CHAPTER 4 SITE CONDITIONS

4.1 Topography

4.1.1 General Topograhy

In the Province of Riau, the big four rivers, namely, the Rokan River, Siak River, Kampar River and Inderagiri River originating respectively from the Barisan range, run in the northeastern or eastern direction and empty into the Strait of Malacca. Among these rivers, the Kampar River is the largest with a catchment area of 21,530 km^2 and mainly consists of the river basins of the Kampar Kanan River and Kampar Kiri River.

The Kampar Kanan River has its headwaters at Mt. Amas (El. 2,271m), Mt. Hidjau (El. 2,274m), etc. belonging to the Barisan range, and while collecting a number of tributaries through a steep mountain zone, it runs slowly on the quasi-plain plataeu. After joining the Mahat River at Muara Matat, the river reaches the Kotapanjang dam site. Near Rantau Berangin, the river runs on a flat alluvial plain, and joins the Kampar Kiri River around Langgam about 30 km southeast of Pekanbaru.

The Kotapanjang dam site is located about 10 km downstream of Muara Mahat at the confluence of the Kampar Kanan River and Mahat River. In other words, the dam site is about 85 km from Pekanbaru, a capital city of Riau Province and about 20 km from Bangkinang. The dam site is easily accessible through the Bukittinggi - Pekanbaru trunk road running on the left bank.

Regarding the topography around the dam site, the river is a valley form over a distance of about 1 km upstream and downstream of the dam site. The dam site was selected at the position where the width of the value is smallest. The river at the dam site is about 80m in width and the elevation of its basin is about 35m with its depth between draught discharge and wet discharge varying from about 2m to 5m.

The river gradient of the reservoir area is gentle, being about 1:1,070 at the Kampar Kanan river, 1:1,500 at the Mahat river and 1:1,090 from the dam site to Rantau Berangin. Moreover, a large pocket is located upstream of the dam site. Therefore, this site is characteristic in that it will be possible to obtain a large capacity reservoir by constructing a medium size dam.

4.1.2 Survey

The main existing data available for the feasibility study were the topographic maps of 1:250,000 and 1:100,000 in scale. In this detailed investigation stage, aerial maps of 1:10,000 were prepared for the reservoir area. Moreover, survey maps of 1:1,000 were also prepared for the area around the dam site and part of sand and gravel sites.

For the purpose of preparing these maps, the survey was carried out as shown in Table 4.1.

Aerial photogrammetry and ground survey were entrusted respectively to P. T. MAGAPLANA and P.T. HEXA KUERA under the supervision of JICA survey team in cooperation with the PLN counterpart.

Table 4.1 Outline of Topographic Survey

Survey items	Locations of survey	Q'ty	Scale	No. of maps
Aerial photogrammetry	Reservoir area	535 km^2	1:10,000	34 sheets
Topographic survey	Dam site	77 ha.	1:1,000	4 sheets
	Kuok sand and gravel site	6.25 ha.	1:1,000	1 sheet
Cross sectioning	Dam site	10 lines	1: 500	5 sheets
Levelling	Muara Mahat - Pangkalan Kotabaru	60 km	-	1 sheet
	Rantau Beranging - Triangulation T. 630	55 km	-	1 sheet

4.2 Geology

4.2.1 General Geology

(1) Physiography

The area of geologic investigation is in the range from lat. $0^{\circ}10'$S to lat. $0^{\circ}35'$N and from long. $100^{\circ}05'$E to long. $101^{\circ}05$E, and covers the entire area of the Kampar Kanan River basin.

The Barisan range running parallel to the longitudinal axis of Sumatra constitutes the western watershed boundary of the Kampar Kanan River. The topography of the project area is simplified as shown in Fig. 4.1. In other words, the Barisan range (I and I') in the northwestern to southeastern direction exists on the west side of the project area, and on the northeast side there is Eastern Barisan Foot Fills (II, II', III). Further on the northeastern side is the mountain front (IV) in parallel. From there, on the northeast side, a flat and low Alluvial plain spreads out and continues to the Strait of Malacca. In this Alluvial plain, there are independent hills in rows. Between each row of hills, there is a slender low-land in parallel to the mountain range. The Kampar Kanan River originates from the Barisan range, and runs in the eastern direction while collecting a large number of tributaries. These large and small rivers flows on low-lands between mountains in a parallel direction, northwest to southeast. When these rivers reach certain points, they pass through faults in mountain ranges and physiographically weak lines, and change their direction from northwest - southeast to east - west. Then, the rivers enter the subsequent low-lands.

The Kotapanjng dam site is located in the last range among the Eastern Barisan foot hills. After passing through the last range, the Kampar Kanan River runs between low hills, and is crooked in the Alluvial plain. There are faults in the northwest and southeast directions upstream and downstream of the dam site.

Although the Kampar Kanan River is croo ed in this area, it runs generally in the west - east direction. Reflecting such a physiographical configulation mainly in the northwest - southeast direction, the reservoir area at the dam site is a slender form in the northwest - southeast direction.

(2) Geology

The geology constituting the project area is roughly classified into the following three categories. The first is the sedimentary rock with its geological a e extending from the Plaeozoic Carboniferrous to the Cenozoic Quaternary. In terms of the lithologic character, this area mainly consists of metamorphic rock and grey wacke, and the Tertiary strata contain mudstone, fine sandstone shale, conglomerate and tuff which are interbedded by coal and lignite deposits. The second is the plutonic rock with its lithologic character mainly consisting of granite. However, the small rock of granite are scattered only in the Palaeozonic strata, and the range of their distribution is limited. Meanwhile, this rock group has been deemed to be the host rock of tin and diamond, and it has become important recently because it is assumed to be even the host rock of uranium ore. The third is the pyroclastic rock formed due to igneous activity from the Neogene period through the Quaternary period. In view of its distribution range, the pyroclastic rock mainly covers the shore line of the Barisan range, and is slightly distributed only in the southwestern direction within the project area. In terms of lithologic character, this rock mainly consists of volcanic breccia and tuff breccia, but andesite and basalt sometimes exist scatteredly as small rock group in the Tertiary strata.

The geology of the Kampar Kanan River basin is shown in Fig. 4.2, and its geologic stratigraphy in Table 4.2. Since geologic survey of this area other than the oil field area has not sufficiently been executed, some strata are given different names even they are the same. Although this investigation was carried

out primarily based upon the Pekanbaru Quardrangle (1:250,000) prepared by Geological survey of Indonesia (GSI), unpublicized geologic map (1:100,000) of Indonesian Atomic Energy Agency (BATAN) and the geologic map (1:250,000) of Mining Service (Dinas Pertambangan) were also referred to.

As for the geologic structure of the Kampar Kanan River basin, synclines and anticlines are repeated along the northwestern to southeastern direction axis, and a large number of faults are observed in parallel to this axis as shown in Fig. 4.3. The topography along the synclinal axis is low and flat, where Tertiary pelitic sediment is mainly distributed. Along the anticlinal axis, Palaeozoic strata are frequently exposed.

Table 4.2 Stratigraphy in the Project Area

Geological Age			Sediments and Metasediments		Volcanics and Intrusives	
CENOZOIC	Quaternary	Holocene	Young Alluvium		Maninjau Pumice Tuff	
		Pleistocene	Older Alluvium			
			Minas Fmn.	Kerumutan Fmn.		
	Tertiary	Pliocene	Petani Fmn.		Kotaalam Volcanic Fmn.	Undifferentiated Minor Volcanics
		Miocene	Kampar Group	Telisa Fmn. Sihapas Fmn.		
		Oligocene and Eocene		Pemataig Fmn.		
Mesozoic		Jurassic and Cretaceous				
		Triassic	Peusangan Group	Tuhur Fmn.	Granites	
Palaeozoic		Permian	Tapanuli Group	Bohorok Fmn.		
		Carboniferous		Kuantan Fmn.		

Note: Fmn.: Formation

4.2.2 Field Investigation

The field investigation in this stage was carried out with respect to the items described in Table 4.3. The entire field investigation other than surface reconnaissance was executed by P.T. WIRATMAN and P.T. ANDALAS G.H. who were entrusted by PLN. The supervision of field investigation and surface reconnaissance were executed in cooperation with the JICA survey team and PLN counterpart.

The surface reconnaissance was conducted in as much detail as possible in the reservoir area and river basin in addition to the dam site, quarry sites, and river deposits sites. Since it had been decided in the preliminary investigation stage that subsequent detailed investigation of the dam site be executed preferentially at the Kotapanjang site, only surface reconnaissance was conducted at the Mahat site. At the Kotapanjang dam site, field investigation was conducted with respect to the dam axes-1, 3 and 4 which had been selected from among the dam axes 1 - 4 as a result of comparative study in accordance with the results of field reconnaissance in the preliminary investigation stage.

Table 4.3 Outline of Geological Survey

Survey items	Survey sites	Contents of survey
Surface reconnaissance	Catchment area, dam site, etc.	The outline of topography and geology were confirmed by surveying on vehicle, aboard boats or on foot, and the policy for subsequent investigation was studied at the same time.
Drilling	Dam site	27 holes and 1,200m in total length
	Quarry sites	14 holes and 525m in total length
	River deposits	2 holes and 20m in total length
Seismic prospecting	Dam site	6 lines and 2,805m in total length
	Quarry sites	9 lines and 2,055m in total length

- to be continued -

Table 4.3 (Cont'd)

Survey items	Survey sites	Contents of survey
Test adits	Dam site	4 adits and 260m in total length
Permeability test	Dam site	20 holes
Lugeon test	Dam site	5 holes
Grouting test	Dam site	2 locations, 12 holes 420m in total length
Block shearing test	Dam site	4 locations
Test pits	River deposits	7 holes and 19m in total length
Laboratory test of sampled materials	Dam site, quarry sites and river deposits sites	Rock: 81 samples from 51 locations and test of 6 items Sand and gravel: 300 kg samples from 6 locations and test of 5 items Microscopic observation of rock: 5 thin test pieces from 5 locations

4.2.3 Geology of the Dam Site

The geology of the dam site belongs to the Tuhur formation of the Mesozoic Triassic period. Although this formation is generally composed of muddy to tuffacious rock, the rock which constitutes the bedrock of the dam site consists mainly of dacitic tuff, and partially of tuffacious shale.

The feature of dacitic tuff is that it is rigid with white patches of pumice scattered here and there and its stratification is not clear. Moreover, a large amount of quartz and iron oxide dikes are parted. Generally, iron oxide dikes film is deposited over the exposed rock surface under water and near the water level, and the surface stratum is substantially rigid in many cases.

The bedrock of the dam site is characteristic in that voids are frequently observed adjacent to the river water level. The maximum size of these voids is 3 to 5m in both width, height and depth. Judging from the fact that the surface that constitutes these voids is well in confirmity to the joint surface, these voids are assumed to have been formed due to blocks which slipped down along the joint surface. Clay and other inclusions which are observed inside the voids, are several centimeters in thickness.

The materials which cover the foundation rock are terrace deposits, river deposits, talus materials and top soil.

The terrace deposits, which are observed around the central part of the right bank at the dam site, are composed of unconsolidated fine sand and silt. At other than the dam site, the terrace deposits are observed at the following two places: namely, on the right side of the Angsa stream of the left bank, and around 50 m downstream along the dam axis-4. The materials which constitute the deposits are entirely the same.

The river deposits are deposited below the water level mainly on the right bank at the dam site, and consist of sand and gravel with a maximum diameter of 4 cm or so, with the maximum thickness of the deposits estimated to be about 5m.

Though the talus materials and top soil are observed everywhere on the ground surface, these strata are very thin around the slope of the left bank and adjacent to the ridges of both banks.
The strata with a thickness of within 2 to 3 m are estimated to be deposited to cover the terrace surface on the right bank toward the mountain side.

The stratigraphy at the dam site is as described in Table 4.4.

Table 4.4 Stratigraphy in the Kotapanjang Dam Area

Geological age		Formations	Lithology
Cenozoic	Quaternary	River bed deposits	Sand and gravel
		Talus deposits	Clay and gravel
		Terrace deposits	Fine sand and silt
Mesozoic	Triassic	Tuhur formation	Dacitic tuff and partial tuffacious shale

4.2.4 Geology in the Reservoir Area

The geology in the area immediately upstream of the Kotapanjang dam site and that in the catchment area including the reservoir are as shown in Fig. 4.4 and 4.2 respectively. In terms of natural science, the feature of the reservoir area can be classified as the depression in the syncline. In other words, the reservoir is a syncline corresponding to a portion of valley the wave of syncline and anticline running parallel in the nowthwestern to southeastern direction. And this area corresponds to a zone submerged due to orogenic movement in the Tertiary period. Thus, the materials eroded from the surrouding uplift mountains had been deposited due to submergence. Therefore, mostly mudstone, shale, fine sandstone and gravel of the Tertiary period are deposited at the central part of the reservoir area. These strata are parted by coal and lignite dikes. Moreover, as a result of volcanic activity which had become intensive in the Quaternary period, a large amount of volcanic ash and volcanic ditritus were deposited over the Tertiary strata. The tuff which was brought about as a result of volcanic activity in the Mesozoic era mainly exists only in the area around the dam site, and the volcanic ash in the reservoir area consists of effusive materials from the Neogene period. Consequently, small andesitic rocks effused everywhere across the Tertiary strata are used as stone materials.

4.2.5 Construction Materials

The construction materials can be obtained from the sand and gravel materials of river bed and sedimentary rock, and those of quarry sites.

Although it is most desirable to obtain sand and gravel materials from the river bed deposits of the existing river, the gravel materials from the upstream area are small in the amount available, those available in large quantity in the downstream area are fine-grained. Moreover, the gravel materials are available from the gravel deposits in the Tertiary strata, but these materials are inferior to river bed gravel in terms of quality.

In the case of quarry, when the tuff of a quality equivalent to that of foundation rock of the dam is to be used, such quarry materials will be available near the dam site. In many cases, however, these materials are parted by a large number of fine quartz dikes. Moreover, such materials tend to be easily crushed, and are thinly weathered on the surface. Therefore, it will be necessary to sufficiently study these factors prior to use of these materials. When volcanic rock materials (andesite and agglomerate) are to be used, the materials which are excellent qualitatively and quantitatively are available at a site which is about 25 km from the dam site. When it comes to the sedimentary rock, sandstone of the Palaeozoic era, which excells in quality and quantity, is distributed about 10 km upstream of the dam site.

Among other materials which are considered for use, gravel in the Diluvium deposits can be obtained at the former tin mines. Although the gravel materials are washed, nearly free from muddy substances and readily available for use, even the nearest mine, Lipai Mine, is as far as 30 km from the site.

The results of the survey regarding the construction materials are summarized in Table 4.5.

Table 4.5 Results of Survey regarding the Cosntruction Materials

Materials	Locations (Sites)	Distance from dam (km)	Quantity (m^3)	Lithology
Sand and gravel	New M. Mahat	11.0	103,500	Sand and gravel
	Muara Mahat	7.0	168,000	Sand and gravel
	Pulaugadang	3.0	51,000	Sand and gravel
	Kuok	9.0	342,000	Sand and gravel
Quarry	QR-I	10.0	350,000	Sand stone

The required amount of concrete aggregate is estimated to be about 340,000 m^3. When this amount is assumed to be supplied totally from the river sand and gravel, the available amount of sand and gravel is estimated to amount to about 464,000 m^3 when some margin (available amount 664,000 m^3 x 70%) is taken into account for safety.

As for quarry sites QR-I located 10 km upstream of the dam site, comparative study with river deposits sites shall be taken hereafter.

4.3 Hydrology

4.3.1 General Hydrology

Climatologically, Sumatra belongs to a monsoon zone of tropical rainy climate. The northeast winds blow from the South China Sea from October through January and the southwest winds blow from the Indian Ocean from March through May. The northeast winds bring larger rainfall than that of the southwest winds.

The annual rainfall in Central Sumatra exceeds 4,000 mm in Padang on the Indian Ocean side, and is about 2,000 mm on the basins in Bukittinggi and Payakung, about 3,000 mm near the Kotapanjung dam site and about 2,500 mm around Pekanbaru. The largest rainfall area is the coastal area in West Sumatra, while the smallest rainfall area is the basin in Bukittinggi and Payakumbuh. Within the catchment area of the Kotapanjang dam site, the rainfall is estimated to be 3,000 - 3,500 mm in the basin of the Kampar Kanan River, 3,000 - 4,000 mm in the basin of the Mahat River, the tributary and 3,000 - 3,500 mm in average in the entire basin.

In Pekanbaru, the yearly average temperature is 25.8°C, and although the monthly average temperature varies from maximum 27.1°C (May) to minimum 24.4°C (January), the monthly temperature range is as small as 2.7°C. In the project area, the monthly average temperature is more or less 27°C, and though the monthly temperature range is small, the daily temperature varies from maximum 35.5°C to minimum 21.6°C with a daily temperature range being as much as 13.9°C. The highest temperature and the lowest temperature occur respectively in May and January.

The daily average relative humidity is 83 - 85% in Pekanbaru 90% or more in the central part of the Island and 90% or less in areas near the sea. The humidity fluctuates as much as about 40% in a day. The highest humidity is recorded in early morning, while the lowest is recorded during mid-day. This is due to the effect of temperature change on the humidity.

The daily average wind velocity is 10.35 km/day (42.6 km/day in maximum) in Pekanbaru. Although the wind velocity is generally low, the higher it becomes, the higher the altitude is.

In the case of the discharge of the Kampar Kanan River, there is a range of 69: 31 between rainy season (November - May) and dry season (June - October). The discharge at the dam site (catchment area: 3,337 km) is abundant with an annual average of (173.52 m^3/sec) and 5.20 m^3/sec per 100 km^2. The annual runoff from the river is 5,472 x 10^6 m^3.

4.3.2 Field Investigation

The items of the site survey carried out under this study are as shown in Table 4.6. Among these survey items, installation of the rain gauge stations and flow gauging station was carried out by P.T. HEXA KUERA based upon the entrustment from PLN. The supervisory services for the installation work and other survey were carried out by the JICA survey team under the cooperation extended by the PLN counterpart.

Table 4.6 Outline of Hydrological Survey

Survey items	Survey site	Contents of survey
Field reconnaissance	Kampar Kanan River	By obtaining data and information pertaining to the Kampar Kanan River on vehicles, boats and on-foot, the survey policy was studied.
Installation of rain gauge stations	Kampar Kanan River	Three observation stations and one station were installed respectively along the Kampar Kanan River and Mahat River.
Installation of flow gauging station	About 4.5 km downsteam of the dam site	One flow gauging station was installed in Rantau Belangin
Discharge observation	Three locations	Rantau Belangin flow gauging station: Establishment of discharge curve formula Immediately downstream of the dam site: Establishment of discharge curve formula Rantau Belangin flow gauging station: Check of discharge curve formula Lubuk Sipopay flow gauging station: Check of discharge curve formula
Survey of the amount of suspended sediment	Rantaun Belangin flow gauging staion	Sampling of suspended sediment specimens and analysis thereof at the Bankginang Office

Table 4.6 (Cont'd)

Survey items	Survey site	Contents of survey
Water quality analysis	Rantau Belang-in flow gaug-ing station	Sampling of water specimens and analy-sis thereof at the Bankinang Office

4.3.3 Long Term Discharge

The long term discharge was calculated according to the methods mentioned below (Refer to Fig. 4.5 and Tables 4.7 and 4.8), because the long term discharge data from the flow gauging stations and rain gauge stations within the catchment area were insufficient to carry out study and planning for this project, and the gauging has been frequently suspended.

The discharge in the catchment area was calculated based upon the data obtained in five years from 1977 through 1981 at the Danau Bingkuang flow gauging station locating about 30 km downstream of the dam site. However, since the observation period at this station is too short, the long term discharge in the catchment area was calculated according to the tank model method by using the rainfall data of the Pangkalan Kotabaru rain gauge station in the catchment area of the Mahat River. Although rainfall has been observed at this station since 1901, rainfall observation has frequently been suspended during the period. Such being the case, the insufficient discharge data were interpolated based upon the rainfall data at the Bangkinang rain gauge station according to the correlative recurrence formula. On the basis of these discharge data, the discharge in the catchment area from 1971 through 1976 were obtained.

In this way, the discharge data extending to 11 years from 1971 through 1981 were used under this study. As a result, the annual average discharge at the dam site (catchment area: 3,337 km^2) was calculated to be 173.52 m^3/S. Therefore, the specific discharge per 100 km^2 was recognized to reach as much as 5.20 m^3/sec. Moreover, the annual discharge was estimated to be about 5.47×10^9 m^3.

Table 4.7 Predicted Monthly Mean Discharge at the Dam Site

(C.A. = 3,337 km^2) (Unit: m^3/sec)

Year	Jan.	Feb.	mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1903	576.78	367.38	268.36	291.54	293.50	254.72	215.03	311.02	404.98	339.18	255.44	311.31	323.99
1904	395.91	378.55	262.41	361.05	223.45	142.37	119.24	127.88	160.39	298.40	178.45	630.02	273.00
1905	419.30	335.27	282.97	265.98	264.24	192.55	150.90	164.85	109.15	168.85	325.91	373.78	254.16
1906	270.56	266.53	307.55	411.29	265.63	207.89	277.75	335.79	161.97	235.73	201.04	599.62	295.89
1907	347.79	358.39	301.74	287.89	216.66	255.89	259.22	167.48	182.04	239.34	342.35	277.61	269.00
1908	355.66	366.21	281.09	407.65	210.18	102.87	122.79	93.97	203.44	235.91	240.94	248.11	237.18
1909	248.76	295.81	465.33	314.43	200.94	162.28	102.30	175.47	125.19	118.26	75.78	273.79	212.99
1910	314.42	251.47	247.38	219.78	177.42	132.03	189.40	133.33	158.37	144.89	139.74	178.79	190.39
1911	338.20	211.13	189.80	188.61	225.93	164.01	114.25	96.45	228.07	378.08	439.23	424.58	250.12
1912	286.71	423.27	345.22	414.05	464.82	383.80	248.18	226.33	215.40	267.49	264.35	475.28	334.01
1913	383.92	415.65	335.44	312.08	258.20	298.27	255.79	169.67	133.44	202.58	505.91	422.86	306.88
1914	502.96	570.86	416.18	330.61	278.42	159.49	96.49	109.59	107.36	75.72	99.78	203.81	244.05
1915	184.76	205.27	152.23	244.99	290.25	166.10	192.31	185.51	213.91	165.48	291.07	242.36	211.04
1916	256.52	171.04	124.15	176.99	181.03	134.63	156.07	160.23	187.32	245.31	167.49	264.78	185.79
1917	353.70	288.81	247.86	280.71	193.76	174.37	265.60	140.73	170.66	173.40	151.28	158.97	216.31
1918	251.67	123.65	193.82	292.40	129.01	92.72	65.20	73.16	128.51	135.44	360.59	348.36	182.97
1919	370.63	353.00	267.13	202.90	159.36	108.18	96.95	117.17	59.77	148.20	147.66	361.99	198.91
1920	427.28	236.46	258.95	223.57	152.86	112.87	39.90	74.71	71.29	37.97	124.71	130.96	157.25
1921	345.35	482.69	353.07	298.65	379.23	305.94	172.04	114.42	252.14	343.72	285.93	299.93	301.47
1922	383.63	206.73	179.91	206.71	240.23	248.42	129.07	241.88	219.86	309.17	389.45	390.92	262.58
1923	256.26	221.86	181.09	216.39	118.80	81.23	114.18	101.61	224.39	114.54	233.43	704.69	214.25
1924	364.40	404.02	530.66	609.79	586.89	327.65	291.81	246.51	379.42	274.65	301.33	270.48	381.88
1925	688.07	588.31	370.14	286.04	221.38	235.88	164.42	232.37	268.89	283.23	336.34	584.23	353.82
1926	466.34	434.87	478.12	389.08	503.98	585.13	358.11	357.84	510.77	480.22	678.22	520.42	479.97
1927	425.26	675.95	480.14	422.29	365.03	238.40	183.20	115.96	150.43	183.27	306.08	421.73	328.37
1928	298.11	266.08	266.72	210.22	100.83	133.14	154.35	128.14	130.72	114.80	240.90	258.87	191.44
1929	210.34	170.66	198.73	154.15	121.67	106.62	65.80	63.61	177.53	267.50	324.76	309.06	180.84
1930	369.78	285.47	308.38	269.74	248.23	182.35	86.93	85.31	209.05	187.78	214.97	259.26	225.13
1931	519.40	360.78	313.34	305.18	278.87	273.51	266.76	204.06	222.09	162.62	202.00	470.19	298.24
1932	397.69	349.71	283.01	270.73	284.47	202.28	174.97	117.48	138.31	201.59	281.55	483.48	265.21
1933	470.03	385.77	399.57	370.16	345.76	196.87	237.40	170.13	193.30	276.77	310.45	389.62	312.03
1934	527.76	335.59	332.45	262.02	173.15	187.18	105.15	89.73	109.62	232.07	324.99	208.37	240.11
1935	292.67	226.72	311.17	292.09	158.80	217.40	162.79	180.15	118.56	151.55	241.98	342.11	224.73
1936	285.70	258.76	206.44	285.40	223.55	168.89	119.35	116.03	143.68	133.96	199.88	320.14	204.77
1937	183.83	213.28	174.20	182.82	207.85	141.79	129.31	61.54	94.18	361.13	391.94	310.37	204.30
1938	261.75	265.63	338.99	275.99	193.00	152.37	118.46	118.47	154.56	208.49	201.95	218.80	208.71
1939	265.55	180.68	191.20	227.48	202.07	182.77	106.35	77.23	155.49	232.46	212.55	377.70	201.20
1940	190.88	348.55	204.92	275.15	182.30	144.03	87.21	109.40	133.76	170.32	529.25	377.95	228.05
1941	353.42	265.99	203.73	295.06	188.49	213.03	114.56	123.43	172.51	137.96	237.74	260.52	213.27
Total	13841.75	12546.85	11253.59	11331.66	9500.17	7769.92	6309.59	5918.64	7180.52	8437.43	10757.41	13705.82	9864.30
Average	354.92	321.71	288.55	290.56	243.59	199.23	161.78	151.76	184.12	216.34	275.83	351.43	252.93

Table 4.7 (Cont'd)

(Unit: m^3/sec)

Year	Jan.	Feb.	mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
*1971	202.96	161.90	131.38	182.15	122.12	145.83	138.43	188.51	161.70	79.11	142.45	168.88	151.97
*1972	136.29	218.09	158.54	241.08	243.73	142.96	116.53	57.53	151.86	106.26	152.56	201.25	159.96
*1973	165.14	141.98	176.70	213.84	205.53	159.45	115.51	100.18	145.93	219.82	246.34	232.83	177.06
*1974	164.39	186.80	171.86	345.49	257.56	176.42	183.49	186.47	111.54	111.93	102.06	157.78	179.54
*1975	113.23	302.41	172.08	269.63	149.76	180.05	199.11	134.47	281.90	137.89	132.06	113.48	180.81
*1976	127.59	120.10	168.53	177.96	118.34	181.78	130.90	246.13	242.08	192.44	291.38	280.46	190.01
1977	235.93	282.86	186.61	212.59	164.01	109.14	95.23	73.93	92.34	131.15	370.58	373.30	193.22
1978	306.82	285.17	354.57	213.59	193.33	86.71	107.65	61.62	63.56	119.15	228.70	368.78	198.99
1979	246.63	216.37	130.63	164.08	132.70	149.12	96.28	60.55	100.72	92.45	354.62	242.61	164.85
1980	204.15	137.35	205.30	188.97	231.52	158.19	83.01	75.09	99.71	104.24	188.36	188.83	155.50
1981	198.87	129.96	231.02	267.29	266.22	114.15	66.21	36.90	87.43	194.34	133.57	153.26	156.89
Total	2102.00	2182.99	2087.22	2476.67	2084.82	1603.80	1332.35	1221.38	1538.77	1488.78	2342.68	2481.46	1908.80
Average	191.09	198.45	189.75	225.15	189.53	145.80	121.12	111.03	139.89	135.34	212.97	225.59	173.52
**	318.88	294.60	266.82	276.2	231.70	187.47	152.84	142.80	174.39	198.52	262.00	323.75	235.46

*: Predicted monthly mean discharge

**: 50 years (1903 - 1941 and 1971 - 1981)

Table 4.8 Discharge Duration at the Dam Site

(C.A. = 3,337 km^2) (Unit: m^3/sec)

Year	Maximum	35 days Run off	95 days Run off	185 days Run off	275 days Run off	355 days Run off	Minimum	Average
1903	1208.37	460.60	379.09	291.68	233.46	166.57	144.95	323.99
1904	1499.83	493.37	339.19	223.74	151.14	86.14	69.88	272.99
1905	755.70	408.42	312.26	242.77	163.14	96.13	82.49	254.15
1906	1577.37	471.37	313.54	246.22	200.63	143.80	130.05	295.88
1907	750.54	390.97	326.44	257.35	194.72	125.68	113.48	269.00
1908	953.37	418.87	306.83	220.37	127.93	61.68	51.29	237.17
1909	1135.11	358.78	269.99	186.75	110.96	68.95	59.83	212.99
1910	496.38	331.91	233.48	169.24	124.87	87.32	78.36	190.39
1911	703.70	465.39	312.45	216.98	144.59	84.26	70.69	250.12
1912	1351.62	515.26	367.95	290.70	239.10	163.03	149.80	334.01
1913	978.89	502.92	383.64	267.84	200.07	118.89	105.74	306.88
1914	1671.19	482.72	350.34	169.31	97.76	56.00	37.35	244.05
1915	864.78	342.20	234.60	179.38	154.97	123.91	119.20	211.04
1916	740.28	315.67	221.40	153.94	120.15	93.94	86.96	185.79
1917	1076.31	336.37	249.64	188.03	148.01	110.87	102.06	216.30
1918	804.74	364.47	258.22	129.58	96.45	43.36	37.63	182.97
1919	969.83	369.26	278.92	165.34	82.83	41.86	32.90	198.91
1920	977.68	326.08	205.84	116.83	62.89	24.62	22.11	157.25
1921	984.07	451.67	346.20	284.74	223.08	93.99	81.25	301.46
1922	1193.71	456.95	300.28	224.28	152.04	95.04	71.40	262.57
1923	1220.40	369.46	245.79	166.91	106.48	47.18	44.45	214.25
1924	1159.06	613.71	459.98	343.74	251.75	177.67	161.11	381.87
1925	2112.32	600.86	423.44	292.73	204.68	135.83	120.97	353.82

Table 4.8 (Cont'd) (Unit: m^3/sec)

Year	Maximum	35 days Run off	95 days Run off	185 days Run off	275 days Run off	355 days Run off	Minimum	Average
1926	1782.16	680.37	536.82	443.16	368.87	229.25	197.46	479.96
1927	1281.01	586.66	408.47	286.87	183.18	99.64	87.75	328.36
1928	567.70	309.39	246.35	185.49	106.99	73.01	68.88	191.44
1929	685.46	314.05	243.49	156.13	106.24	35.45	29.15	180.84
1930	621.51	349.31	285.42	226.54	157.26	48.68	36.98	225.13
1931	1236.71	476.60	337.23	273.51	211.85	120.04	98.38	298.24
1932	991.02	420.31	326.70	237.02	178.75	93.41	81.17	265.20
1933	885.82	490.61	394.27	308.07	198.08	137.25	114.03	312.03
1934	886.28	414.31	301.83	219.85	133.14	80.06	75.04	240.11
1935	789.23	362.09	273.01	203.83	150.43	94.27	77.37	224.72
1936	691.52	306.71	252.11	192.01	134.00	87.84	76.17	204.77
1937	1025.51	366.80	254.50	173.54	123.85	52.96	49.77	204.29
1938	657.69	330.34	248.06	192.39	150.21	93.47	89.57	208.71
1939	700.09	320.30	237.59	189.21	148.21	53.84	50.82	201.19
1940	1207.38	443.20	248.92	180.14	134.84	65.42	62.01	228.04
1941	767.19	331.22	260.99	199.20	145.99	90.68	82.16	213.27
Total	39961.51	16349.55	11975.27	8695.41	6223.59	3701.99	3250.66	9864.15
Average	1024.65	419.22	307.06	222.96	159.58	94.92	83.35	252.93

Table 4.8 (Cont'd) (Unit: m^3/sec)

Year	Maximum	35 days Run off	95 days Run off	185 days Run off	275 days Run off	355 days Run off	Minimum	Average
1971	508.27	257.26	183.05	130.18	100.08	60.35	49.89	151.97
1972	876.66	289.83	191.92	133.70	87.14	48.28	44.29	159.95
1973	656.62	280.12	209.98	158.31	123.67	79.80	72.78	177.06
1974	677.00	289.73	210.60	150.18	120.22	71.26	59.33	179.54
1975	872.25	301.58	202.60	143.95	117.70	86.53	73.28	180.81
1976	828.60	329.01	238.03	163.73	112.15	78.09	64.21	190.01
1977	733.55	422.60	223.29	148.03	101.72	54.17	47.55	193.21
1978	670.70	397.79	274.56	171.19	80.22	41.35	36.47	198.98
1979	544.25	330.80	208.16	130.50	87.25	42.34	36.72	164.85
1980	478.01	287.46	195.17	131.82	84.68	55.08	47.14	155.50
1981	552.93	341.05	199.64	119.91	66.33	33.58	30.27	156.88
Total	7998.84	3527.23	2337.00	1581.5	1081.16	650.83	561.93	1908.76
Average	672.62	320.66	212.45	143.77	98.29	59.17	51.08	173.52
1903 - 1941 and 1971 - 1981								
Total	47960.35	19876.78	14312.27	10276.91	7304.75	4352.82	3812.59	11772.91
Average	959.21	397.54	286.25	205.54	146.10	87.06	76.25	235.46

In order to evaluate whether the discharge data over the 11 year period belong to a flood period or drought period from a long term point of view, a long term discharge was obtained according to the similar method based upon the rainfall data obtained continuously in 39 years from 1903 through 1941 at the Pangkalan Kotabaru rain gauge station.

As a result, the annual average discharge during this period was estimated to be 252.93 m^3/sec, which is larger than that during the above-mentioned 11 year period. Namely, the recent 11 year period can be said to belong to the drought period. However, since the observation data obtained around the dam site are not sufficient and it is impossible to evaluate the accuracy of the results of observation, these data should be treated as reference data. Moreover, according to study on the basis of the discharge data during the recent 11 year period, the generated energy is also smaller than other periods. Therefore, the discharge data can be said to be conservative and rather reliable from an economic point of view.

4.3.4 Flood Discharge

For calculating the flood discharge, 200-years probable rainfall was first obtained according to the Hazen method, Iwai method and Thomas method by using the rainfall records at six locations in the catchment area and surrounding area. In this case, since rain gauge stations are located one-sidely in the Mahat River basin, the average rainfall in the catchment area was calculated based upon the isohyet method. As a result, the daily average rainfall and 5-day average rainfall were estimated to be 264 mm and 526 mm, respectivley.

Then, the past records of floods were investigated in order to calculate the flood discharge. As a result of calculating the flood discharge based upon the records in 1977 - 1981 at Danau Bingkuang observation station (C.A. = 4,035 km^2), 1,799 m^3/sec on December 15, 1978 became the maximum value among the records during the above peirod. However, this value was so small that it was inappropriate to estimate the design flood discharge on the basis of this value.

The hourly rainfall required as input data for computation according to the unit hydrograph method and storage function method was not available for flood analysis. Therefore, the design flood discharge was calculated from the daily rainfall according to the rational method.

In addition, comparative study with the flood discharge calculated based upon the rainfall intensity in Jakarta and the past records of data at other dams in Indonesia was also studied.

On the basis of the results of the above studies, the design flood discharge of 200-years was determined to be 9,000 m^3/sec.

4.3.5 Design Soil Sedimentation

For the purpose of determining the design soil sedimentation, study was carried out based upon the results of investigating the past records of soil sedimentation in Indonesia and the past records of suspended sediment in the Kampar Kanan River and Mahat River, and also using various estimation formulas. As a result, the specific soil sedimentation was determined to be 500 m^3/km^2/year.

4.4 Investigation and Countermeasures Regarding Compensation for Submerged Properties

4.4.1 Land, Houses and Other Properties

According to the results of investigation carried out at villages within the project area (Refer to 4.5 Social and Environmental Investigation), it had been made clear that ten villages in Riau Province and West Sumatra would be affected directly by construction of the dam. When the normal high water level is assumed to be 85.00m, the reservoir area will be enlarged to 124 km^2. Thereby, 2,644 houses or 2,990 families (households) including 3,864 ha of paddy field are estimated to be submerged.

The outline of each village which is assumed to be affected in connection with this project is summarized in Table 4.9.

The number of other buildings and facilities including markets, ferry ports, village offices, police stations, schools, mosques and others are estimated to be submerged in Riau Province and West Sumatra as listed below:

Facilities / Provinces	Markets	Ferry ports	Village offices	Police stations	Schools	Mosques	Total
Riau (Kampar Kanan River)	6	6	20	5	34	68	139
West Sumatra (Mahat River)	-	1	9	1	4	8	23
Total	6	7	29	6	38	76	162

For the residences and other properties to be submerged, compensation and alternative land for resettlement are required at the same time. After discussions with the BAPPEDA and JICA survey teams, the following resettlement sites were selected. Meanwhile, the alternative resettlement sites were divided into those in Riau Province and West Sumatra in view of administrative districts. Moreover, the resettlement sites were selected preferentially from the proposed development project sites as close as possible to the present living areas and the sites where development projects are under way (Refer to Fig. 4.6 - 4.8).

For the residents in Riau Province:

- Bangkinang Transmigration Project Area
- Rokan IV Koto Transmigration Project Area
- Koto Tengam Transmigration Project Area

Table 4.9 Tentative Figures for Submerged Land and Population Distribution by Desa (H.W.L. = 85m)

River	Name of Desa	Population	Family	Houses	Cultivated Land (ha)		
					Paddy Crop	Perennial Crop	Total
Kampar Kanan River	Gunung Bungusu	748	166	165	460	25	485
	Muara Takus*1)	686	176	166*2)	105	331	436
	Koto Tuo	1,659	364	330	727	616	1,343
	Ponkai	1,122	267	250	687	647	1,334
	Batu Bersurat	3,531	810	722	673	1,907	2,580
	Tanjung Alai	940	199	173	311	103	414
	Muara Mahat	1,128	208	170	202	331	533
	Pulau Gadang	1,446	318	294	175	183	358
	Sub-Total	11,260	2,508	2,270	3,340	4,143	7,483
Mahat River	Tanjung Balit	1,622	288	195*2)	340	860	1,200
	Tanjung Pauh	1,025	194	179	184	122	306
	Sub-Total	2,647	482	374	524	982	1,506
	Total	13,907	2,990	2,644	3,864	5,125	8,989

Notes: *1) Candi (Buddhist Remains) of which elevation is 86.25m would not be submerged.

*2) These figures are not the same as the total number of houses since some of them are above 85m.

Source: For population "Penduduk Propinsi Daerah Tingkat I Riau Hasil Registras: Penduduk, 1981" Biro Pusat Statistik and for land "Land Use Map" provided by Dinas Agraria, pekanbaru and Padang and then updated by the information of Camat office.

- Sungai Pagar Transmigration Project Area
- UPP Rubber Plantation Project Area, Muara Mahat
- PTP II Coconut Plantation Project Area, Tandum
- PTP VI Rubber Plantation Project Area, Tandun

For the residents in West Sumatra:

- Pangkalan Kotabaru Transmigration Project Area
- PTP III Rubber Plantation Project Area, Pangkalan Kotabaru

On the occasion of discussions with the JICA survey team, the BAPPEDA stated its intention to continuously carry out detailed studies regarding the implementation of the Transmigration Projects while keeping close communication with the pertinent authorities including PLN, Transmigration Service (Dinas Transmigrassi) and Department of Public Works (DPU). In view of these countermeasures, no problem will arise regarding compensation for submerged properties and resettlement. An authority for executing compensation for the submerged properties is expected to be established.

4.4.2 Roads

Subsequent to ponding in the reservoir, the existing national road extending to 25.3 km between the dam site and Tanjung Balit among a total length of 34 km will be submerged. Moreover, a 27.2 km section of the existing provincial road among a total length of 33 km will also be submerged.

The national road is an important trunk road between Bukkittinggi and Pekanbaru connecting West Sumatra and Riau Province. Thus, it is essential to relocate this road. On the other hand, the provincial road is branched from the national road at Muara Mahat and extends along the Kampar Kanan River. The section of this road up to Muara Takus will be submerged subsequent to ponding in the reservoir. Thus, this road shall also be relocated in order to ensure traffic to Muara Takus, Tanjung and other backland areas.

In order to select optimum relocated routes for the respective roads, overall comparative study was carried out while taking into account the future development in the region. As a result, the two alternative routes, namely, Route-A and Route-B were selected for further study.

According to the results of overall comparative study regarding these two alternative routes, the construction cost is estimated to be US$ 20.7×10^6 in the case of Route-A and US$ 26.9×10^6 in the case of Route-B. Since the Route-A is evaluated to be economically more advantageous than the Route-B, the Route-A was selected as an initial route for relocation of the national road and the provincial road (Refer to Table 4.10, Figs. 4.9 - 4.11).

Table 4.10 Comparative Study for Relocated Roads

Road	Route	Route - A		Route - B	
		Total length (km)	Construction cost (10^3US$)	Total length (km)	Construction cost (10^3US$)
National Road	New Road	41.42	10,698	36.52	9,498
	New Bridge	A1 0.25 A2 0.23	3,060 2,779	B1 0.45 B2 0.20 B3 0.03	5,506 2,417 153
	Temporary Plant	-	L.S. 825	-	L.S. 881
	Sub Total	41.90	17,362	37.20	18,455
	Existing Road	8.70	0	12.80	0
	Total	51.08	17,362	50.00	18,455
Provincial Road	New Road	18.70	3,183	29.45	5,055
	New Bridge	0	0	0.25	3,060
	Temporary Work	-	L.S. 161	-	L.S. 406
	Sub Total	18.70	3,344	29.70	8,519
	Existing Road	5.80	0	5.80	0
	Total	24.50	3,344	35.50	8,519
Total	Road to be Relocated	60.60	20,706	66.90	26,974
	Existing Road	14.50	0	18.60	0
	Total	75.10	20,706	85.50	26,974
Total Length of Existing National Road		34 km (Dam - Muara Mahat - Tanjung Balit)			
Total Length of Existing Provincial Road		33 km (Muara Mahat - Muara Takus - Tanjung)			

4.4.3 Mining Rights

No mining right has been established within the project site. In the reservoir area, the prospecting rights for two lead mines were established in addition to one tin mine with its prospecting right being applied (Refer to Appendix II-4).

No./Location	Mineral deposits	Owners
176/Sumbar	Lead (Pb)	P.T. Harir Jaya Raya
164/Sumbar	Lead (Pb)	SU Sinar Timur Mining Corp.
212/Sumbar	Tin (Sn)	In process

In connection with these prospecting rights, compensation will be required within the extent of effects to be exerted due to ponding.

4.5 Social and Environmental Survey

This survey was carried out to assess the extent of primary effect of the Kotapanjang Project assumed to exert upon the surrounding area. The population and number of households were classified in terms of prefectures (Kabupaten), counties (Kecamatan) and villages (Desa) based upon the census. In order to obtain detailed data concerning social conditions around the project area, "survey of villages" was executed under the cooperation extended by county headmen (Camat) and village headmen (Kepala Desa), and the area, population and number of households of villages, educational and religious facilities, infrastructures, economic and agricultural activities and other major economic indices were investigated. The results of this survey have made it possible to confirm and assess the general conditions in the entire project area. Moreover, by collecting data regarding the policies for and records of transmigration under REPELITA I, II and III, the future potential for accepting migrants in the project area and Riau Province was studied.

The basic environmental data were collected in order to assess the effect of this project expected upon the natural environment, ecology system, etc. In other words, by collecting information and data regarding the distribution and density of population, utilization of land, distribution of farm land, forestry resources, habitats of animal and fish, the impact of this project upon the downstream area and agricultural areas was investigated. In addition, a preliminary draft plan for transmigration of submerged households into adjacent alternative area was also studied.

This survey was carried out by the JICA survey team in collaboration with the PLN counterpart. Particularly for collection of data by the JICA survey team, PLN had sent the letters of introduction requesting the pertinent government authorities to assist the JICA survey team in collecting the data and information. At the same time, the JICA survey team had discussions individually with the personnel of the pertinent authorities in Jakarta and Pakanbaru. Furthermore, the JICA survey team executed field reconnaissance by visiting the branch office of the provincial government, villages and project area, and at the same time the team sent questionnaires to the related village headmen and country headmen as an integral part of the "village survey".

An outline of the results of study based upon the collected data and information is as summarized below:

4.5.1 Social Conditions in the Project Area

In view of administration, the project area is divided into two counties, namely, Kecamatan XIII Koto Kampar of Riau Province and Kecamatan Pangkalan Kotabaru of West Sumatra. The former is located along the Kampar River, and the latter along the Mahat River, a tributary of the Kampar Kanan River. Both of the counties are outlined below.

(1) Kecamatan XIII Koto Kampar

The Kecamatan XIII Koto Kampar is located at the westernmost end of Rian Province, and shares a border with West Sumatra. This

Kecamatan belonging to the Kabupaten Kampar is 1,750 km^2 in total area and consists of 13 villages (Desa). The Kampar Kanan River crosses the central part of the Kecamatan from west to east, and all villages are scattered here and there along the river. On the other hand, another river flowing in the Kecamatan, namely, the Mahat River, a tributary of the Kampar Kanan River joins the main stream around the Muara Mahat Desa.

In 1981, the total population in the Kecamatan was 17,976. When compared with the population statistics in 1978, the population increased at a high rate of 5.0% per annum from 15,528 in 1978. The total number of households is 3,891, and one family consists of an average of 4.1 persons. However, the population is only 10 persons/km^2 resulting in a shortage of the labour force in the Kecamatan.

In view of such a labor shortage, the transmigration plan has been implemented vigorously in the Kabupaten Kampar. From 1979 through 1981, roughly 10,000 households settled in the respective transmigration site areas of Tanjung Medan, Pasir Pengarayan, Rokan IV Kota and Siabu. Although there is not any transmigration project site in the Kecamatan Kampar, inter-Kecamatan transmigration has exerted a substantial impact upon the Kecamatan.

The majority of the population is engaged in agriculture. Although Kecamatan-wise agricultural outcrop data are not available, paddy rice constitutes an important agricultural product in the Kecamatan. Other agricultural commodities grown in this Kecamatan are rubber, orange, cloves and coffee. However, the farm land area for these commodities account for only less than 10% of the total farm land area cultivated in the Kecamatan Kampar.

In view of religions, the majority of the population is Islamic, whereas the rest are Buddhists and Christians.

(2) Kecamatan Pangkalan Kotabaru

The Kecamatan Pangkalan Kobabaru is located in the northwestern part of West Sumatra and borders on Riau Province. Most of the desas are scattered along the Mahat River running longitudinally across the Kecamatan. The road network in this Kecamatan has been replenished comparatively sufficiently, with a national highway connecting it to Padang and Bukittinggi in West Sumatra, as well as to Pekanbaru and Dumai in Riau Province. This road has greatly accelerated the distribution of commodities and interchange of population, thereby forcefully promoting economic and commercial activities between the two provinces.

In view of administration, the Kecamatan consists of six Desa and twenty-six sub-Desas. In a total area of 1,021 km^2, the Kecamatan has a population of 18,567 with the density of only 18 persons per km^2 similarly as in the Kec. XIII Koto Kampar.
Pangkalan Kotabaru, the capital of the Kecamatan with a population equivalent to 50% of the total population in the Kecamatan, has been urbanized at a rapid tempo.

In this Kecamatan, agricultural production constitutes a major economic activity, namely, production of paddy rice, rubber, coconuts and cloves as main crops. However, only 2% of the total area has been cultivated. The farming is small in scale with an average farm land area of about 2 ha per farmer.

The Desa-wise residences, stores, Desa offices, schools, religious facilities and other infrastructures in the Kecamatan XIII Koto Kampar and Kecamatan Pangkalan Kotabaru are as summarized in Table 4.11.

Table 4.11 Social Investigation of Project Area

Desa	Residence		Commercial Activities			Governmental Facilities		Education	Religious Facilities
	Families	Houses	Market	Shops	Ferry	Offices	Police/Army	Schools	Mosques
Kec. XIII Koto Kampar, Riau									
1. Pulau Gadang	318	294	1	61	2	1	-	6	8
2. Muara Mahat	208	170	2	45	-	4	2	7	2
3. Tanjung Alai	199	173	-	17	1	2	-	2	5
4. Batu Bersurat	810	722	1	50	1	7	2	9	24
5. Ponkai	267	250	-	9	-	2	-	2	8
6. Kota Tuo	364	330	1	98	1	1	-	4	12
7. Muara Takus	176	171	1	30	1	2	1	2	5
8. Gunung Bungsu	166	165	-	6	-	1	-	2	4
9. Tanjung	450	360	1	50	3	1	-	3	9
10. Tabing	224	262	1	10	1	1	-	1	5
11. Gunung Malelo	226	173	1	14	1	1	-	2	4
12. Siberuang	443	425	1	20	1	1	-	4	10
13. Balung	112	121	-	8	-	1	-	1	4
Total	3,963	3,616	10	418	12	25	5	45	100
Kec. Pangkalan Kotabaru, West Sumatra									
1. Pangkalan	2,052	1,639	1	170	-	15	3	13	22
2. Manggilang	449	392	N.A.	58	N.A.	4	-	4	4
3. Kota Alam	452	391	N.A.	51	N.A.	3	-	3	6
4. Tanjung Balit	288	219	1	49	1	4	-	2	4
5. Tanjung Pauh	194	179	-	34	-	5	1	2	4
6. Gunung Malintang	791	709	N.A.	71	N.A.	5	4	3	7
Total	4,401	3,529	-	433	-	36	4	27	47

Note : N.A.: Not available
Source : Data provided by the Camat office and the Kepala Desa.

4.5.2 Muara Takus Buddhist Temple Remains (Candi)

These Buddhist remains are located about 1 km south from the Muara Takus Desa along the Kampar Kanan River. Since it is important from an archaeological and historical point of view, study of the high water level of the reservoir was carried out in accordance with a basic policy for preserving the remains so that they will not be submerged nor be affected by execution of this project.

The JICA survey team carried out field investigation jointly with the pertinent provincial government authorities and had joint meetings with the authorities in collaboration with PLN. Moreover, Electric Power Research Center (LMK) had executed field investigation and prepared the "Environmental Study Report concerning the Kotapanjang Hydro-Power Project" (Catatan Peninjauan Lingkungan Proyek PLTA Kotopanjang) in March 1983.

As the data concerning the remains, the JICA survey team obtained "Description of the Buddhist Temple at Muara Takus" (Beschrijving Boeddhistische Rouwwerken tr Moeara - Takoes) prepared by J. W. Yzerman in Dec. 1889, and a pamphlet, "Muara Takus Temple" prepared by the provincial government.

The survey and study for preservation of the remains were carried out while referring to the above information and data. Meanwhile, the Regional Economy Research Institute of the Andalas University is now executing "The Study on the Impact of Kotapanjang Hydro-Power Project upon the Environment" (Study Dampak Lingkungan PLTA Koto Panjang) on behalf of PLN, and the report is scheduled to be submitted to PLN in the near future.

(1) Outline of the Remains

The remains were discovered in 1900, and according to the subsequent investigations, they were confirmed to be built in the 11th century through the 12th century. According to recent study, these remains were presumably built by the Sriwijaya Kingdom, a Buddhist country which had prospered mainly at Muara Takus at that time. This Kingdom had once extended its territory to the present Jambi Province and Palembang, and it is considered, though not confirmed, that the area around the remain was not the capital city at that time.

Investigation of the remains has been carried out several times by archaeologists ever since their discovery, and the remains are attracted world-wide attention in recent years. Moreover, study has been under way since 1979 according to "the ASEAN Nations' Joint Study" program.

The Muara Takus Temple, consists of six remains, have been rehabilitated since 1977. Among these remains, Mahligai Stupa, Panamuan Baru and temple garden have already been rehabilitated with a total cost required amounting to about Rp. 370 million. Although rehabilitation of other remains is difficult due to substantial weathering, these are also scheduled to be completed by 1988. The Temple Mehligai Stupa which has been rehabilitated is 14.45m in height and constitutes a symbol of the existing remains (Refer to Fig. 4.12).

(2) Countermeasures for Preservation of Remains

In this detailed investigation stage, concrete countermeasures for preservation of the remains have not been worked out because of limited investigation period and other restrictions. It is, therefore, required to work out overall countermeasures for preservation based upon the subsequent topographic, geologic and other investigations in the future. Described in this report are the tentative countermeasures for preservation of the remains.

(a) Protection of the temple by constructing an embankment around the remains site

The design high water level of the reservoir is 85 m. In contrast, the lowest elevation of the temple site level was clarified to be 86.25m near Mahligai Stupa based upon the results of the survey. Therefore, the temple will not be submerged by ponding. However, in light of the fact that there are evidences indicating that the temple had been surrounded by wall embankment in the past, it will be necessary to protect the surrounding area with embankment against back water arising in the flood time (200-years FHWL 86.396m). According to the sketches attached to the report of J. W. Yzerman, the area within the past embankment and the total length of the embankment are respectively estimated to be about 1.26 km^2 and 4.4 km (Refer to Fig. 4.13). The area which has already been alloted as a park area is about 300m (east to west) x 150m (south to north), and the other areas are covered by jungle. Since the area to be protected by embankment is scheduled to be used as a park area in the future, such area must be determined based upon detailed investigation after sufficient discussions with the Government of Indonesia. Basically, it is hereby proposed that the embankment be provided along the high water level of the reservoir.

In consideration that the 200-years flood high water level will be raised to 86.396m, the appropriate crest elevation of the embankment is estimated to be 88.0m (Refer to Fig. 4.13).

(b) Reinforcement of the foundation of the temple

The countermeasures for reinforcing the foundation will be studied with respect to Mahligai Stupa and Panamuan Baru which have already been rehabilitated. Regarding the temple yet to be rehabilitated, the countermeasures for reinforcement will be taken into account in coordination with the future rehabilitation plan.

In order to work out the countermeasures for reinforcement, drilling survey will be carried out around the temple in order to confirm the geologic conditions of the foundation. For the purpose of measuring the ground water level and monitoring the fluctuation of ground water level in the future, an observation system will be established. As the reinforcement methods, grouting of cement or chemicals, physical reinforcement of foundation and other methods can be taken into account (Refer to Figs. 4.14 and 4.15).

(c) Installation of rainwater drainage system within the remain site

In order to facilitate drainage of rain water falling inside the embankment to be provided, a drainage system consisting of culvert, gutter, etc. will be installed.

(d) Development of tourism mainly around the remains

At present, 500 to 1,000 people are said to visit the temple remains a year. However, the provincial government is planning to develop this area as a sightseeing spot after completion of the rehabilitation of the remains, and invite tourists not only from the surrounding area but also from foreign countries. In working out the tourism development plan, it is hereby proposed to promote overall tourism development including the area around the reservoir area in combination with construction of a museum, accomodation and leisure facilities, and creation of park areas.

(e) Investigation and preservation of the remains in the area around the temple

Archaeological articles have been unearthed also from the surrounding area in addition to the Muara Takus Temple, and investigation is currently under way. From the archaeological point of view (by the LMK's report), the area reportedly covers about 14 km^2 and extends to Batu Bersurat. Since more than half of this area will be submerged due to ponding in the reservoir, further investigation is required to be completed systematically prior to ponding in the reservoir. Moreover, it is proposed that unearthed articles be displayed in the above-mentioned museum.

4.5.3 Environmental Survey

(1) Forest

The forestry resources in Riau Province mainly consist of tropical rainforest including hill forest, peat swamp forest and mangrove. According to recent estimation, the potential forest resources in the province amount reportedly to 4,714,000 ha (126,158,000 m^3) in total comprised of 1,661,000 ha (49,833,000 m^3) of hill forest and 3,053,000 ha (76,325,000 m^3) of peat swamp forest, although the forest resources have not sufficiently been investigated. In 1980/81, the annual production of log amounted to 1,620,000 m^3.

An aforestation program is now under study by the provincial government. In order to avoid exhaustion of forest resources, however, plantation of valuable species such as Merati, Ramin and Darian Burong has been promoted, and as in 1981/82, afforestation of 550 ha was completed.

According to Forestry Service (Dinas Kehutanan), the forestry area around the Kampar Kanan River and Mahat River including partial area approved for investigation is specified to be a reservation. Therefore, it was clarified that no problem would arise regarding the forestry resources to be submerged in the reservoir area.

(2) Fishery

The fishery industry in Riau Province consists of coastal fishing and fishpond farming, and according to the records in 1981, 93% of the industry was dependent upon coastal fishing. Reflecting the shortage of manpower, river fishing is conducted by farmers in small scale.

Although freshwater fishpond farming is attempted at present, it is still in an experimental stage.

The catch in the Kabupaten Kampar from 1977 through 1981 was as follows:

(Unit: ton)

	1977	1978	1979	1980	1981
Freshwater	1,900.4	2,247.5	2,264.9	2,815.2	2,832.8
Fishpond	33.3	29.3	23.0	81.2	91.1
Total	1,933.7	2,276.8	2,287.9	2,896.4	2,923.9

According to Fisheries Service (Dinas Perikanan), the catch from the Kampar Kanan River and Mahat River in 1981 is estimated to be about 1,120 tons or equivalent to 40% of the catch in the above table.

The major species are Ikan Gabus, Ikan Lais, Ikan Sepat Siam, Ikan Tambakan, Ikan Lainnya and Udang Tawar (shrimp). No migratory fish inhabit the river.

Although there is not any full time fisherman in the Kabupaten Kampar, 3,000 farmers are reportedly engaged in fishing along both of the rivers.

The Dinas Perikanan announced a policy for promoting cultivation of Tawes, Sepat Siam, Nila, Gurame, Tambakan and Udang Gala belonging to the species of specially high added value by utilizing the reservoir, a huge artificial lake as a fish farming pond. Such a secondary utilization method of the dam is expected to bring about a significant benefit by paving the way for increasing the cash income of the farmers in the surrounding area.

(3) Flood Control and Irrigation

The water resource development in Riau Province cannot be said to have been carried out sufficiently. Especially, floods occurring in the major river basins year after year has constituted a serious obstacle to social and economic activities in the province. In the area downstream of the Kampar Kanan River, for

example, the people are suffering serious damages due to flood every year, and according to the results of recent "Land and Water Study", roughly 40,000 ha affected by flood. (Refer to Fig. 4.16)

Nevertheless, there is a large potential for agricultural development in such a frequently flooded area. In this sense, this dam project is expected to bring about very significant benefit as a workable measure for solving the flood control problem.

Now, an agricultural irrigation system is considered as one of the water resource utilization methods.
The present rice producing area is only 140,000 ha equivalent to about 1.5% of the total area of the province, among which about 86,000 ha is the paddy field. Nearly all of the rice producing area is located in the coastal area and swamp areas, and about 20,000 ha is irrigated by providing simple irrigation facilities of a natural flowdown system, though small in scale. (Refer to Fig. 4.17)

In the area along the Kampar Kanan River, the Government of Indonesia is implementing irrigation projects of 2,500 ha at Rumbio Ponalongan and 5,000 ha at Kuamany in the downstream area, and 35 simple irrigation facilities have already been put into operation. (Refer to Fig. 4.18)

For such a purpose, the Kotapanjang project is expected to bring about an indirect benefit by supplying water required for irrigation of farm land during the dry season.

(4) Wildlife

In Riau Province, there are four wildlife preserves, respectively at Kerumutan (120,000 ha), Pulan Berkah (500 ha), Pulau Burang (200 ha) and Pulau Laut (400 ha), where elephants, tapirs, and rhinoceros are preserved. However, no such preserve is located within the project site, and the construction of a dam is not considered to exert any adverse effect upon the preservation of wildlife.

However, elephants are said to appear in the vicinity of the Muara Takus remains, and according to the local people, there is possibly a habitat about 8.5 km back from the opposite (left) bank of the Kampar Kanan River in the northern direction from the remains. Although the habitat area will not be submerged, construction of the dam is considered to affect the living and walking range of elephants. Consequently, it is proposed to provide a walk was for elephants or move the elephants habitat as required.

CHAPTER 5 POWER GENERATION PLAN

5.1 Study on Development Method

In formulation of the Kotapanjang Development Project, two alternative plans, i.e. a single stage development plan and a two stage development plan were studied.

The single stage development plan is to build a dam of 58m height (HWL 85m) at Kotapanjang site approximately 10 km downstream of the confluence of the Kampar Kanan River and its tributary, the Mahat River, and to construct a power station of 111 MW with a reservoir of active storage capacity of 1,040 million m^3 (the proposed Dam site is on the Dam axis-4 mentioned in 5.2). This plan permits effective utilization of the rivers by means of large-scale power development, and the agricultural irrigation and flood mitigation of the downstream area. On the other hand, 2,644 houses, 8,989 ha of cultivated land and national road of 25.3 km and provincial road of 27.2 km would be submerged.

The two stage development plan is to build a regulating pondage by two steps as a measure to reduce compensation costs for land and houses to be submerged. Specifically, the downstream dam of 30.5m height (HWL 58m), a regulating pondage with an active storage capacity of 20 million m^3 and a power generation plant of 42 MW are to be constructed at the aforementioned Kotapanjang Dam site, and another upstream 38 meter high dam (HWL 85m) is to be built to create a regulating pondage of active storage capacity of 20 million m^3 and Mahat power plant of 23 MW at Tanjung Pauh on the Mahat River. According to this plan, about 390 houses, 1,860 ha agricultural land and 16 km national road would be submerged.

Locations and profiles of the two alternative plans are as shown in Fig. 5.1. Results of comparative studies of development methods are as listed in Table 5.1, and indicate that the single stage development plan is verified to be better. Therefore, this report is for the single stage development plan.

Table 5.1 Comparative Study on Development Method between One-Dam Plan and Two-Dam Plan

Item	Development method	Single stage development plan	Two stage development plan		
		Kotapanjang	Kotapanjang	Mahat	Total
Catchment area	(km^2)	3,337	3,337	1,075	
Annual average inflow	(m^3/sec)	173.5	173.5	55.9	
High water level	(m)	85	58	85	
Low water level	(m)	73.5	54	81	
Active storage capacity	($10^6 m^3$)	1,040	20	20	
Power generation type		Reservoir type	Pondage type	Pondage type	
Dam height	(m)	58	30.5	38	
Type of dam		Concrete gravity type	Concrete gravity type	Concrete gravity type	
Max. output	(kW)	111,000	42,000	23,000	65,000
Max. discharge	(m^3/sec)	348	348	110	
Effective head	(m)	38.1	14.2	24.5	
Annual generated energy	(10^6kWh)	495	175	96	271
Facility utilization rate	(%)	50	44	49	
Construction cost	(10^3US$)	190,194	109,700	56,300	166,000
Construction cost per kW	(US$)	1,713	2,612	2,448	2,554
Construction cost per kWh	(US$)	0.38	0.63	0.59	0.61
B/C		1.47	0.92	0.98	0.94
B-C	(10^3US$)	12,551	-1,252	-144	-1,396

5.2 Selection of Dam Site and Dam Type

Upon selection of the Dam site, comparative studies were carried out on dam axes-1, 2, 3 and 4, using existing topographic maps of 1:25,000 scale. As axis-2 was found to be relatively close to axis-3, it was excluded from further study. Field investigations including drilling investigation are also applied to these axes (Refer to Fig. 5.2).

Concrete gravity type dam on the dam axes-1, 3, 4 were studied to select the optimum site for a concrete dam. For a fill dam, on the other hand, dam axis-3 was selected topographically and studied for center core type. In this case, comparative study for the location of spillway was done at both bank (left and right bank).

Such studies were carried out using the following procedure, the optimum layout was drawn for each case and the total construction costs were compared for main dam structure, spillway, diversion work and powerhouse excluding common work costs.

As a result, the construction of a concrete gravity dam on the dam axis-4 was found to be the optimum one, as shown in Table 5.2, because of the high cost of countermeasures against large flood discharge during and after construction.

Table 5.2 Selection of Dam Sites and Dam Types

(Unit: 10^3 US$)

Item		Concrete gravity dam Axis-1	Concrete gravity dam Axis-3	Concrete gravity dam Axis-4	Fill dam Axis-3 (Spillway at right bank)	Fill dam Axis-3 (Spillway at left bank)
Dam	Dam body	22,791	16,626	16,331	10,421	6,974
	Spillway	6,804	7,009	6,756	16,519	19,617
	Diversion work	6,047	6,434	5,149	10,911	12,221
	Concrete plug work	1,617	1,617	1,617	3,234	3,234
	Others	3,728	3,170	2,913	4,111	4,328
	Total	40,987	34,856	32,766	45,196	46,374
Power house		9,689	11,455	9,936	13,174	13,540
Metal work	Gate	9,072	9,072	9,072	10,498	9,272
	Penstock	1,362	1,362	1,362	1,872	1,940
	Total	10,434	10,434	10,434	12,370	11,212
	Grand Total	61,110	56,745	53,136	70,740	71,126

5.3 Study on Dam Scale

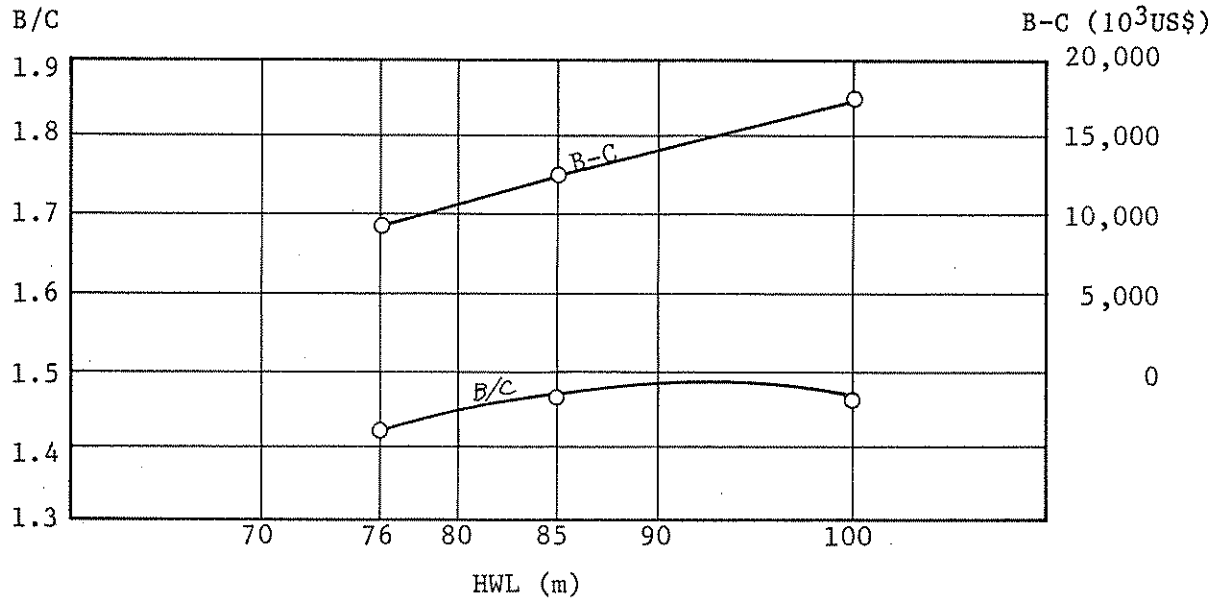
For optimization study on the scale of the proposed Dam, annual generated energy and construction costs by three cases were calculated, taking into account the height of the Dam, operating hours, effective water storage capacity and effective depth, and, then, evaluated on the basis of cost-benefit analysis. According to this analysis, the case of HWL 85m is the optimum. However, beause a part of Pangkalan Kotabaru, upstream along the Mahat River, is located at an elevation of 88.2 - 91.5m (population 8,572) and that Buddhist remains (Muara Takus) lie at an elevation of 86.25m for which rehabilitation works are being restored at present, the proposed high water level (HWL) was set at 85m.

Results of studies are as listed in Table 5.3 and Fig. 5.3.

Table 5.3 Comparison of Dam Scales

Item \ HWL		76m	85m	100m
Max. output	(kW)	90,000	111,000	160,000
Max. discharge	(m^3/sec)	348	348	348
Effective head	(m)	30.7	38.1	54.4
Annual generated energy	(kWh)	393×10^6	495×10^6	697×10^6
Construction cost	(10^3US$)	155,447	190,194	268,796
Construction cost per kW	(US$)	1,727	1,713	1,680
Construction cost per kWh	(US$)	0.40	0.38	0.39
B/C		1.43	1.47	1.47
B-C	(10^3 US$)	9,534	12,551	17,923

Fig. 5.3 B/C and B-C Curves of Dam Scale



5.4 Evaluation of Installed Capacity

Determination of the installed capacity was made by comparing seven cases, assuming that the effective depth 11.5m and active storage capacity 1,040 million m^3. Results of these studies are as shown in table 5.4 and Fig. 5.4.

Basic conditions for calculation of power generation are as follows:

Intake Level	:	Water level at the center of gravity of the re servoir (EL 80.60m)
Tailwater Level	:	EL 41.00m
Maximum Output	:	Pmax = 9.8 x Qmax x h x
where, Qmax	:	maximum discharge (m^3/sec)
h	:	effective head (= 38.1m)
	:	comprehensive efficiency of turbine generator (= 0.86)

B/C and B-C curves gradually increase in proportion to installed capacity, according to Fig. 5.4.

The Kotapanjang power plant will need to bear a base load and correspond to the future peak load, however, excessive scale of power generation will not meet high efficiency of plant utilization.

Although daily load factor was 61.7% in Riau province in September 1982, the load factor is considered to be 50% taking into account the change in demand structure accompanying the future industrial development.

The installed capacity was determined to be 111 MW with 12 hours peak time.

Calculation of generated power for the optimum scale is shown in Table. 5.5, and mass curve of reservoir is shown in Fig. 5.5.

Table 5.4 Comparison of the Installed Capacity

Max. output (MW)	Max. discharge (m^3/sec)	Annual generated energy (10^6 kWh)	Annual benefit B(10^3US$)	Total construction cost (10^3US$)	Annual cost C(10^3US$)	B/C	B–C (10^3US$)
66.8	208	423.3	30,583	171,596	24,195	1.264	6,388
74.2	231	459.1	33,361	174,481	24,602	1.356	8,759
83.5	260	495.2	36,363	178,128	25,116	1.448	11,247
95.4	297	495.2	37,663	182,565	25,742	1.463	11,921
111	348	495.2	39,368	190,194	26,817	1.468	12,551
134	416	495.2	41,882	197,655	27,869	1.503	14,013
167	520	495.2	45,489	209,140	29,489	1.543	16,000

Note: B = 109.3 (US$/kW) x (Max. output) + (US$/kWh) x (Annual generated energy)
C = (Total construction cost) x 0.141

Fig. 5.4 B/C and B-C Curves of Power Generation Plant

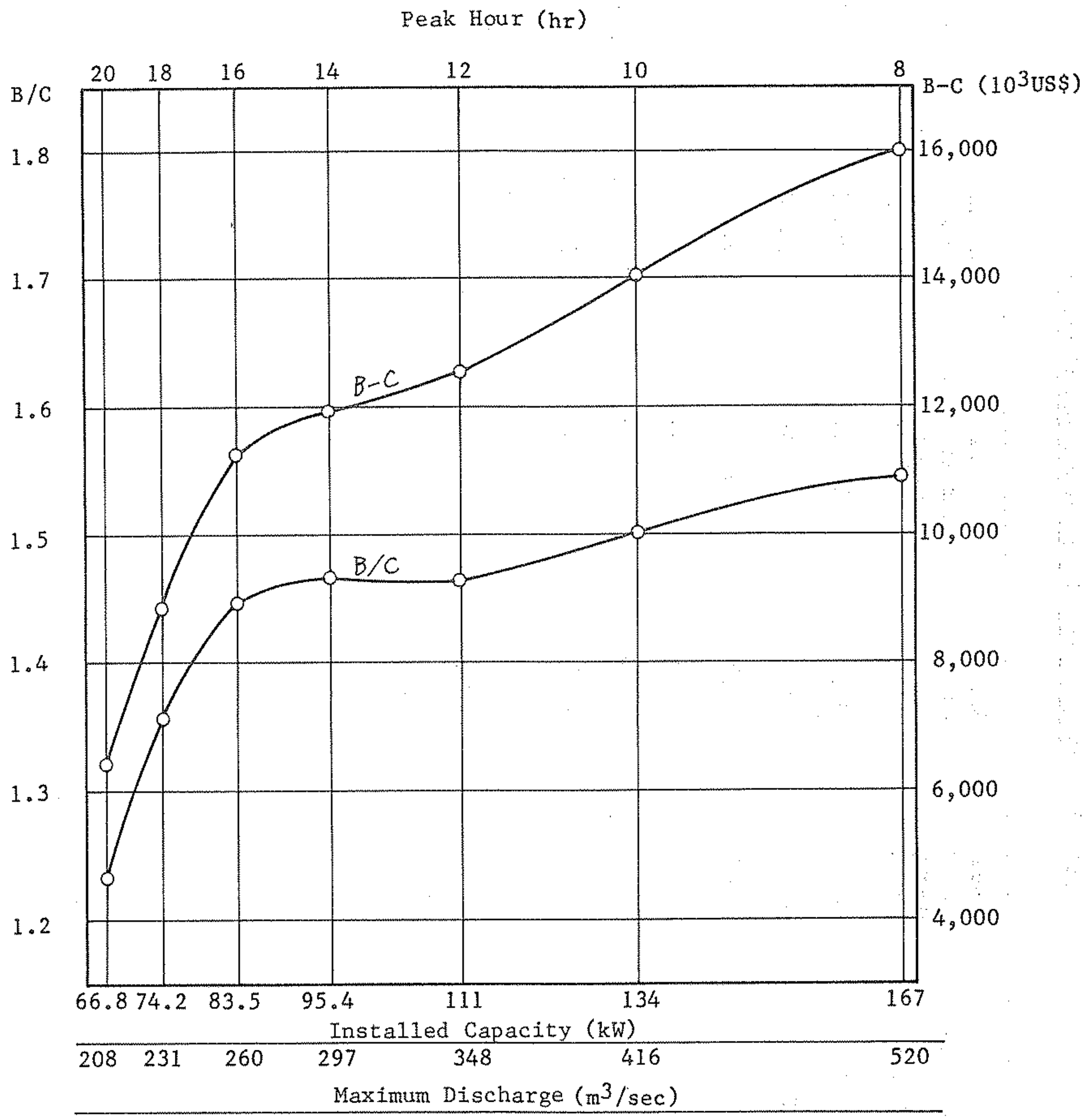


Table 5.5 Annual Generated Energy

(Unit: 10^6 kWh)

Year \ Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1971	36.1	33.3	36.7	35.8	36.5	34.8	35.4	36.1	35.5	35.3	33.2	33.4	422.0
1972	31.2	32.3	32.1	33.8	36.3	37.0	36.1	34.7	33.6	32.2	30.9	33.5	404.8
1973	37.1	32.5	35.8	35.6	38.4	37.9	38.4	36.4	33.7	34.5	40.2	43.3	443.7
1974	44.5	39.8	44.0	45.2	50.3	49.1	50.7	48.5	46.4	46.2	42.5	43.1	550.1
1975	41.5	38.7	44.3	44.0	46.3	44.9	46.4	46.2	45.8	48.1	45.4	45.5	537.1
1976	41.2	39.8	38.7	38.8	37.9	37.4	35.9	36.6	43.9	43.9	45.5	47.2	487.0
1977	53.6	50.0	55.3	54.0	52.7	44.8	44.4	41.3	37.0	35.7	36.4	63.6	568.8
1978	69.5	62.9	72.4	70.9	72.2	49.9	40.4	38.2	34.5	31.6	33.6	42.3	618.3
1979	46.0	42.9	47.2	42.6	44.0	41.7	41.9	39.4	36.0	33.5	34.4	42.6	492.3
1980	41.1	40.9	41.3	42.0	43.1	43.8	41.9	38.5	36.3	35.0	33.2	35.0	471.9
1981	39.0	34.3	39.0	40.1	43.7	43.3	42.4	37.4	33.1	32.7	34.1	33.5	452.6
Average	43.7	40.7	44.2	43.9	45.6	42.2	41.3	39.4	37.8	37.1	37.2	42.1	495.2