5 GEOLOGY AND GROUNDWATER

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CHAPTER 1 PRESENT CONDITIONS OF TOPOGRAPHY, GEOLOGY AND HYDROGEOLOGY

1.1 Topography

The Cote d'Ivoire comes under old basement rock called Precambrian and having week contrast and monotonous topographic relief likewise to major western African countries. Altitude increases slightly from south-east to north-west (refer to Figure 1.1-1). Another typical topographic features are the littoral zone which consists of Plateau Continental, lagoons and sand bars located on southern part of the country extending along the Gulf of Guinea, and which is underlain by superficial sedimentary deposit of Mesozoic and Cenozoic age.

The characteristic of the topographical unit are :

1.1.1 South zone

This zone called plain is extended between altitude from 0m to 200m and is characterized gently undulating land feature. The relief is formed on thick weathered and altered zone developed on surface of basement rocks. This zone almost entirely also covered by forest therefore topographical contrast becomes more week. In detail, "moutonnee rock"(sheep's back shape) is prominent on west of the country where is mainly underlain by granitic rocks and the relief has a tendency of linear arrangement on east of the country where is mainly underlain by metamorphosed sedimentary rocks. Toward south, plain shift to low plateau and which contacts with lagoons by stiff slope.

1.1.2 North zone

Above elevation 200 meter, topographic feature changes to dominant in undulation and reach to plateau. This plateau can be distinguished to several steps from 200 to 500 meter and each plateau separated by slightly high (10 to 30m) slope. Such monotonous relief is broken by isolated relief units called inselbergs. Such relief units are three types:

(a) Alignment of hills, range from southwest to northeast direction and through the country obliquely. The hills with gentle form range about several ten kilometers.

(b) Small table mountain (with flat summit and steep slope), juts out from plateau about 200m to 300m height and on which summit lateritic crust is formed.

(c) Granite dome, with round summit and very steep slope, range on plateau. These domes are; isolated one, group of 2-4 domes, assembly of several ten domes (Seguela region).

1.1.3 West and North-west zone

West and north-west zone is characterized as mountainous relief and is called Guinea ridge. In this area, mountain slopes are steep, differentiation of altitude are large and some peaks exceed more than 1000 meter. This zone can be distinguished to some region : Mountain range of Tieme and Madinani, Table mountains with dolerite, between Odienne and Touba. Mountains situated Man region exceed frequently 1200 meter. Finally, mount Nimba situated frontier of Cote d'Ivoire, Guinea and Liberia.

1.1.4 Littoral zone

Littoral zone of the country shows different feature between western and eastern part. On western Liberian frontier, basement rocks directly face onto sea close to Fresco and the coast consists of mainly a series of capes, bays and sandy beaches. On the other side, toward east to Ghanaian frontier, the coast is sandy and sand bar isolates vast lagoons from sea, and which constitute artificially maintained navigation rout of about 300 km length west to east (Lagoon of Grand-Lahou, Lagoon Ebrie, Lagoon Aby and Lagoon Ehi).

1.2 Geology

1.2.1 Geotectonic history

Cote d'Ivoire belongs to vast African Old Platform (Precambrian Craton). The rocks underlain the platform is dated as from 1800 to 3000 million years old, which belongs to Precambrian and occupied grand area of the country. these Precambrian is divided to phases (refer to Figure 1.2-1) :

i) First phase, named Lower Precambrian or Archaean distributed west of the country occurred 3,000 million years old and continued to 2300 million year.

ii) Second phase, named Middle-Upper Precambrian commenced from Eburnian phase.

(1) Lower Precambrian

The orogeny of Lower Precambrian made a holding mountain rang. Then, as a result of erosion the mountain rang was destroyed and became a first platform named "Liberian semi platform". These rocks composed the semi platform finally have been exposed on mainly west of the country, Liberia and Guinea. The rocks of the Lower Precambrian are granite, migmatite, gneiss, ferro-quartzite and amphibolite.

(2) Middle-Upper Precambrian

In Ebrunian phase, the sea spread gradually on the ancient Liberian basement, deep trench named Geosyncline was sank and filled by sediment of two types called Birrimian formation:

- On first stage, the very deep trenches was filled by volcanic-sedimentary complex and such volcanic rocks especially basic rocks were alternated with shale material.
- Then, on the volcano-sedimentary complex and in the shallower zone, thick detritus layer (Flysch) especially shale result from erosion of mountain ranges was accumulated.

Ebrunian orogeny occurred 2,000million years old and mountain ranges was created by folding, upheaval of sediment accumulated in the geosyncline and intrusion of granites. This folding was accompanied by deep transformation of rocks (metamorphism and granitization) under influence of high pressure and high temperature.

A long geological calm period succeeded the orogeny period, then the mountain ranges were gradually eroded and became to peneplain, and finally to plat-form. It can be said that essential of the country was in place 1,500 million years old. Only some volcanic activities broken this calm period.

(3) Cretaceous - Quaternary

Subsidence of coastal sediment basin distributed on south of the country begins on Cretaceous. The subsidence reached its maximum in the Pliocene (final of tertiary) and has continued up to now. The series of the sediment were formed during Cretaceous-Tertiary and called Continental terminal..

1.2.2 Geology and it's influence for topographic feature

(1) Granite and Meta-sediment rocks

Geological structure of the country is characterized with bands of granites and meta-sedimentary rocks ranging south-west to north-east direction. Two-third of the country is covered by granites and migmatites resulted by geotectonic activity started from Liberian. Mata-sedimentary rocks such as flysh (alternation of sandstone and shale), slate and basic green rocks. There are remarkable topographic contrast between green rocks and slaty rocks. The former made ranges of hills because of these higher resistivity against erosion. The later made gently undulated plateau because of feeble resistivity against erosion therefore big river course of Bandama and Comoe were chosen on slaty rock bands especially on these upper stream. Inselberges of granitic rock are scattered on south-western of the country where belongs flysh dominant area.

(2) Liberian plat-form

Western zone of the country, west of the river Sassandra, belongs Liberian plat-form. Especially Man region underlain by hypersthene granite having high resistivity for erosion is called mountain area.

(3) Continental terminal

Only on the south of the country, clayey sand and clay sediment of the tertiary and quaternary are exposed along the coast occupying 2.5 % of the country and adjoining with basement rocks.

1.3 Hydrogeology and Groundwater

1.3.1 Existing well record

A lot of boreholes are drilled for rural and urban, mainly for domestic water supply. Majority of these well records are arranged and saved as inventory data file in the rural water supply sub-direction, department of hydrology, MIE. There are 17,532 wells totally, and 12,639 is boreholes and 4094 is dug wells. Most of boreholes are drilled on Precambrian plateau, another some are drilled on coastal area to take groundwater from the general aquifer.

1.3.2 Hydrogeological unit

Major two types of aquifers is divided in the country by “Carte de planification des ressources en eau de Cote d’Ivoire’’(1978), one is Discontinuous aquifer formed in the Precambrian which covers 97.6% of the country. The aquifer is formed in weathered and discontinuous fissure zone such as fault. Another is General aquifer which is formed in the porous and pervious layer mainly of the Continental terminal distributed on coastal area. Distribution and hydrogeological characteristic of each unit can be summarized as following table-1.3-1 analyzing above mentioned borehole inventory.

Table-1.3-1 Characteristics of hydrogeological units

Aquifer unit		Proportion to surface of the country (%)*	Number of borehole (rate %) **	Depth of borehole (m) ***	Thickness of weathered zone ****	Static water level (m) *****	Yield (m3/h) ******
General Aquifer	Continental terminal	2.4	671 (6.8)	50.1	--	21.7	9.6
Discontinuous Aquifer	Granitic rocks	62.7	6786 (68.6)	57.2	21.3	10.5	3.0
	Metamorphosed sedimentary rocks	34.9	2441 (24.6)	63.0	28.4	17.4	3.3
	Sub-total	97.6	9227 (93.2)	58.73	23.18	12.32	3.08
Total		100	9890	58.15		12.95	3.52

* Quoted from Inventaire hydrogeologique a l'Hydraulique Villageoise (1982)

** Within registered 12,626 boreholes 9900 are hydrogeologically classified.

*** Average depth of boreholes

**** Average thickness of weathered zone of basement rocks

***** Average static water level measured with pumping test

****** Average of maximum discharge measured with pumping test

(1) Discontinuous aquifer in Precambrian formations

Precambrian formations are essentially impervious under fresh and intact rock condition, so groundwater can be withdraw only from fissures and crack zone, such as faults and joints especially formed in weathered and altered zone usually distributed shallower part of less than 100m depth. Great number of boreholes and dug wells are drilled on the vast Precambrian plateau and groundwater are exploited from discontinuous aquifer for rural and urban water supply purpose. Estimation from well inventory for rural water supply, within 12,600 forages, about 12,000 and within 4100 dug wells 4050 are located on Precambrian plateau. And for urban water supply, within 390 boreholes, about 290 are located on Precambrian plateau and exploiting groundwater from the discontinuous aquifer. The discontinuous aquifer can be classified into two major hydrogeological units. One is granitic rocks and another is metamorphosed sedimentary rocks.

(A) Granitic rocks

Acidic to neutral plutonic rocks, such as granite, diorite are classified into this unit. And gneiss, migmatite are also classified into this unit based on similarity to granite for lithological feature of weathering zone and development of cracks. Average depth, thickness of weathered zone, static water level and well yield of boreholes are 57.2m, 21.3m, 10.5m and 3.0m^3/hr,

(B) Metamorphosed sedimentary and volcanic rocks

Metamorphosed volcanic rocks and volcanic sedimentary rock such as tuff, tuff breccia, "green rocks", and shale, sandstone, conglomerate, quartzite and slate are classified into this unit. Average depth, thickness of weathered zone, static water level and well yield of boreholes are 63.0m, 28.4m, 17.4m and 3.3m^3/hr.

(2) General aquifer in Continental terminal formation and Quaternary

The general aquifer forms excellent water source for rural and urban water supply on the coastal area from Grand-Lahou through Abidjan city to border of Ghana, about 670 boreholes are located in this area and especially water supply for Abidjan capital and peripheral urban center are entirely maintained by groundwater from general aquifer. Average depth, static water level and well yield of boreholes are 50.1m, 21.7m and 9.6m^3/hr. The aquifer of Continental terminal are lithologically divided into clayey sand (or clay), medium sand (with intercalate sandy clay), coarse sand (with intercalate clay) and fine sand to medium sand in descending order. Total thickness of aquifers are about 50m – 150 m under plateau area and more than 200 m under Lagoon Ebrie and coastal area. Depth of major boreholes ranges 50 – 120m.

1.3.3 Distribution and characteristics of boreholes and dug wells for prefectures

Distribution and characteristics of boreholes and dug wells constructed for rural water use are analyzed for each prefectures as table 1.3-2, Table 1.3-3 and for each sub-prefecture as Table 1.3-4.

(1) Boreholes

Total 12,626 boreholes are available for the analysis and 11,997 boreholes belong hydrogeologically into the Discontinuous and 629 into the General aquifer.

(A) Distribution

Biggest number prefecture is Korhogo (719) followed in order of abundance by Yamoussoukro (593), Tanda (509), Danane (463) and Abidjan (437). For the General aquifer, prefectures are of Abidjan (260) followed by Aboisso (188), Dabou (80), Jacqueville (75) and Grand Lahou (26).

(B) Borehole depth

Average depth of boreholes of Jacqueville prefecture which are belong to the General aquifer is 20.17m and this number is seems too shallow compare with average depth of boreholes belonging to the General aquifer. These boreholes are supposed to exploit groundwater from shallower aquifer such as dune sand.

(C) Static water level

Deepest average static water level observed in the Discontinuous aquifer is 29.47m and found on M'bahiakro and after this 26.75m on Daoukro, 21.26m on Bocanda and 19.11m on Agnibilekrou, while, in the General aquifer, deepest is 32.9m on Ground Lahou, 23.70m in Aboisso and 23.70m on Abidjan.

(D) Well yield

Greatest average well yield observed in the Discontinuous aquifer is 5.74m^3/hr and found on Tiassale and after this 5.18m^3/hr on Guigro, 5.08m^3/hr on Danane, 5.01m^3/hr Biankouma, while, in the General aquifer, greatest is 16.3m^3/hr on Abidjan, 14.1m^3/hr on Dabou and 13.7m^3/hr on Ground Lahou.

(2) Dug wells

(A) Distribution and rate of dug well

Biggest number prefecture is Korhogo (671) followed in order of abundance by Gagnoa (368), Lakota (218), Odienne (255), Issia (190) and Daloa(177). Moreover on these prefectures, rate of dug well for total wells (boreholes and dug wells) is also high, such as Lakota 87%, Gagnoa 74%, Daloa 65% and Issia 62%.

(B) Well depth, static water level and well yield

Average well depth is 18.46m and deepest one is 27m on Bocanda, and average static water level is 10.33m and deepest one is 16.2m on Daloa. Average well yield is 1.49m^3/hr.

1.3.4 Actual groundwater use

(1) Water supply purpose

(A) Rural water supply

For rural water supply, total 13,312 boreholes and dug wells are exploitable at present (quoted from Raport du bilan-evaluation du programme national d'hyraulique villageoise 1999.May, refer to Table 1.3-6). According to the above document total 17,779 wells were realized, within them 14,032 are boreholes and 3747 are dug wells. At July of 1999, 13,312 wells are exploitable and 4467 are out of order.

(B) Urban water supply

(a) Nation wide

There are 390 boreholes for urban water supply purpose managed by SODECI (quoted from Alimentation en eau potable en zone urbane 1956-2002 July 1999) . Production of groundwater for nation wide at 1998 is about 105.5 MCM (million m^3) and it is 785% for total urban use consumption (135.2 MCM) (refer to Table 1.3-4). About 88% of groundwater production for urban use is sheared by Abidjan city. About 12 MCM groundwater was produced at 1998 for domestic use of other city exclude Abidjan city. Groundwater accounts for about 79 % of total urban water use and the ratio of each sub-basins are shown on Table 1.3-7.

(b) Abidjan city

About 93.2 MCM groundwater was produced by 70-80 boreholes at 1998 for domestic use of Abidjan city. Groundwater production of Abidjan city has been increasing from 56.7 MCM at 1985 (refer to Table 1.3-5) up to now under growing rate of 3-9% especially 5.8% during last 4 year (1995-1998)(refer to Figure 1.3- 1). Domestic water supply for another cities

(2) Another purpose

Only groundwater use for industry in Abidjan city and its surroundings can be confirmed and according to this, about 0.93 million m^3 groundwater was produced at 1994. Even any statistics for groundwater use for industry of another area and another purpose like agricultural could not be find out, it is supposed by information from MIE and field survey that; 1) Industrial use without Abidjan city may not be so much, 2) Agricultural use may be only for a kitchen vegetables garden size by farmers using water holes.

1.3.5 Aquifer protection program of Abidjan groundwater basin

A study was implemented to get better management plan for the main groundwater resources of Abidjan capital and peripheral area by the authorities responsible for potable water distribution in the country as Department of hydraulic M.I.E, SODECI and BENTD. The authorities make a contract with SOGREAH to construct a mathematical model to simulate limit groundwater exploitation preventing rapid draw down of water level and sea water intrusion into the aquifer at the target year.2010. Flow and result of the simulation is as follows;

(1) Hydrogeology and groundwater of Abidjan city and surrounding area

Out line of Abidjan and surrounding area is shown on Figure 1.3-2. West-east and North-south geological profile are shown as Figure 1.3-3 and Figure 1.3-4. That is, main aquifer of the area is sandy sediment of the Continental terminal and these are underlain by impervious basement rocks and these surface is inclined to the Guinea bay. Many borehole are located on the area having depth usually 75 – 150m. Groundwater head contour line is shown as Figure 1.3-2 at 1992, i.e. on the plateau elevation of water head ranges 50m to 10 m then lowers 5m to 1m close to lagoon. .

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(2) Flow of simulation

(A) Construction of simulation model

Area of simulation is composed of Abidjan city and it's surroundings. Southern boundary is Lagoon Ebrie and northern one is almost border between the Continental terminal formation and the basement rocks. Western and eastern boundaries are river Agneby and river Me. Total area is 1335 km^2 and which is divided into each 1 km^2 grid (refer to Figure 1.3-1). Out line of geological condition is summarized as W-E and N-S profiles (Figure 1.3-2, 1.3-3). 18 existing and planned pumping stations of SODECI are scattered in the simulation area.

(B) Actual groundwater discharge

Groundwater discharge of urban water supply for Abidjan city reached to about 2.3 m^3/s, 73 MCM at 1994 which corresponds with 23 % of average annual infiltration (310 MCM and 230 mm).

(C) Assumption of water demand evolution

Future water demand at 2020 is estimated by SODECI to 4.3 m^3/s, 370,000m^3/day (135MCM) base on water demand of each sector which correspond with 44 % of average annual infiltration. On the assumption figure, 5 m^3/s is adopted on the simulation as future groundwater exploitation and which corresponds with 51 % of average annual infiltration. These discharge ratio seems so high to recharge capacity. .

(D) Reappearance of impact of exploitation in 1994 compare with 1977

It was estimated that groundwater storage was decreased from 12,707 MCM to 12,293 MCM during 1977 to 1995 and decreasing of the storage 414MCM (average decrease ratio is 21.7MCM/year). Statistic water head of the North pumping station has been decreased 7.2 m during 1971 – 1994 and has not reached to stable water head yet (refer to Figure 1.3-5). A part of this, 22 cm will be caused by naturally influenced by decrease of annual precipitation of last several years. For example, average annual precipitation of Abidjan decreased from 1725 mm (1977-1994) to 1556 mm (last several year). By the way total annual water head decrease of the North pumping station is 42 cm (7.2m/14 year).

(E) Future groundwater exploitation and figure of piezometric surface

As a result of the simulation, limit groundwater exploitation was estimated to 4.0 – 4.2 m^3/s, 132MCM at year 2008 - 2010, avoiding drastic draw down of water head to prevent sea water intrusion into aquifer. Critical draw down of groundwater head will be caused surrounding pumping station. As a result of above simulation, it is required to consider rearrangement of pump station on future program. Estimated water table at 2010 and differentiation of water head is shown Figure 1.3-6.

(2) Recommendation for future project adapted to water demand and monitoring of groundwater head and quality

(A) Other possible resources

Surface water of lagoon Potou and/or Aghien seems to have only slight salinity and discharge of $3m^3/sec(260{,}000m^3/day)$, therefor it is recommended to study water quality, environmental aspects of boss lagoons and intake facility to drive lagoon water (Information from officer of MIE/HD)

(B) Monitoring of water quality and fluctuation of piezometric level

(a) Piezometric level monitoring

i) Boreholes

Monthly measurement of piezometric level for 52 boreholes is proposed. In addition this, twice a year measurements for all observation boreholes are also required. Actual situation of these observation boreholes should be inspected before measurement.

ii) Rivers and lagoons

Measuring for water level of 7 rivers and lagoons is proposed. These measures are required twice every year.

(b) Water quality monitoring

i) Periodical measurement

Salinity(Cl), Nitrate, Conductivity for all exploiting borehole, 6 time per year.

ii) Conductivity profile for existing boreholes

To make conductivity profile for old abandoned boreholes or deep observation borehole located on center of pumping station is proposed, 20 boreholes will be available, proposed measurement interval is 3 time per year.

iii) Conductivity profile for newly planned borehole

To make conductivity profile for newly planned deep observation borehole between pumping stations and lagoons. About 7 boreholes is proposed, measurement interval is 3 time per year.

iv) Conductivity measurement of lagoons

Three(3) time per year is required if possible at high tide always, 10 point for each lagoon.

v) Quality for River Me' etc.

Monthly analysis for following items at river Djibi, Bet's, Me and mouth of lagoon Aghien are proposed ; Bacteriological analysis, Physico-chemical analysis for turbidity, pH, conductivity, chlorine, temperature, NO3, NO2, NH4, Cl, So4, DO, bicarbonates, Na

(C) Investigation program for new distributing installation

(a) Location identification, test drilling and definition of facility

Location of the facilities should be identified inspecting hydrogeological condition, land ownership, environmental constraint etc. Then, 2 or 3 test drilling are required to identify lithology of aquifer, water quality and water level. Integrating above investigation type of facilities will be defined.

(b) Impact of groundwater exploitation for aquifer and surface flow

A study to analyze relationship between surface flow and groundwater is required. Therefore piezometric potential (groundwater table) map has to be make integrating water level of rivers and groundwater head. Then, groundwater discharge model developed by SOGREAH will be applied. Influence of groundwater development will be analyzed for hydrological average and sever year.

(3) Actual situation

A study has been requested to BAD to solve above appointed problem. Outline of the study as follows; BAD has been evaluating the request**.**

(A) Title

The Study for Domestic Water Supply Reinforce of Abidjan and Bouake City

(B) Contents

(a) Master plan for water supply Abidjan and Bouake city until 2015

Information from the water department, study for Potou and Aghien lagoon will be included in the master plan

(b) Detail design for water supply project for Abidjan city until 2005 including tender document

Information from the water department, detail design for construction of boreholes will be included.

(c) Period (Original)

i) Finance March 2000

ii) Tender for consultant. June 2000

iii) Final report December 2001

CHAPTER 2 GROUNDWATER RESOURCES POTENTIAL

2.1 Mechanism of Recharge and Flow of Groundwater

2.1.1 Discontinuous aquifer

Rain water which was infiltrated into the ground, is firstly stored in shallower aquifer formed in superficial highly weathered zone and some of them exploited by shallow traditional well (called water hole) or dug well, generally average thickness of them are 22m. Then the groundwater is infiltrated into deeper and stored in deeper aquifer formed in weathered and discontinuous fissure of basement Precambrian rocks. For groundwater flow mechanism, it is supposed that groundwater stored in boss shallower and deeper aquifer usually follows from topographical higher part to lower part forming shallower and deeper groundwater table each other. Generally figure of water tables are parallel to land surface and finally majority of groundwater flows may be discharged at topographical lower part into the river, wazi or marshy ground, and also some groundwater flows away to neighboring groundwater basin. A study for groundwater recharge on Sahel area in Burkina-Faso by M. Nakahara(1999) results ; The water balance estimated by "Tank model method" shows that evapo-transpiration is 66%, the river outflow is 5% and the underground infiltration is 29%.

2.1.2 General Aquifer

Infiltrated water has been stored in aquifers of the Continental terminal formation such as sandy layer. The aquifers are confined by impervious layers and each aquifer has confined individual water head. Usually aquifers are separated by impervious later from ground surface and each aquifers. The infiltration and recharge of rain falls to the aquifer from ground surface is not directory. Groundwater is flows when differentiation of heads are occurred by withdrawal from the aquifer and also recharged by seepage from overlain impervious layer and/or from upper aquifers through impervious layer caused by draw down of water head.

2.2 Method of Estimation of Groundwater Potential

Method of groundwater potential estimation follows " Carte de planification des ressourses en eau de Cote d'Ivoire"(The water resources map 1978), in which groundwater potential was estimated as renewable resources corresponded with effective rainfall and storage capacity classified with lithological characteristics. The estimation process is as follows in accordance with the description of Water resources map;

2.2.1 Elements of Groundwater Potential Estimation

(1) Effective rainfall

Effective rainfall (Rf) is excite (Ex) after subtract real evaporation (Er) from rainfall (R).,

i.e. Rf =Ex=R- Er

Er is calculated from relationship between R, Ep (evapo-transpiration), VR (soil moisture content variation) and RFU (water retaining capacity of soil easily usable for plant). Er was calculated as average of 20 years (1955-1975). Effective rainfall contour line is shown on Figure 2.3-1.

(2) Infiltration capacity of the ground (relating with lithological character)

Infiltration capacity of the ground that is how many percent of Er can be infiltrate into ground is defined following 3 grade of ratio relating with lithological character of ground .

- 1/4 of effective rainfall for sedimentary rocks, slate, sandy slate, metamorphosed volcanic rocks of Precambrian
- 1/3 of effective rainfall for granitic rocks, gneiss, migmatite etc. of Precambrian.
- 1/2 of effective rainfall for non-metamorphosed sedimentary rock of the Continental terminal.

(3) Lithological and stratigraphical classification

(A) Discontinuous aquifer

Concerning hydrogeological characteristic the discontinuous aquifer is classified following 5 classes ;

(a) Upper Precambrian /Birrimian

i) Granitc rocks of Ebrunian period

ii) Metamorphic rock of sedimentary rock origin, sandstone, conglomerate, slate, etc.

iii) Metamorphic rock of volcanic and volcano-sedimentary rock origin, tuff, tuff breccia, crystalline tuff.

iv) Metamorphic rock of volcanic rock origin, acidic to basic lava.

(a) Lower Precambrian /Pre-Birrimian

i) Granite, gneiss, migmatite, etc.

(B) General aquifer

(a) Quaternary

Quaternary system is distributed coastal area and consists of silt, clay and, fluvial and eolian deposit. Sand layer is pervious but to prevent sea water intrusion draw down by pumping and exploitation is limited.

(b) Continental terminal

Exploitable groundwater is estimated as follows considering with permissible draw down to prevent sea water intrusion into aquifer.

Draw down	Exploitable groundwater
More than 30m	more than 3,000,000m^3/km^2
From 20 to 30m	From 2,000,000 to 3,000,000m^3/km^2
From 10 to 20 m	From 1,000,000 to 2,000,000m^3/km^2
Less than 10 m	Less than 1,000,000 m^3/km^2

(4) Classification of renewable groundwater resources capacity

Combining above mentioned ratio and, lithological and stratigraphical characteristic, renewable groundwater resources is classified 7 ranks as Table 2.2-1. Unit potential of every hydrogeological class is defined taking minimum value of the rank define in the water resources map.

Table 2.2-1 Classification of renewable groundwater resources capacity

Rank	Unit potential (mm)	Rang of potential	
		(mm	(m^3/km^2/year)
I	400	more than 400	More than 400,000
II	300	300 to 400	300,000 to 400,000
III	200	200 to 300	200,000 to 300,000
IV	150	150 to 200	150,000 to 200,000
V	100	100 to 150	100,000 to 150,000
VI	50	50 to 100	50,000 to 100,000
VII	25	Less than 50	Less than 50,000

2.2.2 Process of Estimation

At first the study area is classified to two big hydrogeological unit, one is the Discontinuous aquifer area and another is the General aquifer area. Then, each unit is divided to drainage basin and sub-basin almost in accordance with the control point. The discontinuous aquifer area is divided into 32 drainage basin and the general aquifer area is divided into 4. Then areas of sub-basin and areas belong to groundwater potential ranks are measured.

(1) Division of drainage basin and measurement of each classified area

At first the study area is classified to two big hydrogeological unit, one is the Discontinuous aquifer area and another is the General aquifer area. Then, each unit is divided to drainage basin and sub-basin almost in accordance with the control point. The discontinuous aquifer area is divided into 32 drainage basin and the general aquifer area is divided into 4. Then areas of sub-basin and areas belong to groundwater potential ranks are measured.

(2) Estimation method of groundwater potential for sub-basins

Secondary, the areas belonging to each groundwater potential ranks (I-VII) of sub-basin are measured. Then average groundwater potential of the sub-basin is estimated by weighted average of different groundwater potential rank.

2.3 Groundwater Potential

Groundwater potential of big hydrogeological units and main river basins are summarized as Table-2.3-1.and detail estimation of each sub-basins are shown as Table 10.1.3-2, and also distribution of groundwater potential of sub-basins is compiled as “Renewable Groundwater Potential map” (Figure 2.3-1). Average annual groundwater potential of the discontinuous aquifer area is about 31,000 MCM or 92 mm converted into water depth, on the contrary one of the general aquifer area is 2,800 MCM or 334 mm.

2.3.1 Discontinuous aquifer

Average groundwater potential per year of the discontinuous aquifer is 92 mm and it is varied from 31 mm to 244 mm affected by effective annual rain fall.

(1) Sassandra and surrounding basin

The basin is mostly underlain by granitic rocks. Average groundwater potential per year is 151 mm. It is higher in eastern zone of the basin such as Gavally and San Pedro basin, and Kahin sub-basin ranging more than 200 mm.

(2) Bandama and surrounding basin

The basin is underlain by granitic rocks and metamorphosed sedimentary rocks. Average groundwater potential per year is 56 mm. It is mostly lower in major area of the basin reflecting low rainfall. It is only higher in Boubo river basin (119 mm).

(3) Comoe and surrounding basin

The basin is mostly underlain by metamorphosed sedimentary rocks in southern area and underlain by granitic rocks in northern area. Average groundwater potential is 51 mm. It is mostly lower from middle to upper stream of the basin and only higher in southern area such as Bia and Agenby basin, and Lower Comoe basin ranging 90 – 135 mm.

2.3.2 General aquifer

The groundwater basins of general aquifer are independent from surface water basin and are subject to distribution of the Continental terminal formation. Average annual groundwater potential is 200 – 380 mm reflecting high infiltration capacity of the formation and larger amount of precipitation of coastal area. While infiltration capacity of the Continental terminal is estimated as 230 mm or 310 MCM/km^2 for average annual precipitation of 1725 mm (1977 – 1995) according to the study for water supply and aquifer protection program of Abidjan city.

Table 2.3-1 Summary of groundwater potential for river basins (Renewable groundwater resources)

Hydrogeology	River basin		Area of unit basin	Groundwater potential	
			(km^2)	(mm)	MCM/y
		sub-total or average of Sassandra basin	70,550	123	8,656
	Total of Sassandra and surrounding basin		132,005	151	19,912

		Sub-total or average of Mandama basin	101,378	49	5,015
	Total and average of Bandama and surrounding basin		111,714	56	6,245
		Su-total or average of Comoe basin	67,598	43	2,875
	Total and average of Comoe and surrounding basin		93,912	51	4,830
Total or average of Discontinuous aqifer			337,631	92	30,987
Total General aquifer			8,392	334	2,803
Grand total			346,023	98	33,790

Modified from the "Carte de planification des ressources en eau de Cote d' Ivoire" 1978

2.4 Consideration to Select Priority Area for Groundwater Development Project

A trial plan to select priority area is suggested in a process to make groundwater project. For example rural water supply project is taken up and firstly selection of factors is considered and then appraisal of factors to make order priority is done.

2.4.1 Factor to make order of priority

Following factors should be considered to formulate a adequate rural water supply project.

(1) Social condition

(A) Coverage rate of water supply facility

Coverage rate of water supply facility is most important factor. The responsible organization for water supply sector has targets to be achieved under national plan of the sector. One of the targets is to approach coverage rate to 100%. For example, in Cote d'Ivoir, actual coverage rate of safe and stable water supply facility for rural water is investigated and estimated by Rural water supply sub-direction of MIE. The sub-direction has a fundamental policy that aims to cover whole villages with population from 100 to 400 by at least one water point. Therefor these villages under low coverage rate will be on higher priority.

(B) Influence of water born disease

Number of water born disease cases is a important factor and also some special disease like guinea worm will be a impact factor.

(2) Natural condition

(A) Meteorological and hydrological condition

Difficulty to get drinking water will be controlled by meteorological condition as rainfall and continuation of dry season, and also by hydrological conditions as distance from water source which has adequate quantity and quality. .

(B) Feasibility to develop groundwater

Feasibility to develop groundwater is depended on groundwater potential which is depended on infiltrate capacity controlled by effective rainfall hydrogeological condition such as well yield, depth of aquifer (affect well depth), static water level and water quality. These factor

2.4.2 Appraisal of factors

At first, the factors is classified into some groups like A,B,C and then comprehensively is appraised priority comparing these factors considering weight of them. .

(1) Grade of factors

(A) Coverage rate of water supply facility

At first classified into three groups A,B,C referring frequency distribution of coverage rate of rural water supply facility and number of districts of each frequency distribution (refer to Table 2.4-1, Table 1.3-6 and Figure 2.4-1) . Then made a map which shows distribution of the coverage rate distribution and these grade (refer to Figure 2.4-2). Some low coverage rate districts (grade A) are concentrated on south-west area of the country.

(B) Effective Rain fall

Effective rainfall contour line map quoted from “Renewable Groundwater Potential map” is summarized as Figure 2.4-3. In this map, it will be difficult to get water in dray season in the grade A area, in which effective rain fall ranges less than 200 mm/y, and the area will be suffered seriously by drought. The area is distributed east-central area of the country.

(C) Groundwater potential

Groundwater potential is a factor to show feasibility to exploit groundwater. Then, show distribution of groundwater potential summarized as Figure 2.4-4 from the Renewable Groundwater Potential map. In the map, even lowest potential area C, having potential less than 50 (smallest value is 25), has enough potential to exploit groundwater by a manual pump drilled in a village (interval of each well is more than 500 m and a well may have recharge area more than 1 km^2). Because capacity of manual pump is about 1 m^3/hr and can exploit groundwater about 4000 m^3 during a year if pumped 10 hours per day, and this is equivalent of groundwater potential 4 mm/km^2/year. On the other hand, groundwater potential of the area at least 25 mm/y, or 25,000 m^3/km^2/y and it will be enough compare with groundwater exploitation for rural water supply by manual pump. Therefore, groundwater potential is not so mach important factor in case of rural water supply.

(D) Another factor

Following another maters should be considered for appraisal

(a) Preparation of facilities to satisfy basic human needs such as water supply facilities is required in the area where population has been increasing with agricultural development on forest area.

(b) On western boarder area, refuges from Liberia need to preparation of water supply facilities urgently/

(c) On most dry area especially where effective rain fall less than 100 mm/y, it will be very serious to get water especially in dry season.

(d) However have not been collected data for health and sanitation, it is necessary to consider rate of water born diseases cases

(2) Comprehensive appraisal

Finally it is tried to put priority of rural water supply as Table 2.4-2, after comprehensive appraisal of above mentioned factors.

CHAPTER 3 GROUNDWATER BALANCE STUDY

3.1 Method of Groundwater Balance Analysis

The groundwater balanced can be estimated by following formula.

$$\mu\, ds/dt = (Qr-Qd)/A$$

μ : Effective porosity

ds/dt : water level change during a definite period

Qr : groundwater recharge

Qd : groundwater discharge

A : a definite area

$$Qr = P - Ev$$

$$Qd = qp - (qi-qo)$$

P : precipitation

Ev : Evapo-transpiration

qp = groundwater extraction

qi = groundwater inflow from adjacent basin

qo = groundwater out flow to adjacent basin

The value μ ds /dt is difficult to settle because groundwater level fluctuation record has not been found out except the Abidjan snb-basin. So .it is assumed that the value μ ds /dt is constant during a year. The value Qr = P – Ev is settled as renewable groundwater potential. The value qd is estimated from urban, rural and agricultural groundwater use or demand. The value qi and qo usually will be balanced in the same basin because the groundwater will flow through aquifers formed in weathered zone of basement rocks and almost return to river finally. Therefore, groundwater balance is estimated in the study for each sub-basn as difference between the groundwater potential and the actual groundwater use in 1998 or future demand in 2015.

In case of Abidjan groundwater basin, groundwater level has been monitored for many observation boreholes and, groundwater balance was analyzed using these data and making numerical model. Future groundwater level fluctuation caused by increase of demand was also estimated. So that, the result of study of Abidjan sub-basin is compared to verify groundwater balance of the study.

Groundwater potential, actual groundwater use, future use and estimated groundwater balance is shown as summary on Table 3.2-1 and, for each sub-basin on Table-3.2-2 (shown in water depth mm) and Table 3.2-3.(shown in water volume MCM).

3.1.1 Groundwater potential

Ground potential is settled according to Table 2.3-2. The value is varied in discontinuous aquifer from 31 to 244 mm and 92 in average. In general aquifer, the potential is varied from 200 mm to 380 mm.

3.1.2 Actual groundwater use

(1) Urban water use

Urban groundwater use is estimated from data of SODECI. Major of urban areas are supplied water from deep boreholes.

(2) Rural water use

Rural groundwater use is almost depend on groundwater and actual use is estimated multiplying rural population and unit consumption 20 l/day/person.

(3) Agricultural water use

Agricultural water use is estimated from assumed small scale production for vegetable.

3.1.3 Future groundwater use

(1) Urban water use

Future demand is estimated considering population growth and expansion of water consumption. Ratio of groundwater use and surface water use is assumed same as 1998.

(2) Rural water use

Future demand is estimated considering population growth and increase of unit consumption 20l/day/person to 25l/day/person.

(3) Agricultural water use

Future demand is estimated considering agricultural production growth.

3.2 Actual Groundwater Balance in 1998

3.2.1 Urban water use

(1) Discontinuous aquifer

The average extraction of a boreholes is 24,000 m^3/y (7 MCM/290holes) and which is equivalent to groundwater potential of 24 mm. This value is not exceed or almost same as the groundwater potential of poor potential area (VII – VI rank) like as some part of Bamdama and Comoe basin. In such case, when boreholes are concentrated and capacity of aquifers are not enough, groundwater will not be balanced and continuous draw down of groundwater will be caused.

(2) General aquifer

In case of Abidjan sub-basin, the average extraction of a borehole is about 1.300 MCM/y (94.6 MCM/72 holes) and which corresponds to 1,300 mm. Considering annual average recharge capacity of general aquifer area of 230 mm, it will be required to scatter a borehole having enough recharge area at least more than 6 square kilometers (1,300/230=5.6). Therefore actually concentrated draw down is caused during recent years around pumping station where boreholes are concentrated.

3.2.2 Rural water use

(1) Discontinuous aquifer

The average extraction of a borehole can be estimated 1,390 m^3/y (18.5 MCM/13,300 holes) and which is equivalent to 1.39 mm/km^2 of groundwater potential. Usually borehole are scattered in each villages and distance of each other is more than one kilometer. Therefore groundwater potentials even in the poor potential area which varies 25 - 50 mm are entirely enough compare with annual extraction for rural water supply mostly equipped by manual pump which capacity is less than 1 m^3/hr (equivalent to potential 3 – 4 mm/km^2).

(2) General aquifer

The average extraction of a borehole is 1,330 m^3/y (0.80 MCM/600 holes), and equivalent to 1.33 mm of potential. This value is quietly smaller than groundwater potential which varies more than 200 mm.

3.2.3 Agricultural water use

Number of wells for agricultural use are not identified.. Average annual consumption is assumed ranging from 1,873 m^3/ha in whole country average to 5,000 m^3/ha in arid area. If a ha of vegetable fields are scattered in a square kilometer, these unit consumption correspond to 1.83 mm and 5.00 mm and which are smaller than ground potential even in the arid area. .

3.3 Future Groundwater Balance in 2015

Groundwater potential seems totally enough compare with water demand except Abidjan city, However considering small capacity of discontinuous aquifer, it will be unavoidable to occur continuous draw down of groundwater level by concentration of boreholes in case of urban water use. Therefore, study for capacity of aquifer, simulation and monitoring for groundwater level change should be required for such concentrated groundwater development. Aquifer protection of Abidjan city is most important issue for groundwater development of the country and the study for counter measure is now on going.

3.3.1 Urban water use

Urban water demand is assumed considering increase of unit water use per person and improvement of water use coverage. Urban water demands are about 130 MCM on discontinuous aquifer area and about 254 MCM on general aquifer area in which demand of Abidjan sub-basin shares 243 MCM and, correspond to 0.39 mm and 30 mm. Generally these amounts seems entirely within the groundwater potential (92 mm and 334 mm) but considering concentration of groundwater discharge on urban area following for each hydrogeological type issues will be anxious. .

(1) Discontinuous aquifer

Actually concentration of extraction for a borehole is proceeding as mentioned above compare with rural water use. Therefore if the major part of the demand is expected for groundwater, it is anxious that draw down of groundwater level will be caused. For example, capacity of borehole in the discontinuous aquifer is about 0.036 – 0.073 MCM/y (yield of a borehole is 5 - 10 m^3/hr, under pumping of 20 hours per day) and this is equivalent to 36 – 76 mm/km^2 of groundwater potential. Therefore, it is required when the water demand exceed 0.1 MCM, each boreholes have to be scattered with enough distance more than 1 km.

(2) General aquifer

In case of Abidjan sub-basin, as a result of the simulation, limit groundwater exploitation was estimated to 4.0 – 4.2 m^3/s, 138Mm^3/year at year 2010, on the contrary water demand of year 2015 is estimated as about 242 MCM. However estimated limit groundwater exploitation seems not enough safety considering relation between groundwater fluctuation observed on some boreholes and estimated water exploitation shown as Figure 3.3-1 and 3.3-2, i.e. tendency of draw down of groundwater level seems to be continued. Therefore, the study for alternative water resources and monitoring of groundwater level and quality should be urgently required.

3.3.2 Rural water use

Rural water demands are 35 MCM on discontinuous aquifer area and 1 MCM on the general aquifer area and these correspond to 0.10 mm and 0.11 mm. These are entirely small compare with groundwater potential (92 mm and 334 mm). If unit consumption is increased from 20 litter/day to 25 or 30 litter /day, average groundwater extraction will be less than 4000 m^3/year (equivalent to 4 mm/y/km^2) with manual pump. So it is small amount compare with low groundwater potential area, because boreholes will be scattered with enough distance each other more than 1 km.

3.3.3 Agricultural water use

Agricultural water demand is 310 MCM on the discontinuous aquifer area and 28 MCM on the general aquifer, and these correspond to 0.92 mm and 3.3 mm. These are entirely small compare with groundwater potential. Total amount of annual agricultural water demand is increased from about 95 MCM on 1995 to 366 MCM on 2015, but unit consumption keeps same volume (1870m^3/ha at average year for whole country) from 1995. Therefore, if wells are not concentrated and unit discharge per well keeps small amount like as rural water use, agricultural water use will be entirely within the limit of groundwater potential.

CHAPTER 4 HYDROGEOLOGICAL DATA NETWORK MANAGEMENT

4.1 Necessity and Objective of Hydrogeological Network Management

4.1.1 Problems for groundwater resources management

(1) Aquifer management and protection for Abidjan area

Most important issue for groundwater resources management of the country is management and protection of general aquifer for resources of domestic water supply of Abidjan city. Related agency such as MIE, SODECI and BENETD conducted the study to find out suitable management plan. After this MIE has been requesting a study of reinforcement of domestic water supply for Abidjan city to BAD having objective to solve this problem.

(2) Monitoring of groundwater level and quality for provincial urban area

On some borehole for urban domestic water supply of provincial cities and town mainly located on discontinuous aquifer area have problems of decrease of extraction from aquifer caused by continuous draw down of water level by over pumping. This is basically caused by small capacity of discontinuous aquifer but also by concentration of boreholes. Therefore monitoring for groundwater level is required.

(3) Basic data collection of long term groundwater fluctuation in whole country

It is necessary to accumulate long term data collection of groundwater level fluctuation required to analyze relationship between rainfall , groundwater and runoff of rivers and to monitor future change of groundwater resources.

4.1.2 Actual situation and necessity preparation of hydrogeological data observation and network management system

(1) Abidjan area

There are 153 observation boreholes around Abidjan city and surrounding area to monitor groundwater level (water head) fluctuation. Water level of some of these wells have been measured almost once a month manual method by SODECI.

(2) Provincial urban area

Water quality of some boreholes for urban supply have been analyzed by SODECI periodically. There are no observation boreholes to measure water level on the discontinuous aquifer area at the moment.

(3) Long term data accumulation of groundwater level

About 17,000 boreholes are constructed in the country. Except Abidjan area water level and quality are only measured on pumping test conducted at final stage of borehole construction and any continuous measurement of water level have not been conducted.

4.2 Required Observation System

4.2.1 Groundwater level

To solve above mentioned problems preparation of following observation system will be required (refer to Table 4.2-1).

(1) Abidjan area

Considering recommendation mentioned on the report of "Aquifer protection program study", it is required to inspect actual condition of boreholes and to construct newly or to repair according to there situation. A variety of observation boreholes are as follows;

(a) 16 boreholes (each one borehole for one pumping station, including planning ones) for daily observation installing recording gauge. Within them 8 observation points is required to newly construct boreholes additionally.

(b) About 40 boreholes for monthly base by manual. Some of these points is required to repair.

(c) About 100 boreholes for twice a year measurement by manual. Some of these points is required to repair.

(2) Provincial urban area

It is necessary to introduce water level measurement about at 10 cities and towns firstly in which functional disorder of boreholes are anxious caused by continuous draw down of natural groundwater level. It is required to construct observation boreholes newly and it is better to install recording gauge for measurement.

(3) Long term data accumulation of groundwater level

It is required to make observation network covering whole country and every hydrogeological type. Therefore construction of new boreholes are required and it is desirable to install recording gauge for measurement. Firstly at least a borehole for each region, total 16 boreholes are desirable.

4.2.2 Groundwater quality

(3) Abidjan area

Considering recommendation mentioned on the report of "Aquifer protection program study" it is required to monitor following matters;

(a) Periodical measurement

To measure Salinity (Cl), Nitrate, Conductivity for all exploiting borehole Measurements are 6 time per year, Number of boreholes are total 72 for the moment and about 120 in future.

(b) Conductivity profile measurement

To measure vertical conductivity distribution for boreholes using EC meter, about 27 observation points should be selected locating close to center of existing and planned pumping stations, using old abandoned and newly constructed boreholes. Measurements are 3 time per year.

(c) Conductivity measurement for lagoons

Ten (10) measurement point located on the north shore of the lagoon Ebrie and close to pumping station and each one on the lagoon Aghien and Potou. Measurement are 3 time per year at high tide.

(d) Quality for River Me' etc.

Monthly analysis for following items at river Djibi, Bet's, Me and mouth of lagoon Aghien; Bacteriological analysis, Physico-chemical analysis for turbidity, pH, conductivity, chlorine, temperature, NO3, NO2, NH4, Cl, So4, DO, bicarbonates, Na

(4) Provincial urban area

It is required to continue actual periodical analysis conducting by SODECI. The items are; Bacteriological analysis, Physico-chemical analysis for turbidity, pH, conductivity, chloride, temperature, NH4, Na, K, Ca, Mg, Fe, Mn, Zn, Cu, Al, Cl, NO2, NO3,HCO3, CO3, SO4, PO4, F, DO, bicarbonates, Sio3.

(5) Long term data accumulation of groundwater level

It is required to continue analysis for water taken with pumping test performed at well construction stage. The items are; Physico-chemical analysis for turbidity, pH, conductivity, chloride, temperature, NH4, Fe, Mn, Ca, Cl, NO2, NO3, SO4, PO4, F, DO, bicarbonates. Periodical checking of following main items is required ;Conductivity, temperature, and pH.

4.3 Data Processing and Management

4.3.1 Borehole inventory

Records for boreholes and dug wells implemented by rural water supply projects are arranged as well inventory by the Water department of MIE. This inventory is composed of following items as: well location, well depth, well condition, lithological type and pumping test, etc It is required to update these data and to install into GIS system supplementing distribution information like as XY cord or longitude and latitude. And also, it is necessary to manage comprehensively every borehole data including implemented by urban water supply projects.

4.3.2 Groundwater level

(1) Abidjan area

Measured data should be comprehensively processed to make hydrograph of each observation points relating with rainfall, water quality and groundwater exploitation and to make groundwater level/head and conductivity contour line map.

(2) Provincial urban area

It is required to process observed data to monitor water level fluctuation relating with rainfall and groundwater discharge.

(3) Long term data accumulation of groundwater level

The data measured by recording gauge are processed to hydrograph together with rainfall data and water quality. Then after accumulate long term, relation ship between groundwater level fluctuation and rainfall, and groundwater recharge mechanism will be analyzed.

4.3.3 Groundwater quality

It is necessary to process analyzed data to monitor change of quality relating with water level/head fluctuation and groundwater discharge. Especially, in case of Abidjan city, change of chlorine or conductivity should be processed to relating with water level fluctuation and exploitation of boreholes to monitor salty water intrusion into aquifer.

4.3.4 Groundwater exploitation

Groundwater exploitation observed by SODECI should be processed relating with fluctuation of water level and quality.

4.4 Monitoring and Evaluation System

4.4.1 Abidjan area

(1) Improvement of groundwater balance simulation model.

Processed data will be install into the groundwater balance simulation model built by "The study for groundwater management and protection of aquifer supplying domestic water of Abidjan city" to improve the model putting into sea water intrusion phenomena

(2) Simulation

Future fluctuation of water level and water quality will be forecasted using improved model and processed data under some case of forecasting of water demand.

(3) Monitoring

Groundwater level and quality especially salty water intrusion into aquifers will be monitored watching tendency of water level draw down and increasing of conductivity.

(4) Evaluation and improvement of the Model

According to result of monitoring, to improve the simulation model and to estimate limit groundwater exploitation.

4.4.2 Provincial urban area

Water level fluctuation and quality will be monitored watching processed data, then to consult proper management program for pumping of boreholes and recommend reinforcement program if necessary.

4.4.3 Long term data accumulation of groundwater level

At first data accumulation and comprehensive analysis to whole country should be conducted. Then, impact of recent rainfall decreasing tendency to long term groundwater level draw down will be monitored. These result will be useful not only to estimate change of groundwater resources but also change of river run off .

Table 4.2-1 Required observation system

Item		Interval	Country level	Urban water		Long term QWL data	Remarkes
				Abidjan area	Provincial urban		
Borehole inventory			18190	72	318	17800	year 1999
Groundwater exploitation			506	72	318	116	
Observation borehole							
	New construction			10	10	16	
	Rehabilitation			50	0	0	
	Sub-total			60	10	16	
Groundwater level							
	Recording gauge			16	10	10	
	Pumping station	1/month		40	0	0	
	Whole basin	2/year		100	0	0	
	Sub-total			156	10	10	
Water quality							
	Conductivity profile	1/month		120			
	Periodical measurement	3/year		27			
	Lagoon conductivity	3/year		10			
	River water quality	1/month		4			
	Full item SODECI	1/year			220		

	Main item rural water supply	1/year				16	

4.5 Cost estimation of measurement and monitoring equipment

Cost of equipment, observation boreholes and technical assistance are estimated as follows(refer to Table 4.5-1).

Cost of equipment	¥41,000,000
Observation borehole	¥51,000,000
Technical assistance	¥10.000,000
Total	¥102,000,000

CHAPTER 5 RECOMMENDATIONS

(1) Urgent countermeasure for groundwater basin management and alternative water resources development for water supply of Abidjan area

A study has been required to BAD to solve mentioned theme. Taking notice to progress of the study recommend following issues.

(A) Groundwater management

The water supply authorities are considering to enforce water supply of Abidjan and it's peripheral area therefore firstly extend of pumping stations are urgently required. But draw down of groundwater level with increase of groundwater will approach to limit, therefore measurement and monitoring of groundwater level and quality should be immediately referring proposed plan by the JICA study on the Chapter 19.

(B) Alternative water resources development program

Future water demand of Abidjan area at 2015 will be huge amount according to estimation of the study to 242 MCM and which will exceed limit groundwater discharge 320 MCM of the basin therefore it is urgently required to make short term and long term countermeasure to find out alternative water resources development program including development of lagoon Aghien and another future development programs suggested by the JICA study.

(2) Enforcement program for water supply of provincial urban area

Future water demand of provincial urban area in 2015 is estimated to increase too much by the JICA study moreover major part of the demand is expected for groundwater and these large majority of these provincial urban areas are located discontinuous aquifer area. Considering low capacity of the aquifer and especially low groundwater potential in arid zone it is difficult to expect excessively to groundwater. Therefore, in such case comprehensive enforcement program for water supply including surface water development should be considered.

(3) Comprehensive groundwater data net work management

(A) Establishment of a agency to manage data comprehensively

It is required to establish a agency to manage measured data comprehensively by concerning organizations. The agency should manage database for borehole, water level fluctuation, water quality change and GIS.

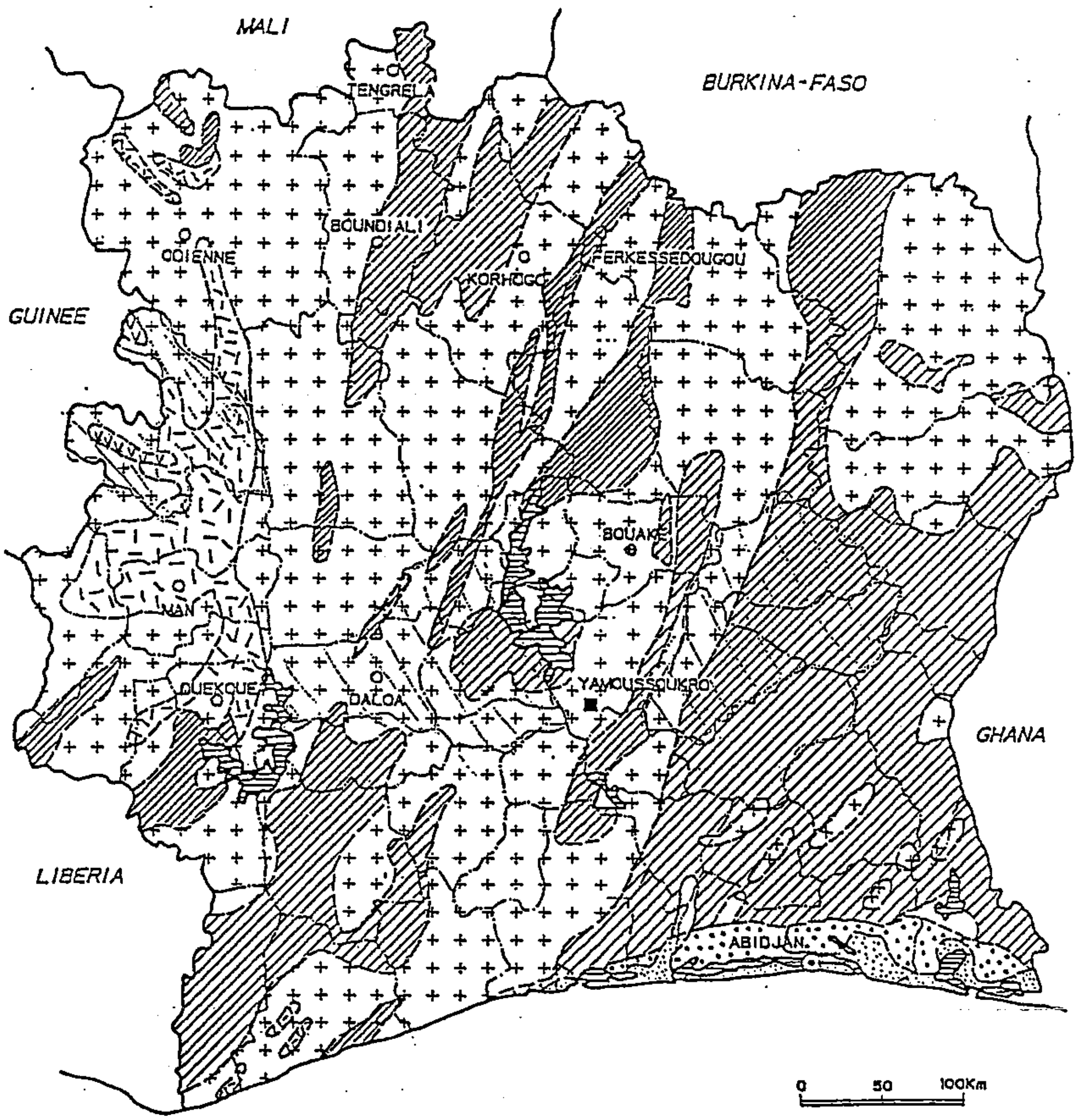
(B) Accumulation of data to the agency

To accumulate data from measuring organizations to the agency, it is required to establish some conference of concerning and measurement organization. The agency should prepare format, software, standard and manual for measurement and data processing. Finally the agency should indicate guideline of monitoring developing computer simulation model.

Figure 1.1-1 Contour Line Map of Cote d'Ivoire

Quoted from Jeune Les Atlas Afrique, Cote d'Ivoire 1983

Figure 1.2-1 Geological Map of Cote d'Ivoire



Quaternary Alluvium	Dolerite, Gabbro, Basalt (Upper Precambrian)
Cretaceous – Tertiary (Continental terminal)	Granite, Migmatite (Middle Precambrian)
	Shale, Quartzite, Arkose, etc (Middle Precambrian)
	Gniss, Granite, Amphibolite (Lower Precambrian)

Quoted from Carte geologique de la Cote d'Ivoire 1965 and simplified by JICA Preparatory Study 1999

Figure 1.3-4 Geological Profile of Abidjan Groundwater Basin(N-S)

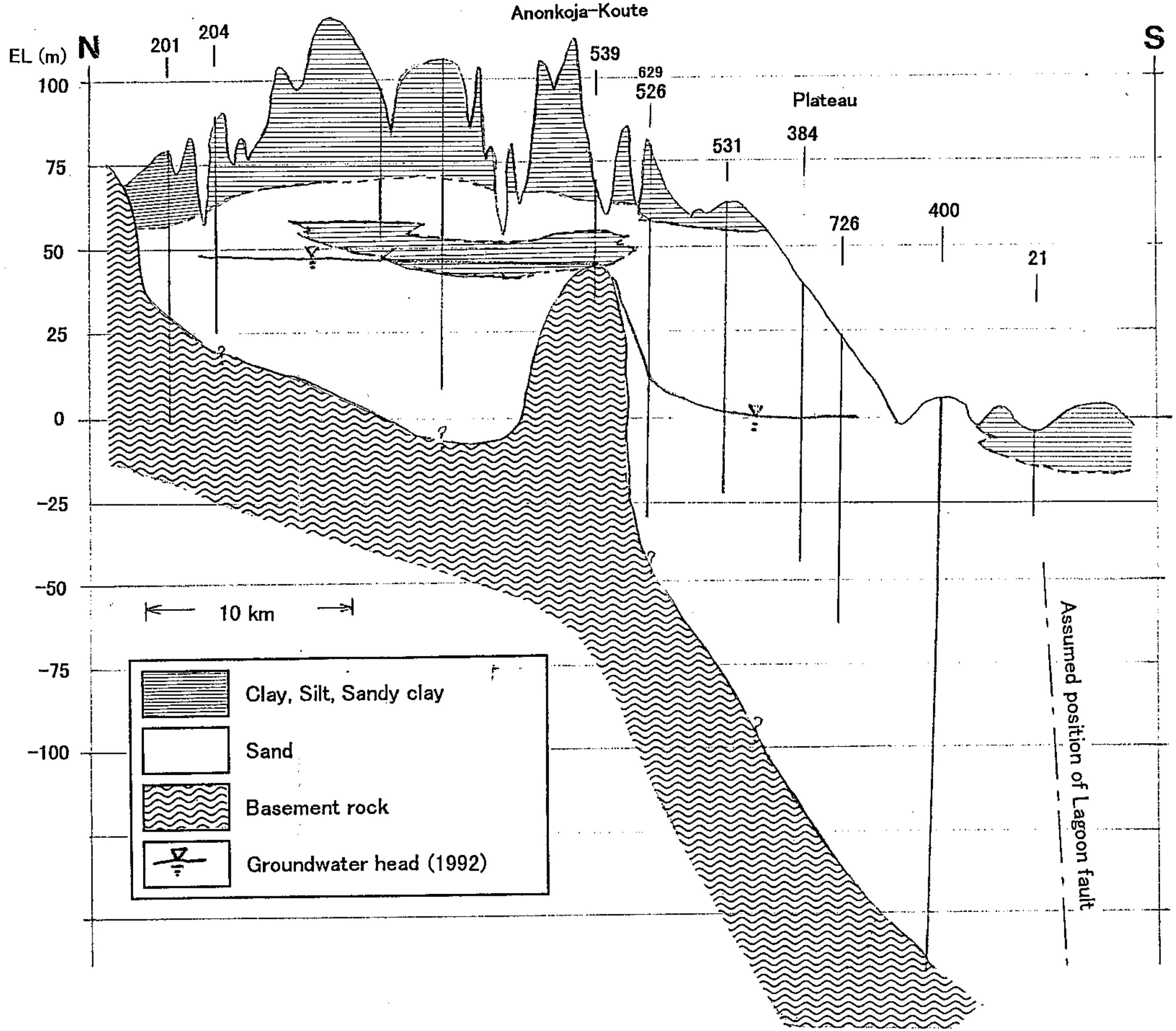
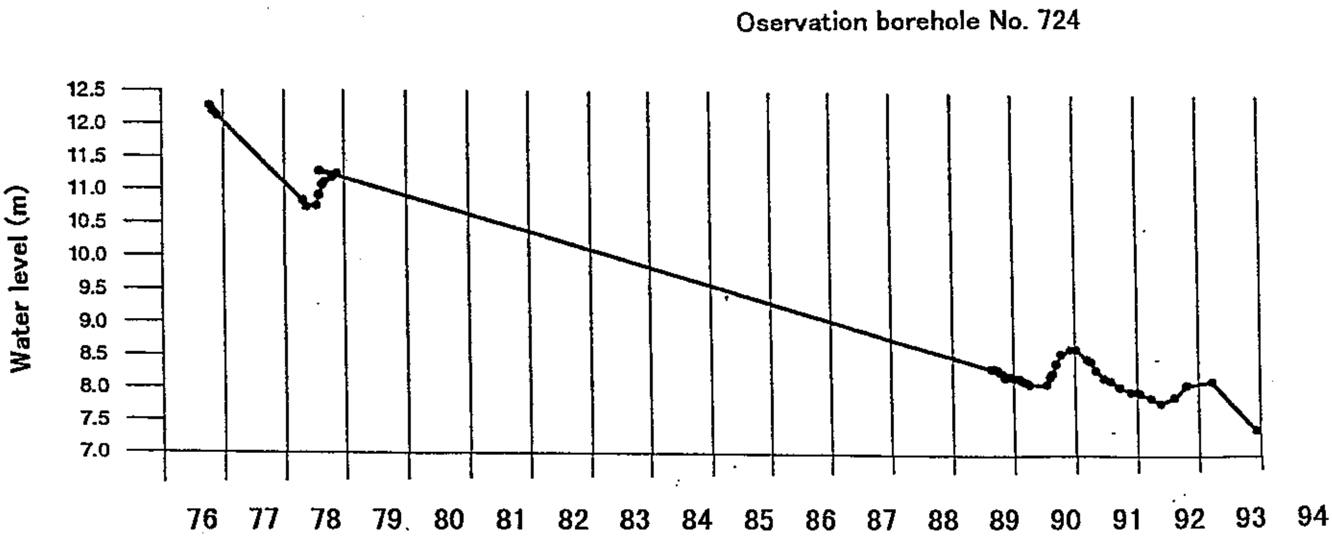


Table 1.3-5 Groundwater level flractuation of Abidjan



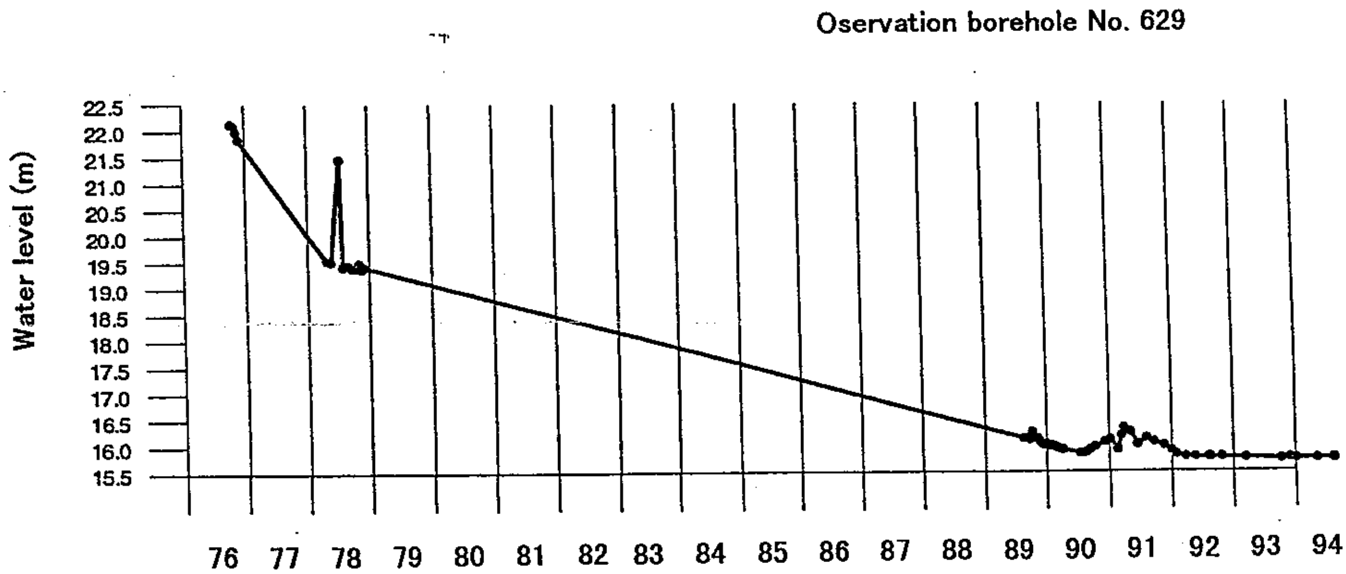
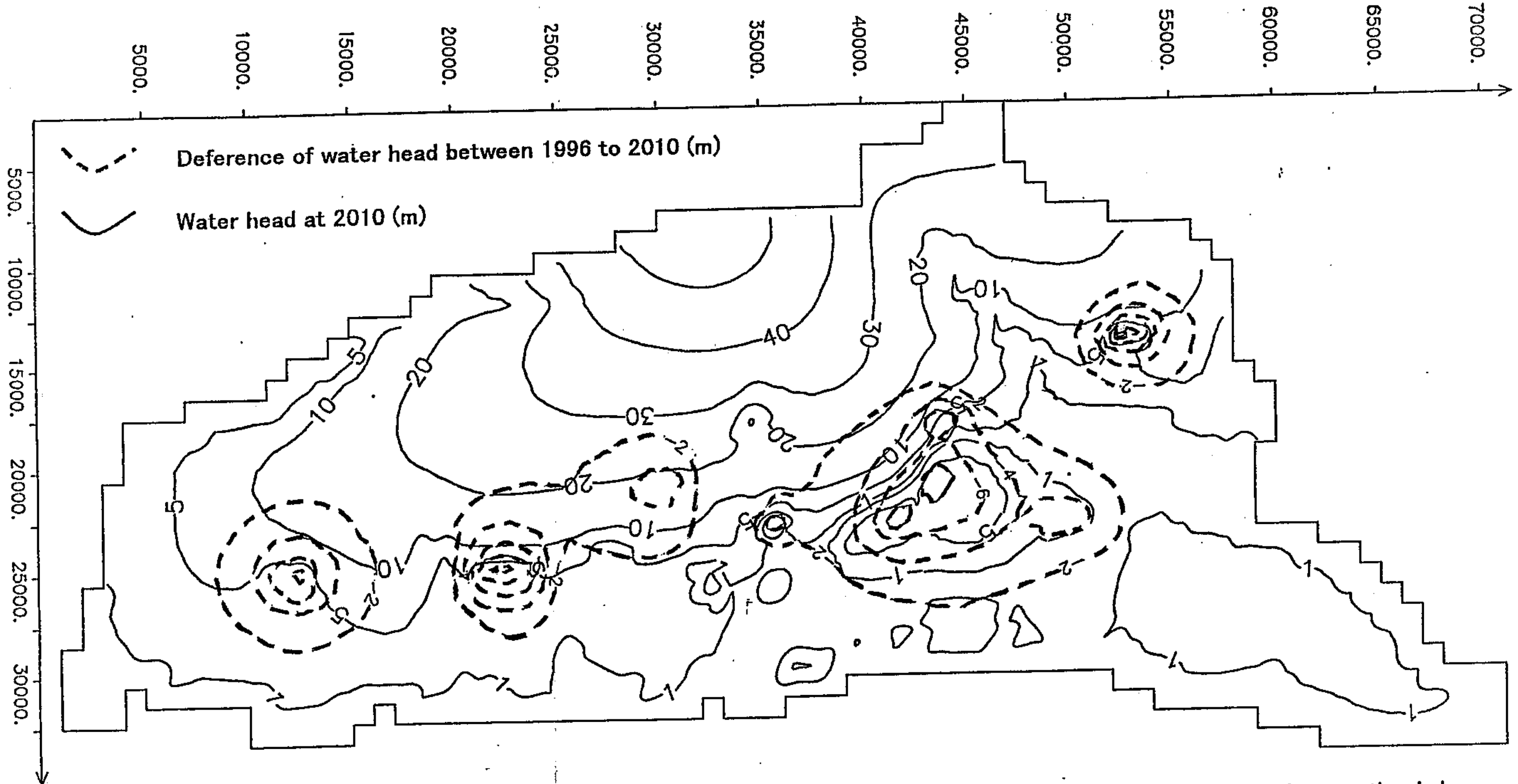


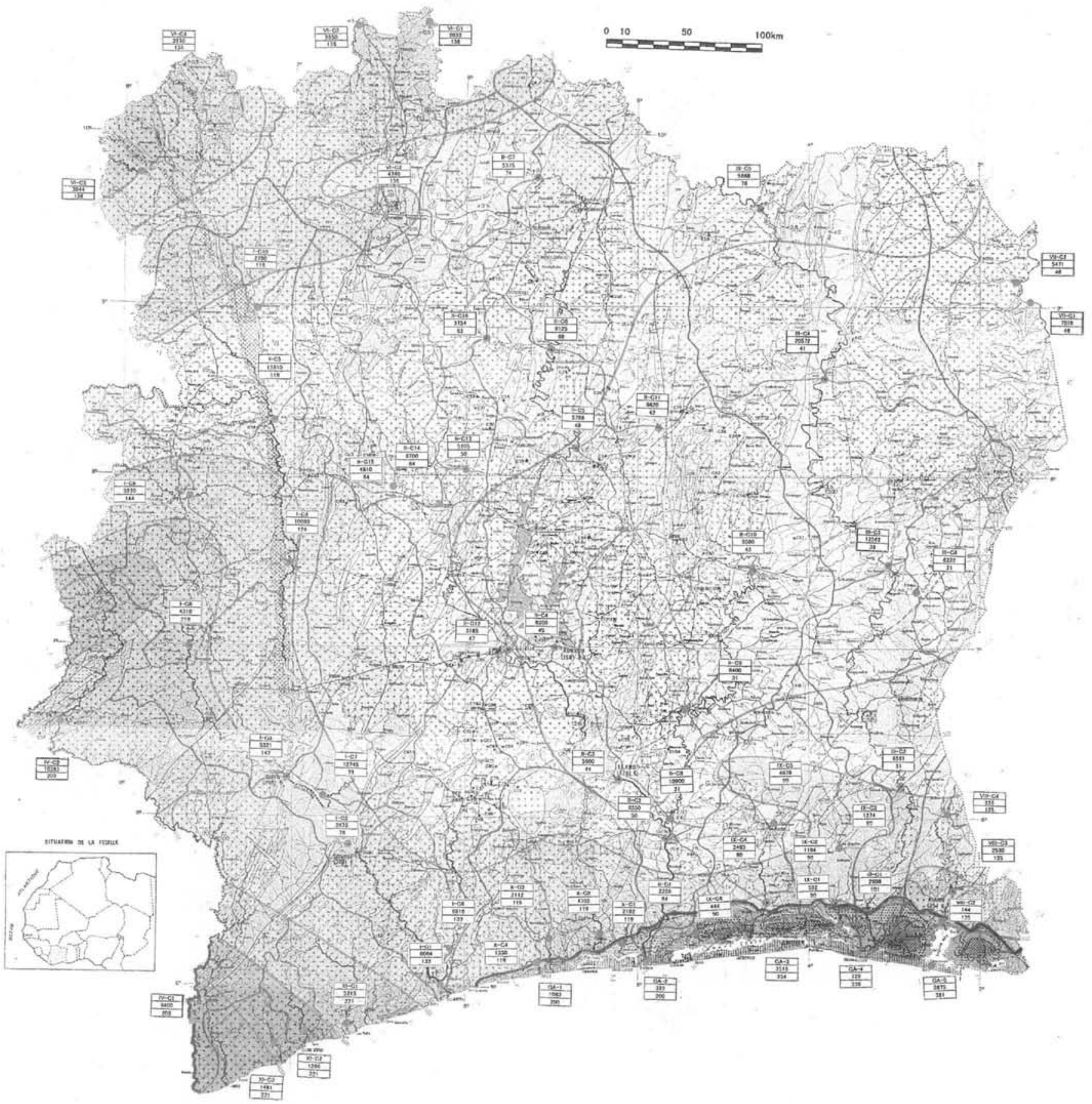
Figure 1.3-6 Estimated Water Table at 2010



Quoted from Final report of "Etude de la gestion et de la protection de la nappe assurant l'alimentation en eau potable d'Abidjan" (by BNETD & MIE/DH 1997)

Figure 2.3-1 Renewable Groundwater Ootential

Modefied from the "Carte planification des ressources en eau de Cote d'Ivoire" 1987



Renewable Aquifer Resources

Renewable groundwater resources corresponds with a fraction ob effective rainfall of concerning zone

1/4 for shale and slate
1/3 for granites gneiss and migmatite
1/2 for sand and sandstone non metamorphosed

Rank	Average unit potential (mm)	
I	400	more than 400 mm or 400,000 m^3/km^2 per year
II	300	between 300 and 400 mm or 300,000 and 400,000 m^3/km^2 per year
III	200	between 200 and 300 mm or 200,000 and 300,000 m^3/km^2 per year
IV	150	between 150 and 200 mm or 150,000 and 200,000 m^3/km^2 per year
V	100	between 100 and 150 mm or 100,000 and 150,000 m^3/km^2 per year
VI	50	between 50 and 100 mm or 50,000 and 100,000 m^3/km^2 per year
VII	25	less than 50 mm or 50,000 m^3/km^2 per year

500 isoeffective rainfall line (annual average mm)

Renewable Groundwater of Unit Basin

Unit Basin	Lower Bandama
Area (km^2)	2346
Goundwater Potential (mm)	84

River basin

General aquifer groundwater basin

Table 1.3-2 Characteristics of borehole for each prefecture

PREFECTURE	Number of boreho		Depth(m)		Depth to	Static water level (m		Well yield (m^3/hr)	
	Whole	GA*	Whole	GA	fresh rock	Whole	GA	Whole	GA
ABENGOUROU	196		67.54		35.47	13.66		3.26	
ABIDJAN	437	260	56.00	51.70	26.98	20.44	23.70	7.81	16.30
ABOISSO	290	188	59.17	59.20	23.53	21.34	27.20	4.36	6.00
ADZOPE	139		60.18			11.82		3.77	
AGBOVILLE	201		58.43		21.47	10.78		3.96	
AGNIBILEKROU	100		67.57		38.02	19.11		5.49	
BANGOLO	133		53.36		18.89	8.22		4.33	
BEOUMI	195		59.73		15.62	8.97		1.82	
BIANKOUMA	149		52.61		17.35	12.16		5.01	
BOCANDA	225		61.42		21.66	21.26		2.97	
BONDOUKOU	330		57.16		21.84	11.82		2.58	
BONGOUANOU	258		61.00		20.59	16.79		3.97	
BOUAFLE	365		59.36		23.30	14.12		3.88	
BOUAKE	335		62.51		17.85	10.28		1.90	
BOUNA	370		65.75		22.97	7.10		2.92	
BOUNDIALI	209		47.96		34.13	9.11		3.31	
DABAKALA	367		71.05		15.11	11.01		1.56	
DABOU	102	80	55.98	53.70	25.39	18.39	18.80	13.56	14.10
DALOA	96		60.41		21.58	12.13		2.47	
DANANE	463		54.88		18.58	9.71		5.08	
DAOUKRO	246		67.43		36.02	26.75		3.10	
DIMBOKRO	129		61.17		21.07	17.55		3.00	
DIVO	283		55.68		19.86	11.30		4.14	
DUEKOUE	23		48.98		19.63	7.59		2.00	
FERKESSEDOUG	358		54.01		24.92	11.88		2.11	
GAGNOA	129		71.43		31.89	14.08		2.90	
GRAND LAHOU	69	26	54.32	54.20	31.89	23.52	32.90	11.95	13.70
GUIGLO	140		55.42		20.74	8.48		5.18	
ISSIA	118		70.89		36.30	14.22		2.64	
JACQUEVILLE	76	75	20.17	20.30		6.99	7.00	3.00	3.00
KATIOLA	104		57.10		22.05	13.17		2.82	
KORHOGO	719		52.36		28.08	9.34		2.27	
LAKOTA	34		67.20		24.82	13.36		1.68	
MAN	404		50.80		17.46	8.95		4.86	
MANKONO	391		55.27		20.77	13.10		1.73	
M'BAHIAKRO	230		65.57		20.23	29.47		2.34	
ODIENNE	333		49.13		25.17	9.33		2.78	
OUME	152		54.79		23.30	13.78		4.65	
SAKASSOU	135		67.70		19.43	10.03		2.94	
SAN PEDRO	115		54.40		34.19	7.38		3.41	
SASSANDRA	118		56.57		15.03	8.10		4.55	
SEGUELA	299		51.52		18.01	9.80		2.25	
SINFRA	255		58.54		27.37	13.59		3.05	
SOUBRE	247		61.55		27.72	8.33		3.93	
TABOU	147		46.33		16.71	7.31		3.49	
TANDA	509		63.64		33.15	16.64		2.58	
TENGRELA	64		43.96		29.72	5.83		3.19	
TIASSALE	171		55.91		15.66	14.70		5.74	
TIEBISSOU	218		67.44		22.18	12.02		2.81	
TOUBA	261		56.72		23.75	9.90		4.50	
TOUMODI	206		59.36		18.34	10.35		3.57	
VAVOUA	190		68.20		17.15	13.93		2.99	
YAMOUSSOUKRO	593		65.87		15.30	11.27		1.52	
ZUENOULA	200		62.99		24.96	12.04		3.25	
Total/Average	12626	629	58.71	50.56	22.72	12.80	22.51	3.45	11.25

* GA : General Aquifer

Table 1.3-3 Characteristics of dug well for each prefecture

Prefecture	Number of dug well	Rate of DW (%)	Depth (m)	Static water level (m)	Well yield (m^3/hr)
ABENGOUROU	29	0.13	13.1	6.8	0.7
ABIDJAN	40	0.08	9.0	5.5	0.8
ABOISSO	15	0.05	6.1	3.0	
ADZOPE	68	0.33	13.7	15.3	0.8
AGBOVILLE	72	0.26	11.5	8.2	3.0
AGNIBILEKROU	7	0.07	10.0	5.1	3.1
BANGOLO	4	0.03	7.3		
BEOUMI	65	0.25	15.9	8.7	1.4
BIANKOUMA	7	0.04	12.7		
BOCANDA	5	0.02	27.0	6.8	
BONDOUKOU	105	0.24	18.5	9.8	0.7
BONGOUANOU	42	0.14	10.0	5.4	2.1
BOUAFLE	57	0.14	14.9	11.7	1.1
BOUAKE	47	0.12	16.5	11.2	1.3
BOUNA	74	0.17	16.9	8.9	0.7
BOUNDIALI	85	0.29	17.2	7.4	1.2
DABAKALA	49	0.12	15.3	8.7	1.1
DABOU	32	0.24	9.3	8.4	7.0
DALOA	177	0.65	21.3	16.2	2.7
DANANE	17	0.04	10.3	8.9	1.7
DAOUKRO	3	0.01			
DIMBOKRO	4	0.03	12.7		
DIVO	88	0.24	19.2	10.4	1.5
DUEKOUE	64	0.74	17.7	10.1	2.1
FERKESSEDOUG	109	0.23	16.9	8.4	0.8
GAGNOA	368	0.74	22.9	14.5	1.3
GUIGLO	135	0.49	20.0	9.7	3.9
ISSIA	190	0.62	24.2	14.9	1.6
JACQUEVILLE	11	0.13	4.4	3.4	
KATIOLA	66	0.39	16.7	10.0	0.9
KORHOGO	671	0.48	18.7	8.6	1.1
LAKOTA	218	0.87	21.0	12.3	1.8
MAN	16	0.04	16.1	13.5	1.1
MANKONO	73	0.16	19.1	10.1	1.5
M'BAHIAKRO	8	0.03	10.8	8.2	1.2
ODIENNE	255	0.43	18.2	8.8	1.3
OUME	112	0.42	21.5	12.9	1.0
SAKASSOU	27	0.17	15.6		
SAN PEDRO	19	0.14	12.7	3.7	1.6
SASSANDRA	58	0.33	19.7	11.7	0.9
SEGUELA	91	0.23	17.2	8.3	1.3
SINFRA	14	0.05	24.0	6.1	0.9
SOUBRE	100	0.29	22.2	12.4	1.4
TABOU	13	0.08	10.6	2.0	1.0
TANDA	43	0.08	17.2	10.3	1.1
TENGRELA	72	0.53	15.3	5.7	1.0
TIASSALE	2	0.01	4.0		
TIEBISSOU	55	0.20	15.2	7.5	1.0
TOUBA	68	0.21	19.6	12.6	1.1
TOUMODI	39	0.16	14.0	6.6	0.9
VAVOUA	19	0.09	16.5	9.1	0.7
YAMOUSSOUKRO	48	0.07	16.4	9.8	1.4
ZUENOULA	38	0.16	18.9	10.7	5.8
Total/Average	4094	0.24	18.46	10.33	1.49

Table 1.3-4 Nature of Borehole & Modern Dug well for Sub Prefecture

Department	Sub Prefecture	Number of water Sources	Average Prof.. (m)	Static Water Level (m)	Yield by Air Lift (m^3/hr)	Yield by Pumping Test (m^3/hr)
ABENGOUROU	ABENGOUROU	162	63.79	14.19	4.90	3.28
	BETTIE	31	59.43	14.47	7.55	2.95
	NIABLE	33	64.09	8.04	5.49	2.60
	Total	226	63.24	13.33	5.35	3.13
ABIDJAN	ABIDJAN	44	47.17	16.51	7.25	10.43
	ALEPE	86	54.76	14.96	4.16	5.51
	ANYAMA	90	69.11	24.01	4.29	10.40
	BINGERVILLE	41	48.85	18.52	12.67	32.50
	BONOUA	51	72.70	48.10	10.53	5.53
	GRAND BASSAM	12	29.39	3.67	58.50	30.30
	SIKENSI	49	51.87	8.38	3.83	3.42
	SONGON	110	43.16	12.18	11.30	16.54
	Total	483	54.57	19.01	8.81	11.72
ABOISSO	ABOISSO	79	73.51	29.88	7.14	3.00
	ADIAKE	62	66.32	31.66	14.56	7.58
	AYAME	58	54.98	7.59	3.40	1.06
	MAFERE	52	59.57	16.44	7.15	5.13
	TIAPOUM	63	42.88	13.56	20.21	8.40
	Total	314	60.21	23.78	10.54	4.98
ADZOPE	ADZOPE	70	46.25	11.68	2.92	2.62
	AFFERY	14	49.34	14.86	5.52	8.05
	AGOU	45	57.54	13.42	6.38	3.29
	AKOUPE	50	51.52	7.62	2.67	2.94
	YAKASSE-ATTOBRO	29	57.32	16.16	3.14	3.96
	Total	208	51.71	11.92	3.81	3.39
AGBOVILLE	AGBOVILLE	204	49.34	10.25	3.87	3.97
	AZAGUIE	25	50.94	7.09	8.91	15.80
	RUBINO	47	58.40	11.14	2.30	3.04
	Total	276	51.03	10.12	4.06	4.89
AGNIBILEKROU	AGNIBILEKROU	109	66.03	18.96	6.67	5.37
	Total	109	66.03	18.96	6.67	5.37
BANGOLO	BANGOLO	138	53.30	8.22	5.40	4.33
	Total	138	53.30	8.22	5.40	4.33
	BEOUMI	159	56.08	8.20	3.27	1.87
	BODOKRO	103	49.88	9.89	2.91	1.71
	Total	262	53.64	8.86	3.13	1.81
BIANKOUMA	BIANKOUMA	112	54.12	11.42	5.77	5.36
	GBONNE	17	51.65	10.46	2.71	7.11
	SIPILOU	45	55.34	15.13	3.20	2.92
		174	54.19	12.29	4.81	4.90
BOCANDA	BOCANDA	225	62.73	23.33	3.75	3.22
	KOUASSI-KOUASSI	47	63.63	11.64	2.40	1.76
	Total	272	62.89	21.31	3.52	2.96
BONDOUKOU	BONDOUKOU	346	46.86	11.57	3.05	2.14
	SANDEGUE	89	57.48	10.53	2.45	2.40
	Total	435	49.03	11.36	2.92	2.19
BONGOUANOU	ARRAH	65	61.59	9.81	6.57	4.75
	BONGOUANOU	149	61.93	16.34	6.51	4.57
	M'BATTO	95	55.61	18.90	4.37	2.83
	TIEMELEKRO	72	53.71	19.25	3.97	3.15
	Total	381	58.74	16.41	5.51	3.90
BOUAFLE	BONON	117	56.14	16.91	4.33	4.14

Department	Sub Prefecture	Number of water Sources	Average Prof.. (m)	Static Water Level (m)	Yield by Air Lift (m^3/hr)	Yield by Pumping Test (m^3/hr)
	BOUAFLE	305	54.42	12.01	4.35	3.31
	Total	422	54.90	13.36	4.34	3.54
BOUAKE	BOTRO	64	61.15	11.78	2.97	2.17
	BOUAKE	161	53.99	10.81	2.39	1.65
	BROBO	63	62.98	9.33	3.49	2.48
	DIABO	82	62.76	10.17	2.59	2.01
	DJEBONOUA	57	61.02	9.49	2.07	1.71
	Total	427	59.01	10.44	2.64	1.93
BOUNA	BOUNA	224	57.81	8.10	4.73	2.51
	DOROPO	76	54.65	5.66	5.37	2.82
	NASSIAN	69	71.00	7.70	3.37	1.81
	TEHINI	80	56.54	6.40	4.70	4.20
	Total	449	59.08	7.32	4.62	2.76
BOUNDIALI	BOUNDIALI	115	37.74	9.52	2.89	2.60
	GBON	25	38.61	8.81	1.53	3.28
	KASSERE	62	51.01	9.88	4.12	2.97
	KOLIA	48	36.67	6.68	3.03	2.07
	KOUTO	55	41.44	7.08	4.14	3.25
	Total	305	41.01	8.65	3.28	2.76
DABAKALA	BASSAWA	41	71.25	15.11	4.45	2.90
	BONIEREDOUGOU	71	49.52	8.63	1.88	1.26
	DABAKALA	208	69.03	11.52	1.75	1.42
	FOMBOLO	42	58.63	8.72	2.12	1.51
	SATAMA-SOKOURA	58	67.24	9.32	2.27	1.23
	Total	420	64.66	10.80	2.14	1.52
DABOU	DABOU	136	55.08	16.03	14.65	13.21
	Total	136	55.08	16.03	14.65	13.21
DALOA	BEDIALA	98	43.79	10.71	1.54	2.45
	DALOA	79	29.19	11.85	1.36	3.19
	GBOGUHE	49	27.98	16.19	1.04	2.48
	ZOUKOUGBEU	55	31.98	23.63	3.74	2.35
	Total	281	34.62	14.51	1.83	2.65
DANANE	BIN-HOUYE	60	59.56	10.74	6.51	3.78
	DANANE	280	53.50	9.96	5.24	4.78
	ZOUAN HOUNIEN	199	62.59	8.90	5.94	6.00
	Total	539	57.53	9.66	5.64	5.12
DAOUKRO	DAOUKRO	139	70.42	27.27	4.23	2.52
	ETTROKRO	59	67.02	26.24	4.93	3.98
	OUELLE	88	69.43	26.07	3.72	3.54
	Total	286	69.41	26.69	4.22	3.13
DIMBOKRO	DIMBOKRO	154	61.18	17.45	4.44	3.01
	Total	154	61.18	17.45	4.44	3.01
DIVO	DIVO	267	47.08	11.42	5.26	3.33
	FRESCO	40	59.52	14.75	4.02	3.60
	GUITRY	70	42.51	8.91	3.82	3.82
	HIRE	26	57.09	9.13	3.20	3.30
	Total	403	48.17	11.16	4.75	3.44
DUEKOUE	DUEKOUE	93	22.21	9.71	3.77	2.13
	Total	93	22.21	9.71	3.77	2.13
FERKESSEDOUG	DIAWALA	74	52.68	14.60	2.56	1.52
	FERKESSEDOUGOU	106	43.30	10.39	2.31	2.16
	KONG	113	50.11	12.48	2.80	2.34
	KOUMBALA	61	46.36	10.02	1.74	1.27

Department	Sub Prefecture	Number of water Sources	Average Prof.. (m)	Static Water Level (m)	Yield by Air Lift (m^3/hr)	Yield by Pumping Test (m^3/hr)
	NIELLE	75	42.76	8.74	2.81	1.80
	OUANGOLODOUGO	45	42.34	9.12	2.68	2.10
	Total	474	46.60	11.12	2.51	1.92
GAGNOA	GAGNOA	202	31.43	13.24	1.53	1.62
	GUIBEROUA	137	39.67	13.85	1.55	1.39
	OURAGAHIO	169	38.98	16.31	2.29	1.84
	Total	508	36.16	14.43	1.79	1.63
GRAND LAHOU	GRAND LAHOU	72	56.45	23.52	10.36	11.95
	Total	72	56.45	23.52	10.36	11.95
GUIGLO	BLOLEQUIN	83	58.01	8.61	4.20	4.27
	GUIGLO	73	32.53	8.29	3.21	4.52
	TAI	52	35.68	7.93	5.10	7.37
	TOULEPLEU	92	36.55	11.07	2.87	3.95
	Total	300	41.36	9.17	3.71	4.77
ISSIA	ISSIA	214	42.86	14.29	1.30	1.90
	SAIOUA	95	37.70	15.50	1.11	1.57
	Total	309	41.27	14.66	1.24	1.80
JACQUEVILLE	JACQUEVILLE	88	20.42	6.65	8.43	3.00
	Total	88	20.42	6.65	8.43	3.00
KATIOLA	FRONAN	30	49.27	10.17	3.54	2.06
	KATIOLA	65	45.53	12.29	2.68	2.66
	NIAKARAMANDOUG	59	47.51	13.52	2.80	2.25
	TAFIRE	20	19.73	10.74	1.12	0.89
	TORTIYA	12	42.49	10.36	2.94	2.24
	Total	186	51.75	14.70	3.07	2.81
KORHOGO	DIKODOUGOU	63	40.78	9.30	2.61	0.97
	GUIEMBE	37	34.27	11.50	2.47	1.25
	KARAKORO	130	37.16	6.87	2.03	1.65
	KOMBORODOUGOU	82	40.00	8.60	2.31	1.60
	KORHOGO	332	35.59	8.64	2.80	1.71
	M'BENGUE	132	47.21	10.29	3.88	3.04
	NAPIEOLEDOUGOU	158	32.44	9.42	1.77	1.75
	NIOFOIN	97	34.58	9.22	2.76	1.48
	SINEMATIALI	234	34.11	9.49	2.11	1.43
	SIRASSO	80	42.50	9.17	3.91	2.45
	TIORONIARADOUGO	62	32.10	7.89	2.32	1.03
	Total	1407	36.85	9.00	2.47	1.73
LAKOTA	LAKOTA	199	25.56	12.70	2.13	1.78
	ZIKISSO	56	34.94	11.34	1.10	1.97
	Total	255	27.62	12.40	1.90	4.14
MAN	FACOBLY	96	54.57	10.58	6.48	6.64
	KOUIBLY	87	45.77	10.17	7.29	4.61
	LOGOUALE	83	51.07	8.45	3.39	2.83
	MAN	118	51.19	7.65	6.80	5.41
	SANGOUINE	72	57.20	9.13	4.83	4.28
	Total	456	51.80	9.13	5.89	4.87
MANKONO	DIANRA	92	41.44	9.08	3.22	1.99
	KONGASSO	50	59.02	13.82	4.95	3.11
	KOUNAHIRI	57	48.11	13.29	2.49	1.20
	MANKONO	87	48.62	11.48	2.97	2.15
	SARHALA	42	59.25	13.30	1.66	1.27
	TIENINGBOUE	181	52.16	14.35	3.61	1.09
	Total	509	50.42	12.65	3.28	1.66

Department	Sub Prefecture	Number of water Sources	Average Prof.. (m)	Static Water Level (m)	Yield by Air Lift (m^3/hr)	Yield by Pumping Test (m^3/hr)
M'BAHIAKRO	M'BAHIAKRO	162	66.58	25.78	3.11	2.15
	PRIKRO	121	68.33	33.67	3.04	2.52
	Total	283	67.33	29.15	3.08	2.31
ODIENNE	BAKO	82	36.02	10.26	4.10	2.48
	DIOULATIEDOUGOU	38	46.62	11.73	4.31	3.02
	GOULIA	72	32.78	7.84	3.00	1.79
	KANIASSO	35	43.00	9.72	2.82	1.13
	MADINANI	76	35.46	7.86	3.32	2.09
	MINIGNAN	41	40.03	9.23	3.46	1.68
	ODIENNE	110	32.93	8.66	3.01	1.94
	SAMATIGUILA	12	26.43	9.94	2.78	3.60
	SEGUELON	53	38.86	8.41	3.67	2.03
	SEYDOUGOU	23	32.15	8.07	4.28	2.70
	TIEME	14	33.45	8.59	3.30	1.39
	TIENKO	49	37.93	9.24	4.70	2.56
	Total	605	36.35	9.00	3.54	2.12
OUME	DIEGONEFLA	113	33.01	12.19	1.46	3.27
	OUME	163	44.86	14.16	2.64	2.76
	Total	276	40.01	13.36	2.16	2.97
SAKASSOU	SAKASSOU	163	63.47	10.05	4.39	2.83
	Total	163	63.47	10.05	4.39	2.83
SAN PEDRO	GRAND BEREBY	43	45.26	6.86	2.57	3.34
	SAN PEDRO	93	55.89	7.32	3.14	3.21
	Total	136	52.53	7.18	2.96	3.25
SASSANDRA	GUEYO	64	25.41	11.44	2.23	0.90
	SASSANDRA	115	57.98	7.89	4.64	4.82
	Total	179	46.34	9.16	3.78	3.42
SEGUELA	DJIBROSSO	27	43.61	7.92	2.12	1.52
	DUALLA	29	49.65	8.02	3.29	3.30
	KANI	45	36.02	8.34	3.03	1.97
	MASSALA	56	51.24	11.34	2.12	2.28
	MORONDO	35	41.94	7.83	3.56	2.43
	SEGUELA	102	48.05	9.60	2.91	1.75
	SIFIE	62	43.24	10.40	2.12	1.81
	WOROFLA	66	39.70	9.66	2.04	1.77
	Total	422	44.50	9.46	2.60	2.00
SINFRA	SINFRA	272	56.31	13.64	3.59	2.92
	Total	272	56.31	13.64	3.59	2.92
SOUBRE	BUYO	66	57.97	8.80	3.88	5.31
	GRAND-ZATTRY	52	38.50	13.44	2.66	3.58
	MEAGUI	109	58.95	8.04	2.60	2.75
	SOUBRE	126	44.73	9.63	2.37	2.56
	Total	353	50.68	9.54	2.77	3.28
TABOU	GRABO	54	50.16	9.10	4.93	3.85
	TABOU	106	44.26	5.56	3.75	3.11
	Total	160	46.25	6.76	4.15	3.36
TANDA	ASSUEFRY	77	65.07	16.59	2.21	2.05
	KOUASSI-DATTEKR	78	66.45	15.98	1.89	3.65
	KOUN FAO	154	60.77	18.32	3.14	3.10
	TANDA	157	57.74	13.52	2.54	1.83
	TRANSUA	90	57.99	17.19	3.25	3.05
	Total	556	60.86	16.21	2.68	1.52
TENGRELA	KANAKONO	22	37.99	5.39	2.10	1.39

Department	Sub Prefecture	Number of water Sources	Average Prof.. (m)	Static Water Level (m)	Yield by Air Lift (m^3/hr)	Yield by Pumping Test (m^3/hr)
	TENGRELA	117	30.87	6.06	3.21	2.28
	Total	139	32.00	5.95	3.03	2.14
TIASSALE	TAABO	54	60.94	11.71	3.00	3.65
	TIASSALE	126	55.25	15.56	5.50	6.47
	Total	180	56.96	14.40	4.75	5.62
TIEBISSOU	TIEBISSOU	304	56.75	11.01	4.42	2.65
	Total	304	56.75	11.01	4.42	2.65
TOUBA	BOOKO	63	60.11	9.36	5.49	4.57
	BOROTOU	35	53.95	9.20	6.99	6.20
	GUINTEGUELA	19	43.07	10.64	4.98	4.84
	KOONAN	35	60.97	11.04	3.79	2.88
	KORO	31	44.94	7.30	6.64	4.52
	OUANINOU	75	40.72	11.60	3.30	2.48
	TOUBA	89	43.45	11.67	4.01	4.01
	Total	347	48.82	10.48	4.69	3.98
TOUMODI	KOKOUMBO	81	52.98	9.07	5.65	3.68
	TOUMODI	166	53.94	10.33	4.31	3.24
	Total	247	53.63	9.92	4.75	3.39
VAVOUA	VAVOUA	238	67.35	13.39	4.61	2.82
	Total	238	67.35	13.39	4.61	2.82
YAMOUSSOUKRO	DIDIEVI	193	65.70	9.90	3.30	1.51
	TIE-N'DIEKRO	83	65.99	11.41	3.43	1.76
	YAMOUSSOUKRO	400	55.19	12.77	17.30	1.18
	Total	676	59.52	11.78	11.60	1.34
ZUENOULA	GOHITAFLA	75	50.77	13.35	4.76	4.04
	ZUENOULA	164	59.24	11.32	2.58	3.35
	Total	239	56.58	11.96	3.27	3.57
		17532	50.67	12.41	4.25	3.40

Table 1.3-5 Production of groundwater and surface water (*1000 m^3/year)

Year	Abidjan		Bouake			Other city/town			Total		
	Groundwa	Surface w	G.W	S.W	SubTotal	G.W	S.W	Total	GW	SW	Total
1985	56,721	0	450	4,432	4,882	6,216	15,316	21,532	63,387	19,748	83,135
1986	58,760	0	261	4,589	4,850	6,014	16,204	22,218	65,035	20,793	85,828
1987	60,826	0	127	5,068	5,195	6,957	16,881	23,838	67,910	21,949	89,859
1988	63,776	0	190	5,151	5,341	7,475	17,967	25,442	71,441	23,118	94,559
1989	67,788	0	319	5,156	5,475	8,275	18,340	26,615	76,382	23,496	99,878
1990	67,544	0	37	5,412	5,449	8,554	18,077	26,631	76,135	23,489	99,624
1991	66,950	0	496	5,045	5,541	8,082	18,924	27,006	75,528	23,969	99,497
1992	70,275	0	711	4,639	5,350	8,757	18,410	27,167	79,743	23,049	102,792
1993	70,653	0	512	5,247	5,759	9,675	16,723	26,398	80,840	21,970	102,810
1994	73,243	0	514	5,445	5,959	8,597	18,118	26,715	82,354	23,563	105,917
1995	75,670	0	781	6,490	7,271	9,987	17,691	27,678	86,438	24,181	110,619
1996	81,269	0	130	6,823	6,953	10,736	19,189	29,925	92,135	26,012	118,147
1997	85,473	0	516	6,248	6,764	12,315	19,688	32,003	98,304	25,936	124,240
1998	93,178	0	364	7,192	7,556	12,036	22,484	34,520	105,578	29,676	135,254

Figure 1.3-1 Groundwater production of Abidjan

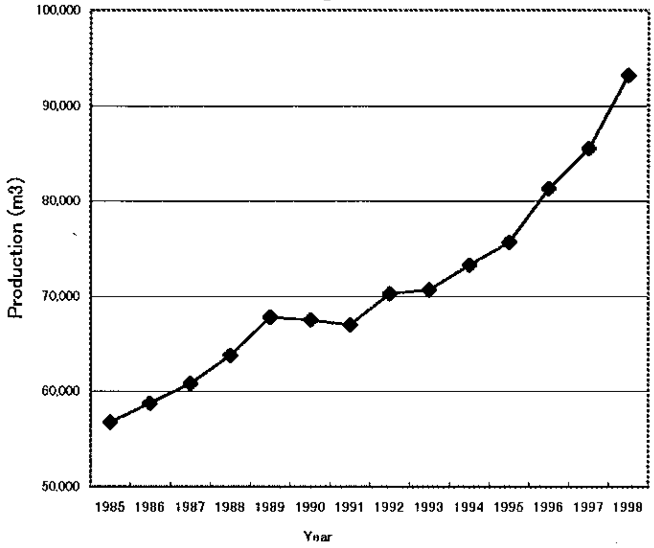


Table 1.3-6. Results of the evaluation of the rural water supply project at May 1999

Region	Department	Population 1999/5	Requitred water point	Realized water point			Situation of water points		Ruck of water points				Cover rate
				Borehole	Dug well	Total	Working	Abundunt	New	Additional	Replace	Total	%
AGNEBY	ADZOPE	139901	222	178	20	198	157	41	4	44	17	65	71
	AGBOVILLE	157517	340	180	21	201	168	32	114	47	11	172	49
	Sub-total	297418	562	358	41	399	325	73	118	91	28	237	58
BAS-SASSANDRA	SAN PEDRO	176798	413	168	19	187	174	13	115	110	14	239	42
	SASSANDRA	223361	402	159	45	204	187	17	48	152	15	215	47
	SOUBRE	248363	648	231	79	310	305	5	122	219	2	343	47
	TABOU	94372	217	169	11	180	165	15	9	36	7	52	76
	Sub-total	742894	1680	727	154	881	831	50	294	517	38	849	49
DENGUELE	ODIENNE	168405	496	315	265	580	372	208	75	21	28	124	75
	Sub-total	168405	496	315	265	580	372	208	75	21	28	124	75
DES LAGUNES	ABIDJAN	55181	111	106	0	106	75	31	9	23	4	36	68
	ALEPE	59680	64	54	2	56	38	18	1	20	5	26	59
	DABOU	54880	48	69	1	70	31	40	4	10	3	17	65
	JACQUEVILLE	26846	61	52	4	56	25	31	2	17	17	36	41
	TIASSALE	95870	308	229	4	233	195	38	67	32	14	113	63
	Sub-total	292457	592	510	11	521	364	158	83	102	43	228	61
HAUT SASSANDRA	DALOA	249730	691	265	215	480	321	160	169	77	124	370	46
	GAGNOA	497085	623	122	355	477	359	118	70	118	76	264	58
	ISSIA	274880	787	113	177	290	103	187	323	173	188	684	13
	VAVOUA	226224	501	239	8	247	225	22	112	144	20	276	45
	Sub-total	1247919	2602	739	755	1494	1008	487	674	512	408	1594	39
LACS	TIEBISSOU	84427	208	256	39	295	123	172	9	15	61	85	59
	TOUMODI	85940	207	241	28	269	133	136	6	30	38	74	64
	YAMOUSSOUKRO	206451	450	639	40	679	129	550	17	38	266	321	29
	Sub-total	376818	865	1136	107	1243	385	858	32	83	365	480	45
MARAHOUE	BOUAFLE	145180	560	432	38	470	431	39	70	46	13	129	77

Region	Department	Population 1999/5	Requitred water point	Realized water point			Situation of water points		Ruck of water points				Cover rate
				Borehole	Dug well	Total	Working	Abundunt	New	Additional	Replace	Total	%
	OUME	411147	459	234	124	358	283	75	39	83	54	176	62
	SINFRA	206915	476	355	13	368	331	36	45	82	18	145	70
	ZUENOULA	146124	442	295	14	309	304	5	47	85	6	138	69
	Sub-total	909366	1937	1316	189	1505	1349	155	201	296	91	588	70
MONTAGNES	BANGOLO	108093	302	171	0	171	169	2	80	51	2	133	56
	BIANKOUMA	83361	241	187	1	188	186	2	25	28	2	55	77
	DANANE	216483	590	502	3	505	495	10	10	74	11	95	84
	DUEKOUE	145484	369	100	44	144	133	11	156	70	10	236	36
	GUIGLO	130291	379	160	53	213	208	6	112	56	3	171	55
	MAN	193605	541	437	5	442	432	9	25	73	11	109	80
	TOULEPLEU	29456	103	34	58	92	91	1	4	7	1	12	88
	Sub-total	906773	2525	1591	164	1755	1714	41	412	359	40	811	68
MOYEN COMOE	ABENGOUROU	153479	287	209	5	214	189	25	28	69	1	98	66
	AGNIBILEKROU	61783	155	130	2	132	121	11	14	20	0	34	78
	Sub-total	215262	442	339	7	346	310	36	42	89	1	132	70
N'ZI COMOE	BOCANDA	87873	268	208	0	208	177	31	33	48	10	91	66
	BONGOUANOU	170146	371	296	3	299	222	77	56	77	16	149	60
	DAOUKRO	99197	384	277	0	277	248	29	79	46	11	136	65
	DIMBOKRO	42003	215	241	4	145	130	15	61	14	10	85	60
	M'BAHIAKRO	109905	373	235	4	239	202	37	70	71	30	171	54
	Sub-total	509124	1611	1157	11	1168	979	189	299	256	77	632	61
SAVANES	BOUNDIALI	101250	307	209	92	301	225	76	13	26	43	82	73
	FERKESSEDOUGOU	170003	669	327	92	419	331	88	261	38	39	338	49
	KORHOGO	340108	1386	694	729	1423	1017	409	115	59	195	369	73
	TENGRELA	41256	125	57	52	109	80	29	5	22	18	45	64
	Sub-total	652617	2487	1287	965	2252	1653	599	394	145	295	834	66
SUD BANDAMA	DIVO	626446	774	345	111	456	411	45	160	170	33	363	53
	GRAND LAHOU	35637	89	65	0	65	55	10	18	12	4	34	62

Region	Department	Population 1999/5	Requitred water point	Realized water point			Situation of water points		Ruck of water points				Cover rate
				Borehole	Dug well	Total	Working	Abundunt	New	Additional	Replace	Total	%
	LAKOTA	306406	303	33	200	233	153	80	16	81	53	150	50
	Sub-total	968489	1166	443	311	754	619	135	194	263	90	547	53
SUD COMOE	ABOISSO	105988	109	147	3	150	67	83	2	28	12	42	61
	ADIAKE	65543	96	109	0	109	65	44	2	22	7	31	68
	GRAND BASSAM	32049	50	52	0	52	27	25	16	7	0	23	54
	Sub-total	203580	255	308	3	311	159	152	20	57	19	96	62
VALLEE DU BANDAMA	BEOUMI	86754	340	300	86	386	262	124	13	17	48	78	77
	BOUAKE	171945	556	580	65	645	421	224	53	43	39	135	76
	DABAKALA	101926	328	379	39	348	230	188	21	13	64	98	70
	KATIOLA	67344	194	152	76	228	124	104	21	20	29	70	64
	SAKASSOU	66134	151	193	53	246	109	137	12	3	27	42	72
	Sub-total	494109	1569	1604	319	1923	1146	777	120	96	207	423	73
WORODOUGOU	MANKONO	186007	574	355	68	423	346	77	92	99	37	228	60
	SEGUELA	153434	427	273	85	358	270	88	48	50	59	157	63
	TOUBA	110941	423	318	71	389	334	55	60	14	15	89	79
	Sub-total	450382	1424	946	224	1170	950	220	200	163	111	474	67
ZANZAN	BONDOUKOU	172750	454	348	99	447	315	132	48	32	59	139	69
	BOUNA	98645	456	387	91	478	370	108	38	4	44	86	81
	TANDA	212466	615	521	31	552	463	89	68	66	18	152	75
	Sub-total	483861	1525	1256	221	1477	1148	329	154	102	121	377	75
TOTAL NATIONAL		8919468	21738	14032	3747	17779	13312	4467	3312	3152	1962	8426	61

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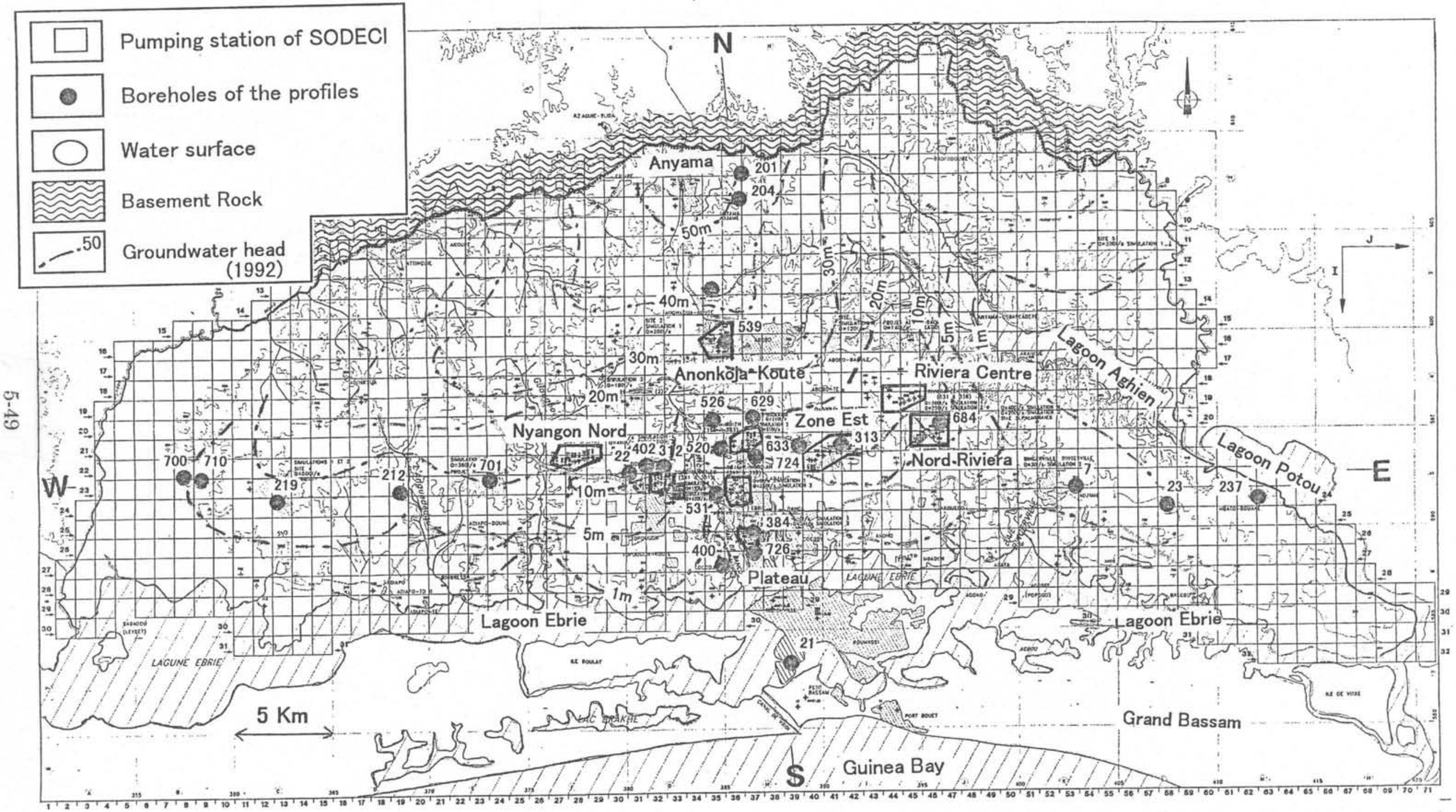
Table 1.3-7 Urban Water consumption in 1998

No.	Controle Points	Water Production			
		Surface water	Groundwater	Total	Well/Total
I-C1	GAHOULOU	0	203,560	203,560	1.00
I-C2	SOUBRE	368,905	30,563	399,468	0.08
I-C3	BUYO Dam	197,026	313,816	510,842	0.61
I-C4	PIEBLY	0	132,425	132,425	1.00
I-C5	DABALA	210,554	36,148	246,702	0.15
I-C6	DAKPADOU	949,158	290,256	1,239,414	0.23
I-C7	LOBOVILIE	2,294,296	77,681	2,371,977	0.03
I-C8	KAHIN	1,057,539	53,583	1,111,122	0.05
I-C9	BADALA	348,977	17,627	366,604	0.05
I-C10	DIOULATIEDOUGOU	0	12,502	12,502	1.00
II-C1	Nzida	0	351,542	351,542	1.00
II-C2	TIASSALE	417,514	0	417,514	0.00
II-C3	TAABO Dam	3,993,854	311,302	4,305,156	0.07
II-C4	KOSSOU Dam	177,853	177,336	355,189	0.50
II-C5	BADA	0	94,552	94,552	1.00
II-C6	TORTIYA	1,859,081	276,912	2,135,993	0.13
II-C7	TAWARA Amont	0	104,264	104,264	1.00
II-C8	ZIENOA	106,980	845,587	952,567	0.89
II-C9	DIMBOKRO	853,672	497,377	1,351,049	0.37
II-C10	M'BAHIAKRO	7,661,628	550,611	8,212,239	0.07
II-C11	Rte KATIOLA-DABAKALA	57,640	15,865	73,505	0.22
II-C12	BOUAFLE	449,514	0	449,514	0.00
II-C13	ZUENOULA	129,033	140,275	269,308	0.52
II-C14	MANKONO	0	47,637	47,637	1.00
II-C15	KOUROUKORO	392,850	0	392,850	0.00
II-C16	BORON	0	22,831	22,831	1.00
III-C1	Grand-Bassam	586,252	497,167	1,083,419	0.46
III-C2	ABRADINOU	935,025	1,617,818	2,552,843	0.63
III-C3	AKAKOMOEKRO	114,239	45,698	159,937	0.29
III-C4	GRANSE	0	27,276	27,276	1.00
III-C5	KAFOLON	146,211	48,922	195,133	0.25
III-C6	N'DAKRO	0	1,441,105	1,441,105	1.00
IV-C1	TATE	0	32,867	32,867	1.00
Iv-C2	TOULEPLEU	0	0	0	0.00
VI-C1	PAPARA	125,577	16,783	142,360	0.12
VI-C2	KOUTO Pont	309,930	91,427	401,357	0.23
VI-C3	DEBETE	0	0	0	0.00
VI-C4	DJIRILA	0	644,270	644,270	1.00
VI-C5	IRADOUGOU	0	0	0	0.00
VII-C2	KONTODOU	0	0	0	0.00
VII-C2	VONKORO	0	174,536	174,536	1.00
VIII-C1	Assnie-Mafia	0	363,471	363,471	1.00
VIII-C2	Krindjabo	472,104	53,370	525,474	0.10
VIII-C3	AYAME Dam-No.2	80,266	27,381	107,647	0.25
VIII-C4	BIAN	0	0	0	0.00
IX-C1	Adjin				0.00
IX-C2	IRHO	404,645	327,691	732,336	0.45
IX-C3	LOBOAKOUDZIN	0	93,792	93,792	1.00
IX-C4	KOSSIHOUEN	0	63,270	63,270	1.00
IX-C5	AGBOVILLE	1,317,958	470,200	1,788,158	0.26
IX-C5	IRA	0	89,033	89,033	1.00
X-C1	Adahi Dougeu	752,063	41,603	793,666	0.05
X-C2	GRAND-LAHOU	0	52,689	52,689	1.00
X-C3	DAHIRI	0	11,786	11,786	1.00
X-C4	FRESCO	0	100,710	100,710	1.00
XI-C1	SAN PEDRO	1,779,779	0	1,779,779	0.00
XI-C2	Grand Bereby	0	0	0	0.00
XI-C3	WEOULO	0	0	0	0.00
	BIANOUAI 1				0.00
	BOUNA				0.00
59	Abidjan Ville	0	93,177,916	93,177,916	1.00
	Abidjan	0	1,446,775	1,446,775	1.00
					0.00
	Total	28,550,123	105,831,863	134,381,986	0.79

Figure 1.3-2 Location of Pumping Station and Main Borehole of Abidjan Area



Quoted from Final report of "Etude de la gestion et de la protection de la nappe assurant l'alimentation en eau potable d'Abidjan" (by BNETD & MIE/DH 1997)

Figure 1.3-3 Geological Profile of Abidjan Groundwater Basin (W-E)

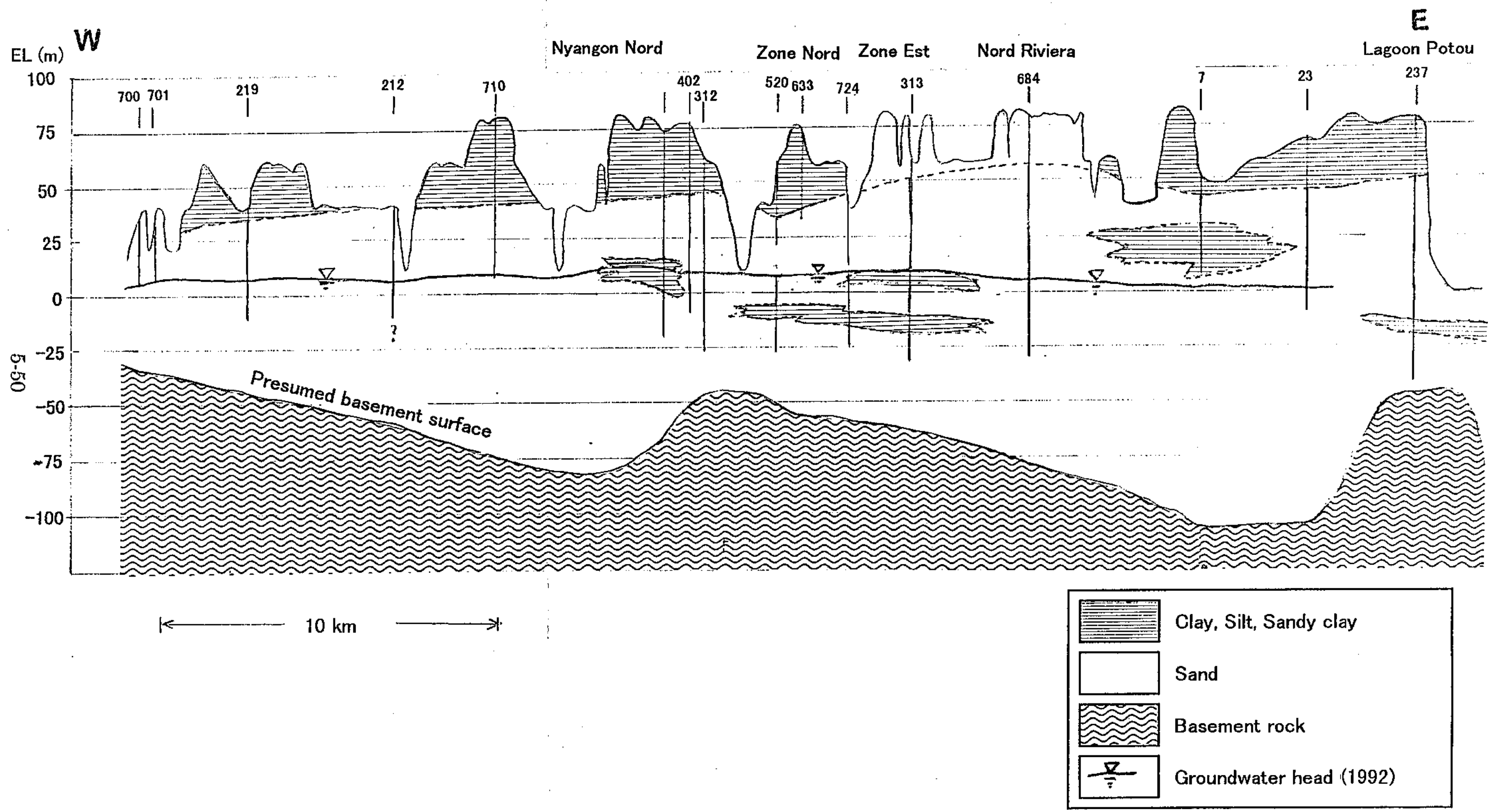


Table- 2.3-2 Groundwater potential for river basins (Renewable groundwater resources)

Hydrogeology	River basin	River name	Sub basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential	
				No	Name	(km2)	(mm)	MCM/y
	Sassandra and surrounding basin							
		Sassandra	Gahoulou	I-C1	***Gahoulou***	6,064	133	807
		Sassandra+Lobo	Soubre	I-C2	Soubre	2,675	78	208
Dis-continuous aquifer		Sassandra	Buyo	I-C3	***Buyo Dam***	5,321	147	781
		Sassandra	Piebly	I-C4	***Piebly***	10,089	124	1,253
	Sassandra	Sassandra	Dabala	I-C5	Dabala	13,810	116	1,602
		Sassandra	Dakpadou	I-C6	Dakpadou	6,816	133	907
		Sassandra	Loboville	I-C7	Lobovilie	12,745	78	994
		Nzo	Kahin	I-C8	Kahin	4,310	216	930
		Bafing	Badala	I-C9	Badala	5,930	144	851
		Tiemba	Dieulatiedougou	I-C10	Dioulatiedougou	2,790	116	324
				sub-total	Sassandra basin	70,550	123	8,656
	Gavally	Gavally	Tate	IV-C1	***Tate***	10,790	209	2,255
		Gavally+Nuon	Toulepleu	IV-C2	Toulepleu	13,337	244	3,254
	Ba-Oule	Bani-Niger	Papala	VI-C1	Papala	8950	136	1,215
		Bani-Niger	Koute	VI-C2	***Kouto Point***	4740	136	643
		Bani-Niger	Debete	VI-C3	Debete	5550	136	753
		Bani-Niger	Djirila	VI-C4	***Djirila***	7082	136	961
		Kouroukele	Iradougou	VI-C5	Iradougou	3044	136	413
	San Pedro	San Pedro	San Perdo	XI-C1	***San Perdo***	5,215	221	1,153
		Nero	Grand Bereby	XI-C2	Grand Bereby	1,266	221	280
		Dodo	Weoulo	XI-C3	Weoulo	1,481	221	327
	Total of Sassandra and surrounding basin			total		132,005	151	19,912
	Bandama and surrounding basin							
	Bandama	Bandama	Lower Bandama	II-C1	Nzide	2,228	84	187
		Bandama	Tiassale	II-C2	***Tiassale***	6,350	50	315
		Bandama	Taabo Dam	II-C3	***Taabo Dam***	5,600	44	248
		Bandama	Kossou	II-C4	***Kossou***	8,350	45	378
		Bandama	Bada	II-C5	***Bada***	5,796	48	277
		Bandama	Toritaya	II-C6	***Toritaya***	9,125	68	621
		Bandama	Nyama	II-C7	Tawara amount	5,375	74	399
		Nzi	Mbimbe	II-C8	Zienoa	10,900	31	334
		Nzi	Dimbokro	II-C9	Dimbokro	8,400	31	258
		Nzi	Mbahiakro	II-C10	***Mbahiakro***	9,080	43	386
		Nzi	Kapele	II-C11	Rte Katiola-Dabakara	6,620	42	276
		Maraoue	Bouafle	II-C12	***Bouafle***	3,185	47	150
		Maraoue	Fizanlouma	II-C13	Zuenola	5,105	50	255
		Maraoue	Kouroukourouga	II-C14	Mankono	6,700	64	427
		Banoroni	Kouroukoro	II-C15	Kouroukoro	4,810	64	307
		Bou	Boron	II-C16	Rte Boron-Kadyoha	3,754	53	197
				sub-total	Bandama basin	101,378	49	5,015
	Boubo	Boubo	Grand Lahou	X-C1	Grand Lahou	2,192	119	261
		Boubo	Grand Lahou	X-C2	***Grand Lahou***	4,702	119	560
		Niouniourou	Dahili	X-C3	Dahili	2,112	119	251
		Bolo	Fresco	X-C4	Fresco	1,330	119	158
	Total and average of Bandama and surrounding basin					111,714	56	6,245
	Comoe and surrounding basin							
	Comoe	Comoe	Lower Comoe	III-C1	Grand Bassan	2,608	101	263
		Comoe	Abaradinou	III-C2	***Abaradinou***	17,300	31	543
		Comoe	Akakomoekro	III-C3	Akakomoekro	13,300	39	522
		Comoe	Ganse	III-C4	***Ganse***	22,500	41	918
		Comoe	Kafolon	III-C5	***Kafolon***	5,668	76	433
		Comoe	N7dakro	III-C6	N'dakro	6,222	31	195
				Sub total	Comoe basin	67,598	43	2,875
	Kolodio	Kolodio	Kontodou	VII-C1	***Kontodou***	7,078	46	328
		Volta Noire	Vonkoro	VII-C2	Vonkoro	5,471	46	253
	Bia	Bia	Mouth Lagoon	VIII-C1	Mouth Lagoon	0	135	0
		Bia	Krindjaabo	VIII-C2	Krindjaabo	144	135	19
		Bia	Ayame Dam2	VIII-C3	***Ayame Dam2***	2,530	135	342
		Bia	Bian	VIII-C4	***Bian***	236	135	32

Hydrogeology	River basin	River name	Sub basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential	
				No	Name	(km2)	(mm)	MCM/y
	Agneby	Agneby	Adjin	IX-C1	Adjin	592	90	53
		Me	Irho	IX-C2	***Irho***	1,184	90	107
		Me	Loboakoudzin	IX-C3	Loboakoudzin	1,274	90	115
		Agneby	Kossihouen	IX-C4	***Kossihouen***	2,483	90	224
		Agneby	Agboville	IX-C5	Agboville	4,878	90	441
		Ira	Ira	IX-C6	Ira	444	90	40
	Total and average of Comoe and surrounding basin					93,912	51	4,830
Total or average of Discontinuous aquifer						337,631	92	30,987
General aquifer	Coastal area	Boubo	Grand Lahou	GA-1	Grand Lahou	1,083	200	217
		Bandama	Mouth of Bandama	GA-2	Mouth of Bandama	389	200	78
		Agenby	Abidjan	GA-3	Abidjan	3,516	354	1,244
		Comoe	Grand Bassan	GA-4	Grand Bassan	729	336	245
		Mouth Lagoon	Mouth of Lagoon	GA-5	Mouth of Lagoon	2,675	381	1,019
Total General aquifer						8,392	334	2,803
Grand total						346,023	98	33,790

Modified from the "Carte de planification des ressources en eau de Cote d'Ivoire"1978

Table 2.4-1　Frequency of rural water supply coverage rate

Frequency distribution	Number of district	Sub-	Grouping
81-90	3	18	C
71-80	15		
61-70	19	29	B
51-60	10		
41-50	8	11	A
31-40	1		
21-30	1		
<21	1		

Figure 2.4-1 Frequency of rural water supply coverage rate

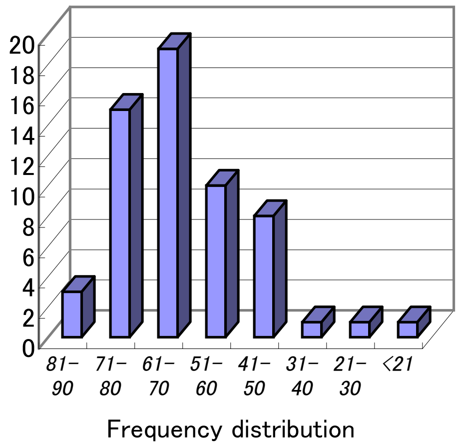
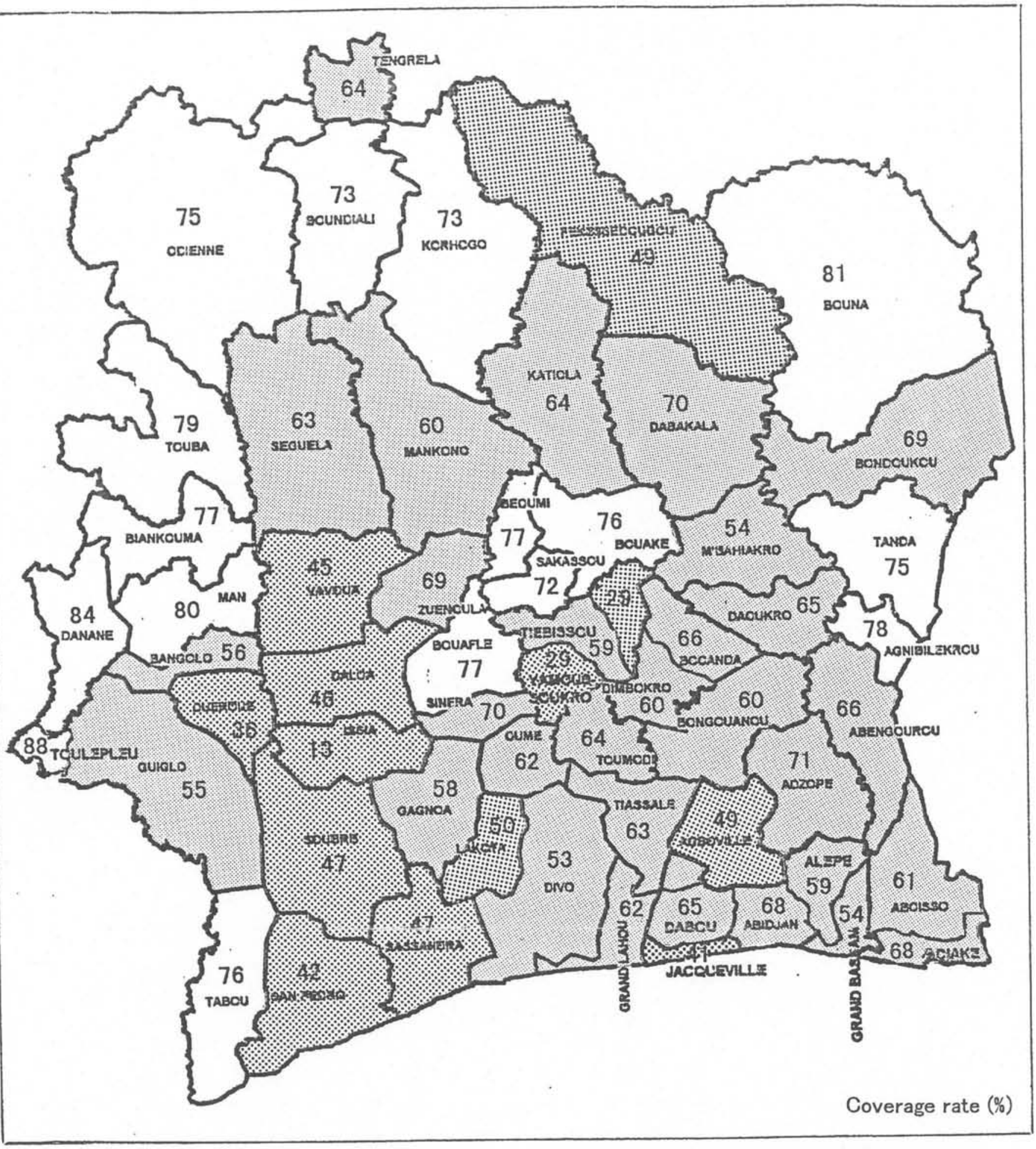
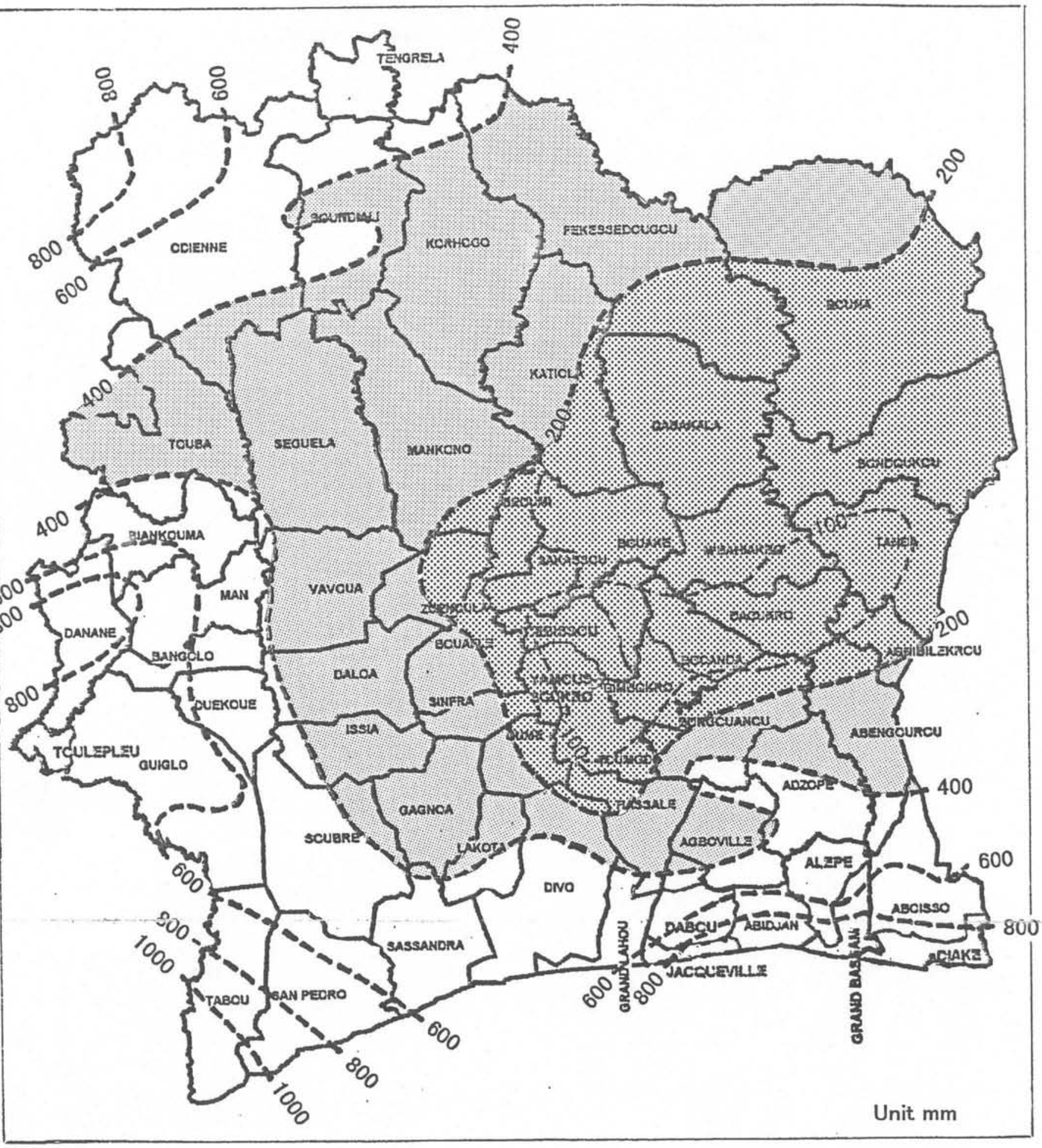


Figure 2.4-2 Rural Water Supply Coverage Rate of Districts



Coverage rate group (%)	Number of districts	Grade
<50	11	A
51-70	29	B
71-90	18	C

Figure 2.4-3 Effective Rainfall Contour line



Grade	Effective Rainfall Range (mm/y)
A	<200
B	201−400
C	400<

Figure 2.4-4 Renewable Groundwater Potencial Grade

Grade	Rank	Unit Potential (mm)
A	I-IV	150 - 400
B	V-VI	50 - 100
C	VII	<50

Table 2.4-2 Comprehensive appraisal for priority area

Region	Department	Coverage Rate	Rainfall	Potential	Comprehensive	Remarks
AGNEBY	ADZOPE	C	C	B	C	
	AGBOVILLE	A	B	B	A	
BAS-SASSANDRA	SAN PEDRO	A	C	A	A	Deforest
	SASSANDRA	A	C	A	A	Deforest
	SOUBRE	A	C	A	A	Deforest
	TABOU	C	C	A	C	Deforest, Refugee
DENGUELE	ODIENNE	C	C	A	C	
DES LAGUNES	ABIDJAN	B	C	A	B	GA, Quality
	ALEPE	B	C	B	B	GA, Quality
	DABOU	B	C	A	B	GA, Quality
	JACQUEVILLE	A	C	A	B	GA, Quality
	TIASSALE	B	B	B	B	
HAUT SASSANDRA	DALOA	A	B	B	A	
	GAGNOA	B	B	B	B	Deforest
	ISSIA	A	B	B	A	Deforest
	VAVOUA	A	B	B	A	
LACS	TIEBISSOU	B	A	C	A	Dry area
	TOUMODI	B	A	C	A	Dry area
	YAMOUSSOUKRO	A	A	C	A	Dry area
MARAHOUE	BOUAFLE	C	B	B	B	
	OUME	B	B	B	B	Deforest
	SINFRA	B	B	B	B	
	ZUENOULA	B	A	B	A	
MONTAGNES	BANGOLO	B	C	A	B	Dry area
	BIANKOUMA	C	C	A	C	
	DANANE	C	C	A	C	
	DUEKOUE	A	C	A	A	Deforest
	GUIGLO	B	C	A	B	Deforest, Refugee
	MAN	C	C	A	C	
	TOULEPLEU	C	C	A	C	Deforest, Refugee
MOYEN COMOE	ABENGOUROU	B	B	B	B	
	AGNIBILEKROU	C	A	C	B	Dry area
N'ZI COMOE	BOCANDA	B	A	C	A	Dry area
	BONGOUANOU	B	B	B	B	
	DAOUKRO	B	A	C	A	Dry area
	DIMBOKRO	B	A	C	A	Dry area
	M'BAHIAKRO	B	A	C	A	Dry area
SAVANES	BOUNDIALI	C	C	B	C	
	FERKESSEDOUGOU	A	B	B	A	
	KORHOGO	C	B	B	B	
	TENGRELA	B	C	A	B	
SUD BANDAMA	DIVO	B	C	A	B	Deforest
	GRAND LAHOU	B	C	A	B	GA, Quality
	LAKOTA	A	B	B	A	Deforst
SUD COMOE	ABOISSO	B	C	A	B	GA, Quality
	ADIAKE	B	C	A	B	GA, Quality
	GRAND BASSAM	B	C	A	B	GA, Quality
VALLEE DU BANDAMA	BEOUMI	C	A	B	B	
	BOUAKE	C	A	B	B	
	DABAKALA	B	A	B	A	
	KATIOLA	B	B	B	B	
	SAKASSOU	C	A	C	B	
WORODOUGOU	MANKONO	B	B	B	B	
	SEGUELA	B	B	B	B	
	TOUBA	C	B	B	B	
ZANZAN	BONDOUKOU	B	A	B	A	
	BOUNA	C	A	B	B	
	TANDA	C	A	C	B	Dry area

GA : General aquifer
Quality : Attention water quality
Dry area : Effective rainfall less than 150 mm/y
Deforest : Population increasing with deforestation for agricultural development
Refuge : Refuge problem from Liveria

Table– 3.3–1 Groundwater balance for river basins (at 2015), presented by water depth (mm)

Hydrogeology	River basin	Area of unit basin	Groundwater potential		Ground water in 1998					Groundwater demand in 2015)					Balance between Potential & Demand (2015)I *		
					Urban	Rural	Agri	Total	Total	Urban	Rural	Agri	Total	Total			
		(km2)	(mm)	MCM/y	(mm)	(mm)	(mm)	MCM/y	(mm)	(mm)	(mm)	(mm)	MCM/y	(mm)	MCM/y	(mm)	%
	Total and average of Sassandra and surrounding basin	132,005	151	19,912	0.015	0.08	0.23	42	0.321	0.38	0.16	0.80	178	1.35	19734	149.49	0.89
	Total and avarage of Bandama and surrounding absin	111,714	56	6,245	0.002	0.04	0.31	40	0.360	0.35	0.07	1.13	173	1.55	6073	54.35	2.75
	Total and of average of Comoe and surrounding basin	93,912	51	4,830	0.051	0.03	0.23	29	0.312	0.44	0.05	0.83	124	1.32	4706	50.11	2.56
Total or average of Discontinuous aquifer area		337,631	92	30,987	0.021	0.05	0.26	112	0.331	0.39	0.10	0.92	475	1.41	30513	90.37	1.53
Total and average of General aquifer area		8,392	334	2,803	11.333	0.10	0.99	104	12.417	30.25	0.11	3.30	283	33.67	2527	300.36	9.87
Grand total		346,023	98	33,790	0.295	0.06	0.27	216	0.625	1.11	0.11	1.06	758	2.19	33040	95.46	2.22

Modified from the "Carte de planification des ressources en eau de Cote d'Ivoire"1978

* Balance between Potential and demand (2015) ; MCM/Y or mm=Groundwater potential – Groundwater demand in 2015

Table- 3.3-2 Groundwater balance for river basins (at 2015), presented by water depth (mm)

Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Ground water in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015)*	
		No	Name	(km2)	(mm)	MCM/y	Urban (mm)	Rural (mm)	Agri (mm)	Total (mm)	Urban (mm)	Rural (mm)	Agri (mm)	Total (mm)	(mm)	%
Dis-continuous aquifer	Sassandra and surrounding basin															
	Sassandra	I-C1	***Gahoulou***	6,064	133	807	0.034	0.21	0.23	0.477	2.14	0.54	0.82	3.49	129.64	2.62
		I-C2	Soubre	2,675	78	208	0.011	0.22	0.26	0.492	0.35	0.54	0.92	1.81	75.97	2.33
		I-C3	***Buyo Dam***	5,321	147	781	0.059	0.29	0.41	0.758	2.05	0.63	1.48	4.15	142.58	2.83
		I-C4	***Piebly***	10,089	124	1,253	0.013	0.06	0.26	0.335	0.64	0.06	0.93	1.62	122.56	1.31
		I-C5	Dabala	13,810	116	1,602	0.003	0.00	0.11	0.120	0.06	0.01	0.40	0.47	115.52	0.40
		I-C6	Dakpadou	6,816	133	907	0.043	0.17	0.30	0.520	0.92	0.40	1.08	2.40	130.60	1.80
		I-C7	Lobovilie	12,745	78	994	0.006	0.22	0.54	0.767	0.07	0.37	1.95	2.39	75.61	3.07
		I-C8	Kahin	4,310	216	930	0.012	0.05	0.42	0.483	0.16	0.07	1.50	1.73	213.99	0.80
		I-C9	Badala	5,930	144	851	0.003	0.01	0.09	0.101	0.01	0.01	0.33	0.35	143.20	0.24
		I-C10	Dioulatiedougou	2,790	116	324	0.004	0.00	0.12	0.124	0.19	0.00	0.38	0.56	115.44	0.49
		sub-total	Sassandra basin	70,550	123	8,656	0.017	0.12	0.29	0.420	0.57	0.23	1.02	1.83	120.87	1.49
	Gavally	IV-C1	***Tate***	10,790	209	2,255	0.003	0.10	0.16	0.271	0.45	0.23	0.58	1.26	207.74	0.60
		IV-C2	Toulepleu	13,337	244	3,254	0.000	0.01	0.15	0.161	0.00	0.02	0.53	0.55	243.45	0.23
	Ba-Oule	VI-C1	Papala	8950	136	1,215	0.002	0.00	0.07	0.077	0.02	0.00	0.26	0.28	135.47	0.21
		VI-C2	***Kouto Point***	4740	136	643	0.019	0.01	0.26	0.291	0.21	0.02	0.93	1.16	134.59	0.85
		VI-C3	Debete	5550	136	753	0.000	0.00	0.15	0.155	0.00	0.00	0.53	0.54	135.22	0.39
		VI-C4	***Djirila***	7082	136	961	0.091	0.00	0.13	0.225	0.52	0.00	0.35	0.87	134.88	0.64
		VI-C5	Iradougou	3044	136	413	0.000	0.00	0.12	0.125	0.00	0.00	0.69	0.69	135.07	0.51
	San Pedro	XI-C1	***San Perdo***	5,215	221	1,153	0.000	0.17	0.25	0.413	0.00	0.41	0.88	1.30	219.70	0.59
		XI-C2	Grand Bereby	1,266	221	280	0.000	0.06	0.22	0.285	0.00	0.16	0.79	0.95	220.05	0.43
		XI-C3	Weoulo	1,481	221	327	0.000	0.02	0.19	0.209	0.00	0.01	0.66	0.67	220.33	0.30
	Total of Sassandra and surrounding basin			132,005	151	19,912	0.015	0.08	0.23	0.321	0.38	0.16	0.80	1.35	149.49	0.89
	Bandama and surrounding basin															
	Bandama	II-C1	Nzide	2,228	84	187	0.117	0.21	0.54	0.100	0.99	0.29	1.97	3.25	82.70	3.88
		II-C2	***Tiassale***	6,350	50	315	0.000	0.03	0.05	0.072	0.00	0.03	0.18	0.20	49.36	0.41
		II-C3	***Taabo Dam***	5,600	44	248	0.056	0.14	0.59	0.783	0.25	0.15	2.11	2.52	41.76	5.68
		II-C4	***Kossou***	8,350	45	378	0.021	0.03	0.43	0.479	0.73	0.06	1.53	2.31	42.99	5.10
		II-C5	***Bada***	5,796	48	277	0.016	0.03	0.30	0.341	0.16	0.12	1.04	1.32	46.40	2.76
		II-C6	***Toritaya***	9,125	68	621	0.030	0.02	0.27	0.320	0.19	0.04	0.96	1.18	66.87	1.74
		II-C7	Tawara amount	5,375	74	399	0.019	0.02	0.40	0.446	0.45	0.03	1.47	1.94	72.32	2.62
		II-C8	Zienoa	10,900	31	334	0.078	0.03	0.42	0.522	0.93	0.03	1.50	2.46	28.22	8.01
		II-C9	Dimbokro	8,400	31	258	0.059	0.02	0.28	0.361	0.35	0.02	1.00	1.36	29.31	4.45
		II-C10	***Mbahiakro***	9,080	43	386	0.061	0.01	0.42	0.496	0.21	0.02	1.52	1.75	40.80	4.11
		II-C11	Rte Katiola-Dabakara	6,620	42	276	0.002	0.01	0.17	0.179	0.08	0.04	0.63	0.75	40.89	1.81
		II-C12	***Bouafle***	3,185	47	150	0.000	0.12	0.50	0.612	0.00	0.21	1.77	1.99	45.14	4.21
		II-C13	Zuenola	5,105	50	255	0.027	0.05	0.25	0.322	0.68	0.11	0.89	1.69	48.31	3.38

Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Ground water in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015)*	
							Urban	Rural	Agri	Total	Urban	Rural	Agri	Total		
		No	Name	(km2)	(mm)	MCM/y	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	%
		II-C14	Mankono	6,700	64	427	0.007	0.01	0.21	0.226	0.43	0.04	0.73	1.19	62.57	1.87
		II-C15	Kouroukoro	4,810	64	307	0.000	0.00	0.11	0.115	0.00	0.01	0.41	0.42	63.34	0.66
		II-C16	Rte Boron-Kadyoha	3,754	53	197	0.006	0.01	0.35	0.367	0.65	0.05	1.26	1.96	50.63	3.73
		sub-total	Bandama basin	101,378	49	5,015	0.033	0.03	0.32	0.390	0.38	0.06	1.16	1.60	47.87	3.23
	Boubo	X-C1	Grand Lahou	2,192	119	261	0.013	0.22	0.18	0.409	0.00	0.31	0.63	0.00	119.00	0.26
		X-C2	***Grand Lahou***	4,702	119	560	0.011	0.09	0.26	0.358	0.00	0.11	0.93	1.04	117.96	0.88
		X-C3	Dahili	2,112	119	251	0.006	0.08	0.24	0.332	0.00	0.13	0.86	0.99	118.01	0.83
		X-C4	Fresco	1,330	119	158	0.076	0.18	0.30	0.554	0.00	0.36	1.07	1.43	117.57	1.20
	Total and average of Bandama and surrounding			111,714	56	6,245	0.002	0.04	0.31	0.360	0.35	0.07	1.13	1.55	54.35	2.75
	Comoe and surrounding basin															
	Comoe	III-C1	Grand Bassan	2,608	101	263	0.124	0.02	1.22	0.097	1.14	0.07	4.40	5.61	100.04	5.55
		III-C2	***Abaradinou***	17,300	31	543	0.094	0.04	0.11	0.242	0.39	0.05	0.38	0.82	30.56	2.62
		III-C3	Akakomoekro	13,300	39	522	0.003	0.01	0.16	0.176	0.16	0.01	0.58	0.75	38.52	1.91
		III-C4	***Ganse***	22,500	41	918	0.001	0.01	0.11	0.121	0.13	0.04	0.41	0.58	40.22	1.43
		III-C5	***Kafolon***	5,668	76	433	0.009	0.05	0.17	0.237	0.10	0.11	0.63	0.83	75.64	1.09
		III-C6	N'dakro	6,222	31	195	0.232	0.03	0.28	0.548	2.31	0.03	1.01	3.36	28.03	10.70
		Sub total	Comoe basin	67,598	43	2,875	0.052	0.02	0.19	0.260	0.44	0.04	0.66	1.15	41.39	2.70
	Kolodio	VII-C1	***Kontodou***	7,078	46	328	0.000	0.00	0.20	0.207	0.00	0.01	0.73	0.74	45.53	1.60
		VII-C2	Vonkoro	5,471	46	253	0.032	0.00	0.08	0.121	0.69	0.01	0.35	1.05	45.22	2.27
	Bia	VIII-C1	Mouth Lagoon	0	135	0	0.000	0.00	0.00	0.000	0.00	0.00	0.00	0.00	135.16	0.00
		VIII-C2	Krindjaabo	144	135	19	0.371	0.61	3.26	4.247	2.04	0.74	11.60	14.38	120.78	10.64
		VIII-C3	***Ayame Dam2***	2,530	135	342	0.011	0.09	0.18	0.283	0.04	0.10	0.67	0.82	134.34	0.60
		VIII-C4	***Bian***	236	135	32	0.000	0.61	0.21	0.822	0.00	0.50	0.81	1.30	133.85	0.96
	Agenby	IX-C1	Adjin	592	90	53	0.000	0.03	1.45	1.481	0.00	0.04	5.14	5.17	85.15	5.73
		IX-C2	***Irho***	1,184	90	107	0.277	0.12	1.51	1.913	1.75	0.17	5.44	7.36	82.97	8.15
		IX-C3	Loboakoudzin	1,274	90	115	0.074	0.03	0.36	0.461	0.97	0.05	1.28	2.29	88.03	2.54
		IX-C4	***Kossihouen***	2,483	90	224	0.025	0.08	0.46	0.564	0.00	0.10	1.64	1.74	88.59	1.93
		IX-C5	Agboville	4,878	90	441	0.096	0.06	0.21	0.368	0.80	0.08	0.75	1.64	88.69	1.81
		IX-C6	Ira	444	90	40	0.201	0.09	2.25	2.545	0.00	0.12	8.11	8.22	82.10	9.10
	Total and of Comoe and surrounding basin			93,912	51	4,830	0.051	0.03	0.23	0.312	0.44	0.05	0.83	1.32	50.11	2.56
Total or average of Discontinuous aquifer				337,631	92	30,987	0.021	0.05	0.26	0.331	0.39	0.10	0.92	1.41	90.37	1.53
General aquifer	Coastal area	GA-1	Grand Lahou	1,083	200	217	0.013	0.40	0.52	0.931	4.49	0.31	0.29	4.79	195.21	2.40
		GA-2	Mouth of Bandama	389	200	78	0.100	0.18	0.51	0.100	0.84	0.25	1.86	1.09	198.91	0.55
		GA-3	Abidjan	3,516	354	1,244	26.910	0.00	1.73	28.642	69.08	0.00	6.23	75.31	278.58	21.28
		GA-4	Grand Bassan	729	336	245	0.097	0.05	0.96	0.097	0.89	0.05	2.74	0.94	335.52	0.28
		GA-5	Mouth of Lagoon	2,675	381	1,019	0.136	0.10	0.28	0.513	1.93	0.18	1.02	2.11	378.93	0.55
Total General aquifer				8,392	334	2,803	11.333	0.10	0.99	12.417	30.25	0.11	3.30	33.67	300.36	9.87
Grand total				346,023	98	33,790	0.295	0.06	0.27	0.625	1.11	0.11	1.06	2.19	95.46	2.22

Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Ground water in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015)*	
							Urban	Rural	Agri	Total	Urban	Rural	Agri	Total		
		No	Name	(km2)	(mm)	MCM/y	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	%

* Balance between Potential and demand (2015) ; mm=Groundwater potential − Groundwater demand in 2015
; % = 100*(Groundwater demand (2015)/Groundwater potential)

Table- 3.3-3 Groundwater balance for river basins (at 2015), presented by water volume (MCM)

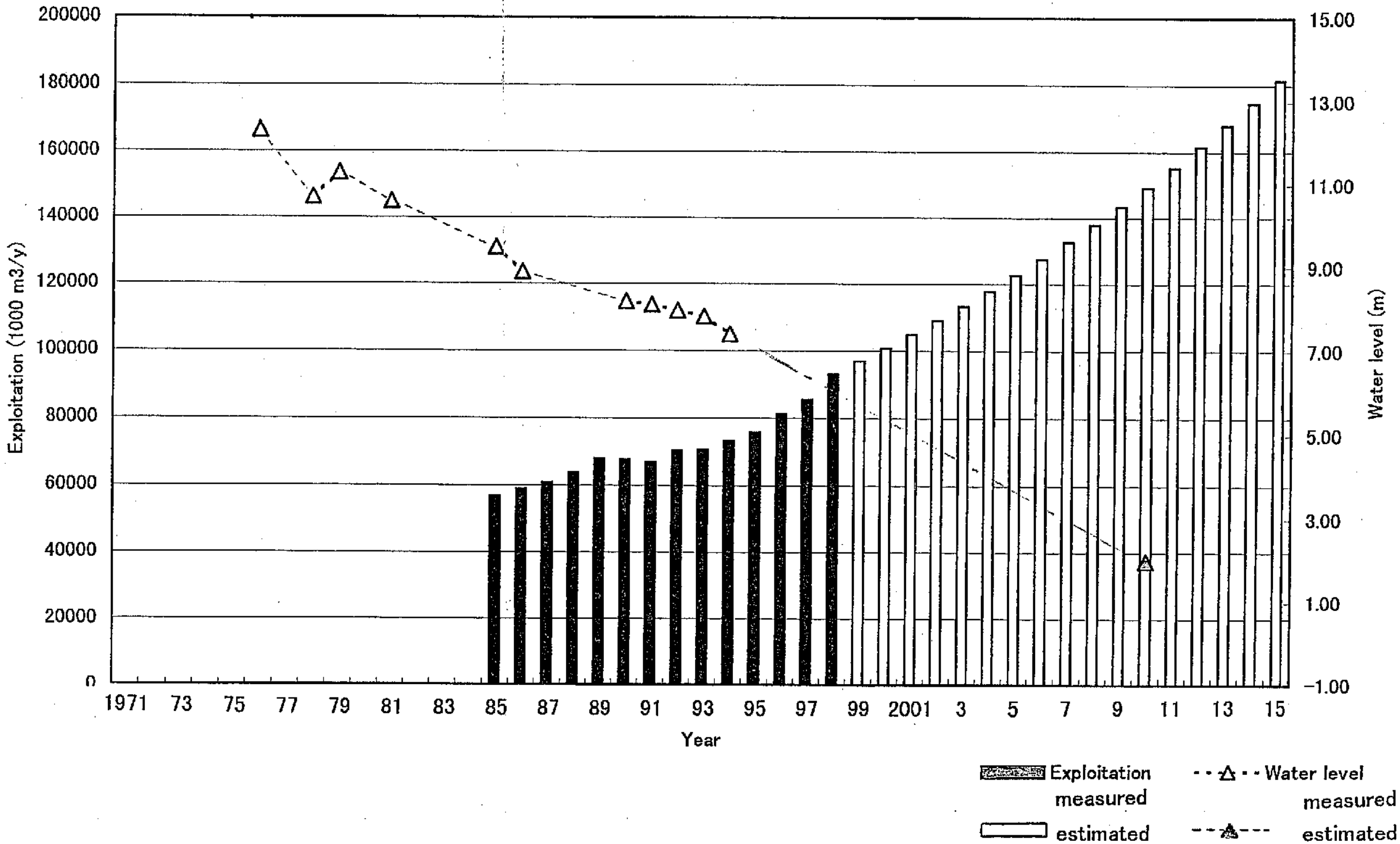
Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Groundwater in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015) *	
							Urban	Rural	Agricu	Total	Urban	Rural	Agricult	Total		
		No	Name	(km2)	(mm)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	%
	Sassandra and surrounding basin															
	Sassandra	I-C1	***Gahoulou***	6,064	133	807	0.204	1.30	1.39	2.89	12.96	3.25	4.98	21.19	786.16	2.62
		I-C2	Soubre	2,675	78	208	0.031	0.58	0.70	1.32	0.95	1.45	2.46	4.85	203.22	2.33
Dis-continuous aquifer		I-C3	***Buyo Dam***	5,321	147	781	0.314	1.54	2.18	4.03	10.91	3.33	7.86	22.11	758.68	2.83
		I-C4	***Piebly***	10,089	124	1,253	0.132	0.63	2.62	3.38	6.41	0.60	9.35	16.36	1,236.55	1.31
		I-C5	Dabala	13,810	116	1,602	0.036	0.03	1.58	1.65	0.77	0.11	5.58	6.46	1,595.29	0.40
		I-C6	Dakpadou	6,816	133	907	0.290	1.18	2.07	3.54	6.26	2.70	7.39	16.35	890.17	1.80
		I-C7	Lobovilie	12,745	78	994	0.078	2.79	6.91	9.78	0.89	4.68	24.90	30.47	963.64	3.07
		I-C8	Kahin	4,310	216	930	0.054	0.22	1.81	2.08	0.67	0.30	6.47	7.44	922.29	0.80
		I-C9	Badala	5,930	144	851	0.018	0.05	0.53	0.60	0.04	0.06	1.96	2.07	849.19	0.24
		I-C10	Dioulatiedougou	2,790	116	324	0.013	0.00	0.33	0.35	0.52	0.01	1.05	1.57	322.07	0.49
		sub-total	Sassandra basin	70,550	123	8,656	1.168	8.33	20.12	29.62	40.38	16.49	72.00	128.88	8,527.25	1.49
	Gavally	IV-C1	***Tate***	10,790	209	2,255	0.033	1.12	1.77	2.92	4.84	2.43	6.30	13.58	2,241.53	0.60
		IV-C2	Toulepleu	13,337	244	3,254	0.000	0.16	1.99	2.15	0.00	0.24	7.11	7.35	3,246.88	0.23
	Ba-Oule	VI-C1	Papala	8950	136	1,215	0.017	0.02	0.66	0.69	0.20	0.03	2.30	2.54	1,212.46	0.21
		VI-C2	***Kouto Point***	4740	136	643	0.091	0.04	1.25	1.38	1.00	0.10	4.40	5.50	637.97	0.85
		VI-C3	Debete	5550	136	753	0.000	0.01	0.85	0.86	0.00	0.01	2.96	2.97	750.46	0.39
		VI-C4	***Djirila***	7082	136	961	0.644	0.01	0.94	1.60	3.70	0.03	2.45	6.18	955.23	0.64
		VI-C5	Iradougou	3044	136	413	0.000	0.00	0.38	0.38	0.00	0.01	2.09	2.09	411.14	0.51
	San Pedro	XI-C1	***San Perdo***	5,215	221	1,153	0.000	0.87	1.28	2.15	0.00	2.16	4.60	6.76	1,145.75	0.59
		XI-C2	Grand Bereby	1,266	221	280	0.000	0.08	0.28	0.36	0.00	0.21	1.00	1.21	278.58	0.43
		XI-C3	Weoulo	1,481	221	327	0.000	0.03	0.28	0.31	0.00	0.01	0.98	0.99	326.31	0.30
	Total of Sass	total		132,005	151	19,912	1.954	10.67	29.80	42.43	50.12	21.73	106.19	178.05	19,733.57	0.89
	Bandama and surrounding basin															
	Bandama	II-C1	Nzide	2,228	84	187	0.260	0.46	1.21	1.93	2.21	0.65	4.38	7.24	179.45	3.88
		II-C2	***Tiassale***	6,350	50	315	0.000	0.16	0.30	0.46	0.00	0.18	1.12	1.30	313.45	0.41
		II-C3	***Taabo Dam***	5,600	44	248	0.311	0.78	3.30	4.39	1.39	0.85	11.84	14.09	233.86	5.68
		II-C4	***Kossou***	8,350	45	378	0.177	0.25	3.57	4.00	6.10	0.46	12.74	19.30	358.99	5.10
		II-C5	***Bada***	5,796	48	277	0.095	0.17	1.71	1.98	0.92	0.67	6.04	7.64	268.95	2.76
		II-C6	***Toritaya***	9,125	68	621	0.277	0.21	2.43	2.92	1.71	0.34	8.74	10.79	610.23	1.74
		II-C7	Tawara amount	5,375	74	399	0.104	0.12	2.17	2.39	2.39	0.18	7.88	10.45	388.73	2.62
		II-C8	Zienoa	10,900	31	334	0.846	0.28	4.56	5.69	10.13	0.33	16.31	26.78	307.61	8.01
		II-C9	Dimbokro	8,400	31	258	0.497	0.19	2.35	3.03	2.91	0.19	8.36	11.46	246.24	4.45
		II-C10	***Mbahiakro***	9,080	43	386	0.551	0.11	3.84	4.50	1.91	0.15	13.83	15.89	370.49	4.11
		II-C11	Rte Katiola-Dabakara	6,620	42	276	0.016	0.05	1.12	1.18	0.56	0.29	4.14	4.99	270.70	1.81
		II-C12	***Bouafle***	3,185	47	150	0.000	0.37	1.58	1.95	0.00	0.67	5.65	6.32	143.79	4.21
		II-C13	Zuenola	5,105	50	255	0.140	0.24	1.27	1.65	3.49	0.58	4.56	8.63	246.62	3.38

Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Groundwater in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015) *	
							Urban	Rural	Agricu	Total	Urban	Rural	Agricult	Total		
		No	Name	(km2)	(mm)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	%
		II-C14	Mankono	6,700	64	427	0.048	0.08	1.38	1.51	2.87	0.25	4.86	7.98	419.20	1.87
		II-C15	Kouroukoro	4,810	64	307	0.000	0.02	0.54	0.56	0.00	0.03	1.99	2.02	304.65	0.66
		II-C16	Rte Boron-Kadyoha	3,754	53	197	0.023	0.04	1.31	1.38	2.44	0.20	4.73	7.37	190.06	3.73
		sub-total	Bandama basin	101,378	49	5,015	3.345	3.54	32.64	39.53	39.02	6.04	117.17	162.24	4,853.01	3.23
	Boubo	X-C1	Grand Lahou	2,192	119	261	0.028	0.48	0.39	0.90	0.00	0.67	1.37	2.05	260.17	0.26
		X-C2	***Grand Lahou***	4,702	119	560	0.053	0.42	1.21	1.68	0.00	0.53	4.37	4.90	554.63	0.88
		X-C3	Dahili	2,112	119	251	0.012	0.18	0.51	0.70	0.00	0.27	1.81	2.08	249.24	0.83
		X-C4	Fresco	1,330	119	158	0.101	0.24	0.40	0.74	0.00	0.48	1.42	1.90	156.37	1.20
	Total and average of Bandama and surrounding			111,714	56	6,245	0.195	4.86	35.15	40.20	39.02	8.00	126.15	173.18	6,073.43	2.75
	Comoe and surrounding basin															
	Comoe	III-C1	Grand Bassan	2,608	101	263	0.322	0.05	3.18	0.38	2.97	0.18	11.47	14.62	248.72	5.55
		III-C2	***Abaradinou***	17,300	31	543	1.618	0.70	1.86	4.18	6.70	0.89	6.65	14.24	528.67	2.62
		III-C3	Akakomoekro	13,300	39	522	0.046	0.12	2.17	2.34	2.07	0.14	7.77	9.98	512.36	1.91
		III-C4	***Ganse***	22,500	41	918	0.027	0.15	2.56	2.73	2.99	0.92	9.20	13.11	904.95	1.43
		III-C5	***Kafolon***	5,668	76	433	0.049	0.30	0.99	1.34	0.54	0.62	3.55	4.71	428.72	1.09
		III-C6	N'dakro	6,222	31	195	1.441	0.21	1.76	3.41	14.39	0.22	6.28	20.89	174.37	10.70
		Sub total	Comoe basin	67,598	43	2,875	3.503	1.54	12.52	17.56	29.67	2.96	44.92	77.56	2,797.79	2.70
	Kolodio	VII-C1	***Kontodou***	7,078	46	328	0.000	0.02	1.45	1.47	0.00	0.04	5.19	5.23	322.27	1.60
		VII-C2	Vonkoro	5,471	46	253	0.175	0.03	0.46	0.66	3.80	0.03	1.91	5.74	247.41	2.27
	Bia	VIII-C1	Mouth Lagoon	0	135	0	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		VIII-C2	Krindjaabo	144	135	19	0.053	0.09	0.47	0.61	0.29	0.11	1.67	2.07	17.39	10.64
		VIII-C3	***Ayame Dam2***	2,530	135	342	0.027	0.23	0.46	0.72	0.11	0.25	1.70	2.06	339.88	0.60
		VIII-C4	***Bian***	236	135	32	0.000	0.14	0.05	0.19	0.00	0.12	0.19	0.31	31.59	0.96
	Agenby	IX-C1	Adjin	592	90	53	0.000	0.02	0.86	0.88	0.00	0.02	3.04	3.06	50.41	5.73
		IX-C2	***Irho***	1,184	90	107	0.328	0.15	1.79	2.26	2.08	0.20	6.44	8.72	98.23	8.15
		IX-C3	Loboakoudzin	1,274	90	115	0.094	0.03	0.46	0.59	1.23	0.06	1.63	2.92	112.15	2.54
		IX-C4	***Kossihouen***	2,483	90	224	0.063	0.20	1.14	1.40	0.00	0.25	4.07	4.32	219.96	1.93
		IX-C5	Agboville	4,878	90	441	0.470	0.30	1.02	1.79	3.89	0.41	3.67	7.98	432.63	1.81
		IX-C6	Ira	444	90	40	0.089	0.04	1.00	1.13	0.00	0.05	3.60	3.65	36.45	9.10
	Total and of Comoe and surrounding basin			93,912	51	4,830	4.802	2.78	21.68	29.27	41.08	5.00	78.03	124.11	4,706.17	2.56
Total or average of Discontinuous aquifer				337,631	92	30,987	6.951	18.32	86.63	111.90	130.23	34.74	310.37	475.34	30,513.17	1.53
General aquifer	Coastal area	GA-1	Grand Lahou	1,083	200	217	0.014	0.43	0.56	1.01	4.86	0	0.31	5.51	211.47	2.40
		GA-2	Mouth of Bandama	389	200	78	0.039	0.07	0.20	0.31	0.33	0.10	0.73	1.15	77.38	0.55
		GA-3	Abidjan	3,516	354	1,244	94.625	0.00	6.09	100.71	242.91	0.00	21.92	264.83	979.58	21.28
		GA-4	Grand Bassan	729	336	245	0.070	0.04	0.70	0.81	0.65	0	2.00	2.68	244.66	0.28
		GA-5	Mouth of Lagoon	2,675	381	1,019	0.363	0.26	0.75	1.37	5.16	0	2.74	8.39	1,013.46	0.55
Total General aquifer				8,392	334	2,803	95.111	0.80	8.30	104.21	253.91	0.96	27.69	282.56	2,526.55	9.87
Grand total				346,023	98	33,790	102.062	19.12	94.93	216.10	384.14	36.66	365.76	757.90	33,039.72	2.22

Hydrogeology	River basin	Control point (***bold-type*** = main Control Point) / Groundwater Basin		Area of unit basin	Groundwater potential		Groundwater in 1998				Groundwater demand in 2015 (MCM/y)				Balance between Potential & Demand (2015) *	
							Urban	Rural	Agricu	Total	Urban	Rural	Agricult	Total		
		No	Name	(km2)	(mm)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	MCM/y	(MCM)	MCM/y	MCM/y	%

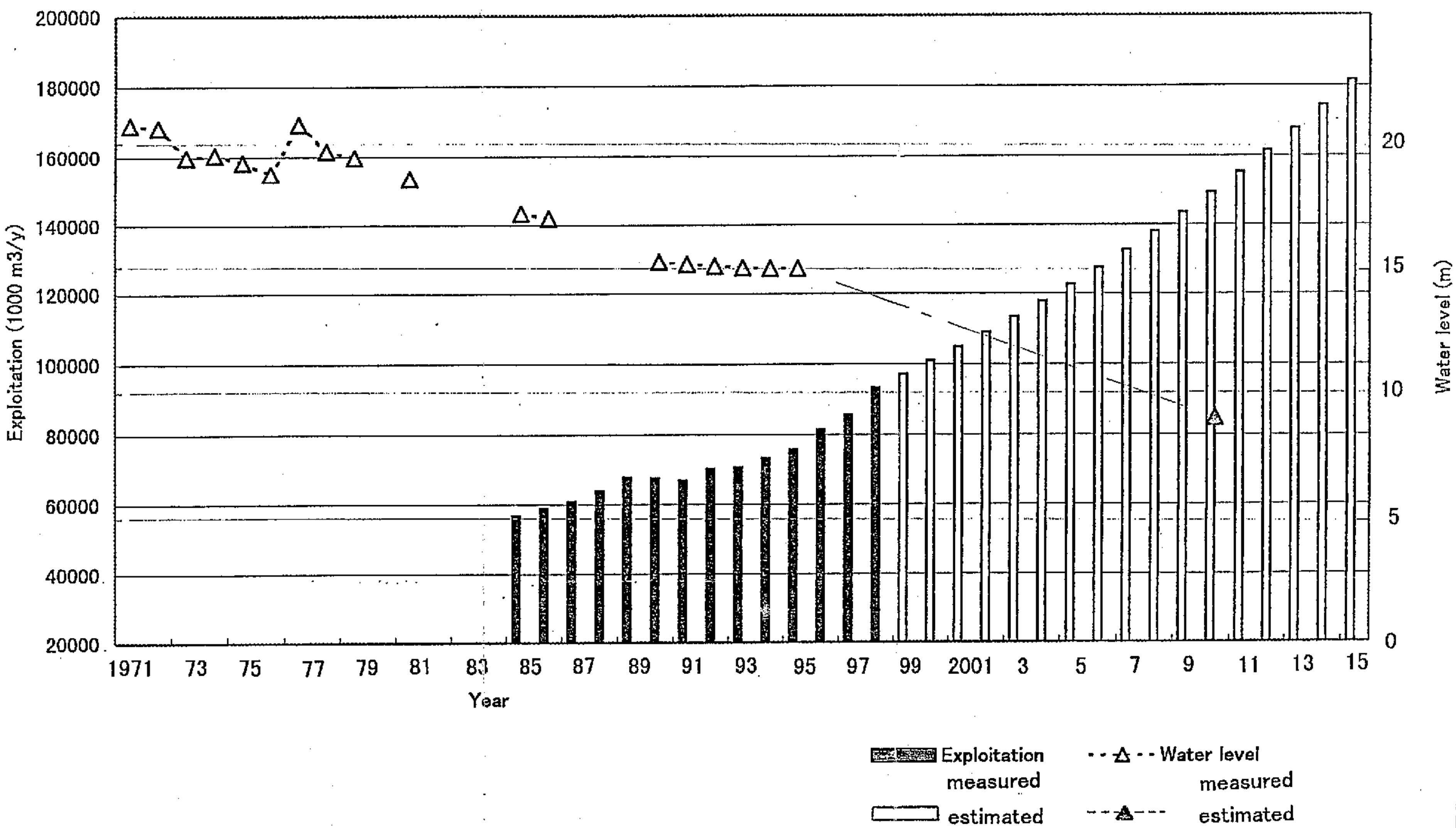
* Balance between Potential and demand (2015) ; MCM/Y=Groundwater potential − Groundwater demand in 2015
; % = 100*(Groundwater demand (2015)/Groundwater potential)

Figure 3.3-1 Relation between groundwater level and exploitation (No. 724 observation borehole)



Modefied from Final report of "Etude de la gestion et de la protection de la nappe assurant l'alimentation en eau potable d'Abidjan" (by BNETD & MIE/DH 1997)

Figure 3.3-2 Relation between groundwater level and exploitation (No. 629 observation borehole)



Modefied from Final report of "Etude de la gestion et de la protection de la nappe assurant l'alimentation en eau potable d'Abidjan" (by BNETD & MIE/DH 1997)