Table 7.1 Input Parameters to The 3-D Simulation Model

Model Layer	Aquifer Unit	Aquifer Type	Top and Bottom Elevation (masl)	Effective Porosity	Specific Storage (m^{-1})	Hydraulic Conductivity		Initial Heads (masl)	Recharge Rate (mm/day)	Pumping Rate (1991) (m^3/day)
						Horizontal (m/day)	Vertical (m/day)			
Layer-1	First Aquitard	Confined/Unconfined	Top: 8.1 to 30.2 Btm: -1.5 to -17.3	0.25	1.00E-04	0.1	0.01 (0.03)*	3.36 to 4.47	1.1	0
Layer-2	First Aquifer	Confined/Unconfined	Top: -1.5 to -17.3 Btm: -7.8 to -33.9	0.25	1.00E-04	10.0 to 35.4	1.0 to 3.54	-6.33 to 7.95	0	0
Layer-3	Second Aquitard	Confined	Top: -7.8 to -33.9 Btm: -21.7 to -49.4	0.25	1.00E-04	0.01	0.001 (0.04)*	-10.63 to 5.19	0	0
Layer-4	Second Aquifer	Confined	Btm: -21.7 to -49.4 Btm: -50.5 to -110.6	0.25	1.00E-04	20.1 to 70.9	2.01 to 7.09	-10.63 to 5.19	0	383,034

*: Modified value by the model calibration

Table 7.2 Groundwater Pumpage in Hanoi Area from 1990 to 1996

(Unit: m^3/day)

Year		1990	1991	1992	1993	1994	1995	1996
HWBC Major Well Field								
	PHAP VAN	46,248	37,968	39,120	32,544	28,752	34,548	21,360
	MAI DICH	42,240	55,728	61,176	65,112	59,400	56,904	55,800
	NGOC HA	39,576	57,672	40,752	44,640	39,000	45,720	44,328
	LUONG YEN	-	-	25,968	79,056	77,016	74,160	57,744
	TUONG MAI	-	-	30,744	26,736	26,496	27,648	23,184
	HA DINH	-	-	30,696	27,504	30,720	31,032	29,232
	NGO SY LIEN	49,200	53,160	45,240	44,592	42,168	33,672	30,504
	YEN PHU	49,032	46,584	45,960	47,928	37,728	39,096	29,328
Total of Major Well Fields		226,296	251,112	319,656	368,112	341,280	342,780	291,480
Other Total		133,986	131,922	135,930	142,500	149,070	155,640	162,210
Grand Total		360,282	383,034	455,586	510,612	490,350	498,420	453,690

[Data source]
Hanoi Dept. of Sci. & Enviro. Tech. and Hanoi Univ. of Mining and Geology (1998)
Dept. of Geology and Minerals of Vietnam (1998)
Nguyen Van Hoang (1993)

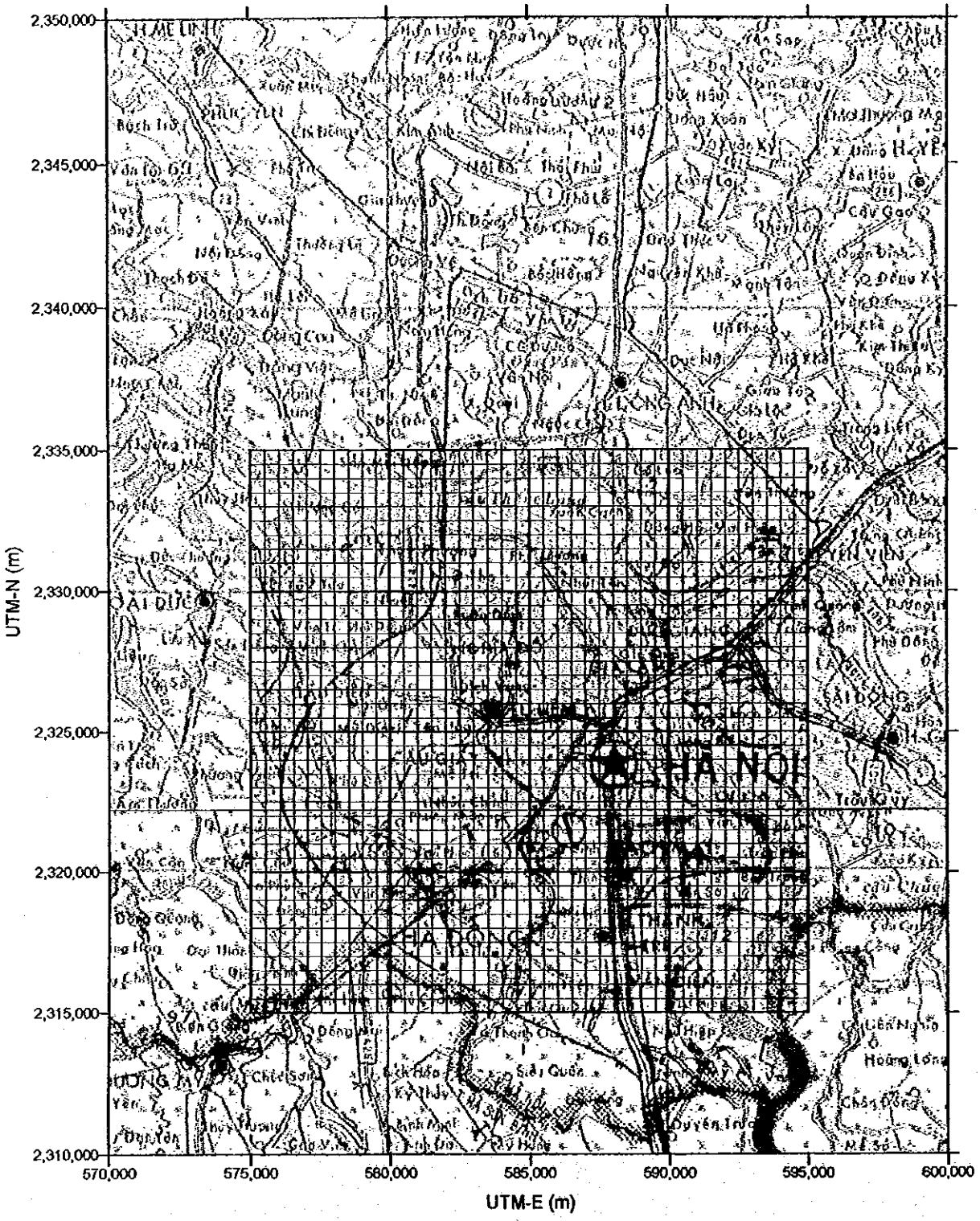
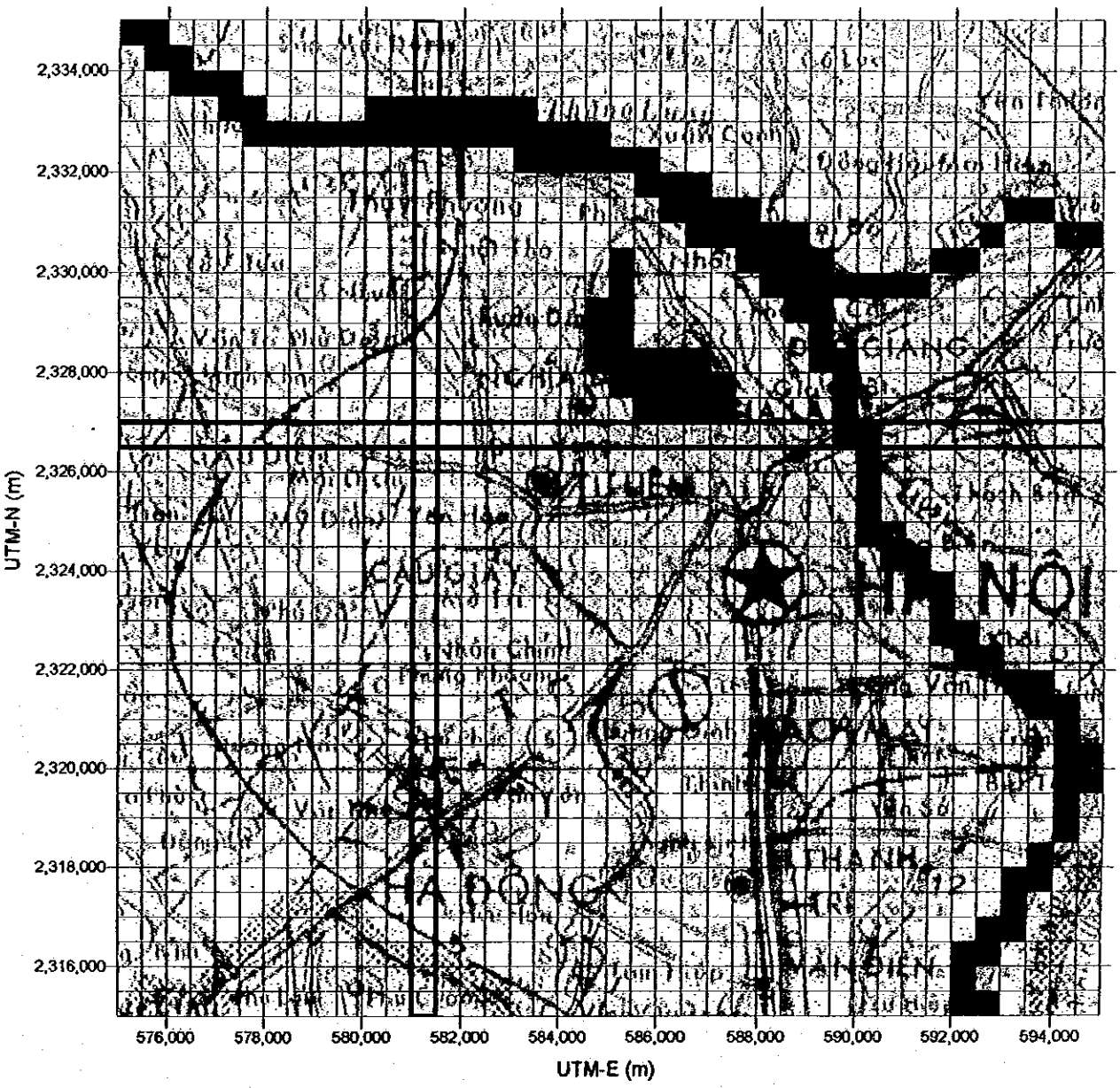


Figure 7.1 Model Grid for Groundwater Simulation Applied to Hà Nội Aquifer System

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Boundary Conditions of Layer-1



Constant-Head Boundaries are set at Red River (Sông Hồng), Duong River (Sông Đuống) and West Lake (Hồ Tây).
No Constant-Head Boundaries are set in Layer-2, Layer-3, and Layer-4.
Water levels at Constant-Head Boundaries are given from the data of Surface Water Observation Points.

Figure 7.2	Boundary Conditions of Hà Nội Groundwater Simulation Model
THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM	
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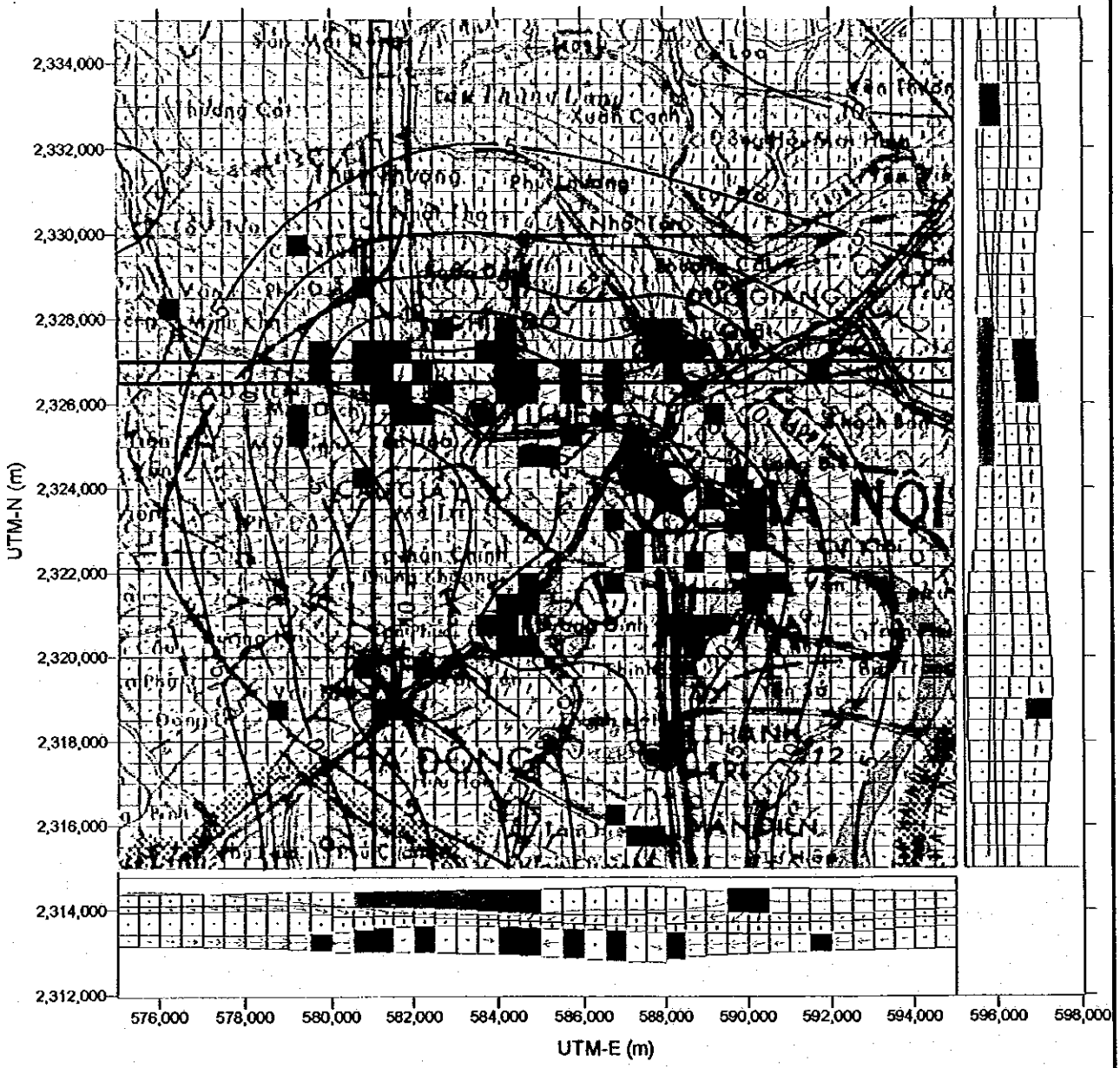
Steady-State 3-D Simulation



Top View: Layer 4 (Main Confined Aquifer)

Cross-Section
Projection Raw = 17
Projection Column = 13

Pumped Cell
Constant Head
Dried Cell
Flow Vector
Simulated Groundwater Table
-10 Equal Line of Simulated Piezometric Surface (masl)

Figure 7.3	Simulated Piezometric Surface by Steady-State Calibration

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Transient 3-D Simulation

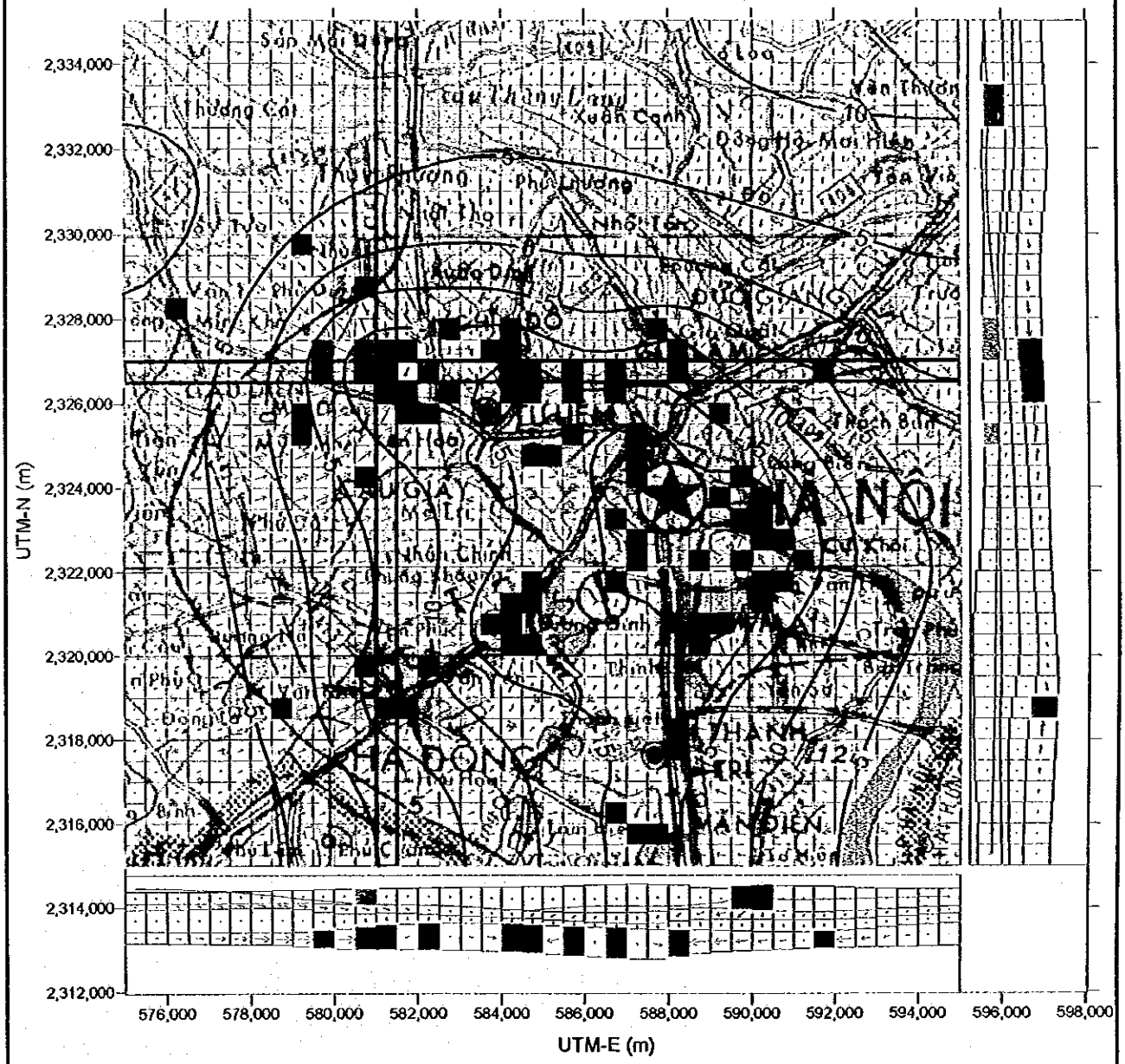


Figure 7.4	Simulated Piezometric Surface in 1996 by Transient Calibration

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

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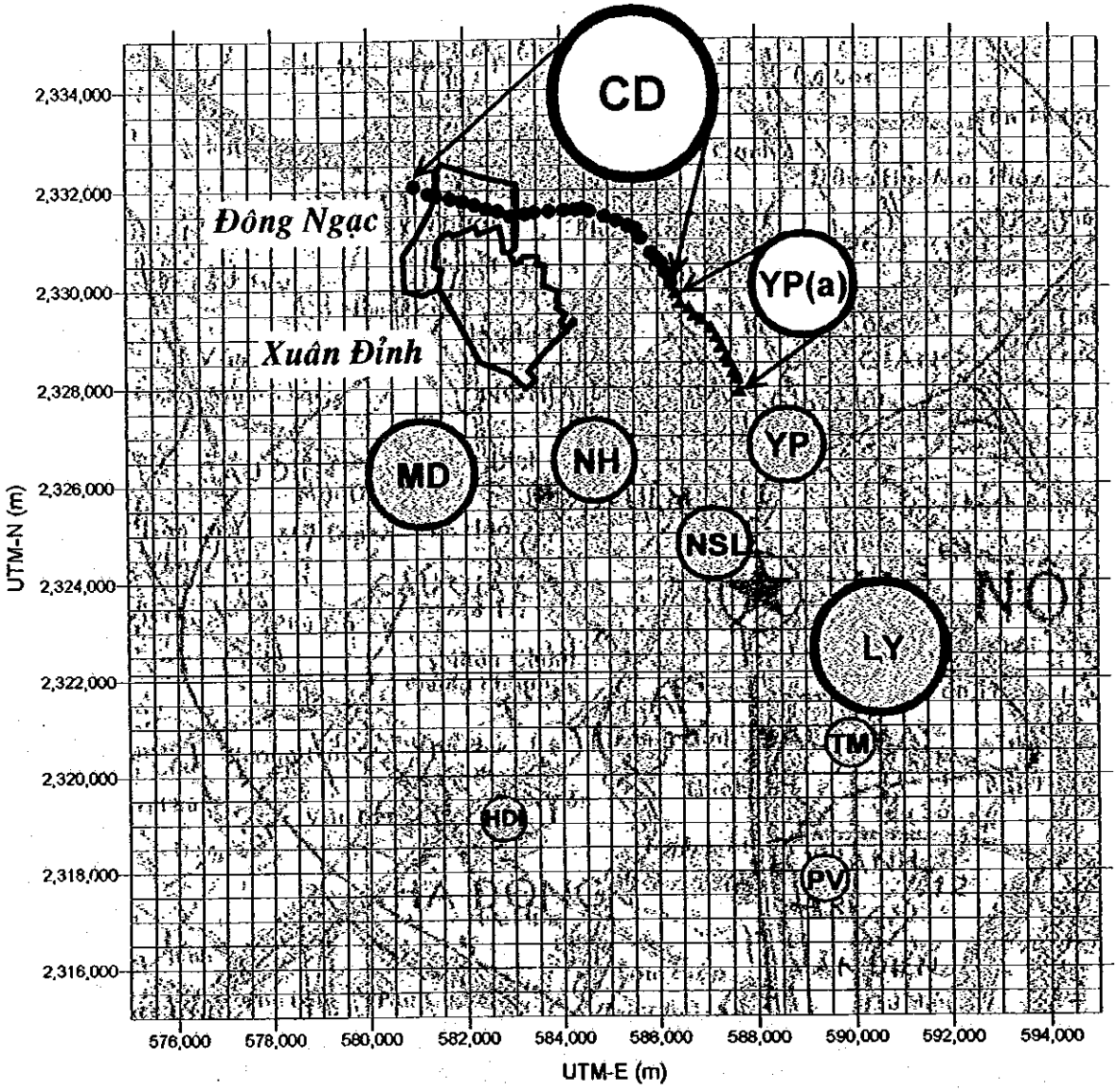
Future Major Groundwater Well Fields in Hà Nội Area



● Proposed Well Location of Cao Dinh Well Field

▲ Proposed Well Location of Yen Phu Well Field

	Name of Well Fields	Number of Wells	Pumping Rate (m^3/day)
1	Cao Dinh	26	97,964
2	Yen Phu (additional)	13	60,777
	TOTAL	39	158,741

[Data source: NHEGD-DGM (1998)]

Existing Well Field

Proposed Well Field

(Symbol size is proportional to its pumpage.)

Figure 7.5 Future Well Fields in Hà Nội Area for Future Prediction (Case-0)

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

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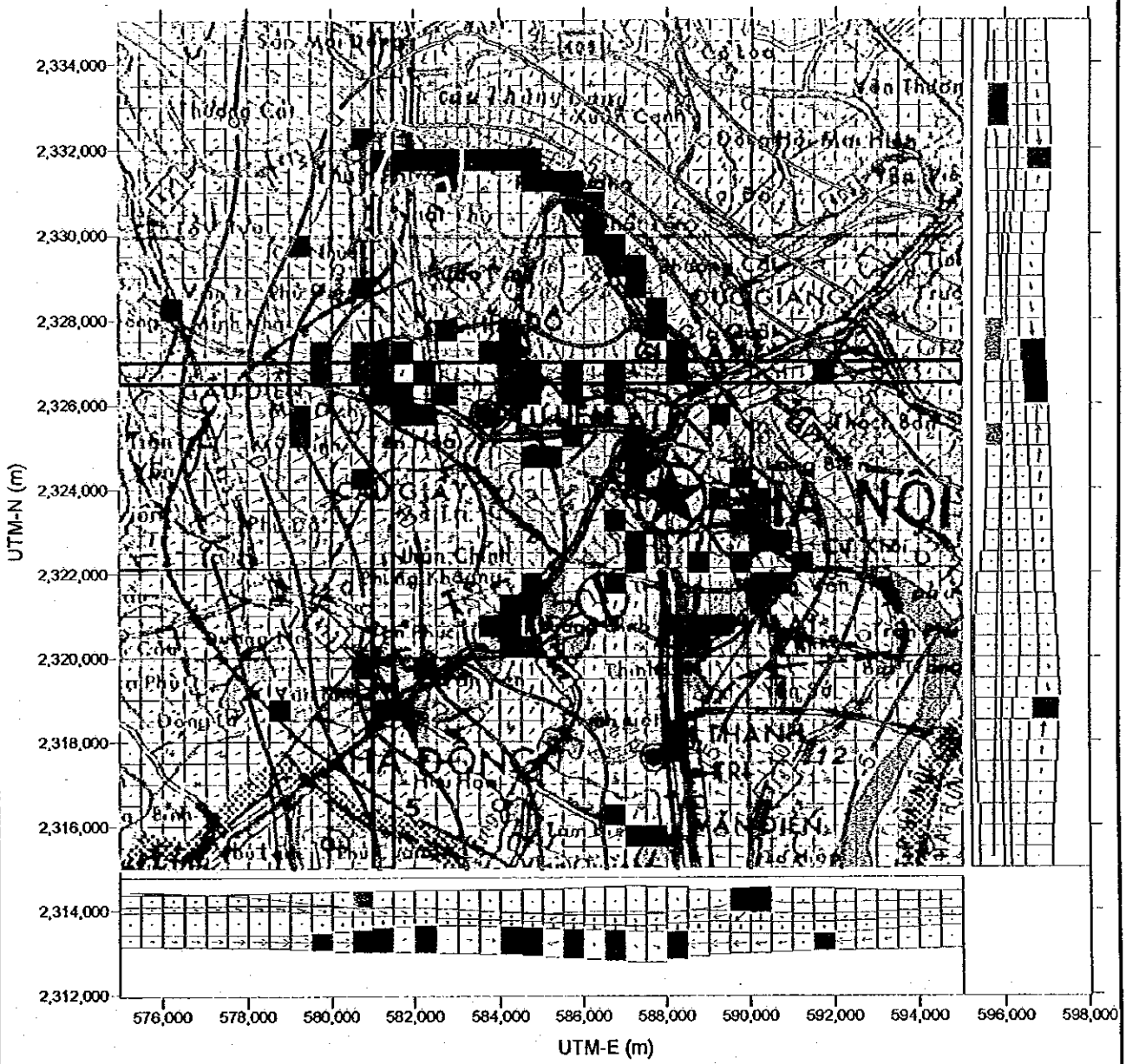
Transient 3-D Simulation (Case-0, after 10 years)



Top View: Layer 4 (Main Confined Aquifer)

Cross-Section
Projection Raw = 17
Projection Column = 13

Pumped Cell
Constant Head
Dried Cell
Flow Vector
Simulated Groundwater Table
-10 Equal Line of Simulated Piezometric Surface (masl)

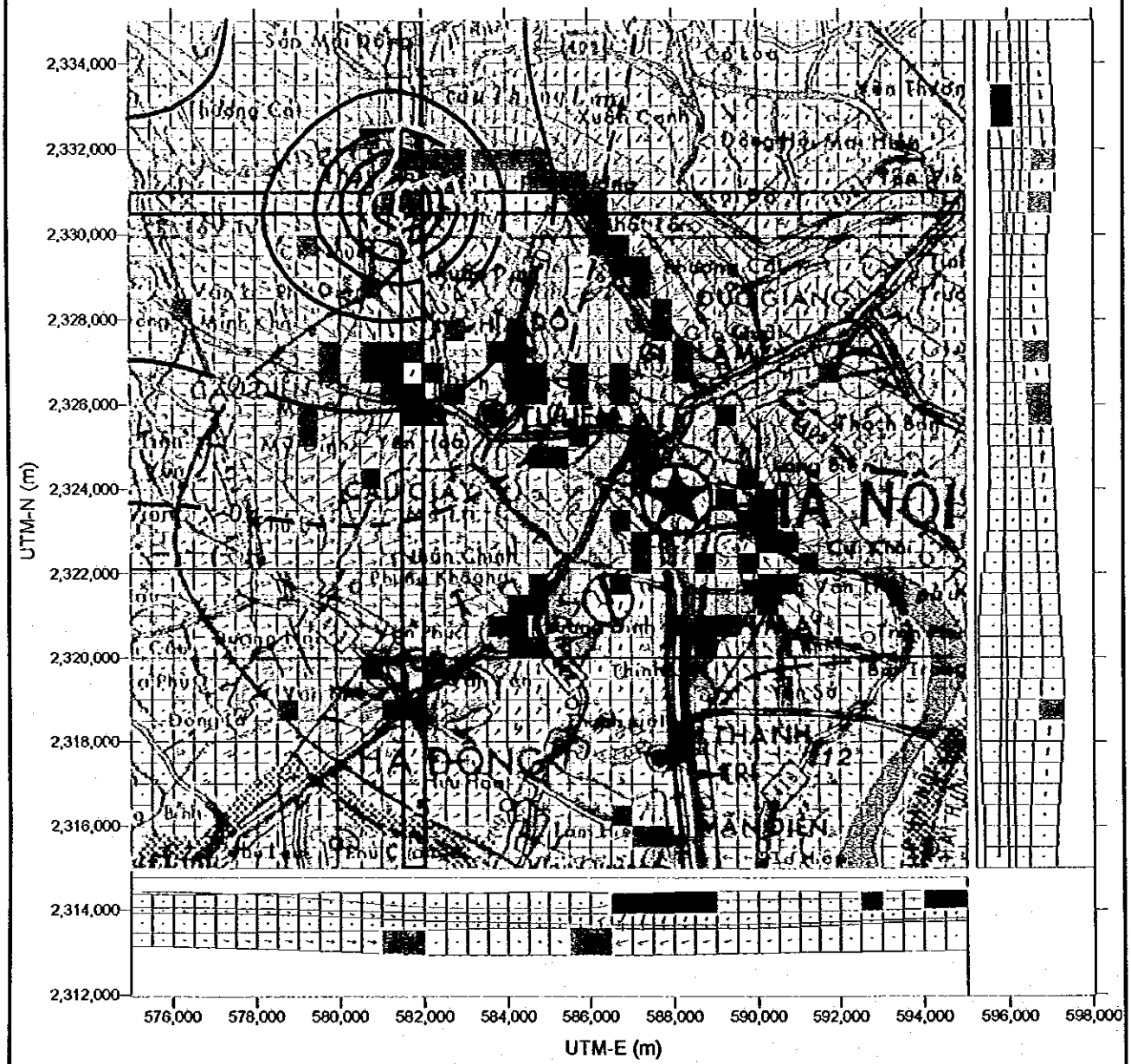
Groundwater pumpage for Case-0 is the actual pumpage in 1996 with proposed pumpage in Cao Dinh well field and additional pumpage in Yen Phu well field.
1996 Q = 453,960 m^3/day
Cao Dinh Q = 97,964 m^3/day
Additional Yen Phu Q = 60,777 m^3/day
[Data source: NHEGD-DGM(1998)]

Figure 7.6 **Simulated Piezometric Surface by Case-0 (after 10 years)**

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Simulated Piezometric Drawdown (Case-1, after 10 years)



Top View: Layer 4 (Main Confined Aquifer)

Cross-Section
Projection Raw = 9
Projection Column = 14

Pumped Cell
Constant Head
Dried Cell
Flow Vector
Simulated Groundwater Table
-1.4 Equal Line of Simulated Piezometric Drawdown (m)

Case-1 Pumping Plan:
Pumpage of Case-0 with following pumpage:
Đông Ngạc (I=9, J=13) Q = 1,260 m^3/day
Xuân Đỉnh (I-9, J=14) Q = 2,850 m^3/day
Pumping from Layer-4.

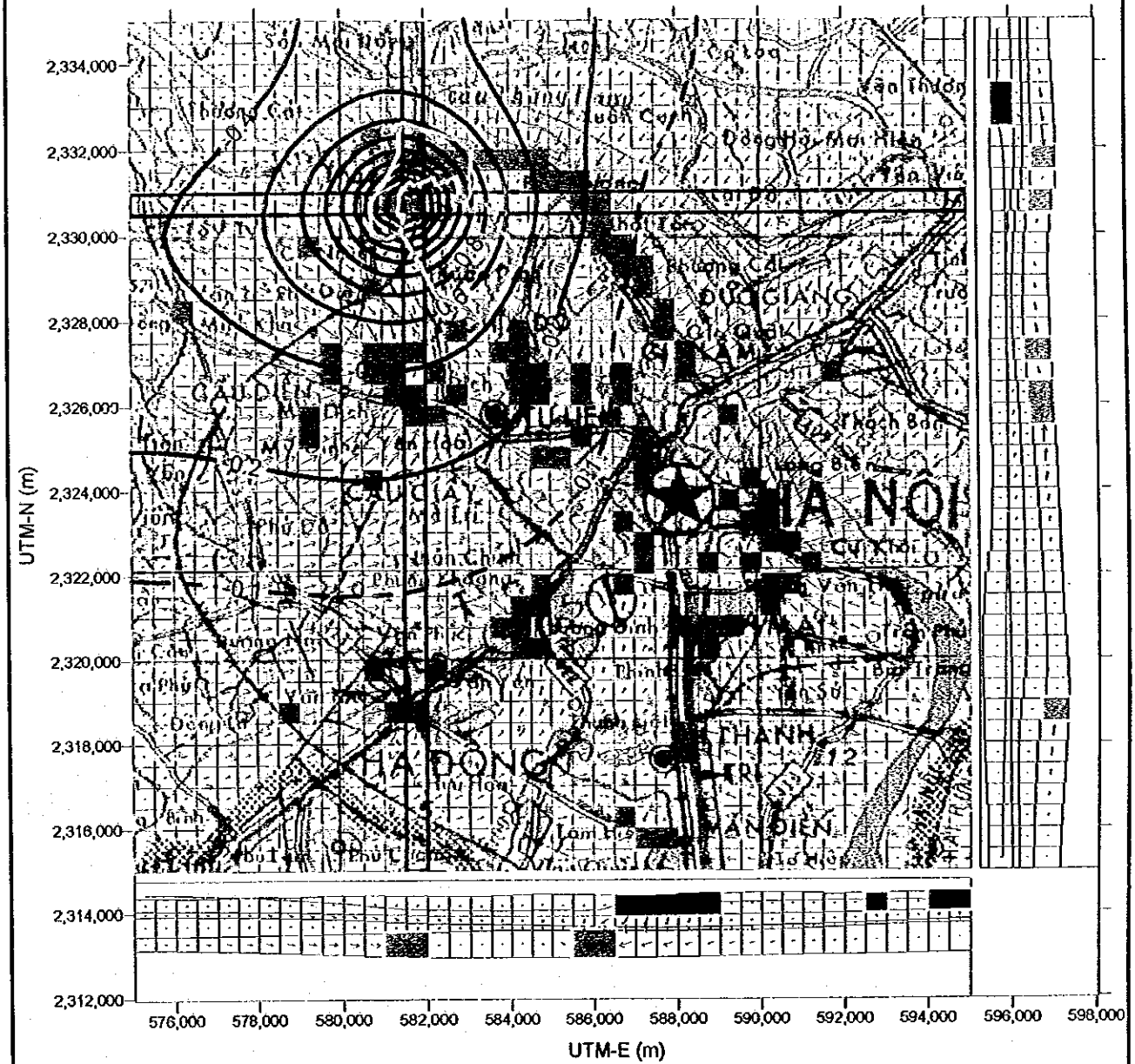
Maximum Drawdown = 2.36 m

Figure 7.7 **Simulated Piezometric Drawdown by Case-1 (after 10 years)**

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Simulated Piezometric Drawdown (Case-2, after 10 years)



Top View: Layer 4 (Main Confined Aquifer)

Cross-Section
Projection Raw = 9
Projection Column = 14

Pumped Cell
Constant Head
Dried Cell
Flow Vector
Simulated Groundwater Table
-2.2 Equal Line of Simulated Piezometric Drawdown (m)

Case-2 Pumping Plan:
Pumpage of Case-0 with following pumpage:
Đồng Ngạc (I=9, J=13) Q = 1,890 m^3/day
Xuân Đỉnh (I-9, J=14) Q = 4,275 m^3/day
Pumping from Layer-4.

Maximum Drawdown = 3.54 m

Figure 7.8	Simulated Piezometric Drawdown by Case-2 (after 10 years)

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

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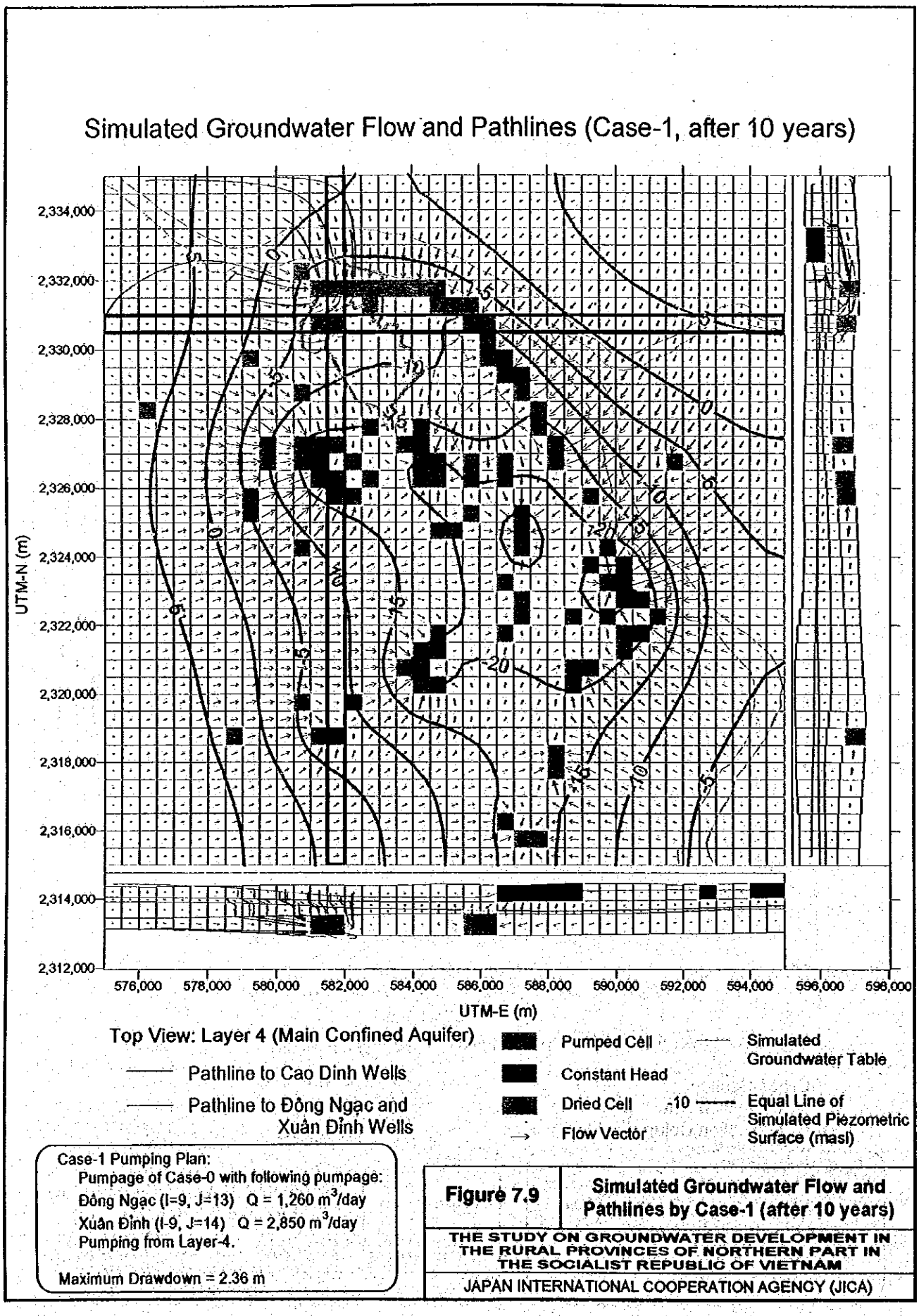

Figure 7.9 **Simulated Groundwater Flow and Pathlines by Case-1 (after 10 years)**

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

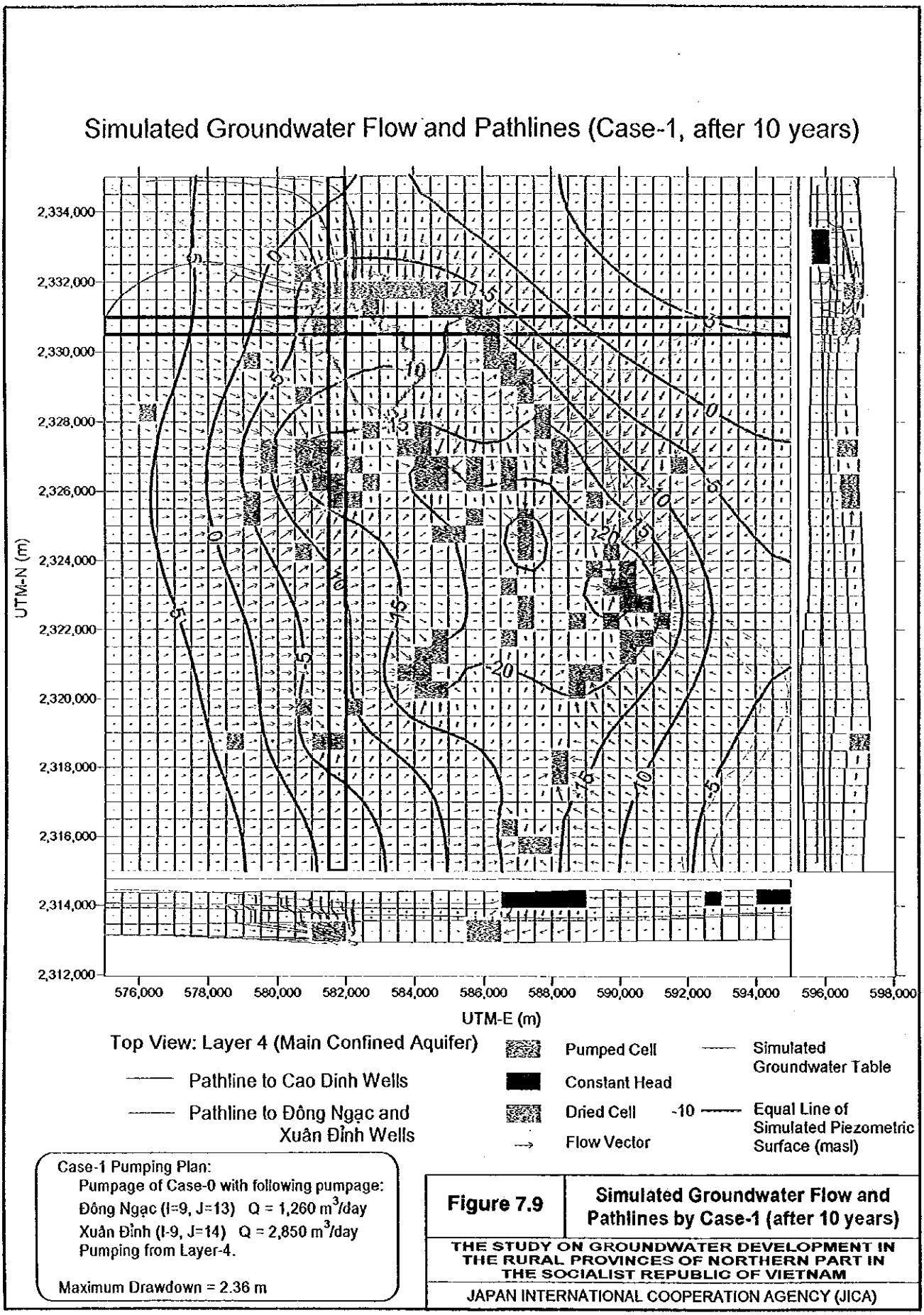

Figure 7.9 **Simulated Groundwater Flow and Pathlines by Case-1 (after 10 years)**

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF NORTHERN PART IN THE SOCIALIST REPUBLIC OF VIETNAM

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PART III

MASTER PLAN

PART III MASTER PLAN

CHAPTER 1 MASTER PLAN FRAMEWORK

1.1 Basic Policy for M/P Formulation

The National Program for Rural Water Supply and Environmental Sanitation (NPRWSS, No. 237/1998/QD-TTg) of the Government of Vietnam was formulated with the aim to provide clean and safe water to 80 % of the rural residents by 2005. The M/P was formulated in accordance with this program (priority plan) and incorporates a long term water supply plan for the 20 communes in the five northern provinces of Vietnam.

The majority of the existing water sources in these 20 communes are insanitary, insufficient in quantity, and inconvenient in terms of location and use. In view of these conditions, the master plan proposes the development of alternative water supply sources in order to provide every household with drinking water.

Each of the 20 communes was provided with water supply facilities which they have to operate and maintain on their own. The guidelines adopted for the formulation of plans were such that would make the plans applicable in other regions nationwide. The water supply facilities constructed under this M/P act as a model to promote the plan nationwide.

The following are the specifications for the construction of water supply facilities under the M/P.

1.1.1 Construction, O&M

- Short construction period
- Inexpensive in terms of construction and operation costs
- Easy to operate, manage, and maintain

1.1.2 Water Quality

- Chlorination of water prior to distribution
- Supply constant pressure to distribution pipes and service pipes to prevent the intrusion of contaminants from outside.

1.2 Target Areas and Water Use Conditions

The M/P targets the 20 communes in the five northern provinces of Thai Nguyen, Hanoi, Ninh Binh, Than Hoa, and Ha Tinh. The population and area coverage of the target communes are shown in Table 1.1.

Table 1.1 Population & Area Coverage of Target Communes

Province	Commune	1998 Population	Area (km^2)
Thai Nguyen	Hoa Thuong	12,800	11.7
	Dong Bam	5,279	4.03
	Thinh Duc	6,236	20.0
	Nam Tien	6,270	9.2
Ha Noi	Dong Ngac	6,900	3.62
	Xuan Dinh	15,774	5.57
Ninh Binh	Dong Phong	10,000	7.4
	Quang Son	7,500	25.4
	Yen Thang	8,530	11.7
Than Hoa	Vin Loc Town	5,075	0.74
	Vinh Thanh	5,984	3.97
	Dinh Tuong	6,518	6.14
	Thie Hung	6,750	5.45
	Thieu Do	7,010	4.00
	Nong Cong Town	5,461	1.00
	Van thang	6,664	9.16
Ha Tinh	Yen Ho	5,254	7.96
	Trung Le	3,396	3.85
	Bui Xa	4,313	6.49
	Duc Yen	3,722	3.37
Total		139,436	150.75

All 20 communes are without water supply facilities, and residents extract water from shallow wells, deep wells, rivers, ponds, and rainfall for domestic use.

1.3 Target Objectives and Goals

The M/P is formulated targeting the year 2010 and a 90 % diffusion rate. The ultimate objective of the M/P is to provide the residents with a healthy and sanitary living

environment, improve standard of living, and generally promote agricultural production, all these through the provision of clean and safe domestic water.

A water supply plan was formulated for every target commune. Regardless of problems in water quality, most households have wells which when attached with small pumps and installed with pipelines would help attain the pressure required to supply water which is seen to consequently improve living conditions. Even if clean and safe water is provided, the construction of water supply facilities, mainly public faucets, at a distance of 100~200 m would only be used by a few and therefore would not contribute to meeting the desired level of sanitary improvement.

The M/P, therefore, aims to establish a 24 hour water supply service by 2010 and a diffusion rate as shown in the table below.

Table 1.2 Water Supply by Household Connection

Year	Unit Production (l/c/d)	Diffusion Rate (%)
2002	80	50
2005	90	80
2010	110	90

1.4 Population Forecast

The present population of every commune was obtained from and confirmed with the Peoples Committee. Population forecast is an essential factor in the formulation of the M/P. With population growth, future land use planning has also become a factor of significance. In particular, city outskirts are forecast to undergo urbanization. Although new town and housing development plans and industrial development plans exist, the existing communes are not obliged to supply water. Consequently, forecasting population growth in these communes would suffice for the formulation of the M/P.

There are various ways of forecasting population. Based on the 1989 national census, the trend for the next 10 years was analyzed by dividing the nation into 8 regions to forecast the high, medium, and low birth rates for every 5 years until 2024 —the results are arranged under April 1999 (see Table 1.3). This study adopts the estimated medium birth rate and forecasts that the present population growth rate of 1.63 % will fall to 0.77 % in 2024. Using this growth rate as a basis, the future population of each commune was forecast (see Table 1.4).

Table 1.3 Growth Rate by Region

Region	Annual Growth Rate					
	1994-1999	1999-2004	2004-2009	2009-2014	2014-2019	2019-2024
VARIANT 1						
All country	**1.26**	**1.14**	**1.07**	**0.99**	**0.83**	**0.63**
1.Red River Delta	0.95	0.87	0.82	0.73	0.59	0.43
2.Northeast	1.25	1.15	1.15	1.11	0.93	0.67
3.Northwest	1.39	1.28	1.32	1.35	1.18	0.88
4.North Central	1.46	1.28	1.22	1.18	1.05	0.85
5.Central Coast	1.53	1.32	1.18	1.09	0.97	0.82
6.Central Highlands	2.07	1.51	1.41	1.3	1.21	1
7.Southeast	1.21	1.05	0.91	0.78	0.62	0.47
8.Mekong River Delta	1.26	1.26	1.22	1.09	0.86	0.61
VARIANT 2						
All country	**1.63**	**1.31**	**1.23**	**1.11**	**0.95**	**0.77**
1.Red River Delta	1.34	1.04	0.97	0.88	0.71	0.52
2.Northeast	1.76	1.4	1.37	1.28	1.08	0.88
3.Northwest	1.93	1.6	1.63	1.49	1.32	1.06
4.North Central	1.91	1.55	1.44	1.29	1.16	1.02
5.Central Coast	1.79	1.49	1.27	1.11	1.01	0.9
6.Central Highlands	1.22	1.11	1.18	1.27	1.15	0.85
7.Southeast	1.49	1.22	1.07	0.92	0.74	0.55
8.Mekong River Delta	1.74	1.4	1.37	1.23	1.02	0.82
VARIANT 3						
All country	**1.76**	**1.57**	**1.41**	**1.22**	**1**	**0.79**
1.Red River Delta	1.4	1.27	1.17	1.02	0.78	0.55
2.Northeast	1.87	1.72	1.61	1.44	1.16	0.89
3.Northwest	2.14	1.91	1.74	1.53	1.32	1.06
4.North Central	1.89	1.72	1.57	1.46	1.28	1.1
5.Central Coast	1.99	1.77	1.5	1.25	1.09	0.97
6.Central Highlands	2.29	2.03	1.91	1.77	1.49	1.16
7.Southeast	1.58	1.34	1.13	0.93	0.73	0.52
8.Mekong River Delta	1.88	1.7	1.51	1.23	0.99	0.79

Source : POPULATION PROJECTIONS OF VIETNAM, 1994-2024.
GENERAL STATISTICAL OFFICE, PROJECT VIE/97/P14.

Table 1.4 Population Forcast

Province	Commune	1998 Populatio	2002 Populatio	2005 Populatio	2010 Populatio	2015 Populatio	2020 Populatio	2025 Populatio
Thai Nguyen	Hoa Thuong	12,800	13,600	14,200	15,200	16,200	17,100	17,900
	Dong Bam	5,279	5,600	5,900	6,400	6,800	7,200	7,500
	Thinh Duc	6,236	6,600	6,900	7,400	7,900	8,300	8,700
	Nam Tien	6,270	6,700	7,000	7,500	8,000	8,400	8,800
	Sub total	30,585	32,500	34,000	36,500	38,900	41,000	42,900
Ha Noi	Dong Ngac	6,900	7,300	7,600	8,100	8,400	8,700	8,900
	Xuan Dinh	15,774	16,600	17,200	18,200	19,000	19,600	20,100
	Sub total	22,674	23,900	24,700	26,300	27,400	28,300	29,000
Ninh Binh	Dong Phong	10,000	10,500	10,800	11,300	11,800	12,200	12,500
	Quang Son	7,500	7,900	8,200	8,700	9,100	9,400	9,600
	Yen Thang	8,530	9,000	9,300	9,800	10,200	10,500	10,800
	Sub total	26,030	27,400	28,300	29,800	31,100	32,100	32,900
Thanh Hoa	Vinh Loc Town	5,075	5,500	5,800	6,300	6,700	7,100	7,500
	Vinh Thanh	5,984	6,400	6,700	7,200	7,700	8,100	8,500
	Dinh Tuong	6,518	6,900	7,200	7,700	8,200	8,700	9,200
	Thieu Hung	6,750	7,200	7,500	8,000	8,500	9,000	9,500
	Thieu Do	7,010	7,500	7,800	8,300	8,800	9,300	9,800
	Nong Cong Tow	5,461	5,900	6,200	6,700	7,100	7,500	7,900
	Van Thang	6,664	7,100	7,400	7,900	8,400	8,900	9,400
	Sub total	43,462	46,500	48,600	52,100	55,400	58,600	61,800
Ha Tinh	Yen Ho	5,254	5,600	5,900	6,400	6,800	7,200	7,600
	Trung Le	3,396	3,700	4,000	4,500	4,800	5,100	5,400
	Bui Xa	4,313	4,700	5,000	5,500	5,900	6,200	6,500
	Duc Yen	3,722	4,100	4,400	4,900	5,200	5,500	5,800
	Sub total	16,685	18,100	19,300	21,300	22,700	24,000	25,300
Total		139,436	148,400	154,900	166,000	175,500	184,000	191,900

Source : JICA Study Team

1.5 Water Demand Forecast

1.5.1 Water Use Classification

Water use in the study area is classified as follows:

(1) Domestic Use

Refers to the use of water for household chores such as drinking, cooking, laundry, bathing, etc.

(2) Non-domestic Use

For water supply in rural villages, the following demands for water may be considered for non-domestic use:

- Use in schools
- Amount of water used by offices and small restaurants in shopping districts
- Other use
- Fire extinguishing activities

1.5.2 Water Use Conditions in the Communes

The results of the questionnaire survey on actual water use conditions in the 20 communes are compiled in Table 1.5.

The daily water consumption per household totaled 400 to 500 liters: 32 to 34 liters for cooking, 116 to 134 liters for laundry, 118 to 158 liters for bathing, 60 to 70 liters for livestock raising, and 100 to 109 liters for miscellaneous use.

Considering that a household consumes 12 to 15 m^3 of water per month, water shortage is not a problem in the communes. The problem lies in the quality of the water produced, e.g. unpleasant odor and color due to iron content, and the sanitary problems that this water condition generates.

Table 1.5 Present Average Water Usage in Dry Season (Household Survey)

Province	Commune	Cooking		Laundry		Shower/Bath		Cooking+	Livestock		Other		Total	
		Number of Anser	l/house/day	Number of Anser	l/house/day	Number of Anser	l/house/day	Laundry+ Shower	Number of Anser	l/house/day	Number of Anser	l/house/day	Number of Anser	l/house/day
Thai Nguyen	Dong Bam	5	25	5	161	5	156	342	4	156	4	163	5	661
	Hoa Thuong	21	49	21	81	21	75	205	14	38	13	42	21	285
	Nam Tien	23	39	23	129	22	134	302	22	73	16	117	23	491
	Thinh Duc	5	23	5	59	5	41	123	3	22	5	60	5	205
	Average	54	40	54	107	53	104	251	43	66	38	89	54	400
Hanoi	Xuan Dinh	51	57	50	126	50	112	296	33	67	37	81	51	444
	Dong Ngac	81	12	81	145	80	127	285	62	51	81	132	81	468
	Average	132	30	131	138	130	122	289	95	56	118	116	132	458
Ninh Binh	Quang Son	29	37	29	152	29	152	342	21	56	17	95	29	494
	Yen Thang	40	33	40	94	40	142	269	39	129	21	89	40	487
	Dong Phong	34	25	34	86	34	86	197	31	38	16	100	34	335
	Average	103	31	103	108	103	127	266	91	81	54	94	103	335
Thanh Hoa	Nong Con Town	20	24	20	93	19	105	222	18	60	14	85	20	367
	Van Thanh	22	30	21	115	22	114	259	22	51	20	67	22	377
	Thieu Hung	35	24	35	105	34	127	256	34	66	25	76	35	397
	Thieu Do	27	60	23	126	25	139	325	27	95	22	231	27	651
	Dinh Tuong	24	32	24	100	24	110	242	24	59	24	57	24	358
	Vin Loc Town	13	61	12	118	12	109	288	10	106	6	77	13	470
	Vinh Thanh	29	66	29	77	29	79	222	25	61	5	78	29	361
	Average	170	42	164	103	165	112	257	160	69	116	101	170	425
Ha Tinh	Duc Yen	26	35	26	145	26	166	346	25	111	21	156	26	613
	Yen Ho	26	19	26	143	25	121	283	26	50	26	74	26	406
	Bui Xa	22	30	21	94	21	95	219	19	40	19	40	22	298
	Trung Le	16	11	16	106	14	80	197	15	37	11	51	16	285
	Average	90	25	89	125	86	121	272	85	63	77	85	90	418
Average(20		549	34	541	116	537	118	268	474	67	403	100	549	436

Source : JICA Study Team

1.5.3 Unit Water Demand

(1) Domestic Water Use

The estimation of the domestic water demand is extremely significant to the formulation of the water supply facility construction plan. Although looking at past figures would be most favorable for the estimation, only a few of the rural villages are connected to the distribution net (pipelines) and this would not reflect the actual demand but only the distribution amount. The results of the previously mentioned questionnaire survey were used therefore to estimate the water demand.

The construction of a water supply system in the communes would enable the provision of safe tap water for cooking, laundry and bathing, while the present source would be used for livestock raising and other miscellaneous use. The amount that will be converted into tap water is estimated to total 60 to 70 ℓ/c/d.

The design standards adopted in Vietnam indicate the temporal changes in the water supply service level as shown in the table below. As shown in the table, water consumption in the communes currently amounts to 60 to 70 ℓ/c/d. It is assumed, however, that a water demand of 80 ℓ/c/d will result from the water supply operation in consideration of the convenience this would provide the residents.

Assuming that the increase is in proportion to economic growth, the unit water demand 10 years after is estimated at 120 ℓ/c/d. No increase is expected after this period as the water supply system will be used to provide a truly clean and safe drinking water, and the old well for sprinkling, livestock raising etc. Water to be provided from public faucets is estimated at 50 ℓ/c/d.

Table 1.6 Temporal Changes in Water Service Level

Urban Level	Design Standard			
	10 years from completion		20 years from completion	
	Coverage (%)	Unit Water Demand (l/c/d)	Coverage (%)	Unit Water Demand (ℓ/c/d)
I	75~90	130~150	85~90	160~180
II	75~85	110~130	80~90	140~150
III, IV, V	70~80	80~100	80~90	120~130

Source: Quy Chuan Xay Dung Viet Nam Tap 1. Nha Xuat Ban Xay Dung, 1997.
This was carried out in levels III, IV, and V.

From the above, the water supply unit water demand is set as shown below.

Table 1.7 Per Capita Water Demand Forecast

Year	2002	2005	2010
House connection (ℓ/c/d)	80	90	110
Public tap (ℓ/c/d)	50	50	50

(2) Non-domestic Water Use

The unit water demand for non-domestic use is set as shown in the table below, based on past study results.

Table 1.8 Unit Water Demand for Non-domestic Use

Water Use Category	Unit Water Demand
Schools	12 ℓ/c/d
Small markets, restaurants, offices, shopping center	6 ℓ/c/d
Miscellaneous	2 % of domestic water amount

Source: Study on Hanoi Water Supply Systems in the Socialist Republic of Vietnam, JICA

The water demand for fire extinguishing purposes is not as large as estimated beforehand. However, as a huge amount of water will be required temporarily, considerations will be placed on the distribution pond capacity and the diameter of distribution pipelines.

1.5.4 Water Demand Forecast

(1) Forecast Method

Water demand was calculated by multiplying the unit water demand by the service population and the service area.

(2) Service Level

Water supply will be provided for 24 hours through household connections. In areas that are remote or where the population is scattered, the construction of public faucets was considered.

The water supply service level until 2010 is as shown in Table 1.9.

(3) Average Daily Water Demand

The average daily water demand is calculated by adding together the water demand.

{average daily water demand}5{domestic water demand}1{water demand for other uses}

(4) Average Daily Supply

Leakage from these new facilities is estimated at 15 %.

{average daily supply}5{average daily water demand}40.85

(5) Maximum Daily Supply

{maximum daily supply}5K3{average daily supply}

Based on the design standards in Viet Nam, K is set at 1.35.

(6) Maximum Daily Production

{maximum daily production}5K3{average daily supply}

K is set at 1.05 with due consideration of the water amount to be treated in the filtering pond.

The forecast water demand in 2002, 2005, and 2001 is shown in Tables 1.10, 1.11, and 1.12, respectively.

Table 1.9 Service Conditions of Water Supply

		2002		2003		2004		2005		2006		2007		2008		2009		2010	
		Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %	Unit Water Demand	Population %
Population Served %		50		60		70		80		82		84		86		88		90	
Densely Populated Area	House Connection	80	90	84	90	88	90	90	90	96	90	100	90	104	90	108	90	110	90
	Public Tap or	50	10	50	10	50	10	50	10	50	10	50	10	50	10	50	10	50	10
Sparsely Populated or Separated	House Connection	80	0	84	0	88	0	90	5	96	5	100	5	104	5	108	5	110	10
	Public Tap or	50	100	50	100	50	100	50	95	50	95	50	95	50	95	50	95	50	90

Source : JICA Study Team

Table 1.10 Water Demand Forecast in 2002

Province	Commune	2002						
		Population	Rate of Population Served %	Population Served	Average Water Demand m3/day	Average Daily Supply m3/day	Maximum Daily Supply m3/day	Maximum Daily Production m3/day
Thai Nguyen	Hoa Thuong	13,600	50	6,800	440	520	700	740
	Dong Bam	5,600	50	2,800	210	250	340	360
	Thinh Duc	6,600	50	3,300	190	220	300	320
	Nam Tien	6,700	50	3,400	250	290	390	410
	Sub total	32,500		16,300	1,070	1,280	1,730	1,830
Ha Noi	Dong Ngac	7,300	50	3,700	300	350	470	490
	Xuan Dinh	16,600	50	8,300	670	790	1,070	1,130
	Sub total	23,900		12,000	970	1,140	1,540	1,620
Ninh Binh	Dong Phong	10,500	50	5,300	410	480	650	680
	Quang Son	7,900	50	4,000	310	360	490	520
	Yen Thang	9,000	50	4,500	350	410	550	580
	Sub total	27,400		13,800	1,070	1,250	1,690	1,780
Thanh Hoa	Vinh Loc Town	5,500	50	2,800	280	330	450	470
	Vinh Thanh	6,400	50	3,200	250	290	390	410
	Dinh Tuong	6,900	50	3,500	270	320	430	450
	Thieu Hung	7,200	50	3,600	280	330	450	470
	Thieu Do	7,500	50	3,800	290	340	460	480
	Nong Cong Town	5,900	50	3,000	300	350	470	490
	Van Thang	7,100	50	3,600	280	330	450	470
	Sub total	46,500		23,500	1,950	2,290	3,100	3,240
Ha Tinh	Yen Ho	5,600	50	2,800	220	260	350	370
	Trung Le	3,700	50	1,900	140	160	220	230
	Bui Xa	4,700	50	2,400	180	210	280	290
	Duc Yen	4,100	50	2,100	160	190	260	270
	Sub total	18,100		9,200	710	820	1,110	1,160
Total		148,400		74,800	5,780	6,780	9,170	9,630
l/day/capita					77	91	123	129

Source : JICA Study Team

Table 1.11 Water Demand Forecast in 2005

Province	Commune	2005						
		Population	Rate of Population Served %	Population Served	Average Water Demand m3/day	Average Daily Supply m3/day	Maximum Daily Supply m3/day	Maximum Daily Production m3/day
Thai Nguyen	Hoa Thuong	14,200	80	11,400	760	890	1,200	1,260
	Dong Bam	5,900	80	4,700	380	450	610	640
	Thinh Duc	6,900	80	5,500	330	390	530	560
	Nam Tien	7,000	80	5,600	450	530	720	760
	Sub total	34,000		27,200	1,920	2,260	3,060	3,220
Ha Noi	Dong Ngac	7,600	80	6,100	530	620	840	880
	Xuan Dinh	17,200	80	13,800	1,210	1,420	1,920	2,020
	Sub total	24,700		19,900	1,740	2,040	2,760	2,900
Ninh Binh	Dong Phong	10,800	80	8,600	720	850	1,150	1,210
	Quang Son	8,200	80	6,600	550	650	880	930
	Yen Thang	9,300	80	7,400	620	730	990	1,040
	Sub total	28,300		22,600	1,900	2,230	3,020	3,180
Thanh Hoa	Vinh Loc Town	5,800	80	4,600	460	540	730	770
	Vinh Thanh	6,700	80	5,400	450	530	720	760
	Dinh Tuong	7,200	80	5,800	490	580	780	820
	Thieu Hung	7,500	80	6,000	500	590	800	840
	Thieu Do	7,800	80	6,200	520	610	820	860
	Nong Cong Town	6,200	80	5,000	500	590	800	840
	Van Thang	7,400	80	5,900	500	590	800	840
	Sub total	48,600		38,900	3,420	4,030	5,450	5,730
Ha Tinh	Yen Ho	5,900	80	4,700	400	470	630	660
	Trung Le	4,000	80	3,200	270	320	430	450
	Bui Xa	5,000	80	4,000	340	400	540	570
	Duc Yen	4,400	80	3,500	290	340	460	480
	Sub total	19,300		15,400	1,290	1,530	2,060	2,160
Total		154,900		124,000	10,280	12,090	16,350	17,190
l/day/capita					83	98	132	139

Source : JICA Study Team

Table 1.12 Water demand forecast in 2010

Province	Commune	2010						
		Population	Rate of Population Served %	Population Served	Average Water Demand m3/day	Average Daily Supply m3/day	Maximum Daily Supply m3/day	Maximum Daily Production m3/day
Thai Nguyen	Hoa Thuong	15,200	90	13,700	1,030	1,210	1,630	1,720
	Dong Bam	6,400	90	5,800	550	650	880	930
	Thinh Duc	7,400	90	6,700	440	520	700	740
	Nam Tien	7,500	90	6,800	640	750	1,010	1,060
	Sub total	36,500		33,000	2,650	3,130	4,220	4,450
Ha Noi	Dong Ngac	8,100	90	7,300	760	890	1,200	1,260
	Xuan Dinh	18,200	90	16,400	1,710	2,010	2,710	2,850
	Sub total	26,300		23,700	2,470	2,900	3,910	4,110
Ninh Binh	Dong Phong	11,300	90	10,200	1,010	1,190	1,610	1,690
	Quang Son	8,700	90	7,800	770	910	1,230	1,290
	Yen Thang	9,800	90	8,800	870	1,020	1,380	1,450
	Sub total	29,800		26,800	2,660	3,120	4,220	4,430
Thanh Hoa	Vinh Loc Town	6,300	90	5,700	650	760	1,030	1,080
	Vinh Thanh	7,200	90	6,500	640	750	1,010	1,060
	Dinh Tuong	7,700	90	6,900	680	800	1,080	1,140
	Thieu Hung	8,000	90	7,200	710	840	1,130	1,190
	Thieu Do	8,300	90	7,500	740	870	1,170	1,230
	Nong Cong Town	6,700	90	6,000	680	800	1,080	1,140
	Van Thang	7,900	90	7,100	700	820	1,110	1,170
	Sub total	52,100		46,900	4,830	5,640	7,610	8,010
Ha Tinh	Yen Ho	6,400	90	5,800	580	680	920	970
	Trung Le	4,500	90	4,100	410	480	650	680
	Bui Xa	5,500	90	5,000	500	590	800	840
	Duc Yen	4,900	90	4,400	440	520	700	740
	Sub total	21,300		19,300	1,910	2,270	3,070	3,230
Total		166,000		149,700	14,520	17,060	23,030	24,230
l/day/capita					97	114	154	162

Source : JICA Study Team

1.6 Water Source

1.6.1 Priority Water Sources

Groundwater is the water source exploited in this study, and since shallow wells are frequently contaminated, deep wells are developed. In the 4 communes in Ha Thinh, river water was exploited as the use of water from deep wells is deemed impossible based on the study results.

1.6.2 Water Quality

The results indicate that samples from a number of wells contain total dissolved solids, sodium ion, and chloride ion exceeding the levels specified for drinking water. Although none of these properties are toxic, high concentrations lead to unpleasant taste that make the water unsuitable for drinking. To use these wells, there is a need to dilute the water. Except for these properties, other items analyzed met the standards for drinking water.

1.6.3 Target Water Quality Treatment

There are several water quality guidelines in Vietnam. This study adopts those for drinking water and domestic water (Boy te 505 BYT/QD ngay 13-4-1992). Comparing the well water quality analysis results with the guidelines showed problems in iron and manganese levels. The removal of these substances would depend on their concentration and other organisms that depend on these substances for survival. Aeration sand filter, the most common method used in Viet Nam, was adopted in this study. Biological treatment by the use of bacteria is also considered a possible removal means.

1.7 Water Supply Facility Design

The fundamental issues regarding the water supply facility construction plan for rural villages are as detailed hereafter.

1.7.1 Water Supply System

Uncontaminated groundwater is the target water supply source. The supply of water by gravity after chlorination is the most desired supply system. However, there are only a few areas that are topographically suited to the development of this system. The most commonly

developed system is one which consists of treatment facilities, supply and distribution pumps. Regardless of the nature of the facility construction plan, the following conditions must be met to use pipelines for water distribution.

- Chlorination of water prior to distribution
- Supply constant pressure to distribution pipes and service pipes to prevent the intrusion of contaminants from outside.

The water supply facility plan was prepared intending to provide 24 hour services, ease in facility operation and maintenance, and inexpensive service expenses.

1.7.2 Water Source

The number of deep wells to be developed is decided in accordance with the target water supply amount; no reserves were constructed. Submersible motor pumps were used (see Chapter 2 for the target deep well pumpage for every commune established based on the test boring results).

1.7.3 Treatment Facilities

Treatment facilities were established for the removal of iron and manganese in the water. Although there are various removal methods, the water quality analysis results indicate the suitability of the use of aeration sand filter (the most commonly used in Viet Nam) or biological treatment. If iron and manganese levels are high, chlorination will be adopted.

Since water quality analysis was only carried out once and not all the required wells have been drilled, the treatment method has not been concluded. The issue of whether to adopt biological or chemical treatment will all depend on the problems that may arise in the operation of the facilities; either method of treatment is applicable to similar facilities. The M/P basically proposes the adoption of biological treatment.

1.7.4 Distribution and Service Pipelines

The distribution facilities consist of a distribution pond and pipelines. The distribution pond will have the capacity to provide 8 hours worth of the daily average water supply. Distribution will be carried out by gravity in consideration of a stable supply and to exploit topographic conditions. In addition, the construction of an elevated tank is also considered in view of the topography and water supply conditions.

The water supply pipelines will be installed at the expense of the beneficiaries. Pipelines are a problematic aspect of the water supply system, particularly because leakage usually originates from these pipes. The standards adopted for pipeline installation and the pipeline operation and maintenance affect future service operations, and would therefore requires careful consideration in the implementation stage.

1.7.5 Power Source

The power required for the well pump and distribution pumps will be acquired from the public electric company. Private generators usually handy in case of emergency will not be provided as the gravity distribution system is considered partially advantageous in times like this.

1.7.6 Public Taps

Basically, water will be supplied to every household (household connection), hence public taps will be installed in restricted confines such as markets, etc. Majority of the target communes consist of several densely populated hamlets. Public taps will also be considered in areas where the population is scattered or in remote areas where the set up of household connections is not possible.

1.7.7 Meter

Meters will be installed to monitor water demand. Measurements and recording of water consumption allows administrative analysis that not only contributes to the stabilization of the services, but also enables accurate technical analysis. The use of meters will not be limited to gauge household consumption, but also to gauge distribution volume, and other factors that would necessitate its installation.

1.7.8 Fire Hydrants

Fire hydrants will be installed in accordance with the standards in force in Vietnam.