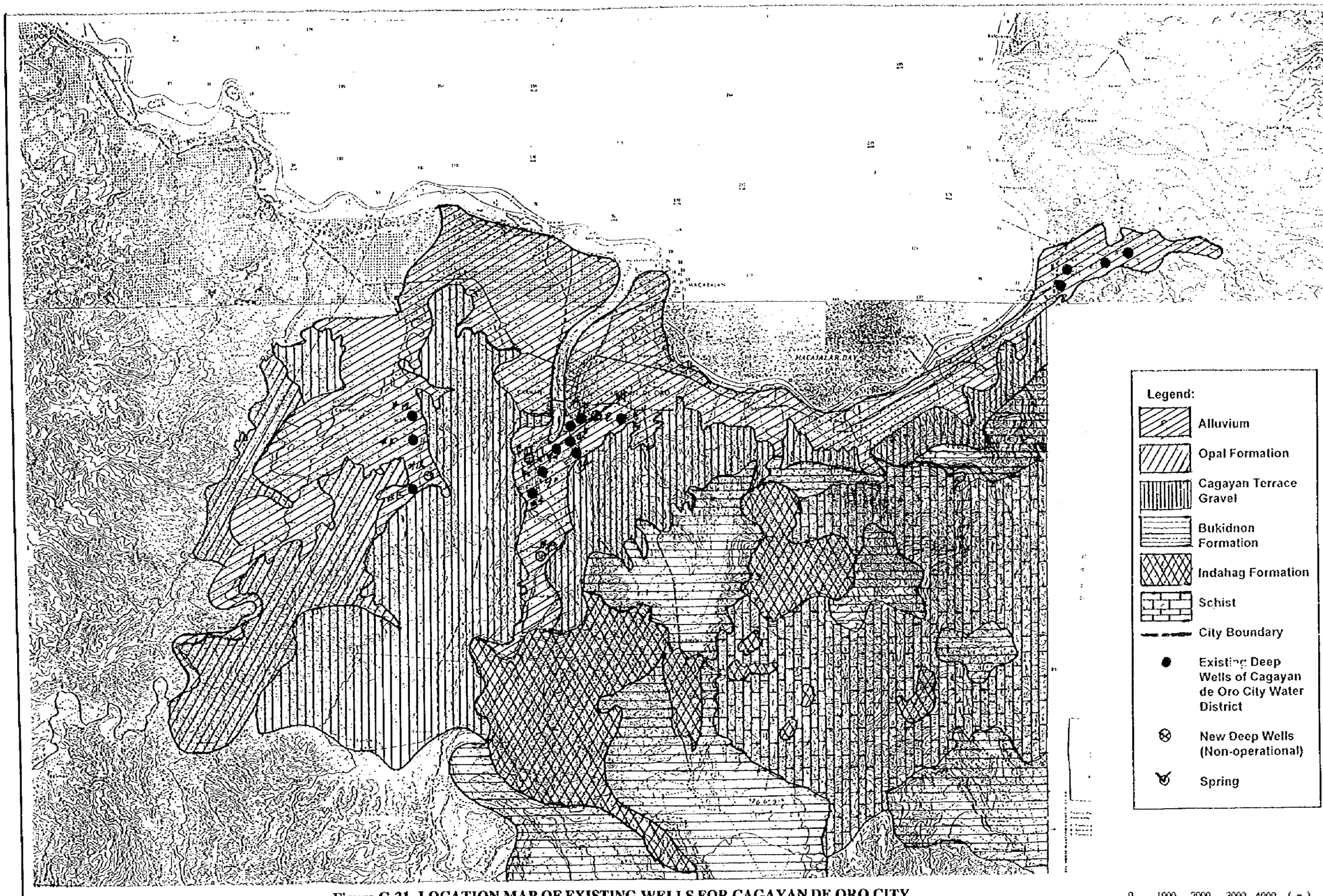

Figure C-21 LOCATION MAP OF EXISTING WELLS FOR CAGAYAN DE ORO CITY WATER DISTRICT

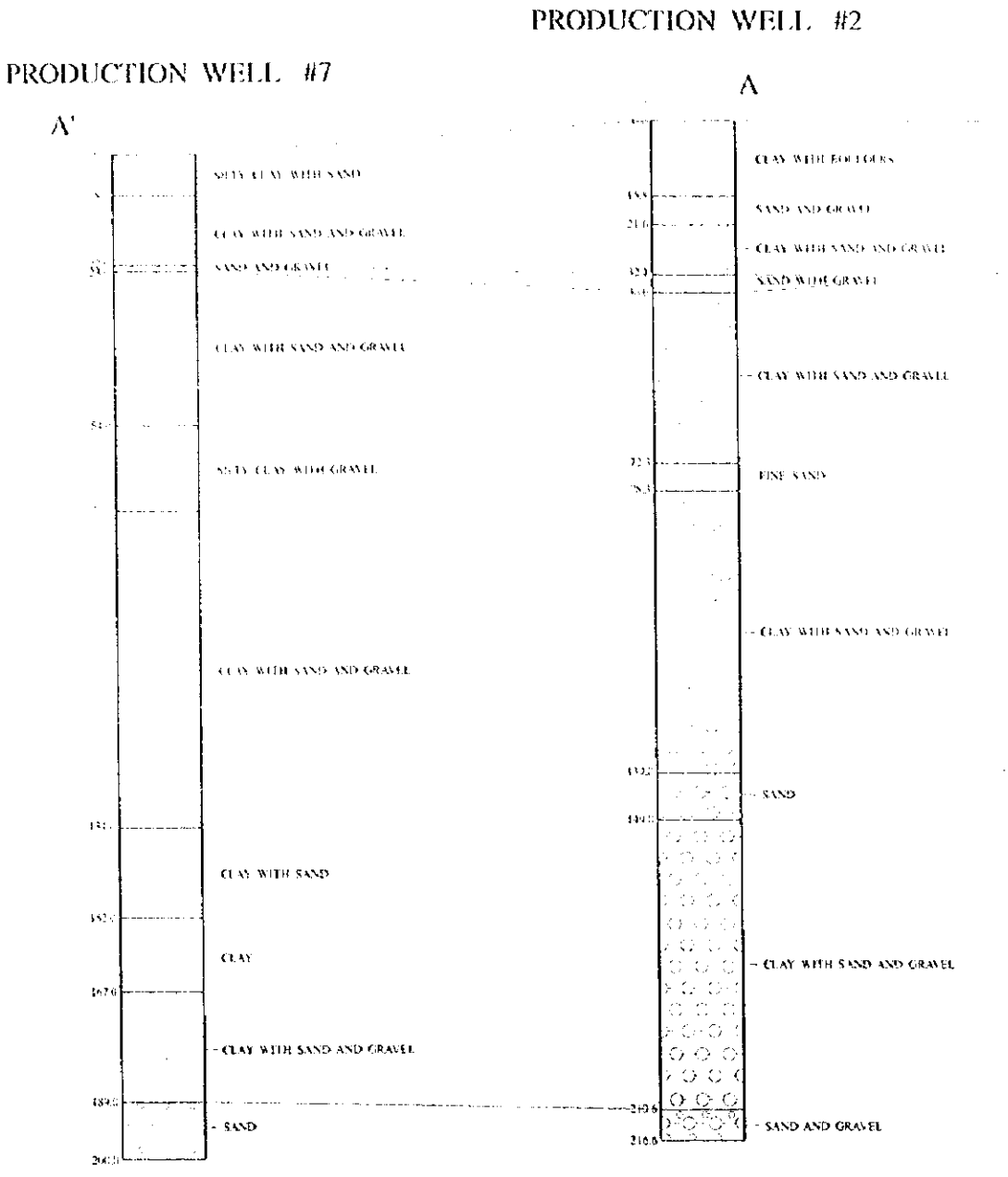

Figure C-22 GEOLOGICAL SECTION IN CAGAYAN DE ORO CITY AREA