

- (6) A "Final Report" within 24 months after commencement of the study, reflecting comments provided by Thai Government on the Draft Report.

3. DETAIL OF THE REQUESTING AGENCY

3.1 Institutional Framework

The Public Works Department is a technical unit belonging to the Ministry of Interior. Its main function is the responsibility on public utilities and welfare, design and supervision provided for every government offices. The scope of work includes surveying, designing, housing control, road, bridge and other sanitary system constructions.

As for the Provincial Water Supply Division (PWSD), a division of the department, it deals with water resources exploration and development both surface and sub-surface and supply the water to the rural people so that those people will have clean water for domestic and agricultural uses. Conservation and protection of the existing water resources including rehabilitation of the water resources for public uses is also assigned.

3.2 Staff of PWSD

The staff amounts to 700 officers and is divided into various categories as follows;

(1) Engineers	
- Civil Engineers	33 persons
- Mechanical Engineers	7 persons
(2) Engineering geologist	1 person
(3) Geologists	7 Persons
(4) Scientists	6 Persons
(5) Technicians & others	646 Persons

4. EXPERTISE INPUTS

4.1 Experts

The following experts and engineers will be required for the study:

	<u>m-m</u>
Team Leader	6
Hydrogeologist	23.5
Groundwater Engineer	14.5
Hydrologist	8
Geotechnical Engineer	5
River Engineer	2.5
Computer Expert	16.5
Water Quality Expert	4
Design Engineer	5
Water Supply Engineer	3.5
Water Resources Expert	13.5
Socio-Economist	9
Water Law Expert	4
Survey Expert (1)	7
Survey Expert (2)	3
Drilling Supervisor	5

The total expertise input necessary for the study is estimated to be 130 man-months. The tentative assignment schedule is shown on Fig. 2.

4.2 Transfer of Knowledge

Transfer of knowledge and training shall be made to the government personnel and/or counterpart personnel throughout the course of the study. The items shall be groundwater model simulation, prevention and remedial countermeasures for land subsidence, and artificial recharge system.

Training and transfer of knowledge on the ground water management against environmental destruction are to be held in Japan.

The total training in Japan is estimated to be 10 man-months.

4.3 Equipment and Field Work

a) Main equipment or instrument to be necessary for the Study

- Bore hole conductivity meter ×1
- Bore hole current meter ×1
- Portable conductivity meter ×2
- Portable PH meter ×2
- Automatic water level recorder ×10
- Portable water level recorder. ×3

b) Main field work to be executed for the Study

- Core boring and soil test ×1
- Installation observation well
for water level and land subsidence 1 set
- Ground levelling surveys LS
- Installation and operation of
experimental recharge system 1 set
- Water quality analysis LS

Fig. 1 TENTATIVE WORK SCHEDULE, 2)

ITEM	1st Stage												2nd Stage													
	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1. First Stage	Month																									
a. Collection/Review of Previous Studies		█																								
b. Core boring and soil test			█																							
c. Hydrogeological Field Investigation and Analysis		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
d. Ground Levelling Survey		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
e. Assessment of Surface Water Resources		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
f. Water quality Monitoring			█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
g. Assessment of Land Subsidence		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
h. Groundwater Level Monitoring		█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
i. Design of Experimental Recharge System										█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
j. Review and Preparation of Groundwater Simulation Models										█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
k. Cost Analysis										█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
l. Study of Groundwater Act										█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
m. Socio-economic Study										█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█

FI TENTATIVE ASSIGNMENT SC EDULE

POSITION	Stage		1st Stage												2nd Stage												Field	Japan	Tot	
	Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
Team Leader																											3	3	6	
Hydrogeologist																												12.5	11	23
Groundwater Engineer																												8	6.5	14
Hydrologist																												5	3	8
Geotechnical Engineer																												4	1	5
River Engineer																												2.5	0	2
Computer Expert																												7.5	9	16
Waterquality Expert																												3	1	4
Design Engineer																												2	3	5
Watersupply Engineer																												3.5	0	3
Waterresources Expert																												6.5	7	13
Socio-economist																												4.5	4.5	9
Water-law Expert																												1.5	2.5	4
Survey Expert (1)																												5	2	7
Survey Expert (2)																												3	0	3
Drilling Supervisor																												5	0	5
TOTAL																												76.5	53.5	130

Field Japan

REQUEST FOR TECHNICAL COOPERATION PROJECT

Project Title : Groundwater-management study in relation to land subsidence in industrial areas adjacent to Bangkok Metropolis.

Requesting agency : Department of Mineral Resources, Ministry of Industry.

Proposed Sources of Cooperation : Government of Japan.

1. Background information and justification for the project

Intensive pumping of groundwater from the aquifers of Bangkok mainly for municipal supply and industrial use has caused a drastic decline of piezometric levels from few metres below ground surface before 1955 to presently about 50 metres. The decline in artesian pressure has resulted in contamination of the fresh water in the aquifers by salt-water encroachment and land subsidence.

The comprehensive investigation and study programme for groundwater resources and land subsidence in Bangkok Metropolis was carried out from 1978 to 1982. The programme consisted of research studies on groundwater development and management jointly conducted by the Department of Mineral Resources and the Asian Institute of Technology (AIT), and land subsidence investigation and surface levelling also, by AIT and the Royal Thai Survey Department, respectively. The Office of National Environment Board acted as coordinator of the programme.

The results of the studies have shown that the centre of the greatest amount of subsidence coincides with the centre of the artesian pressure decline in the east-southeastern part of Bangkok where the annual rate of subsidence was estimated

to be more than 10 centimetres during the studied period. Maximum land subsidence of 54 centimetres was determined from 1978 to 1982 and as much as 1.14 metres of subsidence occurred between 1940 and 1980. Since the altitude of Bangkok is only less than 1.0 to 2.5 metres above mean-sea-level, flood problems in low-lying areas during high tides in the monsoon season are serious and have become a major problem that must be solved.

Based on the recommendations of the said study, remedial measures for mitigation of groundwater crisis and land subsidence in Bangkok were adopted and have been taken since 1983 to control the groundwater pumpage and slow down the rate of land subsidence. However, land subsidence in Bangkok has not yet stopped.

The previous studies were mostly concentrated on Central Bangkok and the eastern suburbs where densely-populated areas were located. Nowadays, groundwater in new industrial areas such as Samut Sakhon, Rangsit and Phra Pradaeng (see map), where rapid industrialization is in progress, is heavily pumped, and a rapid decline of ground water level can be observed. Thus, land subsidence is expected.

Detailed quantitative analysis in these industrial areas to obtain the present magnitude and rate of subsidence is very essential. Mathematical model prediction should also be performed for proper groundwater management.

2. Details of the project

2.1 Project goal

2.1.1 To control the decline of the groundwater levels and raise them to the level balanced by natural recharge to the aquifers of Bangkok, especially in industrial areas.

2.1.2 To stop further land subsidence and to prevent further salt-water intrusion.

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2.2 Project objectives

2.2.1 To determine the present magnitude and rate of land subsidence in the industrial areas adjacent to Bangkok Metropolis : Samut Sakhon, Rangsit and Phra Pradaeng. 3/10

2.2.2 To determine the declining behavior of groundwater levels in relation to pumpage in the three major aquifers ranging in depths between 80 and 200 metres below ground surface.

2.2.3 To determine the aquifers' characteristics and properties of the compressible soil strata.

2.2.4 To study the behaviour of salt-water intrusion.

2.2.5 To predict the effects of future pumpage on water levels and land subsidence by mathematical model simulation.

2.3 Conditions expected at completion of the project

2.3.1 Construction of a groundwater and land subsidence observation station network in industrial areas of Bangkok Metropolis with sufficient vehicles provided for further monitoring on the groundwater levels, quality, and land subsidence. 1/1/89
J. B.

2.3.2 Groundwater maps and reports in relation to the project objectives.

2.4 Recommended sources of information and data related to the project, necessary for project verification.

- Department of Mineral Resources
- Department of Public Works
- Metropolitan Waterworks Authority
- Provincial Waterworks Authority
- Office of the National Environment Board
- Royal Thai Survey Department
- Asian Institute of Technology

2.5 Duration of the project : 3 years, starting January 1989.

2.6 Project sites : Industrial area of Samut Sakhon, Rangsit, Pathum Thani and Phra Pradaeng, Samut Prakan for network stations. Bangkok Metropolis will be included in the mathematical model simulation.

2.7 Project work plan and activities

2.7.1 Review, collection and analysis of existing data relevant to the groundwater and land subsidence.

2.7.2 Drilling of observation wells for water-level and water-quality measurements. Soil samples will be analysed and tested, and borehole geophysical logging will be conducted.

2.7.3 Construction of land subsidence stations each of which will consist of an observation well for installing a land subsidence recorder and a number of piezometers and bench marks in different geologic strata.

2.7.4 Supply and installation of water-level recorders and land-subsidence recorders.

2.7.5 Observations of the water levels, water quality and land subsidence from recorders for a period of 3 years, and analysis of the data obtained.

2.7.6 Surface levelling of the three industrial areas in every 6-month interval to determine changes in ground elevation and compare with the results obtained from the measuring recorders.

2.7.7 Pumping tests to determine the hydraulic characteristics of the aquifers.

2.7.8 Development of mathematical models for groundwater flow, land subsidence and salt-water intrusion.

2.7.9 Simulation and prediction of behaviour of water level, land subsidence and salt-water intrusion into the aquifer with respect to pumpages.

2.7.10 Planning of a groundwater management system.

2.7.11 Preparation of recommendations for countermeasures in legal aspects, substitutional water source and rationalization of industrial water.

2.7.12 Training of Thai hydrogeologists.

2.7.13 Preparation of maps and reports.

3. Details of the implementing/operating agency

3.1 Institutional framework :

The Department of Mineral Resources is responsible for groundwater resources investigation and study as well as ground water development for rural water supply and for enforcing the groundwater law. Groundwater investigation and study in Bangkok was initiated by the Department of Mineral Resources in 1965. Since then, many groundwater maps and hydrogeological profiles have been published. The piezometric-level maps periodically published by the Department of Mineral Resources have indicated a rapid decline of water levels in the three major aquifers in Bangkok, leading to the Government-supported research programme conducted during 1978-1982 on groundwater resources management study and land subsidence investigation. The Department of Mineral Resources has recently been conducting a groundwater monitoring programme for mitigation of groundwater crisis and land subsidence in the critical zones of Bangkok.

In collaboration with other agencies, reports and maps of the groundwater published by the Department of Mineral Resources have been distributed among the agencies concerned. Moreover, the Department of Mineral Resources has provided technical assistance in groundwater investigation and development to requesting agencies.

3.2 Staff/personnel participating in project implementation (i.e. number qualifications, availability, etc) :

A number of technical staff including 2 hydrogeologists, 3 geologists, 1 engineer and 1 technician will be assigned for the project.

Hydrogeologists	:	Ph.D. and M.S. in hydrology
Geologists	:	B.Sc.
Engineers	:	University and technical institute levels

4. Assistance Requested

4.1 Expert

Field of operation/activity	Total		1989		1990		1991	
	No	m/m	No	m/m	No	m/m	No	m/
1) Team Leader	1	5	1	2	1	2	1	1
2) Project Planner/ Water Supply Engineer	1	3.5	1	0.5	1	1.5	1	1.
3) Socio-Economist	1	3.0	1	0.5	1	1.5	1	1
4) Hydrogeologist I/ Geologist/Soil Engineer	1	8.0	1	5	1	3	-	-
5) Hydrogeologist II/ Computer Engineer	1	7.0	-	-	1	7	-	-
6) Geophysicist/ Hydrologist	1	2.5	1	2	1	0.5	-	-
7) Surveyor	1	1.0	1	1	-	-	-	-
Total	7	30	6	11	6	15.5	3	3.

4.1.1 Justification for requesting experts :

Land subsidence due to over-pumping of groundwater had occurred in many cities in Japan, such as Tokyo and Osaka. However, the situation nowadays has completely been controlled, and hence, Japanese expertise in this field is needed.

4.1.2 Job description of each expert requested :

See "Expert's Job Description Form" attached to Form P.

4.2 Fellowships

Field of Study/Training	Total		1990	
	No	m/m	No	m/m
1. Groundwater Flow and Saltwater Intrusion Modeling (Training)	2	4	2	2
2. Groundwater and Land Subsidence Monitoring (Study tour)	2	2	2	1
Total	4	6	4	3

4.2.1 Justification for requesting fellowships :

Two staff members of the Department of Mineral Resources should undergo training in mathematical models of groundwater flow, salt-water intrusion and land subsidence. To remedy the problems for groundwater crisis and land subsidence in Bangkok Metropolis, proper groundwater management should be formulated. This can be done by means of mathematical model simulation. Training in this field is therefore necessary.

Two senior hydrogeologists will take part in a study tour to visit and to participate in the design and analysis of the operational groundwater and land subsidence monitoring in Japan. The knowledge and experience thus gained will be used for proper conducting the groundwater and land subsidence monitoring and management in Bangkok, where network station is planned for covering all affected areas.

4.3 Equipment

Description of equipment item	Amount requested for each item	Unit price (US \$)	Total cost (US \$)	1989 (US \$)	1990 (US \$)
1) Water Level Recorders	10		78,435	78,435	-
2) Subsidence Recorders	10				
3) Water Level indicators (Portable)	3				
4) Water Sampler	1				
5) Levelling equipment (First-order levelling)	1				
6) Vehicles (personal type)	2	19,610	39,220	39,220	-
7) Vehicles for field work	2	19,610	39,220	39,220	-
Total	-	-	156,875	156,875	-

4.3.1 Justification for requested equipment

These equipment items will be used for monitoring groundwater levels, groundwater quality and land subsidence in Bangkok and its adjacent areas. The vehicles are for the Japanese and Thai professional staff working in the field to supervise construction of monitoring wells for the station network and to measure water levels and collect water samples from monitoring wells.

4.4 Others (e.g, sundry, stipend, construction cost)

Item requested	Total cost US, \$	1989 US '\$	1990 US '\$	1991 US, \$
1) Construction cost for monitoring wells	392,160	392,160	-	-
2) Wages for temporary staff	39,215	13,071	15,685	10,459
3) Gasoline	7,845	2,615	2,615	2,615
4) Computer hours	15,700	-	15,700	-
5) Report and map printing cost	7,845	1,423	1,422	5,000
6) Miscellaneous	7,845	2,615	2,615	2,615
Total	470,610	411,884	38,037	20,689

4.4.1 Justification for requested items

The construction cost is for groundwater and land subsidence monitoring wells in the project areas. The work plan for each station includes monitoring well design, drilling, soil sampling and rock coring, field and laboratory determination of hydrogeologic parameters, well construction and installation of water level and land subsidence recorders. The temporary staff consist of 2 hydrogeologists, 2 technicians, 1 secretary/typist and 4 drivers. They will be responsible for the work mentioned above. The computer costs will cover groundwater simulation studies on groundwater flow and salt-water intrusion modeling.

5. Thai Government Counterpart Contribution to the Project

Description of Government Counterpart Contribution	Total contribution (฿)		1989 (฿)	1990 (฿)	1991 (฿)
	already available	to be requested			
1. Project personnel					
1.1 Professional staff					
Hydrogeologists(2)	436,170	-	203,310	112,010	120,850
Geologists (3)	208,175	-	83,405	103,965	20,805
Engineer (1)	114,475	-	48,200	48,200	18,075
Technician (1)	71,155		29,960	29,960	11,235
1.2 Administrative staff					
Typist (1)	50,700		19,500	19,500	11,700
2. Equipment					
2.1 Office space	✓				
2.2 Existing observation wells	✓				
2.3 Electric sounding devices	✓				
3. Others (e.g. miscellaneous expense)	30,000		10,000	10,000	10,000

6. Related projects/activities

6.1 Previous assistance received in fields related to the project: None.

6.2 Present complementary or supplementary project : None

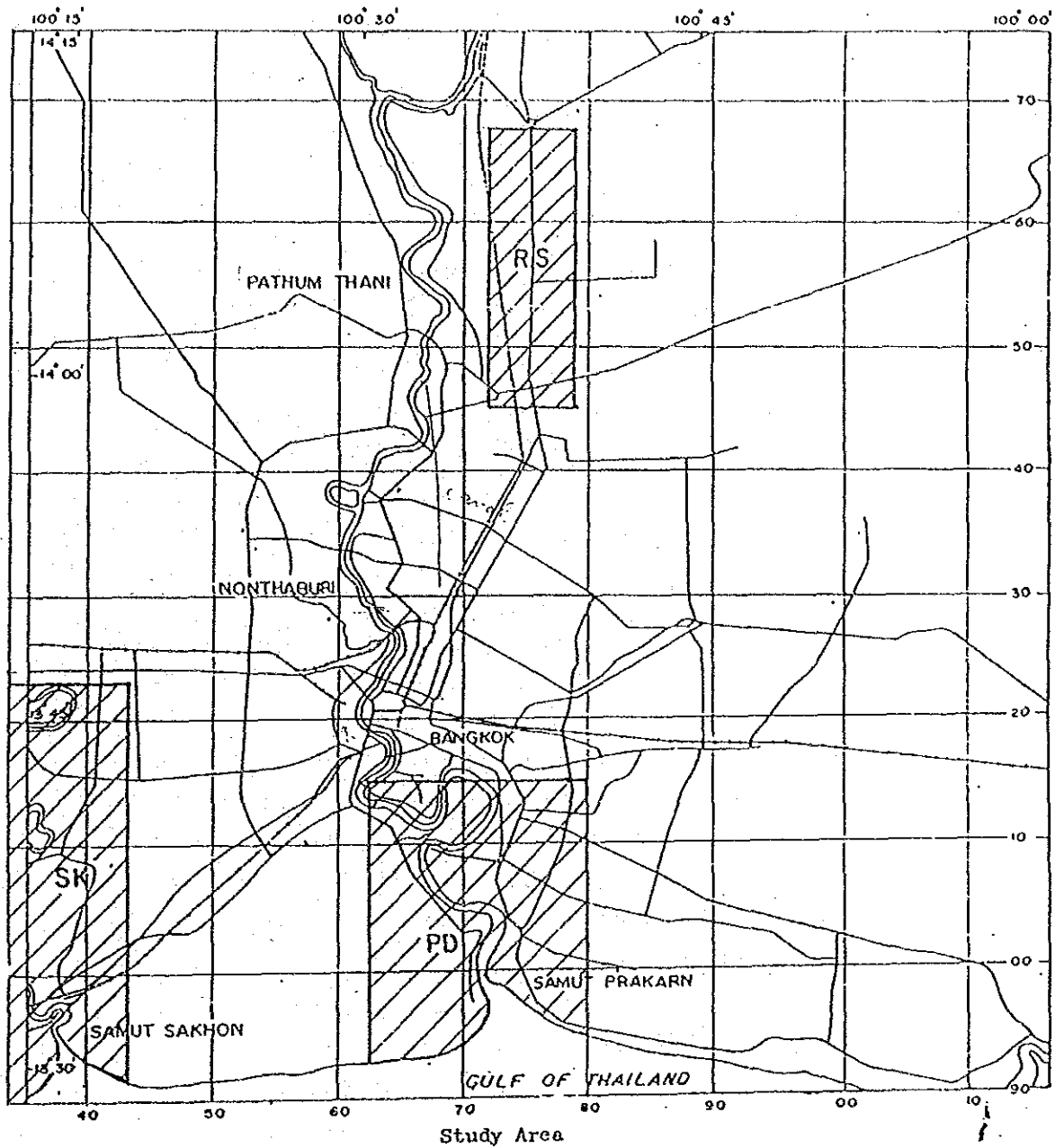
7. Future Work Plan

1. The Department of Mineral Resources is responsible for enforcing the Ground Water Act B.E. 2520 (1977) and implementation of the Remedial Measures for mitigation of the groundwater crisis and land subsidence in Bangkok approved by the Cabinet in 1983. The Measures contain a yearly step-by-step control on the groundwater use, mainly in the critical zones, to reduce groundwater pumpage until the year 2000. Consequently, it is necessary to maintain an ongoing investigation on the development and management aspects as well as on the land subsidence aspect after the project is completed to the same period as that of the Measures.

2. The boundary of the critical zones on the map attached to the Remedial Measures has to be periodically adjusted and revised according to the future situation. Strict control on groundwater use is needed in the critical zones and requests for groundwater utilisation in the private sector should be thoroughly assessed, considering the results of the investigation before each permission is granted.

3. Future heavy pumpage of the groundwater in many areas, which is expected due to population growth is not proportional to an expansion of water supply. Similar investigation and study will be conducted in these areas so that exploitation of the groundwater can properly be managed to prevent the problems of deterioration caused by salt-water intrusion and land subsidence.

Prepared by : 1. Dr. Vachi Ramnarong, Research Expert,
Department of Mineral Resources. Tel : 245-6214-5
2. Ms. Somkid Buapeng, Hydrogeologist,
Ground Water Division, Department of Mineral
Resources. Tel : 246-1161-9 ext. 276



Samut Sakhon Industrial Area (300 sq.km)



Phra Pradaeng Industrial Area (100 sq.km)



Rangsit Industrial Area (160 sq.km)

Expert's Job Description Form

Post Title : Team Leader (Project Manager)

Duration : 5 months

Date Required : June 1989

Duty Station : Department of Mineral Resources, Bangkok
Thailand.

Duties : Planning and Management of the project.

Qualification : A person with an advanced degree in engineering or hydrogeology and several years of experience in the study of groundwater resources development and management and land subsidence problems.

Language : English

Background information : Intensive pumping of groundwater from the aquifers of Bangkok mainly for municipal supply and industrial use has caused a drastic decline of piezometric levels from few metres below ground surface before 1955 to presently about 50 metres. The decline in artesian ^{น้ำบาดาล} pressure has resulted in contamination of the fresh water in the aquifers by salt-water ^{pollution} encroachment and land subsidence.

Previous comprehensive investigation and study programmes for the groundwater development and management and land subsidence in Bangkok were mostly concentrated on the central part and the eastern suburbs of Bangkok where densely-populated areas were located. Nowadays, groundwater in new industrial areas in the provinces adjacent to Bangkok is heavily pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Project Planner/Water Supply Engineer

Duration : 3.5 months

Date Required : June 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for planning of optimum groundwater utilization, planning of alternative water sources and recommendations for rationalization of industrial water.

Qualification : A person with an advanced degree in water resources engineering or related field and several years of experiences in water supply management.

Language : English

Background information : Intensive pumping of groundwater from the aquifers of Bangkok mainly for municipal supply and industrial use has caused a drastic decline of piezometric levels from few metres below ground surface before 1955 to presently about 50 metres. The decline in artesian pressure has resulted in contamination of the fresh water in the aquifers by salt-water encroachment and land subsidence.

Previous comprehensive investigation and study programmes for the groundwater development and management and land subsidence in Bangkok were mostly concentrated on the central part and the eastern suburbs of Bangkok where densely-populated areas were located. Nowadays, groundwater in new industrial areas in the provinces adjacent to Bangkok is heavily pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Socio-Economist

Duration : 3 months

Date Required : June 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for economic evaluation of damages
and unfavourable matters caused by land subsidence,
and planning of the most appropriate means for
controlling groundwater depletion and land
subsidence.

Qualification : A person with an advanced degree in economics
and experience in a water resources development
project.

Language : English

Background information : Intensive pumping of groundwater from
the aquifers of Bangkok mainly for municipal
supply and industrial use has caused a drastic
decline of piezometric levels from few metres
below ground surface before 1955 to presently
about 50 metres. The decline in artesian
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Previous comprehensive investigation
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development and management and land subsidence
in Bangkok were mostly concentrated on the
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where densely-populated areas were located.
Nowadays, groundwater in new industrial areas
in the provinces adjacent to Bangkok is heavily
pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Hydrogeologist I/Geologist

Duration : 8 months

Date required : June 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for construction of monitoring wells for groundwater levels and land subsidence, soil sampling and rock coring, field and laboratory determination of hydrogeologic parameters.

Qualification : A person with a masters degree in hydrogeology or geology and experience in groundwater development and management.

Language : English

Background information : Intensive pumping of groundwater from the aquifers of Bangkok mainly for municipal supply and industrial use has caused a drastic decline of piezometric levels from few metres below ground surface before 1955 to presently about 50 metres. The decline in artesian pressure has resulted in contamination of the fresh water in the aquifers by salt-water encroachment and land subsidence.

Previous comprehensive investigation and study programmes for the groundwater development and management and land subsidence in Bangkok were mostly concentrated on the central part and the eastern suburbs of Bangkok where densely-populated areas were located. Nowadays, groundwater in new industrial areas in the provinces adjacent to Bangkok is heavily pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Hydrogeologist I/Computer Engineer

Duration : 7 months

Date required : June 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for preparation and verification of aquifer model, salt-water intrusion and land subsidence model, model operation for simulation and prediction of water level, land subsidence and salt-water intrusion into the aquifers with respect to pumpage.

Qualification : A person with an advanced degree in hydrogeology and a good knowledge of computer programming and experience in the development of groundwater flow and salt-water intrusion modeling.

Language : English

Background information : Intensive pumping of groundwater from the aquifers of Bangkok mainly for municipal supply and industrial use has caused a drastic decline of piezometric levels from few metres below ground surface before 1955 to presently about 50 metres. The decline in artesian pressure has resulted in contamination of the fresh water in the aquifers by salt-water encroachment and land subsidence.

Previous comprehensive investigation and study programmes for the groundwater development and management and land subsidence in Bangkok were mostly concentrated on the central part and the eastern suburbs of Bangkok where densely-populated areas were located. Nowadays, groundwater in new industrial areas in the provinces adjacent to Bangkok is heavily pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Geophysicist/Hydrologist

Duration : 2.5 month

Date required : June 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for drilling of monitoring wells
for water levels and water quality. Analysis
and testing of soil samples and borehole
geophysical logging and hydrogeologic analysis
and processing.

Qualification : A person with a degree in geophysics or hydrology
and experience in borehole geophysical logging
interpretation.

Language : English

Background information : Intensive pumping of groundwater from
the aquifers of Bangkok mainly for municipal
supply and industrial use has caused a drastic
decline of piezometric levels from few metres
below ground surface before 1955 to presently
about 50 metres. The decline in artesian
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Previous comprehensive investigation
and study programmes for the groundwater
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in Bangkok were mostly concentrated on the
central part and the eastern suburbs of Bangkok
where densely-populated areas were located.
Nowadays, groundwater in new industrial areas
in the provinces adjacent to Bangkok is heavily
pumped and land subsidence is expected.

Expert's Job Description Form

Post title : Surveyor

Duration : 1 month

Date required : August 1989

Duty Station : Department of Mineral Resources, Bangkok,
Thailand.

Duties : Responsible for installation of land subsidence
recorders and bench marks, surface levelling
to determine changes in ground elevation in
the project area.

Language : English

Background information : Intensive pumping of groundwater from
the aquifers of Bangkok mainly for municipal
supply and industrial use has caused a drastic
decline of piezometric levels from few metres
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附 屬 資 料

2. S / W

SCOPE OF WORK

FOR

THE STUDY ON MANAGEMENT OF GROUNDWATER AND
LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA
AND ITS VICINITY

AGREED UPON BETWEEN

DEPARTMENT OF MINERAL RESOURCES
MINISTRY OF INDUSTRY

AND

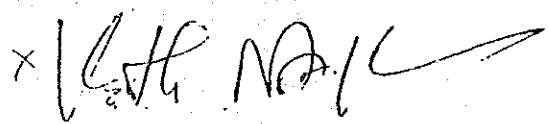
PUBLIC WORKS DEPARTMENT
MINISTRY OF INTERIOR


THE KINGDOM OF THAILAND,

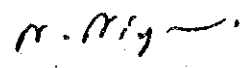
AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Bangkok, February 5, 1992


Mr. VISITH NOIPHAN
DIRECTOR-GENERAL
DEPARTMENT OF MINERAL RESOURCES,
MINISTRY OF INDUSTRY


Dr. TADAHIKO YAGYU
LEADER
THE PREPARATORY STUDY TEAM,
JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)


Mr. NIYOM NIYAMANUSORN
DIRECTOR-GENERAL
PUBLIC WORKS DEPARTMENT
MINISTRY OF INTERIOR

I INTRODUCTION

In response to the request of the Government of Kingdom of Thailand (hereinafter referred to as "GOT"), the government of Japan (hereinafter referred to as "GOJ") decided to implement a Study on Management of Groundwater and Land Subsidence in Bangkok Metropolitan Area and Its Vicinity (hereinafter referred to as "the Study"), within the general framework of technical cooperation between Japan and Thailand, which is set forth in the Agreement on Technical Cooperation between GOJ and GOT, signed on November 5, 1981.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of GOJ, will undertake the Study in accordance with the relevant laws and regulations in force in Japan and in close cooperation with the authorities concerned of the Kingdom of Thailand.

The Department of Mineral Resources, Ministry of Industry (hereinafter referred to as "DMR") and the Public Works Department, Ministry of Interior (hereinafter referred to as "PWD") shall act as counterpart agency to the Japanese study team (hereinafter referred to as "the Team"). DMR is the prime agency and acts as a coordinating body in relation with other relevant organizations for the smooth implementation of the Study.

The present document sets forth the scope of work with regard to the Study.

II OBJECTIVES OF THE STUDY

The objectives of the Study are :

- (1) to establish Groundwater Management System ;
- (2) to prepare alleviation plans against Land Subsidence and Saline Water Intrusion.

III STUDY AREA

The Study area will cover the Bangkok Metropolitan Area and Its Vicinity.

IV SCOPE OF THE STUDY

In order to achieve the objective mentioned above, the Study shall cover the following items ;

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1. Data Collection and Review
 - (1) National and regional socio-economic data
 - (2) Topographical data and maps
 - (3) Meteorological and hydrological data
 - (4) Soil and geological data
 - (5) Tidal observation data
 - (6) Land subsidence data
 - (7) Piezometric data of groundwater
 - (8) Water quality
 - (9) Existing wells and related facilities
 - (10) Present and future land use
 - (11) Water demand and supply
 - (12) Water demand forecast
 - (13) Laws and regulations related to the Study
 - (14) Reports of previous studies and projects related to the Study
 - (15) Other related data and information
2. Basic Investigations
 - (1) Comprehension of the present status of groundwater utilization, land subsidence, and saline water intrusion
 - (2) Collection and compilation of well inventories for preparation of hydrogeological database
 - (3) Review and examination of the previous studies concerning artificial recharge
 - (4) Examination of the law system and organization related to management of groundwater and land subsidence
3. Detailed Investigations
 - (1) Drilling of test wells and conduct of various in-situ and laboratory tests for comprehension of hydrogeological and soil characteristics
 - (2) Observation of groundwater levels and land subsidence
 - (3) Leveling survey
 - (4) Water quality analysis
 - (5) Completion of hydrogeological database
4. Study and Analysis
 - (1) Hydrological and hydraulic analysis
 - (2) Prediction of groundwater behavior, land subsidence and saline water intrusion
5. Planning and Others
 - (1) Planning of groundwater management system
 - (2) Planning for alleviation of land subsidence and saline water intrusion
 - (3) Preliminary estimation of project costs
 - (4) Social and environmental impact
 - (5) Implementation schedule
 - (6) Project evaluation
 - (7) Recommendations

V SCHEDULE OF THE STUDY

The Study will generally be carried out in accordance with the attached tentative schedule (as shown in Annex-1).

VI REPORTS

JICA will prepare and submit the following reports in English to GOT.

1. Inception Report
Thirty (30) copies at the commencement of the first field survey in Thailand.
2. Interim Report 1
Thirty (30) copies within eleven (11) months from the date of the commencement of the Study.
3. Interim Report 2
Thirty (30) copies within twenty-two (22) months from the date of the commencement of the Study.
4. Draft Final Report
Thirty (30) copies within twenty-eight (28) months from the date of the commencement of the Study. DMR and PWD, Thailand shall present their comments on the Draft Final Report within one (1) month after receipt of the Report.
5. Final Report
Fifty (50) copies within one (1) month after the receipt of the comments on the Draft Final Report.

VI UNDERTAKINGS OF THE KINGDOM OF THAILAND

1. In accordance with the Agreement on Technical Cooperation between GOJ and GOT dated November 5, 1981, GOT shall accord benefits to the Team as follows :
 - (1) to permit the members of the Team to enter, leave and sojourn in Thailand for the duration of their assignment therein, and exempt them from alien registration requirements and consular fee;
 - (2) to exempt the members of the Team from taxes, duties, and other charges on equipment, machinery and other materials brought into Thailand for the implementation of the Study ;

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- (3) to exempt the members of the Team from income taxes and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with implementation of the Study;
 - (4) to bear claims, if any arises, against the members of the Team resulting from, occurring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.
2. To facilitate smooth conduct of the Study, DMR shall take necessary measures in cooperation with other relevant organizations :
- (1) to secure permission for entry into private properties or restricted areas for the conduct of the Study.
 - (2) to secure permission for the Team to take all data and documents (including photographs) related to the Study out of Thailand to Japan.
 - (3) to provide medical services as needed. Its expenses will be chargeable on the members of the Team.
 - (4) to ensure the safety of the members of the Team when and as it is required in the course of the study.
3. DMR and PWD shall, at its own expense, provide the Team with the followings in cooperation with other relevant organizations:
- (1) Available data and information related to the Study ;
 - (2) Counterpart personnel and support staff necessary for the Study ;
 - (3) Suitable office space with necessary normal office equipment in Bangkok ;
 - (4) Credential or identification cards.

VII UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take following measures :

1. to dispatch, at its own expense, the Team to Thailand;
2. to pursue technology transfer to the Thai counterpart personnel in the course of the Study ;

IX CONSULTATION

DMR, PWD and JICA shall consult with one another in respect of any matter that may arise from or in connection with the Study.

附 属 資 料

3. 議事録 (M/M)

MINUTES OF MEETING
FOR
THE STUDY ON MANAGEMENT OF GROUNDWATER AND
LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA
AND ITS VICINITY

AGREED UPON BETWEEN

DEPARTMENT OF MINERAL RESOURCES
MINISTRY OF INDUSTRY

AND

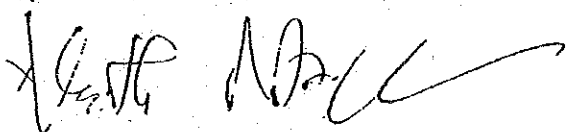
PUBLIC WORKS DEPARTMENT
MINISTRY OF INTERIOR

THE KINGDOM OF THAILAND,

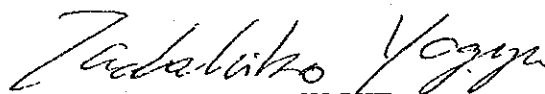
AND

JAPAN INTERNATIONAL COOPERATION AGENCY

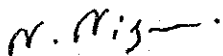
Bangkok, February 5, 1992



Mr. VISITH NOIPHAN
DIRECTOR-GENERAL
DEPARTMENT OF MINERAL RESOURCES
MINISTRY OF INDUSTRY



Dr. TADAHIKO YAGYU
LEADER
THE PREPARATORY STUDY TEAM
JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)



Mr. NIYOM NIYAMANUSORN
DIRECTOR-GENERAL
PUBLIC WORKS DEPARTMENT
MINISTRY OF INTERIOR



1. In response to the request of the Government of Thailand, the Government of Japan has dispatched a Preparatory Study Team for the Study on Management of Groundwater and Land Subsidence in the Bangkok Metropolitan Area and Its Vicinity, from 28th January to 6th February 1992, through the Japan International Cooperation Agency (JICA).
2. The Preparatory Study Team headed by Dr. Tadahiko Yagyu and Thai official concerned headed by Dr. Vachi Ramnarong had a series of discussions and exchanged view on the draft of the Scope of Work (S/W) for the Study. As a result of the discussions, some revisions were made and both Thai and Japanese sides agreed upon and signed the Scope of Work.
3. In addition to the Scope of Work, both sides confirmed the followings;
 - a) Title of the Study
Thai side requested Japanese side to change the title of the Study as shown below, and Japanese side agreed.

The Study on Management of Groundwater and Land Subsidence in the Bangkok Metropolitan Area and Its Vicinity.
 - b) Study Area
The Study area should cover the Bangkok Metropolitan area and its vicinity as shown in the attached map. The locations for drilling wells and area covering alleviation plan against land subsidence and saline water intrusion, however, will be specified after the commencement of the Study.
 - c) Study schedule
Thai side requested Japanese side to execute the analytical work of the Study in Thailand. Japanese side expressed that the initial stage of the analytical work could be executed in Thailand.
 - d) Working Organization
Both side agreed upon to set up meetings consisted of DMR, PWD, ONEB, MWA, BMA, RTSD, IEAT and AIT at the time of submission of each report. The participating agencies will cooperate in terms of data collection upon the request of the study team, and will exchange their views on the study. DMR will provide the chairperson to the meetings.

e) Counterpart

Japanese side requested Thai side to provide counterpart personnel in appropriate field corresponding to the Japanese personnel.

f) Drilling and Installation of Observation Equipment

Both Japanese and Thai side agreed to establish one station which equips with eight observation wells in each aquifer up to about 600m deep and some additional stations in which each station consists of five observation wells penetrating to five different aquifers up to about 300m deep. The Thai side is responsible to secure the land for the installation of the equipments.

g) Leveling Survey

JICA will execute leveling survey in a certain area connecting the newly drilled observation wells. DMR will provide some surveyors for this leveling survey.

h) Artificial Groundwater Recharge

The previous and on-going studies and experiment on artificial groundwater recharge both in Thailand and Japan shall be reviewed and evaluated technically as well as economically and applicability of certain types of recharge shall be scrutinized.

i) Simultaneous Observation of Groundwater level

Simultaneous observations of groundwater level shall be conducted at least twice during the study period.

j) Necessary Equipment and Machinery

The following equipment and machinery are necessary for the Study ; water level recorders, subsidence recorders, water level indicators, water samplers, water quality tester, motor pump, leveling equipment, microcomputer with laser printer for data base and vehicles.

4. Thai side requested Japanese side to convey following matters to JICA Head Quarter. Japanese side agreed and took note ;

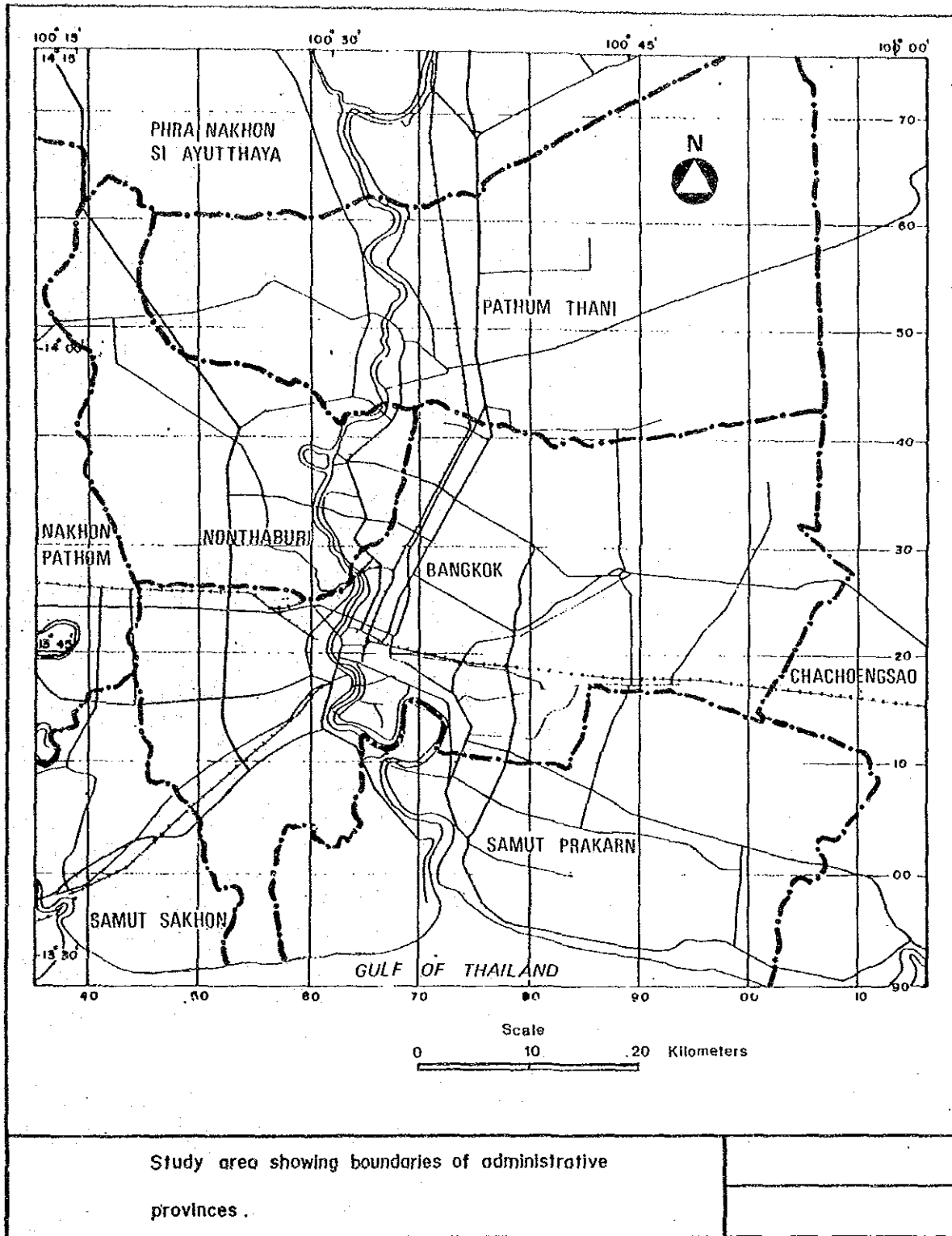
a) To provide the Thai counterpart personnel with the opportunities of training and study tour in Japan in order to transfer technology of land subsidence and artificial recharge effectively.

b) To conduct a seminar in Thailand in order to transfer technology not only to the counterpart agencies but also to the agencies concerned for the effective dissemination of the Study results.

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- c) To donate to Thai side the equipment brought into Thailand for the implementation of the Study on the completion of the Study.
5. Japanese side requested DMR to issue an invitation letter for entry visa for members of the Study Team. DMR accepted the request mentioned above.



LIST OF ATTENDEES

1. THAILAND SIDE

- Vachi Ramnarong - Research Expert, Director of the Mitigation of Groundwater Crisis and Land Subsidence in Bangkok (MGL Project), DMR
- Somkid Buapeng - Chief of Groundwater Data Center, Ground Water Division, DMR
- Posit Nippitawasin - Senior Hydrogeologist, Hydrogeology Sub-division, Water Well Development Division, PWD

2. JAPANESE SIDE

- Tadahiko Yagyu - Managing Director, Social Development Study Department, JICA
- Masahisa Okano - Senior Officer for Disaster Prevention and Restoration, River Bureau, Ministry of Construction
- Masamitsu Mizuno - Director, River Administration Division, River Department, Hokuriku Regional Construction Bureau, Ministry of Construction
- Yuji Maruo - Development Specialist, Institute for International Cooperation, JICA
- Fumiko Tatebayashi - Staff, Social Development Study Department, JICA
- Satoshi Nakamura - Senior Engineer, OYO Corporation

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附 属 資 料

4. 面 談 者 リ ス ト

面談者リスト

- | | | |
|---|--|--|
| 1 | D M R
Mr. Visith Noiphan
Mr. Prapas Tp-ron
Dr. Vachi Ramanarong
Ms. Somkid Buapeng | Director General
Director, Groundwater Division
Research Expert
Chief of Groundwater Data
Center, Groundwater Division |
| 2 | P W D
Mr. Niyom Niyamanusorn
Mr. Sujin Channarong
Mr. Posit Nippidawasin | Director General
Chief Engineer
Senior Hydrogeologist,
Hydrogeology Sub-division,
Water Well Development
Division |
| 3 | D T E C
Mr. Apinan Patiyanon

Mr. Tomikazu Inagaki | Director, External Cooperation
Division 3

JICA Expert |
| 4 | O N E B
Mr. Sonthi Vannanaeng

Mr. Katsumi Otani | Director, Environment Impact
Assessment Division
Senior Advisor, ERTC |
| 5 | M W A
Mr. Watana Yuckpan

Mr. Prasat Silphiphat | Deputy Governor for Planning &
Development
Senior Entgineer, Planning
Department |
| 6 | B M A
Mr. Bampen Jatoorapreuk | Director, Department of Public
Works |
| 7 | I E A T
Dr. Somchet Thinaphong | Governor |
| 8 | R T S D
Maj. Gen. Sompong Kraison | Deputy Director of Survey |
| 9 | A I T
Dr. Prinya Nutalaya

Dr. Yusuke Honjo | Professor of Engineering
Geology
Associate Professor and
Chairman |

附 属 資 料

5. 収集資料リスト

LIST OF COLLECTED DATA

1 MAP

- 1-1 Road map of Bangkok and Thailand, Scale 1:20,000 and 1:2,000,000, RTS
- 1-2 Geological Map of Thailand, Scale 1:1,000,000 (2 sheet), DMR
- 1-3 Geological Map of Thailand, Scale 1:1,000,000 (Ayutthaya, Nakhonpathom, Bangkok, Huahin, Rayong), DMR
- 1-4 Hydrogeological map of Thailand Western Lower Central and Eastern Thailand, 1976 revision 1978, Scale 1:500,000, DMR
- 1-5 Location of Monitoring Wells in Bangkok Metropolitan Area up to 1986, DMR
- 1-6 Map of Thailand Showing location of Wells Drilled (Central), DMR
- 1-7 Groundwater Map No.1 Hydrogeological Profile of the Lower Chao Phraya Basin Showing principal Aquifers, DMR
- 1-8 Groundwater Map No.3 Groundwater level Map of Bangkok Showing Piezometric Surfaces of Phra Paradaeng Aquifer in mid 1985, DMR
- 1-9 Groundwater Map No.4 Groundwater level Map of Bangkok Showing Piezometric Surfaces of Nakhon Luang Aquifer in mid 1985, DMR
- 1-10 Groundwater Map No.5 Groundwater level Map of Bangkok Showing Piezometric Surfaces of Nonthaburi Aquifer in mid 1985, DMR
- 1-11 Location of Land Subsidence Stations in Bangkok Metropolitan Area, DMR
- 1-12 Isochlor map of Phra Pradaeng Aquifer in 1986 Showing Distribution of Chloride Concentration, DMR
- 1-13 Isochlor map of Nakhon Luang Aquifer in 1986 Showing Distribution of Chloride Concentration, DMR
- 1-14 Isochlor map of Nonthaburi Aquifer in 1986 Showing Distribution of Chloride Concentration, DMR

2 OUTLINE OF EACH ORGANIZATION

- 2-1 Department of Mineral Resources (2 sheet), DMR
- 2-2 Thailand Metropolitan Waterworks Authority, MWA
- 2-3 Annual Report 1990 Metropolitan Water Works Authority, MWA
- 2-4 Industrial Estate Authority of Thailand (English and Japanese), IEAT
- 2-5 Annual Report on Research and Activities 1989, AIT Division of Geotechnical & Transportation Engineering
- 2-6 Annual Report on Research and Activities 1990, AIT Division of Geotechnical & Transportation Engineering
- 2-7 Asian Institute Technology Prospectus 1992, AIT

3 GENERAL INFORMATION

- 3-1 Groundwater ACT B.E. 2520
- 3-2 Thailand Country Report to the United Nations Conference on Environmental and Development (UNCED), June 1992

- 3-3 Laws and Standards on Pollution Control in Thailand
2nd ed., ONEB, Jul. 1989
- 3-4 The Fifth Bangkok Water Supply improvement Project
(1992-1996), MWA, Nov. 1991
- 3-5 Master Plan for Water Supply and Distribution of
Metropolitan Bangkok, Volume 1 - 4 and Map, MWA, Oct.1990

4 GROUND SUBSIDENCE AND GROUNDWATER LEVEL

- 4-1 The Setting of Vertical Bench Mark Around Bangkok (1986),
PWD
- 4-2 The Setting of Vertical Bench Mark Around Bangkok
(1989-1990), PWD

5 STUDY PAPER

- 5-1 Mitigation of Groundwater Crisis and Land Subsidence in
Bangkok, 1991, Vachi RAMARONG and Somkid BUAPENG,
Journal of Thai Geosciences
- 5-2 Land Subsidence in Bangkok, Thailand - Results of Initial
Investigation, 1978, Jerasak Premchitt
- 5-3 Some Land Subsidence Experience in Japan and Their
Relevance to Subsidence in Bangkok, Thailand 1979,
Toshinobu Akagi
- 5-4 Flood Control Bangkok and Vicinity Chapter 5 Ground
Subsidence, Bangkok Metropolitan Administration
Department of Drainage and Sewerage, June 1988
- 5-5 Investigation of Land Subsidence caused by Deep Well
Pumping in the Bangkok Area Comprehensive Report
1978-1982, Division of Geotechnical & Transportation
Engineering AIT
- 5-6 Groundwater Resources in Bangkok Area Development and
Management Study Comprehensive Report 1978-1982, AIT &
DMR, April 1982
- 5-7 Workshop on Bangkok Land Subsidence - What's Next?, 22-23
June 1989

6 SOIL INVESTIGATION REPORT

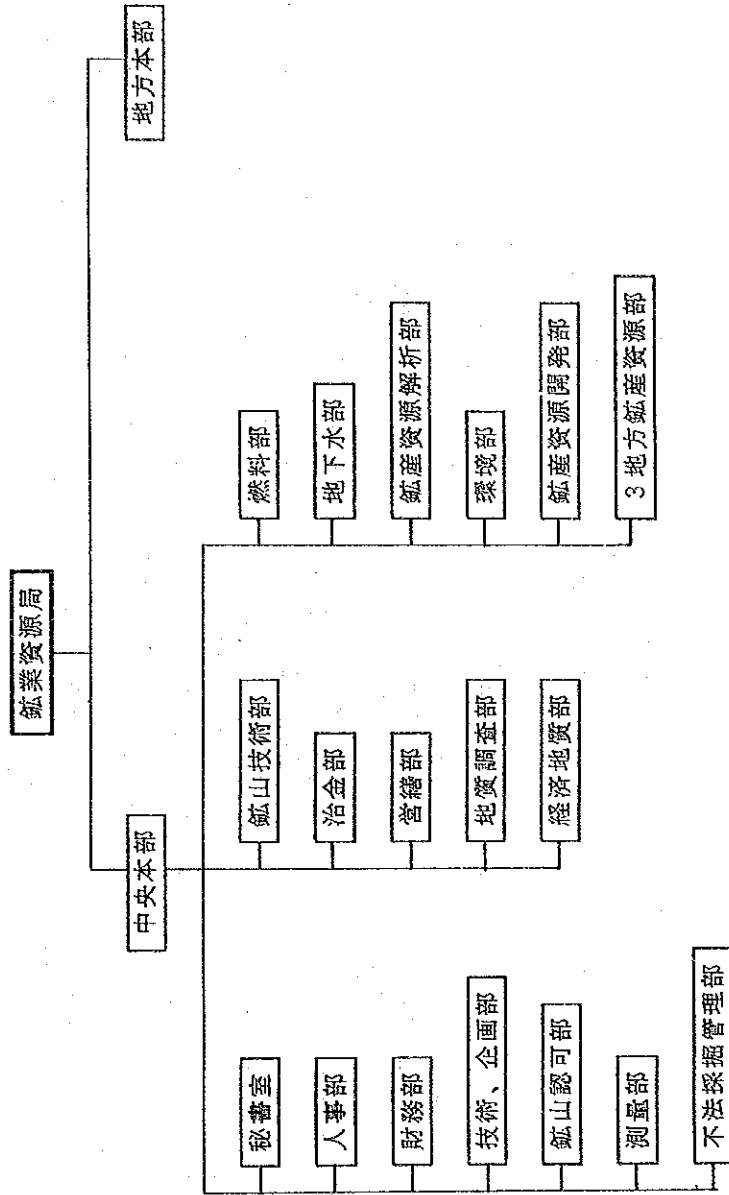
- 6-1 Surveys of Ksemrat - Rama IV - Soi Aree Intersections,
BMA
- 6-2 Surveys of Sri Ayuttaya Rd. - Rajaprarop Rd., STS

附 属 資 料

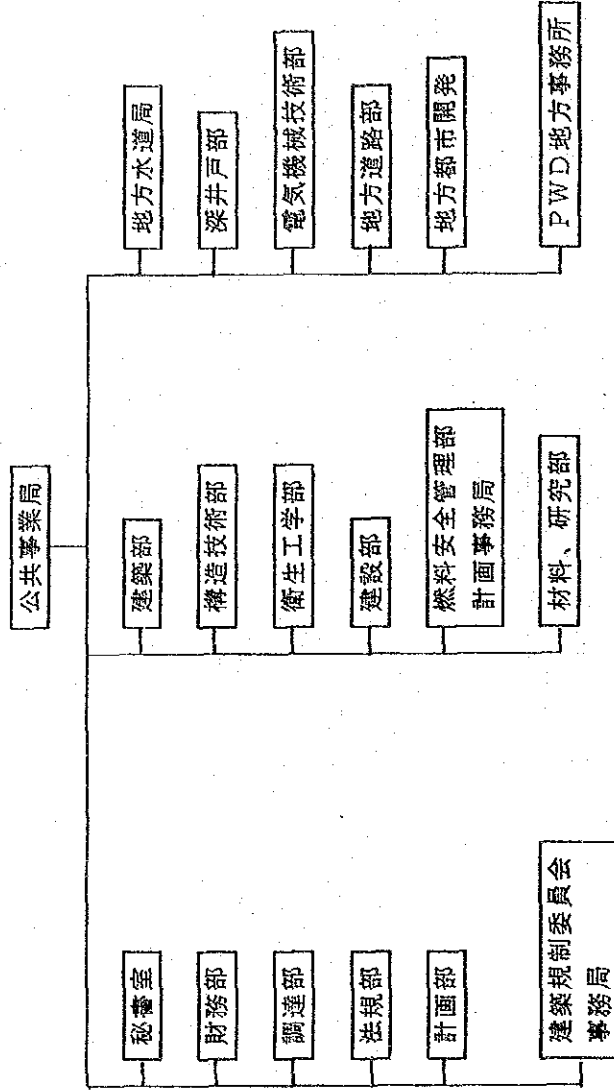
6. 卷 末 資 料

- (1) 鉱業資源局組織図
- (2) 公共事業省組織図
- (3) 首都圏水道公社組織図
- (4) 国家環境委員会組織図
- (5) バンコク首都圏庁組織図
- (6) タイ鉱業用地公社組織図

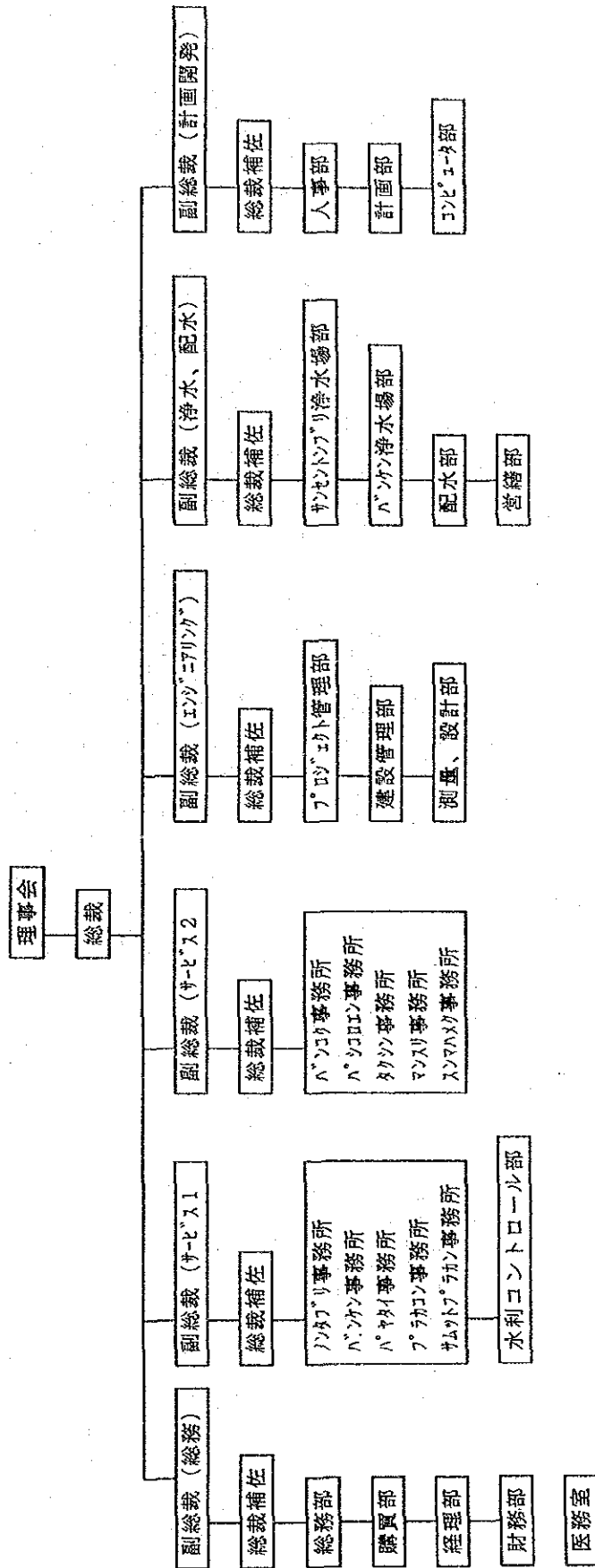
(1) 鈷業資源局組織圖



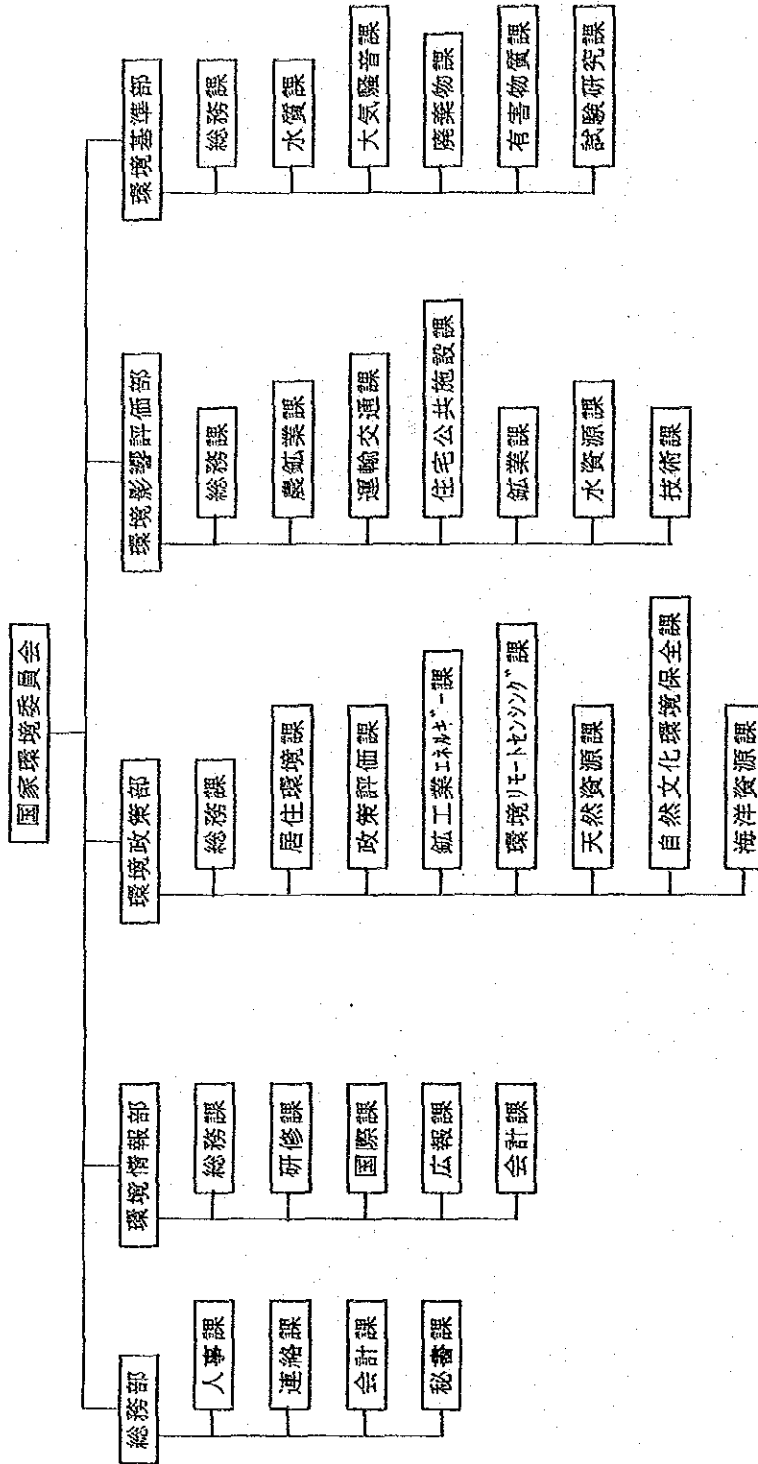
(2) 公共事業省組織圖



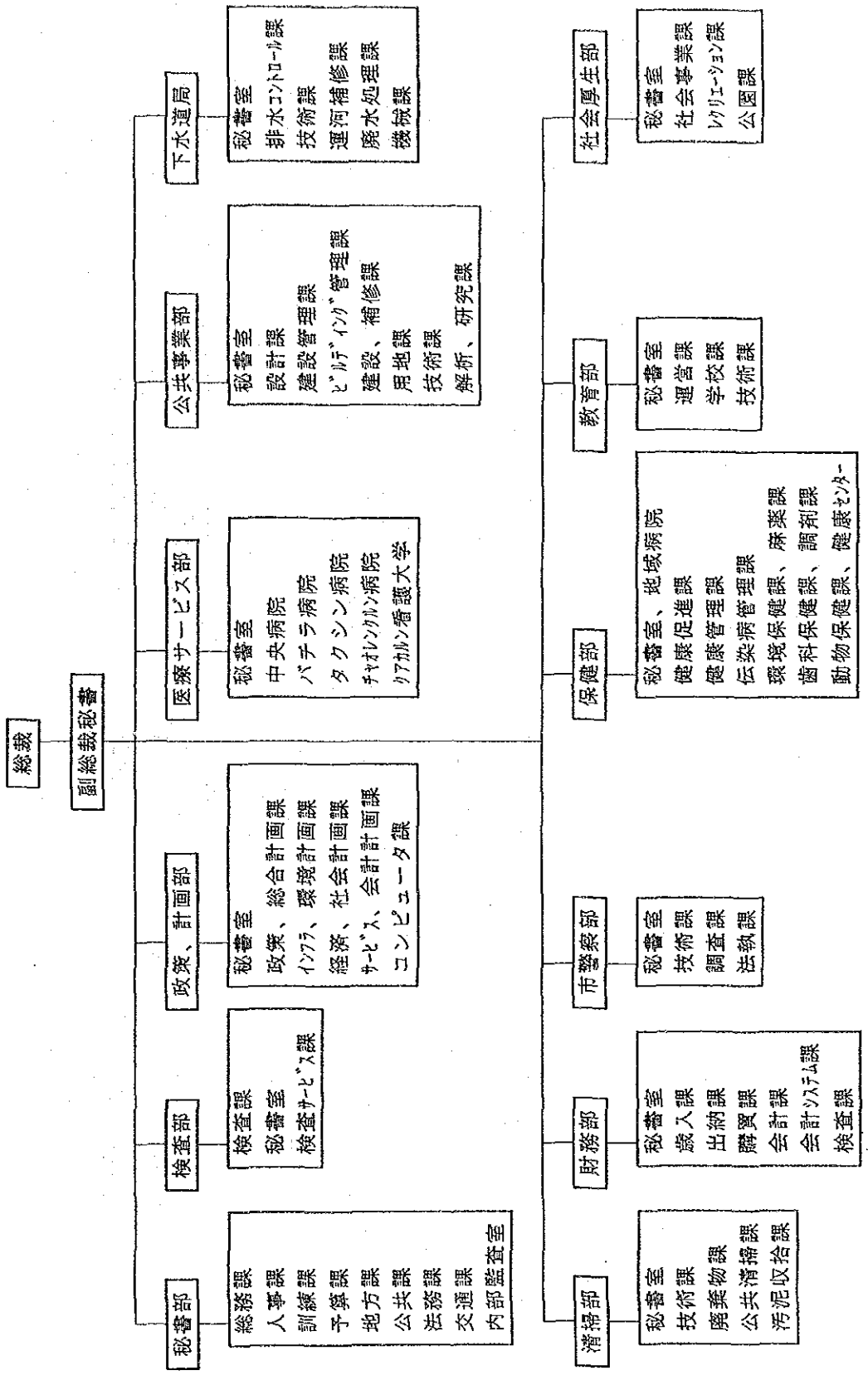
(3) 首都圏水道公社組織図



(4) 国家環境委員会組織図



(5) バンコク首都圏庁組織図



(6) ターミル業用地公社組織図

