The Study on Groundwater Development in Central Cambodia
Final Report

Main Report

LOCATION MAP
EXCHANGE RATE AND LIST OF ABBREVIATION
EXECUTIVE SUMMARY

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4.3 Groundwater Levels

4.3.1 Purpose

Groundwater level is an essential parameter not only for groundwater development planning but also for groundwater flow analysis. In general groundwater level fluctuates over time due to the balance of groundwater inflow and outflow. When the amount of groundwater inflow exceeds the amount of groundwater outflow, the groundwater level rises due to the surplus volume of water.

The depth to the groundwater level from ground surface (DTW) is important particularly for well design and pump selection. The distribution of groundwater table provides important information on groundwater flow system. The changes in groundwater level are also important for designing groundwater development plan as well as for understanding the groundwater characteristics.

4.3.2 Methodology

In the study, groundwater levels were measured in existing dug wells, existing combined wells, and newly constructed JICA Test Wells to evaluate physical groundwater conditions in the study area. At the existing wells, simultaneous observation and periodic observation were carried out. The groundwater levels of the JICA Test Wells were monitored by monthly basis after their constructions. These surveys were carried out by the study team members and the counterparts of DRWS. The measuring method using a portable groundwater level meter and the data recording/processing method were well transferred to the counterparts.

(1) Simultaneous Observation

To understand the groundwater level distribution and its range of fluctuation, simultaneous groundwater level observations were carried out four (4) times during the study period. The groundwater levels in the selected dug wells and combined wells were measured together with the groundwater quality survey. The groundwater levels in the borehole wells were not measured as per the original study plan because it was difficult to remove and re-install the hand pumps.

The number of target wells for the simultaneous observation including groundwater quality survey was planned at about 150, but actually about 250 wells were selected considering

geographical distribution and hydrogeological conditions in the study area. Out of about 250 wells, groundwater levels were measured at about 150 wells; those were dug wells and combined wells.

The 1st time simultaneous observation was carried out in February 2001. The 2nd time and 3rd time simultaneous observations were carried out in May 2001 and in August 2001, respectively. The 4th time observation was carried out in November 2001. The numbers of the surveyed wells are shown in Table 4.3.2.1. The locations of the surveyed wells in the simultaneous observation are shown in Figure 4.3.2.1.

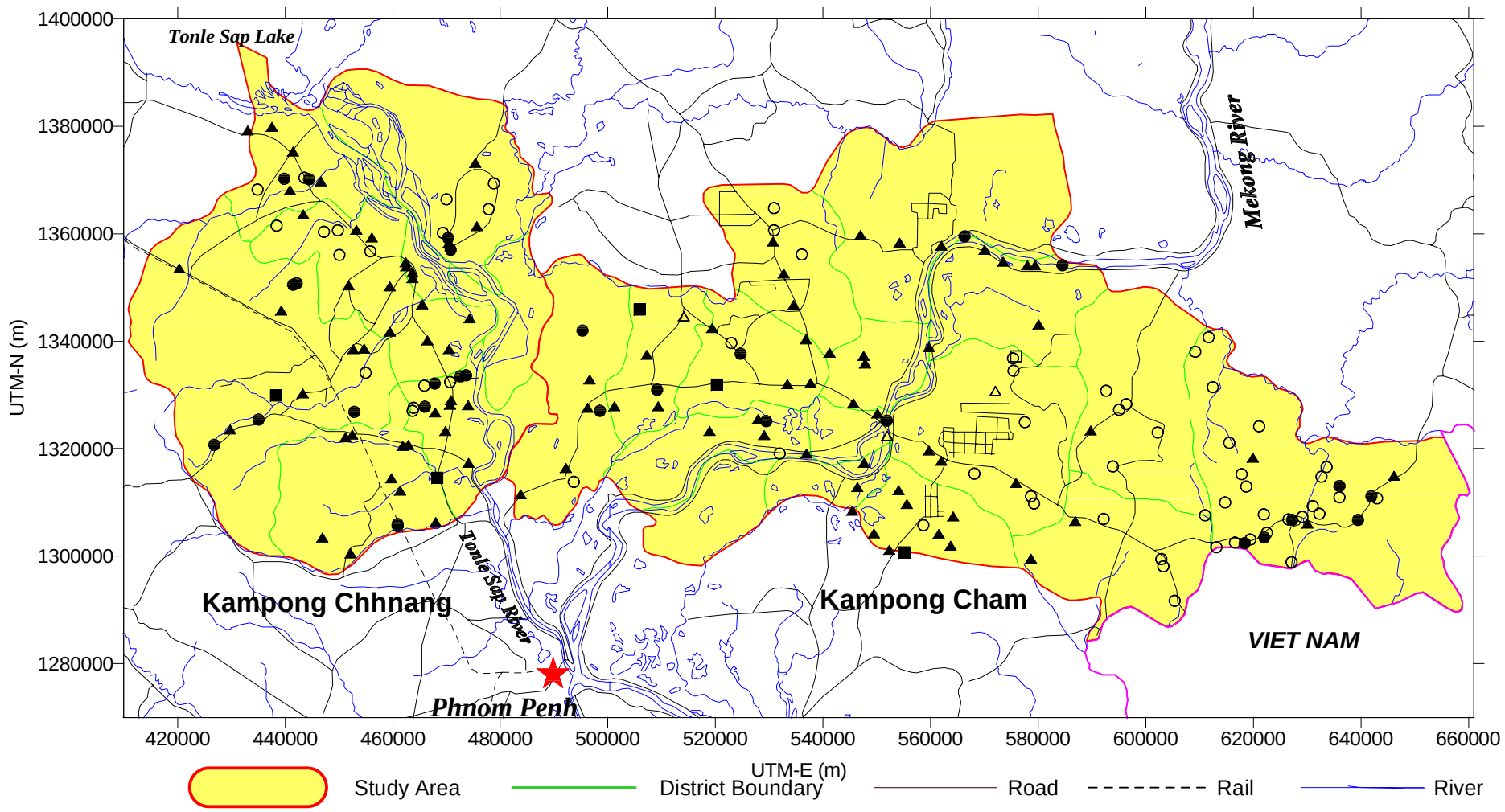
(2) Periodic Observation

Periodic observation was carried out to monitor groundwater levels over in monthly basis. A total of 26 wells out of about 250 wells for the simultaneous observation were selected for the periodic observation, in which groundwater level measurement and groundwater quality monitoring were carried out.

The periodic observation was launched in January 2001 and ended in December 2001. The observation was carried out by the study team members and the counterparts in DRWS. During the absence of the study team members, the counterparts could successfully carry out the survey based on the detailed instructions and technical transfers from the study team members. Figure 4.3.2.2 shows locations of wells for the periodic observation.

(3) Test Well Monitoring

The JICA Test Well has a small observation pipe which enables to measure groundwater level without removing the hand pump. The groundwater level and groundwater quality had been monitored since the completion of the well construction. The groundwater monitoring was started in May 2001 from the earlier completed wells. The construction of the test wells was finally completed in August 2001 and the monitoring of all the test wells began from the same month.



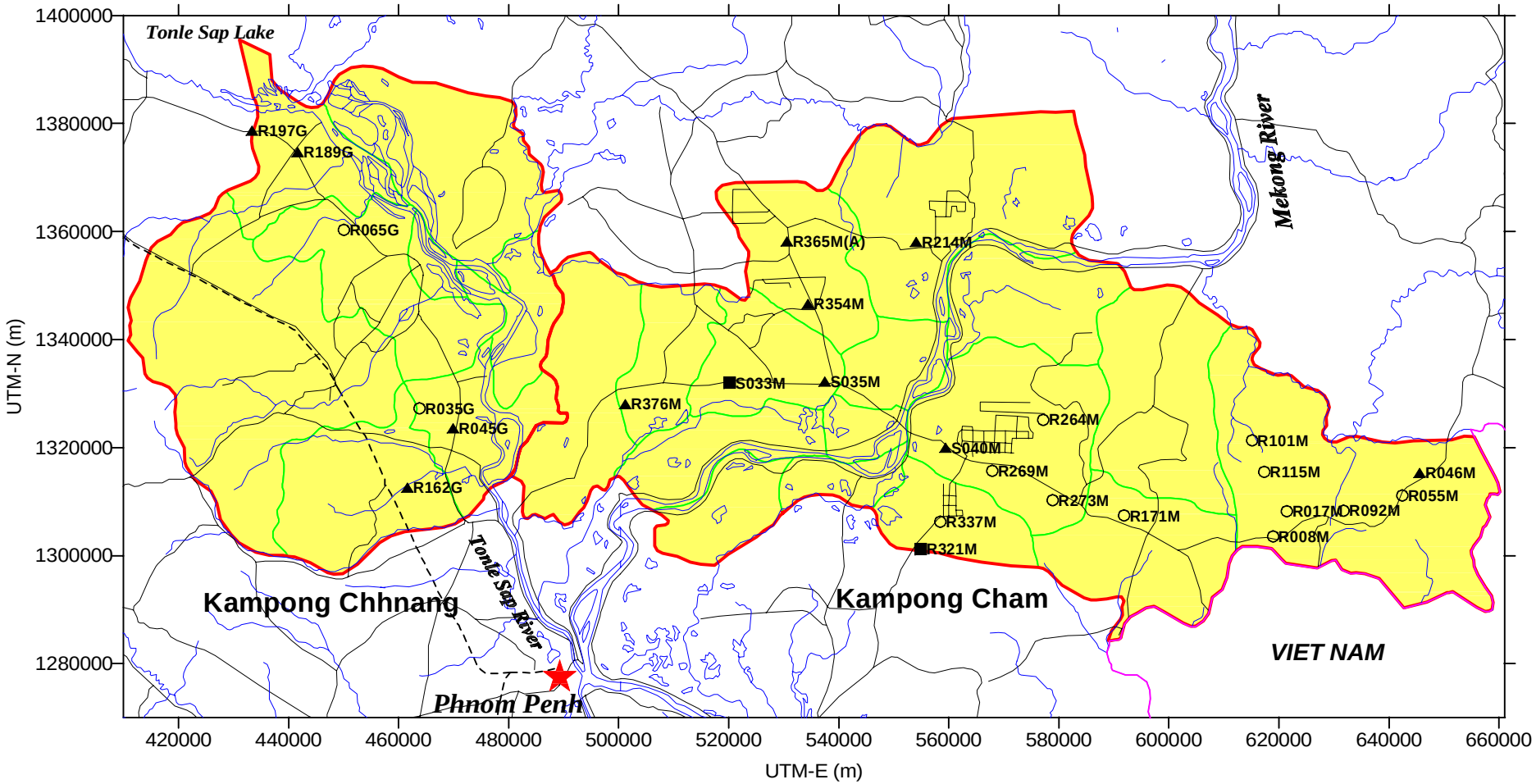
○	DW	●	BH
△	CW	▲	BH + DW
□	DW + CW	■	BH + CW

(DW : Dug Well, CW : Combined Well, BH : Borehole Well)

Figure 4.3.2.1	**Location of Surveyed Wells in Simultaneous Obsevation**

THE STUDY ON GROUNDWATER DEVELOPMENT IN CENTRAL CAMBODIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



Study Area | District Boundary | Road | Rail | River

○	DW	●	BH
△	CW	▲	BH + DW
□	DW + CW	■	BH + CW

(DW : Dug Well, CW : Combined Well, BH : Borehole Well)

Figure 4.3.2.2 **Location of Surveyed Wells in Periodic Observation**

THE STUDY ON GROUNDWATER DEVELOPMENT IN CENTRAL CAMBODIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Table 4.3.2.1 Selected Villages and Selected Existing Wells for Simultaneous Observation

	Kg. Chhnang				Kg. Cham				Total			
	1st Feb 2001	2nd May 2001	3rd Aug 2001	4th Nov 2001	1st Feb 2001	2nd May 2001	3rd Aug 2001	4th Nov 2001	1st Feb 2001	2nd May 2001	3rd Aug 2001	4th Nov 2001
Simultaneous Observation												
Surveyed Village												
Requested village	42	42	49	**42**	62	69	64	**64**	104	111	113	**106**
Supplementary village	17	18	20	**21**	38	37	40	**41**	55	55	60	**62**
Total	**59**	**60**	**69**	**63**	**100**	**106**	**104**	**105**	**159**	**166**	**173**	**168**
Surveyed Well												
Dug well	47	48	57	**52**	87	88	88	**89**	134	136	145	**141**
Combined well	2	1	2	**2**	7	7	8	**8**	9	8	10	**10**
Borehole well	45	46	47	**45**	54	62	64	**62**	99	108	111	**107**
Total	**94**	**95**	**106**	**99**	**148**	**157**	**160**	**159**	**242**	**252**	**266**	**258**
Groundwater Level Measurement												
Surveyed Village												
Requested village	34	35	42	**36**	58	61	60	**60**	92	96	102	**96**
Supplementary village	15	14	17	**18**	36	34	36	**37**	51	48	53	**55**
Total	**49**	**49**	**59**	**54**	**94**	**95**	**96**	**97**	**143**	**144**	**155**	**151**
Surveyed Well												
Dug well	47	48	57	**52**	87	88	88	**89**	134	136	145	**141**
Combined well	2	1	2	**2**	7	7	8	**8**	9	8	10	**10**
Borehole well	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Total	**49**	**49**	**59**	**54**	**94**	**95**	**96**	**97**	**143**	**144**	**155**	**151**

4.3.3 Survey Results

The results of groundwater level measurements as well as the results of water quality measurements are tabulated in the **Appendix** in this main report. The individual data sheet for each surveyed well is presented in the data report.

(1) Simultaneous Observation

1) Depth to Groundwater Level

The horizontal distributions of the depths to the groundwater level (DTW) at dug wells by the simultaneous observation are shown in Figures 4.3.3.1 and 4.3.3.2. The distribution patters of DTW are summarized that groundwater levels are shallow in plain areas in Kg. Chhnang and Kg. Cham. On the other hand, deeper DTW was observed in hilly areas in Memot district, Kg. Cham.

In February 2001, shallow DTW within 2 m was widely distributed in Kg. Chhnang province as shown in the upper map of Figure 4.3.3.1. The DTW in northern and southern parts of Kg. Chhnang province ranges from 2 to 6 m. The DTW in Kg. Cham province ranges from 2 to 4 m in the north, and the west. The DTW from Kg. Cham town to Chamkar Leu in the northwest shows more than 6 m. The greater DTW more than 4 m is also distributed in northeastern to eastern parts of the province. The DTW more than 20 m is found in the eastern part of Memot district.

In May 2001, groundwater levels declined in the most parts of the study area (see the lower map of Figure 4.3.3.1). Only a few small areas have DTW smaller than 2 m. The areas having DTW more than 6 m are distributed in western to southern part and northern part of Kg. Chhnang province, and near Kg. Chhnang town. In Kg. Cham province, the DTW more than 6 m can be seen in the northwest, the areas along the Mekong river, and northeastern to eastern part of the province. The DTW more than 10 m was found at eight (8) dug wells in the surveyed wells. There are two (2) dug wells having DTW more than 20 m in Memot district.

In August 2001, groundwater levels rose in the study area except Memot district (see the upper map of Figure 4.3.3.2). Wide areas in Kg. Chhnang had DTW smaller than 2 m. The groundwater levels in the northwest and south of Kg. Cham province also rose. However, the groundwater levels in Memot district still declined.

In November 2001, the groundwater levels became further shallower in the study area (see the lower map of Figure 4.3.3.2). Most of Kg. Chhnang province and western to southern Kg. Cham province had DTW less than 2 m. The DTW in Memot district also went up in this month.

2) Changes in Groundwater Level

Figures 4.3.3.3 and 4.3.3.4 show the changes in groundwater level based on the simultaneous observations.

For a period from February to May 2001, groundwater levels declined wide areas in the study area (see the upper map of Figure 4.3.3.3). The declined areas are located in most parts in Kg. Chhnang province and the areas along the Mekong River, western part and eastern part of Memot area in Kg. Cham province. The amount of declined groundwater level ranges from 3 to 7 m in western to southern parts of Kg. Chhnang province and the area near Kg. Chhnang town. In Kg. Cham province, the groundwater level declined 1 to 3 m along the Mekong River and 1 to 4 m in some parts in Memot district. On the other hand, the groundwater levels in the western part of Kg. Cham province and in the area between the Mekong River and Memot district rose for the period.

For a period from May to August 2001, the groundwater levels in the most parts of the study area went up (see the lower map of Figure 4.3.3.3). The amount of groundwater level rise ranges from 3 to 8 m in central and southern Kg. Chhnang province and central to southern Kg. Cham province.

For a period from August to November 2001, the groundwater levels still rose at 2 to 4 m in central to southern Kg. Chhnang province and western, northeastern and eastern Kg. Cham province (see the upper map of Figure 4.3.3.4). On the other hand, slight declines of groundwater levels were observed in the northwestern part of Kg. Chhnang province and in the southern and southeastern parts of Kg. Cham province.

The lower map of Figure 4.3.3.4 shows the difference in groundwater levels between February and November 2001. The groundwater levels in most parts in November are higher than those in February. Particularly the levels in central Kg. Cham province are 2 to 6 m higher than those in February. On the other hand, the groundwater levels in November are 1 to 2 m lower in some parts in Memot district.

3) Elevation of Groundwater Level

The distributions of groundwater level elevations are shown in Figures 4.3.3.5 and 4.3.3.6. The groundwater level elevation at each well site was computed by the DTW and the elevation of ground surface read from the topographical maps. The elevation of groundwater level (GWL) shows a good agreement with the general distribution pattern of the ground elevation. Although there are minor seasonal differences in GWL, the general distribution patterns of GWL show almost same over time.

The lower GWL values smaller than 6 m above sea level (masl) are distributed in the areas along the Tonle Sap River in Kg. Chhnang province and the southwestern part of Kg. Cham province. On the other hand, the areas having more than 30 masl are distributed in western part of Kg. Chhnang province, northwest and eastern parts of Kg. Cham province.

Based on the distribution of the elevations of groundwater levels, the dominant groundwater flow direction is from western mountainous areas to eastern low land along the Tonle Sap River in Kg. Chhnang province. In Kg. Cham province, groundwater flow directions are broadly divided into two (2) parts by a ridge of groundwater table having WNW-ESE orientation located along the basalt plateau distributed in northern, central and eastern parts of Kg. Cham province. It is estimated that the groundwater in the south of the ridge flows toward south or southwest. On the contrary, the groundwater in the north of the ridge is presumed to flow toward north or northeast.

(2) Periodic Observation

The groundwater levels at 26 existing wells (24 dug wells and 2 combined wells) were monitored on monthly basis from January to December 2001. The results are shown in Figure 4.3.3.7.

In Kg. Chhnang province, the groundwater levels in most wells declined 1 to 2 m from January to May then start to rise from June and reached the highest water level in October to November 2001. The highest groundwater levels are located within 1 m from the ground surface. The groundwater levels in some wells suddenly rose from July to August the higher water levels continued until November. In December 2001 the groundwater levels in all the wells started to decline.

In northwestern Kg. Cham province (= on the right bank of the Mekong River), most of the

wells show the lowest groundwater levels in February. The water levels once rose in March then again dropped in April. From May the water levels gradually rose until October. From November the water levels sharply dropped particularly at S033M combined well.

In Suong area of Kg. Cham province, there are two (2) types in groundwater level change. The water levels in some wells show the lowest levels in February to March then they gradually went up until October. The water levels in the other wells gradually declined from January to July then rose greatly from September to October. The highest water levels appeared in September to October in most wells. Then the water levels of all the wells sharply dropped from November to December.

In Memot district of Kg. Cham province, the groundwater levels in most of the wells declined from February to June or July. Only a few wells show the lowest water level in April. Then the water levels of most wells rose from August to October. It is noted that R055M dug well having deeper groundwater level has the highest groundwater level in November and December.

(3) Test Well Monitoring

The groundwater levels of the JICA test wells had been monitored since May 2001 at earlier completed wells and all the 30 wells were monitored for a period from August to December 2001. The results are shown in Figure 4.3.3.8.

In the test wells in Kg. Chhnang province, the groundwater levels fluctuated at depths between 0.5 and 6 m. The water levels in most wells went up from May to September and their highest values appeared in September to November. The groundwater level at No. 3 test well, which is located near the Tonle Sap River, clearly dropped from October, indicating that the groundwater level fluctuation coincides with the movement of the river water level. However, there are some wells having irregular fluctuations of groundwater levels, which are presumably caused by the groundwater pumping just before the measurements due to the poor aquifer productivity.

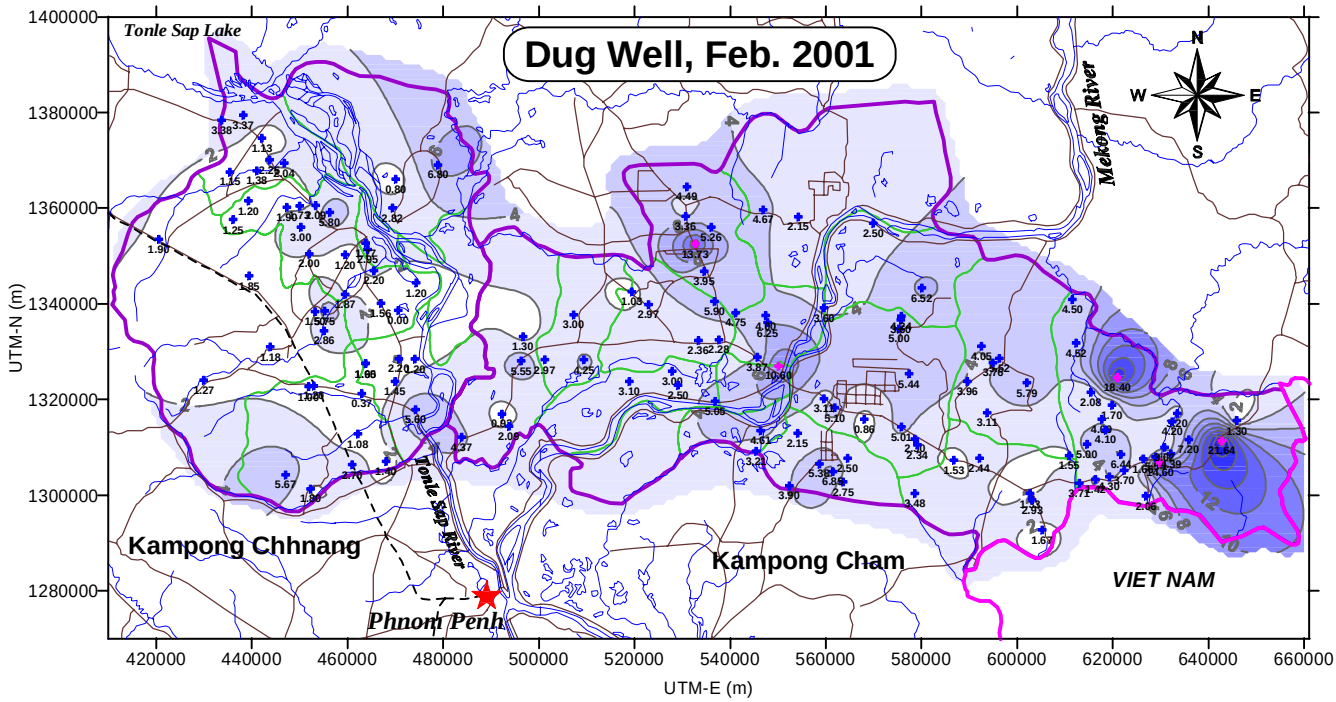
In northwestern Kg. Cham province, No. 22 test well had been an artesian flowing well from May to December 2001. The other three (3) wells have groundwater levels at depths from 1 to 9 m. No. 29 and No. 30 test wells, those are located far from the Mekong River, had the highest groundwater levels in November. The groundwater level of No. 23 well coincides the water level of the Mekong River, showing the highest water level in September then sharp drop of water level at 6 m by December.

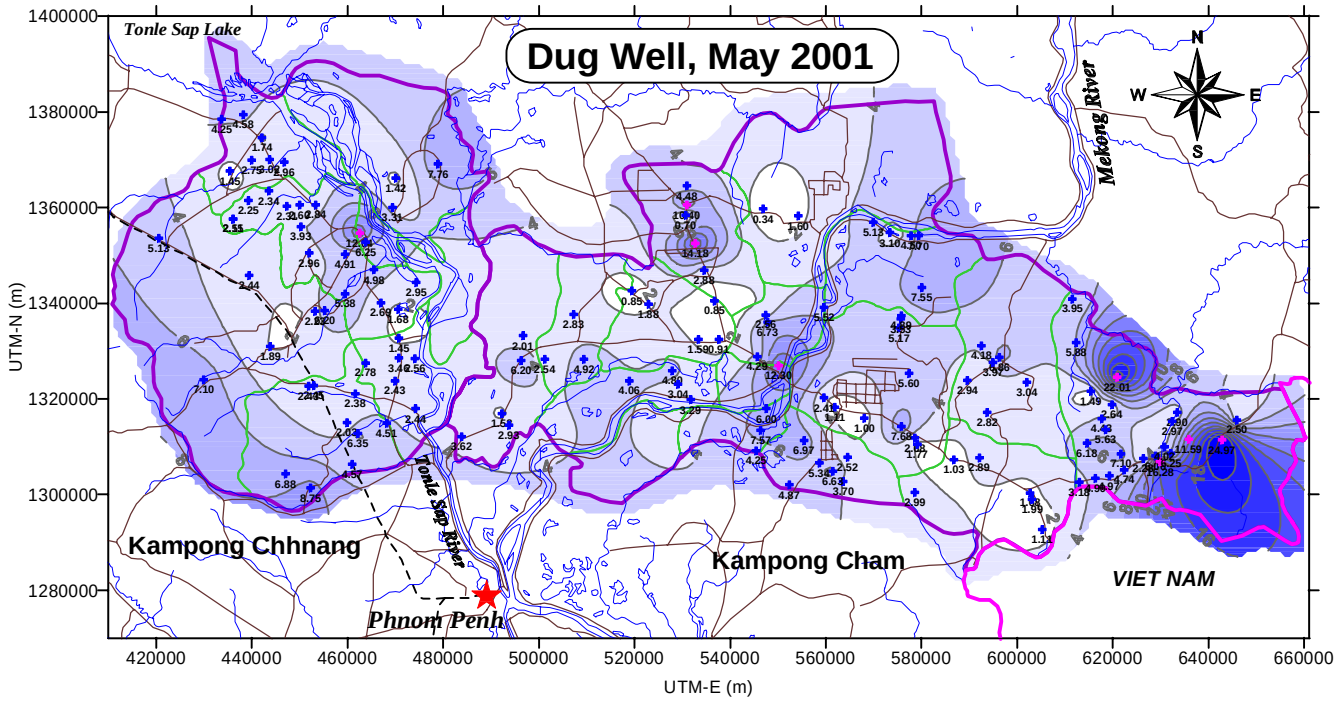
In Suong area in Kg. Cham province, No. 21 well had artesian flow from July to December 2001. The other five (5) wells have groundwater levels fluctuating at depths between 1 to 8 m. No. 25 and No. 26 test wells have shallow groundwater levels at depths between 1 and 2 m. The water levels gradually rose from June to October then dropped in November to December. On the other hand, the groundwater levels at No. 24, No. 27, and No. 28 test wells fluctuated at depths between 4 and 8 m. Among the three (3) wells, the water levels at No. 24 and No. 28 wells are relatively shallower and suddenly went up in September to October.

In Memot district in Kg. Cham province, the groundwater levels of the test wells except No. 15 well ranged from 0 to 13 m in depth. The water levels of No. 14 well are shallow, showed 0.22 m above ground elevation in August 2001. The rest of the wells show rise of groundwater level from July to October. The water levels started to decline from November, however, the amount of decline is relatively small compared with the test wells in other areas. The groundwater level of No. 15 well is deep, ranging from 23 to 30 m in depth. The well had the lowest water level in July then the water level rose in September and dropped in October. The highest water level is recorded in December 2001.

(4) Characteristics of Groundwater Level Change

From the investigations of the groundwater levels, the characteristics of the changes in groundwater level in the study area differ from place to place. The groundwater levels near the Mekong River and the Tonle Sap River change with the river water levels. The patterns of groundwater level change in Memot district vary by the well location and its ground elevation. However, the changes in groundwater level of the area show a delayed seasonal cycle from the rainy season – dry season cycle, showing the lowest levels in the beginning of the rainy season (June to July) and the highest levels in the beginning of dry season (November to December). The rest of the study area has lowest groundwater levels in April to May and the highest values in September to October.





DTW < 10 m

10 m =< DTW

Depth to Groundwater Table from Ground Surface, DTW (m)

0 2 4 6 8 10 12 14 16 18 20

Study Area

District Boundary

Road

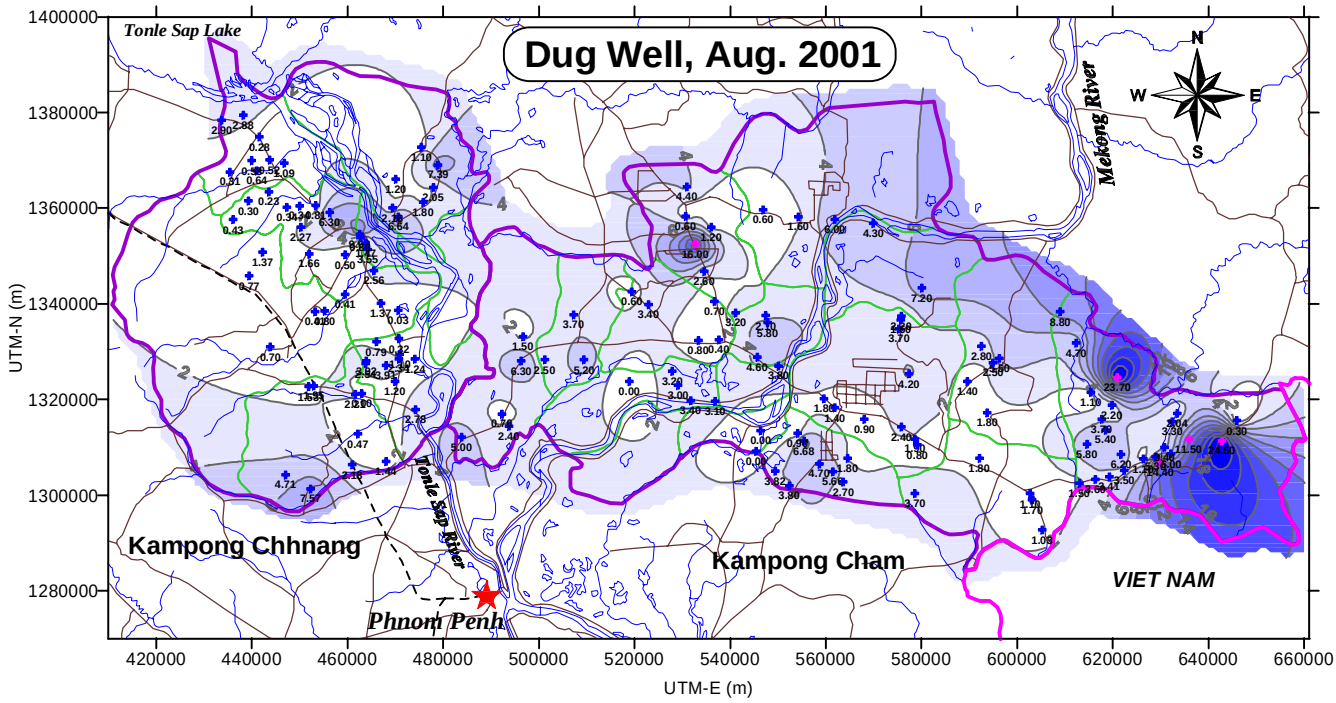
Rail

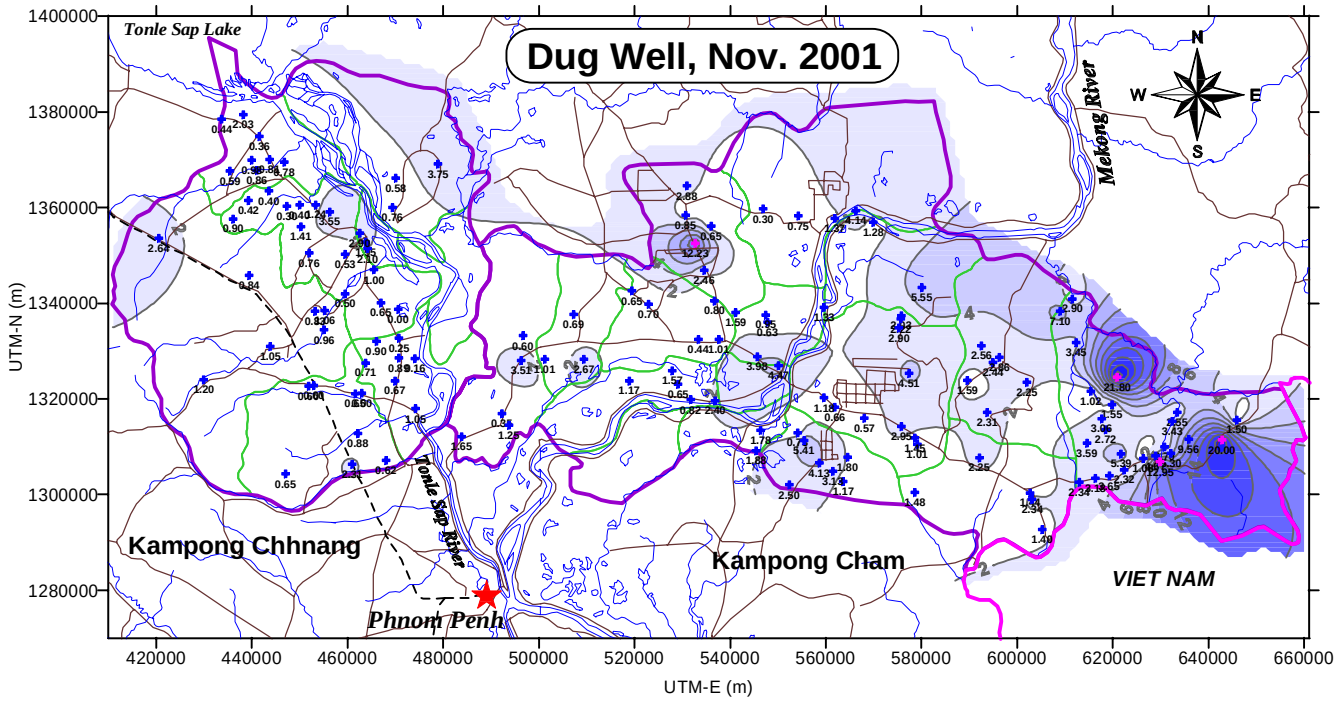
River

Figure 4.3.3.1	**Distribution of Depth to Groundwater Level at Existing Dug Wells (Feb 2001, May 2001)**

THE STUDY ON GROUNDWATER DEVELOPMENT IN CENTRAL CAMBODIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)





DTW < 10 m

10 m =< DTW

Depth to Groundwater Table from Ground Surface, DTW (m)

0 2 4 6 8 10 12 14 16 18 20

Study Area

District Boundary

Road

Rail

River

Figure 4.3.3.2 — **Distribution of Depth to Groundwater Level at Existing Dug Wells (Aug 2001, Nov 2001)**

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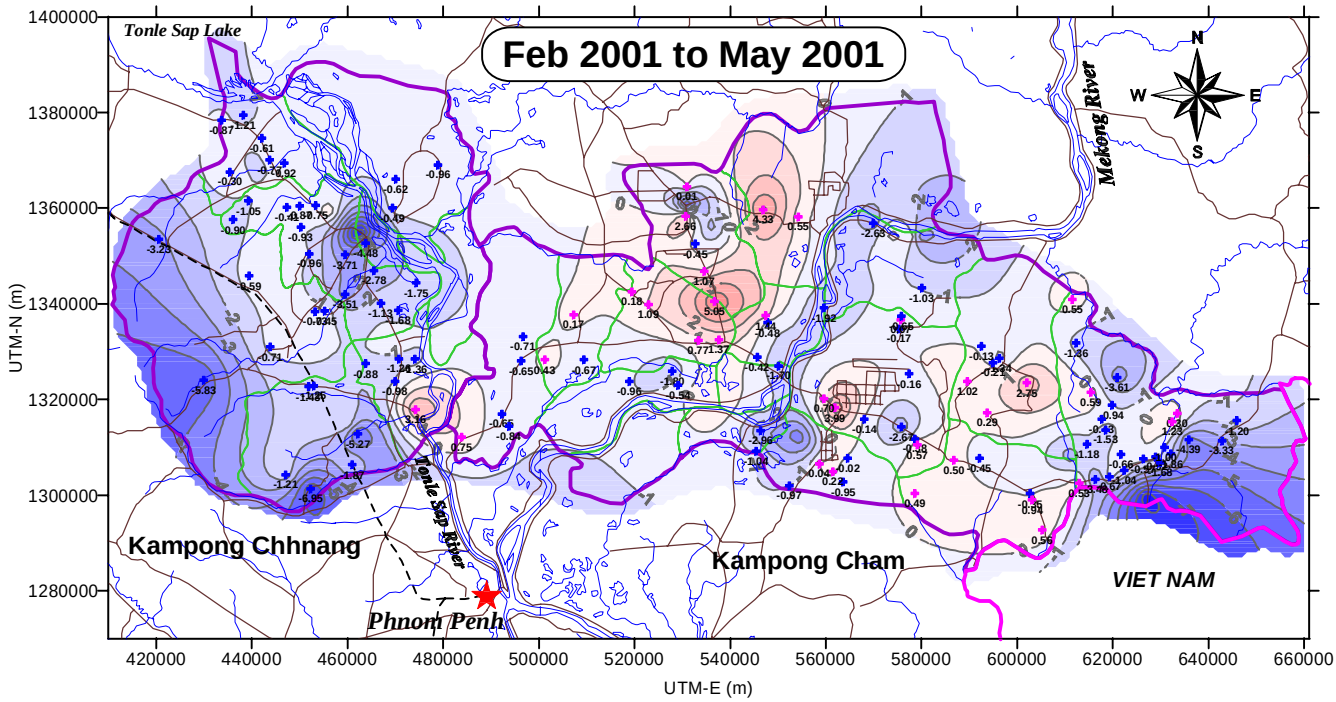

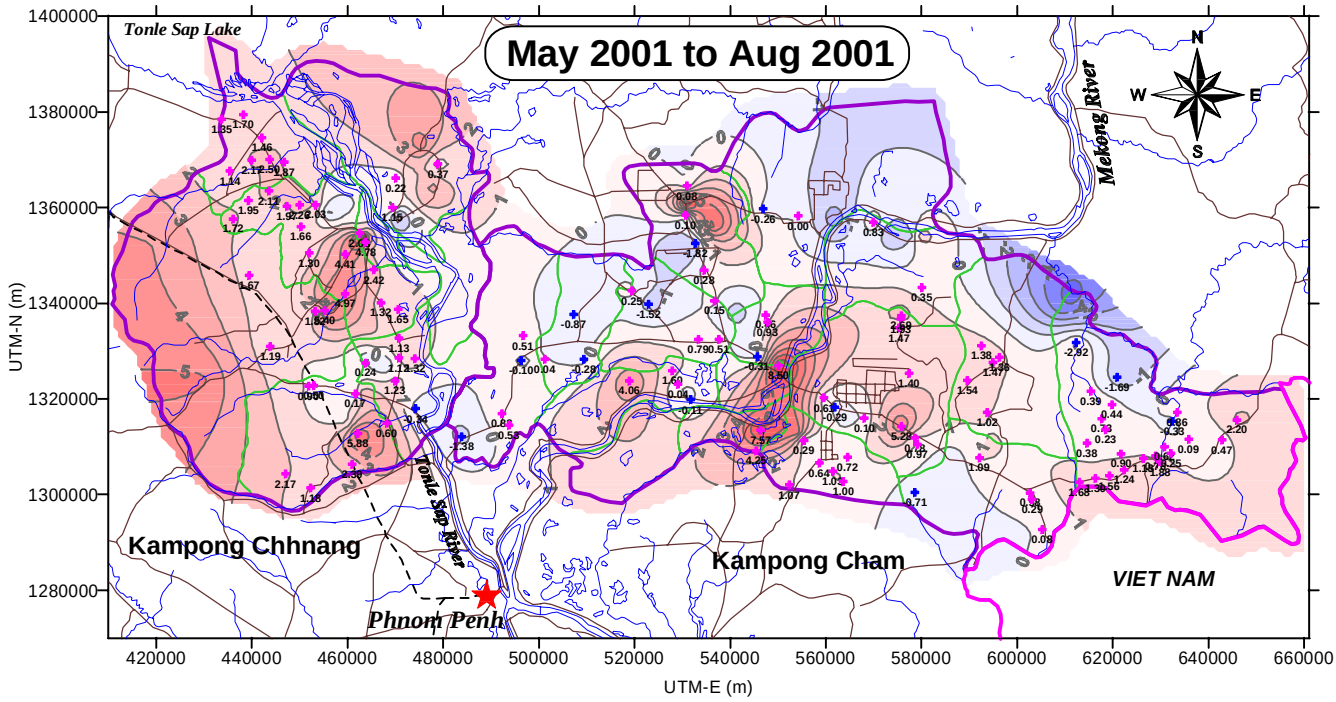

GWL Decreased

GWL Increased

Changes in Groundwater Level [GWL] (m)

-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

Study Area

District Boundary

Road

Rail

River

Figure 4.3.3.3	Changes in Groundwater Level at Existing Dug Wells (Feb to May 2001 and May to Aug 2001)
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