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THE NHRC WATER DATABASE FOR PLANNING AND RESEARCH

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ABSTRACT

The NHRC Water Database is a collection of hydrologic, hydrogeologic and geologic data, and other water-related data and information on the Metro-Manila and the Laguna Lake Basins. Gathered through the course of the three-year IDRC-funded research study "Water Resources Management Model for Metro Manila" undertaken by the NHRC, the data and information were contributed by the MWSS, MGB, EMB, LLDA, UP NIGS, UP University Library, LWUA, NAMRIA, PAGASA, BSWM, DPWH, DOH, and OEA.

The processing and analysis of the data and information were primarily aimed at obtaining the inputs to the Conjuctive-Use Water Resources Management Model or CUWARM. Digitized maps (e.g. soil type, land cover, geology, drainage basin definitions), contour plots (e.g. topography, geologic basement, mean annual rainfall, piezometric levels), statistical parameters and plots of time series data (e.g. rainfall, streamflow, groundwater level), and well lithologic logs are some of the computer-generated outputs from the database. Through the database, water related information can readily be accessed and processed to facilitate various research or planning activities by NHRC and other interested parties or agencies.

(Based on a paper presented in the **Regional Workshop on Management Modelling for Conjunctive Water Use**, sponsored by IDRC-GRC-UPERDFI-NHRC, held on March 16-17, 1993, at the National Engineering Center, U. P. Diliman, Quezon City.)

INTRODUCTION

Realizing the need for a management tool to assist water supply agencies in their efforts to satisfy the increasing water demand, the National Hydraulic Research Center (NHRC) has undertaken the research study "Water Resources Management Model for Metro Manila" with a financial grant from the International Development Research Centre (IDRC) of Canada. Conceived to address the conjunctive use of surface and groundwater resources in the Metro Manila and Laguna Lake Basins, a mathematical model was developed for the study area.

Dubbed with the acronym CUWARM (for Conjunctive-Use Water Resources Management Model), the model can be used to evaluate various alternatives in the development and use of water resources in the region.

As the first logical step to the modeling task, all available secondary data and technical reports relevant to the study area were collected. It has been recognized even prior to the inception of the project that there exists a vast but usually underrated collection of water-related information available with the various public water agencies. Gathered were specialized data and information, published or otherwise, resulting from past and existing water supply programs and agency projects e.g. surveys, feasibility studies, design and construction plans, operational and erehabilitation studies.

Far from being a complete water information collection, the dåtabase is a modest accumulation of water-related data and information relevant to the study area (Metro Manila and Laguna Lake watersheds) which has been achieved through the concerted efforts of the various agencies which contributed the information. It can not be overstated that the NHRC Water Database, a product of multi-agency cooperation, provides the key to information sharing among agencies concerned with water resources management. With the information integrated into a single repository, data access and analysis could be significantly facilitated. Information generated from the database could be utilized by the agencies and other interested parties for various planning and research applications.

This paper describes the data and information available in the NHRC Water Database. It also presents an assessment of the collected data and its application in the water resources management model for Metro Manila and the Laguna Lake Basins. Table 1 provides a summary table of the agency source versus type of collected data, as listed below:.

MWSS - well location, geologic, hydrogeologic and groundwater quality maps; well information; groundwater quality data; and technical reports
MGB - geological maps and technical reports
NWRB - thematic, well location, hydrogeologic and geologic maps, water permitees and well inventory data files; and technical reports
EMB - technical reports; surface and groundwater quality data
LLDA - soil, contour, geologic, groundwater resources, slope and land use maps; surface water quality; lake level data; and technical reports
LWUA - hydrogeologic maps; well data and technical reports
NAMRIA- topographic, land use and land condition maps; and nautical charts
PAGASA- climatic data and technical reports
BSWM - land use, land systems, land management unit and soils physiography maps; and technical reports
DPWH - streamflow and lake stage data; well data; groundwater level data; NIA drilling reports, pumping test data, lithologic logs and water analysis
DOH - physical and chemical analysis data of water samples
OEA - seismic reflection data
UP NIGS- geologic maps and reports
UP University Library - historical maps

Table 1. Source agency versus type of collected data and information

AGENCY	TECHNICAL REPORTS	MAPS	WATER QUALITY DATA	WELL DATA	STREAMFLOW and LAKE STAGE DATA	CLIMATIC DATA	OTHER HYDROGEOLOGIC DATA
MWSS	*	*	*	*			*
MGB	*	*					
NWRB	*	*		*			*
EMB	*		*				
LLDA	*	*	*		*		
UP		*					
LWUA	*	*		*			
NAMRIA		*					
PAGASA	*					*	
BSWM	*	*					
DPWH				*	*		
DOH			*				
OEA							
Others	*						

COLLECTION OF DATA AND INFORMATION

Data and information collected may be generally classified as : technical reports, cartographic information, climatic data, streamflow and lake stage data, groundwater well data, surface water and groundwater quality data and seismic-reflection data.

Technical Reports

A total of 396 published and unpublished technical reports have been collected from the various agencies and other sources. Table 2 shows the summary breakdown of the reports according to agency source and geographic coverage. The reports were annotated to determine the contents of each report and list down information which may be useful for the modeling task. A complete listing of these reports by author or accession number is available at the NHRC library.

Cartographic Information

Cartographic information or maps collected give a combined total of 234, exclusive of attached map plates or figures found in several agency reports. The map collection could be classified as :

	Types	Number of maps
a.	Geologic Cross-sections	4
b.	Geologic Maps	21
c.	Groundwater Level Maps	9
d.	Groundwater Quality Maps	9
e.	Groundwater Quality Stations Map	1
f.	Historical Maps	3
g.	Hydrogeologic Maps	11
h.	Iso-resistivity Maps	11
i.	Land Use/Condition/Management Maps	57
j.	Nautical Charts	2
k.	Slope Map	1
l.	Soil Maps	2
m.	Surface Drainage Thematic Maps (1:250,000 and 1:50,000)	14
n.	Surface Water Quality Stations Map	1
o.	Topographic Contour Maps	76
p.	Water Permit Map	1
q.	Well Location Maps (1:25,000; 1:50,000 and 1:250,000)	11

Table 2. Summary breakdown of technical reports by agency source and geographic coverage

AGENCY	METRO MANILA	BULACAN	BATANGAS	CAVITE	LAGUNA	RIZAL	REGIONAL	NATIONAL	GENERAL	TOTAL
MWSS	24					2				26
MGB	7	29	1	4	17	39	2			99
NWRB		1	1	1	1	1	16	1		22
EMB	12							15		27
LLDA							10			10
LWUA		1		2	9	1		4		17
PAGASA	14				4	3				21
DPWH					45		13			58
BSWM		1	2	2	1					6
Others	19				2		4	3	84	112
TOTAL	74	32	4	9	79	46	45	23	84	396

Climatic Data

Daily rainfall data both in print and in magnetic form for 17 climatic stations within the study area have been collected from PAGASA. The location, period of data coverage and mean annual rainfall for the selected stations can be seen in Figure 1.

Streamflow and Lake Stage Data

A complete collection of streamflow and lake stage data from 29 DPWH-BRS gaging stations within the basin has been gathered. Data collected were in the form of discharge or gage height measurements on a daily basis and in monthly and annual summaries, together with discharge rating curves and tables. Figure 2 shows the location coordinates and periods of available record of the BRS stations.

Groundwater Well Data

A complete set of available well data from NWRB has been collected. Copied were the encoded well inventory data files which were classified according to province, with a combined total of 5659 well records from Batangas, Bulacan, Cavite, Laguna, Rizal and Metro Manila. The well records obtained consist of well location, well design, well lithology, pumping test data and analysis, and water level.

A separate database containing data on water rights was also collected from NWRB. The water rights file contains information on the name, address and location of grantee, the amount of granted water use, the type of water usage, and the date it was granted. Table 3 shows some statistics on the NWRB well inventory and water rights data files.

Groundwater level data for 57 NWRB observation wells monitored in the past were also obtained. Figure 3 shows the coordinates and periods of record for these wells.

Surface Water and Groundwater Quality Data

Surface water quality data from 35 sampling stations in Manila Bay, Laguna Lake and its tributary rivers, and Metro Manila Rivers have been obtained from LLDA and EMB. The location of these surface water quality monitoring stations for EMB and LLDA can be seen in Figures 4 and 5, respectively.

Groundwater quality data have been obtained from MWSS (Central Laboratory Division) for the period 1985 -1990. The data were encoded in a database file which consists of 390 total records containing the location, source and date of sampling, and the following water quality parameters : odor, color, turbidity, alkalinity, acidity, total chloride, total hardness, total iron, total residue, pH, flouride, nitrite, taste, bicarbonate, free carbon dioxide, silica and residual chloride, calcium, magnesium, sulfate and silicate.

Water quality data for the period 1982-1991 from both surface and groundwater sources were also obtained from the DOH (Bureau of Research Laboratory). A separate database file containing 976 entries was prepared for the DOH data. Figure 6 shows a sample screen display of the water quality database.

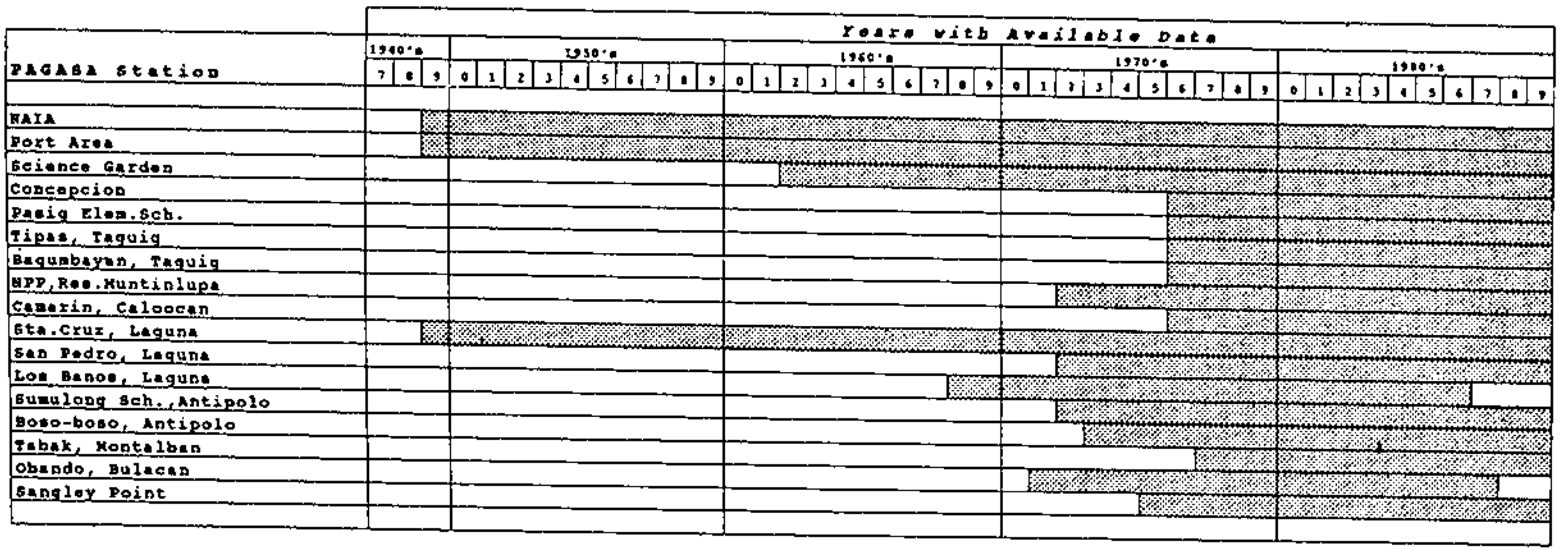


Fig. 1. Available climatic data from selected PAGASA stations

RIVER	LOCATION	COORDINATES						DRAINAGE AREA	1950	1955	1960	1965	1970	1975	1980	1985	1990
		LATITUDE			LONGITUDE												
		°	'	"	°	'	"	(SQ. KM.)									
Arangilan	Calamias, Cabuyao, Laguna	14	14	10	121	7	30	87.0									
Balanac (Lower)	Bucal, Magdalena, Laguna	14	14	0	121	26	15										
Balanac (Upper)	Bucal, Magdalena, Laguna	14	12	24	121	26	33	116.0									
Laguna Lake	Halang, Lumban, Laguna	14	18	58	121	27	50	3158.0									
Laguna Lake	Poblacion, Los Banos, Laguna	14	11	6	121	13	10	3158.0									
Laguna Lake	Poblacion, Muntinlupa, MM	14	21	29	121	2	46	3158.0									
Laguna Lake	Tayuman, Binangonan, Rizal	14	31	22	121	9	16	3158.0									
Mabacan	Mabacan, Calauan, Laguna	14	9	52	121	17	29	46.0									
Marikina	Manggahan, Pasig	14	35	12	121	5	22	527.0									
Marikina	Rosario, Pasig, MM	14	36	12	121	5	11	532.0									
Marikina	San Rafael, Montalban, Rizal	14	44	0	121	10	20	282.0									
Marikina	Sto. Nino, Marikina	14	38	15	121	5	30	499.0									
Mata	Coralan, Sta. Maria, Laguna	14	29	13	121	25	0	35.0									
Mayor	Bagumbayan, Siniloan, Laguna	14	28	0	121	27	40	45.0									
Nangka	Nangka, Marikina, MM	14	41	53	121	6	30	542.0									
Pagsanjan	San Isidro, Pagsanjan, Laguna	14	16	4	121	27	25	247.1									
Paputok	Mabacan, Calauan, Laguna	14	8	12	121	21	3	8.5									
Pasig	Beata, Pandacan, MM	14	35	47	121	0	37	3923.0									
Pasig	Del Pan, Port Area, MM	14	35	48	121	58	2	3923.0									
Pasig	McKinley, Makati, MM	14	33	51	121	3	42	3807.0									
Pasig	Napindan, Taguig, MM	14	32	28	121	5	44	3159.0									
Pasig	Pineda, Pasig, MM	14	33	50	121	3	39	3821.0									
Pasig	San Jose, Makati, MM	14	34	13	121	2	40	3824.0									
Pililia	San Lorenzo, Pililia, Rizal	14	18	53	121	18	26	37.0									
San Cristobal	Calamba, Laguna	14	13	6	121	9	19	106.0									
San Juan	Parian, Calamba, Laguna																
Sta. Cruz	Calumpang, Liliw, Laguna	14	11	55	121	26	30	103.0									
Sta. Cruz	Pagsawitan, Sta. Cruz, Laguna	14	15	46	121	25	20	124.0									
Sta. Maria	Makasipak, Sta. Maria, Laguna	14	29	0	121	25	0	25.0									

Fig. 2. Streamflow and lake stage data of the Laguna Lake Basin from BRS

Table 3. Some statistics for NWRB well database

NWRB WELL INVENTORY FILE									
PROVINCE or REGION	TOTAL RECORDS	WITH WELL LOGS (DEPTH > 50M.)		WITH WELL LOGS AND COORDINATES		WITHIN STUDY AREA		WITHIN STUDY AREA WITH COORDINATES	
		NUMBER	(%)	NUMBER	(%)	NUMBER	(%)	NUMBER	(%)
BATANGAS	1557	552	*35.45%*	205	*13.17%*	99	*6.36%*	20	*1.28%*
BULACAN	433	262	*60.51%*	65	*15.01%*	51	*11.78%*	6	*1.39%*
CAVITE	717	162	*22.59%*	72	*10.04%*	80	*11.16%*	5	*0.70%*
LAGUNA	765	191	*24.97%*	154	*20.13%*	765	*100.00%*	189	*24.71%*
RIZAL	450	86	*19.11%*	26	*5.78%*	450	*100.00%*	74	*16.44%*
MANILA	1737	554	*31.89%*	547	*31.49%*	1737	*100.00%*	623	*35.87%*
TOTAL	5659	1807	*31.93%*	1069	*18.89%*	3182	*56.23%*	917	*16.20%*

NWRB WELL INVENTORY FILE					NWRB WATER RIGHTS FILE				
PROVINCE or REGION	LOG OR DRILL DEPTH > 50M.		W/ DISCHARGE OR PUMPAGE		TOTAL RECORDS	GROUNDWATER USE		SURFACE WATER USE	
	NUMBER	(%)	NUMBER	(%)		NUMBER	(%)	NUMBER	(%)
BATANGAS	867	*55.68%*	577	*37.06%*	288	169	*58.68%*	119	*41.32%*
BULACAN	275	*63.51%*	87	*20.09%*	212	156	*73.58%*	56	*26.42%*
CAVITE	425	*59.27%*	75	*10.46%*	131	71	*54.20%*	60	*45.80%*
LAGUNA	257	*33.59%*	168	*21.96%*	224	125	*55.80%*	99	*44.20%*
RIZAL	183	*40.67%*	137	*30.44%*	315	185	*58.73%*	130	*41.27%*
MANILA	1562	*89.93%*	1343	*77.32%*	786	766	*97.46%*	20	*2.54%*
TOTAL	3569	*63.07%*	2387	*42.18%*	1956	1472	*75.26%*	484	*24.74%*
WITHIN STUDY AREA			2157	90.36%		1108	75.27%		

CODE	LOCATION	COORDINATES					
		LATITUDE			LONGITUDE		
		o	'	"	o	'	"
B3	Sta.Clara, Sta. Maria, Bulacan	14	49	25	120	58	55
B3A	Patag, Sta. Maria, Bulacan	14	49	45	120	58	25
B4	Poblacion, Norzagaray, Bulacan						
B9	Palasan, Valenzuela, Bulacan	14	41	55	120	58	40
BG8	Biga, Sto. Tomas, Batangas	14	6	35	121	8	25
BG12	Poblacion, Malvar, Batangas	14	2	50	121	9	30
CA7	Poblacion, Carmona, Cavite	14	19	30	121	3	25
CA8	Amolong, Silang, Cavite	14	13	50	120	58	25
LA1	San Antonio, Binan, Laguna	14	19	50	121	4	55
LA2	Sala, Cabuyao, Laguna	14	16	45	121	7	25
LA3	Poblacion, Magdalena, Laguna	14	12	40	121	25	20
LA4	Mashai, Los Banos, Laguna	14	10	45	121	15	0
LA5	Pila, Laguna	14	14	50	121	21	40
LA5A	San Antonio, Pila, Laguna	14	13	35	121	21	30
LA6	Poblacion, Sta. Cruz, Laguna	14	17	0	121	24	50
LA6A	Bubukal, Sta. Cruz, Laguna	14	15	50	121	23	45
LA7	Poblacion, Paete, Laguna	14	21	40	121	29	0
LA7A	Kinali, Paete, Laguna	14	21	5	121	28	55
LA8	Poblacion, Mabitac, Laguna	14	25	50	121	25	30
LA9	Poblacion, San Pablo City, Lag.	14	4	25	121	19	25
LA10	Dayap, Calauan, Laguna	14	8	55	121	19	10
LA11	Mabini, San Pedro, Laguna	14	21	35	121	3	10
LA12	Poblacion, Cavinti, Laguna	14	15	5	121	30	5
LA13	Maitim, Bay, Laguna	14	10	40	121	16	0
M3	Macabling, Sta. Rosa, Laguna						
P10	Sta. Cruz, Sta. Rosa, Laguna	14	16	42	121	4	57
P13	Manggera, Sta. Rosa, Laguna	14	15	21	121	4	48
P16	Pulong Sta. Cruz, Sta. Rosa,Lag.	14	16	18	121	4	59
P17	Dita, Sta. Rosa, Laguna	14	17	6	121	6	24
P19	Alas-asan, Sta. Rosa, Laguna	14	14	36	121	5	15
P20	Pulong Sta. Cruz, Sta. Rosa,Lag.						
P21	Alas-asan, Sta. Rosa, Laguna	14	14	37	121	4	57
P23	Sto.Domingo, Sta. Rosa, Laguna	14	14	4	121	3	1
P24	Alas-asan, Sta. Rosa, Laguna	14	14	41	121	5	12
P26	Macabling, Sta. Rosa, Laguna	14	18	39	121	6	6
P40	Langkiwa, Binan, Laguna	14	17	42	121	3	6
P43	Soro-soro, Binan, Laguna	14	19	42	121	3	33
P44	Palo Alto, Calamba, Laguna	14	11	27	121	6	48
P46	Pulong Sta. Cruz, Sta. Rosa,Lag.	14	16	50	121	5	3
P50	Mayapa, Calamba, Laguna	14	13	5	121	8	24
P52	Aplaya, Sta. Rosa, Laguna	14	19	18	121	7	5
RI1	Poblacion, Novaliches, MM	14	43	25	121	2	30
RI2	Poblacion, San Mateo, Rizal	14	41	40	121	6	25
RI3	Lopez Jaena St., Pasig	14	34	15	121	4	26
RI4	Pob., Kakarong St., Makati	14	33	45	121	1	40
RI5	Tambac, Taguig	14	31	20	121	4	35
RI6	Pamplona, Las Pinas	14	27	50	120	58	15
RI6A	Manuyo, Las Pinas	14	28	25	120	58	30
RI7	Poblacion, Binangonan, Rizal	14	28	25	121	11	50
RI7A	Darangan, Binangonan, Rizal	14	29	30	121	11	5
RI8	Poblacion, Morong, Rizal	14	30	10	121	14	25
RI9	Poblacion, Tanay, Rizal	14	30	24	121	17	5
RI10	Maybangkal, Teresa, Rizal	14	33	25	121	12	25
RI11	Poblacion, Jala-jala, Rizal	14	21	40	121	19	40
RI12	Haleyhayin, Pililla, Rizal	14	28	35	121	19	5
RI13	Pob., Malinao St., Taguig, MM	14	33	45	121	4	25
RI14	Hagonoy, Taguig, MM	14	30	55	121	4	10

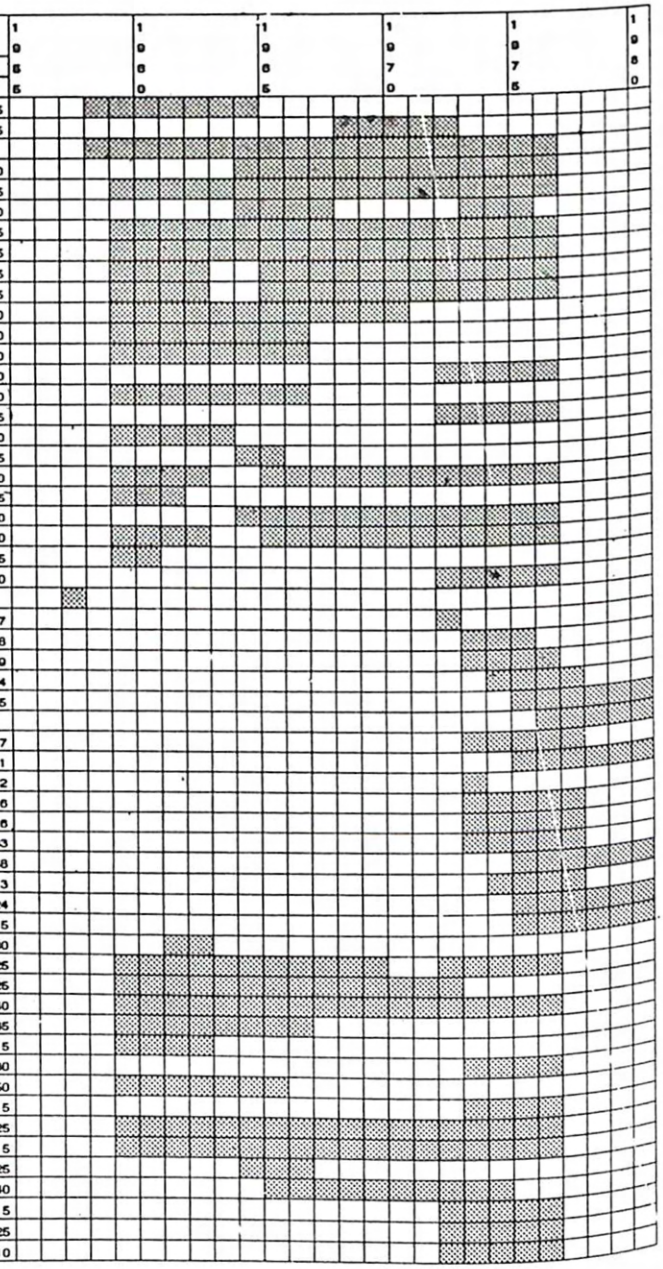


Fig. 3. Groundwater level data from NWRB

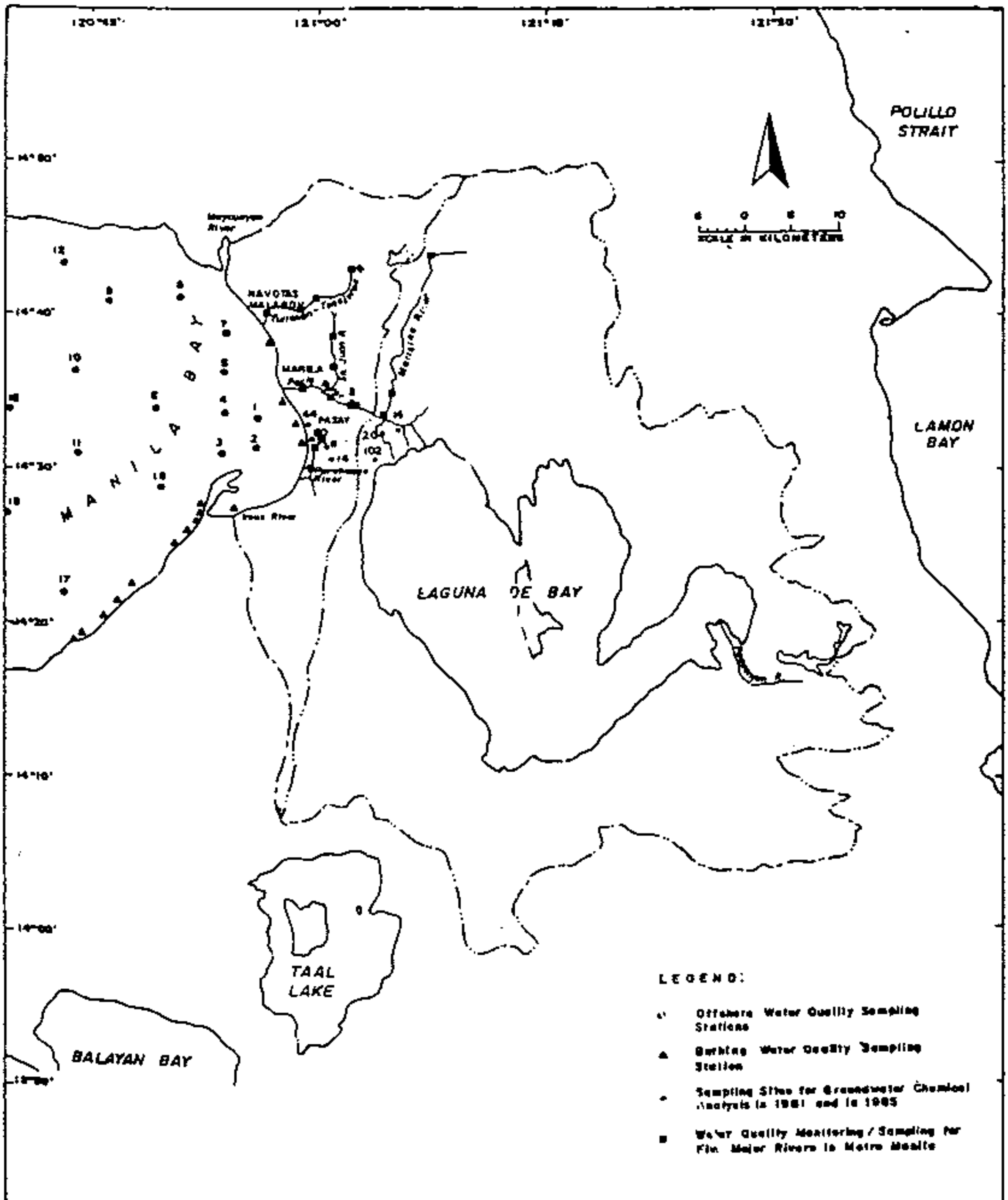


Fig. 4 EMB surface water quality stations

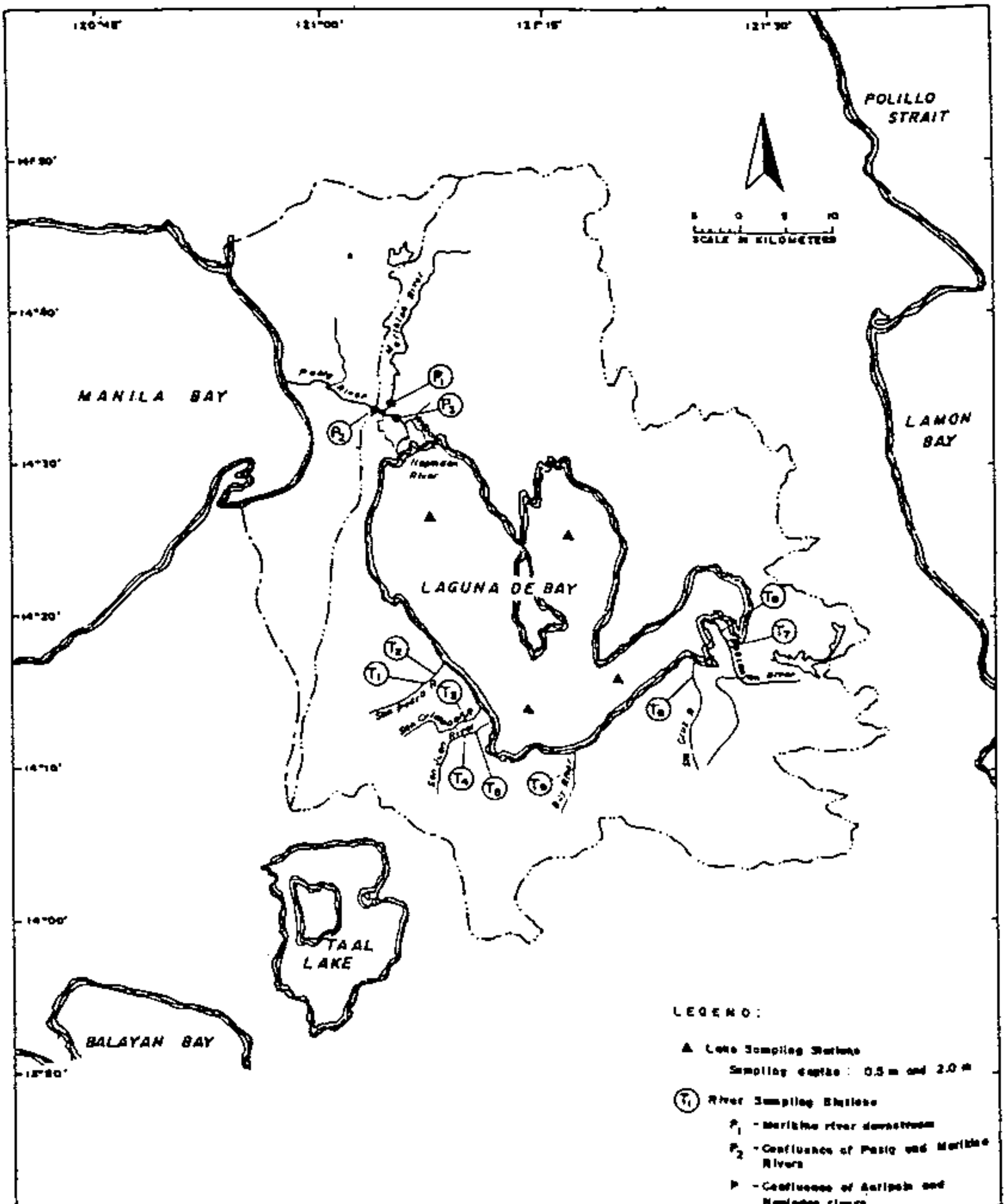
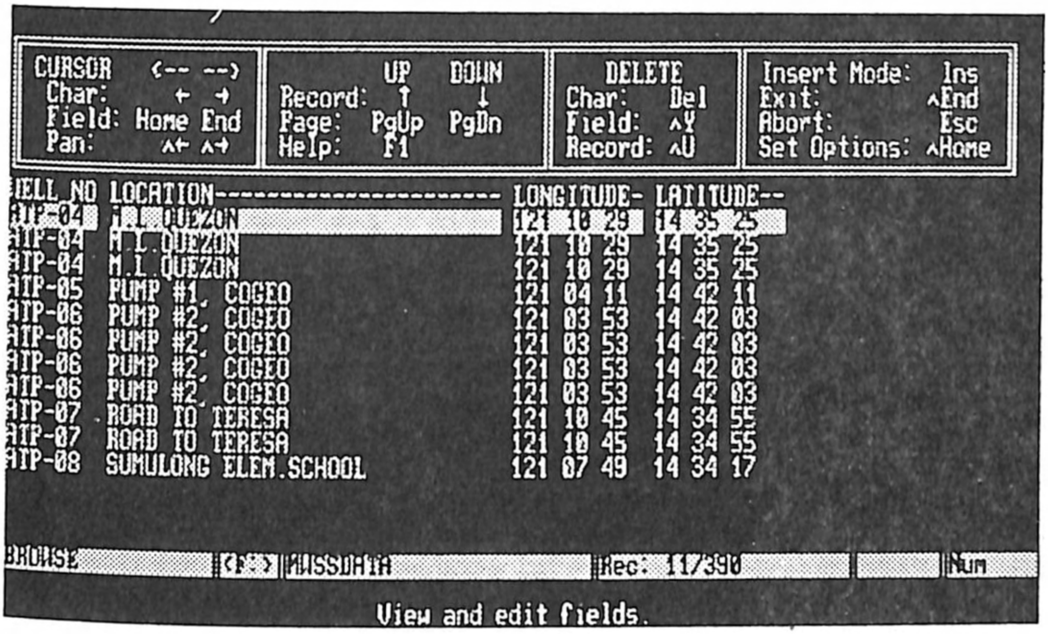


Fig. 5 LLDA surface water quality stations



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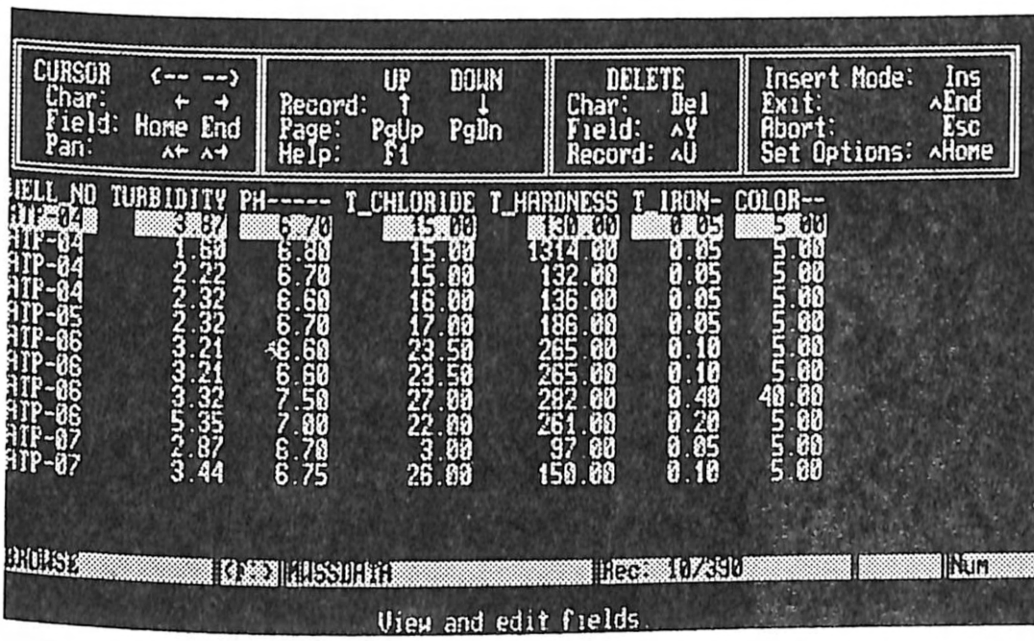
WELL_NO	LOCATION	LONGITUDE	LATITUDE
ATP-04	M.L.QUEZON	121 10 29	14 35 25
ATP-04	M.L.QUEZON	121 10 29	14 35 25
ATP-04	M.L.QUEZON	121 10 29	14 35 25
ATP-05	PUMP #1, COGEO	121 04 11	14 42 11
ATP-06	PUMP #2, COGEO	121 03 53	14 42 03
ATP-06	PUMP #2, COGEO	121 03 53	14 42 03
ATP-06	PUMP #2, COGEO	121 03 53	14 42 03
ATP-06	PUMP #2, COGEO	121 03 53	14 42 03
ATP-07	ROAD TO TERESA	121 10 45	14 34 55
ATP-07	ROAD TO TERESA	121 10 45	14 34 55
ATP-08	SUMULONG ELEM.SCHOOL	121 07 49	14 34 17

BROWSE <F:> AWSSDATA Rec: 11/390 Num

View and edit fields.



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Insert Mode: Ins Exit: ^End Abort: Esc Set Options: ^Home

WELL_NO	TURBIDITY	PH	T_CHLORIDE	T_HARDNESS	T_IRON	COLOR
ATP-04	3.87	6.70	15.00	130.00	0.05	5.00
ATP-04	1.60	6.80	15.00	1314.00	0.05	5.00
ATP-04	2.22	6.70	15.00	132.00	0.05	5.00
ATP-04	2.32	6.60	16.00	136.00	0.05	5.00
ATP-05	2.32	6.70	17.00	186.00	0.05	5.00
ATP-06	3.21	6.60	23.50	265.00	0.10	5.00
ATP-06	3.21	6.60	23.50	265.00	0.10	5.00
ATP-06	3.32	7.50	27.00	282.00	0.40	40.00
ATP-06	5.35	7.00	22.00	261.00	0.20	5.00
ATP-07	2.87	6.70	3.00	97.00	0.05	5.00
ATP-07	3.44	6.75	26.00	150.00	0.10	5.00

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Fig. 6. Sample screen displays for the water quality database

Seismic-reflection Data

Seismic-reflection survey data for six (6) seismic lines (final stack/wave migration) taken in 1981 at eastern Cavite and western Laguna were obtained from OEA-EDS. The NWRB georesistivity survey in 1982 provided thickness data of qualitatively described aquifers in Laguna and Rizal. A more recent MWSS/JICA (1990) electro-resistivity survey provided data for the interpreted hydrogeologic basement in Antipolo, Rizal. The geographical coverage of these surveys can be seen in Figure 7.

OVERALL ASSESSMENT OF DATA

Table 4 shows an overall quantitative assessment of data and information according to data type and geographical coverage. It can be observed from the table that Metro Manila is the most favored region having the most number of available data followed by Laguna and Rizal provinces. Although a comparable amount of data were found in the other provinces (Bulacan, Cavite and Batangas), the number is not significant as far as the Metro Manila and Laguna Lake Basins are concerned because only a few of them actually apply to the study area. The maps were mostly regional in scope while the more localized ones mostly cover the Metro Manila area.

A closer look at the collection also indicates that the data collection process is being undertaken by various agencies thus generating a vast information base. The monitoring programs may however vary among agencies, depending upon their respective programs or concerns. A number of short-term studies, mostly localized, have remained reliable sources of primary data. However, there appears to be a great need for a standardized and coordinated program of collecting and monitoring hydrologic, hydrogeologic and water-related data and information.

FIELD VERIFICATION

Field visits to PAGASA climatic stations, DPWH lake and river gaging stations and EMB water quality monitoring stations were done to evaluate the actual location and condition of the monitoring stations thus giving indications on the reliability of the data collected. Figure 8 shows the location of the monitoring stations visited. A narrative description of the monitoring stations has been previously reported by NHRC (1992).

PROCESSING AND ANALYSIS OF DATA

The selected method by which data is processed and analyzed mainly depends on the intended use of the information. Having been collected for the purpose of developing a regional conjunctive water use model, data analysis was aimed at producing the required model data inputs. The computer-generated maps or graphic displays merely illustrate examples for presentation of the data for subsequent analysis. Once these geographically-referenced information are transcribed into computer-readable form such as in ASCII or digitized format,

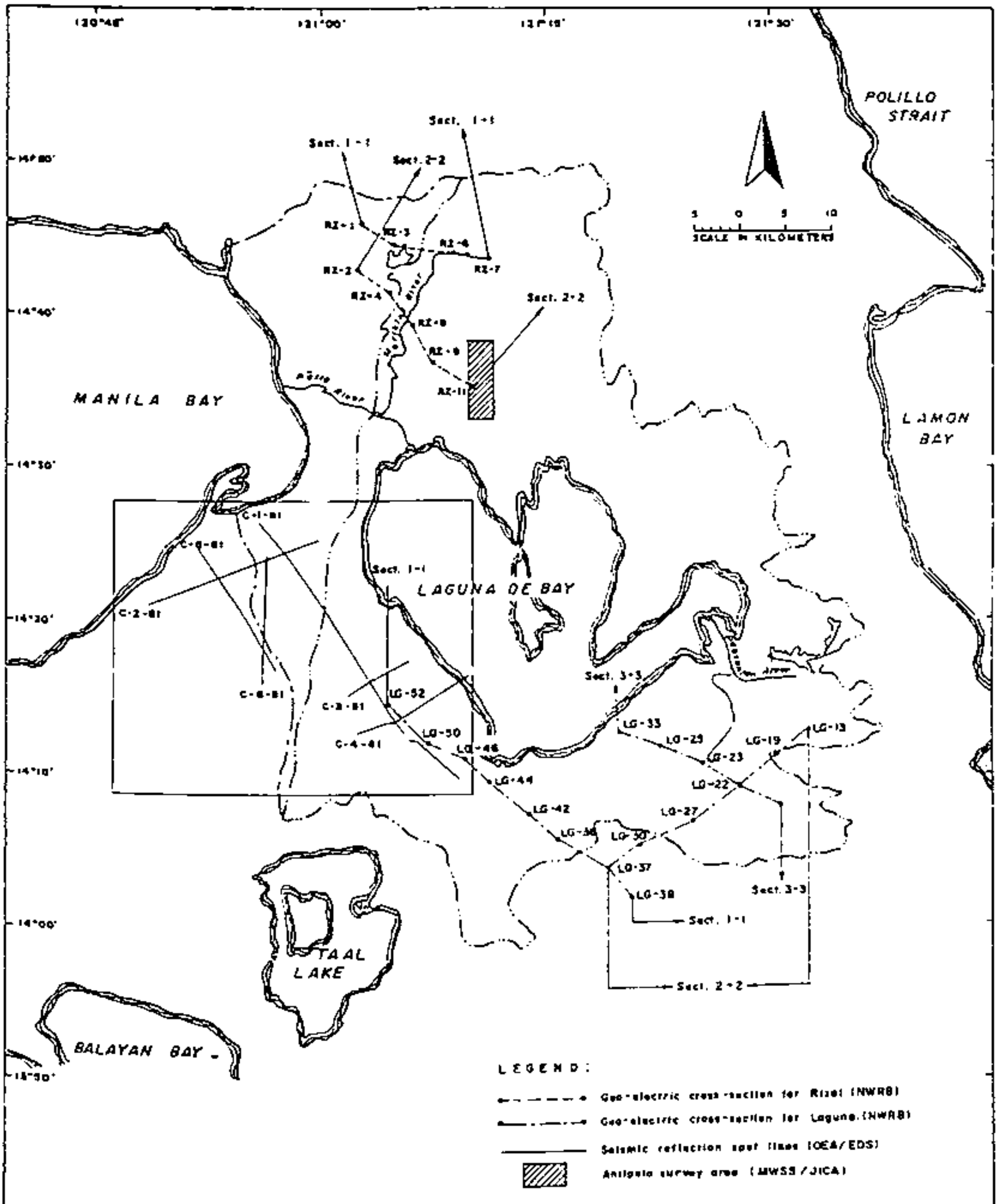

Fig. 7 Location map of geophysical surveys by OEA, MWSS/JICA and NWRB

Table 4. Quantitative assessment of data and information by geographic coverage

DATA TYPE	METRO MANILA	BULACAN	BATANGAS	CAVITE	LAGUNA	RIZAL	REGIONAL	TOTAL
TECHNICAL REPORTS	21	32	4	9	29	43	16	154
MAPS	19		1	4	2	6	202	234
WATER QUALITY STATIONS	24				9		4	37
GROUNDWATER DATA *(No. of Stations)*								
NWRB well data	1989	433	1557	717	765	450		5911
NWRB water level	8	4	2	2	33	8		57
DPWH-PMO data				115	158	73	49	395
DPWH-NIA data					26			26
SURFACE WATER STATIONS	11				15	3		29
CLIMATIC DATA STATIONS	18	2		1	8	8		37

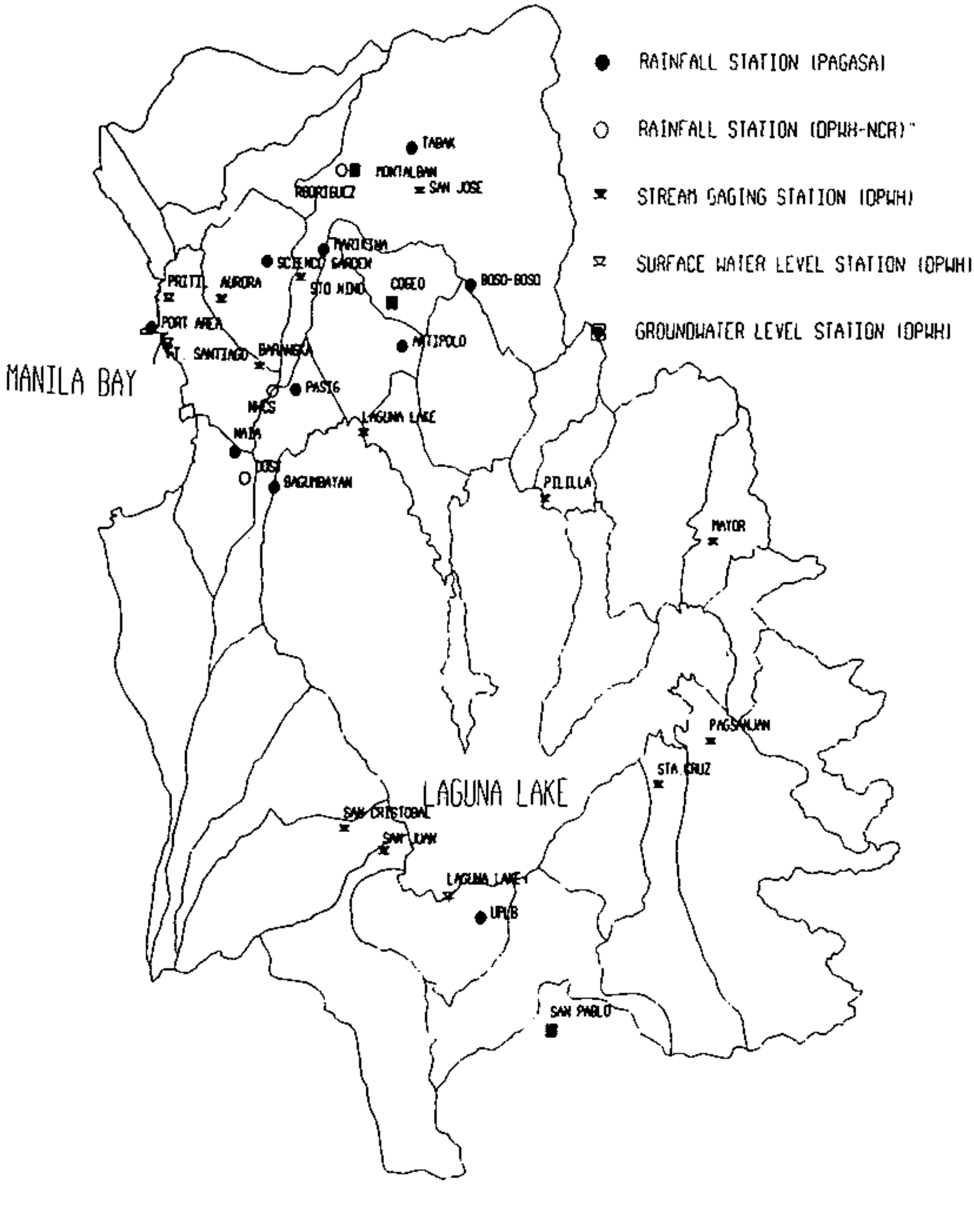

Fig.8. Location map of visited monitoring stations

there are countless ways of transforming and analyzing them as more sophisticated applications software or computer programs could readily access these files. For instance, generation of new grid files by overlaying of various grids and creating color-coded maps could be done through a GIS software. Computer programs could also read these files as input for a mathematical model such as CUWARM.

Prior to analysis, however, initial screening of source information to assess data quality has been performed. The use of commercially available computer softwares undoubtedly expedited the processing stage tremendously.

Whenever available, computer data files from the source agencies were copied. Otherwise raw data from the reports or hardcopy files were transcribed and encoded in a computer database. Computer programs were written to access the database, perform statistical analyses, or extract specific data to create export files in standard ASCII text format which could easily be imported by other specialized softwares for further processing. Relevant cartographic data were also encoded thru the digitizer.

As desired in any database management system, the database should be independent of the applications programs that use it. Although most of the agency users are familiar with the more common database or spreadsheet softwares, different agencies adopt their own unique database structure, thus requiring specially written programs to import and export these files in the desired format. One fundamental consideration in the design of the database structure must be, that regardless of the database software used, it must have a facility to export data in standard format according to the needs of different users. This step is necessary to render flexibility to the database and to overcome format incompatibility which often times hinders the exchange of information desired between databases or application softwares.

INFORMATION GENERATED FROM DATABASE

To demonstrate the applications of the database in water resources modelling, the most relevant information generated from the database which provided the necessary inputs to CUWARM are discussed in the following sections.

Soil Type and Land Use

Soil maps for Laguna and Rizal were digitized based on retraced BSWM maps dated 1946. Figure 9 shows a digitized soil map compiled for the Metro Manila and Laguna Lake Basins.

Land cover based on classified Landsat thematic map image were also compared with available BSWM land use maps. In one related research, Liongson and Blanco (1992) also presented the reclassed and resampled land use/cover image map using GIS software (Figure 10).

The digitized soil type and land use data provided the input parameters to a surface water balance model of the various sub-basins comprising the Laguna Lake Basin.

Fig.9. Digitized soil map for Metro Manila and Laguna Lake Basins

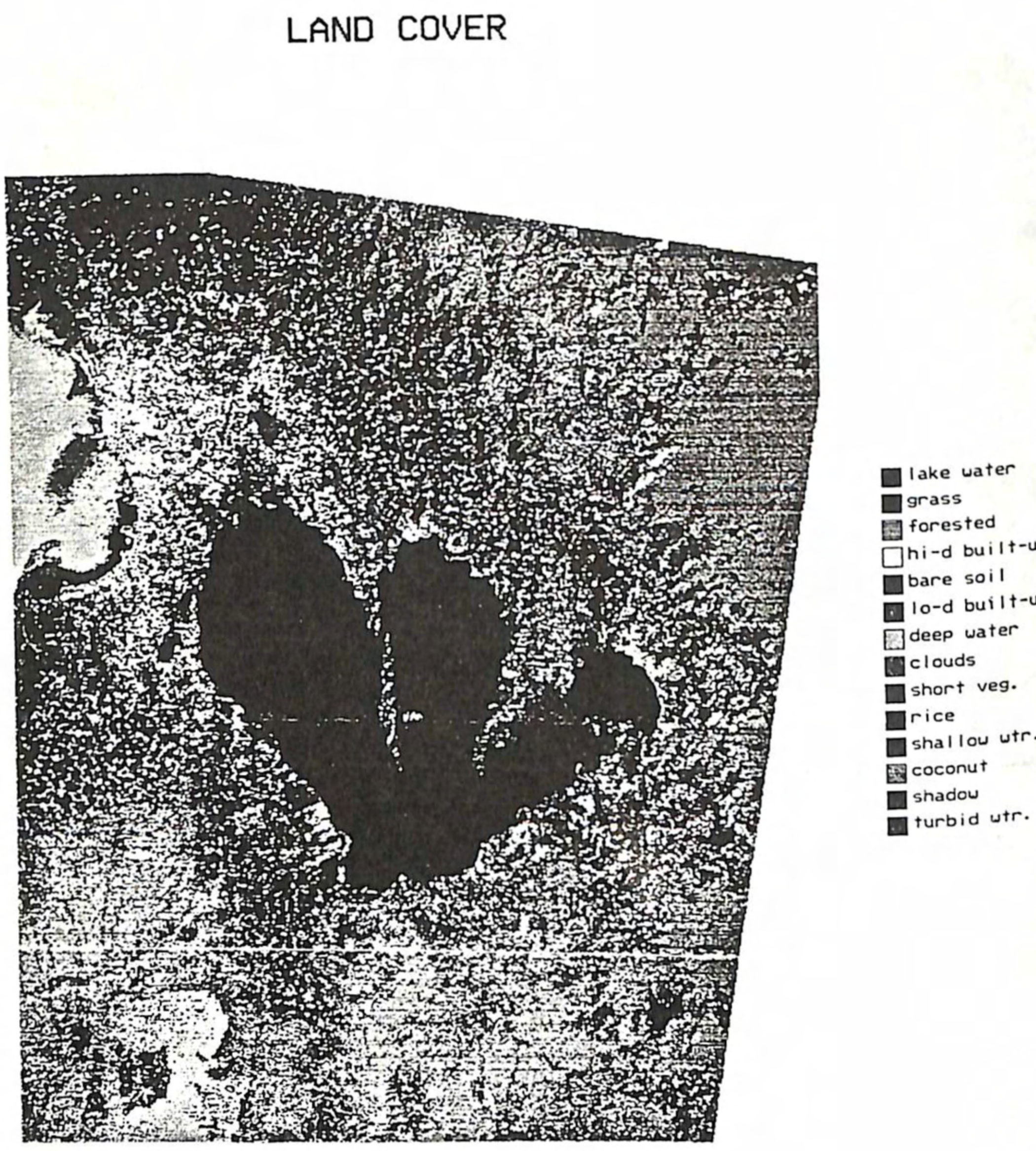

Fig. 10. Digitized land cover image map for Metro Manila and Laguna Lake Basins

Surface Geology

NHRC (1992) has previously presented a more detailed review of the geology of the Laguna Lake and Metro Manila basins based on the various technical reports. Geologic maps representing the significant geologic strata were digitized based on the maps and reports from MGB and NIGS. Figure 11 shows the digitized map showing surface geology, major fault alignments and available geological cross-sections in the area.

Climatic Data

The collected daily rainfall values could be aggregated on a weekly, monthly or annual basis depending on the time step requirements of a model. The mean monthly rainfall from 15 rain gaging stations within the Laguna Lake Basin could be found in Table 5. To present the spatial distribution of rainfall, Figure 12 shows an isohyetal map for the region based on the mean annual rainfall for 15 PAGASA stations (2 stations were not used due to data inconsistencies). Potential evapotranspiration (PET) was computed from evaporation data from two of the PAGASA stations (Los Banos and Science Garden). The temporal and spatial distribution of rainfall and PET comprise the basic data inputs to a watershed water balance model.

Streamflow and Lake Stage Data

Streamflow and lake stage data from 29 DPWH-BRS stations were encoded and analyzed. Figure 13 shows the streamflow hydrograph for the upper Balanac River (1967-1970) as input data to a baseflow separation model.

The Laguna Lake level time series data were used in a lake water balance model. Figure 14 presents the lake water balance model for 1985-1990.

Watershed Delineation and Lake Floodplain

The topographic and thematic maps were used to define the watershed boundaries of the basins draining to Laguna Lake and those encompassing Metro Manila. Where data is scarce, small sub-basins were lumped together to form one sub-basin. Using 1:50,000 NAMRIA topographic maps, the map-delineated boundaries were digitized, an activity which produced not only the sub-basin boundaries (Figure 15) but also the drainage area of each sub-basin (Table 6).

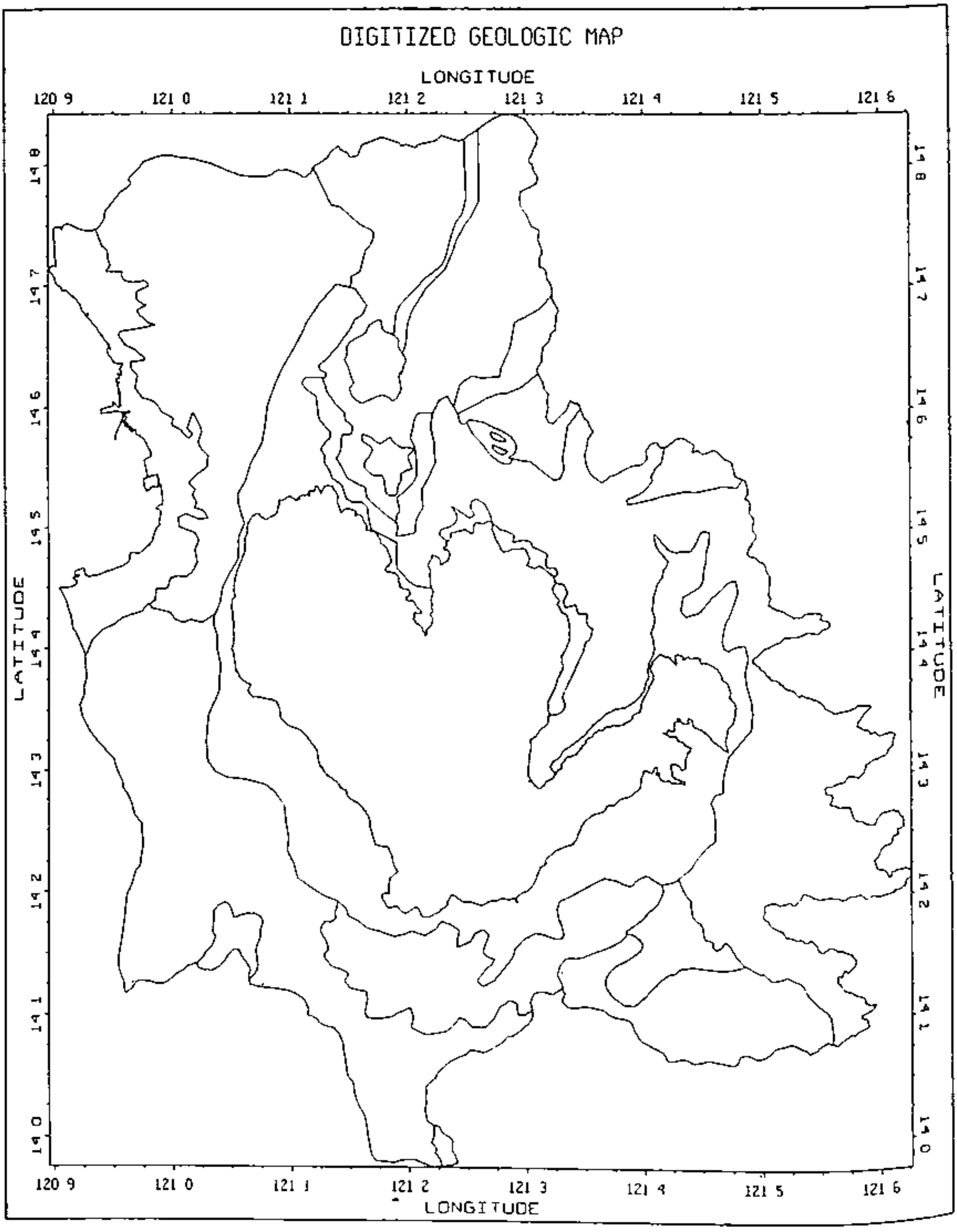

Fig. 11. Digitized geologic map

Table 5. Annual rainfall data from PAGASA stations (mm)

Year	NAIA	Port Area	Science Garden	Camarin	CES Marikina	Boso-Boso	JSES Antipolo	B'bayan	Tipas	PES Pasig
1949	1355.0	1456.7								
1950	1702.5	1799.8								
1951	1628.8	1855.2								
1952	2056.4	2545.4								
1953	2517.0	2230.1								
1954	1624.4	1821.5								
1955	1039.8	1327.0								
1956	1941.7	2212.3								
1957	1175.1	1452.1								
1958	2338.7	2472.6								
1959	1305.3	1593.3								
1960	2543.5	2427.8								
1961	2278.4	2281.9	1001.3 ?							
1962	1960.1	2285.8	935.4							
1963	1852.1	1803.3	887.9							
1964	1946.1	2169.4	2717.5							
1965	1513.4	1865.1	2129.4							
1966	2030.9	2360.9	2570.4							
1967	1938.2	2034.6	2773.5							
1968	1457.6	1532.3	1999.0							
1969	1469.5	1672.0	1645.9							
1970	2109.4	2260.4	2509.2							
1971	1690.8 ?	1887.8	2053.9				209.0 ?			
1972	3360.8 ?	3336.9	3679.8			617.5 ?	2323.6 ?			
1973	1622.3	1550.9	1583.3			0.0 ?	1808.8			
1974	2023.1	2844.4	2878.0	3580.3 ?		0.0 ?	1251.7			
1975	1682.0	1694.7	1918.2 ?	1875.9	803.5 ?	0.0 ?	172.0	817.4 ?	1216.4 ?	1296.5 ?
1976	2059.3	1305.2 ?	88.9 ?	3366.2	3312.1	375.9 ?	2140.1	1503.0	2751.0	2495.2
1977	1921.5	1893.2	2228.4	1869.5	1549.6	144.5	3156.0	805.4	1871.3	1829.4
1978	2733.8	0.0 ?	2611.4	3120.3	980.9	353.4	3792.1	524.2 ?	1982.8	2041.7
1979	1454.8	0.0 ?	1979.8	2345.8	573.6	270.6	882.5	877.9	276.3 ?	1677.1
1980	1447.8 ?	0.0 ?	2186.1	2384.0	548.8	217.0 ?	975.7	558.4	1379.5	1520.3 ?
1981	1687.1	1111.6 ?	2257.7	2120.8	207.6 ?	370.9	1463.6	1140.2	2130.3	1346.6 ?
1982	1040.8	1602.6	1969.5	1800.7	1446.5	473.9	1553.6	908.3	1715.5	1812.8
1983	1052.0	1150.6	1303.2	1604.7	0.0 ?	207.1	829.3	402.9 ?	1488.4	1290.8
1984	1692.1	1903.6	1639.2	2621.6	1868.3	3846.3	1289.2	2068.4	1815.2	1673.1
1985	1910.2	2268.2	2532.6	3019.1	2713.7	1819.7	1326.0	805.5	1961.3	1721.6
1986	2746.1	3323.2	3613.6	3365.3	2962.3	3002.5	1688.8	503.5	2924.7	2495.6 ?
1987	1505.8	1272.5	1684.3	1524.9	597.0 ?	1387.3	1188.8 ?	296.1	1203.7	1049.1
1988	1900.7	2360.5	2603.5	2667.6	2241.8	2359.9	992.2	415.4	0.0	1874.9
1989	1480.5	1944.7	2455.8	2919.6	2530.0	2202.9	1854.3	446.3	0.0	1124.9
1990	2208.4	2485.4	3084.3	3945.8	3604.7	2505.4	2041.8	205.2	3123.2	2250.0

NOTE: ? - years with missing data

Table 5. (cont.) Annual rainfall data from PAGASA stations (mm)

year	UPCA Los Banos	NAS UPLB Los Banos	Sta. Cruz	San Pedro	Obando	Sangley Point	Tabak	NPP M'nglupa
1956	2077.6		2622.1					
1957	1450.3		1490.4					
1958	1587.0		1577.2					
1959	1731.3		1786.2					
1960	2925.0		2859.1					
1961	2043.5		2354.0					
1962	2107.9		2094.7					
1963	1826.2		1909.2					
1964	2433.8		2145.9					
1965	1403.5 ?		446.4 ?					
1966	1652.0 ?		2138.0					
1967	1833.3		0.0 ?					
1968	1064.0 ?		343.9 ?					
1969	1027.0 ?		1351.8					
1970	1855.1 ?		2446.8		3079.9			
1971	2230.6		2662.9	1619.6 ?	1899.7			645.5 ?
1972	2480.3		2319.2	2441.4	1725.4			2585.2
1973	2088.2		1898.3	1717.2	536.1 ?			148.6 ?
1974	1221.0 ?		2073.8	2099.8	3308.5	1297.2 ?		119.5 ?
1975	1707.6 ?		2004.9	1704.2	1671.3	1143.3		119.8 ?
1976	42.3 ?		2078.8	1962.2	3607.8	1877.3	563.8 ?	929.0 ?
1977		1366.3 ?	1573.6	1593.9	2721.9	1882.4	2533.3 ?	1320.0
1978		2678.4 ?	2195.8	2005.0	2943.3	2138.3	3336.7	704.7 ?
1979		1570.8	1820.7	2000.1	2005.3	1337.1 ?	3641.6	1026.3 ?
1980		2255.3	1588.1	1786.4	3348.7	1291.7 ?	2472.9	1022.3 ?
1981		1450.1 ?	1863.8	1204.0	2699.7	1527.6	3356.6	1554.6 ?
1982		1427.3	1521.8 ?	570.5	2160.6	1008.4	2460.2 ?	0.0 ?
1983		1677.4	1144.1	522.8	1619.4	1327.4	2323.8	0.0 ?
1984		2072.0	1785.5	639.4	1849.4	2044.6	3149.0	0.0 ?
1985		2032.7	1700.5	1291.4	2431.5	1951.5	2545.0 ?	311.0 ?
1986		3019.6	1646.1	2596.5	2612.8	2955.0	2995.0 ?	0.0 ?
1987		893.4 ?	997.9	1588.7		1686.6	2576.7 ?	0.0 ?
1988		2255.0 ?	2094.9	1405.5		1981.4	3125.4	894.8 ?
1989		1447.0 ?	1760.9	2605.3		2117.2	3012.8	1574.4 ?
1990		1134.6 ?	1897.6	7.9 ?		2595.5	4085.4	2145.5

NOTE: ? - years with missing data

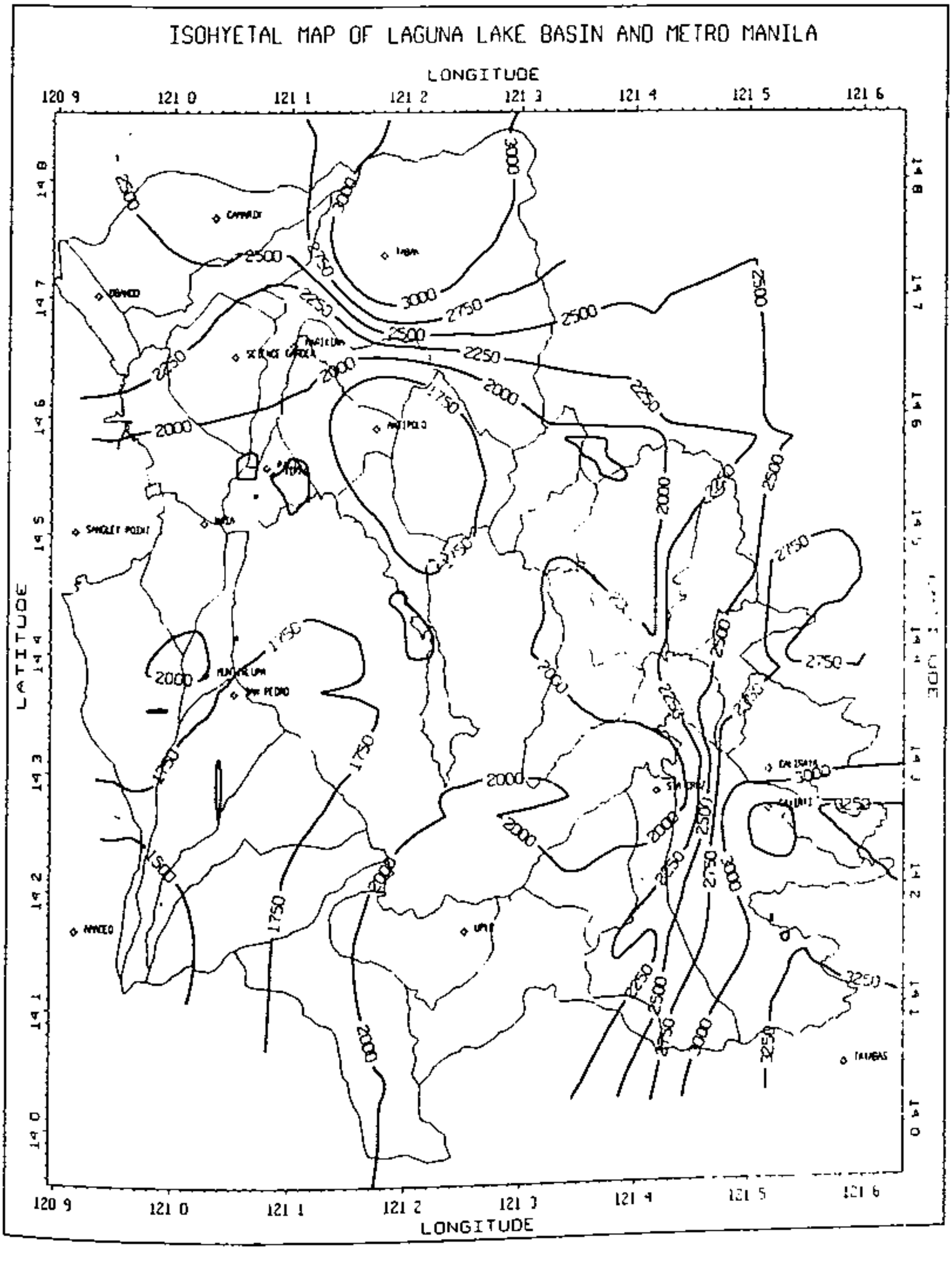

Fig. 12. Mean annual isohyetal map

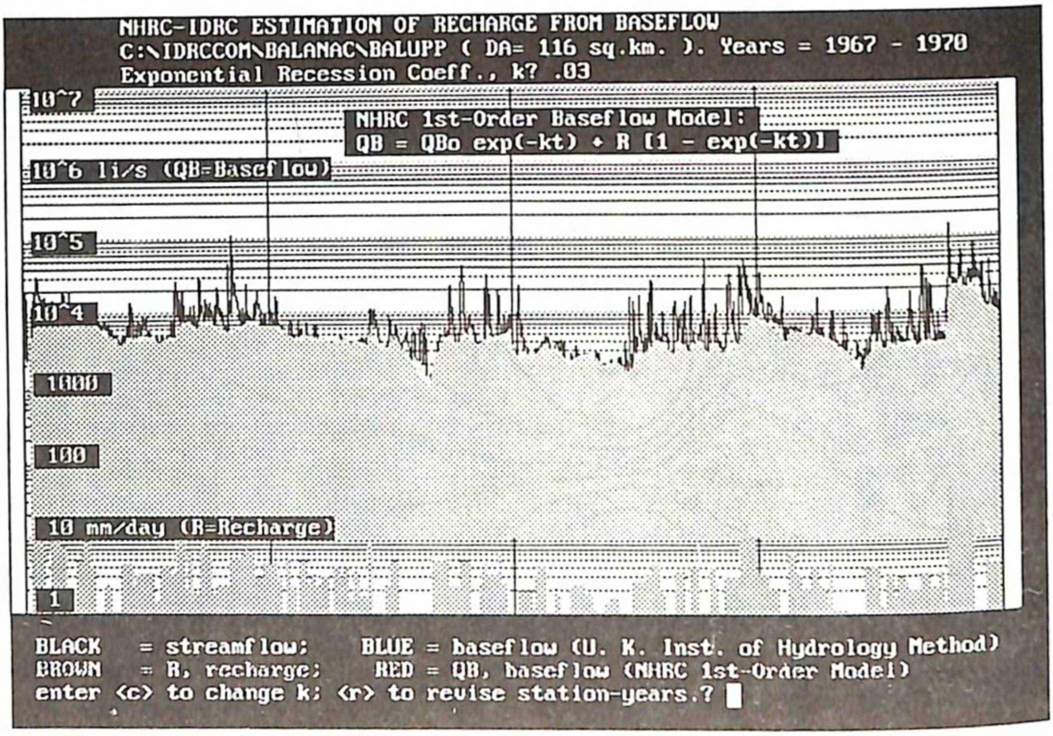

Fig. 13. Baseflow separation model for Balanac River (1967-1970)

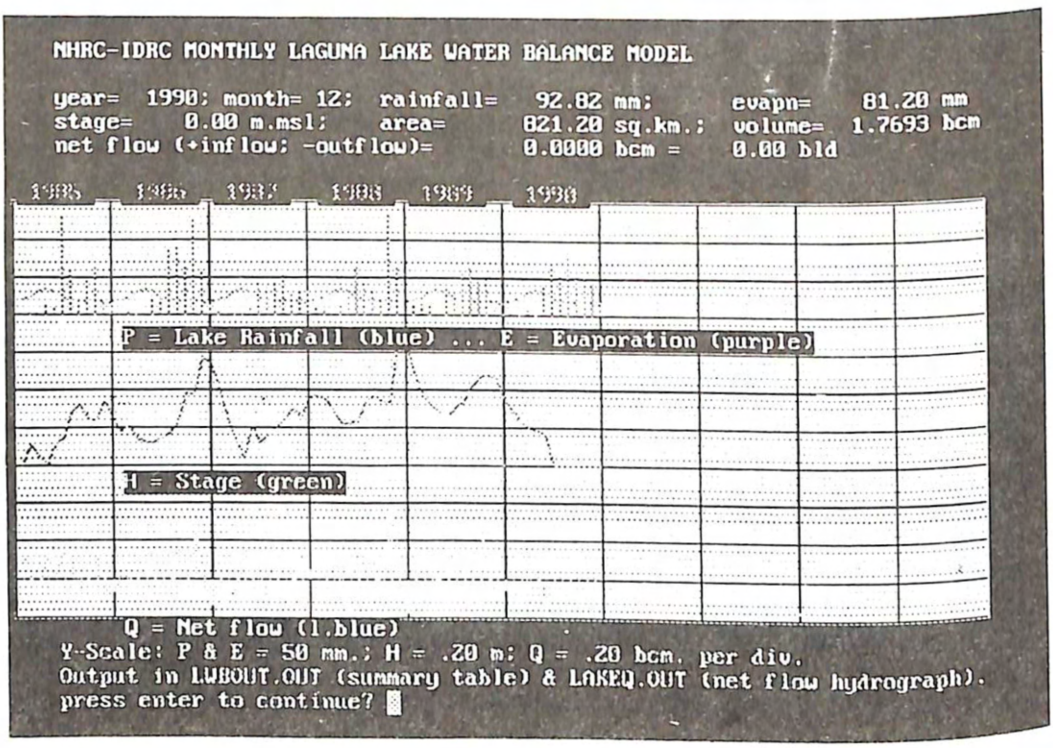

Fig. 14. Laguna Lake water balance model (1985-1990)

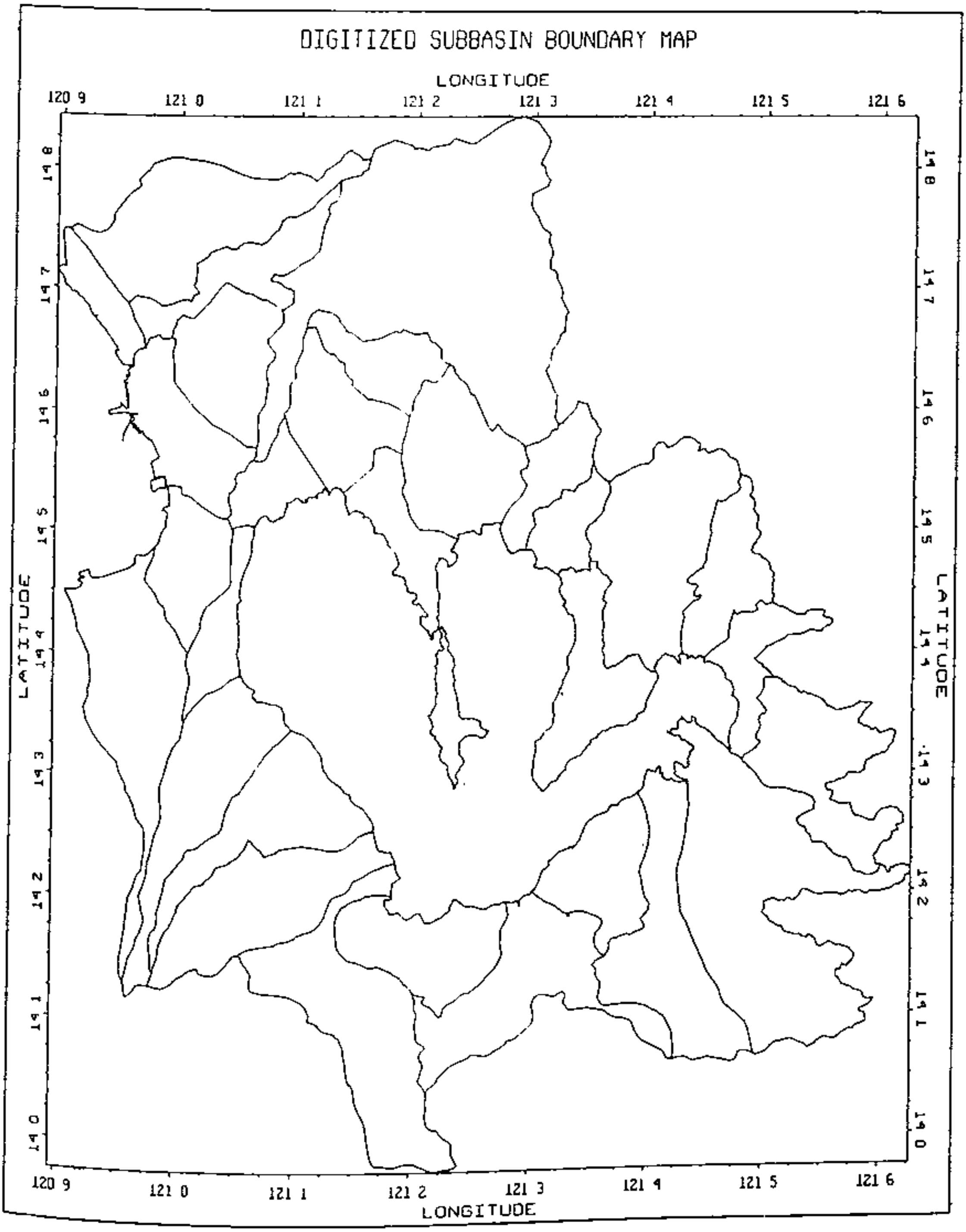

Fig. 15 Digitized subbasin boundaries

Table 6. Subbasin codes, names and drainage areas

Code	Subbasin Name	Drainage Area (sq.km)	
SB1	*Marikina River Basin*	472	
SB1-a	*Nangka River Basin*	57	
SB2	*Mangahan Floodway-Taytay Basin*	63	
SB3	*Angono-Morong Peninsula-Talim Island*	61	
SB4	*Morong-Baras River Basin Group*	123	
SB5	*Tanay River Basin*	53	
SB6	*Pililia River Basin*	42	
SB7	*Jala-jala Peninsula*	96	
SB8	*Sta.Maria River Basin*	180	
SB9	*Siniloan/Romero River Basin*	81	
SB10	*Paete Basin*	54	
SB11	*Pagsanjan River Basin*	315	
SB11-a	*Caliraya Reservoir Basin*	129	
SB12	*Sta.Cruz River Basin*	124	
SB13	*Pila Basin*	87	
SB14	*Calauan Basin*	155	
SB15	*Los Banos-Mt.Makiling Basin*	102	
SB16	*Calamba/San Juan River Basin*	156	
SB17	*Canlubang/San Cristobal River Basin*	139	
SB18	*Sta Rosa-Cabuyao River Basin Group*	120	
SB19	*San Pedro-Binan River Basin Group*	132	
SB20	*Sucat-Alabang-Muntinlupa Basin*	43	
SB21	*Taguig-Napindan Basin*	45	
	subtotal		2829
SB22	*Meycauayan River Basin*	169	
SB23	*Obando-Malabon-Navotas Estuary*	35	
SB23-a	*Novaliches Reservoir/Tullajan River Basin*	72	
SB24	*Pasig River Basin*	91	
SB24-a	*San Juan River Basin*	94	
SB25	*Paranaque-Las Pinas River Basin Group*	73	
SB26	*Zapote-Bacoor-Imus River Basin Group*	168	
	subtotal		702
LB1	*West Bay of Laguna Lake*	398	
LB2	*Central Bay of Laguna Lake*	214	
LB3	*East Bay of Laguna Lake*	134	
LB4	*South Bay of Laguna Lake*	183	
	subtotal		929
	Laguna Lake Basin		3758
	Other Metro Manila Basins		702
	Study Area		4460

The Laguna Lake bathymetry was digitized from 1:60,000 bathymetric charts and is shown in Figure 16. Based on the digitized map, a depth-area relationship for the Laguna Lake was derived. This derived information was later used in a water balance study of the Laguna Lake.

Well Information

Well location maps, well lithologic logs and well-to-well section logs have been processed from the well data files. The graphic presentation of well logs and well location maps using a geologic software facilitated data verification activities such as the correction of mislocated wells and the discrimination of the less useful data from the most reliable lithologic logs. The lithologic logs were important inputs to the characterization of the aquifer system in the Metro Manila and Laguna Lake Basin model area. Figure 17 shows the location of wells included in the NWRB well inventory within the Metro Manila and Laguna Lake Basins. Figure 18 shows a sample graphic display of a well lithology, while Figure 19 presents a well-to-well section display of adjacent wells.

Groundwater level data, used as basis for model calibration, have been assembled. Piezometric maps for Metro Manila were prepared for 1955, 1967, 1981 and 1991 based on the various maps and technical reports. A sample piezometric map for the Metro Manila area based on MWSS survey taken in 1991 is shown in Figure 20.

Definition of Aquifer Geometry

The well lithologies, geophysical surveys and various significant reports were used to define the aquifer geometry. One important model parameter is the definition of the hydrogeologic basement which could be treated as the lower boundary of the conceptual aquifer system.

Results of various geo-resistivity surveys have been assembled to define the hydrogeologic basement for the study area. NIGS interpreted the OEA seismic data and conducted an additional seismic reflection survey to compliment the results of previous surveys conducted in localized areas such as the MWSS survey for Antipolo. A map of the hydrogeologic basement for the entire Metro Manila and Laguna Lake Basin was assembled as shown in Figure 21.

CONCLUDING REMARKS

The NHRC Water Database has been assembled through multi-agency cooperation. Relevant information derived from the database provided the necessary inputs to the water resources modeling study of the Metro Manila and the Laguna Lake Basins. The modeling task has indeed exhibited the application of the database in water resources planning.

Results and recommendations from the modeling study could identify new and emerging issues which could be addressed by further research, thus, making the database an indispensable tool for water resources research.

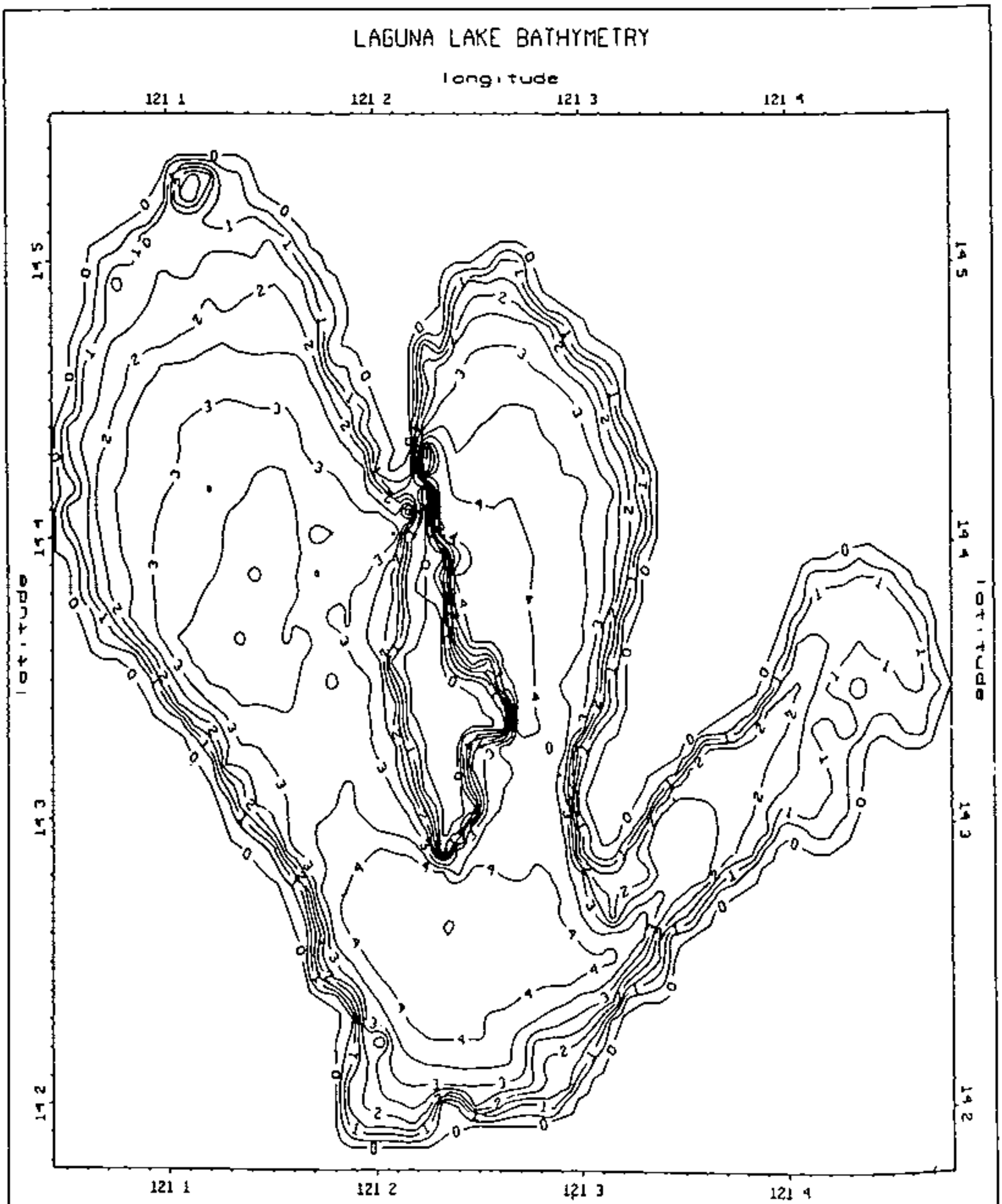

Fig. 16. Laguna Lake bathymetry

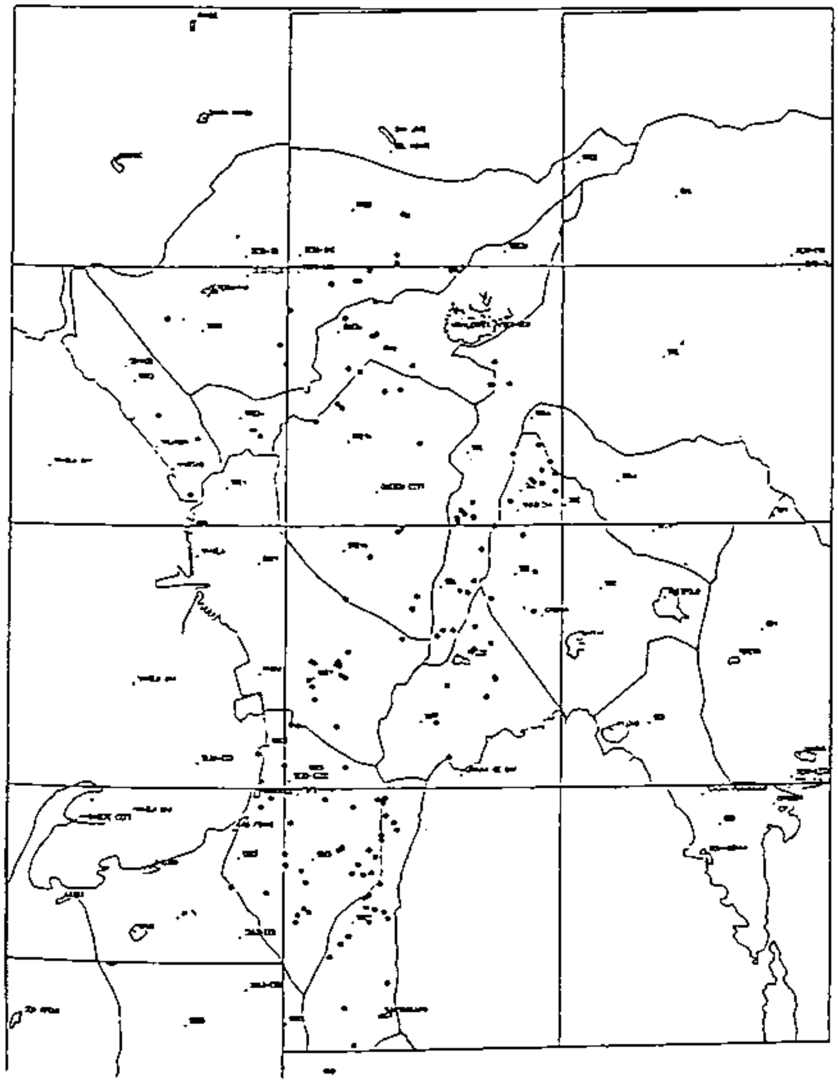

Fig. 17. Well location map for Metro Manila

```
SETUP: lag056.plt lag056.inf 2 -592.00  0.00 121.1244 14.2517 0.00  LAG056 (, CABUTAO)
OPERATOR: NHRC GROUNDWATER MODELING & MANAGEMENT TEAM
LITHOLOGY:  -0.00  -10.00   -0.00
GRAY ADOBE:
LITHOLOGY:  -10.00  -50.00   -45.54
SANDY CLAY AND SHALE:
LITHOLOGY:  -50.00  -95.00   -91.08
BROWN SHALE:
LITHOLOGY:  -95.00  -120.00   -136.62
GRAY SANDY SHALE:
LITHOLOGY:  -120.00  -190.00   -182.15
BROWN SHALE WITH GRAVEL:
LITHOLOGY:  -190.00  -254.00   -227.69
GRAY SHALE SANDY:
LITHOLOGY:  -254.00  -302.00   -273.23
SANDY CLAY:
LITHOLOGY:  -302.00  -438.00   -318.77
FINE SANDY CLAY:
LITHOLOGY:  -438.00  -460.00   -364.31
COARSE SAND:
LITHOLOGY:  -460.00  -500.00   -409.85
SANDY CLAY:
LITHOLOGY:  -500.00  -548.00   -455.38
BROWN SANDY CLAY:
LITHOLOGY:  -548.00  -555.00   -500.92
SANDY CLAY:
LITHOLOGY:  -555.00  -592.00   -546.46
BROWN STICKY CLAY:
END-LOG
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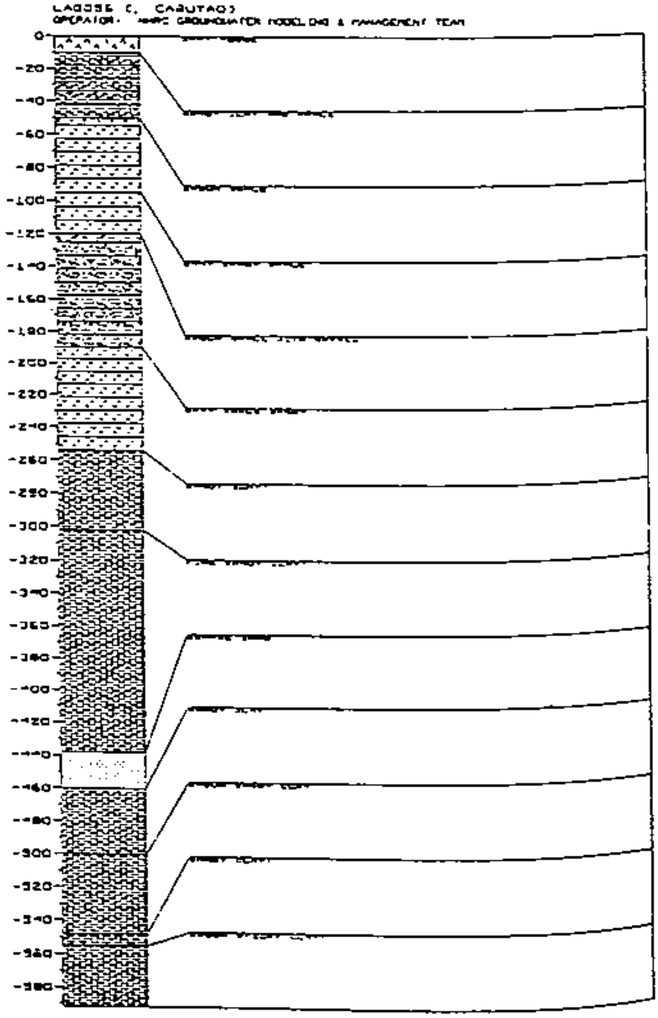

Fig. 18. Sample well lithology

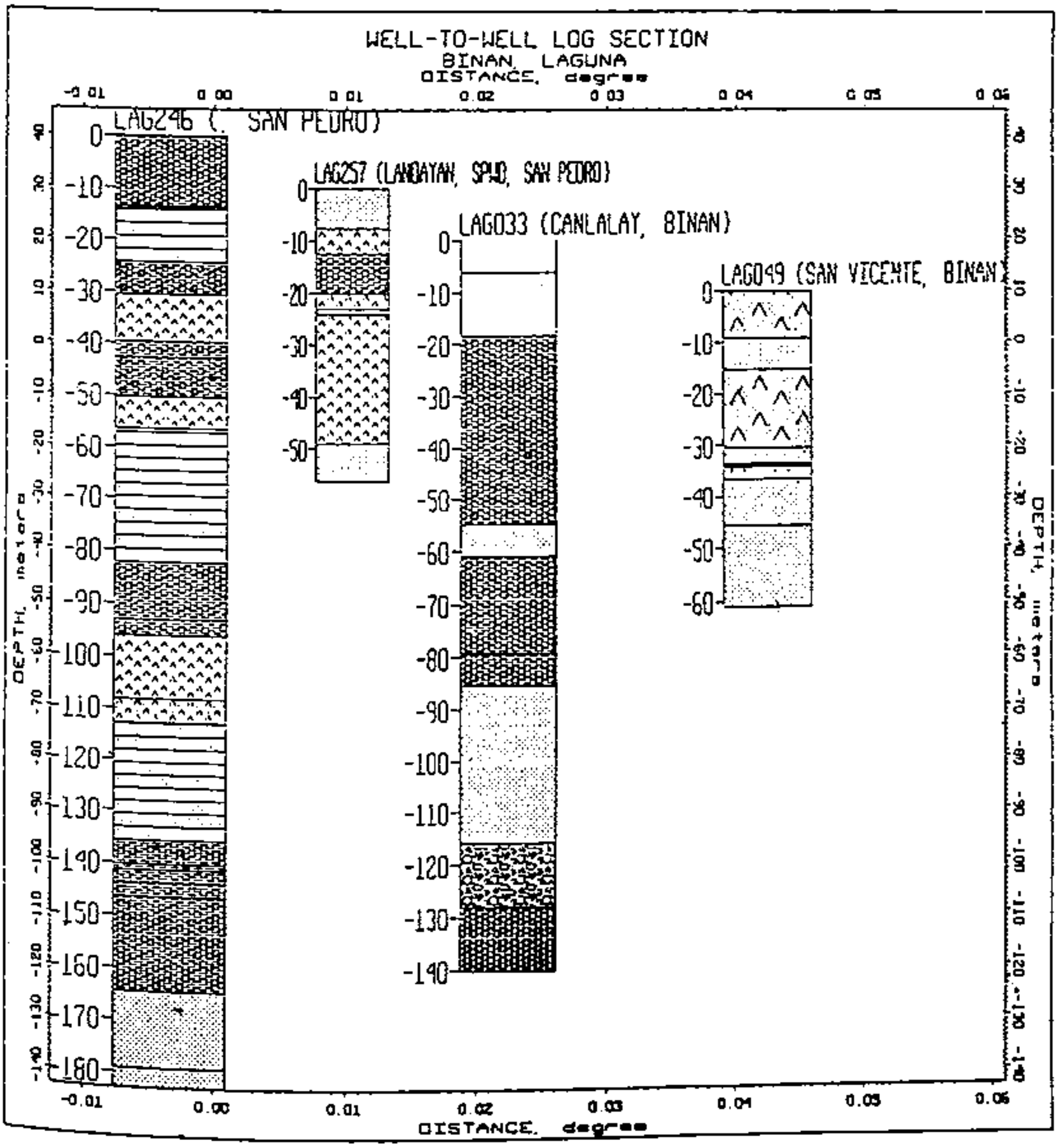

Fig. 19. Well-to-well section plot

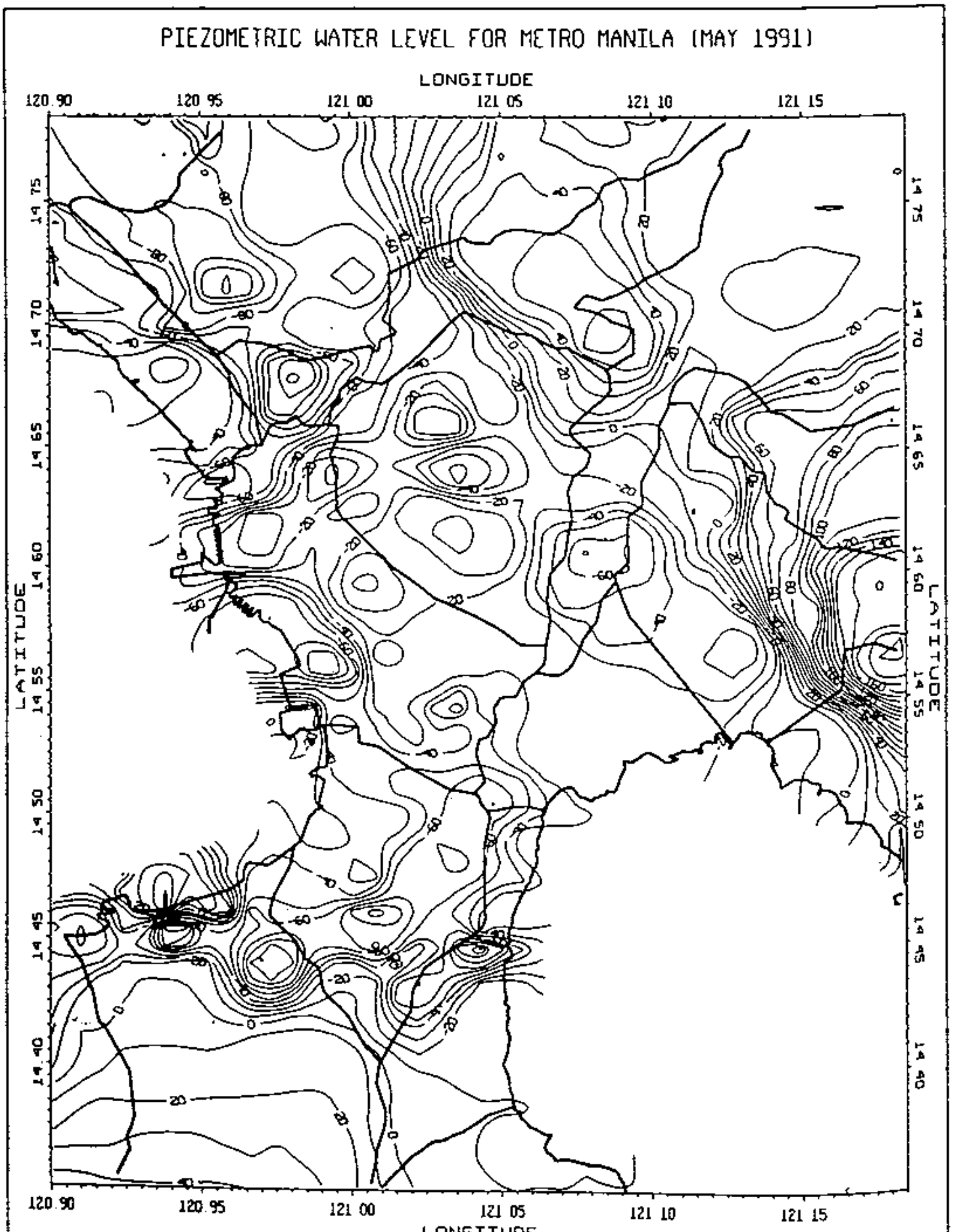

Fig. 20. Piezometric map for Metro Manila (1991)

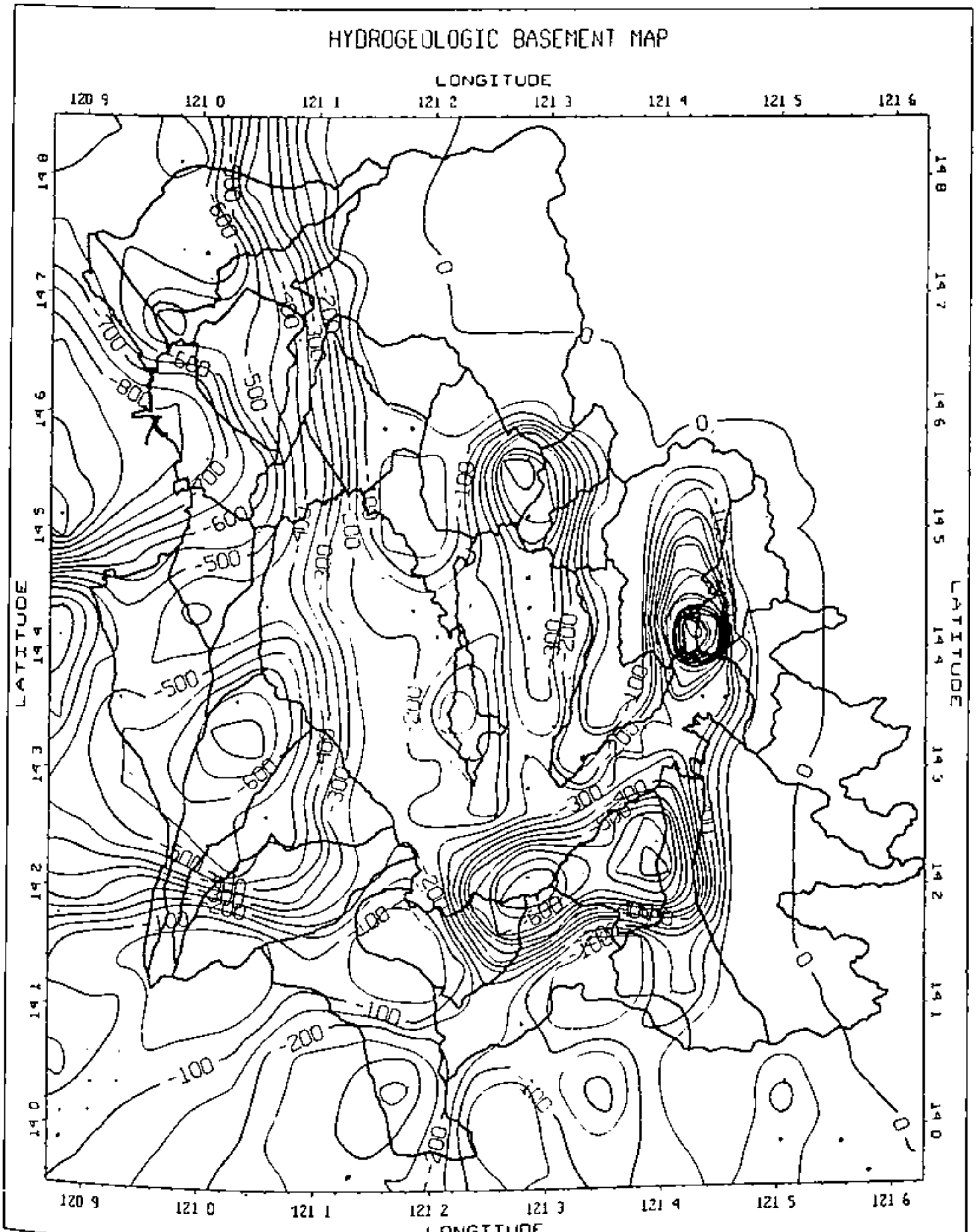

Fig. 21. Hydrogeologic basement map

A review of the database collection reveals a vast amount of available information while providing some insight on the need for more information or the lack thereof. Future data collection efforts and monitoring programs may be geared towards closing out the identified data gaps or verifying and complementing the existing ones. The mere exercise of collecting water-related information in a single repository is in itself a self-fulfilling task, as more data become available for the database. Moreover, the management model could be further refined and recalibrated as more recent information such well withdrawals to depict more reliable groundwater extraction patterns and time series of piezometric levels, are made available to the database.

Initially intended as a database for the conjunctive use modeling of the surface and groundwater resources within the Metro Manila and the Laguna Lake Basins, the NHRC water database can facilitate data access for interested users in support of their various research activities, aside from serving as a forum for information exchange among researchers and planners in the water resources sector.

REFERENCES

NHRC (1993). **Water Resources Management Model for Metro Manila.** Final Report. NHRC: Quezon City.

Liongson, L. Q. and J.M.B. Blanco (1992). **A Water Balance Study of Laguna Lake Basin Using a GIS Approach.** NHRC, Diliman, Quezon City.

Liongson, L. Q. (1991). **A Groundwater Database for Metro Manila and Laguna Lake Basin.** Philippine Engineering Journal, XXII(3):15-48, (June).