Table 2.4 Historical GDP by Economic Sector

(Unit : VND bil. At 1989 constant price)

Year	GDP	GDP growth rate (% p.a.)	Agriculture, forestry and fishery	Industry and construction	Service
1985	23,875	-	10,455	5,231	8,189
	(100.0)		43.8%	21.9%	34.3%
1986	24,431	2.3%	10,705	5,769	7,957
1987	25,321	3.6%	10,649	6,297	8,375
1988	26,835	6.0%	11,069	6,630	9,136
1989	28,093	4.7%	11,818	6,444	9,831
1990	29,526	5.1%	12,003	6,629	10,894
1991	31,286	6.0%	12,264	7,228	11,794
1992	33,991	8.6%	13,132	8,242	12,617
1993	36,735	8.1%	13,634	9,324	13,777
1994	39,982	8.8%	14,169	10,631	15,182
1995	45,929	14.9%	12,052	12,956	20,921
1996	50,219	9.3%	12,583	14,803	22,833
1997	54,313	8.2%	13,127	16,651	24,534
1998	57,462	5.8%	13,590	18,049	25,823
	(100.0)		23.7%	31.4%	44.9%
Growth rate : (% p.a.)					
85-90	4.3%		2.8%	4.9%	5.9%
90-95	9.2%		0.1%	14.3%	13.9%
95-98	7.8%		4.1%	11.7%	7.3%

Note: Values at 1994 constant prices shown in "Statistical Yearbook 1998" were converted to those at 1989 constant price level by applying GDP deflator adopted in preparing the macro economic projection in this Study.

Source: Computed based on "Statistical Yearbook 1997 and 1998"

Table 2.5 National Accounts : Percentage to GDP (at Current Price)

(Unit : %)

Items	Historical				Preliminary	Estimated
	1993	1994	1995	1996	1997	1998
Gross Domestic Product	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	29.8	28.7	28.4	27.2	26.2	26.0
Industry	28.9	29.7	30.0	30.7	31.2	31.7
Services	41.2	41.7	41.7	42.1	42.6	42.3
Total Consumption	78.8	82.0	83.5	85.9	80.4	83.2
Domestic fixed investment	24.9	25.5	27.3	27.9	27.6	23.6
Gov't investment	7.0	6.9	5.4	6.0	5.9	6.0
Private investment	17.9	18.6	21.9	21.9	21.7	17.6
(C+I)	103.7	107.5	110.8	113.8	108.0	106.8
Exports	29.5	34.4	36.3	43.1	46.1	48.8
Imports	33.2	42.0	47.1	56.9	54.0	55.5
(E - I)	-3.7	-7.6	-10.8	-13.8	-7.9	-6.7
Gross national savings	17.3	17.0	17.0	16.7	20.1	17.0

Source: "Country Assistance Strategy" World Bank, August 1998

Table 2.6 Infrastructure Indicators of Vietnam with Comparison to Other Countries

Infrastructure Indicators		Vietnam 1980	Vietnam 1995	Thailand 1980	Thailand 1995	Philippines 1980	Philippines 1995	Low income group 1980	Low income group 1995
1) Electric power:									
consumption per capita	kWh	50	146	279	1199	353	337	156	269
2) Commercial energy use:									
kg of oil equivalent per capita	kg	75	104	259	878	276	307	133	198
3) Access to safe water:									
% of population with access	Urban:	-	53	-	89	-	-	-	79
	Rural:	-	32	-	72	-	-	-	67
4) Paved roads: % of total	%	24	25	55	98	-	-	17	18
5) Telephone main lines:									
per 10^3 people in 1996		-	16	-	70	-	25	-	11
6) Air passengers carried:									
per 10^3 population in 1996	10^3	-	32.5	-	230.8	-	99.5	-	17.1
Reference: Population in 1997:	millions	77		61		73		2,048	

Note: "Low income group" is composed of 61 countries including those Asian countries like Cambodia, Lao PDR, Mongolia, Myanmar, Afghanistan, Bangladesh, Bhutan, India, Nepal and Pakistan besides Vietnam.

Source: "World Development Report 1998/99" World Bank

Table 2.7 Monthly Average Income per Capita of Households (at current price)

Region	1994 VND 10^3	1994 Index	1995 VND 10^3	1995 Index	1996 VND 10^3	1996 Index	Average growth (%) 94/95	Average growth (%) 95/96
Red River Delta	163.3	97.1	201.2	97.6	223.3	98.5	23.2%	11.0%
Northeast and Northwest	132.4	78.8	160.7	78.0	173.8	76.7	21.4%	8.2%
North Central	133.0	79.1	160.2	77.7	174.1	76.8	20.5%	8.7%
Central Coast	144.7	86.1	176.0	85.4	194.7	85.9	21.6%	10.6%
Central Highlands	197.2	117.3	241.1	117.0	265.6	117.2	22.3%	10.2%
Southeast	275.3	163.8	338.9	164.4	378.1	166.8	23.1%	11.6%
Mekong River Delta	181.7	108.1	222.0	107.7	242.3	106.9	22.2%	9.1%
Whole Country	168.1	100.0	206.1	100.0	226.7	100.0	22.6%	10.0%

Source: "Statistical Yearbook 1997" General Statistical Office

Table 2.8 Monthly Average Expenditure per Capita of Households in 1994

(Unit: VND 10^3)

Region	Household Expenditure: Food, beverage & tobacco	Household Expenditure: Others	Household Expenditure: Total expenditure	Index: Whole country=100	Total Household Income	Income − Expenditure	Engel's Coefficient	Savings ratio
Red River Delta	89.4	54.5	143.9	101	163.3	19.4	62%	12%
Northeast and Northwest	81.6	35.5	117.1	83	132.4	15.3	70%	12%
North Central	73.7	38.9	112.6	79	133.0	20.4	65%	15%
Central Coast	84.1	41.9	126.0	89	144.7	18.7	67%	13%
Central Highlands	91.5	64.1	155.6	110	197.2	41.6	59%	21%
Southeast	135.1	87.4	222.5	157	275.3	52.8	61%	19%
Mekong River Delta	95.2	54.4	149.6	105	181.7	32.1	64%	18%
Whole Country	91.2	50.7	141.9	100	168.1	26.2	64%	16%

Source: (1) "Statistical Yearbook 1997" General Statistical Office
(2) "Major Social and Economic Information obtained from Surveys in 1990-1996" General Statistical Office

Note: Three columns at the right end of the table were computed by JICA Study Team based on the above Source

Table 2.9 Price Indices in Vietnam

Items	Historical 1993	Historical 1994	Historical 1995	1996	Preliminary 1997	Estimated 1998
(1989 = 100)						
(1) Merchandise export price index	99	102	112	113	117	119
(2) Merchandise import price index	113	111	115	111	106	107
(% growth rate)						
(3) Consumer price index	8.3	9.3	16.8	5.6	3.2	8.0
(4) GDP deflator	14.3	14.5	19.5	6.1	5.5	6.0

Source: "Country Assistance Strategy" World Bank, August 1998

Table 2.10 Average Retail Prices of Selected Goods and Services

(Unit of Price : VND)

Items	Unit	Annual Average Retail Price				Increase
		1995	1996	1997	1998	95/98 (% p.a)
(1) Paddy	kg	1,957	2,031	1,866	2,190	3.8%
(2) Pork	kg	22,972	22,734	23,785	22,009	-1.4%
(3) Beef	kg	27,221	30,773	35,285	32,798	6.4%
(4) Chicken	kg	21,409	22,822	22,935	23,264	2.8%
(5) Sea shrimp	kg	30,515	36,082	48,323	-	25.8%
(6) Green beans	kg	7,378	8,833	8,793	8,518	4.9%
(7) Soybeans	kg	5,030	5,540	5,806	5,806	4.9%
(8) Dried sea fish	kg	14,713	18,203	68,670	-	116.0%
(9) Salt	kg	1,128	1,101	1,406	1,222	2.7%
(10) White sugar	kg	6,755	6,316	7,013	7,131	1.8%
(11) Beer	Litter	4,663	4,608	4,707	4,724	0.4%
(12) Tea	kg	27,994	34,058	40,707	-	20.6%
(13) Cotton fabrics	m	6,233	7,207	9,665	8,781	12.1%
(14) Woolen fabrics	kg	78,748	76,076	71,127	70,508	-3.6%
(15) Papers	set	1,429	1,546	1,740	1,687	5.7%
(16) Kerosene	Litter	2,779	2,958	3,616	3,630	9.3%
(17) Petrol	Litter	3,382	3,661	4,225	4,323	8.5%
(18) Electricity	kWh	520	519	531	580	3.7%
(19) Supply water	m^3	1,254	1,379	1,453	1,578	8.0%

Source: "Statistical Yearbook 1997 and 1998" General Statistical Office

Table 2.11 Merchandise Exports by Commodity

(Unit : US$ million)

Items	1990	% for 1990	1991	1992	1993	1994	1995	1996	1997	% for 1997	Growth 90/97 (%p.a)
(1) Rice	272	20.8%	225	300	363	429	549	855	870	9.7%	18.1%
(2) Petroleum	390	29.9%	581	756	844	866	1,024	1,346	1,419	15.8%	20.3%
(3) Coal	38	2.9%	48	47	70	75	81	115	111	1.2%	16.5%
(4) Rubber	16	1.2%	50	54	74	133	181	163	191	2.1%	42.5%
(5) Tea	2	0.2%	14	16	26	16	33	29	48	0.5%	57.5%
(6) Coffee	25	1.9%	74	86	110	328	495	337	491	5.5%	53.0%
(7) Marine products	220	16.9%	285	302	427	551	620	651	781	8.7%	19.8%
(8) Agriculture & forestry products	203	15.6%	440	434	400	608	1,050	1,481	1,780	19.9%	36.4%
Cashew nut	13	-	26	41	44	59	130	130	133	-	39.4%
Meat	28	-	45	21	26	45	-	-	-	-	7.0%
Pepper	12	-	18	15	15	17	-	-	63	-	26.7%
(9) Handicrafts/light industrial goods	20	1.5%	204	321	576	870	1,020	1,952	2,950	32.9%	104.1%
Textiles & garments	20	-	156	221	336	550	800	1,150	1,349	-	82.5%
Footwear	-	-	-	-	-	-	-	530	965	-	-
(10) Others	119	9.1%	78	158	88	178	145	401	315	3.5%	14.9%
Total Exports	1,305	100.0	1,999	2,474	2,978	4,054	5,198	7,330	8,956	100.0	31.7%
Ditto annual growth rate	-		53.2%	23.8%	20.4%	36.1%	28.2%	41.0%	22.2%		

Source: "Vietnam-Rising to the Challenge" World Bank, Dec. 1998

Table 2.12 Major Imports by Commodity

(US$ million)

Items	1990	% for 1990	1991	1992	1993	1994	1995	1996	Prelim. 1997	% for 1997	Growth 90/97 (%p.a)
(1) Petroleum	356	1780.0%	485	615	614	696	856	1,079	1,094	81.1%	17.4%
(2) Fertilizers	210	1050.0%	246	320	189	247	339	643	425	31.5%	10.6%
(3) Steel	23	115.0%	25	104	233	211	-	651	529	39.2%	56.5%
(4) Machines/equipment/spare parts	-	-	-	100	922	1,815	2,761	-	1,777	131.7%	77.8%
(5) Others	619	3095.0%	1,090	1,396	1,574	2,276	3,419	n.a.	n.a.	-	40.7%
Cotton textiles	102	510.0%	32	23	54	55	96	-	164	12.2%	7.0%
Raw cotton	38	190.0%	61	13	20	43	77	-	-	-	15.2%
Wheat	32	160.0%	36	59	51	52	60	-	-	-	13.4%
Cars & trucks	50	-	12	39	69	103	134	222	189	14.0%	20.9%
Sugar	3	-	5	4	14	39	61	-	-	-	82.7%
Motor-bikes	-	-	-	50	286	347	460	434	95	7.0%	9.6%
Pharmatheuticals	-	-	-	60	86	140	114	-	66	4.9%	1.4%
Total Imports	1,208	100.0	1,846	2,535	3,532	5,245	7,375	10,481	10,313	-	35.8%
Ditto annual growth rate	-		52.8%	37.3%	39.3%	48.5%	40.6%	42.1%	-1.6%		

Source: "Vietnam-Rising to the Challenge" World Bank, Dec. 1998

Table 2.13 Exports and Imports by Regions and Major Traded Countries

(Unit : US$ million)

Regions and Countries	1995		1996		1997		% for 1997	
	Export	Imports	Export	Imports	Export	Imports	Export	Imports
(1) South east Asia	1,112.1	2,377.7	1,777.5	2,992.1	2,022.5	3,245.2	22.0%	28.0%
Cambodia	94.6	23.5	99.0	17.9	108.9	24.7	1.2%	0.2%
Indonesia	53.8	190.0	45.7	149.0	47.6	200.0	0.5%	1.7%
Laos	20.6	84.0	24.9	68.1	30.4	52.7	0.3%	0.5%
Malaysia	110.5	190.5	77.7	200.3	141.6	226.8	1.5%	2.0%
Philippines	41.5	24.7	132.0	28.9	240.6	36.3	2.6%	0.3%
Singapore	689.8	1,425.2	1,290.0	2,032.6	1,215.9	2,128.0	13.2%	18.4%
Thailand	101.3	439.7	107.4	494.5	235.3	575.2	2.6%	5.0%
(2) Other Asian Countries	2,832.6	3,940.5	3,474.0	5,602.3	3,994.6	5,840.5	43.5%	50.4%
Taiwan	439.4	901.3	539.9	1,263.2	814.5	1,484.7	8.9%	12.8%
Hong Kong	256.7	418.9	311.2	795.4	430.7	598.9	4.7%	5.2%
Korea Republic	235.3	1,253.5	558.3	1,781.4	417.0	1,564.5	4.5%	13.5%
Japan	1,461.0	915.7	1,546.4	1,260.3	1,675.4	1,509.3	18.2%	13.0%
China	361.9	329.7	340.2	329.0	474.1	404.4	5.2%	3.5%
(3) Europe	983.0	1,088.8	1,174.6	1,558.3	2,207.6	1,726.6	24.0%	14.9%
Russia	80.8	144.8	84.7	186.5	124.6	158.0	1.4%	1.4%
United Kingdom	74.6	50.7	125.1	83.7	265.2	103.9	2.9%	0.9%
Germany	218.0	175.5	228.0	288.2	411.4	280.8	4.5%	2.4%
Netherlands	79.7	36.3	147.4	51.4	266.8	51.5	2.9%	0.4%
France	169.1	276.6	145.0	416.8	238.1	550.8	2.6%	4.8%
(4) America	238.3	169.7	299.5	304.4	426.1	305.5	4.6%	2.6%
	169.7	130.4	204.2	245.8	291.5	251.5	3.2%	2.2%
(5) Africa	38.1	22.6	26.7	12.9	49.5	23.7	0.5%	0.2%
(6) Oceania	56.9	103.9	72.9	155.5	254.9	218.4	2.8%	1.9%
(7) Other Countries	187.8	430.6	430.7	518.1	229.8	232.4	2.5%	2.0%
Total	5,448.9	8,155.4	7,255.9	11,143.6	9,185.0	11,592.3	100.0%	100.0%

Note: The statistics do not add to total figures.

Source: "Statistical Yearbook 1998" General Statistical Office

Table 2.14 International Balance of Payment

(Unit : US$ million)

Items	1990	1991	1992	1993	1994	1995	1996	pre.1997
Total exports	1,731	2,042	2,475	2,985	4,054	5,198	7,330	8,955
Total imports	-1,775	-2,107	-2,535	-3,532	-5,250	-7,543	-10,483	-10,313
Trade balance	-44	-65	-60	-547	-1,196	-2,345	-3,153	-1,358
Services and transfers	-218	-69	49	-221	11	417	710	-338
Interest payments	-238	-248	-284	-335	-221	-360	-494	-462
Private remittances	50	36	0	0	0	0		
Official transfers	88	55	64	194	135	150	150	175
Others	-118	88	269	-80	97	474	1,046	713
Current account balance	-262	-134	-11	-768	-1,185	-1,928	-2,443	-1,696
Capital account balance	122	189	657	-79	897	1,762	2,105	1,980
Disbursements	233	109	540	54	272	443	772	695
Scheduled amortization	-279	-104	-175	-652	-547	-733	-674	-796
Short term loans (net)	48	19	-41	-313	124	-184	169	-520
Direct foreign investment	120	165	333	832	1,048	2,236	1,838	2,601
Errors and omissions	-2	-4	-378	-210	-121	-32	40	-57
Overall balance	-142	51	268	-1,057	-409	-198	-298	227
Financing	142	50	-268	1,055	409	199	298	-228
Change in NFA (excl. IMF)	-159	-276	-463	477	-292	-439	-471	-368
IMF credit (net)	0	-6	0	-39	175	92	178	-41
Debt rescheduling	0	0	0	883	0	0	0	0
Change in arrears	301	332	195	-266	526	546	591	181
Memorandum item:								
Dong per US$	5,133	9,274	11,150	10,640	10,978	11,100	11,500	12,938

Source: "Vietnam-Rising to the Challenge" World Bank, Dec. 1998

Table 2.15 Summary of Government's Budgetary Operations

(Unit : VND billion)

Items	1990	1991	1992	1993	1994	1995	1996	Estimate 1997	% for 1997
Revenue and grants	6,153	10,353	21,023	30,696	42,125	53,370	62,387	66,310	97.4%
Tax revenue (non-SOEs)	1,698	2,814	5,480	11,337	16,846	23,375	28,414	30,245	44.4%
Tax and transfers from SOEs	3,620	6,189	11,913	15,322	20,557	21,938	25,817	27,461	40.3%
Other non-tax revenues	835	1,080	2,782	3,020	3,522	6,437	6,613	6,980	10.2%
Grants	0	270	848	1,017	1,200	1,620	1,543	1,624	2.4%
Current expenditure(excl. interest)	6,156	8,728	15,452	25,626	31,121	39,615	44,559	48,409	71.1%
Capital expenditure	2,124	2,135	6,450	9,600	11,715	12,079	15,630	17,385	25.5%
Interest (paid)	310	650	1,000	1,710	1,094	2,895	2,700	2,166	3.2%
Contingency								150	0.2%
Total expenditure	8,590	11,513	22,902	36,936	43,930	54,589	62,889	68,110	100.0%
Overall balance (cash basis)	-2,437	-1,160	-1,879	-6,240	-1,805	-1,219	-502	-1,800	-2.6%
Financing	2,437	1,160	1,879	6,240	1,805	1,219	502	1,800	2.6%
Foreign loans (net)	1,264	767	2,673	3,726	240	-1,490	-50	-953	-1.4%
Domestic loans (net)	1,173	393	-794	2,514	1,565	2,709	552	2,753	4.0%

Source: "Vietnam-Rising to the Challenge" World Bank, Dec. 1998

Table 2.16 Government Budget: Capital Expenditure

(Unit : VND billion)

Items	1990	1991	1992	1993	1994	1995	1996	preliminary 1,997	Accumulation 1990-97	Ditto % to Total
(1) Industry and construction	746	49	2,284	5,692	2,925	1,408	825	1,102	15,031	19.5%
(2) Agriculture and forestry	113	70	345	266	580	830	1,100	1,622	4,926	6.4%
(3) Irrigation	244	244	456	623	1,240	1,516	1,355	1,557	7,235	9.4%
(4) Transport and communication	323	335	613	1,020	2,999	3,631	3,711	3,963	16,595	21.5%
(5) Commerce and services	91	23	17	27	35	152	120	247	712	0.9%
(6) Non-productive sector a/	425	367	790	763	2,323	3,228	3,820	4,498	16,214	21.0%
(7) Contingency fund b/	0	136	0	0	0	0	-	-	136	0.2%
(8) Others	6	566	452	1,209	1,613	1,314	4,699	4,396	14,255	18.5%
(9) Unallocated	176	345	1,494	0	0	0	-	-	2,015	2.6%
Total capital expenditure	2,124	2,135	6,450	9,600	11,715	12,079	15,630	17,385	77,118	100.0%

Note: a/ Includes education, health, culture, finance and government.
b/ Stockpiling of key commodities and materials.
Source: "Vietnam-Rising to the Challenge" World Bank, Dec. 1998

Table 2.17 Targets in Five Year National Development Plan for 1996-2000

1. Overall tasks

(1) Overall tasks

- To accelerate industrialization and modernization of the country
- To develop the multi-sector economy along the socialist-oriented market mechanism

(2) Three socio-economic targets

- A high sustainable and efficient economic growth
- Firm macro-economic stabilization
- Preparation of the premises for the phase of more advanced development beyond 2000: Development of human resources, science and technology, infrastructure, and the streamlining of the institutional system.

(3) Targets of economic sector

Targets	Primary sector Agriculture, forestry & fishery	Secondary sector Industry and construction	Tertiary sector Service industries
- Average annual growth rate (% p.a.)	4.5-5%	14-15%	12-13%
- GDP share in 2000 (%)	19-20%	34-35%	45-46%

- GDP annual average growth : 9-10%
- Per-capita GDP in 2000 : To double per-capita GDP over that of 1990
- Total development investment in 2000 : about 30% of GDP
- Budget deficit in 2000 : less than 4.5% of GDP
- Target of CPI : less than 10% per year
- Export growth : annual average growth of 28%
- Population growth : less than 1.8% per annum in 2000

2. Sectoral programs

(1) Agriculture and rural development

- Food output : 30 million tons and food per capita of 360-370 kgs
- To develop highly profitable industrial crops, fruit trees and vegetables.
- Target of industrial crops : 45% of total output of cultivation in 2000
- To develop processing industries, small industries and handicrafts in rural areas

(2) Industrial development

- To develop light industries, particularly textile, garment, leatherware, paper, art and handicraft production.
- To increase power supply capacity of 2,500-3,000 MW to reach 30 billion kWh in the plan period.
- Rural electrification : 100% districts and 80% communes be supplied power in 2000

(3) Foreign economic relations

- To attract 7 billion US$ from ODA and 13-15 billion US$ (1995 price) from FDI in the plan period.

3. Financing the development investment

- Investment capital requirement : 41-42 billion US$ (1995 price) of which domestic capital accounts for over 50%.
- Financing plan
  - Domestic budget and ODA: : 21%
  - State credit capital : 7%
  - Self investment by SOE : 24%
  - Domestic investment capital : 17%
  - FDI : 31%

Source: "Report of the Central Committee, the VIIth Tenure, to the VIIIth National Congress" June 1996

Table 2.18 Historical and Projected Macro Indices up to year 2015

Item		Historical										
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	'90-'98
(1) GDP												
1) GDP current price	VND bil.	28,093	41,955	76,707	110,535	136,571	170,258	228,892	272,036	313,623	361,468	30.9%
2) ditto growth	% p.a.	82.2%	49.3%	82.8%	44.1%	23.6%	24.7%	34.4%	18.8%	15.3%	15.3%	
3) GDP 1989 price	VND bil.	28,093	29,526	31,286	33,991	36,735	39,982	44,980	50,385	55,059	59,867	9.2%
4) ditto growth	% p.a.	4.7%	5.1%	6.0%	8.6%	8.1%	8.8%	12.5%	12.0%	9.3%	5.8%	
5) Per capita GDP	US$ current		123	122	143	181	214	279	323	341	348	
(2) Population												
1) Population	10^3	64,774	66,233	67,774	69,405	71,026	72,510	73,962	75,355	76,714	78,059	2.1%
2) ditto growth	% p.a.	-	2.3%	2.3%	2.4%	2.3%	2.1%	2.0%	1.9%	1.8%	1.8%	
(3) Memorandum items												
1) GDP deflator	1989=100	100.0	142.1	245.2	325.2	371.8	425.8	508.9	539.9	569.6	603.8	19.8%
2) ditto growth	% p.a.	74.0%	42.1%	72.5%	32.6%	14.3%	14.5%	19.5%	6.1%	5.5%	6.0%	
3) Official exch. rate	VND/US$	n.a.	5,133	9,274	11,150	10,640	10,978	11,100	11,180	12,000	13,300	

Item		Projected						
		1999	2000	2001	2005	2010	2015	'98-'15
(1) GDP								
1) GDP current price	VND bil.	422,931	486,275	508,816	815,765	1,475,766	2,580,549	12.3%
2) ditto growth	% p.a.	17.0%	15.0%	4.6%	12.6%	12.6%	11.8%	
3) GDP 1989 price	VND bil.	62,860	66,632	71,429	94,331	133,545	182,968	6.8%
4) ditto growth	% p.a.	5.0%	6.0%	7.2%	7.2%	7.2%	6.5%	
5) Per capita GDP	US$ current	377	401	412	625	1,059	1,744	9.9%
(2) Population								
1) Population	10^3	79,506	80,937	82,394	87,106	92,917	98,627	1.4%
2) ditto growth	% p.a.	1.80%	1.80%	1.80%	1.40%	1.30%	1.20%	
(3) Memorandum items								
1) GDP deflator	1989=100	640.0	678.4	712.3	865.9	1,105.1	1,410.4	5.1%
2) ditto growth	% p.a.	6.0%	6.0%	5.0%	5.0%	5.0%	5.0%	
3) Official exch. rate	VND/US$	14,100	15,000	15,000	15,000	15,000	15,000	0.7%

Data Sources:

GDP - Historical: Those by current price : "Statistical Yearbook 1997 & 1998"up to 1998 preliminary figures. Those by 1989 constant price: "Statistical Yearbokk 1997" up to 1994 and "ditto 1998" thereafter convrting those of current preie to 1989 price level by applying GDP deflator.

GDP - Projection: GDPs for 1999 and 2000 were adopted from those projection of DSI in July 1999. Growth rates for 1999 and 2000 were adopted from DSI projection in July 1999. Growth rates after 2000: "Power Demand Forecast" prepared by Institute of Energy August, 1999.

GDP deflator: "Vietnam - Rising to the Challenge; WB Dec.1998" up to 1994.
Growth: "Country Assistance Strategy; World Bank, August 1998" after 1994.

Population: Historical (up to 1998) : "Statistical Yearbook 1998"
Projection : DSI projection for 1999 and 2000 and the projection by the JICA Study Team thereafter.

Per capita GDP: For 1993 and 1995: "Water Resources Sector Review" World Bank, May 1996

Exchange rate: Historical: "Vietnam - Rising to the Challenge" up to 1995 and DSI for 1996-1998.
Projection: DSI for 1999-2000 and the JICA Study Team thereafter.

Table 2.19 Projection of GDP by Sector

	Historical				Projected						
	1990	1995	1998	Growth 90-98	1999	2000	2001	2005	2010	2015	Growth 98-2015
1. GDP (VND billion at 1989 prices)											
1) Agriculture	12,003	12,051	13,590	1.6%	13,830	14,074	14,322	16,036	17,361	18,297	1.8%
2) Industry & Construction	6,629	12,954	18,049	13.3%	19,734	21,577	23,592	33,016	53,418	82,336	9.3%
3) Services	10,894	19,975	28,229	12.6%	29,296	30,981	33,515	45,279	62,766	82,336	6.5%
4) Total GDP	29,526	44,980	59,867	9.2%	62,860	66,632	71,429	94,331	133,545	182,968	6.8%
2. Sector share in %											
1) Agriculture	40.7%	26.8%	22.7%		22.0%	21.1%	20.1%	17.0%	13.0%	10.0%	
2) Industry & Construction	22.5%	28.8%	30.1%		31.4%	32.4%	33.0%	35.0%	40.0%	45.0%	
3) Services	36.9%	44.4%	47.2%		46.6%	46.5%	46.9%	48.0%	47.0%	45.0%	
4) Total GDP	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
3. Employment(10^3)											
1) Agriculture	22,594	24,122	25,444	1.5%	25,803	26,167	26,537	26,912	27,291	32,291	1.4%
2) Industry & Construction	3,661	4,431	4,480	2.6%	4,638	4,801	4,971	5,146	5,327	8,073	3.5%
3) Services	4,034	6,038	7,072	7.3%	7,380	7,695	8,018	8,350	8,689	13,455	3.9%
5) Total Employed Laborforce	30,289	34,591	36,996	2.5%	37,821	38,664	39,526	40,407	41,308	53,819	2.2%
4. Employment structure											
1) Agriculture	74.6%	69.7%	68.8%		68.2%	67.7%	67.1%	66.6%	66.1%	60.0%	
2) Industry & Construction	12.1%	12.8%	12.1%		12.3%	12.4%	12.6%	12.7%	12.9%	15.0%	
3) Services	13.3%	17.5%	19.1%		19.5%	19.9%	20.3%	20.7%	21.0%	25.0%	
5) Total Employed Laborforce	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
4. Productivity (VND 10^3=GDP/Employment)											
1) Agriculture	531	500	534	0.1%	536	538	540	596	636	567	0.3%
2) Industry & Construction	1,811	2,924	4,029	10.5%	4,255	4,494	4,746	6,416	10,027	10,199	5.6%
3) Services	2,701	3,308	3,992	5.0%	3,970	4,026	4,180	5,423	7,224	6,119	2.5%
4) Total Employment	975	1,300	1,618	6.5%	1,662	1,723	1,807	2,335	3,233	3,400	4.5%
5. Total population(10^3)	66,233	73,962	79,506	2.3%	79,506	80,937	82,394	86,422	92,187	97,853	1.2%
6. Labor force participation rate	45.7%	46.8%	46.5%		47.6%	47.8%	48.0%	46.8%	44.8%	55.0%	

Source: Historical GDP by sector: "Statistical Yearbook 1997 and 1998"
Employment: General Statistical Office.(referred from "Rising to the Challenge")
For other sources, refer to the macro framework shown in Table 11.9.

List of provinces/cities

I. Đồng bằng Sông Hồng (Red River Delta)
17. Hà Nội
18. Hải Phòng
19. Hà Tây
20. Hải Dương
21. Hưng Yên
22. Thái Bình
23. Hà Nam
24. Nam Định
25. Ninh Bình

II. Đông Bắc (Northeast)
1. Hà Giang
2. Tuyên Quang
3. Cao Bằng
4. Lạng Sơn
6. Lào Cai
7. Yên Bái
8. Bắc Kạn
9. Thái Nguyên
12. Phú Thọ
13. Vĩnh Phúc
14. Bắc Giang
15. Bắc Ninh
16. Quảng Ninh

III. Tây bắc (Northwest)
5. Lai Châu
10. Sơn La
11. Hoà Bình

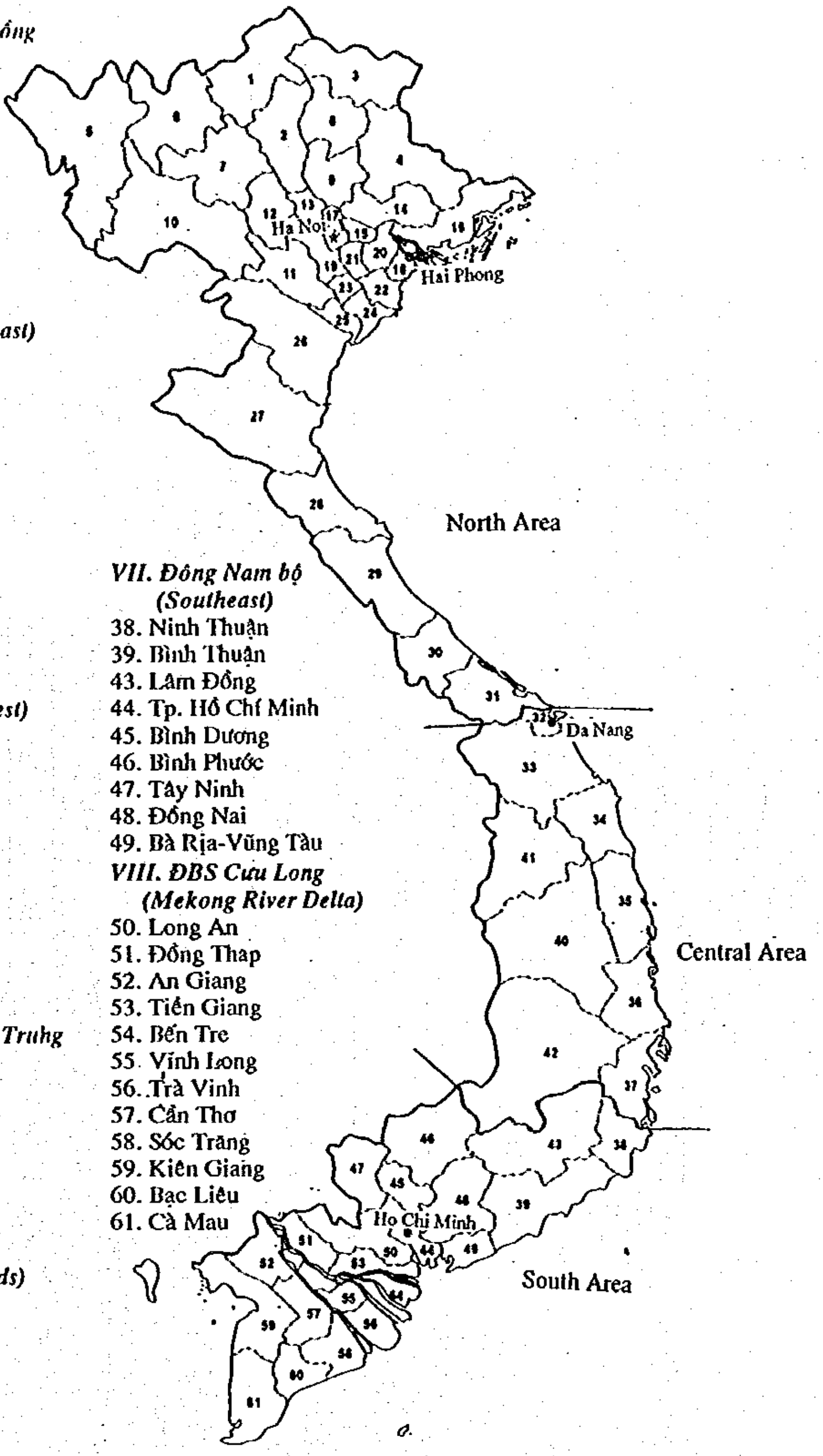
IV. Bắc Trung bộ (North Central)
26. Thanh Hoá
27. Nghệ An
28. Hà Tĩnh
29. Quảng Bình
30. Quảng Trị
31. Thừa Thiên-Huế

V. Duyên hải miền Trung (Central Coast)
32. Đà Nẵng
33. Quảng Nam
34. Quảng Ngãi
35. Bình Định
36. Phú Yên
37. Khánh Hoà

VI. Tây Nguyên (Central Highlands)
40. Gia Lai
41. Kon Tum
42. Đắc Lắc

VII. Đông Nam bộ (Southeast)
38. Ninh Thuận
39. Bình Thuận
43. Lâm Đồng
44. Tp. Hồ Chí Minh
45. Bình Dương
46. Bình Phước
47. Tây Ninh
48. Đồng Nai
49. Bà Rịa-Vũng Tàu

VIII. ĐBS Cửu Long (Mekong River Delta)
50. Long An
51. Đồng Thap
52. An Giang
53. Tiền Giang
54. Bến Tre
55. Vĩnh Long
56. Trà Vinh
57. Cần Thơ
58. Sóc Trăng
59. Kiên Giang
60. Bạc Liêu
61. Cà Mau



Source : "Population Projections of Vietnam, 1994-2024", GSO, May 1999

Figure 2.1 Administrative Boundary in Vietnam

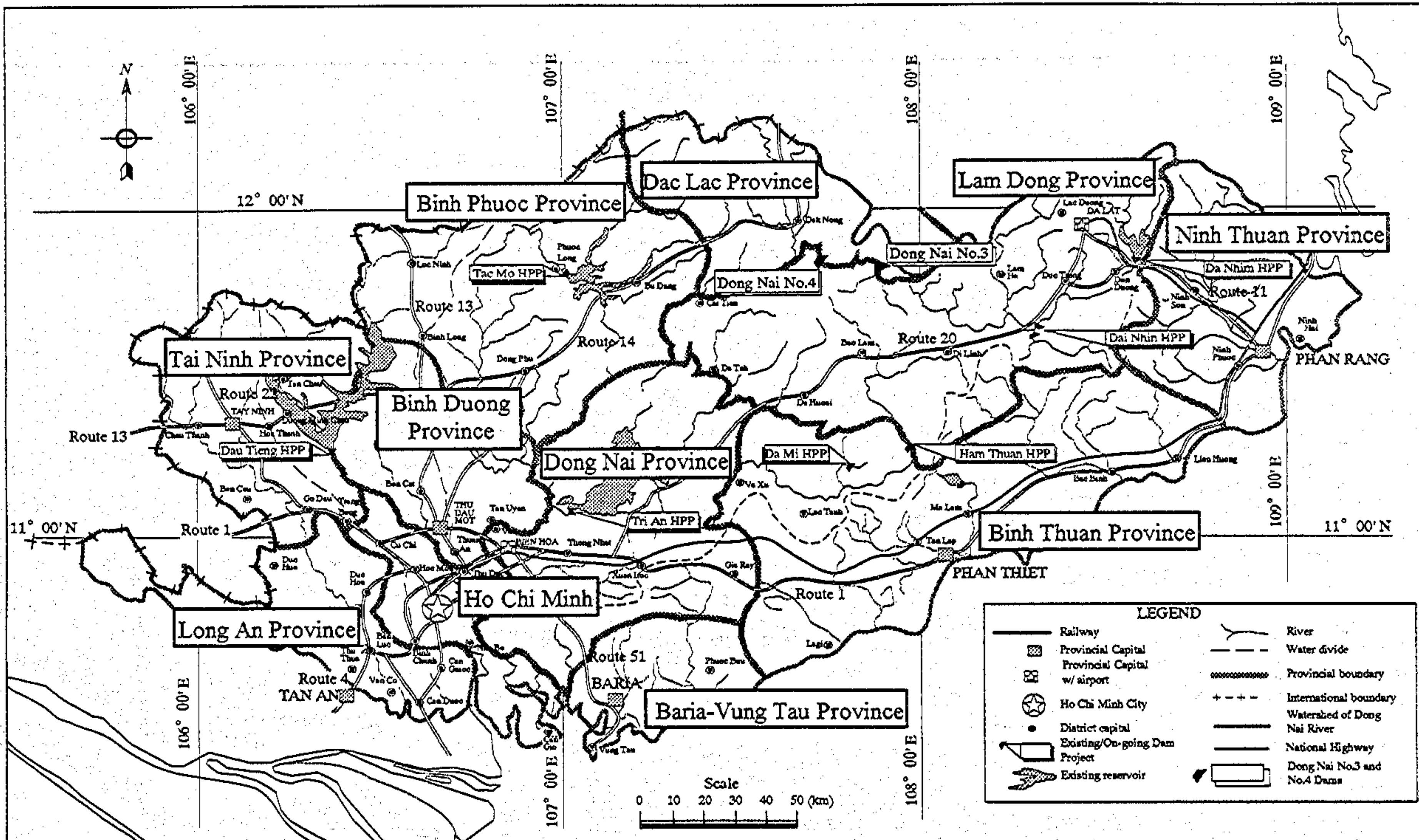
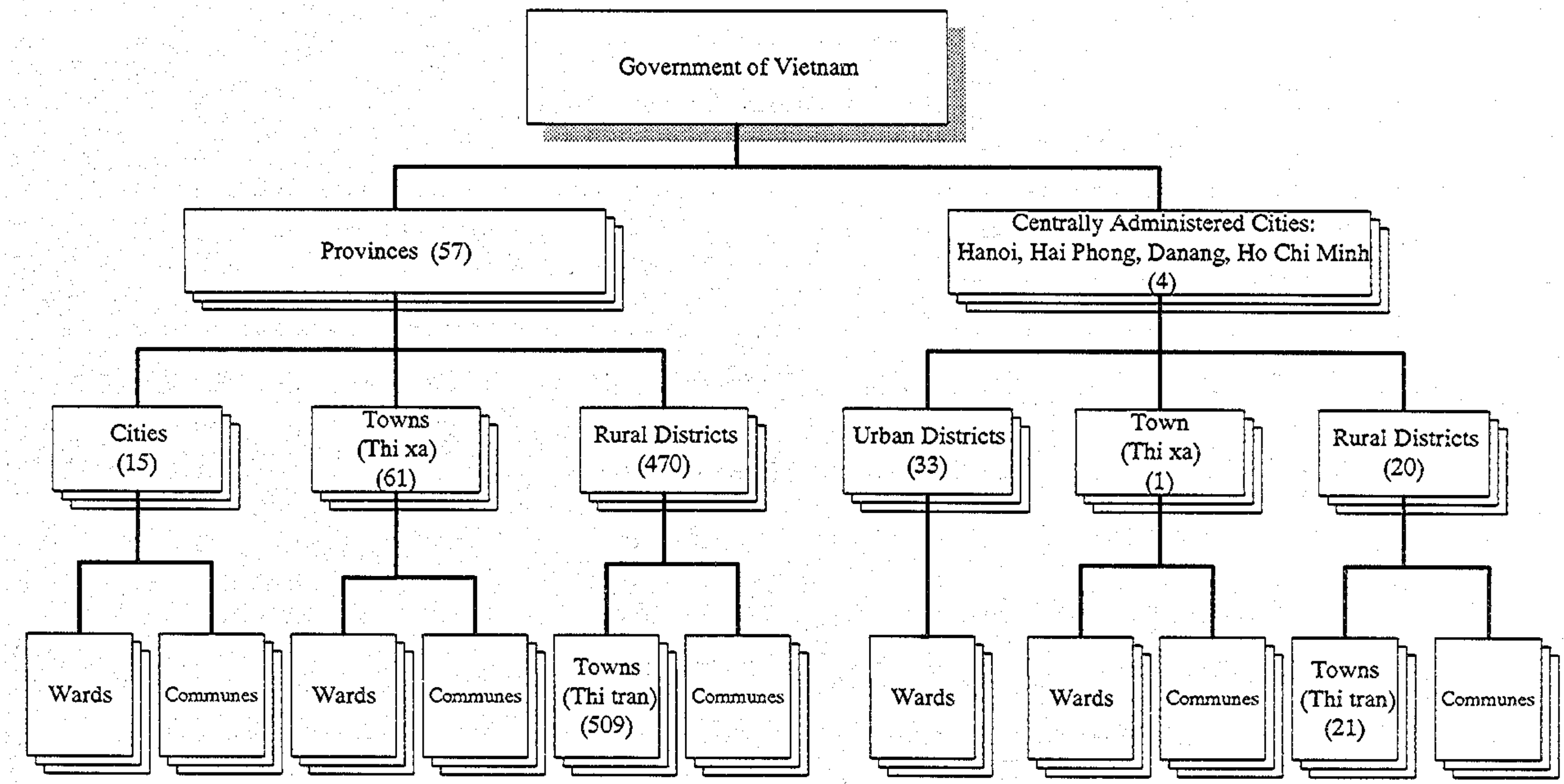


Figure 2.2 Administrative Boundaries in the Dong Nai River Basin



Total number of Wards in 57 Provinces: 529
Total number of Communes in 57 Provinces: 8,499

Total number of Wards in 4 Cities: 422
Total number of Communes in 4 Cities: 351
(Source: "Statistical Yearbook 1998" General Statistical Office)

Figure 2.3 Administrative Structure of Vietnam

CHAPTER 3 SITE CONDITIONS

3.1 Location and Topography

3.1.1 Present River System

The mainstream of the Dong Nai River originates from high hilly areas with elevations of 1,000 m to 2,000 m in the northern part of Lam Dong Province where the city of Da Lat is situated. The Dong Nai River joins three large tributaries till it finally debouches into the Sea. These are the La Nga River, Be River and Saigon River in the order from upstream to downstream, of which the La Nga River flowing down from the east meets the Dong Nai mainstream in the existing Tri An reservoir. The Saigon River joins the Dong Nai mainstream near Ho Chi Minh City located about 30 km upstream of its estuary. The gross catchment area of the Dong Nai River including those of the three major tributaries is about 31,000 km^2. The river system of the Dong Nai is shown in Figure 3.1 and the river profile up to the middle reach is depicted in Figure 3.2.

The Dong Nai mainstream generally flows in the southwestern flow direction in its uppermost reach, flowing into existing Dran reservoir created under the Da Nhim hydropower project (HPP) after it flows down about 50 km from the watershed. The Da Nhim HPP was completed and started power generation in 1964. The streamflow of the Dong Nai mainstream regulated by Dran reservoir is diverted to the neighboring eastern basin, the Phan Rang River basin, through a waterway of the project. Thus, most of the river flow at the existing Dran Dam is not discharged downstream except during a large-scale flood when the reservoir water is released to the downstream reach through opening of the spillway.

After joining the Da Queyon River, a tributary of the Dong Nai River flowing from the east, the flow direction of Dong Nai mainstream changes to the west. Two storage type dams are proposed to be constructed under the on-going Dai Ninh HPP, one on each of the Dong Nai mainstream and Da Queyon River just upstream of their confluence. The Dai Ninh hydropower project also contemplates to divert streamflow of the Dong Nai to the neighboring eastern basin through a waterway. The construction of the project is going to start in the year 2000. After completion of the project, the downstream reach of the confluence is to lose most of runoff, which comes from catchment above the confluence.

The Dong Nai River reaches the proposed Dong Nai No.3 dam after flowing for a river course of about 80 km downstream of the Dai Ninh project site generally in the west or northwest direction. The Dong Nai No.4 dam site is selected at a location about 20 km downstream of the Dong Nai No.3 dam site.

The Dong Nai River takes a southern flow direction after making a large loop downstream of the Dong Nai No.4 dam site. Thereafter, it pours into the existing Tri An reservoir through the Cat Tien National park. In a broad sense, the middle reach of the Dong Nai River is defined to be the reach up to the Tri An reservoir with a total catchment area of 14,979 km^2 including that of the La Nga River.

3.1.2 Topography of Dong Nai No.3 and No.4 Dam Sites

The Dong Nai No.3 and No.4 Combined HPP site is dominantly composed of hilly areas covered with basalt, which are dissected by the Dong Nai River to form steeper slopes on riverbed. While the flat lands of hilly areas are utilized for the cultivation of crops, mainly coffee trees, the steep-sloped lands from riverbed to edges of the hills are hardly utilized. Especially, no inhabitants are resided at and in the vicinity to the Dong Nai No.4 dam site where steep slopes of 45° to 50° are formed on both banks. Although the gorge is formed over a river section from the Dong Nai No.3 dam site to No.4 dam site, the river channel becomes wider upstream of the Dong Nai No.3 dam site, implying that the Dong Nai No.3 dam is much suitable for securing a large-scale reservoir storage capacity.

In the First Field Investigation performed for about two (2) months from the middle of January to the middle of March 1999, the optimal layout plan of main structures of the Project was determined through the Preliminary Optimization Study. Based on the selected layout plan, the scope of work for topographic survey performed in the successive Second and Third Field Investigations was determined to satisfy the requirement of the feasibility-grade design as follows:

Main Item of Topographic Survey	Quantity
1. Traversing & Leveling	-
2. River cross section survey and longitudinal profile survey	11 km
3. Topographic mapping for main structure sites (Dong Nai No.3 and No.4 dam sites and waterway sites including powerhouse sites) at a scale of 1:1,000	320 ha

The above field investigation works were conducted on a local contract basis and were wholly completed by November 1999. The above survey products were utilized for the feasibility-grade design mentioned in the succeeding Chapter 7. The main structures such as dams and powerhouses of the Dong Nai No.3 and No.4 schemes were laid out on 1:1,000 scale topographic maps and the river water levels required for design of main structures such as diversion tunnel, powerhouses were determined through the hydraulic analyses based on the above river cross sections and longitudinal profiles.

Besides, EVN produced new 1:10,000 scale topographic maps for the Dong Nai No.4 reservoir area. After the accuracy of these new topographic maps were verified by the Survey Expert of the JICA Study Team during the field investigation, they were provided to the JICA Study Team. The new topographic maps produced by EVN were utilized to construct the reservoir storage curve of the Dong Nai No.4 and to examine the layout plans of main components of the Dong Nai No.3 and No.4 schemes.

The topographic survey products including the 1 to 10,000 scaled topographic maps produced by EVN are attached to Appendix B of Supporting Report of this Final Report.

The topographic survey products show that the river bed width on the Dong Nai No.3 dam axis is about 120 m with the lowest river bed elevation of El. 489 m. While the river bed at the Dong Nai No.4 dam site is as narrow as about 40 m at the river bank elevation of 362 m that is about 8 m higher than the river bed.

3.2 Meteorology and Hydrology

3.2.1 Available Data

A wide range of meteo-hydrological data related to the Dong Nai River basin are presented in the previous master plan study reports completed by JICA in August 1996 that were collected at the commencement of this Feasibility Study. The meteo-hydrological data presented in the reports were utilized for this Feasibility Study and have been supplemented through collection of the latest data in the First and Second Field Investigations. The available data for the present feasibility study are discussed in the following paragraphs:

(1) Runoff Data

The location of streamflow gauging stations in upper and middle reaches of the Dong Nai River are shown in Figure 3.3. These data were collected in cooperation with counterpart personnel of EVN, who is in charge of hydrology. The collected data were comprehensibly checked by the JICA Study Team for the whole data period to assess their reliability. Especially, runoff data at Ta Lai SGS were carefully checked, since those data play a very important role in carrying out a hydrological analysis for this Feasibility Study. The available periods of runoff data at those streamflow gauging stations are shown in Figure 3.4.

(2) Rainfall Data

The daily rainfall data at rainfall stations located in and around the Project catchment were collected and arranged during the field investigation to supplement those collected in JICA's master plan study. Consequently, the daily rainfall data related to the Project have been made available through the field investigation as shown in Figure 3.4.

3.2.2 Hydrological Field Investigation Works Carried Out

There existed no meteorological and hydrological gauging stations in the neighborhood of the Project site until they were newly built in this Feasibility Study. In the Second Field Investigation, new streamflow gauging station and rainfall station were installed near the Dong Nai No.3 dam site, whose locations were selected through the field reconnaissance during the First Field Investigation as shown in Figure 3.5.

Installation works of those stations, which consist of installation of automatic water level recorder, staff gauges and some accessory facilities at streamflow gauging station and automatic rainfall gauge, recorder and some accessory facilities at rainfall station, were completed in early July 1999 and since then the rainfall and water level observations have been carried on by EVN.

The meteorological and hydrological observations and measurements at these new gauges that were conducted by EVN including the following:

- Daily stage water level at the new SGS,
- Discharge measurement at the new SGS,
- Water sampling at the new SGS for suspended load analysis, including measurement

of concentration of suspended load contained in river water, and

- Daily and hourly rainfall at the new rainfall station

The meteorological and hydrological records are presented in Appendix C : Hydrological Investigation of Supporting Report of this Final Report.

3.2.3 Meteorology

The project catchment is in a tropical monsoon climate area where two distinctly different climate seasons take place during a year, namely dry season and wet season lasting usually between November and April and between May and October, respectively. The seasonal climatic features of the Project catchment are characterized in more detail as follows:

- Jan. to Mar. : Dry and cool season under continental winter monsoon
- Apr. and May : Thunderstorm season with the highest temperature in all seasons
- June to Aug. : Summer season with west wind, accompanied by long rain
- Sep. to Dec. : Changeable weather, sometimes struck by typhoon with heavy rainfalls resulting in flood

Of the climatic stations located in and around the Project site, the Bao Loc station at an elevation of 800 m is indicative of the climatic features of hilly areas extending near the Project site. The air temperature at Bao Loc is comparatively constant throughout a year with the minimum mean monthly value of 19.9℃ in January and the maximum one of 23.2℃ in May. The average relative humidity at Bao Loc is about 86 %, while the mean monthly value varies from 77 % in February to 93% in August. The recorded maximum wind velocity at Bao Loc is 22.0 m/sec in 1978.

The annual rainfalls observed at rainfall stations in and around the Project catchment are listed in Table 3.1. On the basis of the mean annual rainfalls, an isohyetal map for the Project catchment is shown in Figure 3.6. Although the annual rainfall in the middle reach of the Dong Nai River including the Dong Nai No.3 and No.4 dam sites increases to about 2,600 mm from 1,400 mm in the downstream reach, it again decreases to 1,400 mm in the upper reach as seen in Figure 3.6. The annual basin average rainfall for the Project catchment is approximated at 1,950 mm based on the Thiessen's Polygon method (see Figure 3.11). In the Project catchment, 80% to 90% of the annual rainfall takes place between May and October.

The evaporation from reservoir surface is one of the important factors in carrying out the reservoir operation study to estimate the project outputs such as dependable peak power and energy. The evaporation records observed at climatic stations in the Dong Nai River basin were used to derive a typical relationship between ground elevation and annual evaporation depth as shown in Figure 3.7. From the relationship, the annual evaporation from the Dong Nai No.3 reservoir of a FSL being El. 590 m was estimated at 1,071 mm/year as shown in Table 3.2. The monthly evaporation depths thereat are determined applying the ratios of monthly evaporation to annual one at Bao Loc.

3.2.4 Runoff Analysis

(1) Methodology Adopted

As discussed above, the water level records at the new SGS that were commenced in July 1999 are insufficient for estimating the long-term discharges at the proposed Dong Nai No.3 and No.4 dam sites. Hence, the long-term discharges were estimated by transposing those at existing SGS on the Dong Nai mainstream to the proposed Dong Nai No.3 and No.4 dam sites. In the past pre-feasibility study carried out by PECC2, the long-term runoff data at Ta Lai SGS with a gross catchment area of 9,625 km^2 were utilized for the same purpose. On the other hand, the other data series is the inflow data to existing Dran dam with a catchment of 775 km^2 in the uppermost reach. The hydrological condition of the Dong Nai No.3 dam site with a gross catchment area of 4,374 km^2 can be represented by the data at Ta Lai SGS more consistently rather than by those at Dran dam situated in the uppermost reach. Hence, the long-term discharges at the proposed Dong Nai No.3 and No.4 dam sites were estimated by transposing the runoff data at Ta Lai thereto, after the reliability of the Ta Lai data were verified through a crosscheck with the annual basin rainfall and runoff data of the neighboring basin as discussed hereunder.

As shown in Figure 3.4, the runoff data at Ta Lai SGS are available for years after 1979. It has to be noted that inflow to existing Dran Reservoir (Da Nhim HPP) is being diverted to the Phan Rang plain for hydropower generation and irrigation use. As long as the reservoir operation records of Dran Dam show, release from the spillway has taken place with a very low frequency, usually once in a few years. Therefore, it is assumed that the catchment area covered by the existing Dran Dam did not contribute to increase of runoff in its downstream reach over the observation period at Ta Lai SGS. Besides, the Dai Nhin HPP whose construction is committed to start in the year 2000 is planning to divert most of inflow at the proposed two dam sites according to the basic design report on Dai Ninh HPP (July 1997). Based on these considerations as well as measurements of catchment areas on 1:50,000 scale topographic maps using a planimeter, the effective catchment areas at the key points are determined as follows:

- The effective catchment area at Ta Lai SGS is 8,850 km2 excluding a catchment area of 775 km2 at Dran dam site from the gross catchment area of 9,625 km2.
- The effective catchment area at Dong Nai No.3 dam site is 2,441 km2 excluding a gross catchment area of 1,933 km2 at Dai Ninh project site from the gross catchment area of 4,374 km2.
- The intervening catchment area between the Dong Nai No.3 and No.4 dam sites is 149 km2 based on the results of the planimetering on the topographic maps.

(2) Crosscheck of Reliability of Observed Discharge Data at Ta Lai SGS

The monthly runoff data at Ta Lai SGS for the period from 1979 to 1995 are summarized in Table 3.3. First of all, the reliability of the runoff data observed at Ta Lai SGS were crosschecked through a comparison with the following meteo-hydrologic data using the double mass curve method:

- Runoff data observed at Ta Pao SGS

- Basin average rainfall

(i) Comparison with discharge data observed at Ta Pao SGS

The existing Ta Pao SGS is located on the La Nga River, a tributary of the Dong Nai River, about 45 km from Ta Lai SGS to the west. In view of their proximity in location, the runoff characteristics for these two SGS are considered to exhibit similar hydrologic features. Furthermore, the runoff data at Ta Pao SGS were utilized for the detail design of Ham Thuan - Da Mi HPP that is under construction. Hence, it is considered that the reliability of the runoff data had been verified in the past study.

To check the reliability of runoff data at Ta Lai SGS, a double mass curve for annual runoff depths at Ta Lai SGS and Ta Pao SGS were constructed as shown in Figure 3.8. As seen in the figure, a relationship between these two values is represented almost by a straight line. Thus, the runoff data observed at Ta Lai SGS is reliable in relation to the runoff data at Ta Pao SGS.

(ii) Verification by the comparison with the annual average basin rainfall at Ta Lai SGS

It was informed during the first field investigation that the water levels at Ta Lai SGS observed before 1984 were converted into mean daily discharges using a stage-discharge rating curve constructed based on discharge measurements in 1985, since no discharge measurements at Ta Lai SGS were available for the period from 1979 to 1984. Hence, there was a possibility that runoff data at Ta Lai before 1985 might be inaccurate as compared with those for the latter period.

To check the reliability of runoff data observed at Ta Lai SGS from the basin rainfall, annual average rainfalls for a catchment of Ta Lai SGS were calculated by the Thiessen Polygon method based on annual rainfall records at rainfall station in and around the Project catchment (see Figure 3.11). Figure 3.9 shows that a double mass curve representing a relationship between these two annual values becomes almost a straight line. This means that the runoff data at Ta Lai SGS gives a comparatively constant annual runoff coefficients throughout the observation period of 1979 to 1992, implying that there is no significant difference between runoff coefficients derived from the data before 1985 and after 1985.

It is assessed through the above examination that the runoff data observed at Ta Lai SGS are applicable to the runoff analysis to estimate the long-term discharges at the proposed Dong Nai No.3 and No.4 dam sites.

(3) Estimate of long-term-runoff at Dong Nai 3 and 4 dam sites

The long-term runoff at the Dong Nai No.3 and No.4 dam sites were estimated through transposition of the observed runoff data at Ta Lai SGS thereto. The present Study used a similar formula to that used in the previous M/P for the purpose of transposition of the runoff data at Ta Lai SGS, but only the observed data at Ta Lai SGS were applied following the review results discussed above.

The detailed design for the Dai Ninh hydropower project has been completed before the start of the first field investigation in January 1999. Some of the hydrologic data on the project were provided by EVN to the JICA Study Team during the field investigation.

In the detailed design, the runoff data were estimated by transposing those at existing Dran dam site to the project site, in consideration of their catchment areas as well as annual average runoff depths. However, it appears that the inflow records of existing Dran reservoir are characterized by stable runoff even in the dry periods, which deems to be slightly different from that in downstream middle reach. Hence, it is considered that the further analysis would be necessary to verify the Dran inflow records are applicable to the downstream basins.

As far as the results of reservoir operation study for the project are concerned, almost all of streamflow at the Dai Ninh dam sites are to be diverted to the other basin where a powerhouse is to be constructed. Thus, it is assumed that no flow from the upstream catchment including that of the Dai Ninh HPP will enter into the Dong Nai No.3 reservoir, taking into consideration the conservative estimate of runoff at the Dong Nai No.3 and No.4 dams. To estimate the inflow discharges to the Dong Nai No.3 and No.4 reservoirs, the following formula was used to transpose to the Ta Lai SGS discharge data to effective catchment areas of the Dong Nai No.3 and No.4 schemes:

$$Q_{DN3,4}=Q_{Ta\ Lai} \times F_t$$

$$F_t= R_{rain} \times R_{catch}$$

Where,

F_t : Transposition factor of effective catchment areas of Dong Nai No.3 or Dong Nai No.4 dam sites for discharge data at Ta Lai SGS

$Q_{DN3,4}$: Mean monthly discharges at Dong Nai No.3 or No.4 dam sites (m^3/sec)

$Q_{Ta\ Lai}$: Observed mean monthly discharge for effective catchment area of 8,850 km^2 at Ta Lai SGS (m^3/sec)

R_{rain} : Ratio of annual basin average rainfall for effective catchment of the Dong Nai No.3 or No.4 dam site to that for effective catchment of Ta Lai SGS

R_{catch} : Ratio of effective catchment area at Dong Nai No.3 or No.4 dam site to that at Ta Lai SGS

The transposition factors (Ft) for the Dong Nai No.3 and No.4 schemes are derived to be 0.23 and 0.02, respectively. As a result, mean discharges at Dong Nai No.3 and for residual area intervening between the Dong Nai No.3 and No.4 dam sites are estimated at 75.2 m^3/sec and 6.54 m^3/sec for the period from 1979 to 1998 as shown in Tables 3.5 and Table 3.6, respectively. The mean discharge of 75.2 m^3/sec at the Dong Nai No.3 dam site falls in the intermediate rang of those estimated in the previous M/P study (57 m^3/sec) and Pre-F/S (81 m^3/sec). These discharge data are used as the basic hydrologic data for reservoir operation study to estimate the project outputs of alternative development plans for the Dong Nai No.3 and No.4 Combined Hydropower Project.

(4) Cross-check of Estimated Long-Term Discharge at Dong Nai No.3 and No.4 Dam Sites

The consistency of the estimated discharges for the Dong Nai No.3 and No.4 dam sites were further crosschecked through the following comparisons:

- Comparison with neighboring SGS in terms of hydrologic values such as specific runoff and runoff depth,

- Comparison with the observed runoff at the new streamflow station near the Dong Nai No.3 dam site, and
- Comparison with Annual Average Basin Rainfalls

(i) Comparison with neighboring SGS in the Dong Nai River basin in terms of hydrologic values

On the basis of runoff data in Table 3.5, annual specific discharge and runoff depth and runoff coefficient for the effective catchment area of the Dong Nai No.3 (2,441 km^2) are derived as follows:

No.	Item of Hydrologic Value	Values derived for Dong Nai No.3 dam site
1.	Annual specific discharge	0.03 ($m^3/sec/km^2$)
2.	Annual runoff depth	972 (mm/year)
3.	Annual runoff coefficient	0.50

To check the adequacy of the above hydrologic values for the Dong Nai No.3 dam site, those for the neighboring 4 existing SGS and Da Nhim dam site are estimated based on their runoff data. The results are presented in Figure 3.6. As seen from the Figure, the hydrologic values for the effective catchment areas of the Dong Nai No.3 dam site are in their adequate ranges in comparison with those for the neighboring basins.

(ii) Comparison with the observed discharges at new streamflow gauging station near the Dong Nai No.3 dam site

In January 2000, the JICA Study Team received from EVN the following hydrological data at the new streamflow gauging station, which has been installed at the nearby location of the proposed Dong Nai No.3 dam site in June 1999:

- Mean daily stage water levels observed between June and December 1999
- Results of discharge measurements performed in 1999

In this final stage of the Feasibility Study, an attempt was made to reflect this hydrological data into the present runoff analysis. The mean daily stage water levels observed at the new stream flow gauging station are compiled in Appendix C of Supporting Report of this Final Report. As the first step, a new stage-discharge rating curve was constructed based on the results of the discharge measurement to convert the observed mean daily stage water levels into mean daily discharges.

To clarify a relationship between runoff observed at Ta Lai SGS and the new SGS near the Dong Nai No.3 dam site, the concurrent 5-day mean discharges in the year 1999 were plotted in Figure 3.10. Consequently, the following relationship between those concurrent discharges was attempted to be represented:

$Q_{DN3}=Q_{Ta\ Lai} \times F_c$

Where,

F_c : Ratio of discharges observed at the new SGS (Dong Nai No.3 dam site) to those at Ta Lai SGS

Q_{DN3} : Observed mean 5-day discharge observed at Ta Lai SGS (m³/sec)

$Q_{Ta\ Lai}$: Observed mean 5-day discharge observed at the new SGS (Dong Nai No.3 dam site) (m³/sec)

On the basis of the concurrent mean 5-day discharges at Ta Lai SGS and new SGS near the Dong Nai No.3 dam site, the Factor (Fc) was calculated at 0.346 as shown in Figure 3.10. On the other hand, the observed discharges at the new SGS is a sum of the discharge from the effective catchment of the Dong Nai No.3 scheme (2,441 km^2) and that from the Dai Ninh HPP (1,158 km^2). Dividing this factor of 0.346 in proportion to their catchment areas, the transposition factor for the effective catchment of Dong Nai No.3 comes to 0.23, which is almost coincident with that derived from the ratios of catchemnt areas and basin average rainfalls, that is estimated in this Subsection 3.2.4(3). Therefore, the discharge data at the Dong Nai No.3 that were estimated above are consistent in comparison with the observed discharges at the new SGS near the Dong Nai No.3 dam site.

On the other hand, the annual basin average rainfall for the effective catchment area of Dong Nai No.3 scheme is obviously larger than that of the Dai Ninh HPP as seen in the isohyetal map shown in Figure 3.6. Thus, there is a possibility that the transposition factor for the Dong Nai No.3 scheme becomes larger if the ratio of annual rainfalls for the two catchment areas is taken into consideration. In view of the limited available period of discharge data at the new SGS, however, it is recommended that the analysis with the observed data at the new SGS should be used only for the purpose of cross-checking the reliability of the runoff analysis.

(iii) Comparison with Annual Average Basin Rainfalls

To check the reliability of the estimated runoff data at the Dong Nai No.3 dam site, the annual basin average rainfalls are calculated by the Thiessen's Polygon method based on rainfall records at stations in and around the catchemnt. The relationship can be represented by a straight line as shown in Appendix C (See Figure C3.7). Accordingly, there would be no inconsistency in the estimated runoff data in relation to the basin average rainfall.

3.2.5 Flood Analysis

The flood analysis was carried out for the gross catchment area of the Dong Nai No.3 (4,374 km^2).

(1) Methodology Adopted for Flood Analysis

In the Project area, a large-scale flood is caused by thunderstorm or typhoon. Generally, the flood in the thunderstorm season is fairly less than that in the typhoon season in the magnitude of runoff.

Since the streamflow records at the nearby location of the Dong Nai No.3 and No.4 dam sites were not sufficiently available, the flood analysis to estimate the probable floods at the proposed dam sites was carried based on rainfall records as well as an unitgraph derived from typical flood records in the Dong Nai River basin.

(2) Probable Basin Average Daily Rainfall

To estimate the probable rainfalls of various return periods at the proposed Dong Nai No.3 and No.4 dam sites, the annual maximum daily basin average rainfall was estimated by applying the Thiessen's Polygon shown in Figure 3.11. The estimated annual maximum daily basin average rainfalls are listed in Table 3.7. Out of the 45 samples of annual maximum basin average daily rainfalls shown in Table 3.7, the value of the year 1952 is outstandingly high as compared with those of other years, showing that heavy rainfalls occurred over the entire catchment on the date.

The frequency analysis for the daily basin average rainfalls was carried out by using the three (3) distributions:

a) Iwai,
b) Log Pearson Type III, and
c) Gumbel

The results of the frequency analysis are summarized below:

Return Period	Probable Daily Rainfall (mm)			Maximum Value
	Iwai	Log Pearson Type III	Gumbel	
5-year	81	76	93	93
20-year	107	120	136	136
30-year	114	137	148	148
50-year	123	161	163	163
100-year	136	199	183	199
200-year	148	245	204	245
1,000-year	177	395	251	395

As seen in this table, the probable daily basin average rainfall estimated by Log Pearson Type III gives the largest values for return periods of more than 100-year, while the largest ones for return periods of less than 100-year are derived by the Gumbel distribution. For a safety design of the dam/spillway and its appurtenant structures, the maximum value among those estimated by the three (3) distributions was adopted for each of the different return periods.

For the time being, the basic data such as dew point which are required to estimate a PMP of the Project catchment by means of the meteorological approach in consideration of the upper physical limits of moisture source are not available. Concerning the PMP value for the Dong Nai No.3 catchment, an attempt was made to estimate it by applying two different methods, the Hershfield's empirical formula and the method suggested by the World Meteorological Organization (WMO). The method suggested by the World Meteorological Organization (WMO) is discussed in Appendix C.

The PMP was estimated to be 499 mm/day and 687 mm/day by means of the former and latter methods, respectively. There is a large difference between the PMP values estimated by the two methods. As long as the isohyetal map of the PMP for the whole Mekong River basin which was prepare by the WMO shows , the PMP values in a watershed of the Mekon River basin located near to the Dong River basin range approximately between 600 and 700 mm. Therefore, it is determined to adopt 687 mm/day estimated as the PMP value for the Project catchment, that was estimated in accordance with the procedures suggested by WMO.

(3) Design Rainfall Pattern

The rainstorm records at rainfall station in the middle reach of the Dong Nai River, as shown in Figure 3.4, are available for 49 years from 1949 to 1997 except some years that have no records. Out of those rainstorm records, that in 1952 was selected to determine the rainfall patterns of the probable rainfalls estimated above, since it is ranked as the largest basin average daily rainfall in the middle reach of the Dong Nai River since the 1950's. In the 1952 rainstorm, the heavy rainfall occurred on 20 October 1952, while rainfall amounts on dates after and before October 20 were much less. The duration of the design rainfalls is determined to be sixteen (16) days based on the 1952 rainstorm. The design rainfalls for probable rainfalls of various return periods were constructed by multiplying a ratio of the probable daily rainfall to the basin average rainfall on 20 October 1952.

(4) Runoff Coefficient

The runoff coefficient of large-scale floods were examined based on the major floods at Ta Lai SGS and the corresponding rainfall records, which are illustrated in Figure 3.12. Table 3.8 shows the runoff coefficients for their major floods observed at Ta Lai SGS. As far as the flood records at Ta Lai are concerned, the runoff coefficients are derived to be very small, 0.46 to 0.64, as shown in Table 3.8, even considering the base flow.

In this feasibility study, 0.7 is taken as the runoff coefficient for the gross catchment of the Dong Nai No.3 dam site for the following reasons:

a) First of all, the runoff coefficients for major floods observed at Ta Lai SGS falls in the values of less than 0.7 as mentioned above.

b) In the detailed design for Ham Thuan HPP - Da Mi HPP, a runoff coefficient of 0.7 is applied to estimate the probable floods of 10-year to 2,000-year return periods using the rational formula, which is expressed as Qp=C x Ri x A, where Qp is flood peak discharge, C is runoff coefficient, Ri is rainfall intensity, and A is catchment area.

c) In Japan, a runoff coefficient of 0.7 is adopted to estimate the probable floods of any return periods for the mountainous areas where no flood records for determining the runoff coefficient are available. Also for the river basins in East-Asian countries including Indonesia that exhibit similar runoff characteristics to the Dong Nai River basin, a runoff coefficient of 0.7 has been usually adopted to estimate the probable floods.

(5) Flood Hydrograph Analysis

(i) Derivation of Unitgraph

- To derive an unitgraph from the past flood records, the flood hydrograph at Ta Lai SGS on 22 August 1987 was selected for the following reasons:
- It has the largest peak discharge out of floods observed thereat since 1979, and
- It was caused by the comparatively short duration of rainfall, while most of the observed hydrographs at Ta Lai SGS seems to result from long-term and complicated rainfall over the catchment.

The unitgraph was derived by means of the dimensionless flood hydrograph method through defining the flood concentration time and unit rainfall that is the same method adopted in the pre-feasibility study. The flood concentration time at the Dong Nai No.3 dam site was fixed at 30 hours, while the unit time at 6 hours. The unitgraph at the Dong Nai No.3 dam site is shown in Figure 3.13.

(ii) Hydrographs of probable floods

The flood hydrographs of various return periods at the Dong Nai No.3 dam site were worked out by applying the design rainfalls to an unitgraph derived above. The design rainfalls on a daily data basis were converted into six (6) hour rainfall by using the empirical Mononobe's formula. The four 6-hour rainfalls in each day which were calculated by this formula were arranged so that the largest 6-hour rainfall takes place in the second 6-hour duration. Consequently, the probable floods at the Dong Nai No.3 dam site were derived as shown in Figure 3.14 and summarized below:

Return Period	Flood Peak Discharge (m^3/sec)
5-year	1,810
20-year	2,590
30-year	2,800
50-year	3,070
100-year	3,720
200-year	4,540
1,000-year	7,240
PMF	12,480

To check the consistency of the probable floods estimated by the unitgraph method above, the flood hydrographs were also constructed with the storage function model. As a result, the PMF estimated by the storage function model becomes almost same with that by the unitgraph method, while the probable floods of the smaller return periods by the former method gives the smaller magnitudes than those by the unitgraph method.

Taking into account the uncertainty associated with the flood analysis, the probable floods estimated by the unitgraph method are adopted at this feasibility study stage.

(6) Crosscheck of Estimated Design Flood for Spillway and Diversion Facility

In the present Feasibility Study, 1,000-year probable flood is adopted as the design flood for dam and spillway of the Dong Nai No.3 and No.. Besides, these dams need to keep a sufficient freeboard against the PMF. A 20-year probable flood is adopted as the design flood for diversion facilities, while a 30-year probable flood is considered for checking the safety.

In the present feasibility-grade design, the design floods for spillway and diversion facilities are determined through adopting the probable floods estimated by the flood analysis using the unitgraph method. The design floods and PMF estimated in the present Feasibility Study are converted into the Creager's C value expressed by the following formula:

$$Q_p = 46 \times C \times A^{\alpha}$$

$\alpha = 0.894 \times A^{-0.048} - 1$

where, C :Creager's coefficient (Creager's C value)

A :Catchment area in $mile^2$

Q_p :Specific discharge in $feet^3/sec/mile^2$

The Creager's C values corresponding to the design floods are tabulated below:

Structure	Probable Flood Adopted for Design	Peak Discharge (m^3/sec)	Creager's C Value
• Diversion facility	20-year probable flood (design flood)	2,590	19.0
• Spillway	1,000-year probable flood (design flood)	7,240	53.2
	PMF	12,480	91.4

For the purpose of cross-checking of the estimated design floods, they are compared with design flood and PMF or PMF adopted for other large dams in Vietnam in terms of the Creager's C value. Figure 3.15 shows the design floods and PMF adopted in large dams in Vietnam. From the Figure, it is assessed that the design flood and PMF are in an acceptable range in terms of the Creager's C value. It is generally accepted that the design flood corresponding to a Creager's C value of 100 gives an upper limit in Southeast Asia region. It appears that the estimated PMF is applicable as the upper limit to ensure the safety of the dam.

Besides, the 20-year probable flood (2,590 m^3/sec) corresponding to 19 in the Creager's C value is considered to be reasonable, since it is almost coincident with the Creager's C value (C=18.2) for the recorded maximum peak discharge (3,260 m^3/sec) and larger than that (C=14.5) for the 20-year probable flood (2,680 m^3/sec) at Ta Lai SGS with a gross catchment area of 9,625 km^2 as discussed in Appendix C.

3.2.6 Sediment Analysis

(1) General

During the field reconnaissance, it was found that the mountainous area in the catchment of the existing Dran dam was remarkably deforested, probably due to shifting cultivation by the mountain people, although it was blessed with dense forest when the Da Nhim HPP was constructed.

Also in the vicinity of the Dong Nai No.3 and No.4 dam sites, shifting cultivation is regularly and habitually conducted by the local inhabitants. It has to be noted that in general the sediment transport rates will increase with development of lands in the catchment. Therefore, the sedimentation study needs to be carried out taking into consideration increase of erosion rate attributed to expansion of land uses in future, which will be accelerated with increase of population in the middle and upper reaches of the Dong Nai River.

The sedimentation study was made primarily based on the results of the suspended load measurements at Ta Lai SGS between 1985 and 1990 that were provided by EVN to the Study Team during the field investigation.

(2) Long-Term Suspended Load Yield

The sediment load is broadly divided into suspended and bed loads, out of which the bed load moves downstream along the river bed. Usually, the suspended load contained in streamflow is quantified through the suspended load measurements, while it is hardly possible to accurately measure the bed load in a natural river. In the usual estimate, the rate of bed load transport is assumed to be equivalent to 10 to 20% of that of the suspended load. For a conservative estimate, 20% is adopted as the ratio for the Dong Nai No.3 and No.4 Combined Hydropower Project.

Table 3.9 shows the results of laboratory tests for the suspended load analysis which were carried out for water samples collected at Ta Lai SGS. On the basis of the results of the suspended load measurements, a rating curve of the suspended load was established based on all the measurement as shown in Figure 3.16 and below:

$$Q_S = 0.0038 \times Q^{2.1}$$

where, Q_S : Daily suspended load transport in m^3/day

Q : Mean daily discharge in m^3/sec

On the other hand, the values of suspended load yield shown in Figure 3.16 distribute comparatively in a wide range against discharge. In general, the suspended load exponentially increase with discharge so that the estimate of the suspended sediment transport largely depends on the samples at the flood time. The suspended load measurement in a high flow deems somewhat lacking for working out a fair rating curve. Taking into consideration such uncertainties associated in the estimate, the following rating curve was set up as a conservative one by applying the samples giving the higher suspended yield for each of the two stream gauging stations:

$$Q_S = 0.0175 \times Q^{2.0}$$

The conservative suspended load rating curve at Ta Lai SGS is also shown in Figure 3.16. For the purpose of conservative estimate, the latter formula was adopted. The long-term suspended load transports at Ta Lai SGS were simulated by applying the aforesaid rating formulae to the mean daily discharges. Consequently, the mean annual suspended load yield was estimated at 1.687 million m^3 as shown in Table 3.10, which corresponds to a specific sediment transport of 191 m^3/km^2/year for the Project catchment. The specific sediment transport is equivalent to a denudation rate of about 0.2 mm/year.

Figure 3.17 shows the denudation rates estimated and/or adopted for large dams in Vietnam. In general, there is a tendency for the denudation rate to become smaller with catchment area, in case the conditions of basins which are concerned with sediment yield are almost common. Figure 3.17 doesn't exhibit such a tendency, but shows that a denudation rate of about 0.2 mm is adopted for the dam planning in Vietnam as a whole, which is quite close to the value estimated above.

(3) Sediment Deposition in the Planned Reservoirs

The design code in Japan specifies that the reservoir life should be 100 years, unless the facilities for flushing sediments deposited in the reservoir are provided in the dam body or its appurtenant structures. In the present Feasibility Study, the sediment deposition volumes in the planned reservoirs were estimated adopting the reservoir life of 100 years in consideration of sediment traps by upstream reservoirs.

To estimate the net sediment yields at the planned dam sites, the sediment transport rates for the upstream reservoirs were determined based on the Brunei's curve. The trap efficiencies of the Dong Nai No.3 and No.4 reservoirs are derived to be 0.97 and 0.80, respectively, from the Brunei's curve. The sediment deposition volumes in the Dong Nai No.3 and No.4 reservoirs were calculated as follows:

Estimated Sediment Deposition for the Reservoir Life

No.	Name of dam	Sediment inflow (10^6 m^3)	Trap efficiency (%)	Sediment Deposition: Annual (10^6 m^3/year)	Sediment Deposition: For reservoir life of 100 years (10^6 m^3)
1.	Dong Nai No.3 reservoir (Sediment inflow from the catchment area of 4,374 km^2)	0.87	97	0.85	84.6
2.	Dong Nai No.4 reservoir				
	i) Sediment inflow from intervening catchment (149 km^2)	(0.03)			
	ii) Outflow from Dong Nai No.3 reservoir	(0.03)			
	Total of i) and ii)	0.06	82	0.05	5.1

The storage capacity curves of the Dong Nai No.3 and No.4 reservoirs are shown in Figure 3.18. The present Feasibility Study contemplates that the Dong Nai No 3 and No.4 dams have the sediment storage capacity of 298.2 million m^3 and 63.1 million m^3, respectively. Accordingly, both of the planned Dong Nai No.3 and No.4 reservoirs have enough capacity to store sediment inflow for 100 years.

Furthermore, these rates of sediment inflow to the Dong Nai No.3 and No.4 reservoirs are estimated on the assumption that sediment inflow from catchment above Dai Nih dam site wholly reaches the Dong Nai No.3 dam site. In actuality, however, a considerable quantity of the sediment transports at Dran dam and Dai Ninh dam will be conveyed to the other basins through their turbines, since these hydropower projects consisting of water trans-basin projects convey most inflow discharges to other river basins with exception of large-scale flood. For the time being, it is foreseen that the contemplated Dong Nai No.3 and No.4 reservoirs would not face critical sedimentation problems. However, it is recommended to formulate and implement the appropriate basin conservation plan for the upper and middle reaches in order to enable the sustainable operation of the storage type dams built or to be built in the Dong Nai River basin.

3.3 Geology

3.3.1 Regional Geology

From a tectonic point of view, the land of Vietnam is largely divided into two parts by the Red River that develops in the direction from northwest to southeast along a major fault zone. The Red River Fault is a sort of transform fault between a couple of plates with different movement, that is, the South China plate on the north side and the Indochina plate on the south. A major part of Vietnam is situated on the Indochina plate and tectonically sub-divided into a few blocks.

Geology of Vietnam covers from Archaean (of Pre-Cambrian era) to Quaternary. The area south of the Red River and north of Qui Nhon is charaterised by Palaeozoic fold system with axes of northwest-southeast trend.

Tay Nguyen, or the Central Highland, in the central to southern part of Vietnam, forms the core of Indosinian Continent, named Indochina Platform, that was built in Mesozoic, developed and stabilised till the recent age. In the northern part of the Indochina Platform develops an up-lifted Kon Tum Massif where the Pre-Cambrian metamorphic and igneous rocks, the oldest in Vietnam, are exposed. Da Lat Zone, southwest of the Kon Tum Massif and a part of the Indochina Platform, is an area of Mesozoic tectonic movement, marine sediment and granite intrusion and Plio-Pleistocene effusion of basalt flow.

The Da Lat Zone, where the Dong Nai Project is located, is composed mainly of the Jurassic sandstone, siltstone and shale with granite or granodiorite masses, covered widely with basalt flow. The Dong Nai River flows through the hills of Mesozoic sediments between Da Lat and Ho Chi Minh City. The location of the Dong Nai No.3 and No.4 Combined Hydropower Project is shown in Figure 3.19.

Main bedrock of the upper Dong Nai area is Lower to Middle Jurassic sediment of La Nga Formation, which consists of light or dark grey shale, siltstone and sandstone, partly altered to hornfels or quartzite. The La Nga Formation is reported to have total thickness of 700 to 800 m in Gia Nghia along the highway No.28. In spite of faults and folds, the strike of the beds shows almost constantly around N45° E. Intrusive granodiorite is located in parts.

Plio-Pleistocene Tuc Trung basalt flow is wide-spread over the ground surface at altitude of 600 m or higher and unconformably covers the La Nga Formation. The basalt flow makes flat surfaces of plateau at elevation 550 m to 800 m and separated by dissection of valleys as shown in Table 3.11.

Tectonic activity in Vietnam was for the most part completed before the Quaternary age, except in the Red River fault zone in the furthest northern part of the country. The land of the Indochina Platform is generally stabilized and has only a few earthquakes on its margin as shown in Figure 3.20.

3.3.2 Geology of Reservoir Areas

(1) Reservoir of Dong Nai No.3 Dam

The No.3 dam will make a reservoir with surface area of 54 km^2 in the surface area at the full supply level of elevation 590 m, or the height of approximately 100 m above the river bed of the dam site at elevation 490 m. The reservoir will develop to about 20 km upstream of the dam site, around a section of the Dong Nai River which meanders and changes direction frequently but flows largely northwest until it reaches the dam site No.3 at a large river bend to the west as shown in Figure 3.21.

A geological map of the reservoir area was prepared through field mapping to the scale of 1:10,000 and incorporated into the 1:100,000 geological map of the project area in Figure 3.21. The bedrock under the reservoir is the Jurassic sediments of La Nga Formation, composed of sandstone, siltstone and shale. The bedding planes show almost constantly similar strikes around N45°E and dip northwest or southeast, reflecting folds.

Topographic lineament shows a major northeasterly fault of Ta Lai – Dak Mo Rung crossing the reservoir at a few kilometres upstream of the dam site. A few smaller faults of northwesterly and northeasterly orientations are read on the aerial photograph as shown in Figure 3.21.

The sedimentary rock of La Nga Formation has no special evidence of high leakage potential. The unconformable bottom of the Tuc Trung Basalt, which may provide leakage paths, is located higher than the reservoir level in the reservoir area. The reservoir is deemed practically water-tight.

Slopes are generally well covered by thick vegetation. For the large thickness, even to reach 40 m at places, of the completely or highly weathered rock and residual soil, the possibility of slides of the slopes cannot be eliminated. The slides, however, will be of minor harmless scale. Large slides are not seen in and around the reservoir area, except one located on the right bank upstream of the dam site No.3. Account and risk of this potential landslide area are presented below:

A land of gentle slope at 15° and less from horizontal is developed in a 600 m wide and 700 m long area upstream of the Dong Nai No.3 Dam Site. It is located on the right bank of the Dong Nai River and more than 500 m upstream of the dam site. Landslide was suspected of this area in the Master Plan Study as was suggested from its topographic feature and colluvial deposits as usually seen in landslide areas. In the previous studies, however, the possibility of a landslide has never been positively proved through detailed investigation.

An unusual feature of this potential land slide area is that it is blocked at its foot by a low ridge stretching from the upstream side, forming a sort of barrier against the slide with a constricted outlet to the river. While there could be some doubt against the interpretation of landslide, it is duly conservative to assume existence of an old land slide.

Trunks of trees remaining after a burning-and-cultivating operation by the local inhabitants are all straight and vertical in this potential landslide area, indicating that the land has been stable at least for a few tens of years. Even if it has once stabilized, the balance would be lost and a slide movement might be resumed on the reservoir impounding up to the high water level, which corresponds the middle height of the land slide area.

Resumption of the landslide, however, would not cause any serious trouble upon the safety of the reservoir or the dam. Volume of the colluvial deposit entering in the reservoir by the landslide is estimated at approximately 10 million m^3 or less. This sliding material will replace only a minor part of the dead water that is about 70 m deep between the low water level (El. 560 m) and the river bed (El. 490 m) in front of the land slide area. The sliding volume may actually be far less because of the said barrier ridge hindering the movement. Slide of the colluvial deposit on a low-angled sliding surface, if occurs, can be too slow to jeopardize the safety of the reservoir and the dam by rapidly raising the water surface or generating high waves.

This potential landslide, therefore, has no significance for the safety of the structures.

The reservoir area is practically water-tight and free from any major harmful slope instability.

(2) Reservoir of Dong Nai No.4 Dam

The reservoir formed by the Dang Nai No.4 Dam will have only 4.2 km^2 of surface area at the full supply level of elevation 440 m. The reservoir is in a narrow and long gorge stretching east to west. The geologic setting is shown in Figure 3.21.

The interbedding sandstone, siltstone and shale of the Jurassic La Nga Formation are the bed rock of the reservoir area. Two major faults of steep dip develop through the reservoir area, one oriented northeast to southwest and the other with the northwest to southeast trend. The former is located in the upstream part of the reservoir and the latter in the downstream part, both nearly parallel with the river channel.

Similar to the reservoir of Dong Nai No.3, there is neither signs of landslide of substantial scale nor much water loss from the reservoir.

3.3.3 Geology of Project Sites

(1) Geological investigation

Before the present Feasibility Study, geology of the Dong Nai No.4 site was investigated with core drilling at fifty two locations and 2,019 m in total length, and with borehole permeability test and laboratory test, by the Power Engineering Consulting Company No.1 (PECC 1) from 1991 to 1993. The Dong Nai No.3 site was investigated in 1997 and 1998 by the Power Engineering Consulting Company No.2 (PECC 2), with core drilling at five locations totaling 313 m, and tests in the boreholes and laboratory.

Succeeding the previous investigations, a new series of geologic investigation has been performed for this feasibility study by PECC 2 from June to October 1999. It has covered core drilling of 1,550 m with standard penetration tests and borehole water tests, seismic refraction prospecting for 15,000 m in total length of prospecting traverse lines and laboratory tests of core samples.

(2) Geology of Dong Nai No.3 Site

The site for the contemplated Dong Nai No.3 Dam will be immediately downstream of a bend of the Dong Nai River turning from a south-to-north flow to a east-to-west flow. It is located approximately 10 km east-southeast from the village of Quang Khe and 9 km northwest of Kinh Duc ferry across the Dong Nai River upstream. The width of the valley is approximately 450 m around the contemplated dam crest at elevation 600 m as shown in Figure 3.22 and Figure 3.24.

River bed is at elevation 490 m and is 130 m wide. The slope on the right bank shows gradient of 1 Vertical / 1 Horizontal in the lower part and 1 Vertical / 2 Horizontal in the upper part. The slope on the left bank shows 1 Vertical / 1.2 Horizontal near the river and 1 Vertical / 2.5 Horizontal in the higher reaches. The right bank is steeper than the left bank, and the lower part of the slope is steeper than the upper part. The slopes are covered by thick forests.

The bedrock of the dam site is Jurassic sedimentary rock of La Nga Formation consisting mainly of sandstone with intercalation of thin shale layers. The sandstone is fine to medium grained, dark grey well cemented hard rock in the fresh or slightly weathered condition. The shale is dark colored slaty hard rock, if it is not highly weathered. The beds show monotonously northeasterly strikes and 65 to 70 degrees' dips to southeast. Dips to northwest are also observed upstream and downstream, indicating a fold structure.

The slightly weathered or fresh rock indicates the bulk density around 2.7 g/cm^3 and the uniaxial (unconfined) compressive strength over 1,000 kgf/cm^2 (100 MPa) except a few weak samples. Shear strength for this sort of hard rock can empirically assumed at 25 kgf/cm^2 (2.5 MPa) for the cohesion and 40 degrees for the internal angle of friction as conservative value.

Weathering is intensive and deep-reaching as seen in the geological profile along the dam axis in Figure 3.24. Surface zone of intensive weathering, including a completely weathered rock zone and highly weathered rock zone, is 10 to 20 m thick on the right bank slope and 20 to 30 m thick on the left bank, according to the core drilling BD901U through BD906U and the seismic prospecting on the line S901U along the dam axis. In the completely weathered zone the rock is almost entirely disintegrated into its component particles or to the condition of soil by serious weathering, though the original rock structure still remains. The highly weathered rock is deteriorated less, but is disintegrated to soil in its half part or more as shown in Table 3.12. Permeability varies rather irregularly in this sort of intensively weathered rock, and ordinary cement grouting is very often not convincing method for seepage cut-off in such weathered zone. These completely to highly weathered rocks, therefore, cannot be foundation for the impervious core zone of fill-type dam, while there are examples to utilize the highly weathered rock for foundation of a dam shell zone.

Moderately weathered rock zone, underlying the highly weathered, is also decomposed in its half part, while the original rock structure with framework of still solid parts remains. Seepage potential is diverse, varying from 10 to 40 in Lugeon test and from 2.5 x 10^{-5} cm/sec to 2.1 x 10^{-4} cm/sec in the static permeability test. This zone corresponds with the layer of primary wave velocity of 1.5 to 1.7 km/sec in the seismic refraction prospecting. It is recommended to remove this zone in foundation excavation for the dam core zone.

Slightly weathered rock zone is reached at the depth of 30 to 35 m under the slopes on both banks. The depth gradually decreases toward zero metre at the river bed, where the solid rock of slight or no weathering is exposed. Fresh rock lies under the slightly weathered rock.

The slightly weathered rock in this site is for the most part weathered and stained by iron-oxide only along such discontinuity planes as open joints and eminent bedding planes. The rock is fresh and strong in other parts. Water pressure tests in boreholes show Lugeon values not more than 20, and less than 10 in most sections. The seepage potential of this magnitude in hard rock can be treated by cement grouting without much difficulty.

The slightly weathered rock will provide good foundation for an impervious earth core zone of rockfill dam, and for a 100 m high concrete gravity dam as well. The foundation excavation has to be made up to the surface of the slightly weathered rock zone, which is at the depth of 35 m on both abutments. In the river bed section, the excavation will be required only for trimming of the rugged rock surface.

The sedimentary rock of La Nga Formation is capped by the wide-spread lava flow of the Plio-Pleistocene Tuc Trung Basalt at the top of slopes. The basalt flow is located higher than elevation 650 m and away from the dam and reservoir staying below elevation 600 m.

The headrace tunnel of the Dong Nai No.3 will be laid out on the right bank. Length of the tunnel will be approximately 7 km including the intake tunnel section. The slightly weathered sedimentary rock is deemed to lie below elevation 600 m, according to the seismic refraction prospecting on the lines S902U, S903U and S904U along the contemplated intake-tunnel-penstock alignment, together with the core drilling BI907U, BI908U, BP909U, BP910U and BP911U at the intake site, the surge tank and the penstock. The tunnel will be driven through sound rock for the most part of its route. Bottom of the basalt cap is estimated to lie around elevation 600 m at the lowest, and not to descend to the tunnel formation height. This is to be further confirmed by drilling at the time of detailed design in order to avoid troubles in the tunneling work caused by relatively soft old surface soil layer that may remain below the basalt flow as shown in Figure 3.25.

A large excavation will be required at the intake portal where the highly to completely weathered rock is 45 m in thickness. The surge tank shaft will reach the moderately weathered rock at the depth of 30 m and the slightly weathered rock at 40 m.

The tunnel will encounter faults at places. The locations and sizes are not clearly identified. The design should take into account some sections requiring heavy support and groundwater drainage for some 20 % of the tunnel length, other than the poor rock sections near portals.

(3) Geology of Dong Nai No.4 Site

The Dong Nai No.4 Dam is contemplated to be placed on a northwest-bound channel of the meandering Dong Nai River, approximately 8 km west-southwest of the Quang Khe village on the Route No.28. The river bed is at elevation 355 m with a 40 m wide river channel. Including the terrace on both sides of the channel, the valley floor is about 70 m wide. The bedrock of sandstone with minor shale and siltstone layers, of the Jurassic

La Nga Formation, is widely exposed on the valley floor, whereas the slopes on both banks are thickly covered by forests. On the right bank, the slope rises at a gradient of 1 Vertical / 1 Horizontal from the end of the terrace but the angle changes as gentler as 1/1.5 in the higher part . On the left bank the slope is a little steeper than 1/1 up to the contemplated dam crest height near elevation 450 m. Width of the valley at this elevation is approximately 260 m. The Dong Nai valley forms a steep and narrow gorge at this dam site as shown in Figure 3.23 and Figure 3.24.

Geological setting is similar to the Dong Nai No.3 Dam site. The general strike of the beds is invariably northeast to southwest, as in the No.3 site, and the dip shows 60 to 70 degrees northwest. The direction of the dips, however, varies in a wide range upstream and downstream of the dam site. According to the existing geological record, a fault of medium size (Degree-III) develops through the river channel at the dam site in the direction of northwest to southeast. The fault was not visible probably due to covering by the deep river water and vegetation. Fault of this degree, with the width from 1 m to 10 m, can be treated by a routine method of concrete replacement, if encountered during construction work.

The uniaxial compressive strength of the rock is lower than that in the Dong Nai No.3 site, with the laboratory test data scattering between 350 kgf/cm^2 (35 MPa) and 1,300 kgf/cm^2 (130 MPa). The majority falls under the range of 500 to 800 kgf/cm^2 (50 to 80 MPa). This shows still high strength to support conservatively the empirical assumption of 25 kgf/cm^2 for the cohesion and 40 degrees for the internal angle of friction, similar to the rock at Dong Nai No.3.

The weathering is deep-reaching also in this dam site. The slightly weathered rock, competent for foundation of a concrete gravity dam and a core zone of rockfill dam, lies at the depth of 25 m in the higher part of the right abutment and less deep under the lower slope. On the left abutment, the sound rock is reached by 25 to 30 m thick excavation of the completely, highly and moderately weathered rock.

A 5.4 km long headrace tunnel for the Dong Nai No.4 scheme will pass under the plateau on the left bank, short-cutting a 16 km long river channel of a large incised meander as shown in Figures 3.23 and 3.25. Surface of the plateau undulates between elevation 550 m and 650 m in general, with the deepest gully dissecting to elevation 500 m. The Tuc Trung Basalt covers the top of the plateau with varied thickness from 10 m to several tens of metres. A soil layer is found at the bottom of the basalt flow. This is old residual soil or surface soil which covered the old ground surface of the La Nga sedimentary bedrock, before the basalt flow came over it. The sedimentary rock of La Nga Formation underlying the old residual soil is weathered in various degrees. Changes of the direction of dips, seen on outcrops, indicate folding of the La Nga Formation in the tunnel route. Surface of the fresh sedimentary rock lies at elevation 520 to 580 m under the core of the plateau, but descend to the river bed at the intake site and the penstock route. If the tunnel formation height is approximately at elevation 400 m, the tunnel route will be almost entirely within the fresh hard sedimentary rock except for some 50 m sections at each portals and a few sections to meet faults. One of the faults that may be encountered near the 4 km point from the intake is a north-to-south trending major fault of Tanh Linh-Dak Nong. Its geotechnical condition is to be examined by drilling in the future stage for detailed design.

3.3.4 Seismicity and Seismic Risk

The land of Vietnam, except its most northern part, is situated on a craton or a stabilised continental mass called Sunda Shelf. This area is characterised by low seismicity and little earthquake.

In the Institute of Geophysics, Hanoi, a set of earthquake record was obtained that covered twenty-four (24) events for years from 1715 to 1992. A probabilistic estimate of the maximum earthquake acceleration was tried, though the number of data is not always relevant enough for this process. Ruling out three data before 1990, probable maximum earthquakes were sought on twenty-one (21) data in 70 years between 1923 and 1992 as shown in Table 3.13 and Table 3.14 for the return periods of 100 years and 200 years.

Earthquake intensity that could be felt at the middle part between Dong Nai dam sites No.3 and No.4 (11°52'N, 107°50'E) was initially estimated for each of the recorded earthquake by use of attenuation formulae of Cornell and Kawasumi. Cornell's formula has given some low intensities as shown in Table 3.13, while effects of the earthquakes to the dam sites are all zero (0) according to Kawasumi as shown in Table 3.14.

The probabilistic calculation, therefore, was made only on Cornell's intensities that were supposed to be felt at the dam sites in sixteen (16) events of the earthquakes out of twenty-one (21). The estimate is as shown in Figure 3.26, giving the probable maximum accelerations of:

a) 0.009g for 100 years of return period,

b) 0.014g for 200 years of return period.

Since the estimated probable earthquake acceleration is very low, the design earthquake acceleration should be determined by a different approach from the above, taking into widely adopted practice.

The earthquake factor is 0.035 for rock-base structures in the Ham Thuan – Da Mi Project and 0.07 for earth-base structures, while the study of design criteria for the Dai Ninh Project proposed 0.1. The value of 0.1 will be taken for the Dong Nai No.3 and No.4 dams as a conservative minimum value for the design. The reservoir-induced earthquake may not be conceivable. Although faults of various sizes are reported from interpretation of topographic lineament, the sedimentary bedrock is little disturbed and shows almost constant trend of bedding around N45° E in the strike without serious distortion in spite of folds. The land is tectonically stable as self-evident in the study of the earthquake data mentioned above.

3.4 Construction Materials

3.4.1 Construction Materials for Dong Nai No.3 Scheme

(1) Rock material for the Dong Nai No.3 dam

The Tuc Trung Basalt covering the La Nga sedimentary rock at elevation higher than 600 m was investigated for the potential rock quarry by means of the seismic refraction prospecting on a line (S905U) and the core drilling at three locations (BQ912U, BQ913U and BQ914U) as shown in Figure 3.22. Six test pieces were selected from the drilling core samples for laboratory test.

The contemplated quarry site is located at a basalt escarpment behind the so-called landslide area as mentioned before, on the right bank of the Dong Nai River approximately 1.5 km northwest of the dam site No.3. Hard basalt is exposed on the escarpment.

The basalt is deemed preferable to the sedimentary rock. It has merits of the isotropic and homogeneous nature of the rock, a reasonable haul distance not too far and not too near to the dam site and its wide exposure on the escarpments, even though it is covered by very thick overburden in other part of the plateau.

The seismic prospecting and the core drilling were performed at elevations of 810 to 820m on the plateau and at the distance of 100 m to 200 m from the top of the escarpment. It found a thick setting of a superficial residual soil layer and a completely to moderately weathered rock zone, of which total thickness is 25 m on average, ranging from 20 m to 33 m. The moderately weathered basalt zone consists of a mixture of disintegrated soft rock and remnants of hard rock, which is not fully exploitable for a quarry. Competent rock of the slightly weathered or fresh zone is reached at the average depth of 25 m. Thickness of the overburden and intensively weathered rock will decrease toward the escarpment. If the basalt is taken within 200 m distance from escarpment in one kilometre section and for a height of 50 m, the rock material of 10 million m^3 will be provided. The overburden is thick as shown in Figure 3.27 but will be usable for earth core material. The quarrying operation will not result in much environmental change except for retreat of the existing basalt escarpment by approximately 200 metres from the present location. The new escarpment has to be designed for stability considering the geological condition observed after quarrying.

The basalt shows 400 to 1,100 kgf/cm^2 (40 MPa to 110 MPa) of unconfined compressive strength in the laboratory test, that is, around 1,000 kgf/cm^2 (100 MPa) for massive basalt and less than 900 kgf/cm^2 (90 MPa) for porous (vesicular) basalt. The porous basalt is weaker than the massive one but will be still viable as rock material if it is stronger than 400 kgf/cm^2 (40 MPa). Water absorption is as high as 2 % probably due to the vesicular nature of the basalt even in apparently massive zones, which, however, will not justify rejection of this rock except for very porous portions. Weight loss in the soundness test with sodium sulfate is negligible, and all the results of the alkali reactivity test in chemical method fall under the realm of innocuousness as shown in Table 3.15.

The basalt can be used for rock material and concrete aggregate. A few weathered rock layers intercalated in the sound rock will also be usable for sources of fine rock material or random fill.

(2) Earth core material for the Dong Nai No.3 dam

A borrow area for the earth core material was proposed on the flat land on the basalt plateau on the right bank, approximately 1.5 to 2.0 km north-northeast from the dam site. Test pits were dug at thirteen locations, each to the depth of 5 m, or to the depth of groundwater table or rock that may not be dug by manpower. Disturbed soil samples were taken in parts above and below the depth of 2.5 m in each pit, and provided for laboratory test as shown in Figure 3.22.

Results of the test are shown in Table 3.16. Most of the samples, except three from the pits TP7U and TP8U, are mixtures of clay, sand and gravel, classified to GC of the Unified Soil Classification. The clay occupies 10 to 20% in weight and the gravel over 4.75 mm shows approximately 50 %. The material can be well compacted to acceptably stable embankment. The optimum moisture content (OMC) is around 20% and generally lowers than the natural moisture content. The maximum dry density by compaction at the optimum moisture content ranges from 1.65 to 1.75 g/cm^3. The material can be usable for the dam core embankment.

3.4.2 Construction Materials for Dong Nai No.4 Scheme

(1) Rock material for the Dong Nai No.4 dam

A quarry site for the Dong Nai No.4 scheme was proposed at a basalt plateau on the right bank of the Dong Nai River and 4 km north of the dam site No.4. A basalt escarpment develops in this site and a waterfall of the right bank tributary is formed on a part of the escarpment as shown in Figures 3.23 and 3.25.

The seismic refraction prospecting was carried out on two lines (S910D and S911D) crossing at right angle and the core drilling was performed on three locations (BQ921D, BQ922D and BQ923D) on the seismic prospecting lines, all at elevation from 650 to 675 m.

Seismic prospecting profiles and drill logs show a 20 m to 30 m thick completely weathered rock zone with residual soil at the top. An underlying highly to moderately weathered rock zone with varied thickness from 8 m to 45 m is composed of irregular mixture of soft products of intensive weathering and remaining hard rock blocks. The competent rock of the slightly weathered or fresh basalt zone is located at the depth of 30 m to 50 m. The overburden is thinner toward the escarpment where the hard basalt is exposed. Nevertheless, removal of much overburden will be required as inevitably will be the case in this area with very thick weathering. Ten million cubic metres of rock material can be taken from one kilometre stretch of the escarpment by bench-cutting in a zone of 200 metres in horizontal and 100 metres in vertical. A new escarpment that will be created after completion of the quarrying work should be designed for the permanent stability with the gradient to the geological condition actually encountered..

Six core samples were tested in laboratory, and the results are presented in Table 3.15. The water absorption shows rather high value from 0.91 to 1.66, except for the extremely porous and moderately weathered rock. The bulk specific gravity of massive or slightly porous basalt is more than 2.6 g/cm³, and the uniaxial compressive strength is approximately 1,000 kgf/cm² (100 MPa).

The basalt can be used for rock material and concrete aggregate, although its highly vesicular part is to be rejected.

(2) Earth core material for the Dong Nai No.4 dam

A contemplated earth borrow area is located at the top of the basalt plateau higher than elevation 600 m on the right bank of the Dong Nai River and approximately one kilometre northeast of the dam site. Test pits were dug at ten locations, each to the depth of 5 m. Two disturbed soil samples were taken above and below the depth of 2.5 m in each pit, and provided for laboratory test.

As shown in Table 3.17, the samples are more diverse in quality than those of the borrow site for the Dong Nai No.3 scheme. The quality changes also by the depth, showing visible contrast between the upper layer and the lower layer. The boundary of these layers lies within the depth of 5 m (the depth of the test pit) at some locations and is deeper at other places. The upper layer is generally fine with 30 to 40 % of clay contents and falls under MH of the Unified Soil Classification. The lower layer is coarser with more sand and/or gravel and belongs to the classification SC or GC. The upper layer is lacked at the pits TP7D and TP10D. The optimum moisture contents for compaction is generally lower than the natural moisture content and the maximum dry density of the SC and GC soil remains rather low as 1.4 to 1.6, though that of the MH soil is lower.

3.4.3 Sand for Concrete Aggregate and Filter Material

Sand deposit, sufficient in volume for concrete aggregates and filter material of the fill-type dam, is absent in the Project area. River deposits on the Dong Nai River are too scarce and scattered in small scale. The nearest substantial deposits so far found are located more than 100 km from the dam site, i.e., Krong Kno River to the north and Thong Nhat sand pit on the Dong Nai River to the southwest as shown in Figure 3.19.

While the quality of the sand in these deposits appears generally acceptable in spite of a little high water absorption, the serious drawback of these sand borrow pits is their unusually long haul distance, that is, 120 km for Krong Kno, 170 km for Srepok and 150 km for Thong Nhat. Considering that these deposits can provide only sand, and not gravel, it is deemed more economical to produce sand and gravel by crushing the quarry rock obtained in the project area.

Conditions of those sand borrow pits are as follows:

(1) Sand borrow pit on Krong Kno River

A large sand deposit is located in the vicinity of the Quang Phu village on the Krong Kno River, the uppermost reaches of the Srepok River. The deposit is accessible from the Project area through the highway No.28 and the provincial road 693, of which distance is approximately 120 km.

The sand deposit is formed under the river channel and on river banks.

Three sand samples along the river were collected and tested in laboratory. The results indicate that the sand is clean, well-graded and chemically innocuous in the alkali reactivity test as shown in Table 3.18.

As the result of previous investigation, the proven reserves have been estimated at 447,000 m^3.

(2) Sand borrow pit on Srepok River

This sand deposit is located on the Srepok River, about 170 km from the project area through the highway No. 28 and No. 14.

The sand deposit lies generally under the water along the river channel, and is currently taken with pump barge by local contractor.

Three sand samples were taken in the site and tested in laboratory. The sand is clean, well-graded and chemically innocuous according to the laboratory test, which is summarized in Table 3.18.

In the previous study, the proven reserves had been estimated at 2,577,000 m^3.

(3) Sand borrow pit at Thong Nhat on the Dong Nai River

This sand borrow pit is located on the Dong Nai River, far downstream of the project area, and in the Thong Nhat Commune, Bu Dang District. For access, there is an earth road about 30 km long which connects the borrow pit site with Highway No.14. The haul distance will be about 150 km to the Project area,

This sand deposit was once exploited to supply construction material for the Thac Mo hydropower project, and its quality has already been proved. As the result of previous investigation, the proven reserves has been estimated at 1,200,000 m^3.

Table 3.1 Annual Rainfall in the Dong Nai River Basin

Unit = mm

Year	Da Lat	Dong Duong	Tan My	Lien Khuong	Dai Ninh	Di Linh	Bao Loc	Ta Pao	Da Te	Phuoc Long	Ta Lai
1950	-	-	-	1,813	-	-	2,456	-	-	-	-
1951	-	-	-	1,768	-	-	2,769	-	-	-	-
1952	3,923	-	-	1,782	-	-	3,072	-	-	-	-
1953	1,362	-	-	1,769	-	-	2,884	-	-	-	-
1954	2,130	-	-	1,730	-	-	2,318	-	-	-	-
1955	1,911	-	-	1,634	-	-	2,473	-	-	-	-
1956	1,962	-	-	1,433	-	-	2,599	-	-	-	-
1957	1,704	-	-	1,261	-	-	2,537	-	-	-	-
1958	1,459	-	-	991	-	-	2,350	-	-	-	-
1959	1,609	-	-	1,451	-	-	2,354	-	-	-	-
1960	1,951	-	-	1,833	-	-	2,577	-	-	-	-
1961	1,829	-	-	1,547	-	-	3,115	-	-	2,710	-
1962	2,142	-	-	1,645	-	-	2,299	-	-	2,821	-
1963	1,691	-	-	1,282	-	-	1,718	-	-	3,090	-
1964	2,108	-	-	1,967	-	-	2,466	-	-	2,761	-
1965	1,607	-	-	1,278	-	-	2,599	-	-	-	-
1966	-	-	-	1,857	-	-	2,590	-	-	-	-
1967	-	-	-	1,862	-	-	2,965	-	-	-	-
1968	1,678	-	-	1,401	-	1,745	2,657	-	-	-	-
1969	1,499	-	-	1,589	-	1,433	2,784	-	-	-	-
1970	2,120	-	-	1,813	-	1,885	2,986	-	-	-	-
1971	-	-	-	1,662	-	-	2,181	-	-	-	-
1972	1,648	-	-	1,643	-	-	3,347	-	-	-	-
1973	-	1,903	-	1,708	-	-	-	-	-	-	-
1974	-	1,500	-	1,591	-	-	2,603	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	2,490	2,031	-	-	-
1977	1,493	-	-	1,058	-	-	2,326	-	-	-	-
1978	1,551	-	1,023	1,505	1,265	2,029	3,132	2,437	-	2,570	-
1979	1,968	-	963	1,806	1,541	2,318	3,071	2,815	2,219	2,802	2,632
1980	1,980	-	1,304	1,838	-	2,062	3,191	2,406	-	2,461	2,806
1981	1,332	-	1,209	1,662	1,249	1,652	2,814	2,455	5,199	2,288	2,594
1982	1,776	-	736	1,296	1,439	1,683	3,025	2,395	3,414	2,192	2,964
1983	1,751	-	965	2,085	-	2,131	2,752	2,609	2,893	2,083	2,912
1984	1,701	1,423	1,137	1,651	1,753	-	2,316	2,753	3,437	2,484	2,784
1985	1,864	1,377	928	1,304	1,278	-	2,717	2,294	2,503	2,548	-
1986	2,033	1,459	1,243	1,522	1,494	-	3,189	3,008	2,927	2,960	3,403
1987	1,622	-	943	1,510	1,254	1,004	2,449	1,983	2,715	2,572	2,561
1988	1,799	-	890	1,468	1,125	-	2,195	2,065	-	2,125	2,418
1989	2,015	-	1,004	1,958	1,597	-	2,579	2,940	2,608	2,645	2,699
1990	1,936	-	1,010	1,496	1,817	1,561	2,811	2,256	2,821	2,858	2,871
1991	1,714	-	842	1,450	-	-	2,401	2,383	2,585	2,265	2,667
1992	1,665	-	756	1,339	1,154	-	2,477	2,081	-	2,600	2,589
1993	1,773	-	-	1,530	1,512	1,227	2,708	2,261	2,451	2,346	3,000
1994	1,589	-	912	1,463	1,343	-	-	2,770	-	3,199	3,038
1995	1,941	-	1,185	1,672	1,417	-	2,592	2,180	-	2,906	2,335
1996	1,830	-	1,903	1,850	1,518	-	2,421	1,972	-	3,206	2,719
1997	1,899	-	1,209	1,649	1,460	1,469	3,383	2,261	-	2,927	2,599
1998	1,998	-	2,010	1,818	1,458	-	2,472	2,460	-	2,296	2,659
Mean	1,839	1,532	1,109	1,601	1,426	1,708	2,657	2,401	2,981	2,629	2,750

Table 3.2 Estimated Monthly Evaporation at Dong Nai No.3 Reservoir in Case of FSL of El. 590m

(Unit : mm/month)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
123	132	137	102	78	64	60	56	53	62	91	113	1,071

Table 3.3 Observed Mean Monthly Discharges at Ta Lai SGS (Effective C.A. = 8,850 km^2)

(Unit : m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1979	56.66	37.08	32.65	37.99	92.13	340.39	910.46	1059.51	530.93	717.73	359.73	155.17	364.01
1980	76.14	48.96	35.25	37.34	88.48	280.70	364.33	521.91	951.83	773.72	543.60	208.94	327.75
1981	101.72	71.54	38.49	39.45	82.90	410.15	356.89	923.77	698.57	736.39	415.36	210.49	342.14
1982	92.38	52.73	47.27	75.87	76.41	175.01	526.88	590.41	1075.05	546.32	330.47	165.01	313.85
1983	84.77	47.03	34.40	30.30	46.64	175.68	319.64	714.22	515.69	972.77	440.94	163.23	297.54
1984	85.99	46.80	33.48	49.96	117.82	263.75	293.44	1163.47	911.54	778.44	282.87	152.40	349.66
1985	71.60	44.90	39.60	69.20	155.00	346.00	368.00	497.00	626.00	680.00	325.00	185.00	285.28
1986	85.10	52.40	39.20	38.90	113.00	176.00	347.00	1140.00	859.00	808.00	404.00	203.00	357.80
1987	93.60	52.50	37.40	33.80	44.90	181.00	476.00	741.00	830.00	649.00	362.00	166.00	307.18
1988	82.50	52.30	37.60	47.10	64.40	202.00	277.00	335.00	444.00	718.00	411.00	137.00	234.53
1989	72.70	42.00	49.40	61.60	152.00	253.00	529.00	625.00	787.00	640.00	256.00	111.00	299.88
1990	65.50	41.80	43.20	39.80	49.50	459.00	422.00	893.00	1030.00	650.00	503.00	177.00	365.56
1991	86.70	52.60	37.40	41.30	64.00	120.00	476.00	794.00	1080.00	849.00	299.00	114.00	336.26
1992	72.10	43.10	26.90	58.20	79.50	361.00	401.00	891.00	895.00	638.00	301.00	128.00	325.24
1993	75.90	49.20	46.60	48.80	88.10	160.00	357.00	660.00	728.00	877.00	347.00	260.00	310.12
1994	94.50	63.80	51.90	61.90	155.40	235.90	720.50	824.90	1261.00	744.60	279.30	150.90	388.91
1995	78.70	49.60	40.60	40.50	71.00	120.00	342.00	458.00	1000.00	817.00	276.00	134.00	286.75
1996	74.49	52.98	38.10	79.13	199.43	331.27	384.81	610.19	924.87	900.13	698.20	312.00	384.25
1997	113.55	101.53	61.86	96.02	150.32	223.13	715.10	1080.35	794.50	644.87	320.97	130.88	371.74
1998	69.65	48.34	31.76	36.51	107.15	126.35	203.94	252.35	624.40	710.03	710.13	506.97	286.61
Mean	81.71	52.56	40.15	51.18	99.90	247.02	439.55	738.75	828.37	742.55	393.28	188.55	326.75

Table 3.4 Estimated Mean Monthly Discharges at Dong Nai No.3 Dam Site (C.A. = 2,441 km^2)

(Unit : m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1979	13.03	8.53	7.51	8.74	21.19	78.29	209.41	243.69	122.11	165.08	82.74	35.69	83.72
1980	17.51	11.26	8.11	8.59	20.35	64.56	83.80	120.04	218.92	177.96	125.03	48.06	75.56
1981	23.39	16.45	8.85	9.07	19.07	94.34	82.08	212.47	160.67	169.37	95.53	48.41	78.69
1982	21.25	12.13	10.87	17.45	17.57	40.25	121.18	135.79	247.26	125.65	76.01	37.95	72.18
1983	19.50	10.82	7.91	6.97	10.73	40.41	73.52	164.27	118.61	223.74	101.42	37.54	68.43
1984	19.78	10.76	7.70	11.49	27.10	60.66	67.49	267.60	209.65	179.04	65.06	35.05	80.61
1985	16.47	10.33	9.11	15.92	35.65	79.58	84.64	114.31	143.98	156.40	74.75	42.55	65.61
1986	19.57	12.05	9.02	8.95	25.99	40.48	79.81	262.20	197.57	185.84	92.92	46.69	82.29
1987	21.53	12.08	8.60	7.77	10.33	41.63	109.48	170.43	190.90	149.27	83.26	38.18	70.65
1988	18.98	12.03	8.65	10.83	14.81	46.46	63.71	77.05	102.12	165.14	94.53	31.51	54.06
1989	16.72	9.66	11.36	14.17	34.96	58.19	121.67	143.75	181.01	147.20	58.88	25.53	68.97
1990	15.07	9.61	9.94	9.15	11.39	105.57	97.06	205.39	236.90	149.50	115.69	40.71	84.08
1991	19.94	12.10	8.60	9.50	14.72	27.60	109.48	182.62	248.40	195.27	68.77	26.22	77.34
1992	16.58	9.91	6.19	13.39	18.29	83.03	92.23	204.93	205.85	146.74	69.23	29.44	74.98
1993	17.46	11.32	10.72	11.22	20.26	36.80	82.11	151.80	167.44	201.71	79.81	59.80	71.33
1994	21.74	14.67	11.94	14.24	35.74	54.26	165.72	189.73	290.03	171.26	64.24	34.71	89.45
1995	18.10	11.41	9.34	9.32	16.33	27.60	78.66	105.34	230.00	187.91	63.48	30.82	65.95
1996	17.13	12.19	8.76	18.20	45.87	76.19	88.51	140.34	212.72	207.03	160.59	71.76	88.59
1997	26.12	23.35	14.23	22.08	34.57	51.32	164.47	248.48	182.74	148.32	73.82	30.10	85.50
1998	16.02	11.12	7.30	8.40	24.64	29.06	46.91	58.04	143.61	163.31	163.33	116.60	65.92
Mean	18.79	12.09	9.24	11.77	22.98	56.81	101.10	169.91	190.52	170.79	90.45	43.37	75.20

Table 3. 5 Estimated Mean Monthly Discharges at Dong Nai No.4 Dam Site (C.A. = 149 km^2)

(Unit : m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1979	1.13	0.74	0.65	0.76	1.84	6.81	18.21	21.19	10.62	14.35	7.19	3.10	7.28
1980	1.52	0.98	0.71	0.75	1.77	5.61	7.29	10.44	19.04	15.47	10.87	4.18	6.57
1981	2.03	1.43	0.77	0.79	1.66	8.20	7.14	18.48	13.97	14.73	8.31	4.21	6.84
1982	1.85	1.05	0.95	1.52	1.53	3.50	10.54	11.81	21.50	10.93	6.61	3.30	6.28
1983	1.70	0.94	0.69	0.61	0.93	3.51	6.39	14.28	10.31	19.46	8.82	3.26	5.95
1984	1.72	0.94	0.67	1.00	2.36	5.27	5.87	23.27	18.23	15.57	5.66	3.05	7.01
1985	1.43	0.90	0.79	1.38	3.10	6.92	7.36	9.94	12.52	13.60	6.50	3.70	5.71
1986	1.70	1.05	0.78	0.78	2.26	3.52	6.94	22.80	17.18	16.16	8.08	4.06	7.16
1987	1.87	1.05	0.75	0.68	0.90	3.62	9.52	14.82	16.60	12.98	7.24	3.32	6.14
1988	1.65	1.05	0.75	0.94	1.29	4.04	5.54	6.70	8.88	14.36	8.22	2.74	4.70
1989	1.45	0.84	0.99	1.23	3.04	5.06	10.58	12.50	15.74	12.80	5.12	2.22	6.00
1990	1.31	0.84	0.86	0.80	0.99	9.18	8.44	17.86	20.60	13.00	10.06	3.54	7.31
1991	1.73	1.05	0.75	0.83	1.28	2.40	9.52	15.88	21.60	16.98	5.98	2.28	6.73
1992	1.44	0.86	0.54	1.16	1.59	7.22	8.02	17.82	17.90	12.76	6.02	2.56	6.52
1993	1.52	0.98	0.93	0.98	1.76	3.20	7.14	13.20	14.56	17.54	6.94	5.20	6.20
1994	1.89	1.28	1.04	1.24	3.11	4.72	14.41	16.50	25.22	14.89	5.59	3.02	7.78
1995	1.57	0.99	0.81	0.81	1.42	2.40	6.84	9.16	20.00	16.34	5.52	2.68	5.74
1996	1.49	1.06	0.76	1.58	3.99	6.63	7.70	12.20	18.50	18.00	13.96	6.24	7.70
1997	2.27	2.03	1.24	1.92	3.01	4.46	14.30	21.61	15.89	12.90	6.42	2.62	7.43
1998	1.39	0.97	0.64	0.73	2.14	2.53	4.08	5.05	12.49	14.20	14.20	10.14	5.73
Mean	1.63	1.05	0.80	1.02	2.00	4.94	8.79	14.78	16.57	14.85	7.87	3.77	6.54

Table 3.6 Mean Daily Discahrges Observed at New Straemflow Gauging Sation Installed Near the Dong Nai No.3 Dam Site

Location : Dong Nai No.3 Dam Site
C.A. : 2,441 km2
Year : 1999

(Unit : m3/sec)

Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	---	---	---	---	---	---	300.46	294.91	255.94	150.71	202.29	114.58
2	---	---	---	---	---	---	213.31	275.70	326.93	150.71	173.32	140.17
3	---	---	---	---	---	---	161.76	286.37	339.73	138.47	179.29	469.95
4	---	---	---	---	---	---	173.32	395.23	350.41	136.78	213.31	271.43
5	---	---	---	---	---	---	143.63	369.62	322.66	140.17	282.10	243.63
6	---	---	---	---	---	---	165.56	341.87	282.10	158.02	506.23	211.08
7	---	---	---	---	---	---	191.62	318.39	246.07	206.66	337.60	183.35
8	---	---	---	---	---	---	175.30	297.04	231.69	250.97	241.22	185.39
9	---	---	---	---	---	---	122.19	271.43	213.31	248.51	213.31	135.10
10	---	---	---	---	---	---	125.33	238.81	199.70	229.34	197.98	148.92
11	---	---	---	---	---	---	119.10	211.08	211.08	202.29	200.13	133.43
12	---	---	---	---	---	---	130.15	197.98	236.42	195.85	197.98	220.10
13	---	---	---	---	---	---	191.62	185.39	222.39	163.65	200.13	173.32
14	---	---	---	---	---	---	158.02	163.65	206.66	171.36	234.05	165.56
15	---	---	---	---	---	---	128.53	150.71	187.46	175.30	197.98	177.29
16	---	---	---	---	---	222.39	103.15	156.17	169.41	246.07	175.30	175.30
17	---	---	---	---	---	213.31	91.38	161.76	227.01	227.01	159.88	131.78
18	---	---	---	---	---	184.57	104.53	224.69	183.35	204.47	177.29	147.14
19	---	---	---	---	---	154.34	103.15	234.05	138.47	303.45	163.65	128.53
20	---	---	---	---	---	165.56	123.75	255.94	133.43	365.35	126.92	100.44
21	---	---	---	---	---	173.32	103.15	322.66	126.92	208.86	120.64	95.18
22	---	---	---	---	---	135.10	136.78	290.64	120.64	187.46	165.56	97.78
23	---	---	---	---	---	119.10	120.64	297.04	116.07	195.85	224.69	90.14
24	---	---	---	---	---	108.75	110.19	358.95	130.15	380.29	150.71	88.92
25	---	---	---	---	---	111.64	286.37	275.70	158.02	566.00	120.64	78.56
26	---	---	---	---	---	125.33	336.53	258.62	171.36	378.16	111.64	78.56
27	---	---	---	---	---	215.56	275.70	234.05	163.65	307.72	113.10	80.76
28	---	---	---	---	---	215.56	311.99	208.86	187.46	246.07	103.15	76.41
29	---	---	---	---	---	191.62	311.99	193.73	167.48	236.42	141.89	72.29
30	---	---	---	---	---	331.20	331.20	260.75	---	248.51	105.92	75.36
31	---	---	---	---	---		320.52	224.69		224.69		69.35
Mean	---	---	---	---	---	177.82	182.93	256.66	207.79	233.71	191.26	147.09
Max.	---	---	---	---	---	331.20	336.53	395.23	350.41	566.00	506.23	469.95
Min.	---	---	---	---	---	108.75	91.38	150.71	116.07	136.78	103.15	69.35

Note : "---" means that no records are available.

Table 3.7 Annual Maximum Basin Average Daily Rainfall for the Project Catchment

No	Year	Date of Occurrence	Annual Maximum Basin Average Daily Rainfall (mm)
1	1950	Jul. 4	83.0
2	1951	Mar. 18	69.1
3	1952	Oct. 20	260.5
4	1953	Sep. 20	47.0
5	1954	Aug. 28	50.5
6	1955	Oct. 30	62.5
7	1956	Oct. 5	47.2
8	1957	Sep. 17	53.6
9	1958	Aug. 20	65.3
10	1959	Jul. 22	63.7
11	1960	Oct. 1	63.6
12	1961	Jun. 25	58.8
13	1962	Jul. 30	58.8
14	1963	Sep. 29	53.9
15	1964	Dec. 11	113.2
16	1965	Sep. 17	42.9
17	1966	Sep. 18	69.9
18	1967	Sep. 29	94.9
19	1968	Oct. 20	52.0
20	1969	Jul. 19	57.7
21	1970	Oct. 28	54.2
22	1971	Sep. 19	76.9
23	1972	Sep. 4	49.7
24	1974	Sep. 28	82.7
25	1977	Sep. 25	66.7
26	1978	Oct. 7	69.5
27	1979	Nov. 18	97.3
28	1980	Oct. 2	60.0
29	1981	Oct. 14	55.3
30	1982	Mar. 25	65.5
31	1983	Oct. 17	62.2
32	1984	Aug. 30	34.5
33	1985	Sep. 18	54.1
34	1986	Oct. 1	82.9
35	1987	Sep. 16	65.3
36	1988	Nov. 7	47.5
37	1989	May 20	47.4
38	1990	Jun. 16	62.5
39	1991	Apr. 5	68.0
40	1992	Jun. 26	34.6
41	1993	Oct. 28	34.0
42	1994	Jun. 28	51.2
43	1995	Oct. 7	47.7
44	1996	May 16	54.9
45	1997	Sep. 14	39.1

Table 3.8 Runoff Coefficients for Major Floods at Ta Lai SGS

Year	Rainfall (mm)	Runoff Depth (mm)	Rainfall Loss (mm)	Runoff Coefficient
1979	1,151	573	578	0.50
1982	1,870	865	1,005	0.46
1984	1,489	832	657	0.56
1986	1,062	489	573	0.46
1987	369	235	134	0.64
1990	1,308	681	627	0.52
1991	1,508	876	632	0.58
1993	1,581	753	828	0.48
			Average	0.52
			Max.	0.64
			Min.	0.46

Table 3.9 Suspended Load Concentrations at Ta Lai SGS

Date			Daily Discharge	Sediment Consentration
Year	Month	Day	(m^3/sec)	(g/m^3)
1985	Jul.	13	424.0	50.0
		26	301.0	69.8
	Aug.	10	587.0	61.0
		15	614.0	75.1
		26	712.0	138.2
		29	647.0	38.3
	Sep.	4	445.0	52.4
		6	566.0	41.9
		10	810.0	63.5
		15	673.0	62.1
		20	770.0	81.3
		22	665.0	90.7
	Oct.	3	912.0	157.9
		4	1060.0	215.1
		6	961.0	137.4
		7	844.0	69.7
		11	703.0	62.6
		14	788.0	51.9
		18	614.0	50.7
		25	545.0	41.8
		29	466.0	40.3
	Nov.	3	381.0	23.5
		15	326.0	25.3
		21	280.0	11.5
		25	241.0	6.8
	Dec.	3	202.0	0.7
		6	244.0	5.9
		9	216.0	4.6
1986	Jan.	6	100.0	24.1
		13	90.2	28.2
		25	70.4	15.8
	Feb.	7	57.3	6.1
		16	52.4	5.4
	Mar.	3	42.6	4.2
		13	34.2	5.6
		28	40.0	4.4
	Apr.	10	32.0	13.1
		14	51.3	7.2
	May	1	28.0	6.2
		3	26.0	6.8
		18	133.0	19.5
		19	289.0	54.0
	Jun.	1	115.0	16.0
		19	249.0	24.3
		24	399.0	78.7
	Jul.	12	322.0	34.8
		16	438.0	74.7
	Aug.	5	606.0	146.9
		6	733.0	119.2
		7	1230.0	294.3
		9	1320.0	165.2
		10	1480.0	156.8
		11	1560.0	103.2
		28	1070.0	26.5
	Sep.	1	846.0	21.0
		5	906.0	90.6
	Oct.	22	662.0	53.0
		30	529.0	68.2
	Nov.	9	359.0	18.7
		19	655.0	166.4
	Dec.	28	148.0	9.7
1987	Jan.	1	119.0	3.1
		9	104.0	4.2
		23	78.5	5.5
	Feb.	4	64.7	11.1
		16	49.1	8.1
	Apr.	27	22.3	3.6
	May	21	72.8	68.7
	Jun.	16	227.0	55.9
		18	324.0	59.0
		19	427.0	98.6
		21	452.0	95.1
		24	200.0	35.4
		26	148.0	30.6
		29	287.0	44.9
	Jul.	2	391.0	83.6
		5	527.0	110.1
		14	1400.0	771.4
		15	995.0	182.9
		16	697.0	104.3
		17	600.0	91.3
		19	664.0	99.4
		23	552.0	73.9
		24	470.0	70.4
		30	357.0	62.7
	Aug.	16	760.0	207.9
		20	456.0	106.6
		21	1170.0	906.0
		21	1930.0	1233.2
		25	1230.0	203.3
		26	1080.0	135.2
		27	974.0	98.5
		29	890.0	17.3
	Sep.	16	864.0	75.1
		18	1330.0	254.1
	Oct.	7	827.0	34.5
		26	512.0	28.3
	Nov.	14	431.0	39.9
	Dec.	3	261.0	5.9
		31	111.0	0.6
1988	Jan.	1	111.0	0.2
		13	89.4	0.1
		21	68.8	0.4
		30	59.8	0.2
	Mar.	3	43.8	2.5
		13	37.6	1.4
		16	36.3	1.7
		18	35.0	1.6
		21	34.2	1.7
		28	31.4	1.9
	Apr.	26	63.8	1.1
	May	15	77.0	4.5
	Jun.	4	107.0	9.3
		6	271.0	96.3
		6	300.0	182.0
		9	206.0	79.1
		10	161.0	12.5
		17	342.0	37.1
		24	180.0	207.6
	Jul.	13	235.0	38.7
		16	432.0	104.4
		21	382.0	41.1
	Aug.	1	590	84.4
		2	553	49.4
		5	501	9.0
	Sep.	13	273	57.5
		23	788	209.4
		24	712	129.1
		29	908	134.4
	Oct.	8	1120	48.5
		10	1230	64.0
		11	1020	27.0
		12	879	29.7
		21	670	39.0
	Nov.	9	831	278.0
	Dec.	13	143	3.4
		31	90	1.2
1989	Jan.	1	92.2	1.8
		15	71.8	2.1
		31	60.9	1.2
	Feb.	18	39.9	1.2
		26	33.3	0.9
	Mar.	14	27.4	1.0
	Apr.	2	50.5	8.9
		21	72.8	10.3
	May	8	112.0	23.0
		21	195.0	21.3
		22	328.0	53.7
		25	252.0	73.8
	Jun.	20	138.0	30.0
		24	348.0	74.1
		27	493.0	95.9
	Jul.	10	692.0	100.3
		12	546.0	80.2
		13	449.0	59.5
		22	934.0	106.4
		24	846.0	35.9
	Sep.	8	1150.0	126.1
		9	1110.0	99.1
		10	978.0	81.1
		11	895.0	79.6
		18	798.0	71.3
	Oct.	31	373.0	26.8
	Nov.	11	291.0	13.2
		13	269.0	4.4
		21	202.0	1.9
		27	164.0	1.4
	Dec.	2	147.0	8.7
		8	123.0	8.0
		12	116.0	5.2
		15	108.0	5.0
		19	101.0	5.6
1990	Jan.	1	80.9	3.3
		5	77.0	4.9
		19	62.1	2.2
		22	60.4	1.1
	Feb.	12	42.7	8.4
		16	39.6	10.8
	Mar.	12	53.0	7.9
		21	31.1	8.6
	Apr.	3	36.9	7.2
		14	22.5	10.9
	May	1	34.7	4.4
		26	104.0	5.3
	Jun.	7	170.0	16.4
		8	146.0	16.6
		12	231.0	18.4
		14	343.0	25.6
	Jul.	10	283.0	16.3
		21	459.0	49.7
	Aug.	9	566.0	25.4
		15	660.0	35.5
		17	1300.0	68.8
		21	1070.0	36.5
		26	1380.0	41.4
		29	1520.0	61.9
	Sep.	16	837.0	28.9
	Oct.	2	886.0	94.7
		6	782	74.9
		19	623	101.3
		26	489	85.7
		30	435	75.4
	Nov.	3	372	41.4
		28	314	25.8
	Dec.	2	257	21.6
		12	197	12.7