REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

AUGUST 2011

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REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

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AUGUST 2011

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REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000-2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT

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LIST OF ABBREVIATION

AAF	Annual Average Flow
AE	Actual Evaporation
AAGR	Average Annual Growth Rate
AKSB	Air Kelantan Sdn Bhd
AN	Ammoniacal Nitrogen
ARI	Average Recurrence Interval
BAKU	Bekalan Air Kelantan Utara
BCM	Billion Cubic Metres
BKSA	Badan Kawal Selia Air Pahang /State Water Regulatory Body
BLS	Barat Laut Selangor
BOD	Biochemical Oxygen Demand
BRH	Bernam River Headworks
COD	Chemical Oxygen Demand
CAPEX	Capital Expenditure
CORPRI	Corporatization/Privatization
CNII	Critical National Information Infrastructure
COAG	Council of Australian Government
CST	Centralised Septic Tanks
DAINET	Development Alternatives Information Network
DBKL	Dewan Bandaraya Kuala Lumpur
DID	Department of Irrigation and Drainage / Jabatan Pengairan dan Saliran
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOE	Department of Environment / Jabatan Alam Sekitar
DSA	Drought Sequence Analyses
DSS	Decision Support System
DVS	Department of Veterinary Services Malaysia
ECER	Eastern Corridors Economic Region
ECM	Energy Commission of Malaysia
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPU	Economic Planning Unit (Federal)
EQA	Environmental Quality Act
ESCP	Erosion and Sediment Control Plan
Eto	Evapo-transpiration

LIST OF ABBREVIATION

FAO	Food and Agriculture Organisation
FR	Forest Reserves
FT	Federal Territory / Wilayah Persekutuan
FTPP	Fair Trade Practices Policy
FTWCR	Federal Territories Water Resources Council
FTWRD	Federal Territories Water Resources Department
FWRD	Federal Water Resources Division
GDP	Gross Domestic Product
GEV	General Extreme Value
GIS	Geographical Information System
GNP	Gross National Product
GWh	Gigawatt-hour
GWh/a	Gigawatt-hours per annum
GWP	Global Water Partnership
ha	hectare
HEP	Hydro-electric Project
IADA	Integrated Agricultural Development Area
IADP	Integrated Agricultural Development Project
ICM	Integrated Catchment Management
ICZM	Integrated Coastal Zone Management
ICWE	International Conference on Water and the Environment
IFM	Integrated Flood Management
IFR	In-Flow-Requirement
ILBM	Integrated Lake Basin Management
INWQS	Interim National Water Quality Standard
IP	Intellectual Property
IPP	Independent Power Producer
IRBM	Integrated River Basin Management
IST	Individual Septic Tanks
ISRWT	Inter-State Raw Water Transfer
IUCN	International Union for the Conservation of Nature
IWK	Indah Water Konsortium Sdn Bhd
IWRM	Integrated Water Resources Management
IWRSNR	IWRS - Northern Region of Peninsular Malaysia
JAS	Jabatan Alam Sekitar / Department of Environment
JBA	Jabatan Bekalan Air / Water Supply Department

LIST OF ABBREVIATION

JICA	Japanese International Cooperation Agency
JKR	Jabatan Kerja Raya / Public Work Department
JMG	Jabatan Mineral dan Geosains / Department of Minerals and Geo-Science
JPS	Jabatan Pengairan dan Saliran / Department of Irrigation and Drainage
JPSPN	Jabatan Pengurusan Sisa Pepejal Negara
KeTTHA	Kementerian Tenaga, Teknologi Hijau Dan Air Malaysia / Ministry of Energy, Green Technology and Water Malaysia
KKM	Kementerian Kesihatan Malaysia / Ministry of Health
km	Kilometre
kW	kilowatt
KWB	Kuching Water Board
kWh	kilowatt-hour
LAP	Lembaga Air Perak
LPPP	Laporan Penyiasatan Pengeluaran Padi
l/c/d or lcd	litres/capita/day
l/w/d of lwd	litres/worker/day
LNG	Liquefied Natural Gas
LN2P	Log-normal 2- parameter
LN3P	Log-normal 3-parameter
LSAN	Lembaga Sumber Air Negeri Kedah
LUAS	Lembaga Urus Air Selangor / Selangor Water Management Authority
LUAN	Lembaga Urus Air Kedah / Kedah Water Resource Board
MADA	Muda Agricultural Development Authority
MAF	Mean Annual Flood
MAM	Mean Annual Minimum
MAR	Mean Annual Catchment Rainfall
MARDI	Malaysian Agricultural Development Institute
MC&I	Malaysian Criteria & Indicator
MCM	Million Cubic Metres
MD	Maximum Demand
ME	Multiple Effect
MHLG	Ministry of Housing and Local Government
Ml	Million Litres
Mld	Million Litres Per Day

LIST OF ABBREVIATION

MMD	Malaysian Meteorological Department / Jabatan Meteorologi Malaysia
MNC	Multinationals Company
MNMP	Malaysian National Medicine Policy
MOH	Ministry of Health
MoNRE/NRE	Ministry of Natural Resources and Environment Malaysia
MP	Malaysia Plan
MSF	Multi-stage Flash
MSMA	Manual Saliran Mesra Alam
MVA	Manufacturing Value-added
MW	Megawatt
m3/s	Cubic metres/second
NAHRIM	National Hydraulic Research Institute of Malaysia
NAM	Non-aligned Movement
NATIP	National Timber Industry Policy
NCER	Northern Corridors Economic Region
NDWQSP	National Drinking Water Quality Surveillance Programme
NERC	National Environment Research Council
NGO	Non Government Organisation
NIPP	National Intellectual Policy
NLC	National Land Council
NREO	Natural Resources and Environment Ordinance
NRW	Non Revenue Water
NWI	National Water Initiative
NWMS	National Water Market System
NWQMS	National Water Quality Management Strategy
NWRC	National Water Resources Council
NWRD	National Water Resources Department
NWRL	National Water Resources Law
NWRP	National Water Resources Policy
NWRS	National Water Resources Study
NWSC	National Water Services Commission
OIC	Organization of Islamic Conference
OPP3	Third Outline Perspective Plan
PAAB	Pengurusan Aset Air Berhad
PCC/pcc	Per capita consumption
PDMP	Power Development Master Plan

LIST OF ABBREVIATION

PE	Population Equivalent
PFR	Permanent Reserved Forests
PGMS	Pacific Garbage Management Systems
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PPA	Power Purchase Agreement
PSMP	Power Systems Development Master Plan
PTG	Pejabat Tanah dan Galian / Land and Mines Department
PWD	Public Works Department / Jabatan Kerja Raya
RBC	Rotating Biological Contractor
RC	Reinforced Concrete
RDC	Regional Development Corridor
RDZ	Regional Demand Zone
RO	Reverse Osmosis
SAINS	Syarikat Air Negeri Sembilan Sdn Bhd
SAIP	Sabah Agro-Industrial Precinct
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
SAMB	Syarikat Air Melaka Berhad
SAP	Sabah Agricultural Policy
SBCP	Sapangar Bay Container Port
SCORE	Sarawak Corridors of Renewable Energy
SDC	Sabah Development Corridor
SESB	Sabah Electricity Sdn Bhd
SESCO	Sarawak Electricity Supply Company
SEB	Sarawak Energy Berhad
SFMLA	Sustainable Forest Management License Agreement
SFZ	Sapangar Free Zone
SITExT	Sandakan Integrated Trade Exchange Terminal
SMI	Small And Medium Industry
SPAN	Suruhanjaya Perkhidmatan Air Negara / National Water Services Commission
SSMP	Sabah Shoreline Management Plan
STIDC	Sarawak Timber Industry Development Corporation
STP	Sewage Treatment Plant
SWB	Sibu Water Board
SWR	State Water Resources
SWRA	State Water Resources Agency
SWRC	State Water Resources Council
SWRD	State Water Resources Department

LIST OF ABBREVIATION

SWRTC	State Water Resources Technical Committee
SYABAS	Syarikat Bekalan Air Selangor Sdn Bhd
TCM	Total Catchment Management
TEM	Transient electromagnetic
TNB	Tenaga Nasional Berhad
Tonnes/ha	Metric tons per hectare
TOR	Terms of Reference
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UPEN	Unit Perancang Ekonomi Negeri / State Economic Planning Unit
URS	Conduct a User Requirements Study
VC	Vapour Compression
WAMCO	Water Asset Management Company
WDM	Water Demand Management
WF	Water for the Future
WHO	World Health Organization
WP	Wilayah Persekutuan / Federal Territory
WQI	Water Quality Index
WQIP	Water Quality Improvement Plan
WRP	Water Resources Plans
WRDMC	Water Resources Development and Management Corporation
WSIA	Water Services Industry Act 2006
WTP	Water Treatment Plant
WWC	World Water Council

SECTION 1

INTRODUCTION

Section 1 INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND

Perlis covers an area of 821 km^2 and is located on the north-western most region of Peninsular Malaysia, bordered by parts of southern Thailand to the north and Kedah to the south. The geography of the State is made up mainly of alluvial plains, with highlands in the north and west adjoining to the limestone of the Nakwan range.

The landuse of the State is mainly under agriculture, where the major crops grown are paddy, rubber, fruits and sugarcane. Water supply and irrigation needs come from the Timah-Tasoh Dam and Rancangan Pengairan Muda. The major town centres such as Kangar, Padang Besar, Arau and Ulu Pauh have been earmarked for further development and hence, existing paddy lands will be converted to urban landuse. Livestock and fisheries industries are also important in Perlis.

The sections below provide details of the Study on the economics, demography, surface water hydrology, ground water availability, potable water demand, irrigated paddy water demand, non-paddy agriculture water demand, alternative sources of water, irrigation water demand, hydropower, water resource analysis, sewerage, flood mitigation, river sedimentation, river navigation, coastal, existing raw water quality, for the engineering components. The environmental and non-engineering aspects of the Study include water quality, landuse, forestry, environmental flows, fisheries, livestock and solid wastes, all of which are seen in the context of sustainability of water resources. In total, all these will culminate in the development of projects pertaining to water resources, in particular, potable water supply through exploitation of surface water, ground water, irrigation projects and in some areas for hydropower development.

1.2 COVERAGE OF THIS REPORT

The State report will cover the engineering and environmental aspects of the water resources development in the State. The subject matter covered in the Perlis State Report is as follows:

Section 2	-	Economic and Demography
Section 3	-	Surface Water Hydrology
Section 4	-	Ground Water
Section 5	-	Alternative Water Source
Section 6	-	Water Demand - Potable Water
Section 7	-	Water Demand - Irrigation
Section 8	-	Water Demand - Non Paddy Cultivation
Section 9	-	Water Demand - Animal Husbandry
Section 10	-	Hydropower
Section 11	-	Sewerage
Section 12	-	Flood Mitigation

Section 13 - River Sedimentation
Section 14 - River Transportation
Section 15 - Coastal Aspects
Section 16 - Environmental Aspects
Section 17 - Water Resources Analysis
Section 18 - Development Works
Section 19 - Environmental Evaluation Of Identified Immediate Works Projects

1.3 SUMMARY OF KEY FACTORS – WATER DEMAND AND AVAILABILITY

From the foregoing section, the aspect of water demands and the availability of water resource within the State from the different sectors are summarized below. This summary gives an overall insight to the water needs of the State in relation to the degree water resource that available and regulated in the State, and whether there is a need for the importation of raw water from neighbouring states.

A key element in water resources is the water demand by the various demand sectors. The water demand by the various sectors are measured in various units, million litres per day (MLD) for potable water supply, acre-feet for irrigation, or alternatively as million cubic metres per annum (MCM). It may be convenient for water resources planning to simplify and rationalise all water demand in the common denominator of rainfall. The water demand in millimetres (mm) rainfall for the State is derived by dividing the annual water demand for the State by the State's total land area. With this it would be convenient to regard the water demand in a particular State as a "how much rain that falls in the particular State is required to satisfy the total and various water demand sectors". This then becomes a measure on how sufficient the State's surface water resource is to meet its own water requirements, and how dependent the State is on interstate water transfer to meet its future requirements.

Table 1.1 below shows the water resources available in terms of rainfall for the various States. It can be seen that Perlis receives among the lowest rainfall in the country.

Table 1.1 - Available Rainfall in Malaysia

State	State Area (sq km)	Rainfall (mm)	Actual Evaporation (mm)	Ground Water Recharge (mm)	Surface Runoff (mm)
Perlis	**821**	**1,880**	**1,290**	**120**	**470**
Kedah	9,500	2,310	1,430	130	750
Pulau Pinang	1,048	2,350	1,430	120	800
Perak	21,035	2,480	1,320	170	990
Selangor	8,396	2,190	1,280	150	760
Negeri Sembilan	6,686	1,830	1,210	130	490
Melaka	1,664	1,880	1,210	100	570
Johor	19,210	2,470	1,130	200	1,140
Pahang	36,137	2,470	1,250	120	1,100
Terengganu	13,035	3,310	1,470	150	1,690
Kelantan	15,099	2,600	1,290	140	1,170
West Malaysia	132,631	2,495.5	1,283.8	147.6	1,064.0
Sabah	73,631	2,560	1,190	190	1,180
Sarawak	124,450	3,640	1,250	240	2,150
FT Labuan	91	3,100	1,480	150	1,470
East Malaysia	198,172	3,238.5	1,227.8	221.4	1,789.3
Malaysia	**330,803**	**2,940.6**	**1,250.3**	**191.8**	**1,498.5**

The water demands for the various sectors of potable water, irrigation, non-paddy agriculture crops, animal husbandry and fisheries are tabulated in **Table 1.2**. They are expressed in MCM and mm per year so that a comparison can be made with the available rainfall in the state.

Of the 5 sectors, 4 sectors, namely, potable water, irrigated paddy, non-paddy irrigation and animal husbandry are consumptive users whereas fisheries constitute a non-consumptive user as the waters are only used for circulation in the pond to provide aeration. Water abstracted from the river is returned a short distance from the abstraction point.

The sufficiency for surface water resource is analysed for the consumptive use of water.

Table 1.2 - Water Demand for Various Sectors In Perlis

Sectors	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
	Water Demand MCM per year					Water Demand mm rainfall per year				
Potable Water Demand	54.8	61.3	65.3	70.1	75.2	66.7	74.7	79.6	85.4	91.6
Irrigated Paddy	198.0	184.0	165.0	155.0	141.0	241.2	224.1	201.0	188.8	171.7
Non-Paddy Crops	52.0	52.0	52.0	52.0	52.0	63.3	63.3	63.3	63.3	63.3
Livestock	0.9	1.7	3.3	6.5	12.8	1.1	2.1	4.1	8.0	15.6
Total consumptive water demand	***305.6***	***299.0***	***285.7***	***283.6***	***281.0***	***372.3***	***364.2***	***348.0***	***345.5***	***342.3***
Fisheries	9.4	10.4	11.5	12.7	14.1	11.5	12.7	14.0	15.5	17.1
Total demand	**315.1**	**309.5**	**297.2**	**296.4**	**295.1**	**383.8**	**376.9**	**362.0**	**361.0**	**359.4**

Table 1.3 shows the total water demand in mm/year of rain as compared with the available rainfall less runoff.

It is estimated that about 70% of the runoff is "lost" to the sea by way of flood discharge. Of the remaining 30%, about half (15%) can be considered available for use for all sectors and hence considered as "effective rainfall". The full 30% is not adopted as the last river water intake is not located at the river mouth, and hence not able to capture the full total amount of water. Another is the impact of saline intrusion that makes abstraction of raw water not feasible.

"Effective rainfall" is used as an index and not as an absolute amount. The index indicates the state of affairs with regard to the availability of unregulated flows without dams that can capture part of the high flows.

Table 1.3 – Total Water Resource Demand in Perlis (mm rainfall per year)

Year	Runoff	Estimate % available (15%)	Total consumptive water demand	Deficit
2010	470	70.5	372.3	(301.8)
2020	470	70.5	364.2	(293.7)
2030	470	70.5	348.0	(277.5)
2040	470	70.5	345.5	(275.0)
2050	470	70.5	342.3	(271.8)

It can be seen that Perlis is in deficit for water. The deficit reduces with time as it is projected that with increasing irrigation efficiency, the water demand will be reduced. Irrigation is the largest user of water in the State and with work focused on water demand management in this sector, much can be achieved. Even so Perlis will continue to be dependent on Kedah for its water needs.

Figure 1.1 shows the water demand in various sectors as compared with the available water in the State.

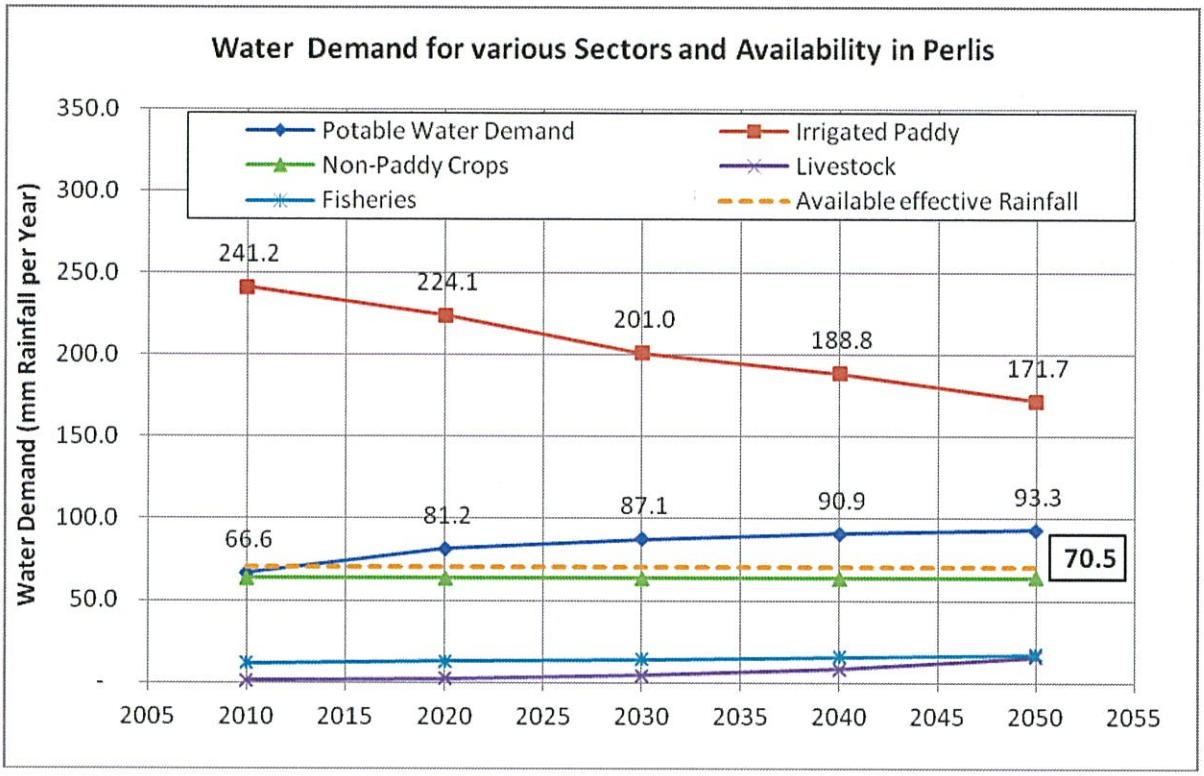


Figure 1.1 – Water Demand in Various Sector

SECTION 2

ECONOMICS AND DEMOGRAPHY

Section 2

ECONOMICS AND DEMOGRAPHY

2.0 ECONOMICS AND DEMOGRAPHY

2.1 MALAYSIAN ECONOMIC ANALYSIS

2.1.1 Overview of Malaysia Economy 2000 – 2010

2.1.1.1 Gross Domestic Product Performance, 2000 – 2010

Table 2.1 shows Malaysia economic performance between 2000 and 2010. The figures are in RM million at constant 2000 price. Like other economies, the Malaysian economy during the past decade was also affected by the adverse world economy. During the same period, the Malaysian GDP experienced a low growth of 0.6% in 2001, a high growth of 8.9% in 2003 and negative growth of 1.7% in 2009. The national average annual growth rate (AAGR) over the 10-year period was 4.2%.

Table 2.1 - Economic Performance 2000 – 2010 – GDP Malaysia (Value at constant 2000 prices)

Year	Value (in RM billion)	Average Growth Rate(%)
2000	356.4	-
2001	358.4	0.57
2002	366.6	2.27
2003	399.4	8.96
2004	426.5	6.78
2005	449.3	5.33
2006	475.5	5.85
2007	504.9	6.18
2008	528.3	4.63
2009	519.3	-1.7
2010	535.9	3.2
AAGR (2000 – 2010)	-	**4.2**

Source: Annual Economic Report, Treasury (2000 – 2010)
Department of Statistics, Malaysia

Note: 1. For 2009, the figure was based on the Prime Ministers' statement and Bank Negara Media Statements.
2. 2010 Figure was reviewed based on the latest statement by the Prime Minister on new target for Malaysia GDP growth rate (i.e. from initial 2.53% to 5.5% [an average of 5% and 6% target]).

2.1.1.2 GDP Performance by Major Economic Activities 2000 – 2010

Table 2.2 shows Malaysia GDP performances by major economic sectors between 2000 and 2010. The 2010 figures are the Treasury estimates as reported in the 2009/2010 Economic Reports and the 2009/2010 National Budget.

Table 2.2 - Economic Performance 2000 – 2010 – GDP Malaysia
Value in RM billion at constant 2000 prices

Key Economic Sectors	2000		2006		2010		AAGR
	RM bil	%	RM bil	%	RM bil	%	(%)
Agriculture	30.6	8.6	37.7	7.9	39.8	7.4	2.6
Mining & Quarrying	37.6	10.6	42.0	8.8	41.8	7.8	1.1
Manufacturing	110.0	30.9	147.2	30.9	137.5	25.7	2.2
Construction	14.0	3.9	14.6	3.1	16.7	3.1	1.8
Services	175.7	49.3	247.1	52	307.3	57.3	5.8
Utilities	10.7	3	14.5	3.1	15.5	2.9	3.8
Wholesale & Retail	40.0	11.2	54.8	11.5	70.7	13.2	5.9
Accommodation & Restaurant	8.0	2.2	10.7	2.2	13.5	2.5	5.4
Transport and Storage	13.9	3.9	17.4	3.7	20.0	3.7	3.8
Communication	11.0	3.1	17.8	3.7	23.0	4.3	7.6
Finance & Insurance	32.6	9.2	48.6	10.2	62.1	11.6	6.7
Real Estate & Business Services	15.7	4.4	22.7	4.8	28.3	5.3	6.1
Other Services	21.3	6	27.2	5.7	33.1	6.2	4.5
Government Services	22.6	6.3	33.4	7	41.0	7.7	6.2
Miscellaneous	(11.5)	-3.2	(13.1)	-2.8	(7.2)	-1.3	4.4
Undistributed FISIM (-)	17.3	4.9	18.4	3.9	13.5	2.5	3.1
Import Duties (+)	5.8	1.6	5.3	1.1	6.3	1.2	-0.1
Total	**356.4**	**100**	**475.5**	**100**	**535.9**	**100**	**4.2**

Source: 1. Annual Economic Reports, Treasury 2009-2010
2. Department of Statistics, Malaysia (for 2000 and 2006)
Note: FISIM = Financial Intermediation Services Indirectly Measured

(i) Agriculture

The agriculture sector continues to record declining average annual growth rate (AAGR) of 2.6% between 2000 and 2010. It contribution to the GDP also continues a declining trend from 8.6% in 2000 to 7.4% in 2010. In 1990, this sector contribution was much higher at 16.3%.

The main agriculture activity contributor to the GDP[1] is palm oil. This sector contribution accounts for 32% of the agriculture sector contribution to GDP. In 2009, oil palm was greatly affected by the significant drop in production due to low yield although palm oil price remain stable. The contribution of rubber remains low, dropped from 5.5% in 2008 to 4% in 2009 due to continued decline in price. Whilst planted land area for palm oil record an

1 Based on 2009 performance

increase, land area for rubber has reduced significantly to 1.237 million hectares from almost 1.6 million hectares in 1990. Planted land area for palm oil in 2009 was 4.575 million hectares compared to 0.8 million in 1990.

Forestry contribution is also significant, contributing about 17% to the agriculture sector. However, this sector records a decline over the last 2 years; 5.6% in 2008 and 14.3% in 2009. Fisheries contribution accounts for about 18% in 2009 compared to 16% in 2008. Two significant factors are increased landing (marine produces) and aquaculture produces. Other agriculture produces include paddy, vegetable, commercial fruits, tea, flowers and tobacco.

(ii) Mining and Quarry

This subsector records a low average annual growth at only 1% between 2000 and 2010. Its contribution to the GDP also drops from 10.6% in 2000 to 8.8% in 2006 and 7.8% in 2010. The main contributor is oil and gas. Two factors that affect this sector is lower production due to lower demand by major importers and generally low average market price. The impact of the price hike in 2006 and 2007 did not generate significant impact on output due to reduced demand. In fact even the consumption of liquefied natural gas (LNG) by USA, China and India increased significantly, the price drops to its lowest of the decade to USD31 per barrel in 2008.

(iii) Manufacturing

The impact of economic slowdown on manufacturing sector is shown by the low average annual growth rate of 2.2% between 2000 and 2010. This sector was worst hit in 2009 and recorded a huge drop of 12.1% compared to 2008. The sharp decline in performance was due to deterioration in especially export oriented industries. This sector contribution to GDP also recorded significant drop from average 30% to 26.4% in 2009 and 25.7% in 2010.

Despite the declining export, Malaysia manufacturing sector does not experience major shift in importance with the contribution of the domestic-oriented industries increase slightly from 45.0% in 2000 to 46% in 2010 (45.8% in 2009) while the export-oriented industries drops from 55% to 54%. This indicates Malaysia manufacturing sector's continued dependence on export market and parallel impact on the domestic-oriented industries.

Three main manufacturing activities that remain the threshold of the sector are electrical and electronic products and petroleum products on the export-oriented subsector and chemical and chemical products on the domestic-oriented subsector. The three contribute about 57% of total manufacturing output. Other export oriented industries include textile, apparel and foot ware, wood and wood products, rubber products, machinery and equipment and medical, optical and scientific equipment. On the domestic-oriented

industries, the activities include plastics product, food product, transport equipment, off-estate processing and fabricated metal products.

Impact of manufacturing dependence on export market is having a toll on Malaysia manufacturing sector. Cheap labor elsewhere is making production cost in Malaysia more expensive. Option for cheap labor to high productivity is due to the fact that cost of initial investment on high productivity operation is relatively higher when return is on long term. Thailand has become more attractive since labor is not only cheap but productivity in manufacturing is considered as relatively at par to Malaysia. Similarly, in certain industries such as electronic, Malaysia does not hold advantage to India.

(iv) Construction

The construction sector is among the economic activities badly hurt by economic slowdown. This sector recorded a relatively low average growth rate of 1.8% for this decade. Between 2004 and 2006, this sector record negative growth for 3 consecutive years. Only after this the construction sector managed to improve slightly with significant growth rate of 4.7% in 2007.To assist this sector, the Government exercises two stimulus packages in 2008 and 2009 and subsequently this sector manage to record annual growth exceeding 3% for 2009 and 2010. The Government spent more than RM 14 billion in 2009 to implement 84,730 projects that include low and medium-cost housing, public sector building and roads.

Construction sector performance is parallel to economic development. This sector performance between 1990 and 1997 was at its peak when the Malaysian economy was at its peak. And the construction sector always need public sector stimulus when the economy slows over more than 2 years while recovery takes a longer period.

(v) Services

Malaysia is experiencing a shift in economic dependence from agriculture to manufacturing and now to services sector. Between 2000 and 2010, the services sector saw a significant increase in its contribution to Malaysia GDP; from 49.3% to 57.3%. This shift in economic sector performance is in line with the general trend that developed countries economic structure is largely dependent on services sector[2]. Since Malaysia is heading toward a developed nation by 2020, the probability is Malaysia economy will further shift to higher contribution of the services sector; current target is 62.5% of national GDP. This element has to be given a thought by the consultant when projecting future water demand/consumption due to the different population equivalent for manufacturing and services activities.

2 This is the general assumption by the respective head of states in Malaysia through various reports by their consultants on Develop State status. Refer to reports on Selangor Maju 2005 and Melaka Maju 2010. This is also highlight as a precondition for Malaysia Maju 2020.

The wholesale and retail subsector accounts for 23% of the services sector total and is the largest contributor to the GDP among the services sector activity. Its contribution to national GDP in 2010 is 13.5% in 2010 compared to 11.2% in 2000. This sector records a higher than national average AAGR of 5.9% between 2000 and 2001. The main contributor of this subsector is consumption goods.

The finance and insurance subsector is the second highest contributor to the services sector with 20.0%. This sector contribution to the national GDP is 11.8%. This subsector expanded at a relatively high annual growth rate of 6.7% between 2000 and 2010; the second highest growth rate among the economic activities. The growth is supported by steady financing activities for consumer credit, business investment and loans to small and medium entrepreneurs.

The Accommodation and Restaurant subsector indicates the support for tourism activities in Malaysia. The value added of this subsector accounts for only 2.6% of total GDP. Nevertheless this does not reflect the scope of Malaysia tourism industry since this industry runs across other subsectors; retail, transport, communication and other services. This sector has expanded by 5.4% between 2000 and 2010 which is quite consistent to the growth of the tourism industry within the decade.

Performance of the Government Services subsector also expanded higher than the national average. This sector record an AAGR of 6.2% and its contribution to national GDP also increased from 6.3% to 7.8%. This nevertheless does not speak well on the privatization impact of Government services. However, this element is also an indicator on the future institutions demand for water.

2.1.2 Growth Corridors – Northern Corridors Economic Region (NCER)

The NCER development plan, which encompasses the states of Kedah, Perak, Perlis and Penang, vision is to achieve a world-class economic region by the year 2025. It aims to become a sustainable economic region empowered by a population living a balanced lifestyle with a holistic approach to business.The rationale behind NCER was to increase the competitiveness level of the country in order to facilitate improvement in the standard of living of the nation.

The NCER contributes to over a third of Malaysia's manufacturing exports. One of the strategies of the NCER blueprint is to see that the region becomes the high-tech electronic hub of the region. expanding from the currently predominant assemblies and test activities to higher value-added activities.

One of the Northern Corridor's initiatives is to make Malaysia the centre of excellence (CoE) for certain specialisations in the Electricals & Electronics (E&E) sector including:

- Silicon Design

- Automation Design
- Materials and Packaging Design

The objective is to increase the local capability to perform R&D in these areas in the region. The Northern Corridor initiatives also aim to move the E&E sector up the value chain from assembly and test activities to cutting and polishing silicon wafers, chip design and wafer fabrication.

(i) NCER Objectives

The three objectives of NCER are;

- To help the region reach its maximum economic potential and bridge the developmental and income gap between the different states.
- To move the Malaysian economy towards higher value-added and knowledge based economic activities to increase income per capita.
- To develop the region in targeted economic areas that emphasize on community involvement.

(ii) NCER Economic Strategy

a. Agriculture

The NCER is the agricultural centre of the country, and it is aiming to upgrade its efficiency in production by restructuring technologies used, as well as implementing methods to conform with commercial scale holders. The targets are;

- Increase agricultural exports from RM32 billion to RM48 billion.
- Increase paddy yields from 4 tonnes per hectare to 8 tonnes per hectare.
- Increase average profit per hectare of cultivated land to RM10,000 per hectare per annum.
- Increase the amount of agricultural land utilised from around 800,000 hectares to 1 million hectares.

b. Manufacturing

The electrical and electronic (E&E) sector is one of the major contributors to the nation's economy.The conversion of the region into a high-tech

electronics hub enriches higher value-added activities including wafer fabrication, chip design, automation design, and materials or packaging research and development. In addition to E&E, other manufacturing sub-sectors that will be promoted are downstream agriculture, oil and gas, biotechnology, automotive, and sustainable materials. The targets for 2012 are;

- Increased investments in the Northern region manufacturing sectors from RM16.5 billion in 2006 to RM24.3 billion.
- Increased percentage of the manufacturing sector's workforce involved in high value-added activities to 30%.
- Increase value-added activities as a percentage of manufacturing output to 30%.

c. Tourism

Key Tourism areas in the North such as Langkawi and Pulau Pinang will have their expenditure increased, enhancing and expanding the size of the industry to attract higher revenue-yielding tourists.

The NCER will also be touted as the regional medical tourism hub in Asia by providing high-quality and more affordable medical specialists and procedures. The Region will be known as a centre of excellence for areas such as cardiac care and oncology, globally-accredited hospitals and highly-qualified medical and healthcare professionals

2.1.3 GDP Projection 2011 – 2020

Between 2000 and 2009, global economy experience significant impact from fluctuating economic performance of world major economic leaders; United State, Japan and China. In 2006, the crisis faced by the United State had a far reaching impact on world economy. The collapse of a global housing bubble which peaked in the U.S. in 2006, caused the values of securities tied to housing to plummet thereafter, damaging financial institutions globally. Questions regarding bank solvency, declines in credit availability, and damaged investor confidence had an impact on global stock markets, which suffered large losses during late 2008 and early 2009. Economies worldwide slowed during this period as credit tightened and international trade declined.

Whilst the impact of the 1997 crisis saw Malaysian GDP dipped by 7%, the impact of the extended 2007 and 2008 crisis saw Malaysian GDP dropped by 3% in 2009. Malaysia GDP recorded an average 7.1% growth in the 1990s (1990-2000) but the growth rate dropped to 3.8% in the 2000s (2000-2010).

Currently, there is no sign of certainty on what lay ahead to lead the economy. On the one hand, the United States economy has shown some recovery though most economists considered at a slow rate but her unemployment rate is relatively high. Her banking and

financial structure has not fully recovered from the infamous subprime lending. Since the United State crisis also badly affected Europe economy, global economic recovery depends very much on the recovery of Europe economy.

Malaysia has also seen a changing economic structure. Since late 1990s, Malaysia manufacturing sector has experience a significant structural change; reduced export, relocation of manufacturing plants to other countries (with cheap labor), reduced foreign investment and increasing focus on production of domestic demand. Malaysian investors are also seeking opportunity to establish manufacturing plants outside Malaysia.

On her way towards a developed nation, Malaysia concentration is on improving the service sector activities. The importance of the final services sector, which includes accommodation and restaurant and wholesale and retail activities is growing corresponding to the national objective of making Malaysia a popular tourist destination. Both Manufacturing becomes the determining factor in projecting National GDP to 2020.

This study provides 3 growth scenarios for Malaysia GDP until 2020. The basic understanding is the assumption that Malaysia GDP average annual growth rate will not exceed the 1990s average annual growth rate (7.1%) nor will it be lower than the 2000s mean average annual growth rate (3.2%). In the absence of significant indicator on the global economy, the study adopts the official economic projection as documented in the respective planned with some adjustment to the economic performance between 2000 and 2010. For details, please refer to the main report.

The following **Table 2.3** is the New Economic Model projected National GDP up to 2020 announced by the Prime Minister in 2010. Technically the table is accepted as the official projection for Malaysian economic performance till 2020. Since the figures are very recent and announced by the Prime Minister himself, we are using this figures as our base to determine for future GDP. This is consistent with our high growth projection although the NEM projected a slightly higher growth rate. The difference however is quite significant i.e. about 8%.

Table2.3 - GDP 2010 – 2020, Malaysia

Sector	Year (Value in RM Billion)			Year (Value in %)			AAGR 2011-2015	AAGR 2016-2020
	2010	2015	2020	2010	2015	2020		
Agriculture	40.2	46.7	53.2	7.2	6.3	5.1	3.1	2.6
Mining	41.9	44.3	46.6	7.5	5.9	4.4	1.1	1.0
Manufacturing	138.9	181.5	245.1	25.0	24.3	23.3	2.5	6.2
Construction	17.0	20.6	24.0	3.1	2.8	2.3	3.9	3.2
Services	317.0	453.8	682.4	57.2	60.7	64.9	7.4	8.5
GDP Total	**555.0**	**746.9**	**1,051.3**	**100.0**	**100.0**	**100.0**	**6.1**	**6.9**

Source: New Economic Model, Prime Minister's Department

2.1.4 GDP PROJECTION 2020 – 2050

2.1.4.1 Overall Projection

The GDP projection for 2020 – 2050 is based on the NEM 2011 – 2020 GDP projection. **Table 2.4** describes 3 possible scenarios for Malaysian economy as follows:

(i) Declining GDP Growth of with constant rate of 0.5% for every five years planning period.

(ii) Declining GDP Growth of with constant rate of 1.0% for every ten years planning period.

(iii) Declining GDP Growth of with reduce rate of 0.1% for every five years planning period. It means that for every five years, the GDP growth rate will reduce at a reduce rate of 0.1 point.

The projection is based on the following assumptions:

(i) Taking the Prime Ministers order as achievable, the study assumes that by 2020, Malaysia will become a developed nation status.

(ii) And taking the historical examples of developed nation, the GDP growth will decline and sustain around a small growth rate percentage. Nevertheless, this study assumes that by 2050, Malaysia GDP will still exceed 3.5%.

(iii) Declining growth rate is due to the increasing contribution of the services sector to the overall GDP.

Table 2.4 - GDP Projection 2016 – 2050, Malaysia

Scenario	Scenario 1		Scenario 2		Scenario 3	
Year	RM billion	AAGR (%)	RM billion	AAGR (%)	RM billion	AAGR (%)
2016 – 2020	1,051	6.9	1,051	6.9	1,051	6.9
2020 – 2025	1,407	6.0	1,400	5.9	1,407	6.0
2025 – 2030	1,839	5.5	1,865	5.9	1,821	5.3
2030 – 2035	2,347	5.0	2,369	4.9	2,291	4.7
2035 – 2040	2,925	4.5	3,009	4.9	2,815	4.2
2040 – 2045	3,558	4.0	3,644	3.9	3,392	3.8
2045 – 2050	4,226	3.5	4,412	3.9	4,029	3.5

Source: 2020:New Economic Model, Prime Minister's Department

2.1.4.2 Projection by Economic Sector

To provide the GDP projection by economic sectors, the study assumes that sectors' performance is somewhat stable and does not change invariably over time. The projection was based on the respective sector contribution assumed in the following Table 2.5. One significant assumption is reducing contribution of the mining sector based on the assumed reduced contribution of petroleum. Despite the insinuation of lower contribution of the manufacturing sector, this study assumes a constant contribution rate for this sector throughout the planning period.

Table 2.5 - Assumed Sectors Contribution to GDP, 2020 – 2050

Economic Sector	Year (Value in %)						
	2020	2025	2030	2035	2040	2045	2050
Agriculture	5.0	5.0	5.0	5.0	4.0	4.0	4.0
Mining	4.5	2.9	2.9	2.9	2.5	2.5	2.5
Manufacturing	24.3	22.0	22.0	22.0	22.0	22.0	22.0
Construction	2.3	2.4	2.4	2.4	2.2	2.2	2.2
Services	64.9	67.7	67.7	67.7	69.3	69.3	69.3
GDP Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Based on the above sectors' contribution, the following **Table 2.6** indicates the projected Malaysia GDP by sector between 2020 and 2050. This projection is based on Scenario 2, the GDP projection adopted by this study as the GDP base for projecting future demand for water.

Table 2.6 - GDP Projection by Sector 2020 – 2050, Malaysia

Year	Value in RM million							AAGR (%)
	2020	2025	2030	2035	2040	2045	2050	
Agriculture	53	70	93	118	120	146	176	4.1
Mining	47	41	54	69	75	91	110	2.9
Manufacturing	245	308	410	521	662	802	971	4.7
Construction	24	34	45	57	66	80	97	4.8
Services	682	948	1,263	1,604	2,085	2,525	3,058	5.1
GDP Total	**1,051**	**1,400**	**1,865**	**2,369**	**3,009**	**3,644**	**4,412**	**4.9**

2.1.5 Comparative States GDP performance

The state economic data for 2005, 2006, 2007 and 2008 is based on the state GDP report prepared by the Department of Statistics and the Economic Planning Unit (EPU) of the Prime Ministers' Department. The 2009 and 2010 data is estimates.

The reason for using the EPU figures instead of data from the respective states is due to the discrepancies arising from the GDP total from state data to total national GDP. By using the

EPU figures, the total state GDP is consistent to total national GDP. Moreover, as announced by the Minister in the Prime Minister's Department, the EPU figures for state GDP derived is based on acceptable international standard and is conducted by the Department of Statistics and EPU with the assistance of internationally recognized agencies.

2.1.5.1 GDP Performance by States 2000 – 2010

Table 2.7 and Table 2.8 show the respective state GDP between 2000 and 2010. **Table 2.7** indicates the GDP in monetary value and **Table 2.8** indicates the state contributions to national GDP in percentages. The figures are based on 2000 constant prices. The 2005, 2006, 2007 and 2008 figures are official figures from the Department of Statistics and EPU (Prime Ministers' Department).

Two important elements in the table need clarification. It is noted that there is an item called supra state in the table. Supra State covers production activities that beyond centre of predominant economic interest for any states in Malaysia. Supra States is shown only from 2005 onwards. Year 2000 and earlier, there is no such subject/division of states. Technically, supra states involves mining and quarrying sector (actually this refers to petroleum and gas component). Another element is the state GDP distribution for 2009 and 2010. The distribution method by states was based on the average performance/percentage distribution of the previous 4 years (2005-2008).

Table 2.7 - GDP by States, 2000 – 2010 (value in RM million)

State\Year	Adjusted Data (2000 Base)	Published/Official Data (2000 Base)				Estimated Data (2000 Base)		AAGR (%)
	2000	2005	2006	2007	2008	2009	2010	
Johor	39,651	44,276	46,498	48,044	50,040	50,219	53,033	2.9
Kedah	15,381	15,475	16,632	18,081	18,153	18,326	19,483	2.4
Kelantan	8,567	7,538	7,985	8,583	9,273	8,768	9,310	0.8
Melaka	10,406	12,064	13,072	13,901	14,385	14,249	15,094	3.8
Negeri Sembilan	11,469	16,243	17,695	18,691	19,353	19,219	20,335	5.9
Pahang	13,964	20,667	22,080	22,614	24,217	23,709	24,989	6.0
Pulau Pinang	29,307	37,779	41,516	44,264	46,744	45,238	47,916	5.0
Perak	29,034	23,930	25,503	26,986	28,518	27,789	29,433	0.1
Perlis	2,305	2,561	2,615	2,784	2,890	2,871	3,048	2.8
Selangor	75,675	96,008	100,884	108,527	116,883	110,910	117,824	4.5
Terengganu	21,575	12,425	13,258	14,125	14,715	14,488	15,361	4.3
FT Kuala Lumpur	43,955	58,701	63,931	69,713	73,536	70,439	74,884	5.5
Peninsula Malaysia	301,290	347,667	371,669	396,313	418707	406,225	430,710	3.6
Sabah	19,596	25,286	26,647	27,844	29,827	28,910	30,577	4.6
Sarawak	33,893	43,878	45,560	48,540	49,484	49,939	53,000	4.6
FT Labuan	1,622	2,110	2,191	2,303	2,272	2,387	2,529	4.5
East Malaysia	55,111	71,274	74,398	78,687	81,583	81,237	86,106	4.6
Supra State	-	30,309	29,457	29,919	28,021	31,868	33,673	2.1
TOTAL	**356,401**	**449,250**	**475,524**	**504,919**	**528,311**	**519,330**	**550,489**	4.4

Source: 1. Annual Economic Reports, Treasury 2009-2010
2. Department of Statistics, Malaysia (for 2000 and 2005- 2008)

Note: AAGR of 2.1 for Supra States is for a period between 2005 and 2010.
Terengganu AAGR is calculated between 2005 and 2010.
For 2010, GDP Total for Malaysia is slightly different than Table 2.1 because the figures for states are raw data. This figure is referred from here onward.

Table 2.8 - GDP by States, 2000 – 2010

State\Year	Adjusted Data (Value in %)	Published/Official (Value in %)				Estimated (Value in %)	
	2000	2005	2006	2007	2008	2009	2010
Johor	11.1	9.9	9.8	9.5	9.5	9.7	9.6
Kedah	4.3	3.4	3.5	3.6	3.4	3.5	3.5
Kelantan	2.4	1.7	1.7	1.7	1.8	1.7	1.7
Melaka	2.9	2.7	2.7	2.8	2.7	2.7	2.7
Negeri Sembilan	3.2	3.6	3.7	3.7	3.7	3.7	3.7
Pahang	3.9	4.6	4.6	4.5	4.6	4.6	4.5
Pulau Pinang	8.2	8.4	8.7	8.8	8.8	8.7	8.7
Perak	8.1	5.3	5.4	5.3	5.4	5.4	5.3
Perlis	0.6	0.6	0.5	0.6	0.5	0.6	0.6
Selangor	21.2	21.4	21.2	21.5	22.1	21.4	21.4
Terengganu	6.1	2.8	2.8	2.8	2.8	2.8	2.8
FT Kuala Lumpur	12.3	13.1	13.4	13.8	13.9	13.6	13.6
Peninsula Malaysia	84.5	77.4	78.2	78.5	79.3	78.2	78.2
Sabah	5.5	5.6	5.6	5.5	5.6	5.6	5.6
Sarawak	9.5	9.8	9.6	9.6	9.4	9.6	9.6
FT Labuan	0.5	0.5	0.5	0.5	0.4	0.5	0.5
East Malaysia	15.5	15.9	15.6	15.6	15.4	15.6	15.6
Supra State	-	6.7	6.2	5.9	5.3	6.1	6.1
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: 1. Annual Economic Reports, Treasury 2009-2010
2. Department of Statistics, Malaysia (for 2000 and 2006)

2.1.5.2 Manufacturing Sector GDP Performance 2005 – 2008 by States

Table 2.9 shows the respective states contribution to the national manufacturing sector in 2005, 2006, 2007 and 2008. Selangor's manufacturing is the largest accounting for 27.5% of national manufacturing GDP valued at RM 40,125 million in 2008. Pulau Pinang and Johor is second and third accounting for 17.2% and 11.9% respectively. Kelantan, Perlis and FT Labuan contributions are very small with total contribution for the three states account for less than 1%. The study does not anticipate significant change in this performance trend between 2009 and 2010.

Table 2.9 - GDP by State – Manufacturing Sector, 2005 – 2008
(Value in Constant year 2000 prices)

State	Value (in RM million)				% to National Total			
	2005	2006	2007	2008	2005	2006	2007	2008
Johor	17,441	17,810	17,946	17,285	13.27	12.68	12.4	11.9
Kedah	5,934	6,450	7,128	6,342	4.52	4.59	4.9	4.3
Kelantan	381	355	366	400	0.29	0.25	0.3	0.3
Melaka	6,139	6,702	6,841	6,895	4.67	4.77	4.7	4.7
Negeri Sembilan	8,517	9,405	9,765	9,847	6.48	6.70	6.8	6.8
Pahang	6,399	7,139	7,077	7,309	4.87	5.08	4.9	5.0
Pulau Pinang	20,575	23,457	24,274	25,072	15.66	16.71	16.8	17.2
Perak	4,739	5,333	5,489	5,765	3.61	3.80	3.8	3.9
Perlis	329	324	304	328	0.25	0.23	0.2	0.2
Selangor	37,409	37,859	38,384	40,125	28.47	26.96	26.6	27.5
Terengganu	4,056	4,477	4,793	4,741	3.09	3.19	3.3	3.2
Sabah	2,411	2,489	2,543	2,613	1.84	1.77	1.8	1.8
Sarawak	12,329	13,433	14,033	13,865	9.38	9.57	9.7	9.5
FT Kuala Lumpur	4,270	4,471	4,834	4,994	3.25	3.18	3.3	3.4
FT Labuan	461	704	646	456	0.35	0.50	0.4	0.3
TOTAL	**131,388**	**140,407**	**144,423**	**146,037**	**100.00**	**100.00**	**100.0**	**100.0**

Source: 1.Department of Statistics, Malaysia, 2009 and 2010
2.Economic Planning Units, Prime Ministers' Department, 2009 and 2010

2.1.5.3 Services Sector GDP Performance 2005 – 2008 by States

Table 2.10 shows the respective states services sector GDP performances between 2005 and 2008. FT Kuala Lumpur and Selangor are the two most significant contributors to the national services sector. The two contributes almost 47% of national services sector GDP amounting to RM 122 billion. FT Labuan and Perlis are the least each contribution accounts for only 0.6% of national services sector GDP in 2008.

Table 2.13 - 4 Northern States GDP Performance; 2010 – 2050, Malaysia (Value in RM million)

State\Year	Adjusted Data (2000 Base)	Published/Official Data (2000 Base)				Estimated Data (2000 Base)		AAGR (2005-2010) (%)
	2000	2005	2006	2007	2008	2009	2010	
Kedah	15,381	15,475	16,632	18,081	18,153	18,326	19,483	4.7
Pulau Pinang	29,307	37,779	41,516	44,264	46,744	45,238	47,916	4.9
Perak	29,034	23,930	25,503	26,986	28,518	27,789	29,433	4.2
Perlis	2,305	2,561	2,615	2,784	2,890	2,871	3,048	3.5
4Northern States Total (4NST)	**76,027**	**79,745**	**86,266**	**92,115**	**96,305**	**94,224**	**99,880**	**4.6**
MALAYSIA	**356,401**	**449,250**	**475,524**	**504,919**	**528,311**	**519,330**	**550,489**	**4.2**
Perlis/4NST (%)	**3.0**	**3.2**	**3.0**	**1.9**	**3.0**	**3.0**	**3.1**	-
Perlis/Malaysia (%)	**0.6**	**0.6**	**0.5**	**0.6**	**0.5**	**0.6**	**0.6**	-

Source: 1.Department of Statistics, Malaysia, 2009 and 2010
2.Economic Planning Units, Prime Ministers' Department, 2009 and 2010

Table 2.14 - 4 Northern States Projected GDP; 2010 – 2050, Malaysia

State	Year (Value in RM million)					AAGR (%)	
	2010	2020	2030	2040	2050	2010-2050	2020-2050
Kedah	19,483	37,531	62,713	107,611	159,971	5.4	4.9
Pulau Pinang	47,916	91,245	151,169	269,634	384,848	5.3	4.9
Perak	29,433	60,701	103,791	187,210	260,459	5.6	5.0
Perlis	3,048	5,697	9,209	16,126	23,832	5.3	4.9
4Northern States Total (4NST)	**99,880**	**195,174**	**326,882**	**580,581**	**829,110**	**5.4**	**4.9**
MALAYSIA	**550,489**	**1,051,328**	**1,865,000**	**3,009,000**	**4,412,060**	**5.3**	**4.9**
Perlis/4NST (%)	**3.1**	**2.9**	**2.8**	**2.8**	**2.9**	-	-
Perlis/Malaysia (%)	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	-	-

Table 2.12 - Projected GDP by States, 2010 – 2050, Malaysia

State	Year (Value in RM million)					AAGR(%)	
	2010	2020	2030	2040	2050	2010-2050	2020-2050
Johor	53,033	102,117	180,262	296,852	424,743	5.3	4.8
Kedah	19,483	37,531	62,713	107,611	159,971	5.4	4.9
Kelantan	9,310	19,672	32,839	57,511	86,634	5.7	5.1
Melaka	15,094	29,337	48,652	83,788	124,440	5.4	4.9
N.Sembilan	20,335	38,198	63,485	107,991	159,590	5.3	4.9
Pahang	24,989	48,236	81,153	137,355	203,307	5.4	4.9
Pulau Pinang	47,916	91,245	151,169	269,634	384,848	5.3	4.9
Perak	29,433	60,701	103,791	187,210	260,459	5.6	5.0
Perlis	3,048	5,697	9,209	16,126	23,832	5.3	4.9
Selangor	117,824	232,312	444,157	672,357	1,000,134	5.5	5.0
Terengganu	15,361	30,554	51,098	88,499	132,235	5.5	5.0
FT Kuala Lumpur	74,884	171,750	324,99	506,478	733,258	5.9	4.9
Sabah	30,577	56,835	95,493	154,088	236,040	5.2	4.9
Sarawak	53,000	88,776	150,493	241,775	381,843	5.1	5.0
FT Labuan	2,529	5,354	8,595	13,926	22,824	5.6	5.0
Supra State	33,673	33,013	56,900	67,800	77,902	2.1	2.9
TOTAL	**550,489**	**1,051,328**	**1,865,000**	**3,009,000**	**4,412,060**	**5.3**	**4.9**

Table 2.10 - GDP by State - Services Sector, 2005 – 2008
(Value in Constant year 2000 prices)

State	Value (in RM million)				% to National Total			
	2005	2006	2007	2008	2005	2006	2007	2008
Johor	20,069	21,543	23,097	25,002	9.1	9.08	8.9	8.9
Kedah	7,559	8,062	8,593	9,356	3.43	3.4	3.3	3.3
Kelantan	5,535	5,838	6,184	6,788	2.51	2.46	2.4	2.4
Melaka	5,202	5,577	6,109	6,425	2.36	2.35	2.3	2.3
Negeri Sembilan	6,172	6,622	7,284	7,792	2.8	2.79	2.8	2.8
Pahang	9,826	10,218	11,147	12,358	4.45	4.31	4.3	4.4
Pulau Pinang	15,520	16,305	18,182	19,717	7.04	6.87	7	7.1
Perak	14,913	15,764	17,109	18,322	6.76	6.64	6.6	6.6
Perlis	1,343	1,379	1,469	1,593	0.61	0.58	0.6	0.6
Selangor	48,424	53,512	60,217	65,543	21.95	22.55	23.1	23.4
Terengganu	6,803	7,086	7,524	7,978	3.08	2.99	2.9	2.9
Sabah	12,113	13,041	14,445	14,529	5.49	5.5	5.5	5.2
Sarawak	13,942	14,391	15,644	17,015	6.32	6.07	6	6.1
FT Kuala Lumpur	51,616	56,573	61,951	65,405	23.4	23.84	23.8	23.4
FT Labuan	1,556	1,367	1,542	1,689	0.71	0.58	0.6	0.6
TOTAL	**220,595**	**237,279**	**260,496**	**279,512**	**100.0**	**100.0**	**100.0**	**100.0**

Source: 1.Department of Statistics, Malaysia, 2009 and 2010
2.Economic Planning Units, Prime Ministers' Department, 2009 and 2010

2.1.5.4 Agriculture Sector GDP Performance 2005 – 2008 by States

Table 2.11 shows the respective states agriculture sector GDP performances between 2005 and 2007. Sabah and Sarawak are the two most significant contributors to the national agriculture sector. The two contributes 41% of national agriculture sector GDP amounting to almost RM 15.5 billion. FT Labuan and FT Kuala Lumpur are the least each contribution accounts for 0.2% and 0.1% of national agriculture sector GDP respectively in 2007. Selangor and Pulau Pinang, the two key industrial states account for only 4.0% and 2.1% of agriculture GDP respectively the same period. Johor, however, is the third largest with 12.4% (i.e. RM 4.7 billion) in 2007.

Table 2.11 - GDP by State - Agriculture Sector, 2005 – 2008
(Value in Constant year 2000 prices)

State	Value (in RM million)				% to National Total			
	2005	2006	2007	2008	2005	2006	2007	2008
Johor	4,578	4,962	4,697	5,344	13.0	13.3	12.4	13.6
Kedah	1,415	1,563	1,765	1,824	4.0	4.1	4.7	4.6
Kelantan	1,450	1,624	1,873	1,913	4.1	4.3	4.9	4.9
Melaka	434	515	561	658	1.2	1.4	1.5	1.7
Negeri Sembilan	1,109	1,229	1,194	1,222	3.1	3.3	3.2	3.1
Pahang	3,940	4,230	3,892	4,011	11.1	11.3	10.3	10.2
Pulau Pinang	713	790	802	824	2.0	2.1	2.1	2.1
Perak	3,602	3,737	3,854	3,876	10.1	10.0	10.2	9.8
Perlis	631	708	825	830	1.8	1.9	2.2	2.1
Selangor	1,325	1,591	1,501	1,783	3.7	4.3	4.0	4.5
Terengganu	1,159	1,254	1,235	1,445	3.3	3.4	3.3	3.7
Sabah	7,433	7,654	8,029	7,810	20.8	20.5	21.2	19.8
Sarawak	7,628	7,393	7,483	7,714	21.5	19.8	19.7	19.6
FT Kuala Lumpur	40	32	44	38	0.1	0.1	0.1	0.1
FT Labuan	67	93	91	100	0.2	0.2	0.2	0.2
TOTAL	**35,524**	**37,375**	**37,846**	**39,392**	**100.0**	**100.0**	**100.0**	**100.0**

Source: 1.Department of Statistics, Malaysia, 2009 and 2010
2.Economic Planning Units, Prime Ministers' Department, 2009 and 2010

2.1.5.5 GDP Projection by States 2010 – 2050, Malaysia

Table 2.12 indicates the projected GDP by states between 2010 and 2050. The projected GDP assumes an average annual growth rate (AAGR) of 5.3% for the planning period (2010-2050) and 4.9% between 2020 and 2050. The reason to adopt this scenario is to ensure water resources planning will take into consideration the probability high water demand due to higher economic growth.

2.1.6 Northern States GDP Performance and Projection

Table 2.13 indicates the performance of the 4 northern states of Perlis, Kedah, Pulau Pinang and Perak. Total GDP for the states is RM 79,745 in 2005 and increases at an average rate of 4.6% to reach RM 99,880 million in 2010. Total contribution to national GDP is 17.8% in 2005 and increased to 18.8% in 2010. In 2050, its' contribution is expected to remain at 18.8%. This is shown in **Table 2.14**.

2.1.7 Perlis GDP Performance

2.1.7.1 Comparing to NCER Performance

Perlis records the lowest GDP among the northern States. **Table 2.13** compares the GDPs among States within the NCER and the National performance. Perlis is among the least developed States in Malaysia. Her economy is nevertheless developing over the last five years. The GDP is only 6.3% of Pulau Pinang. The State GDP accounted for only 3.1% of the Northern States' total GDP, and 0.6% of the national GDP in 2010. The GDP average growth rate of 3.5% is lower than the national average of 4.2%.

2.1.7.2 States' GDP Performance by Sector 2005 – 2010

The economy of Perlis is among the few States which is dependent on agriculture, even though the contribution from agriculture to the national GDP is low. Manufacturing is also an important component in the State economy. However contribution from the services sector is the highest, accounting for more than half of the State GDP. This is indicated in **Table 2.15**.

Table 2.15 – Perlis GDP by Sector 2005 – 2010 (*Constant year 2000 prices*)

Year	Agriculture	Mining & Quarrying	Construction	Manufacturing	Services	Plus : Import Duties	Total
			Value in RM million				
2005	631	17	71	329	1,343	170	2,560
2006	708	16	69	324	1,379	119	2,615
2007	825	18	66	304	1,469	102	2,784
2008	830	19	64	328	1,593	56	2,890
2010	884	21	76	338	1,615	113	3,048
			% to State Total				
2005	24.6	0.7	2.8	12.9	52.4	6.6	100.0
2006	27.1	0.6	2.6	12.4	52.7	4.6	100.0
2007	29.6	0.7	2.4	10.9	52.8	3.7	100.0
2008	28.7	0.7	2.2	11.3	55.2	1.9	100.0
2010	29.0	0.7	2.5	11.1	53.0	3.7	100.0

Source:
1. Annual Economic Reports, Treasury 2009-2010
2. Department of Statistics, Malaysia (for 2005 – 2007)
3. Review NWR (2000-2050) and Formulation of NWR Policy

(i) Manufacturing

Manufacturing is one of the components of Perlis economy, contributing about 11% of the State's GDP. This sector generates more than 20% of the State employment. Unlike the more developed States, Perlis manufacturing activities are largely local oriented and the activities are mainly plastic products, electrical and electronics, scientific equipment, textiles and metal fabrication. There are less than 200 manufacturing plants in Perlis with total industrial land area of less than 125 hectares in Jejawi, Chuping, Kuala Perlis and Padang Besar. The State has nevertheless allotted another 420 hectares of land in Kuala Perlis, Ulu Pauh and Guar Nangka for industry.

(ii) Services

The services sector is the major contribution to the State GDP. It accounts for more than 53% of State GDP. This sector's contribution to employment is the highest where more than 60% of employment is within this sector activity. The State is blessed with many tourism products. However, the most popular is the border town of Padang Besar for two reasons; firstly because the town is one of the key entry point to Malaysia from Thailand and the second, the town is a popular shopping destination among Malaysians visiting the northern States. Although the town attracts visitors to Perlis, the State tourism is confined to stop-over tourists. Commerce and trading are the key activities mainly due to tourism. The public sector services contributions are also significant.

(iii) Agriculture

The contribution of agriculture is significant accounting for almost one third of State GDP. The key crop is rubber. Other key crops are sugarcane and paddy. Perlis is also facing continual manpower problems and issues related to irrigation water supply. Unlike other States, it has not seen drastic changes in landuse pattern, indicating that a need to plan for adequate water supply to the agriculture water to meet demand in future.

2.1.7.3 Projection

Table 2.16 (GDP in monetary value) and **Table 2.17** (Sector GDP contribution in percentage to total GDP) show our projections of the GDP for Perlis between 2010 and 2050. The projection for 2010 to 2020 was based on structured breakdown of performance by States and economic sectors. The State GDP was extracted from the New Economic Model projection on national GDP (see Volume 3: Section 2) and apportioned based on 2010 GDP distribution by State.

The Tables indicate that Perlis GDP will grow at an average rate of 4.9% per annum between 2010 and 2050. The State economic structure is also expected to change with a high services sector contribution to the GDP of 73% in 2050 compared to 53% in 2010.

Table 2.16 - Perlis State GDP Projection, 2010 – 2050 by Sector

Year	Sector (Value in RM million)						Total (RM mil)
	Agriculture	Mining	Construction	Manufacturing	Services	Others	
2010	884	21	76	338	1,615	113	3,048
2015	1,000	21	92	425	2,510	-	4,048
2020	1,134	21	112	600	3,830	-	5,697
2025	1,385	23	135	786	4,888	-	7,217
2030	1,695	27	172	1,032	6,238	-	9,164
2035	2,070	31	220	1,352	7,962	-	11,635
2040	2,530	36	279	1,773	10,162	-	14,780
2045	3,096	42	355	2,320	12,970	-	18,783
2050	3,754	49	452	2,880	16,697	-	23,832
AAGR	**3.7%**	**2.1 %**	**4.6%**	**5.50%**	**6.00%**	**-**	**5.3%**

Table 2.17 - Perlis State GDP Distribution by Sector, 2010 – 2050 (Value in %)

Year	Sector (Value in %)						Total (%)
	Agriculture	Mining	Construction	Manufacturing	Services	Others	
2010	29.0	0.7	2.5	11.1	53.0	3.7	100.0
2015	24.7	0.5	2.3	10.5	62.0	-	100.0
2020	19.9	0.4	2.0	10.5	67.2	-	100.0
2025	19.2	0.3	1.9	10.9	67.7	-	100.0
2030	18.5	0.3	1.9	11.3	68.1	-	100.0
2035	17.8	0.3	1.9	11.6	68.4	-	100.0
2040	17.1	0.2	1.9	12.0	68.8	-	100.0
2045	16.5	0.2	1.9	12.4	69.1	-	100.0
2050	15.8	0.2	1.9	12.1	70.1	-	100.0

2.1.8 Assumptions

The above projections were based on the following assumptions:

(i) Perlis is categorized as a developing State. Unlike most other States, it will see a gradual increase in contributions from the manufacturing sector to the State GDP. However, this sector will not increase significantly but will likely to remain at about 12% by 2050 compared to 11.1% currently.

(ii) Perlis will also experience a gradual increase in the contribution of the services sector. Tourism will remain a key contributor to the services sector and the State will continue to observe significant contributions from the public services sector of the State economy. Better border management and bilateral relationships with Thailand will improve tourist arrivals. Although tourism industry is not expected to grow significantly, it will continue to become a major contributor to the economic growth of the State.

(iii) We continue to see limitations to manufacturing in Perlis. The study does not anticipate significant expansion of industrial lands in the State. However, this sector will continue to generate new employment opportunities for the local community in view of the development in the NCER.

(iv) Commerce and trading are anticipated to lead the services sector and remain the main contributors to the services sector GDP.

(v) The agriculture sector's contribution to State GDP is expected to remain relatively high, at 15.8% in 2050. Perlis will continue to be the nation's largest producer of cane sugar. Paddy and rubber will continue to contribute to the GDP while other crop products are also expected to increase, especially cattle farming.

(vi) Between 2010 and 2050, Perlis GDP is projected to grow at an average growth rate of 5.3%. The services sector is projected to increase by 6.0%, and manufacturing by 5.5%.

2.2 DEMOGRAPHY

2.2.1 Current Status

2.2.1.1 Population and Density

According to the Department of Statistics, the estimated total population in 2010 stands at 240,100 persons with a density of 292 persons per square kilometers (**Table 2.18**). Taking into account the small size of the State, it can be considered that Perlis is densely populated.

Table 2.18 - Basic Population by Districts, 2010

Districts	Land (km^2)	Population ('000)	Population Density (persons/km^2)	Rate of Population growth (2009-2010) in %
Padang Besar	821	240.1	292	1.3
Kangar				
Arau				

Source: Department of Statistics (2010), Basic Population Characteristics by Districts, 2010

2.2.1.2 Rate of Population Growth

The State as a whole recorded a growth rate of 1.3% during the 2009 to 2010 period. Based on the Population Census of 1991 and 2000, **Table 2.19** shows the population growth rate of Perlis for the period 1991 to 2000 as 0.8% per annum over the 10-year period. Perlis was classified as a "less developed State". The significant difference in population growth rate between 2000 and 2010 could be due to the State having attained a higher developed status, or that the differential pace of economic development amongst the States due to governmental policies, attracting a larger number of population to the State through in-migration.

Table 2.19 - Population Size and Average Annual Rate of Population Growth by State 1991, 2000

	1991		2000		1991-2000
	Number	Percent	Number	Percent	Rate of growth (%)
More developed states					
Johor	2,162,400	11.8	2,740,625	11.8	2.63
Melaka	529,200	2.9	635,791	2.7	2.04
N.Sembilan	722,000	3.9	859,924	3.7	1.94
Perak	1,974,900	10.7	2,051,236	8.8	0.42
P.Pinang	1,116,800	6.1	1,313,449	5.6	1.80
Selangor	2,413,600	13.1	4,188,876	18.0	6.13
FTKL	1,226,700	6.7	1,379,310	5.9	1.30
FT Labuan	54,800	0.3	76,067	0.3	3.64
Less developed states					
Kedah	1,364,500	7.4	1,649,756	7.1	2.11
Kelantan	1,207,700	6.6	1,313,014	5.6	0.93
Pahang	1,081,100	5.9	1,288,376	5.5	1.95
Perlis	**190,200**	**1.0**	**204,450**	**0.9**	**0.80**
Sabah	1,808,800	9.8	2,603,485	11.2	4.05
Sarawak	1,718,400	9.3	2,071,506	8.9	2.08
Terengganu	808,600	4.4	898,825	3.9	1.18
Peninsula Malaysia	***14,852,500***	**80.8**	***18,599,699***	**79.9**	***2.50***
TOTAL	**18,379,700**	**100.0**	**23,274,690**	**100.0**	**2.62**

Sources: 1991 and 2000 population censuses

2.2.2 Population Projection Up to 2050

To develop the population projection to 2050, the natural population growth (births less than deaths) is augmented, taking cognizance of proposed and implemented governmental plans and policies, to include changes in urbanisation and rural distribution, workforce changes and immigration impacts.

2.2.2.1 Growth Corridor

Perlis is included under Northern Corridor Economic Region (NCER) growth corridor, with a focus on agriculture, human capital development, infrastructure, manufacturing and tourism. The total allocation for this total corridor is RM1.57 billion and the total expected investment is RM178 billion (of which RM8.05 billion had been received as at 2009). At the time of the Mid-term Review of Ninth Malaysia Plan, a total of 33 projects have been approved, but only 8 have been implemented. The necessary manpower, including foreign labour is required to meet the demands of development in these corridors. Hence, the successful implementation of these growth corridors

will have significant impact on population growth and distribution in across the regions. According to the Ninth Malaysia Plan, the development period for the NCER is from 2007 until 2025. This specific growth corridor is expected to generate a total of 3.1 million jobs in the respective region.

2.2.2.2 Assumptions for Projections

(i) Urbanisation Level

For Perlis, the level of urbanisation is considered for the State as a whole, not divided into its districts. According to the projected level of urbanisation (**Table 2.20**), Perlis will only be 80% urbanised by 2050.

Table 2.20 - Projected Level of Urbanisation in Perlis, 2010-2050

Year	2010	2015	2020	2030	2040	2050
Urbanisation Level (%)	35	42	50	60	70	80

(ii) Workforce

The two percent sample tape of the 2000 Population and Housing Census from DOS is used to project workforce population to year 2050. The workforce is grouped into agriculture, manufacturing, and services and others sectors.

These distributions are used as basis for projection up to 2050. **Tables 2.21-2.22** show the distribution of working population by main industrial group district for the year 2000-2050.

Table 2.21 - Percentage Distribution of Workers by Main Industrial Groups By District In Perlis, 2000

State	Main Activity Status				Total
	Urban	Agriculture and fishery	Manufacturing	Services	
Perlis	35.2	24.5	13.6	61.8	100

Table 2.22 - Percentage Distribution of Workers by Main Industrial Groups in Perlis, 2010-2050

Year	2010			2015			2020			2030			2040			2050		
Sectors	A	M	S	A	M	S	A	M	S	A	M	S	A	M	S	A	M	S
Perlis	24	15	61	23	16	61	22	16	62	21	17	62	20	17	63	20	17	63

Note: A= Agriculture, M=Manufacturing, S= Services and others

The proportion of working population engaged in agriculture is projected to decline gradually up to 2040 and held constant thereafter. The services and other sectors will remain the main industry in large urban centres where demand for domestic water consumption is greatest. The trend is projected

to continue to 2050 with more than 60% of the distributions falls under this sector. (**Figure 2.1**).

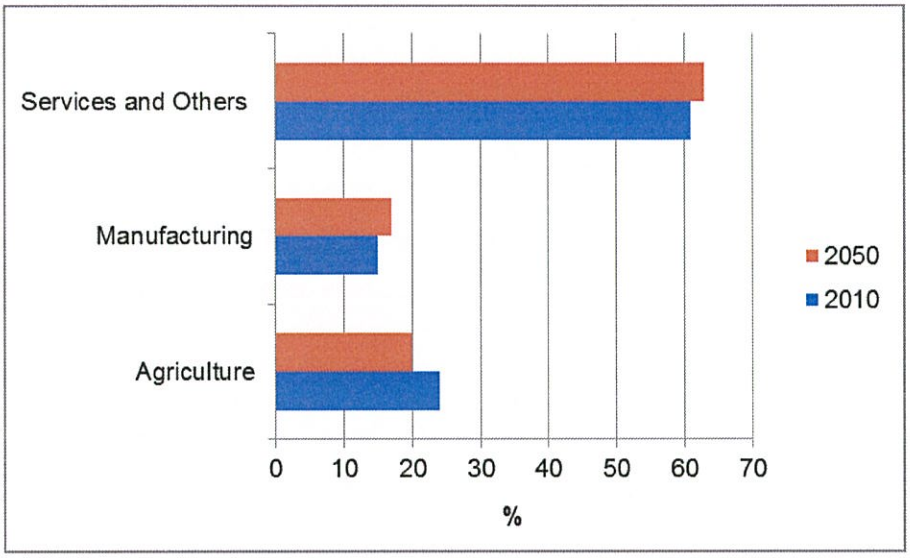


Figure 2.1 - Percentage Distribution of Workers for Main Economic Sector in 2010 and 2050

2.2.2.3 Population Projections for Perlis and its Districts

Apart from the above-mentioned assumptions, the National population projection up to 2050 is obtained under high, medium and low variant scenarios. Under the **high variant** projection (using the projected figures by DOS), foreign workers are assumed to make up 16% of the population by 2020 and increasing to more than 25% by 2050. The **medium variant projection** assumed foreign workers to make up about 13% to 14% of the population. The **low variant projection** assumed a national 1.5 million foreign workers throughout the projection period. The 1.5 million foreign workers is the cap proposed by the foreign worker laboratory (NST, 14, April, 2010).

The National population is projected for the period 2010-2050 based on the cohort component method, using the Demproj programme developed by Future Groups International. The total fertility rate is assumed to decline from the current level of about 2.4 per woman to 2.2 in 2020 and 2.1 in 2030 and thereafter remains at 2.0 throughout the projection period. Given the low mortality rate, increase in life expectancy will have a relatively small effect on population growth. For State and district level projections, since data on births, deaths and migration are not readily available, past trends in the rate of population growth and the location of growth corridors are used as a guide for distributing the projected national population to the State and district levels.

The State population projection under the three variants is presented in **Figure 2.2** it shows a steady and paralleled increasing trend for the medium and low variant projections from 2010 to 2050. However, for the high variant projection, the trend increases substantially more than the other two variants from year 2020 onwards.

The State total level of projection is presented in **Table 2.23.** More detailed projection of urban and rural population distribution is in **Table 2.24**.

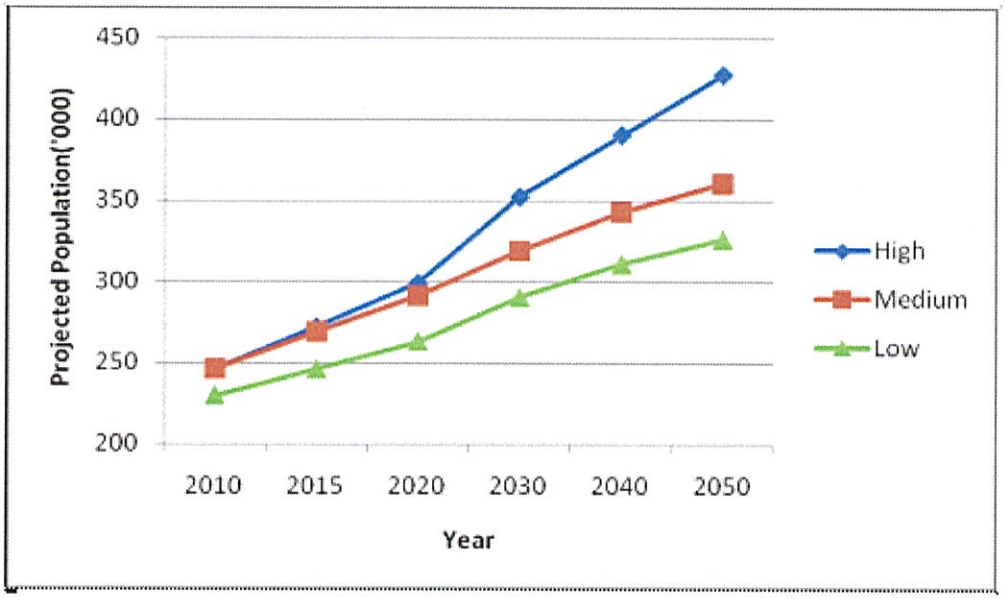


Figure 2.2 - Total Population Projection Growth for the State of Perlis, 2010-2050

Table 2.23 - Population Projections ('000) under High, Medium and Low Variant Assumption for Perlis

Variant/ Year	2010	2015	2020	2030	2040	2050
High	246	272	299	352	390	427
Medium	246	269.3	291.4	319.3	342.9	360.5
Low	229.8	246.1	263.3	290.5	311.1	326.4

Table 2.24 - Estimated urban and rural population ('000) based on the high, medium and low variant projection

Perlis	Total						Urban						Rural					
Year	2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050
High	246	272	299	352	390	427	103	125	150	211	273	341	143	147	150	141	117	85
Medium	246	269.3	291.4	319.3	342.9	360.5	103	124	146	192	240	288	143	145	146	128	103	72
Low	229.8	246.1	263.3	290.5	311.1	326.4	97	113	132	174	218	261	133	133	132	116	93	65

SECTION 3

SURFACE WATER - HYDROLOGY

Section 3

SURFACE WATER HYDROLOGY

3.0 SURFACE WATER – HYDROLOGY

3.1 INTRODUCTION

This Section describes the hydrological study for the State of Perlis. Hydrological analyses are required in this Study to establish the parameters and input data necessary for the water resources assessment. Compilation, collation and analysis of the long-term historical hydrological data (rainfall, streamflow, and evaporation) are prerequisites to the quantification of various hydrologic variables and parameters for the assessment of water resources availabilities and other future engineering undertakings in the Study area.

The previous NWRS (2000) Study was reviewed and updated wherever relevant and form the basis for this Study. Besides NWRS (2000) Study, the following studies were also reviewed whenever found relevant to this Study:

(i) National Water Resources Study, Malaysia, 1982 (*NWRS JICA 1982*)

(ii) Water Resources Master Plan, Negeri Sabah, 1994 (*WRMP Sabah 1994*)

(iii) Assessment of the Current Water Resources Availability and Demand/Consumption for the states of Sabah, Sarawak to complement the Previous Water Resources Study for Peninsular Malaysia, 2006 (*WR Sabah and Sarawak 2006*)

(iv) Integrated Water Resources Study for Northern Region of Peninsular Malaysia, 2009 (*IWRSNR 2009*)

(v) Sarawak Integrated Water Resources Management Master Plan Study, 2009 (*IWRMPS Sarawak 2009*)

The previous studies were reviewed and the water resources availability was reworked with the additional hydrological data obtained over the period between the studies. To fulfill the objective of this Study, the following tasks were carried out *in tandem*. The tasks include:

(i) Review of past water resources studies and reports.

(ii) Collate and compile up-to-date hydrological records from JPS and other agencies.

(iii) Carry out data screening, correction and gap-filling of missing data.

(iv) Derive long term monthly and annual rainfalls and evapotranspiration for general assessment of water resources availability.

(v) Derive monthly drought rainfalls for irrigation studies.

(vi) Derive 1-day and 7-day low flows and 36-month drought sequence for the key streamflow stations for run-of-river and dam storage yield analysis.

(vii) Derive 1-day and 7-day low flows and 36-month drought sequence for the ungauged sites using various flow transposition methods or regional analysis.

(viii) Derive design flood peaks of various ARI for the key streamflow stations.

3.2 GENERAL DESCRIPTION OF STUDY AREA

3.2.1 River Basins

Perlis state is located in the northern most part of the west coast of Peninsular Malaysia. It has a total area of about 821 km^2. There are two major river basins in Perlis state, namely Sg Perlis basin in the north and Sg Arau basin in the south.

3.2.1.1 Sg Perlis Basin

Sg Perlis basin has a total catchment area of about 724 km^2 comprising major tributaries of Sg Arau, Sg Timah, Sg Tasoh, Sg Jarum, Sg Repoh, Sg Korok, Sg Kechor and Sg Temenggong. These tributaries of Sg Perlis flow through the river basin in southerly and south-westerly directions to join Sg Perlis in close proximity to Kangar Town. After joining at Kangar Town, Sg Perlis flows south-westerly to discharge to the Straits of Melaka. A Northern Diversion Channel has been constructed to the north of Kangar Town under the Kangar Flood Mitigation Project to divert the flood water.

The highlands of Sg Perlis basin are generally covered with thick tropical forest growth. Low-lying plains have been cleared at various places for rubber plantations, sugar-cane and paddy cultivation.

Timah-Tasoh dam is the only dam in Perlis, located at Sg Korok about 17 km north of Kangar Town. It has a catchment area of 191 km^2 and is drained by two main rivers namely Sg Timah and Sg Tasoh with contributing area of 51 km^2 and 140 km^2 respectively. Sg Timah is originated from the Nakawan limestone range at the north-western extremity of Peninsular Malaysia. The dam is presently providing water to meet irrigation and water supply need. In addition, it also provides flood mitigation control to alleviate the flooding problem of Kangar Town.

Sg Arau as a major sub basin in Sg Perlis basin has a total catchment area of about 110 km^2 of which about 16 km^2 of the upper catchment falls within the Changlun area of Kedah State. Sg Arau basin is predominated by sugar plantation and paddy fields. Sg Arau main river flows in a south-westerly direction from the upper reach till the Straits of Melaka. The main river flows through Arau town, which is located about 8 km east of Kangar Town. Originally, Sg Arau flowed into Sg Perlis; nevertheless it has been diverted, right after the KTM railway bridge, to discharge into the Arau Canal to provide additional irrigation supply for MADA irrigation scheme. Water level

along Arau Canal is regulated by several control structures. The water from the canal is discharged to the sea at Kuala Sg Baru through tidal gates. Sg Arau has a total length of 18.6 km from the upstream watershed to Arau Canal Regulator and from Arau Canal Regulator to the sea at Kuala Sg Baru is approximately another 16.5 km.

3.3 HYDROLOGICAL DATA

JPS is the main agency in Malaysia operating a network of hydrological stations and maintaining the national hydrological database. The JPS hydrological stations can be categorized into two types, National Network and Non-National Network.

Currently, there are 18 rainfall stations under JPS National Network in operation in Perlis. The JPS National Network stations are supplemented by 5 Non-National Network stations. This totals to 23 rainfall stations in operation in Perlis.

There are 3 water level stations under the JPS National Network in operation in Perlis. The JPS National Network stations are supplemented by 5 Non-National Network stations. This totals to 8 water level stations in operation in Perlis. For evaporation stations, there is only 1 station in operation under the JPS National Network.

To conduct the analysis under this Study, hydrological data from JPS and MMD are utilized. Selection and adoption of the hydrological stations are based on the following criteria:

(i) Hydrological stations selected in the NWRS (2000) Study were selected for analysis in this Study to maintain consistency.

(ii) Sufficiently long records with up-to-date data: up-to-date data with records length more than 10 years is more representative of the long-term trends and recent characteristics of the hydrological variables.

(iii) Minimum data gaps: extensive missing records especially during critical period of dry and wet seasons could render records to be unsuitable for use particularly when the missing data could not be filled with confidence.

(iv) Reasonably good quality and reliable data: doubtful data (outliers or repeated constant data values) were verified using data from nearest stations.

3.4 HYDROLOGICAL ANALYSIS

The methodology and design criteria adopted for the hydrological analysis under this Study are consistent with those used in NWRS (2000) Study. The details are described in Volume 3 Section 4.2. **Figure 3.1** shows the location map of hydrological stations used in the analysis.

3.4.1 Rainfall Analysis

The rainfall analysis carried out in the Study include the derivation of the long term monthly and annual rainfalls for general assessment of annual water resources availability as well as monthly drought rainfalls for irrigation studies.

Apart from the 6 stations used in NWRS (2000) Study, additional rainfall stations fulfilling the criteria in Section 3.3 were included in this Study at places where the station spatial distribution is found to be inadequate. Some rainfall stations used in the NWRS (2000) Study were replaced by stations with better quality and longer length of records. **Table 3.1** shows the details and location of 11 rainfall stations used for rainfall analysis in this Study.

Rainfall data from the selected stations were subject to data treatment which included gap-filling and correction of data with obvious error. As mentioned in the above criteria, yearly data comprises 6 months and above of monthly data completeness less than 65% are disregarded from the analysis. Gap-filling of daily missing data was carried out using the long term daily mean of each month. The calculation of the long term daily mean also disregard the year with 6 months and above where the data completeness less than 65%. Gap-filling using this approach is acceptable as the emphasis of the rainfall analysis is not on the daily variation of the rainfall data but the annual value.

Correction of data with obvious error was carried out by identifying stations that exhibits daily rainfall reading exceeds 500 mm or repeated constant daily rainfall value for 2 days and above. The reliability of these data was confirmed using the rainfall data from the nearest stations and was corrected accordingly or disregarded if confirmed to be erroneous.

Long term monthly and annual rainfall were computed and presented in **Table 3.2**. The mean annual rainfall computed from rainfall isohyetal map for the state of Perlis is about 1880 mm ranges from the lowest of 1704 mm to the highest of 2005 mm. The mean annual rainfall is lesser at the northern part with the annual rainfall of about 1800 mm and increases to about 2000 mm when moving towards south-west.

Perlis State is sheltered by the central mountain chain of the peninsula and receives little rain during the Northeast monsoon season from December to January. From May to July, the Southwest monsoon brings moderate rainfall to Perlis. In the transition period between the monsoons, from April to May and August to October, Perlis experience a peak in rainfall compared to that of other monsoons. Due to these climatic characteristics, there are two distinct rainy periods and a drought period which is often prolonged in the central and Northern part of Perlis. The drought period that is associated with the Northeast monsoon often spans the month of December to March with the mean monthly rainfall in the range of 30 mm to 120 mm. The two periods of rainfall peak occur between April-May and August-October with the mean monthly rainfall between 160 mm to 270 mm. Major floods generally occur between the months of September to December. The floods occurring in November and December are mainly caused by the Northeast monsoon which occasionally spills over the mountain range.

Drought rainfall analysis aims to establish the magnitude, duration and probability of occurrence of low rainfall depth for the estimation of the crop water requirement and hence irrigation demand. Frequency analysis was carried out on the monthly rainfall using the 3-parameter log-normal distribution to derive the 1 in 5 year monthly drought rainfall. **Table 3.2** presented also the monthly drought rainfall of 1 in 5 year for the selected stations.

3.4.2 Evaporation Analysis

Potential evapotranspiration (PE) values are required for the general assessment of annual water resources availability and estimation of the crop water requirement and hence irrigation demand. **Table 3.3** shows the details and location of the E-pan stations used for analysis in this Study.

E-Pan readings from the stations were converted to PE values according to the pan types and landuse at the surrounding of the respective stations. Conversion of the pan readings into PE values followed the procedure prescribed in JPS Water Resources Publication Number 11 entitled "Comparison of Performance of U.S. Class "A" Evaporation Galvanised Iron Pan and Aluminium Pan, 1982".

As most of the JPS evaporation stations are located in the low land area, the PE for the highland area was estimated from the graph relating the elevation to the potential forest evapotranspiration published in JPS Water Resources Publication Number 5 entitled "Evaporation in Peninsular Malaysia, 1976". Since forest and plantation crops constituted the largest landuse surface in Malaysia, the PE was estimated with forest surface using WRP No 11.

The long term monthly and annual PE were computed and presented in **Table 3.4**. The mean annual PE is about 1715 mm with the mean monthly minimum of 116 mm in November and maximum of 183 mm in March. The lowest PE in November is associated with the wet month while the highest PE in March is associated with the dry month.

3.4.3 Low Flow Analysis

Low flow is required for the determination of the reliability of water supply projects. Two types of low flows are required, namely monthly low flow sequence and 1-day and 7-day low flows. Monthly low-flow sequences are used for the assessment of yields for storage schemes while the 1-day and 7-day low flows are used for the assessment of run-of-river yields in meeting the irrigation and potable water demand at various water intake points.

Table 3.5 shows the details and location of the streamflow stations used for analysis. Similar to the NWRS (2000) Study approach, naturalizing river flows by adding back abstractions and accounting for return flows was not carried out.

3.4.3.1 Derivation of 1-day and 7-day Low Flows for Key Streamflow Stations

1-day and 7-day low flows are required for the assessment of run-of-river yields in meeting the irrigation and potable water demand at various water intake points.

Follow the same criteria in NWRS (2000), the 1 in 50 year ARI low flow is adopted in the design of potable water supply schemes whereas the 5 year low flow is adopted in the design of irrigation schemes.

The annual series of 1-day and 7-day low flows were fitted using the 2- and 3-parameter Log-normal distribution (LN2P and LN3P), whichever is appropriate. The data series were ranked and plotted on the log-normal probability graph using the Blom's plotting position formula as follows:

$$P = (M - 0.375) / (N + 0.25)$$

Where, P = probability of non-exceedance
M = ranking of the data
N = Number of data

An initial attempt was made to fit a 2-parameter log-normal distribution. If it appeared that the distribution was skewed, an alternative attempt was opted to fit a 3-parameter log-normal distribution by taking into account the skewness of the annual low flow series.

Table 3.6 shows the results of the 5 and 50-year 1-day and 7-day low flow at the key streamflow stations. The details are presented in **Table 3.8**.

3.4.3.2 Derivation of the 1-day and 7-day Low Flows for Ungauged Sites

As most of the intake points are ungauged, low flow derived at the key streamflow stations were used to estimate the low flow at the respective ungauged site using regional analysis similar to HP 12.

3.4.3.2.1 Regional Analysis

In deriving the regional equation for estimating the low flow at ungauged site, the key streamflow stations used must be at a natural catchment without major water control structures or significant amount of water abstraction at the upstream. However if the flow records before the construction of the water control structures at the upstream of the key streamflow stations are sufficiently long, the data are used in the regional analysis.

The regional analysis consists of two components:

(i) Derivation of the low flow regions and their respective regional low flow frequency curves.

(ii) Derivation of regional regression equations relating mean annual 1-day low flow (MAM) to catchment characteristics.

The procedure adopted for regional low flow analysis is described in detail in the Main Report (Vol. 3 – Section 4 - Hydrology).

3.4.3.3 Derivation of 36-Month Drought Sequence for Key Streamflow Stations

The 1 in 5 and 50-year 36-month drought sequence (monthly low-flow sequences) are required for the assessment of yields for storage schemes. Monthly low flow sequences were derived using the method by Twort et al in Water Supply, 1994. The same method was also prescribed in NWRS (2000) Study.

The steps in deriving the monthly low flow sequence are as follows:

(i) Annual series of 1-month, 2-month up to 36-month cumulative low flows were extracted from historical monthly flow records.

(ii) Low flow frequency analysis was carried out on the 1-month up to 36-month cumulative low flow series using the 2P and 3P Log-normal distribution to derive the 5-year and 50-year ARI cumulative low flows.

(iii) The 5-year and 50-year ARI cumulative low flows were plotted to form a minimum flow diagram which is similar to the cumulative flow curve. The minimum flow diagram indicates the dam storage required or the guaranteed yield under a 5-year or 50-year ARI drought event.

(iv) The minimum flow diagram is useful for single reservoir analysis. To cater for multiple reservoirs, reservoir simulation needs to be carried out where the monthly low-flow sequence is required as input to the reservoir simulation model.

(v) From the 5-year and 50-year ARI cumulative low flows, the respective incremental low flows were computed. The incremental low flows were then rearranged in accordance with the temporal distribution of long term mean monthly flow.

Table 3.7 (a) and **Table 3.7 (b)** shows respectively the 5-year 36-month and 50-year 36-month low flow sequence at the key streamflow stations. The analysis details are shown in **Table 3.9.**

3.4.3.4 Derivation of 36-Month Drought Sequence for Ungauged Sites

As most of the dam sites are ungauged, the 36-month drought sequence derived at the key streamflow stations were used to estimate the drought sequence for the respective ungauged site using flow transposition methods.

The procedure adopted for flow transposition is described in detail in the Main Report (Vol. 3 – Section 4- Hydrology).

3.4.4 Flood Flows Analysis

Flood frequency analysis was carried out using the annual maximum flood peak discharge at the selected key streamflow stations. Similar to NWRS 2000, flood flow analysis was carried out using General Extreme Value (GEV) distribution. **Table 3.10** shows the flood flows of various Average Recurrence Interval (ARI) derived at the key streamflow stations.

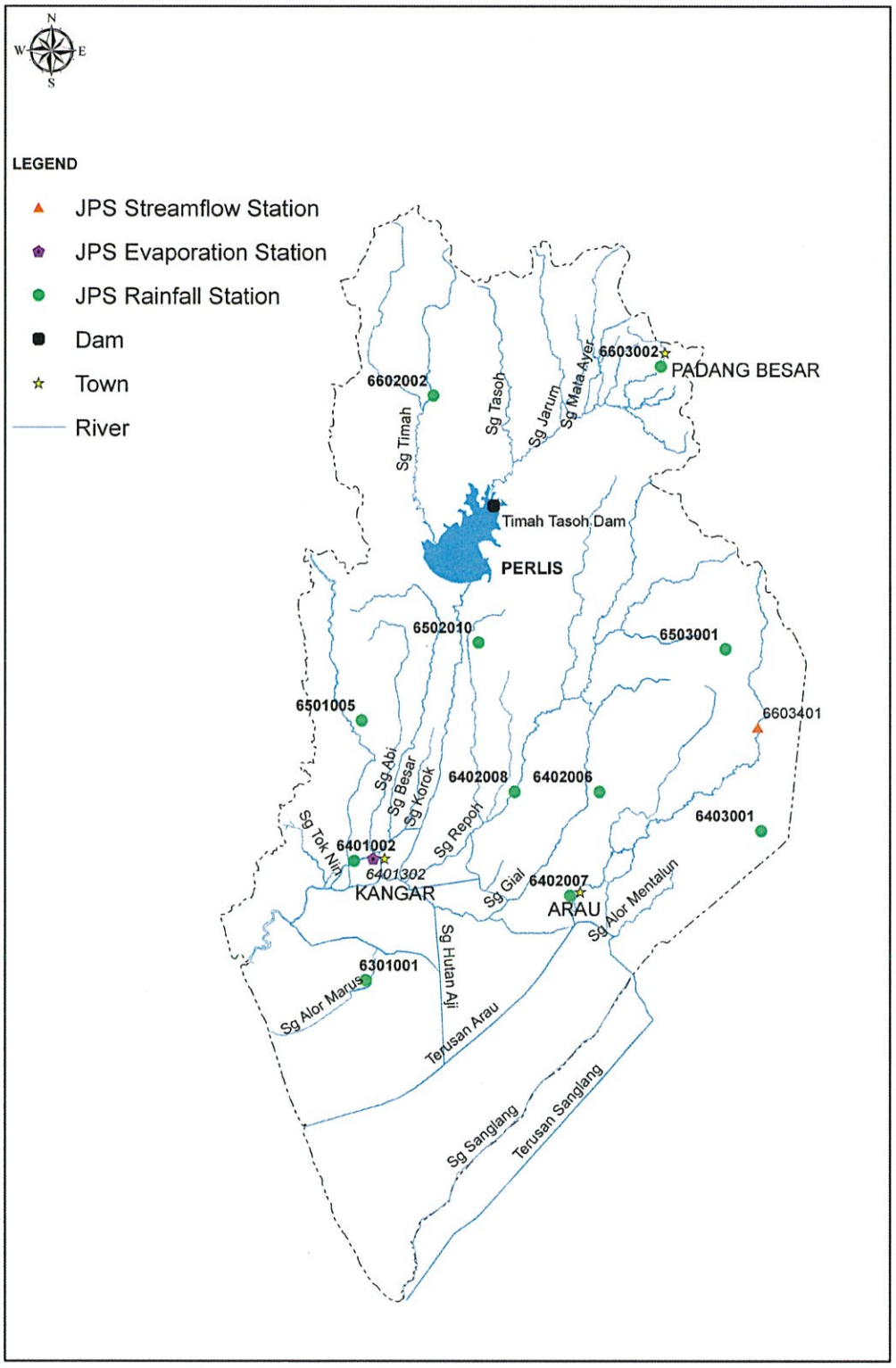


Figure 3.1 - Hydrological Stations Used for Analysis

Table 3.1 - Rainfall Stations Used In Analysis

No.	Station ID	Station Name	River Basin	Lat (D,M,S)	Long (D,M,S)	Year Open	Year Closed	National Network	Type of Reading		
									Manual	Auto	Telemetric
1	6301001	Kg Behor Lateh	Sg Perlis	06 23 40	100 11 01	06/79	-	Y	√	√	
2	6401002	Padang Katong at Kangar	Sg Perlis	06 26 45	100 11 15	11/74	-	Y	√	√	
3	6402006	Guar Nangka	Sg Perlis	06 28 30	100 17 00	02/58	-	Y	√	√	
4	6402007	Arau	Sg Perlis	06 25 50	100 16 15	01/47	-	Y	√	√	
5	6402008	Ngolang	Sg Perlis	06 28 30	100 14 50	06/82	-	Y	√	√	
6	6403001	Ulu Pauh	Sg Perlis	06 27 30	100 21 10	04/74	-	Y	√	√	
7	6501005	Abi Kg Bahru	Sg Perlis	06 30 20	100 10 55	01/63	-	Y	√	√	
8	6502010	Bukit Temiang	Sg Perlis	06 32 20	100 13 55	11/67	-	Y	√	√	
9	6503001	Ldg Perlis Selatan	Sg Perlis	06 32 10	100 20 15	04/74	-	Y	√	√	
10	6602002	Kaki Bukit	Sg Perlis	06 38 40	100 12 45	01/46	-	Y	√	√	√
11	6603002	Padang Besar at Titi Keretapi	Sg Perlis	06 39 25	100 18 35	11/74	-	Y	√	√	

Table 3.2 - Long Term Mean Monthly, Annual Rainfall and Drought Monthly Rainfall

No	Station ID	Station Name		Mean Monthly Rainfall (mm)												Mean Annual Rainfall (mm)
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	6301001	Kg Behor Lateh	Mean	19	45	115	165	185	153	211	244	263	258	206	107	1971
			5 years Drought RF	3	19	55	99	111	99	121	128	183	183	118	43	
2	6401002	Padang Katong at Kangar	Mean	27	43	101	156	180	157	210	224	272	259	190	78	1905
			5 years Drought RF	2	17	59	57	92	97	137	141	186	188	111	33	
3	6402006	Guar Nangka	Mean	33	50	113	165	186	138	171	189	235	276	190	96	1842
			5 years Drought RF	7	10	51	83	118	86	99	120	161	194	116	28	
4	6402007	Arau	Mean	35	50	123	182	192	162	183	216	264	283	215	95	2005
			5 years Drought RF	10	9	54	101	122	103	107	144	192	204	132	32	
5	6402008	Ngolang	Mean	25	52	131	148	154	119	152	162	196	231	166	95	1704
			5 years Drought RF	4	15	75	68	84	70	85	81	113	134	96	26	
6	6403001	Ulu Pauh	Mean	21	50	139	173	159	137	155	186	215	292	200	108	1836
			5 years Drought RF	9	9	71	93	92	95	90	95	153	218	122	35	
7	6501005	Abi Kg Bahru	Mean	37	43	110	149	197	169	192	215	266	288	196	98	1959
			5 years Drought RF	6	14	38	84	115	104	116	140	175	205	126	43	
8	6502010	Bukit Temiang	Mean	35	48	117	146	170	138	168	180	243	252	190	106	1792
			5 years Drought RF	12	13	61	74	105	93	109	108	155	181	116	43	
9	6503001	Ldg Perlis Selatan	Mean	31	51	135	185	170	128	158	207	246	300	227	136	1961
			5 years Drought RF	10	11	72	102	102	74	85	122	167	215	127	47	
10	6602002	Kaki Bukit	Mean	36	26	93	149	180	148	174	193	237	264	212	110	1852
			5 years Drought RF	9	13	46	82	97	85	99	114	153	188	105	35	
11	6603002	Padang Besar at Titi Keretapi	Mean	31	37	97	162	158	141	123	170	203	245	222	148	1809
			5 years Drought RF	7	2	24	94	91	82	60	101	122	174	119	64	

Table 3.3 - Evaporation Station Used In Analysis

No.	Station ID	Station Name	River Basin	Lat (D,M,S)	Long (D,M,S)	Year Open	Year Closed	National Network	Type of Reading		Pan Type
									Manual	Auto	
1	6401302	Padang Katong at Kangar	Sg Perlis	06 26 45	100 11 15	02/75	-	Y	√		MAA

Table 3.4 - Long Term Mean Monthly and Annual Evapotranspiration

No.	Station ID	Station Name	Mean Monthly Potential Evapotranspiration, PE (mm)												Mean Annual PE (mm)
			Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
1	6401302	Padang Katong at Kangar	163	174	183	159	142	130	133	135	126	124	116	132	1715

Table 3.5 - Streamflow Stations Used in Low Flow and Drought Sequence Analysis

No.	Station ID	Station Name	River Basin	Catchment Area (km^2)	Lat (D,M,S)	Long (D,M,S)	Water Control Structure (year of completion)	Catchment Area at Water control Structure (km^2)	Period used for Analysis
1	6503401	Sg Arau at Ldg Tebu Felda	Sg Perlis	20.6	06 30 10	100 21 05	-	-	1984 - 2007

Table 3.6 - 1-day and 7-day Low Flow at Key Streamflow Stations

						5 yr m^3/s (Mld)		50 yr m^3/s (Mld)	
No	Station ID	Station Name	River Basin	Catchment Area (km^2)	Period	1 day	7 day	1 day	7 day
1	6503401	Sg Arau at Ldg Tebu Felda	Sg Perlis	20.6	1984 - 2007	0.07 (6.4)	0.1 (8.2)	0.01 (1.1)	0.04 (3.4)

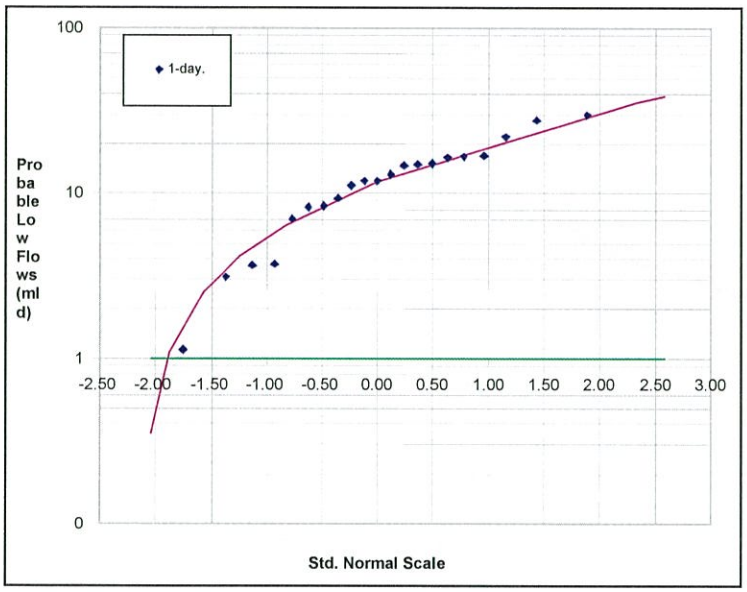
Table 3.7 (a) - 5-year 36-Month Drought Sequence at Key Streamflow Stations

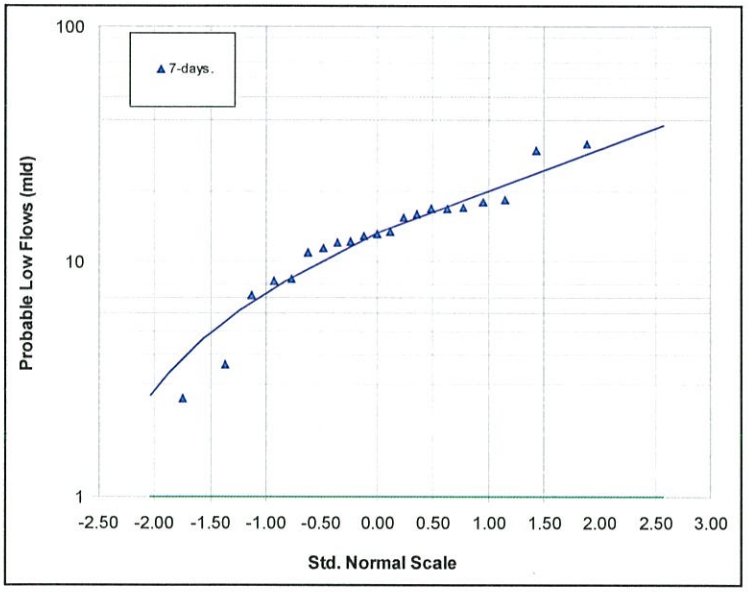
6503401 Sg Arau at Ldg Tebu Felda	
Flow duration (month)	**Monthly flow (%AAF)**
1	1.15
2	2.95
3	5.23
4	8.83
5	12.39
6	16.22
7	19.39
8	23.39
9	28.26
10	34.46
11	45.46
12	51.91
13	61.27
14	65.79
15	71.43
16	78.13
17	83.50
18	88.34
19	95.52
20	102.02
21	109.90
22	119.43
23	130.91
24	140.97
25	145.92
26	148.98
27	154.87
28	161.24
29	165.03
30	169.56
31	175.31
32	180.36
33	186.19
34	195.67
35	206.92
36	218.58
Area (km^2)	**20.6**
AAF (mm)	**1166**

Table 3.7 (b) - 50-year 36-Month Drought Sequence at Key Streamflow Stations

6503401 Sg Arau at Ldg Tebu Felda	
Flow duration (month)	**Monthly flow (%AAF)**
1	0.61
2	1.80
3	3.25
4	6.22
5	8.54
6	10.96
7	13.21
8	16.12
9	19.06
10	23.28
11	32.25
12	37.93
13	44.82
14	47.78
15	52.24
16	58.09
17	62.43
18	66.28
19	72.00
20	77.17
21	84.23
22	92.70
23	102.88
24	112.10
25	116.00
26	117.81
27	122.97
28	128.29
29	130.14
30	132.96
31	137.31
32	141.37
33	145.55
34	153.25
35	162.56
36	174.02
Area (km^2)	**20.6**
AAF (mm)	**1166**

Table 3.8 - The Results Of 1-Day and 7-Day Low Flow at the Key Streamflow Stations

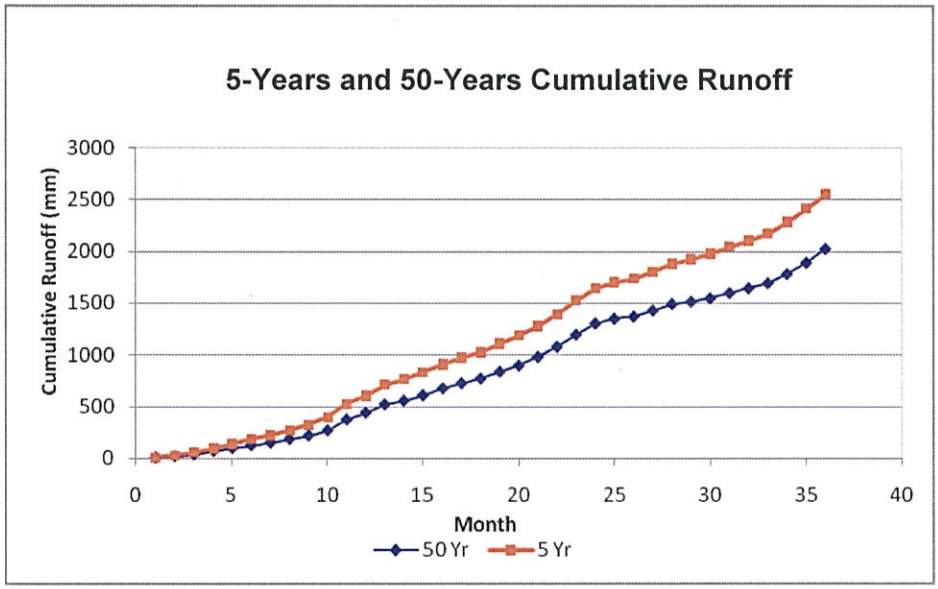




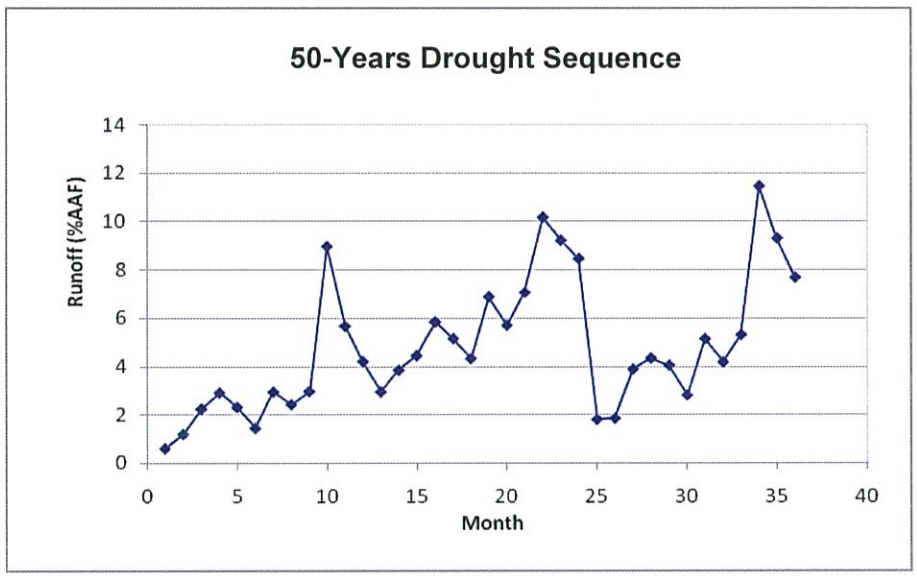
Year	Annual Minimum Flow			
	1-Day		7-Day	
	(cumec)	Mld	(cumec)	Mld
1984	0.32	28	0.21	18
1985	0.14	12	0.14	12
1986	0.19	16	0.21	18
1987	0.20	17	0.2	17
1988	0.10	8	0.1	8
1989	0.08	7	0.08	7
1990	0.04	4	0.04	4
1991	0.19	17	0.19	17
1993	0.10	8	0.1	8
1994	0.04	3	0.13	11
1995	0.11	9	0.14	12
1996	0.17	15	0.18	16
1997	0.13	11	0.15	13
1998	0.14	12	0.15	13
1999	0.17	15	0.18	15
2000	0.25	22	0.19	17
2002	0.34	30	0.36	32
2003	0.15	13	0.15	13
2005	0.04	4	0.13	11
2006	0.01	1	0.03	3
2007	0.18	15	0.34	30
MEAN	0.15		0.16	
SD	0.09		0.08	
SKEW	0.64		0.95	
5-yr	**0.07**	**6**	**0.1**	**8**
50-yr	**0.01**	**1**	**0.04**	**3**

1-day and 7-day Low Flow Frequency Analysis
(Stn 6503401, Sg Arau at Ldg Tebu Felda)

Table 3.9 - The 50 Year 36-Month Low Flow Sequence at the Key Streamflow Stations



Month	Cumulative Runoff (mm)	
	5-yr	50-yr
1	13	7
2	34	21
3	61	38
4	103	73
5	144	100
6	189	128
7	226	154
8	273	188
9	329	222
10	402	271
11	530	376
12	605	442
13	714	523
14	767	557
15	833	609
16	911	677
17	973	728
18	1030	773
19	1114	839
20	1189	900
21	1281	982
22	1392	1081
23	1526	1199
24	1643	1307
25	1701	1352
26	1737	1373
27	1805	1433
28	1880	1496
29	1924	1517
30	1977	1550
31	2044	1601
32	2103	1648
33	2171	1697
34	2281	1787
35	2412	1895
36	2548	2029



Month	AAF (%)	
	5-yr	50-yr
1	1.15	0.61
2	1.79	1.20
3	3.18	2.24
4	3.82	2.91
5	3.60	2.31
6	2.28	1.45
7	4.00	2.95
8	3.57	2.43
9	4.87	2.98
10	11.00	8.97
11	6.45	5.68
12	6.20	4.21
13	4.52	2.96
14	4.84	3.85
15	5.64	4.46
16	7.18	5.85
17	6.70	5.17
18	5.37	4.34
19	7.88	6.89
20	6.50	5.72
21	9.37	7.07
22	11.48	10.18
23	10.06	9.23
24	9.53	8.47
25	3.06	1.81
26	3.79	1.85
27	4.95	3.90
28	5.84	4.35
29	5.75	4.06
30	4.53	2.82
31	5.89	5.15
32	5.05	4.19
33	6.36	5.32
34	11.66	11.46
35	11.25	9.31
36	9.47	7.69

Annual Average Flow (AAF) = 1166 mm
Stn 6503401, Sg Arau at Ldg Tebu Felda

Table 3.10 - Flood flows of various Average Recurrence Interval (ARI)

No	Station ID	Station Name	River Basin	Catchment Area (km^2)	Period	Q peak of Various ARI (m^3/s)						
						2	5	10	20	25	50	100
1	6503401	Sg Arau at Ladang Tebu Felda	Sg Perlis	20.6	1984 - 2010	15	25	36	51	57	79	110

SECTION 4

GROUND WATER

Section 4

GROUND WATER

4.0 GROUND WATER

4.1 INTRODUCTION

Systematic basinal studies have not been undertaken by the Jabatan Mineral dan Geosains (or, JMG) in Perlis. However, some 163 exploratory tube-wells have been drilled by JMG in the state. The coastal alluvial aquifers are believed to possess saline water at depth (below 5 metres) but this need to be confirmed through geophysical surveys. The hydrogeological map for the state is shown in **Figure 4.1**.

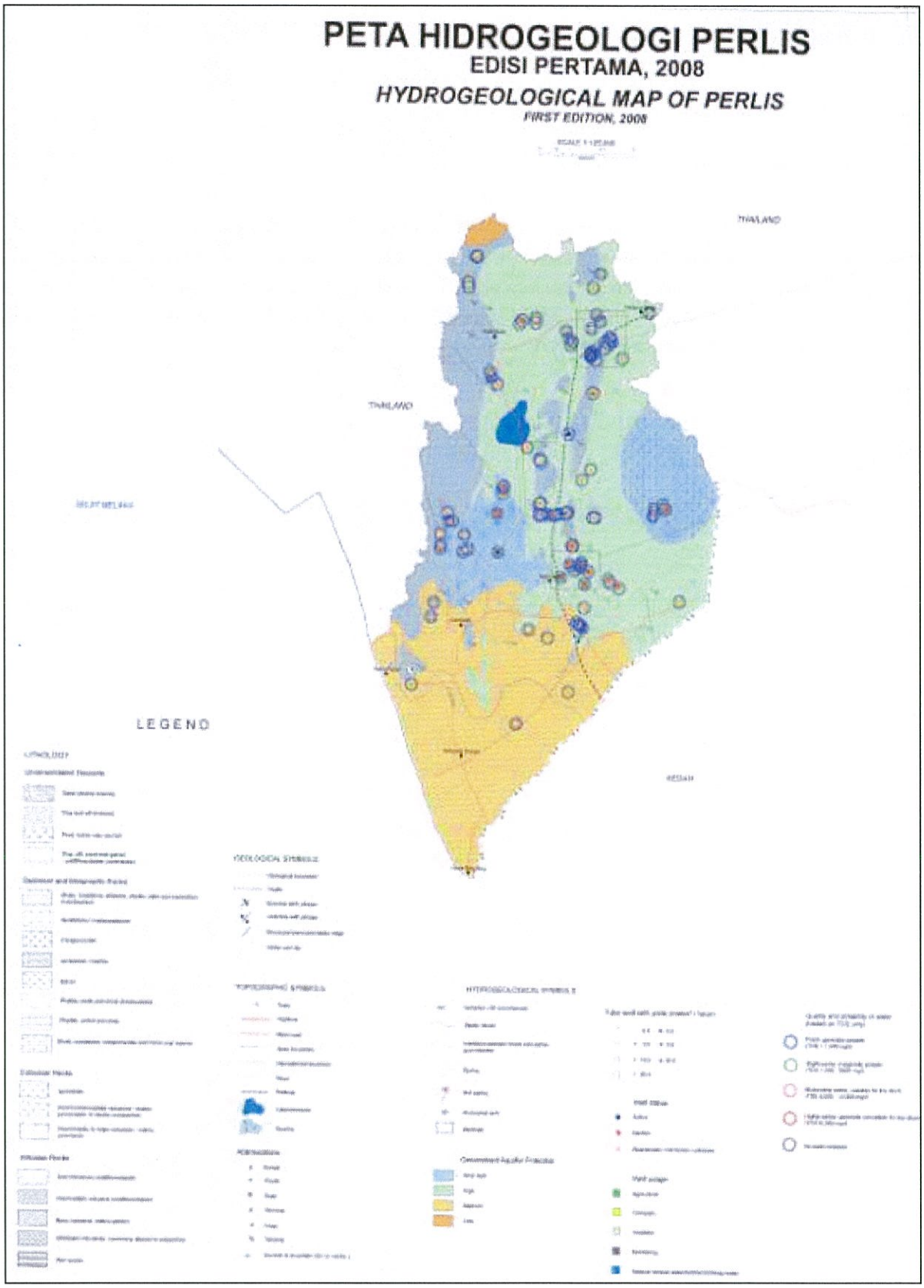


Figure 4.1 – Hydrogeological Map of Perlis (After JMG 2008)

4.2 PRESENT UTILIZATION

4.2.1 Agriculture

In Perlis, ground water is used mainly for the sugar-cane plantations, which use the sprinkler system. However, the amount of ground water used daily is not known. In the ground water resources study undertaken by JMG in sporadic areas at the request of various government agencies, such as in the Sg Batu Pahat, in Mukim Kurong Batang, Perlis, (at the request of the Perlis Forestry Department for usage in the Animal Garden and Herb Garden in the area), the well was capable of producing a yield of $23m^3$/hr (equivalent to 0.55 MLD).

4.2.2 Domestic

Ground water, although currently is not used extensively in Perlis, there are however 2 ground water sources, Felda Chuping (Chuping) and Semandong (Beseri), which are utilized for water supply. The Water Treatment Plant capacities at these two sites are 3.6 MLD and 1.4 MLD respectively. There are also villages that use dug-wells for their water supply. In the ground water resources study undertaken in sporadic areas at the request of various government agencies, a number of wells in Perlis were reported to be productive with high yields (producing $63.54m^3$/hr - equivalent to 1.52 MLD - and $91.64m^3$/hr - equivalent to 2.20 MLD) but were not developed further. All of these wells were constructed in hard-rock but the amounts pumped per day are unknown as there is no agency, Federal or State, monitoring the pumpage. Similarly, it is not known how many wells have been constructed by the private sector and the amount of ground water pumped per day.

4.2.3 Industrial

In Bukit Keteri, a tube-well to supply ground water for industrial use has been developed.

4.3 PREVIOUS STUDIES

4.3.1 Aquifers Identified (Eighth Malaysia Plan (2001 – 2005))

As mentioned earlier, during the 8th Malaysia Plan (2001 – 2005), JMG undertook a ground water resources study in the Sg Batu Pahat, Perlis, at the request of the Perlis Forestry Department for usage in the Animal Garden and Herb Garden in the area. Drilling was carried out in September 2005. The constructed well was productive with a yield of $23m^3$/hr and sufficient for the purpose. The Sg Batu Pahat area is located in the western part of Perlis in the Mukim Kurong Batang and approximately 20km from Kangar. According to departmental records, there are two tube-wells in the vicinity of the study area (GS 780 and GS 781) which were drilled during the Kedah-Perlis Water Resources Management Study in 1979 - 1982. These wells were reported to be productive with high yields (producing $63.54m^3$/hr and $91.64m^3$/hr) but were not developed further. The Perlis Forestry Department had requested that the ground water was for use as water supply for the animals, the herbal garden and for plants and watering the landscape during droughts and required about $500m^3$/day. Drilling was conducted to a total depth of 48m. The rock formation comprised of red mudstone and interbedded sandstone and slate and finally into dark grey limestone. The fractures which

were water-bearing were located at depths of 28m (yield of 2.8m^3/hr) and 36m (yield of 20.2m^3/hr). Total yield after completion of drilling was 23m^3/hr.

4.3.2 Safe yields

Safe yields are usually set at 75% of the long duration (either 72-hour or 120-hour constant discharge pumping test when draw-down water levels become constant, or static,(which means that ground water flow into the well is identical to the ground water being pumped out of the well).

4.3.3 Ground water Monitoring Wells

In Perlis, JMG is monitoring 2 wells in the Arau and Rimba Mas areas. In Arau, the chloride content was noted to slightly higher than usual for ground water derived from the limestone aquifer. This was believed to be due to mixing of slightly brackish water from the overlying clay. In the Rimba Mas area, there was an elevated nitrate level (10-25 mg/l) found in ground water sample due to anthropogenic activities carried out from agricultural practices in the surrounding area.

4.4 MANAGEMENT AND REGULATION

4.4.1 Present

Perlis does not as yet have an enactment that regulates ground water drilling, development and pumping and, as such, there is no state agency which manages the resource.

4.4.1.1 Licensing

As there is no enactment, licensing for the use of ground water is not enforced as yet.

4.4.1.2 Quantity abstracted

The amount of ground water abstracted in Perlis is not known.

4.4.2 Proposed

4.4.2.1 Licensing

(i) It is proposed that the Perlis state enact a comprehensive water enactment that includes ground water management and regulation administered by a state water regulatory authority. The enactment should also incorporate licensing for ground water use.

(ii) Regulations need to be prepared for the assessment and development of ground water projects/schemes in accordance with relevant State Enactments.

(iii) To enforce existing Laws and Enactments related to ground water, it is proposed to include registration of all ground water development companies by the state water regulatory authority and the Jabatan Mineral dan Geosains, the Federal agency responsible for ground water exploration, evaluation and development, and monitoring.

(iv) To gazette ground water protection zone/buffer zones.

(v) To review the State Water Enactment to incorporate regulations to license all ground water development companies.

(vi) To enforce Uniform Building By-Laws regarding domestic, industrial, husbandry waste and seepages from agricultural activities to be directed to waste discharge centers.

(vii) To review the State Water Enactment to include ground water aspects especially on abstraction quantities, metering, tariff rates, monitoring and protecting the ground water recharge area and ground water aquifers.

(viii) To prepare a mechanism to manage trans-boundary ground water aquifers.

4.4.2.2 Metering and tariff

Once the enactment is gazetted and enforced, this will require all state-registered ground water tube-wells to be installed with meters which will indicate amount of ground water being pumped. A ground water tariff should also be enacted with the appropriate rates being set by the state government for domestic, industrial and agricultural use.

SECTION 5

ALTERNATIVE WATER SOURCE

Section 5

ALTERNATIVE WATER SOURCE

5.0 ALTERNATIVE WATER SOURCE

5.1 INTRODUCTION

The potential alternative sources of water for potable water supply that have been assessed are summarized in **Table 5.1**.

Table 5.1 – Alternative Water Sources

No.	Alternative Water Source	Description
1	Rainfall harvesting	Rainfall harvesting is the process of collecting, diverting and storing rainwater from an area (usually roofs or another surface catchment area) for non-potable use by households and industry.
2	Desalination	Desalination is the specialized treatment method used to remove dissolved minerals and mineral salts (demineralization) from the seawater.
3	Recycling of treated sewerage	There are two types of wastewater re-use: direct and indirect. Direct wastewater re-use refers to the treated wastewater that is piped into a water supply system without first being incorporated in a natural stream or lake or in ground water. Indirect wastewater re-use involves the mixing of reclaimed wastewater with other sources of raw water before re-use or final treatment for drinking purposes.

The main source of water for Perlis is from the Timah Tasoh Dam and the MADA system in Kedah. The water demand for Perlis is relatively low, for example its projected 2020 demand is about 10% of Kedah's.

Preliminary assessment revealed that the surface water source from within the State and that of the MADA system is adequate to meet the potable water supply of the State until 2050. Hence, the alternative water sources as listed in **Table 5.1** are not required.

SECTION 6

WATER DEMAND - POTABLE WATER

Section 6

WATER DEMAND POTABLE WATER

6.0 WATER DEMAND – POTABLE WATER

6.1 BASIS AND CRITERIA

Assessment of future water demand is a fundamental and critical requirement in any water resources study. In this Review of the National water Resources Study (2000-2050), water demand projection was undertaken to year 2050. As required in the TOR, the projection in the NWRS (2000) for the States in Peninsula Malaysia was reviewed and updated. Demand projection was also carried out for Sabah and Sarawak which were not included in the 2000 study.

Data relating to water production and consumption have been collected for this purpose from relevant parties especially the State water service providers. This includes information on dams, WTPs (designed capability, production records up to 2009, etc), NRW, projects under implementation, etc.

The total demand is made up of 5 components i.e. domestic, industrial, commercial, institutions and NRW, and the projection is done to obtain the demand for each component to 2050. This approach is similar to the approach in the previous NWRS (2000).

The future increase in water demand is very much dependent on the country's and States' economy while demography has a major impact on the domestic demand. In turn commercial and institutional demands are closely correlated to domestic demand. Landuse planning particularly the State's structure and local plans, also significantly influence the water demand. Hence, this section contains a discussion on the economic outlook of the State and country, demography and landuse.

The water demand projection for the State was carried out at the district level and summed to obtain the total State demand. Perlis is considered as one region by itself as shown in **Figure 6.1**.

The projection covers the period from 2010 to 2050 with specific projections for the years 2010, 2015, 2020, 2030, 2040 and 2050. The projected 2010 demand was compared to the 2010 actual projection, if available, or to the 2009 actual production to ensure the reasonableness of the 2010 projection which is the commencement year of the projection. The projected water demand trend was also compared to the historical trend.

Three demand scenarios were assessed:

(i) Low demand.

(ii) Median demand which shall be adopted for water supply and resources planning purposes.

(iii) High demand.

Generally, for water resource planning it is prudent to adopt a more conservative approach when projecting the water demand. This is because capital developments works require a long lead time. However, a too conservative projection will result in over sizing of the capital works, which can lead to commitment of scarce monetary resource for a particular scheme at the expense of other schemes.

The term demand is the quantity of water which has to be put into a supply and distribution system so as to satisfy the requirement of household use, commerce, institutional services, industry recreation and tourism, meet losses that occur through leakage and satisfy other unaccounted for water components. 'Demand' and 'production' may be considered to be synonymous since the only reliable data available for forecasting are the historical records to total water put into the supply system.

Consumption is the quantity delivered to consumers as measured by meters. Any inaccuracies in the measuring instrumentation would affect the quantities recorded.

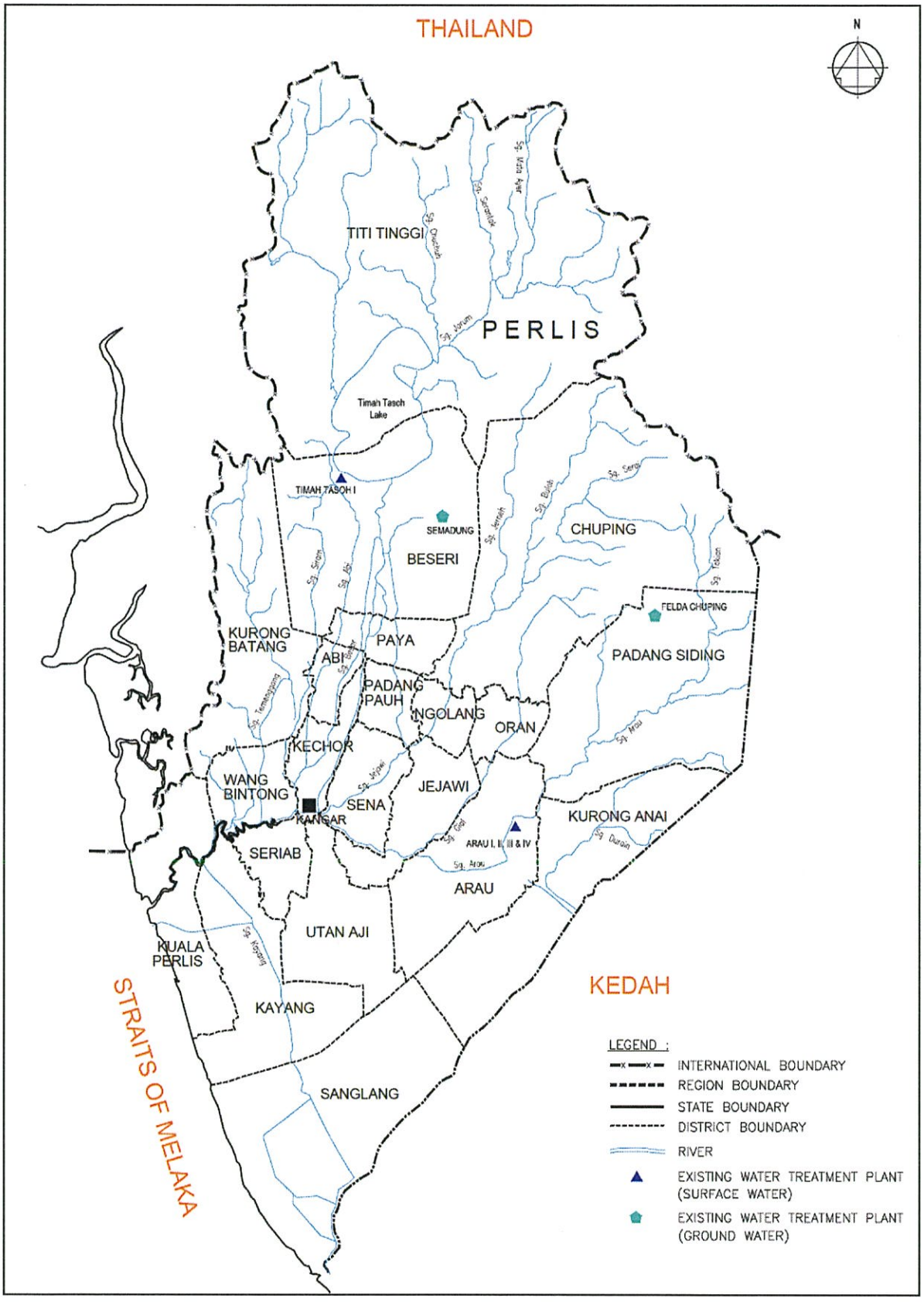


Figure 6.1 – Water Supply Regions in Perlis

6.2 REVIEW OF NWRS (2000) WATER DEMAND PROJECTION

6.2.1. Basis of Water Demand Projection

In the NWRS (2000), water demand projection was carried until year 2050. A summary of the key features of the projection are as follows:

Period of assessment and projection : 1995 to 2050

Projection scenarios : 3 scenarios:

Low Projection: based on assumptions to derive the domestic, commercial, institutional and industrial demands with allowance for NRW.

Planning Projection: from 1997 to 2020 - an additional 0.5% over the low demand and for 2020 to 2050 an additional 0.2%. The planning projection was then used as the basis for the development of the water resources in the study.

High projection: from 1997 to 2020 - an additional 1% over the low demand and for 2020 to 2050 an additional 0.4%. The high projection was used as a limit in considering possible additional source requirements for purpose of gazetting catchments to reserve rights to develop new resources in the future.

Projection for State and districts : The projection was carried out for urban and semi urban. Kangar is the only urban centre in Perlis.

The urban and semi urban demands were then totaled to obtain the State demand.

Consumers Types : The water demand was categorized into 4 consumer types and an allocation for NRW as shown below:

(i) Domestic
(ii) Commercial
(iii) Institutional
(iv) Industrial
(v) NRW

Projections were undertaken for each consumer category and for the NRW, which were then summed to obtain the total demand.

It is noted that only physical water losses in terms of leakages is projected in the NWRS (2000) study assuming as base of 25% in 1997 where 12% of the then 37% NRW was attributed to commercial losses.

6.2.2. Actual Production Versus Projected Water Demand

The NWRS (2000) projected demand for the period 2000 to 2010 is compared to the actual water production obtained from Jabatan Kerja Raya (JKR) Negeri Perlis, and is shown in **Table 6.1** and **Figure 6.2**.

Table 6.1 - Actual Production versus NWRS (2000) Projection

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Low	89	92	94	97	100	103	105	108	111	113	116
Planning	90	93	97	100	103	107	110	113	116	120	123
High	91	95	99	103	107	111	115	119	123	127	131
Actual (source: JKR Perlis)	**84**	**84**	**88**	**93**	**93**	**92**	**95**	**97**	**100**	**109**	**146**

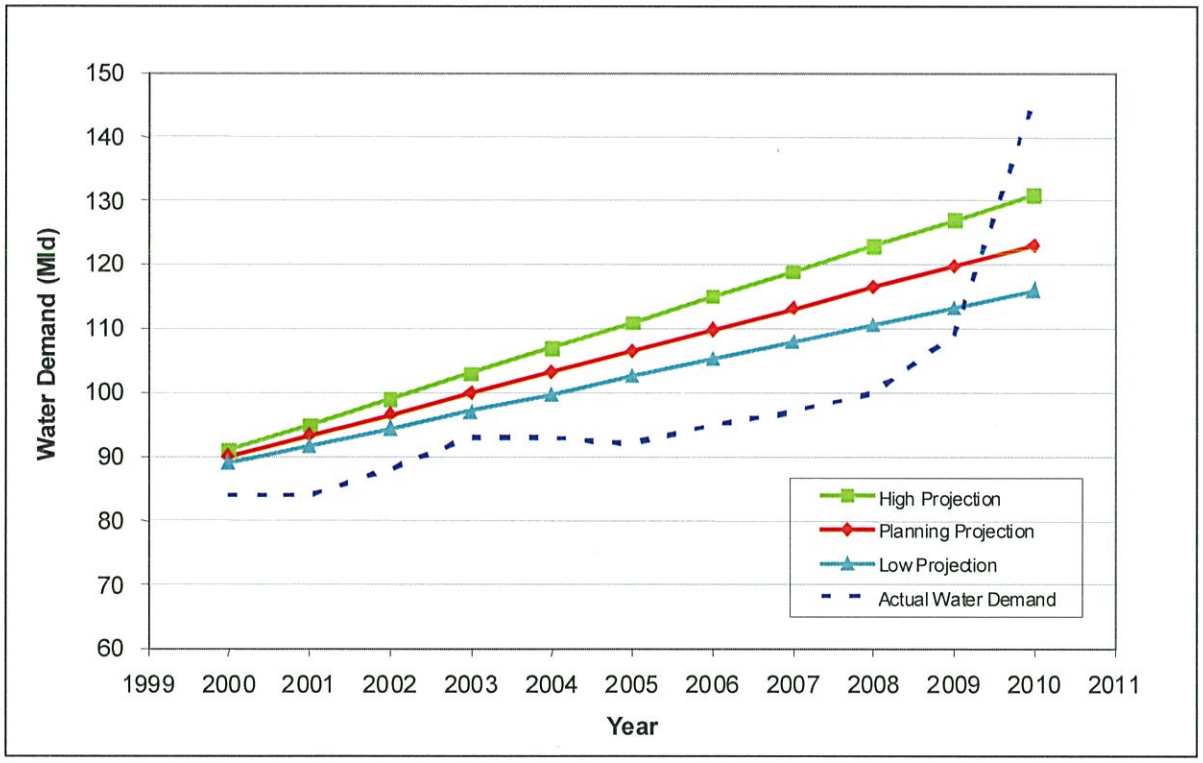


Figure 6.2 – Actual Production versus NWRS (2000) Projected Water Demand

As can be seen, the actual water production for the State is lower than the NWRS (2000) low projection before Year 2010. However, there is a sudden increase of water production in year

2010 after the ARAU IV water treatment plant is in operation at the beginning of year 2010. The water supply operator briefed that Perlis State has been experiencing water shortage for the last few years before completion of ARAU IV water treatment plant. This has resulted in a high percentage of unsatisfied demand, which is met with the commissioning of the 123 MLD ARAU IV water treatment plant.

6.3 WATER DEMAND ESTIMATION

6.3.1 Domestic Water Demand

The domestic demand is determined by the population and the consumption per person as follows:

Domestic Demand = population x per capita consumption

Future population has been projected by the Demographer. In line with the water demand scenarios, the population likewise was projected according to low, median and high population variants. Furthermore, the population in each district was divided into its urban and rural components.

In selecting the population per capita consumption (ppc) to be used, the following were taken into account:

(i) Where data is available, the actual current and past pcc were determined. The pcc is measured in litre per capita per day (lcd).

(ii) Higher pcc was adopted for the urban population compared to the rural population. It is generally acknowledged that the more urbanized an area the higher is the water consumption on a per capita basis, which is a reflection of the urban lifestyle.

(iii) The pcc was assumed to increase, albeit at the slower rate of increase, from 2010 to 2050. This approach is similar to the approach adopted in the NWRS (2000). While it is acknowledged that per capita water consumption in advanced country is lower, in Malaysia, we have yet to reach this level. In addition, the water tariff in Malaysia is still relatively cheap and therefore, does not provide the incentive for consumers to use less water.

Table 6.2 below summarizes the pcc adopted for the State.

The actual 2010 pcc was estimated to be 285 lcd for Perlis State.

Table 6.2 - Summary of pcc (lcd)

State	Actual 2010	Low						Median						High					
		2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050	2010	2015	2020	2030	2040	2050
URBAN																			
Perlis	285	290	296	302	307	311	315	290	297	304	310	315	320	290	298	306	313	319	325
RURAL																			
Perlis	285	280	286	292	297	301	305	280	287	294	300	305	310	280	288	296	303	309	315

6.3.2 Industrial Water Demand

The industrial water demand was estimated using the projected number of workers in the manufacturing sector and the estimated daily water consumption per worker as follows:

Industrial consumption per day = projected number of workers in the manufacturing sector x water consumption per worker per day

The projected number of workers in the manufacturing sector was obtained from the demographic projection. The unit for the water consumption per worker per day is litre per worker per day (lwd).

The water consumption per worker per day adopted in the projection is summarized in **Table 6.3**. The 2010 consumption was estimated based on the actual industrial consumption obtained from JKR Perlis and the number of workers in the manufacturing sector estimated by the Demographer. The rate of consumption was found to be 420 lwd for Perlis.

The projection assumes that the consumption per worker per day increases progressively in the period of the projection.

Table 6.3 - Summary of Industrial Consumption Per Worker Per Day (lwd)

Region	Actual 2010	2010	2015	2020	2030	2040	2050
Perlis	420	420	435	445	545	665	810

6.3.3 Institutional and Commercial Demands

Commercial demand includes demand by shophouses, shopping complexes, offices (except government), hotels, commercial seaport and airports, etc. As commercial activities are very much dependent on the size of the population, it is therefore, not surprising that commercial demand is closely related to domestic demand.

Institutional demand includes demand by government offices, schools, institutions of higher learning (colleges, universities, etc), army camps, naval bases, hospitals, etc. Again institutional activities e.g. schools are also dependent on the population, therefore, its demand will be closely related to the domestic demand.

Both commercial demand and institutional demand are projected as a percentage of the domestic demand. **Table 6.4** below summarizes the percentages used in the projection.

Table 6.4 - Commercial and Institutional Demand (as % of Domestic Demand)

State	Commercial Demand			Institutional Demand		
Perlis	Estimated Actual	adopted (2010-2050)		Estimated Actual	adopted (2010-2050)	
	2010	U	R	2010	U	R
	5%	10%	5%	10%	12%	10%

6.3.4 Serviced Factor

The service factor is the potential percentage of the population served by the public water supply system. A service factor of 100% means that the water distribution system can adequately covers 100% of the area and the population located in that area can get easy access to a public water supply. However, it does not mean that 100% of the population has service connection.

The population served by the water supply system is thus calculated as follows:

Population served = service factor x total population

The 2010 service factor is estimated to be approximately 100% for urban and rural areas. It is assumed in the projection that 100% service factor will be remain by all district by 2050.

6.3.5 Unsatisfied Demands

Unsatisfied demand occurs where the demand for water exists but for certain reasons, the demand is not able to be fulfilled. The reasons can be due to constraints and shortcomings in the water distribution systems such as low pressure, no pipeline to the area of demand, etc resulting in consumers not been able to receive water and/or at the quantities they would have consumed had there been no constraints.

It is difficult to assess the amount of unsatisfied demand. The NWRS (2000) adopts the approach that the low per capita consumption as reflected in the records is an indication of the presence of unsatisfied demand whereas higher per capita consumption is an indication of its absence. Hence, unsatisfied demand is deemed to have been taken into account in the assumption of per capita consumption in the water demand assessment. It is proposed to continue to adopt this approach in this revised projection in view of the lack of information.

6.3.6 Non Revenue Water

Non-revenue water (NRW) is defined as the difference between the measured supply and the metered and billed consumption, expressed by equation:

$$NRW = \sum Supply\ (Measured) - \sum Consumption\ (Metered)$$

Part of the NRW includes leakage from the distribution system.

Table 6.5 below summarizes the actual NRW and the NRW assumed in the projection.

Table 6.5 - Summary of NRW (%)

Region	Actual				Adopted					
	2007	2008	2009	2010	2010	2015	2020	2030	2040	2050
Perlis	34.2%	31.2%	44.7%	41.0%	41.0%	37.5%	34.0%	29.0%	26.0%	24.0%

Current NRW is relatively high at 41.0% for Perlis. It is assumed that the NRW will be reduced through the NRW reduction program to 24.0% by year 2050.

6.4 WATER DEMAND MANAGEMENT

6.4.1 Water Demand Management Principles

Water demand management (or WDM) is becoming increasingly important as a means to manage and conserve limited water resources especially in advanced countries like the US, UK, Australia and South Africa. WDM involves the adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and usage of water in order to meet any of the following objectives: economic efficiency, social development, social equity, and environmental protection, sustainability of water supply and services, and political acceptability.

WDM is thus a conscientious manipulation of the level and timing of water usage to bring about beneficial changes. WDM is normally applied in conjunction with water conservation (WC) and Integrated Resource Management (IRM). Water Conservation involves the minimization of loss or waste, care and protection of water resources and the efficient and effective use of water whereas IRM involves analyzing the change in demand and operation of water institutions by evaluating a variety of supply-side and demand-side management measures to determine the optimal way of providing water services.

The rational for implementing WC and WDM is based on the need to improve the economic efficiency due to the significant cost in the provision of water services. The economic benefit from WC/ WDM could be achieved through cost savings in deferring capital infrastructure and savings in operating costs. WDM not only reduces the demand for potable water but also the amount of wastewater generated as a consequence of the reduction in potable water usage. Hence, the cost of providing and constructing facilities for wastewater facilities can be reduced and deferred.

6.4.2 Tools and Techniques

WDM can be implemented both on the supply and demand sides and can consist of both temporary measures (e.g. during emergencies such as drought) and permanent measures to improve long-term efficiency. Demand-side management involves measure or initiative that reduces water usage and/or demand whereas supply-side management involves implementing measure or initiative that increases the capacity of a water resource or water supply system to supply water. Another aspect of WDM is distribution management which involves managing the maintenance and operation of the water supply system including structures, pipes, valves, pumps, meters or other associated equipment, including all mains, connection pipes and water installations that are used or intended to be used in connection with the supply of water.

Some of the demand management techniques include:

(i) Conservation-oriented pricing.

(ii) Improve the quality and standards of water fixture plumbing and retrofitting.

This includes water metering.

(iii) Improve efficiency in landscaping watering.

(iv) Changes in water use practices.

(v) Public education.

(vi) Water pricing management.

6.4.3 Water Pricing Management

Domestic per capita consumption of water is largely a function of demography i.e. household size, type and size of property and income level, and is relatively price elastic i.e. changes in price generally do not induce large change in water use. On the other hand water usage by industries depends very much on the type of industry. Some industries are particularly heavy users of water such as food and beverage, steel and paper mills, etc and therefore, relatively more sensitive. Therefore, tariff management can be effective to promote a more efficient use of water among non-domestic users particularly industrial users.

Although the domestic user is less price sensitive, nevertheless pricing is still an essential tool of demand management as it can send a powerful message to the consumers on the value of water.

Tariff design may include increasing block rates (unit rates increasing with increase usage), seasonal rates (higher unit rates during peak usage periods) and water budget and excess use rates (higher rate for usage above specified level).

Through new technologies combined with a change in water usage behavior significant reduction in water demand can be achieved without sacrificing the quality of life of the consumers.

6.4.4 Overseas Experience

With increasing demand for fresh water by the increasing human population and further exacerbated by climate change, WDM is being looked upon as an important means to manage and conserve the limited water resources especially in advanced countries like the US, UK, Australia and even South Africa.

A South African study estimated that the economic benefit from WC/WDM can amount to R50 billion (RM21 billion) in 15 years through cost savings in deferring capital infrastructure and savings in operating costs.

Likewise in Malaysia it is necessary to intensify efforts in looking into WDM and implementing its water reduction measures. For example, our current per capita domestic consumption is way in excess of 200 lcd whereas in advance countries it is as low as 150 lcd as in Singapore. The honorable Dato' Sri D. Lim Keng Yaik, the former Minister of Energy, Water

and Communication, in his keyword in The Water Tablet has warned that Malaysians "*cannot continue to consume water with total disregard for the long term sustainability for our future generation. We need to consume responsibly taking into account the resources, environment and impact on future generations*".

The implementation of WDM will require proper study and the will on the part of the water authorities and government to put the various measures and strategies into use. Time will be required. Hence, it is recommended that the effect of water demand reduction due to WDM on the water resource planning to 2050, which is only 40 years away, not be considered in this study.

6.4.5 Demand pcc Under Managed Scenario

The participants of the 3 workshops held during the course of this Study has suggested that the domestic pcc of 150 l/c/d be considered as a long term planning based on the existing pcc of the developed countries. The developed countries have implemented the above measures for demand management over the years. An important aspect of WDM is the tariff structure and it would be some time before Malaysia can achieve the levels of pcc of the levels in those countries. A date of 2050 is deemed practicable.

At this stage, the study does not recommend the use of the WDM in the demand projections as any slippage in WDM would jeopardize economic development in the state. The WDM targets will rather form the lower bound water demand for the state. For this scenario, the basis for the projections shall be the high growth case where only the domestic demand component is subject to WDM pcc with the rest, i.e., commercial, institutional and industrial remaining the same.

Reference for Section 6.4:

(i) Demand Management, water encyclopedia, http://www.waterecyclopedia.com./DaiEn/Demand-Management.html

(ii) Water Conservation And Water Demand Management Strategy For The Water Services Sector, http://www.info.gov.za/view/DownloadFileAction?id=70350

6.5 PROJECTED WATER DEMAND

The projected water demand for the State of Perlis is set out in **Table 6.6** and shown graphically in **Figure 6.3**. The summary of water demand projection is shown in **Table 6.7**.

Table 6.6 - Projected Water Demand for Perlis

	2010	2015	2020	2030	2040	2050
Low	140.0	145.1	151.1	160.6	171.9	183.7
Median	149.7	159.2	168.2	178.7	191.8	205.7
High	149.7	161.5	173.9	198.4	220.6	246.8

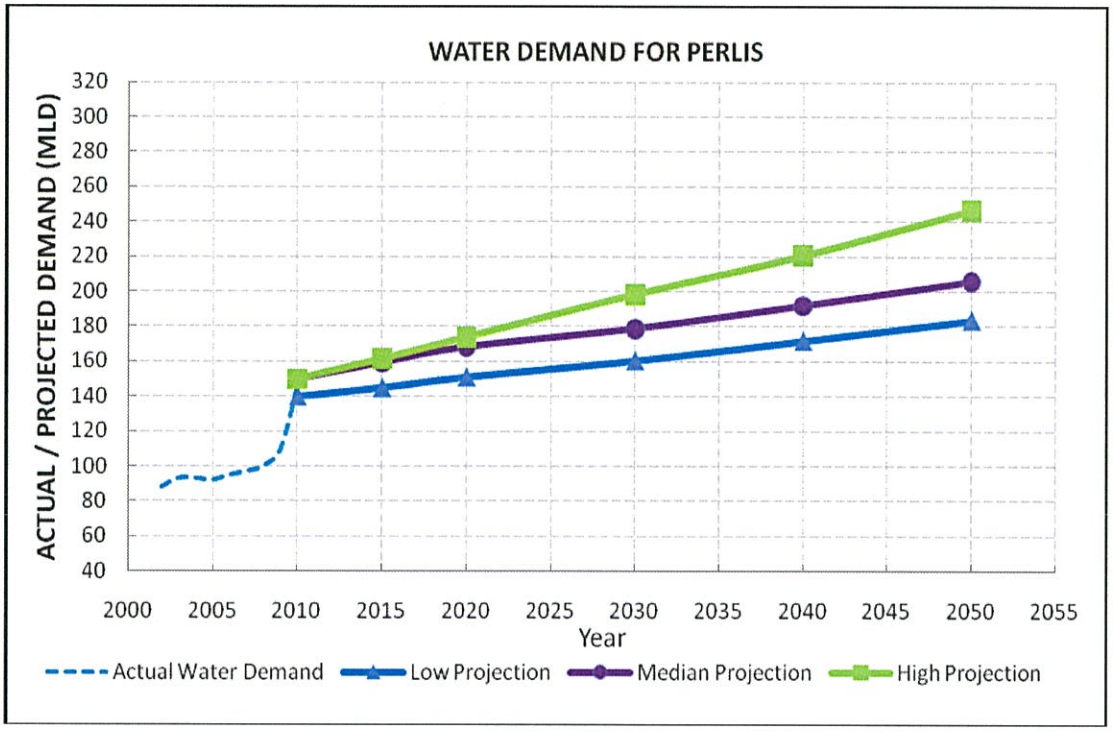


Figure 6.3 - Projected Water Demand for Perlis

Table 6.7 Summary of Water Demand Projection

State: Perlis

	LOW						MEDIAN						HIGH					
	2010	**2015**	**2020**	**2030**	**2040**	**2050**	**2010**	**2015**	**2020**	**2030**	**2040**	**2050**	**2010**	**2015**	**2020**	**2030**	**2040**	**2050**
Domestic Demand																		
Urban																		
Population ('000)	97,000	113,000	132,000	174,000	218,000	261,000	103,000	124,000	146,000	192,000	240,000	288,000	103,000	125,000	150,000	211,000	273,000	341,000
pcc (lhd)	290	296	302	307	311	315	290	297	304	310	315	320	290	298	306	313	319	325
Rural																		
Population	133,000	133,000	132,000	116,000	93,000	65,000	143,000	145,000	146,000	128,000	103,000	72,000	143,000	147,000	150,000	141,000	117,000	85,000
pcc (lcd)	280	286	292	297	301	305	280	287	294	300	305	310	280	288	296	303	309	315
Domestic Demand																		
Urban	28.1	33.4	39.9	53.4	67.8	82.2	29.9	36.8	44.4	59.5	75.6	92.2	29.9	37.3	45.9	66.0	87.1	110.8
Rural	37.2	38.0	38.5	34.5	28.0	19.8	40.0	41.6	42.9	38.4	31.4	22.3	40.0	42.3	44.4	42.7	36.2	26.8
Total Domestic (mld)	**65.4**	**71.5**	**78.4**	**87.9**	**95.8**	**102.0**	**69.9**	**78.4**	**87.3**	**97.9**	**107.0**	**114.5**	**69.9**	**79.6**	**90.3**	**108.8**	**123.2**	**137.6**
Industrial Demand (mld)																		
No. manufacturing workers	13,020	14,099	15,241	16,896	18,530	20,340	13,938	15,428	16,867	18,571	20,424	22,465	13,938	15,583	17,307	20,473	23,230	26,610
consumption rate (l/worker/d)	420	435	445	545	665	810	420	435	445	545	665	810	420	435	445	545	665	810
Total Industrial Water (mld)	**5.5**	**6.1**	**6.8**	**9.2**	**12.3**	**16.5**	**5.9**	**6.7**	**7.5**	**10.1**	**13.6**	**18.2**	**5.9**	**6.8**	**7.7**	**11.2**	**15.4**	**21.6**
Commercial Demand																		
Urban (10% x domestic Urban)	2.8	3.3	4.0	5.3	6.8	8.2	3.0	3.7	4.4	6.0	7.6	9.2	3.0	3.7	4.6	6.6	8.7	11.1
Rural (5% x domestic rural)	1.9	1.9	1.9	1.7	1.4	1.0	2.0	2.1	2.1	1.9	1.6	1.1	2.0	2.1	2.2	2.1	1.8	1.3
Total Commercial (mld)	**4.7**	**5.2**	**5.9**	**7.1**	**8.2**	**9.2**	**5.0**	**5.8**	**6.6**	**7.9**	**9.1**	**10.3**	**5.0**	**5.8**	**6.8**	**8.7**	**10.5**	**12.4**
Institutional Demand																		
Urban (12% x domestic urban)	3.4	4.0	4.8	6.4	8.1	9.9	3.6	4.4	5.3	7.1	9.1	11.1	3.6	4.5	5.5	7.9	10.5	13.3
Rural (10% x domestic rural)	3.7	3.8	3.9	3.4	2.8	2.0	4.0	4.2	4.3	3.8	3.1	2.2	4.0	4.2	4.4	4.3	3.6	2.7
Total Institutional (mld)	**7.1**	**7.8**	**8.6**	**9.9**	**10.9**	**11.8**	**7.6**	**8.6**	**9.6**	**11.0**	**12.2**	**13.3**	**7.6**	**8.7**	**9.9**	**12.2**	**14.1**	**16.0**

Sub-total A (dom + indus + comm + inst)																		
urban	39.8	46.9	55.4	74.4	95.0	116.8	42.3	51.6	61.7	82.7	105.8	130.6	42.3	52.2	63.7	91.7	121.7	156.8
rural	42.8	43.7	44.3	39.6	32.2	22.8	46.0	47.9	49.4	44.2	36.1	25.7	46.0	48.7	51.1	49.1	41.6	30.8
Service Factor (%)																		
Urban	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
Rural	100.0%	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
Demand Before NRW (mld) = sub-total A x Service Factor																		
Urban	39.8	46.9	55.4	74.4	95.0	116.8	42.3	51.6	61.7	82.7	105.8	130.6	42.3	52.2	63.7	91.7	121.7	156.8
Rural	42.8	43.7	44.3	39.6	32.2	22.8	46.0	47.9	49.4	44.2	36.1	25.7	46.0	48.7	51.1	49.1	41.6	30.8
Urban + Rural	82.6	90.7	99.7	114.0	127.2	139.6	88.3	99.5	111.0	126.9	141.9	156.3	88.3	100.9	114.8	140.9	163.3	187.6
NRW																		
%	41.0%	37.5 %	34.0 %	29.0 %	26.0 %	24.0 %	41.0 %	37.5 %	34.0 %	29.0 %	26.0 %	24.0 %	41.0 %	37.5 %	34.0 %	29.0 %	26.0 %	24.0 %
Amount (mld)	57.4	54.4	51.4	46.6	44.7	44.1	61.4	59.7	57.2	51.8	49.9	49.4	61.4	60.5	59.1	57.5	57.4	59.2
TOTAL DEMAND	**140.0**	**145.1**	**151.1**	**160.6**	**171.9**	**183.7**	**149.7**	**159.2**	**168.2**	**178.7**	**191.8**	**205.7**	**149.7**	**161.5**	**173.9**	**198.4**	**220.6**	**246.8**

SECTION 7

WATER DEMAND - IRRIGATION

Section 7

WATER DEMAND IRRIGATION

7.0 WATER DEMAND - IRRIGATION FOR PADDY

7.1 INTRODUCTION

This section reviews the irrigation water demand, and projects the demands for the State of Perlis. The previous NWRS (2000) is reviewed and updated on the irrigation water demand projection for paddy cultivation. Water demand for non-paddy crops and livestock farming is described in another section of the report. Determination of future irrigation demand for each decade from 2010 to 2050 is explained in this section of the report. To fulfill the objective of this study, the following scope of work was carried out:

(i) Review the NWRS (2000) and in particular, on the subject of irrigation water demand for irrigation of granary areas, mini granary areas and minor irrigation schemes.

(ii) Carry out necessary data collection of irrigation data from relevant irrigation agencies (i.e. JPS States, IADA granary offices, MARDI and MOA) for irrigation water demand projection.

The projected irrigation water demand for paddy cultivation was used as input for river basin water balance (demand/supply) analyses. This allows the water requirements for irrigated paddy production (being the largest user of water resources) to be evaluated under the present water source and proposed source work development.

7.2 PRESENT IRRIGATION SCHEMES

7.2.1 Granary Areas

The State of Perlis, together with the neighboring State of Kedah, is known as the 'Rice bowl of Malaysia'. Paddy cultivation is the major consumption of water.

Irrigation water supply for Muda Irrigation Scheme in Perlis is mainly drawn from 3 sources, namely the supply from 3 dams (Muda, Pedu and Ahning Dam) through the Northern Canal. However, the detailed irrigation water demand projection of this granary area is described in the Kedah State report, where water for the Muda Irrigation Scheme is also mainly drawn from Ahning, Muda and Pedu dams in the State of Kedah.

7.2.2 Mini Granary and Minor Irrigation Schemes

The designated mini granary areas of 3,758 ha and minor schemes of 3,656 ha are mostly dependent on stream flows. Several mini granary schemes are located downstream of the Timah-Tasoh Dam (refer **Figure 7.1**). These schemes fall within the river basins where irrigation water supply has been developed and operated by JPS.

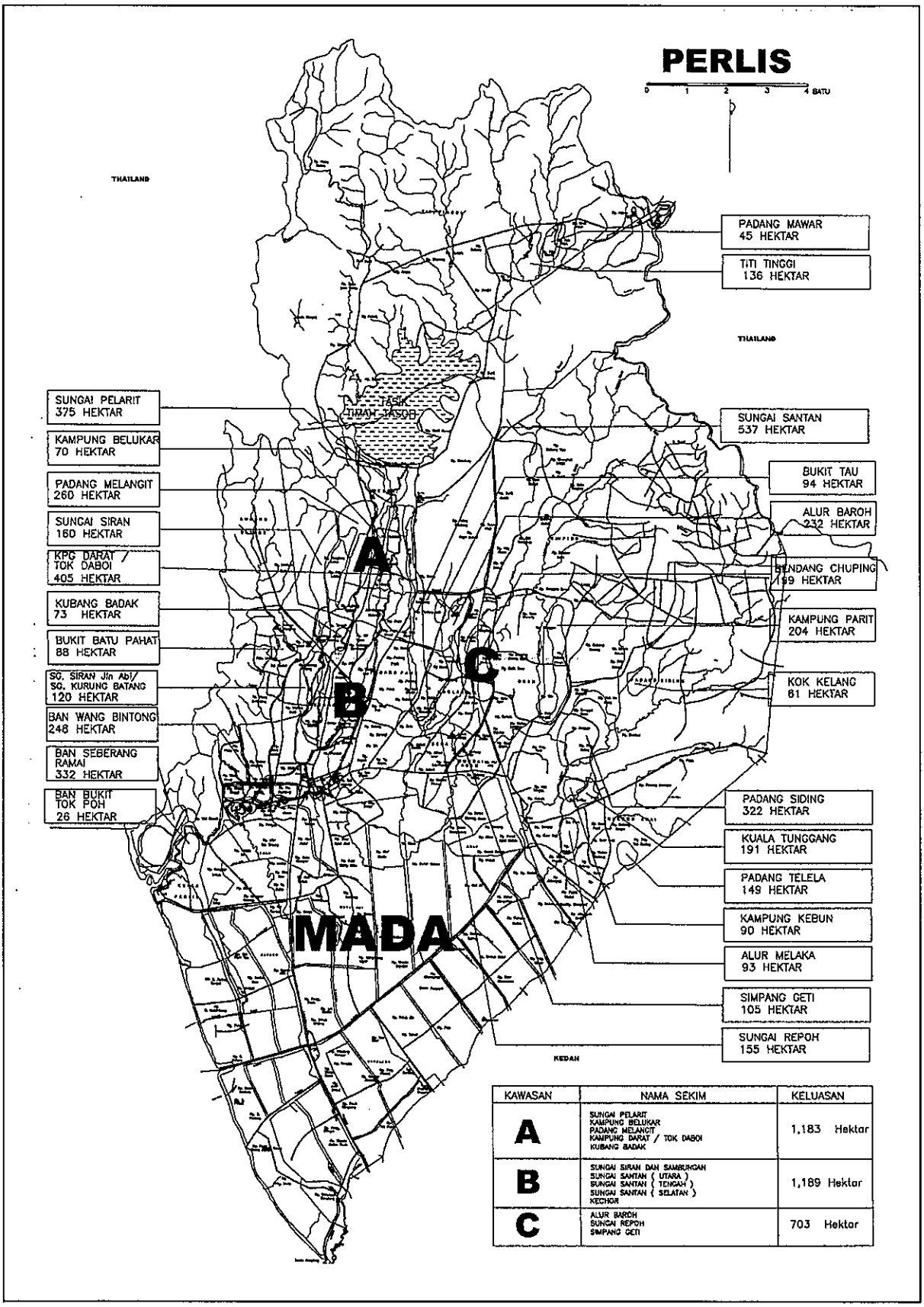


Figure 7.1 - Mini and Minor Irrigation Schemes in Perlis

There is no recent study and measurement of the current irrigation efficiency at the irrigation schemes, hence, the present and future projected irrigation efficiency adopted in the Study is based on the Stakeholders Participation Workshop 2 carried out in the PWTC FT Kuala Lumpur from 31 May to 1 June 2010 as in **Table 7.1** below:

Table 7.1 - Irrigation Efficiencies Adopted in Water Demand Projection

Irrigation Scheme	Irrigation Efficiencies (%)				
	2010	2020	2030	2040	2050
Granary Area	50	55	65	70	75
Muda*	70	70	75	75	75
Kemubu	55	60	65	70	75
Mini Granary	40	45	50	55	60
Minor Schemes	40	40	45	45	50

*IWRSNR 2009

7.3 FUTURE IRRIGATION DEVELOPMENT

Although it was the Government's intention under the NAP3 to phase out the minor irrigation schemes by 2010, by gradually converting these schemes for cultivation of other crops, some of these minor irrigation schemes still remain with paddy cultivation activities at the present time. Nevertheless, it is anticipated that these minor irrigation schemes will decrease gradually over the projection horizon due to the progress of urbanization.

7.4 WATER DEMAND FOR IRRIGATION

The rational and basis for the irrigation water demand projection is described in the Sectoral Report (Irrigation Water Demand for Paddy Cultivation). The list of mini granary and minor irrigation schemes is shown in **Table 7.2 and Table 7.3**. The following **Table 7.4** illustrates the projected irrigation water demand for the irrigation schemes.

Table 7.2 - Irrigation Water Demand Projection in Perlis State

Irrigation Scheme	Projected Annual Irrigation Water Demand (MCM)				
	2010	2020	2030	2040	2050
Mini Granary	133	119	107	97	89
Minor Schemes	65	65	58	58	52
Total	**198**	**184**	**165**	**155**	**141**

The projected irrigation water demand shows that there will be a decreasing trend towards year 2050 due to conversion of small irrigation schemes into upland or high value crops, and urbanization at many of the minor irrigation scheme areas, which are being abandoned. The downtrend projected water demand is also attributed to an increase in projected irrigation efficiency. The projected higher irrigation efficiency approach is intended to be a policy target to reduce the irrigation water demand in the country.

7.4.1 List Of Reference

(i) SMHB, Ranhill and JPZ, Unit Perancang Ekonomi Kerajaan Malaysia, 2000 *Kajian Sumber Air Negara 2000 – 2050 (Semenanjung Malaysia).* (NWRS (2000)).

(ii) Japan International Cooperation Agency (JICA), 1982. *National Water Resources Study, Malaysia.* Government of Malaysia (JICA 1982).

(iii) Perunding Kejuruteraan Perdana , 2009, *Integrated Water Resources Study For The Northern Region Of Peninsular Malaysia, Department of Irrigation and Drainage, Malaysia* (IWRSNR 2009).

Table 7.3 - Estimation of Irrigation Water Demand for 2 Planting Schedules for Direct Wet Seeded Rice Perlis Minor Irrigation Scheme

Month		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Eto (mm) per day		4.00	4.50	4.30	4.10	3.50	3.10	3.10	3.30	3.30	3.00	3.10	3.10	
Irrigation Area (ha)														
Schedule 1	0.5			0.5	0.5	0.5	0.5			0.5	0.5	0.5	0.5	
Schedule 2	0.5	0.5			0.5	0.5	0.5	0.5			0.5	0.5	0.5	
Total Area	1													
Reference Crop Evaporation (Eto) in mm		124.0	126.0	133.3	123.0	108.5	93.0	96.1	102.3	99.0	93.0	93.0	96.1	
Schedule 1														
Crop Coefficient Kc				1.1	1.15	1.25	1.2			1.1	1.15	1.25	1.2	
Presaturation - Off Season	120			0	0					0	0			
Presaturation - Main Season	100													
Soil Saturation + standing water = S+H				228	67					208	67			
Evapo-tranpiration, Etcrop = Kc x Eto (mm)				147	141	136	112			109	107	116	115	
Percolation, P mm/day	2			20	60	60	60			20	60	60	60	
Field Crop Water Requirement, Fc = Etcrop + P				395	268	196	172			337	234	176	175	
Effective rainfall (Re) in mm		0	2	34	64	77	60	66	78	116	124	78	17	
Net Monthly crop requirement in mm (Fc-Re)				361	204	119	112			221	110	98	158	
Irrigation Efficiency, Ie	50%			0.5	0.5	0.5	0.5			0.5	0.5	0.5	0.5	
Net Monthly irrigation demand (Iw) = (Fc-Re)/Ie, mm				721	409	237	223			442	220	197	317	
Net Monthly irrigation demand l/s				1.39	0.79	0.46	0.43			0.85	0.42	0.38	0.61	
(1 mm (ha) = 0.00386 lit/se)														

* table continue next page

Month		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Schedule 2														
Crop Coefficient Kc		1.2			1.1	1.15	1.25	1.2			1.1	1.15	1.25	
Presaturation - Off Season	120				0	0					0	0		
Presaturation - Main Season	100													
Soil Saturation + standing water = S+H					228	67					208	67		
		149			135	125	116	115			102	107	120	
Percolation, P mm/day	2	60			20	60	60	60			20	60	60	
Field Crop Water Requirement, Fc = Etcrop + P		209			383	252	176	175			330	234	180	
Effective rainfall (Re) in mm		0	2	34	64	77	60	66	78	116	124	78	17	
Net Monthly crop requirement in mm (Fc-Re)		209			319	175	116	109			206	156	163	
Irrigation Efficiency, Ie	50%	0.5			0.5	0.5	0.5	0.5			0.5	0.5	0.5	
Net Monthly irrigation demand (Iw) = (Fc-Re)/Ie, mm		418			639	350	233	219			413	312	326	
Net Monthly irrigation demand l/s		0.81			1.23	0.67	0.45	0.42			0.80	0.60	0.63	
(1 mm (ha) = 0.00386 lit/se)														
Total irrigation demand l/s for 2 schedules		0.81	0.00	1.39	2.02	1.13	0.88	0.42	0.00	0.85	1.22	0.98	1.24	
Total irrigation demand in mld for 2 schedules		69.64	0.00	120.27	174.67	97.85	75.99	36.46	0.00	73.67	105.47	84.78	107.20	
Total Water Demand in Million Cubic meters/month		0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Mini Granary demand, area (ha)	3656	7.64	0.00	13.19	19.16	10.73	8.33	4.00	0.00	8.08	11.57	9.30	11.76	
Cropping intensity = 50%		3.82	0.00	6.60	9.58	5.37	4.17	2.00	0.00	4.04	5.78	4.65	5.88	
Mini Granary water demand in MCM		3.8	0.0	6.6	9.6	5.4	4.2	2.0	0.0	4.0	5.8	4.6	5.9	51.9

Table 7.4 - Estimation of Irrigation Water Demand for 2 Planting Schedules for Direct Wet Seeded Rice Perlis Mini Granary Scheme

Month		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Eto (mm) per day		4.00	4.50	4.30	4.10	3.50	3.10	3.10	3.30	3.30	3.00	3.10	3.10	
Irrigation Area (ha)														
Schedule 1	0.5			0.5	0.5	0.5	0.5			0.5	0.5	0.5	0.5	
Schedule 2	0.5	0.5			0.5	0.5	0.5	0.5			0.5	0.5	0.5	
Total Area	1													
Reference Crop Evaporation (Eto) in mm		124.0	126.0	133.3	123.0	108.5	93.0	96.1	102.3	99.0	93.0	93.0	96.1	
Schedule 1														
Crop Coefficient Kc				1.1	1.15	1.25	1.2			1.1	1.15	1.25	1.2	
Presaturation - Off Season	120			0	0					0	0			
Presaturation - Main Season	100													
Soil Saturation + standing water = S+H				228	67					208	67			
Evapo-tranpiration, Etcrop = Kc x Eto (mm)				147	141	136	112			109	107	116	115	
Percolation, P mm/day	2			20	60	60	60			20	60	60	60	
Field Crop Water Requirement, Fc = Etcrop + P				395	268	196	172			337	234	176	175	
Effective rainfall (Re) in mm		0	2	34	64	77	60	66	78	116	124	78	17	
Net Monthly crop requirement in mm (Fc-Re)				361	204	119	112			221	110	98	158	
Irrigation Efficiency, Ie	60%			0.6	0.6	0.6	0.6			0.6	0.6	0.6	0.6	
Net Monthly irrigation demand (Iw) = (Fc-Re)/Ie, mm				601	341	198	186			368	183	164	264	
Net Monthly irrigation demand l/s				1.16	0.66	0.38	0.36			0.71	0.35	0.32	0.51	
(1 mm (ha) = 0.00386 lit/se)														

* table continue next page

Month		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Schedule 2														
Crop Coefficient Kc		1.2			1.1	1.15	1.25	1.2			1.1	1.15	1.25	
Presaturation - Off Season	120				0	0					0	0		
Presaturation - Main Season	100													
Soil Saturation + standing water = S+H					228	67					208	67		
		149			135	125	116	115			102	107	120	
Percolation, P mm/day	2	60			20	60	60	60			20	60	60	
Field Crop Water Requirement, Fc = Etcrop + P		209			383	252	176	175			330	234	180	
Effective rainfall (Re) in mm		0	2	34	64	77	60	66	78	116	124	78	17	
Net Monthly crop requirement in mm (Fc-Re)		209			319	175	116	109			206	156	163	
Irrigation Efficiency, Ie	60%	0.6			0.6	0.6	0.6	0.6			0.6	0.6	0.6	
Net Monthly irrigation demand (Iw) = (Fc-Re)/Ie, mm		348			532	291	194	182			344	260	272	
Net Monthly irrigation demand l/s		0.67			1.03	0.56	0.37	0.35			0.66	0.50	0.52	
(1 mm (ha) = 0.00386 lit/se)														
Total irrigation demand l/s for 2 schedules		0.67	0.00	1.16	1.68	0.94	0.73	0.35	0.00	0.71	1.02	0.82	1.03	
Total irrigation demand in mld for 2 schedules		58.03	0.00	100.23	145.56	81.54	63.32	30.38	0.00	61.39	87.89	70.65	89.34	
Total Water Demand in Million Cubic meters/month		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Mini Granary demand, area (ha)	3758	6.542	0	11.3	16.41	9.19	7.14	3.43	0.00	6.92	9.91	7.96	10.07	
Cropping intensity = 100%														
Mini Granary water demand in MCM		6.5	0.0	11.3	16.4	9.2	7.1	3.4	0.0	6.9	9.9	8.0	10.1	88.9

SECTION 8

WATER DEMAND - NON-PADDY CULTIVATION

Section 8

WATER DEMAND NON-PADDY CULTIVATION

8.0 WATER DEMAND IN PERLIS - NON-PADDY CULTIVATION

8.1 AREAS OF CROPS: CURRENT AND PROJECTED

The projected crop areas in Perlis are shown in **Table 8.1**. For 2007, the areas are actual, but the later years are all projected. The basis of the projection is given in **Annex 8.1**. In essence, the reasoning is that Perlis is one of the Peninsular states. In the Peninsula, it is generally reckoned that there is little new land left for agricultural development, i.e., no more forest clearing, or at best only very small areas. Thus, there will be no further increases in the plantation crops – oil palm and rubber. Industrial crops (which are mainly coconut), fruits and vegetables will also not increase because simple calculations show that the areas are more than sufficient to supply the nation several times over even if only moderate yields are obtained. Increased production from them will have to come from greater intensification, Good Irrigation Practices (GIP), Good Agricultural Practices (GAP), improved pre-harvest practices and post-harvest handling.

The only crop likely to increase in area is flowers. Flowers are in increasing demand as society develops and gets richer. They are also a high-value crop on a very small area, and encouraged to increase in the 10th Malaysia Plan, so may be able to expand even if land is scarce.

The area under oil palm is so small that there is reckoned to be no need for oil palm nurseries (the calculated need is only 0.1 hectare). Against this, almost all the industrial crops is sugar cane (7,790 hectares) which is assumed to be irrigated throughout the year although, in practice, the crop is 'dried off' (not irrigated) prior to harvest to increase its sugar content.

Table 8.1 - Crop Areas in Perlis Projected to 2050 (ha)

Crop	2007 (Actual)	2010	2020	2030	2040	2050
Oil Palm (Nursery area)	260 -	260 -	260 -	260 -	260 -	260 -
Rubber	4,275	4,275	4,275	4,275	4,275	4,275
Tobacco+	57	57	57	57	57	57
Fruits	718	718	718	718	718	718
Vegetables	193	193	193	193	193	193
Flowers	6	7	11	19	30	49
Industrial Crops^	7,799	7,799	7,799	7,799	7,799	7,799

* Areca Nut, Coconut, Coffee, Nipah, Roselle, Sago, Sugar Cane, Tea.

8.2 CROP WATER CONSIDERATIONS

Malaysia, being just above the equator, has a humid tropical climate with rain throughout the year although some months are drier/wetter than others. The perennial commodity crops, with their deep root systems, are unlikely to suffer severe water stress in the dry periods (notwithstanding freak years of long dry spells) as they have access to the large reserves of water stored in the soil. Thus, in trials, they have never responded well to irrigation making the practice uneconomic.

Fruits are increasingly irrigated because of the high price produce and to ensure regular cropping. For estimating the total water demand, it will be assumed that all fruits are irrigated as this is the trend.

Vegetables are totally irrigated. Even in those days when they were not considered 'irrigated', they were hand-watered several times daily. They are extremely highly priced, short term (with shallow roots) and are, in fact, mostly water. The farmer is, therefore, unlikely to skimp on his watering to obtain the highest yields. This is also true for flowers.

8.3 ESTIMATION OF CROP EVAPORATION

The crop evaporation is given by:

*Crop Evaporation = Pan Evaporation * Crop Coefficient*

Pan evaporation is the water loss from an open pan of water. Shorn of the technical jargon, the pan is a simulation of an open body of water from which evaporation can be measured directly. It is known that a turgid crop loses as much water as an open body of water.

The crop itself has some influence on water loss. A young crop may not catch all the sunlight, so loses less water than the mature crop. Generally, the crop coefficient for a young crop is 0.30 – 0.50, i.e., it loses only 30% - 50% of the water by a mature crop.

The mature crop may lose even more water than the pan as, being higher up, it catches more wind and suffers additional losses by the wind. Thus, the coefficient for a mature crop is generally 0.90 – 1.10.

As this study is to estimate the total (= maximum) water requirement by crops, the mature crop coefficient will be used to err on the side of safety. Therefore,

*Crop Evaporation = Pan Evaporation * 1.0, or*

Crop Evaporation = Pan Evaporation

8.3.1 Total Water Requirement

Of the crops in **Table 8.1**, it is assumed that only tobacco, fruits, vegetables, herbs and flowers are irrigated. Generally, farmers will over-irrigate their crops because their produce is such high value. Therefore, tobacco, fruits and herbs are assumed to be irrigated to 1.5x their evaporative loss of water.

Vegetables and flowers require even more water. The soil has always to be glistening wet so that the plants can take up as much water as possible for faster and greater growth. They are assumed to be irrigated to 2.0x their evaporative loss of water.

Although mature oil palm is not irrigated, the nurseries - where the young palms are raised for replanting - are. The practice is to irrigate twice a day, so there is over-watering. It is assumed, as for vegetables, that the water requirement is 2.0x the evaporative water loss.

Oil palm is a 30-year crop, i.e., it is replanted after 30 years. On average, therefore, 1/30 of the area is re-planted each year. Perlis has only 260 hectares of oil palm, so only 9 hectares will be replanted a year. At 146 palms/hectare, rounded up to 150 palms/hectare for casualties, the number of new palms required is 1,350 a year. This is such a small requirement that it is uneconomic to have a nursery. There is therefore no water requirement for oil palm nurseries.

Rainfall and evaporation data were obtained for Perlis as shown in **Table 8.2**.

Table 8.2 - Mean Monthly Rainfall (mm) and Evaporation (mm/day) for Perlis

	Jan	Febb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	21.3	48.0	165.	194.1	138.8	153.2	210.7	169.5	231.9	272.4	173.4	175.7	1,957.4
Evaporation	5.0	5.8	5.4	4.8	4.0	3.8	3.5	3.5	3.4	3.3	3.3	3.7	4.1

Note: Data from Chuping for 2002 - 2008.

The monthly water requirements are shown in **Table 8.3**.

Table 8.3 - Monthly Water Requirements for Non-Paddy Crops in Perlis 2007 – 2050 ('000 m^3)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007 (Base)	18,490	17,465	7,649	2,116	4,436	1,507	7	95	0	0	47	109	51,920
2010	18,493	17,468	7,650	2,117	4,437	1,508	7	95	0	0	48	109	51,932
2020	18,505	17,479	7,657	2,120	4,442	1,511	7	97	0	0	49	111	51,978
2030	18,528	17,502	7,671	2,128	4,451	1,576	8	101	0	0	50	116	52,069
2040	18,559	17,532	7,689	2,138	4,463	1,524	8	106	0	0	53	122	52,195
2050	18,613	17,586	7,721	2,156	4,484	1,538	9	115	0	0	58	132	52,412

The calculations can be seen in **Annex 8.2**.

Perlis is the most northernmost state in Peninsular Malaysia and suffers a severe drougth in January/February when evaporation greatly exceeds rainfall. Over the year, rainfall exceeds evaporation by 30 per cent because of the good rains in the other months. Unfortunately, the surplus cannot be stored for future use (except some by the soil), so has to be wasted.

Sugar cane takes the bulk of the irrigation needs due to its overwhelming area - almost 90 per cent of the irrigable area. If it is not irrigated in the dry season of January/February, to stress it and increase its sugar content, the irrigation need falls substantially by 60 percent. Most of the residual non-sugar cane irrigable land is under fruits. If these are also not irrigated to induce them to flower, the water needs fall another five per cent, so in total 65 percent of the irrigation calculated for may not be needed.

8.4 SOURCES OF WATER

Despite the dryness of the state, little water may be required because of the nature of the crop – sugar cane and fruits which benefit agronomically from some drought. However, it must be noted that for Malaysian states, the dry season here is very dry. Streams may dry up, and so ponds and wells may have to be dug.

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REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000 – 2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

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ANNEX 8.1 – FORECAST OF CROP AREAS

ANNEX 8.1 - FORECAST OF CROP AREAS

Out of the national cultivated area of about seven million hectares, oil palm is planted on about 4.5 million hectares. It is thus the major crop of the country. **Table 8.1** shows the oil palm areas by individual states (in alphabetical order). Up to 2007, the areas are actual. It can be seen that in the Peninsula, the states are already running out of land and the oil palm area is only increasing slightly, mainly from the conversion of rubber. It is assumed that there will be no further increase in the oil palm area there. Some rubber land may still be converted, but against this some agricultural land may be converted to other uses – housing, roads, etc. – and by virtue of the fact that oil palm is the predominant crop, most of the land will be from oil palm.

In East Malaysia, the oil palm area is still expanding rapidly. From the water resources point of view, this is the best scenario because Sabah and Sarawak are the wettest states in the country and the problem with water there is more of floods than drought.

Sarawak is the larger state in East Malaysia, by itself almost as large as the Peninsula. But it has been a late comer to planting oil palm largely because of legal problems over land ownership. However, its area is now increasing rapidly, and it has stated its intention to have a final area of two million hectares of the crop. For simplicity, a straight line growth is assumed to its target area in 2050, i.e., in the 43 years from 2007 to 2050, the area will grow by 31,056 hectares a year. In 2030, for example, it will have 1,378,900 hectares.

Sabah is roughly in the same situation as Sarawak. It has a smaller area, but against this its land is more suitable for planting oil palm – less peat and less embroiled in legal issues. It is thus assumed that Sabah will also have two million hectares of oil palm eventually. Again, for simplicity's sake, a straight line increase is taken to 2050, i.e., an increase of 16,785 hectares a year from 2007 to 2050. By 2030, for example, its area will be 1,664,299 hectares.

The oil palm area will therefore not expand in the Peninsula, only in East Malaysia.

The estimates may be disputed. However, it is not necessary that they be very accurate as they are not for land use planning, but for estimating the crop water demand. Oil palm in the field is not irrigated; only the nurseries are. The crop area is only required to estimate the area of nurseries for supplying the seedlings for replanting. Generally, the nursery area is only about 0.05 percent of the crop area.

Table 8.1 – Projected Oil Palm Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia										
Johor	525,000	579,000	634,716	667,872	670,641	670,641	670,641	670,641	670,641	670,641
Kedah	30,000	36,000	57,375	75,472	75,096	75,096	75,096	75,096	75,096	75,096
Kelantan	60,000	67,000	72,065	89,886	99,763	99,763	99,763	99,763	99,763	99,763
Melaka	26,000	36,000	43,589	52,015	49,113	49,113	49,113	49,113	49,113	49,113
Negeri Sembilan	85,000	106,000	123,343	155,164	170,843	170,843	170,843	170,843	170,843	170,843
Pahang	434,000	507,000	514,710	606,821	641,452	641,452	641,452	641,452	641,452	641,452
Perak	220,000	262,000	303,533	340,959	350,983	350,983	350,983	350,983	350,983	350,983
Perlis	0	0	0	278	260	260	260	260	260	260
P. Pinang	-	-	-	-	-	-	-	-	-	-
Selangor	148,000	153,000	135,467	132,100	129,315	129,315	129,315	129,315	129,315	129,315
Terengganu	121,000	147,000	145,767	163,967	161,287	161,287	161,287	161,287	161,287	161,287
Total	1,649,000	1,893,000	2,030,565	2,284,534	2,348,753	2,348,753	2,348,753	2,348,753	2,348,753	2,348,753
E. Malaysia										
Sabah	276,171	518,133	1,000,777	1,209,368	1,278,244	1,328,599	1,496,449	1,664,299	1,832,149	2,000,000
Sarawak	54,795	118,783	330,387	543,398	664,612	757,780	1,068,340	1,378,900	1,689,460	2,000,000
Total	330,966	636,916	1,331,164	1,752,766	1,942,856	2,086,379	2,564,789	3,043,199	3,521,609	4,000,000
Total (Malaysia)	**1,979,966**	**2,529,916**	**3,361,729**	**4,037,300**	**4,291,609**	**4,435,132**	**4,913,542**	**5,391,952**	**5,870,362**	**6,348,753**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

Table 8.2 shows the rubber areas by state. All the states have falling areas from 1995 to 2007. Rubber is a difficult crop. While prices are currently high, putting a gloss on it, there are few willing to undertake the physically demanding task of tapping. However, the situation may be changing. With white- and blue-collared jobs in descendency, the rubber price is in ascendancy, so the area may stabilize. It is therefore forecast that the present area will remain to 2050. As explained earlier, the accuracy of the forecast is not very important so long as it is reasonable. Like oil palm, rubber is not irrigated and whatever the area will not impact the agricultural water demand. Even better than oil palm, there are not even nurseries – only budwood plots of stumps to produce grafting materials.

Table 8.2 – Projected Rubber Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P. Malaysia										
Johor	-	290,692	213,348	188,877	183,437	183,437	183,437	183,437	183,437	183,437
Kedah	-	244,398	240,022	212,491	206,371	206,371	206,371	206,371	206,371	206,371
Kelantan	-	142,366	152,914	135,375	131,475	131,475	131,475	131,475	131,475	131,475
Melaka	-	59,861	54,327	48,096	46,710	46,710	46,710	46,710	46,710	46,710
Negeri Sembilan	-	223,238	176,045	155,853	151,363	151,363	151,363	151,363	151,363	151,363
Pahang	-	265,401	180,833	160,091	155,480	155,480	155,480	155,480	155,480	155,480
Perak	-	218,258	198,759	175,961	170,893	170,893	170,893	170,893	170,893	170,893
Perlis	-	9,312	4,972	4,402	4,275	4,275	4,275	4,275	4,275	4,275
P. Pinang	-	13,487	13,013	11,520	11,189	11,189	11,189	11,189	11,189	11,189
Selangor	-	41,127	22,707	20,103	19,523	19,523	19,523	19,523	19,523	19,523
Terengganu	-	87,957	83,884	74,263	72,123	72,123	72,123	72,123	72,123	72,123
Total	-	1,596,097	1,340,824	1,187,032	1,152,839	1,152,839	1,152,839	1,152,839	1,152,839	1,152,839
E. Malaysia										
Sabah	91	93	87	65	71	71	71	71	71	71
Sarawak	209	211	158	157	157	157	157	157	157	157
Total	300	304	245	222	228	228	228	228	228	228
Total (Malaysia)		**1,596,401**	**1,341,069**	**1,187,254**	**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**	**1,153,067**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

The cocoa area by state is shown in **Table 8.3**. The crop, once threatening to be the main crop, is hardly grown in the Peninsula anymore. It is now mainly in Sabah and even there the area is fast declining – the 2007 area being less than 10% that in 1990. Sarawak is the second state growing cocoa but, like Sabah, its area is greatly diminished from the past. It is therefore assumed that there is no increase in the crop area to 2050, the 2007 figures remaining constant.

Table 8.3 – Projected Cocoa Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
E. Malaysia										
Sabah	179,648	113,691	51,810	21,861	17,544	17,544	17,544	17,544	17,544	17,544
Sarawak	75,886	28,732	8,814	2,913	4,350	4,350	4,350	4,350	4,350	4,350
Total	255,531	142,423	60,624	24,774	21,894	21,894	21,894	21,894	21,894	21,894
Total (Malaysia)	**255,531**	**142,423**	**60,624**	**24,774**	**21,894**	**21,894**	**21,894**	**21,894**	**21,894**	**21,894**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

Tobacco is a socio-political crop. Anyone can plant it, but the high production cost in Malaysia makes its cultivation unprofitable. The price is however subsidized for poor farmers.

Despite the subsidy, the area has fluctuated about 10,000 hectares since 1990 (**Table 8.4**). The subsidy has not kept up with inflation and thus has become less attractive with time. With an effectively lower subsidy (reduced by inflation), the area is not expected to increase and will remain constant at best to 2050.

Table 8.4 – Projected Tobacco Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia										
Johor	-	-	-	-	-	-	-	-	-	-
Kedah	318	517	338	350	57	57	57	57	57	57
Kelantan	6,281	6,196	11,097	5,580	5,417	5,417	5,417	5,417	5,417	5,417
Melaka	-	-	-	-	-	-	-	-	-	-
Negreri Sembilan	-	-	-	-	-	-	-	-	-	-
Pahang	252	69	59	87	6	6	6	6	6	6
Perak	317	516	339	350	58	58	58	58	58	58
Perlis	318	517	338	350	57	57	57	57	57	57
P. Pinang	-	-	-	-	-	-	-	-	-	-
Selangor	-	-	-	-	-	-	-	-	-	-
Terengganu	2,368	2,685	3,518	1,752	1,083	1,083	1,083	1,083	1,083	1,083
Total	9,854	10,500	15,689	8,469	6,678	6,678	6,678	6,678	6,678	6,678
E. Malaysia										
Sabah	401	226	661	1,155	1,200	1,200	1,200	1,200	1,200	1,200
Sarawak	-	-	-	-	-	-	-	-	-	-
Total	401	226	661	1,155	1,200	1,200	1,200	1,200	1,200	1,200
Total (Malaysia)	**10,255**	**10,726**	**16,350**	**9,624**	**7,878**	**7,878**	**7,878**	**7,878**	**7,878**	**7,878**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates

Pepper is also largely grown in East Malaysia. It is very labour intensive, and unlikely to expand much as the country strives to become a high-income nation. Sarawak has the largest area – around 12,000 hectares – but the area has fluctuated around this level since 1990 and shows no sign of increasing (**Table 8.5**). Sabah has less than 20 hectares of the crop, very much decreased from 1990. It is therefore assumed that the area of the crop will not increase and that the 2007 figures will remain to 2050.

Table 8.5 - Pepper Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
E. Malaysia										
Sabah	155	102	45	16	16	16	16	16	16	16
Sarawak	11,207	9,690	13,327	12,674	11,801	11,801	11,801	11,801	11,801	11,801
Total	11,362	9,792	13,372	12,690	11,817	11,817	11,817	11,817	11,817	11,817
Total (Malaysia)	**11,362**	**9,792**	**13,372**	**12,690**	**11,817**	**11,817**	**11,817**	**11,817**	**11,817**	**11,817**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

Industrial crops are mostly coconut although they also include areca nut, coffee, nipah, roselle, sago, sugar cane and tea. There is some tea in Cameron Highlands, sugar cane in the northern Peninsular states and coffee in Selangor. Other than that, it is almost all coconut. In the Peninsula, the area has almost halved (**Table 8.6**). The largest areas in the Peninsula are in Johor, Perak and Kedah, but Sarawak dwarfs them all and even Sabah is just behind Johor.

In East Malaysia, the area has increased slightly and is now almost that in the Peninsula. There is no import of coconut by the Peninsula from East Malaysia or, for that matter, from abroad (except possibly during festivals when some shortages occur). The point is that if 100,000 hectares can supply coconut to 25 million people in the Peninsula, there is no need for another 100,000 hectares to supply the 5 million people in Sabah/Sarawak. The area of industrial crops is thus also not expected to increase to 2050, and the 2007 areas are assumed.

Table 8.6 – Projected Industrial Crop Areas by State, 1995 – 2050 (hectares)

State	1990	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia										
Johor	-	50,448	38,235	28,151	25,192	25,192	25,192	25,192	25,192	25,192
Kedah	-	22,078	14,661	10,058	10,344	10,344	10,344	10,344	10,344	10,344
Kelantan	-	8,753	8,472	8,580	6,444	6,444	6,444	6,444	6,444	6,444
Melaka	-	3,100	3,125	3,028	2,953	2,953	2,953	2,953	2,953	2,953
Negreri Sembilan	-	1,818	1,811	1,344	1,371	1,371	1,371	1,371	1,371	1,371
Pahang	-	7,447	5,682	3,764	7,680	7,680	7,680	7,680	7,680	7,680
Perak	-	37,524	24,468	17,005	14,159	14,159	14,159	14,159	14,159	14,159
Perlis	-	8,314	NA	7,799	7,799	7,799	7,799	7,799	7,799	7,799
P. Pinang	-	2,547	2,570	2,219	2,086	2,086	2,086	2,086	2,086	2,086
Selangor	-	31,801	28,829	11,656	20,239	20,239	20,239	20,239	20,239	20,239
Terengganu	-	5,109	5,193	2,820	2,662	2,662	2,662	2,662	2,662	2,662
Total	-	178,939	133,046	96,424	100,929	100,929	100,929	100,929	100,929	100,929
E. Malaysia										
Sabah	-	NA	28,732	25,869	22,083	22,083	22,083	22,083	22,083	22,083
Sarawak	-	NA	88,025	76,747	74,932	74,932	74,932	74,932	74,932	74,932
Total	-	NA	116,757	102,616	97,015	97,015	97,015	97,015	97,015	97,015
Total (Malaysia)	-	**178,939**	**249,803**	**199,040**	**197,944**	**197,944**	**197,944**	**197,944**	**197,944**	**197,944**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

Herbs are but a small area in the country, in total only just over 500 hectares in 2007. East Malaysia hardly grows any. Limited data are available on their cultivation – in fact, only for 2005 and 2007 (**Table 8.7**). In these two years, most states had hardly changed areas except for Pahang which jumped from 117.3 hectares to 326.7 hectares.

Herbs are usually high-value crops and quite intensive to grow. Thus, generally only small areas are planted. They also do well as undercrops and can be planted in between perennial crops like oil palm and rubber. Thus, dedicated areas for herbs are unlikely to increase. If need be, e.g., from a spike in demand, they can be planted as intercrops. However, to err on the side of safety in estimating the water requirements, the area will be assumed to increase five percent annually compounded in the producing states.

Table 8.7 – Projected Herb Areas by State, 1995 – 2050 (hectares)

State	2005	2007	2010e	2020e	2030e	2040e	2050e
P. Malaysia							
Johor	108.1	85.8	99.3	161.7	263.5	429.2	699.0
Kedah	0.5	0.1	1.0	1.6	2.7	4.3	7.0
Kelantan	10.0	11.4	13.2	21.5	35.0	57.0	92.9
Melaka	1.0	3.0	4.0	6.5	10.6	17.3	28.2
Negeri Sembilan	0.7	15.7	6.6	10.8	17.5	28.6	46.5
Pahang	117.3	326.7	378.2	616.0	1,003.5	1,634.6	2,662.5
Perak	1.6	2.9	4.0	6.5	10.6	17.3	28.2
Perlis	-	-	-	-	-	-	-
P. Pinang	1.0	8.1	9.4	15.3	24.9	40.6	66.2
Selangor	62.8	64.8	75.0	122.2	199.0	324.1	528.0
Terengganu	-	-					
Total	303.0	518.5	590.7	962.1	1,567.3	2,553.0	4,158.5
E. Malaysia							
Sabah	-	-	-	-	-	-	-
Sarawak	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-
Total (Malaysia)	**303.0**	**518.5**	**590.7**	**962.1**	**1,567.3**	**2,553.0**	**4,158.5**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

There are also limited data for flowers. The area increased substantially from 2000 to 2005 but has since stagnated (**Table 8.8**). Flowers are a high price crop, and the general lack of land may not hinder their expansion as much as other crops because the growers can afford the land, even if scarce. They are also coming into vogue as the country gets richer and more people are 'saying it' with a bouquet. Nevertheless, in the largest states, Johor and Pahang, land at any price is getting scarcer, putting a lid on the expansion. It is therefore assumed that the area increases by five percent a year. Thus, in 2050, the national area will be 15,016 hectares.

Table 8.8 – Projected Flower Areas by State, 1995 – 2050 (hectares)

State	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia								
Johor	739	1,021	1,000	1,158	1,886	3,073	5,005	8,152
Kedah	6	19	25	29	47	77	125	204
Kelantan	8	21	29	34	55	90	147	239
Melaka	3	17	22	25	41	66	108	176
Negeri Sembilan	4	9	12	14	23	37	61	99
Pahang	484	296	308	357	582	947	1,543	2,513
Perak	86	91	101	117	191	310	506	824
Perlis	-	2	6	7	11	19	30	49
P. Pinang	-	1	7	8	13	21	35	56
Selangor	44	215	220	255	415	677	1,102	1,795
Terengganu	-	7	14	16	26	42	69	113
Total	1,374	1,699	1,769	2,020	3,290	5,359	8,731	14,220
E. Malaysia								
Sabah	23	24	35	41	67	109	177	289
Sarawak	18	53	62	72	117	191	311	507
Total	41	77	97	113	184	300	488	796
Total (Malaysia)	**1,415**	**1,776**	**1,866**	**2,133**	**3,474**	**5,659**	**9,219**	**15,016**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

The fruit areas are shown in **Table 8.9**. Up to 2007, the actual figures show them to be greatly reduced in the Peninsula and more or less stable in East Malaysia.

The areas are expected to stay the same to 2050 for the following reasons:

The annual per capita consumption of fruits in Malaysia is <70 kgs. Fruit yields can be very high because as much as 90% of the fruit, or possibly even more, is water. MARDI gives the yield of papaya at 70 tonnes/hectare/year. Taking this as an example fruit yield, the total production from the almost 280,000 hectares under fruits will be 19.6 million tonnes/year, or 754 kg/person taking the Malaysian population at 26 million. This is >10x the annual per capita consumption. Clearly, not every farmer will get MARDI yields, but equally clearly there is a big margin of safety in the estimates because even at 20% MARDI yields, there would be sufficient fruits even if the population doubles and the per capita consumption increases by, say, 20%.

It is known that the 'hard' fruits like durian and mangosteen may not yield 70 tonnes/hectare/year even under good management. However, the main fruits consumed are banana, papaya and watermelon and under good management (fertilized, irrigated and good pest and disease control) will match or exceed the figure. Durian, notwithstanding exclamations for its popularity, is very much less consumed.

Thus, the area will be stable with increased production to come from intensification and better management practices.

Table 8.9 - Fruit Areas by State, 1995 – 2050 (hectares)

State	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia									
Johor	256,365	83,551	67,741	61,181	61,181	61,181	61,181	61,181	61,181
Kedah	16,329	15,100	16,997	17,028	17,028	17,028	17,028	17,028	17,028
Kelantan	54,072	55,221	60,080	51,388	51,388	51,388	51,388	51,388	51,388
Melaka	8,297	8,850	9,430	7,832	7,832	7,832	7,832	7,832	7,832
Negeri Sembilan	8,260	17,183	8,439	8,811	8,811	8,811	8,811	8,811	8,811
Pahang	18,960	20,831	22,189	23,372	23,372	23,372	23,372	23,372	23,372
Perak	29,309	23,089	23,562	21,373	21,373	21,373	21,373	21,373	21,373
Perlis	1,280	NA	740	718	718	718	718	718	718
P. Pinang	7,082	7,282	6,905	6,747	6,747	6,747	6,747	6,747	6,747
Selangor	15,020	10,928	5,743	4,787	4,787	4,787	4,787	4,787	4,787
Terengganu	19,361	21,526	18,837	24,780	24,780	24,780	24,780	24,780	24,780
Total	434,335	263,561	240,663	228,017	228,017	228,017	228,017	228,017	228,017
E. Malaysia									
Sabah	-	17,212	16,141	17,001	17,001	17,001	17,001	17,001	17,001
Sarawak	-	37,300	33,998	34,695	34,695	34,695	34,695	34,695	34,695
Total		54,512	50,139	51,696	51,696	51,696	51,696	51,696	51,696
Total (Malaysia)	**434,335**	**318,073**	**290,802**	**279,713**	**279,713**	**279,713**	**279,713**	**279,713**	**279,713**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

Vegetables produce even higher yields than fruits for two reasons. Firstly, the leafy vegetables - lettuce, sawi, bayam, kai lan, etc. - contain even more water than fruits. The fruit vegetables

(cucumber, brinjal, chilli, etc.) are, actually, fruits, so should contain more or less the same amount of water as banana, papaya, etc. Secondly, for leafy vegetables, the whole plant is considered *yield* as opposed to only the reproductive organs in fruits. Obviously, higher yields are obtained if the whole plant is taken rather than just a part of it. Thus, a reasonable expected yield is 100 tonnes/hectare/year, and this should be obtainable because vegetable farms are generally quite intensively managed, and especially as the consumer connives in getting very high yields – he wants the freshest vegetables, i.e., those with the most water.

In **Table 8.10**, the vegetable areas have been stable from 2000 to 2007. Given the present 50,000 hectares and assuming a yield of 100 tonnes/hectare/year, the annual production will be 5 million tonnes, or 192 kg/person assuming a population of 26 million. The annual per capita of vegetables is coincidently similar to fruits at <70 kg. Given the possible production from the present area, it should suffice to 2050 even with the population doubling and some increase in per capita consumption.

Table 8.10 – Projected Vegetable Areas by State, 1995 – 2050 (hectares)

State	1995	2000	2005	2007	2010e	2020e	2030e	2040e	2050e
P Malaysia									
Johor	13,012	11,026	14,739	15,237	15,237	15,237	15,237	15,237	15,23
Kedah	1,630	2,126	1,029	1,557	1,557	1,557	1,557	1,557	1,557
Kelantan	3,753	4,036	4,053	5,969	5,969	5,969	5,969	5,969	5,969
Melaka	869	1,101	1,129	1,578	1,578	1,578	1,578	1,578	1,578
Negeri Sembilan	713	1,149	1,027	768	768	768	768	768	768
Pahang	6,697	7,695	6,367	8,424	8,424	8,424	8,424	8,424	8,424
Perak	4,047	4,411	4,957	3,855	3,855	3,855	3,855	3,855	3,855
Perlis	173	[illegible]	95	193	193	193	193	193	193
P. Pinang	1,770	1,867	1,224	1,224	1,224	1,224	1,224	1,224	1,224
Selangor	3,937	2,011	1,809	3,174	3,174	3,174	3,174	3,174	3,174
Terengganu	2,042	2,275	984	984	984	984	984	984	984
Total	38,643	37,697	37,413	42,963	42,963	42,963	42,963	42,963	42,96
E. Malaysia									
Sabah	-	5,240	3,760	3,760	3,760	3,760	3,760	3,760	3,760
Sarawak	-	4,067	4,330	4,330	4,330	4,330	4,330	4,330	4,330
Total		9,307	8,090	8,090	8,090	8,090	8,090	8,090	8,090
Total (Malaysia)	**38,643**	**47,004**	**45,503**	**51,053**	**51,053**	**51,053**	**51,053**	**51,053**	**51,05**

Note: Up to 2007, the figures are actual. From 2010 on, they are estimates.

ANNEX 8.2 – MONTHLY WATER REQUIREMENTS BY CROPS IN PERLIS IN 2007- 2050

ANNEX 8.2 - MONTHLY WATER REQUIREMENTS BY CROPS IN PERLIS IN 2007 - 2050

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Meterological data													
Rainfall (mm)	21.3	48.0	165.7	194.1	138.8	153.2	210.7	169.5	231.9	272.4	173.4	175.7	1,954.7
Evaporation (mm/day)	5.0	5.8	5.4	4.8	4.0	3.8	3.5	3.5	3.4	3.3	3.3	3.7	4.1
Daily water needs of crops (mm)													
Fruits/tobacco/sugar cane (1.5 x Evaporation)	7.4	8.8	8.1	7.2	6.1	5.6	5.2	5.3	5.1	4.9	4.9	5.6	6.2
Flowers/vegetables (2.0 x Evaporation)	9.9	11.7	10.8	9.6	8.1	7.5	6.9	7.0	6.8	6.5	6.6	7.4	8.2
Monthly water needs of crops (mm):													
Fruits/tobacco/sugar cane (1.5 x Evaporation)	230.5	245.4	251.1	216.6	188.0	169.1	160.8	162.8	152.4	152.1	147.9	172.7	2,249.3
Flowers/vegetables (2.0 x Evaporation)	307.3	327.2	334.8	288.9	250.7	225.4	214.3	217.0	203.1	202.8	197.1	230.3	2,999.0
Surplus/deficit of rainfall (mm)													
Fruits/tobacco/sugar cane (1.5 x Evaporation)	-209.2	-197.4	-85.4	-22.5	-49.2	-15.9	50.0	6.7	79.6	120.3	25.5	3.0	-294.6
Flowers/vegetables (2.0 x Evaporation)	-286.1	-279.2	-169.1	-94.7	-111.9	-72.3	-3.6	-47.5	28.8	69.6	-23.8	-54.6	-1,044.4
Irrigation need (mm)													
Fruits/tobacco/sugar cane (1.5 x Evaporation)	209.2	197.4	85.4	22.5	49.2	15.9	0.0	0.0	0.0	0.0	0.0	0.0	579.6
Flowers/vegetables (2.0 x Evaporation)	286.1	279.2	169.1	94.7	111.9	72.3	3.6	47.5	0.0	0.0	23.8	54.6	1,142.7
(Note: Positive figures ignored as rainfall cannot be carried forward for future use)													
Irrigation need/ha (m^3)													
Fruits/tobacco/sugar cane (1.5 x Evaporation)	2,092.4	1,974.3	853.7	225.0	491.9	159.1	0.0	0.0	0.0	0.0	0.0	0.0	5,796.4
Flowers/vegetables (2.0 x Evaporation)	2,860.7	2,792.3	1,690.7	947.1	1,118.6	722.7	36.3	475.1	0.0	0.0	237.9	545.7	11,427.1
Irrigation need in 2007 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (6 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	17.2	16.8	10.1	5.7	6.7	4.3	0.2	2.9	0.0	0.0	1.4	3.3	68.6
Total	18,490.3	17,465.4	7,648.5	2,115.6	4,436.0	1,506.9	7.2	94.6	0.0	0.0	47.3	108.6	51,920.4
Irrigation need in 2010 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (7 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	20.0	19.5	11.8	6.6	7.8	5.1	0.3	3.3	0.0	0.0	1.7	3.8	80.0
Total	18,493.2	17,468.2	7,650.2	2,116.6	4,437.1	1,507.6	7.3	95.0	0.0	0.0	47.6	109.1	51,931.8

Irrigation need in 2020 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (11 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	31.5	30.7	18.6	10.4	12.3	7.9	0.4	5.2	0.0	0.0	2.6	6.0	125.7
Total	18,504.6	17,479.4	7,657.0	2,120.3	4,441.6	1,510.5	7.4	96.9	0.0	0.0	48.5	111.3	51,977.5
Irrigation need in 2030 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (19 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	54.4	53.1	32.1	18.0	21.3	13.7	0.7	9.0	0.0	0.0	4.5	10.4	217.1
Total	18,527.5	17,501.7	7,670.5	2,127.9	4,450.5	1,516.3	7.7	100.7	0.0	0.0	50.4	115.7	52,069.0
Irrigation need in 2040 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (30 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	85.8	83.8	50.7	28.4	33.6	21.7	1.1	14.3	0.0	0.0	7.1	16.4	342.8
Total	18,559.0	17,532.4	7,689.1	2,138.3	4,462.8	1,524.2	8.1	106.0	0.0	0.0	53.0	121.7	52,194.7
Irrigation need in 2050 ('000 m^3)													
Fruits (718 hectares), tobacco (57 hectares), sugar cane (7,790 hectares), vegetables (193 hectares) and flowers (49 hectares)													
Fruits (1.5 x Evaporation)	1,502.3	1,417.5	613.0	161.6	353.2	114.3	0.0	0.0	0.0	0.0	0.0	0.0	4,161.8
Tobacco (1.5 x Evaporation)	119.3	112.5	48.7	12.8	28.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	330.4
Sugar cane (1.5 x Evaporation)	16,299.5	15,379.7	6,650.4	1,752.8	3,832.1	1,239.7	0.0	0.0	0.0	0.0	0.0	0.0	45,154.2
Vegetables (2 x Evaporation)	552.1	538.9	326.3	182.8	215.9	139.5	7.0	91.7	0.0	0.0	45.9	105.3	2,205.4
Flowers (2 x Evaporation)	140.2	136.8	82.8	46.4	54.8	35.4	1.8	23.3	0.0	0.0	11.7	26.7	559.9
Total	18,613.3	17,585.5	7,721.2	2,156.3	4,484.1	1,538.0	8.8	115.0	0.0	0.0	57.6	132.1	52,411.8

SECTION 9

WATER DEMAND - ANIMAL HUSBANDRY

Section 9

WATER DEMAND
ANIMAL HUSBANDRY

9.0 WATER DEMAND - ANIMAL HUSBANDRY (PERLIS)

Perlis is the northernmost State in Peninsular Malaysia. It is the smallest State, apart from the Federal Territories, with 821 km^2 and a projected population of 245,63 by 2010. The State receives annual rainfall ranging between 1704mm and 2005mm and experience distinct dry months between January and April. Relative to the others, it has little vegetation for grazing. It is therefore not surprising that it has the smallest ruminant population of all, except, of course, for FT Kuala Lumpur. Being largely Muslim, hog rearing is also not in vogue.

9.1 LIVESTOCK POPULATION

9.1.1 Existing Population

The poultry population, consisting mainly chicken and ducks, is shown in **Table 9.1**. This production is enough for local consumption. **Table 9.2** shows the ruminant and hog distribution by districts. The small herds are scattered fairly evenly in all the districts. The hog population of 1,200 is from a single farm located in the district of Arau. Table 9.3 shows the percentage changes in livestock populations in Perlis between 2005 and 2006, between 2006 and 2007 and between 2007 and 2008.

Table 9.1 - Poultry Standing Populations (2008)

	Broiler	Layer	Breeder	Local Fowl	Total
Chicken	1,785,000	-	-	138,560	1,923,560
Duck	6,854	1,860	-	13,800	22,514

Source: Department of Veterinary Services Statistic Reports

Table 9.2 - Ruminants Standing Populations (2008)

District	Buffalo	Beef Cattle	Dairy Cattle	Goat	Sheep	Hog
Kangar	14	1,049	-	1,248	368	0
Padang Besar	32	2,092	84	2,236	1,004	0
Arau	22	3,185	41	2,903	664	1,200
Total	**68**	**6,326**	**125**	**6,387**	**2,036**	**1,200**

Source: Department of Veterinary Services Statistic Reports

Table 9.3 - Percentage Change in Livestock Populations in Perlis

	Buffalo	Beef Cattle	Dairy Cattle	Goat	Sheep	Hog	Chicken	Duck
2005-2006	6.6	8.2	-3.5	18.2	-13.4	-0.5	6.6	1.0
2006-2007	-9.2	10.0	59.0	10.0	17.6	10.0	6.2	16.3
2007-2008	-4.2	3.6	-5.3	10.8	-42.8	17.2	9.3	188.6

Source: Department of Veterinary Services Statistic Reports

9.1.2 Projected Population to 2050

The assumptions used for the projection of livestock population to 2050 for Perlis are based on the following observations and rationale:

(i) The national population of buffaloes has been stagnant since 1999; it is reasonable to assume it would remain the same for many years to come. However, indications are that it is likely to decline in the years ahead, as exemplified by the declining population numbers in Perlis since 2006. Unless the State government introduces special programmes to conserve and increase the present small number, the buffalo population may disappear altogether. Nevertheless, for the purpose of water demand projection, in which slight over-projection is better than under-projection, it is assumed that the buffalo population would grow minimally at 1% per year.

(ii) The national population of beef cattle has been increasing steadily since 2002; this is also the case in Perlis where the percentage annual increase range between 3.6% and 10.0%. Thus it can be assumed that the population will increase steadily corresponding to human population increase and demand for beef, provided there is a corresponding increase in purchasing power as indicated by economic growth. A growth of 7% is assumed, since this is the rate of increase in Perlis during the past few years.

(iii) Dairy cattle number in Perlis is small, only 125. Thus, some small changes in numbers would make large percentage changes. An examination of national figures shows that diary cattle population in the country has been stagnant since 2001. It is projected that diary cattle population in Perlis would not change much in the years ahead. For the purpose of projection based on national trend, a token annual growth of 1.5% is assumed.

(iv) The national population of goats has steadily increased since 2002, while sheep has remained stagnant. It is expected that Perlis would show the same trend. The rate of increase in goat population would probably follow that of GDP growth. An annual growth of 7% is assumed for goat and 2% is assumed for sheep.

(v) There is only one farm engaged in hog production in Perlis. The farm is being passed down from father to son. Thus far, it has been producing just sufficient for the local pork consuming population. A token growth of 1% in numbers is assumed.

(vi) The poultry sector of chicken and ducks is likely to expand to meet local demand. The rate of increase will probably correspond to that of the national GDP growth. An annual growth of 7% is assumed for both chicken and ducks, taking into consideration that it would be possible for Perlis to export a small proportion of poultry produced to southern Thailand.

Based on the above, the animal standing population projections are computed and presented in **Table 9.4**.

Table 9.4 - Projected Livestock Standing Populations

Year	Buffalo	Beef Cattle	Dairy Cattle	Goat	Sheep	Hog	Chicken	Duck
2008	68	6,326	125	6,387	2,036	1,200	1,923,560	22,514
2009	69	6,769	127	6,834	2,077	1,212	2,058,209	24,090
2010	70	7,243	129	7,312	2,118	1,224	2,202,284	25,776
2020	77	14,248	149	14,385	2,712	1,352	4,332,223	50,706
2030	85	28,028	173	28,297	3,471	1,494	8,522,131	99,746
2040	93	55,135	201	55,664	4,443	1,650	16,764,310	196,215
2050	103	108,460	234	109,500	5,688	1,822	32,977,912	385,985

9.1.3 Projected Slaughter Numbers to 2050

The projected number of slaughtered animals per annum, presented in **Table 9.5**, are obtained from the standing population numbers by applying the following extraction rates:- buffalo, 0.20; beef cattle, 0.25; goat, 0.20; sheep, 0.15; hog, 1.6; chicken, 6.0; and ducks, 4.0. These extraction rates take cognizance of the commercial life cycle of the animals and also account for "unrecorded" slaughter.

Table 9.5 - Projected Slaughtered Animals per Year

Year	Buffalo	Beef Cattle	Goat	Sheep	Hog	Chicken	Duck
2010	14	1,843	1,462	318	1,958	13,213,704	103,104
2020	15	3,599	2,877	407	2,163	25,993,338	202,824
2030	17	7,050	5,659	521	2,389	51,132,786	398,984
2040	19	13,834	11,133	666	2,639	100,585,860	784,860
2050	21	27,174	21,900	853	2,915	197,867,472	1,543,940

9.2 WATER DEMAND

Water, in livestock production, is required for drinking, washing of animals and pen, and for abattoir operation. It is critical for the drinking water to be clean and treated for the sake of animal health and hygiene. Similarly, abattoir operations should be undertaken using clean and treated water to prevent contamination and disease carry-over to humans. Wash water should also be clean and treated to prevent water-borne diseases from spreading within the production area and affecting animal growth, health and hygiene.

9.2.1 Drinking Water Demand

Table 9.6 presents the drinking water requirement of different livestock. These figures are typically used in water consumption estimates of livestock populations under hot weather condition.

Table 9.6 - Typical Water Consumption under Hot Weather Condition

Livestock category	Average Consumption (L/head/day)
Poultry & Duck	
Broiler chickens	0.5
Broiler breeders	0.6
Layer breeders	0.25
Layer hens	0.40
Average for poultry	**0.5**
Hogs	
Weaners	2.0
Growers	4.5
Finishers	9.0
Gestating sows/boars	15
Lactating sows	20
Average for Hogs	**10.1**
Beef cattle & Buffalo	
Calves	8
Feedlot cattle	41
Lactating cows	55
Dry cows, bred heifers and bulls	38
Average for beef cattle	**35.5**
Dairy cattle	
Calves	9
Heifers	25
Milking cows	115
Dry cows	41
Average for dairy cattle	**47.5**
Small ruminants (Goat & Sheep)	
Feeder lambs	4.5
Gestating meat ewe	5.5
Lactating meat ewe	10
Gestating dairy ewe	6
Lactating dairy ewe	11
Average for small ruminants	**7.4**

Sources: Brown, L (2006); MAF (2009); OMAFRA (2009); Winchel, W (2001)

Applying the typical consumption figures to the standing population in **Table 9.4**, the projected drinking water demand is computed and presented in **Table 9.7**.

Table 9.7 - Projected Drinking Water Demand (m^3/year)

Year	Buffalo	Beef Cattle	Dairy Cattle	Goat	Sheep	Hog	Chicken	Duck	Total
2008	881	83,304	2,167	17,251	5,499	4,424	351,050	4,109	468,685
2009	894	87,709	2,202	18,459	5,610	4,468	375,623	4,396	499,361
2010	907	93,851	2,237	19,750	5,721	4,512	401,917	4,704	527,878
2020	998	184,618	2,583	38,854	7,325	4,984	790,631	9,254	1,039,247
2030	1,101	363,173	2,999	76,430	9,375	5,508	1,555,289	18,204	2,032,079
2040	1,205	714,412	3,485	150,348	12,001	6,083	3,059,487	35,809	3,982,830
2050	1,335	1,405,370	4,057	295,760	15,363	6,717	6,018,469	70,442	7,817,513

9.2.2 Washing Water Demand

The typical wash water requirement for the animals is given in **Table 9.8**. These figures are used to estimate the total wash water demand for each animal type presented in **Table 9.9**.

Table 9.8 - Wash Water Requirement under Malaysian Condition (L/head/day)

Category	L/head/day
Buffalo & Beef Cattle	45
Dairy Cattle	50
Goat and Sheep	7
Hog	30
Poultry & Duck	0.15

Sources: Teoh et al. (1988); Lim, Y.S. (2010)

Table 9.9 - Projected Wash Water Demand (m^3/year)

Year	Buffalo	Beef Cattle	Dairy Cattle	Goat	Sheep	Hog	Chicken	Duck	Total
2008	1,117	103,905	2,281	16,319	5,202	13,140	105,315	16,435	263,717
2009	1,133	111,181	2,318	17,461	5,307	13,271	112,687	17,586	280,944
2010	1,150	118,966	2,354	18,682	5,411	13,403	120,575	18,816	299,357
2020	1,265	234,023	2,719	36,754	6,929	14,804	237,189	37,015	570,698
2030	1,396	460,360	3,157	72,299	8,868	16,359	466,587	72,815	1,101,841
2040	1,528	905,592	3,668	142,222	11,352	18,068	917,846	143,237	2,143,513
2050	1,692	1,781,456	4,270	279,773	14,533	19,951	1,805,541	281,769	4,188,985

9.2.3 Abattoir Water Demand

The animal slaughter water requirement per head in abattoir is shown in **Table 9.10**. These parameters are used to determine the abattoir water demand which is presented in **Table 9.11**.

Table 9.10 - Abattoir Water Requirement under Malaysian Condition

Category	Litres/Head
Cattle abattoir	400
Hog abattoir	250
Small ruminant abattoir	220
Poultry processing plants	4

Source: Teoh et al. (1988); Lim, Y.S. (2010)

Table 9.11 - Projected Abattoir Water Requirement (m^3/year)

Year	Buffalo	Beef Cattle	Goat	Sheep	Hog	Chicken	Duck	Total
2010	6	737	322	70	490	52,855	412	54,892
2020	6	1,440	633	90	541	103,973	811	107,494
2030	7	2,820	1,245	115	598	204,531	1,596	210,912
2040	8	5,534	2,449	147	604	402,343	3,139	414,224
2050	8	10,870	4,818	188	610	791470	6,176	814,140

9.2.4 Total Livestock Water Demand

The total water demand for drinking, washing and slaughter of livestock are presented in **Table 9.12**.

Table 9.12 - Total Livestock Water Requirement (m^3/year)

Year	Wash Water Requirement	Drinking Water Requirement	Abattoir Water Requirement	Total Water Requirement
2010	299,357	527,878	54,892	882,127
2020	570,698	1,039,247	107,494	1,717,439
2030	1,101,841	2,032,079	210,912	3,344,832
2040	2,143,513	3,982,830	414,224	6,540,567
2050	4,188,985	7,817,513	814,140	12,820,638

The total water required for livestock production of 0.9 million cubic metres in year 2010 is projected to increase to 12.8 million cubic metres in 2050. Drinking water accounts for the highest requirement followed by wash water and abattoir water. Drinking water generally accounts for more than the wash water requirement, with abattoir water demand being the least. The reason is that daily washing is not done as normal practice for chicken, goat and sheep production whereas water is consumed by all species daily. Broilers are kept in litters and their pens are not washed until they are removed for the market. Layer dung is collected periodically for sale and the floor is not washed except before a new batch of pullets is brought in. Similarly, daily washing is not the normal husbandry practice for goat and sheep production.

9.3 WATER SOURCE

The water supply for animal drinking and abattoir operations should mainly be portable piped water. Wash water, however, can be from portable piped water or from pond or well water. In

the latter cases, the water should be treated before use. The drinking water, especially, needs to be clean and devoid of pathogen and chemicals so as not to affect the healthy and growth of the animals deleteriously.

While a national standard for human drinking water exists (MOH, 2004), a national livestock drinking water quality standard for Malaysia has not yet been established. Acceptable drinking water quality criteria established in other developed countries under hot summer conditions are used here as a guide. These are shown in **Table 9.13 and Table 9.14** for non-ruminants and ruminants, respectively.

Table 9.13 - Acceptable Drinking Water Quality for Non-Ruminants

Contaminants	Maximum acceptable level	Remarks
Bacteria		
Total bacteria	100/mL	
Total coliform	50/mL	
pH	6.0-8.0	
Hardness	180 ppm Ca	<60 is considered soft; >180 is very hard and will interfere with disinfections and medications
Total dissolved solids	<3000 mg/L	
Nitrogen		
Nitrates	25 mg/L	
Nitrites	4 mg/L	
Other chemicals		
Calcium (Ca)	600 mg/L	Scale formation at > 600 mg/L
Chlorine (Cl)	250 mg/L	Related to sodium content
Copper (Cu)	0.6 mg/L	
Iron (Fe)	0.3 mg/L	Affects taste at higher levels
Lead (Pb)	0.02 mg/L	Can be toxic
Magnesium (mg)	125 mg/L	Higher levels have laxative effect
Sodium (Na)	50 mg/L	Related to sulpha te & chlorine
Sulphate (SO4)	250 mg/L	levels
Zinc (Zn)	1.5 mg/L	Related to magnesium & chlorine Can be toxic

Sources: Blake and Hess (2009); MAF (2009); OMAFRA (2009); Winchel, W (2001)

Table 9.14 - Acceptable Drinking Water Quality for Ruminants

Contaminants	Maximum acceptable level	Remarks
Bacteria		
Total bacteria	5000/L	
Total coliform	150/L	
Cyanobacteria	11,500 cells/mL	
pH	6.0-8.0	
Hardness	180 mg/L Ca	<60 is considered soft; >180 is very hard and will interfere with disinfections and medications
Total dissolved solids	<4,000 mg/L	Potential problem at >5,000 mg/L
Nitrogen		
Nitrates	25 mg/L	
Nitrites	4 mg/L	
Other chemicals		
Calcium (Ca)	150 mg/L	Scale formation at > 600 mg/L??
Chlorine (Cl)	300 mg/L	Related to sodium content
Copper (Cu)	0.5 mg/L	
Iron (Fe)	0.3 mg/L	
Lead (Pb)	0.02 mg/L	Affects taste at higher levels
Magnesium (mg)	100 mg/L	Can be toxic
Sodium (Na)	300 mg/L	Higher levels have laxative effect
Sulphate (SO4)	300 mg/L	Related to sulphate & chlorine levels
Zinc (Zn)	5 mg/L	Related to magnesium & chlorine Can be toxic

Sources: Brown (2006); MAF (2009); OMAFRA (2009)

SECTION 10

HYDROPOWER

Section 10

HYDROPOWER

10.0 HYDROPOWER DEVELOPMENT IN PERLIS STATE, PENINSULAR MALAYSIA

10.1 INTRODUCTION

The total hydropower potential which can be technically exploited (referred to as the technical potential) in Malaysia was estimated in 2008 to be 123,000 GWh/a, of which 13% comes from Peninsular Malaysia. The economic exploitable potential (economic potential) is approximately 9,400 GWh/a, about 59% of the technical potential (around 16,000 GWh/a). Out of the 9,400 GWh/a, about 6,700 GWh/a is currently being generated by the hydropower plants already in operation. Thus, the balance of 2,700 GWh/a is the potential energy production from prospective projects (prospective potential) that have been identified or investigated. These projects are bigger than 1MW in capacity. Anything smaller will be referred as mini-hydro (installed capacity 0.1-1.0MW) and micro-hydro (0.01-0.1MW) installations which are beyond the scope of this Study.

Hydropower is essentially a form of clean and renewable energy, thus, in the long term it will contribute to the sustainability of energy supply and minimizes the negative impacts of energy generation, transmission, conversion and consumption on the environment compared with the conventional means of energy generation using oil, gas and coal. Its development was given great emphasis through the so-called 'four-fuel' energy strategy (the four being oil, gas, coal and hydropower) of the 1980s. In addition the latest energy policy, Fifth-Fuel Policy 2001, also called for better utilization of renewable resources. The government's commitment to adopt the strategy of fuel source diversification through greater utilisation of renewable energy and moving to a more integrated planning approach to enhance sustainable development of the energy sector was continued into the Ninth Malaysia Plan, 2006-2010.

10.2 STUDY OBJECTIVES AND REFERENCES

The current Study is essentially to review and update the NWRS (2000) carried out in 1999. With regards to the hydropower, the main objective is to review, assess, update and catalogue the economic hydropower resources and projects in the various States of Malaysia, and to formulate a proposed plan for systematic development of viable hydropower projects up to 2050. In this evaluation, consideration will also be given to the environmental, social and other relevant factors but these aspects would not be examined in detail. The current approach therefore differs from that of the first NWRS where project economics did not appear to be the criteria for selection.

Towards this objective, water requirements for hydropower development will be based on identified hydro-electric projects (>1MW) which have been assessed as technically feasible and economically viable now or likely to be economically viable in the near future. For this purpose it will be necessary to have a general review of power demand and supply scenarios for the Study period, to evaluate in general the economics of other power plants and their functional roles.

For this latest exercise, various reports and publications were sourced and compiled. The more significant reports among the compiled past studies relevant to the Peninsula, included the JICA Report (1982), NWRS (2000) and Hydro Ranking Study 2005. A review of the findings in these previous reports provides an insight on the overall changing trend and outlook on hydropower development. In addition, other publications by relevant authorities or corporations such as Annual Reports by Energy Commission Malaysia (ECM) and Tenaga Nasional Berhad (TNB) and electronic news press were also used as reference.

10.3 POWER DEMAND

In the Peninsula, the 2009 peak load demand was 14,245MW and generation capacity was 21,817MW, giving a generation plant reserve margin of 53% as at the end of 2009. The high reserve margin was a result of the recently commissioned 1400MW Jimah Power Plant and 694MW extension of Tuanku Ja'afar Power Station. Although somewhat excessive for economic power supply operation, it indicates that Tenaga Nasional Berhad (TNB) has a healthy margin to cater for increasing demand in the coming years and not be at risks of being under reserve before their next major power plant is scheduled for commission on 2014/2015.

Based on historical records and projected economy outlook from various sources, the Peninsula load growth beyond 2010 is expected to grow at a modest 4% per annum up to 2020. In an increasingly uncertain global economic climate, obviously much may change beyond 2020 and prediction of future load growths would be without much reliability in the Peninsula. In the absence of any load forecast from official sources beyond 2020, the approach adopted for the hydropower review is to use a scenario approach. Based on predictions of future GDP in Malaysia, load demand growths from 2010 may vary from 4% to 8% and Peninsula would most likely be in the low growth scenario. Thus the average 4% growth rate is assumed to continue up to 2050.

The hydropower potential in the Peninsula is limited. Even with the full realisation of this potential in years to come, the total installed capacities will still be insufficient to meet the projected demand load growth. Other sources of power generation or alternative means of power supply will need to be evaluated.

10.4 EXISTING HYDROPOWER

There is no existing hydropower scheme in the state of Perlis.

10.5 HYDROPOWER POTENTIAL IN PERLIS

Several studies carried out in the past on hydropower projects did not identify any potential hydropower in Perlis which is the smallest State (<1,000 sq.km) in Malaysia. Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. The power extracted from the water depends on the volume of flow and on the difference in height between the water source and the outflow point. This height difference is called the head. The amount of potential energy in water is proportional to the head.

The existing topography of Perlis is rather unsuitable for hydropower generation for various reasons. The runoff catchments are very small with short streams, thus, the available flow is insufficient for a viable hydropower scheme. In addition the terrain is flat in most parts. These constraints, in short, are unfavourable for hydropower.

Nonetheless, for the record, the hydropower projects that have been identified for Peninsular Malaysia are shown in **Figure 10.1**.

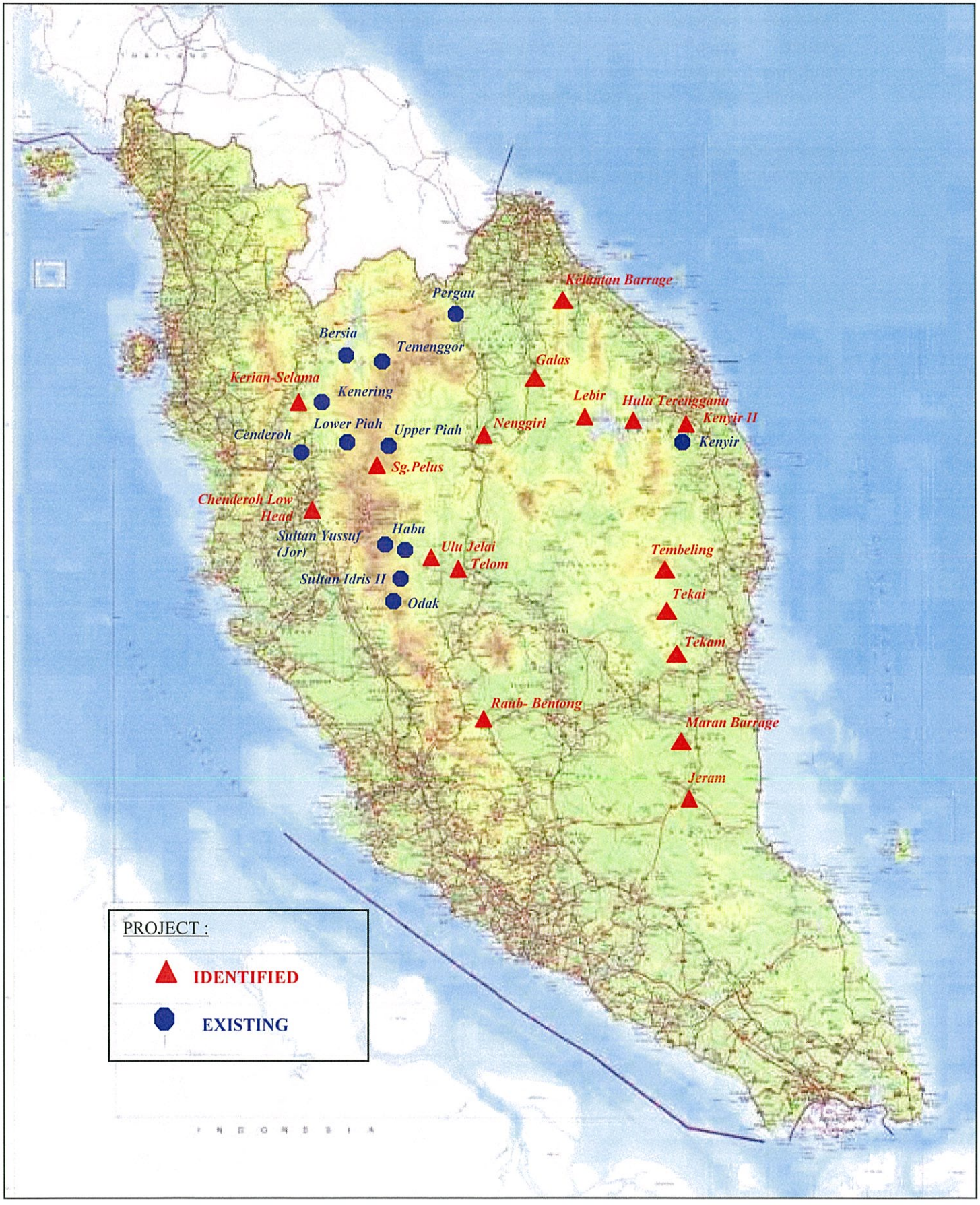


Figure 10.1 - Existing & Identified Hydropower Sites In The Peninsular Malaysia

REVIEW OF THE NATIONAL WATER RESOURCES STUDY (2000 – 2050) AND FORMULATION OF NATIONAL WATER RESOURCES POLICY

FINAL REPORT, VOLUME 7 - PERLIS
AUGUST 2011

SECTION 11

SEWERAGE

11.0 SEWERAGE

11.1 INTRODUCTION

The sewerage services for most part of the state of Perlis are being rendered by IWK. Approximately, 17.7% of Perlis is served by connected services, while 30.9% is served by IST and 51.4% via Pour Flush as shown **Figure 11.1**.

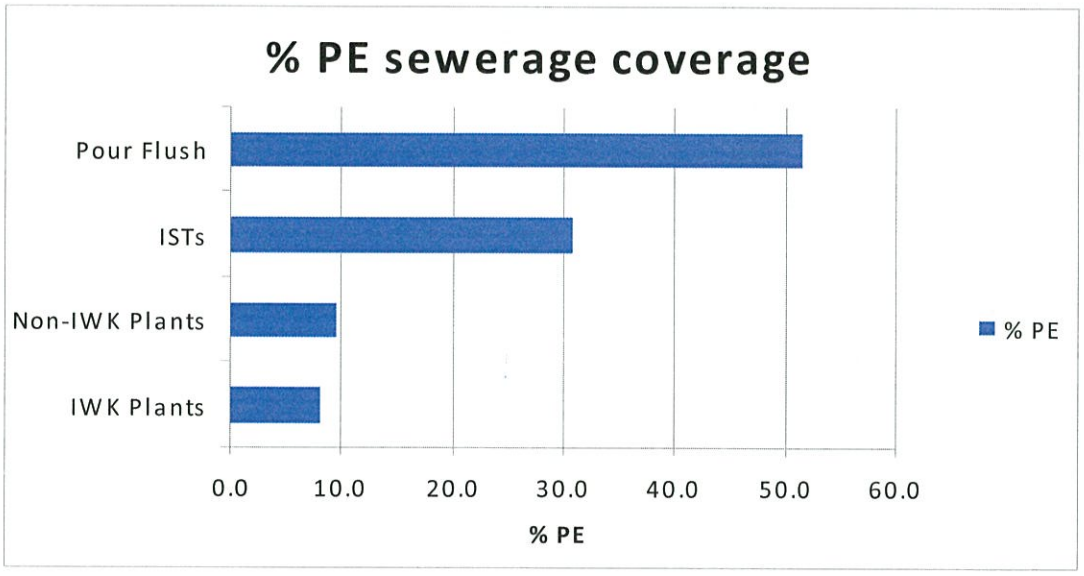


Figure 11.1 - Percentage of Population Equivalent (PE served by type of sewerage facilities for State (Perlis)

11.2 PROFILE OF SEWERAGE SYSTEM

Distribution of sewerage infrastructures based on Local Authorities and the type of sewerage facilities with its associated Population Equivalent (PE) are as shown in **Table 11.1** below.

Table 11.1 - Sewerage facilities and Population Equivalent (PE) served in Perlis (March 2010)

	Regional Plants (STP)				Multi-point Plants (STP)				ISTs		Pour Flush	
	IWK Plants		Not Served by IWK		IWK Plants		Not Served by IWK [a]		Private on site facilities [b]		Private on site facilities [b]	
	No.	PE	No.	PE	No.	PE	No.	PE	No.	PE	No.	PE
MP Kangar	1	1000	0	0	36	16,726	416	20,758	13,401	67,005	22,339	111,695
TOTAL	**1**	**1000**	**0**	**0**	**36**	**16,726**	**416**	**20,758**	**13,401**	**67,005**	**22,339**	**111,695**

Facility	No.	PE	% PE
IWK Plants	37	17,726	8.2
Non-IWK Plants	416	20,758	9.6
ISTs	13,401	67,005	30.9
Pour Flush	22,339	111,695	51.4
Total		217,184	100

Source of data: IWK, March 2010

Note: a) Statistics for plants not serviced by IWK are estimates only. Data are not available.
b) These on-site facilities are serviced on request of property owners/tenants.

Sewerage coverage based on Local Authorities and population equivalent (PE) served by type of facility is as shown in **Table 11.2** and graphically in **Figure 11.2** below.

Table 11.2 - Sewerage facilities in Local Authority area and percentage Population Equivalent (PE) served (Perlis)

	Connected Services, % PE	ISTs, % PE	Pour Flush, % PE	% Total PE
MP Kangar	17.7	30.9	51.4	100
TOTAL	**17.7**	**30.9**	**51.4**	**100**

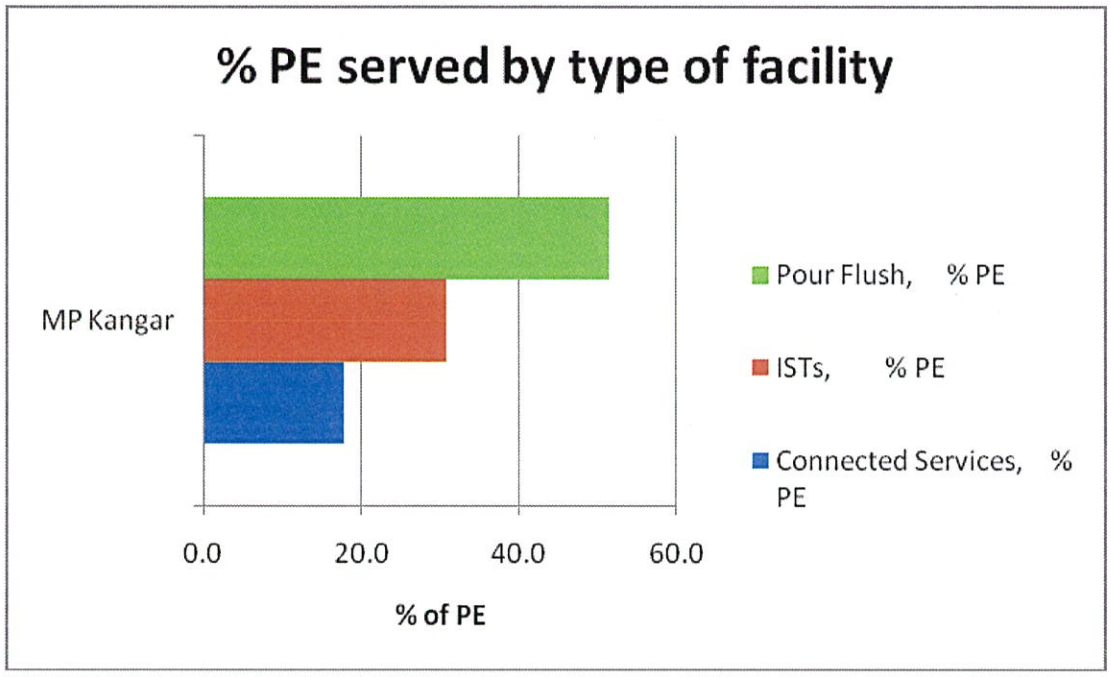


Figure 11.2 - Percentage of sewerage coverage based on Local Authority (Perlis)

11.3 SLUDGE GENERATION

Sludge is generated from all types of sewerage facilities. The current estimate of sludge generated from all sewerage facilities in Perlis is as in **Table 11.3**. Facilities for sludge reception, treatment and dewatering have been provided by IWK at its new regional STP.

Table 11.3 - Annual estimated sludge quantity generated from all sewerage facilities (year 2006, Perlis)

	Sludge Quantity (tonnes/year)	
	Sludge from STPs	Sludge from CST, IT & IST
Perlis	5,315	8,867
TOTAL	**5,315**	**8,867**

Source: IWK

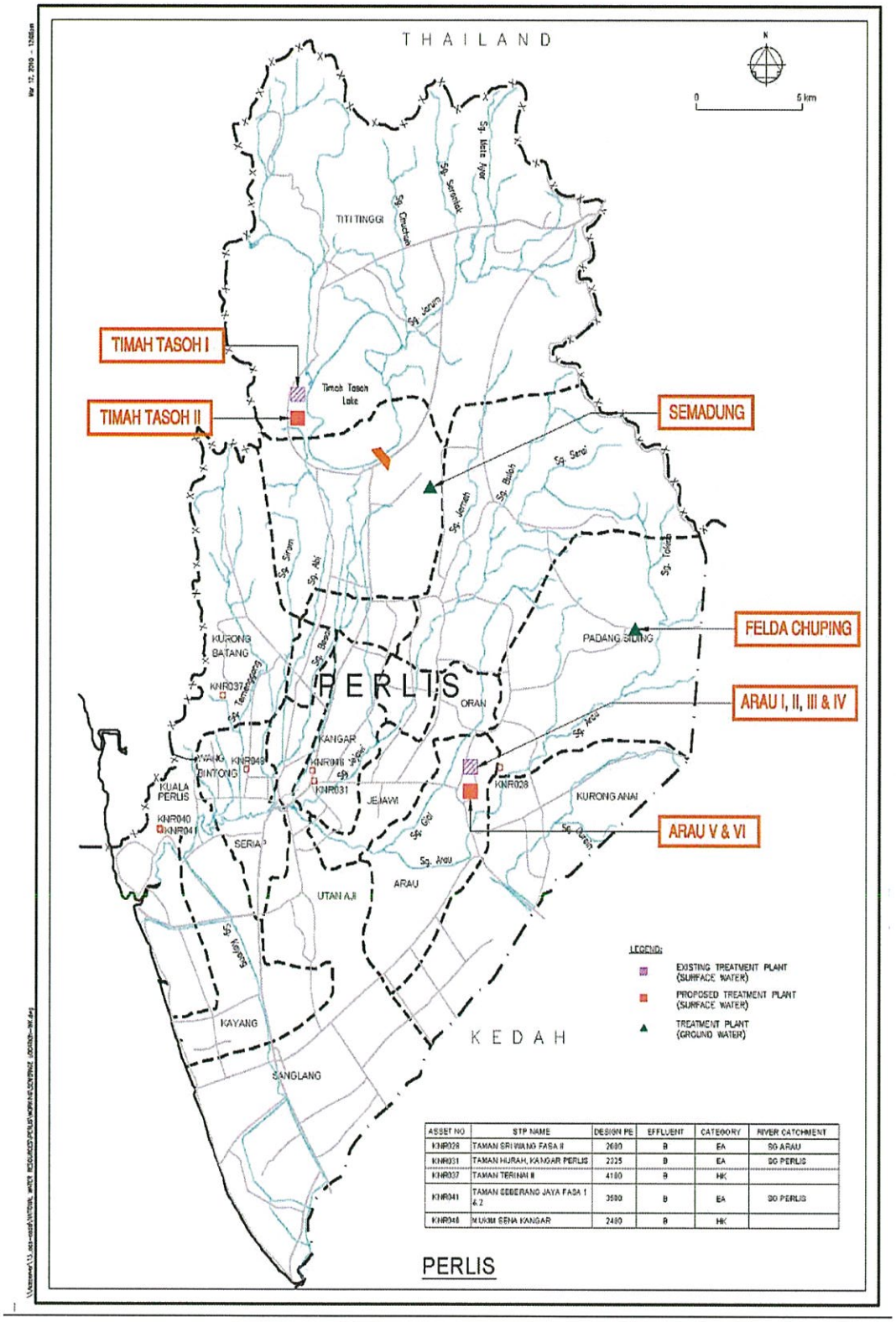
STP: Sewage Treatment Plant

IT: Imhoff Tank

CST: Communal Septic Tank

IST: Individual Septic Tank

List, details and location of existing Sewage Treatment Plants (STP, PE>2,000 only shown) together with location of Water Treatment Plants (WTP) and Dams (PE>2,000) are as shown in **Figure 11.3 and Table 11.4**.



ASSET NO	STP NAME	DESIGN PE	EFFLUENT	CATEGORY	RIVER CATCHMENT
KNR028	TAMAN SRI WANG FASA II	2680	B	EA	SG ARAU
KNR031	TAMAN HIJRAH, KANGAR PERLIS	2225	B	EA	SG PERLIS
KNR037	TAMAN TERINAI II	4180	B	HK	
KNR041	TAMAN SEBERANG JAYA FASA 1 & 2	3580	B	EA	SG PERLIS
KNR048	MUKIM SENA KANGAR	2480	B	HK	

Figure 11.3 - Location of existing Sewage Treatment Plants together with location of Water Treatment Plants (WTP) and Dams

Table 11.4 - List of STPs with PE 2,000

Asset No	Stp Name	Location	Mukim	Design Pe	Eff Std	Stp Type	River Branch	River Catchment
KNR028	Taman Sri Wang Fasa Ii	Jln Kolej Matrikulasi	Arau	2,600	B	EA	Sg Arau	Sg Perlis
KNR031	Taman Hijrah, Kangar	Jln Raja Syed Alwi	Utan Aji	2,325	B	EA	Sg Perlis	Sg Perlis
KNR037	Taman Terinai Ii		Wang Bintong	4,100	B	HK		
KNR041	Tmn Seberang Jaya Fasa 1 & 2		Kuala Perlis	3,500	B	EA	Sg Perlis	Sg Perlis
KNR046	Mukim Sena Kangar		Sena	2,400	B	HK		
KNR	Kangar Central Stp (Jbic)		Wang Bintong	30,000	B	OD		

SECTION 12

FLOOD MITIGATION

Section 12

FLOOD MITIGATION

12.0 FLOOD MITIGATION

12.1 INTRODUCTION

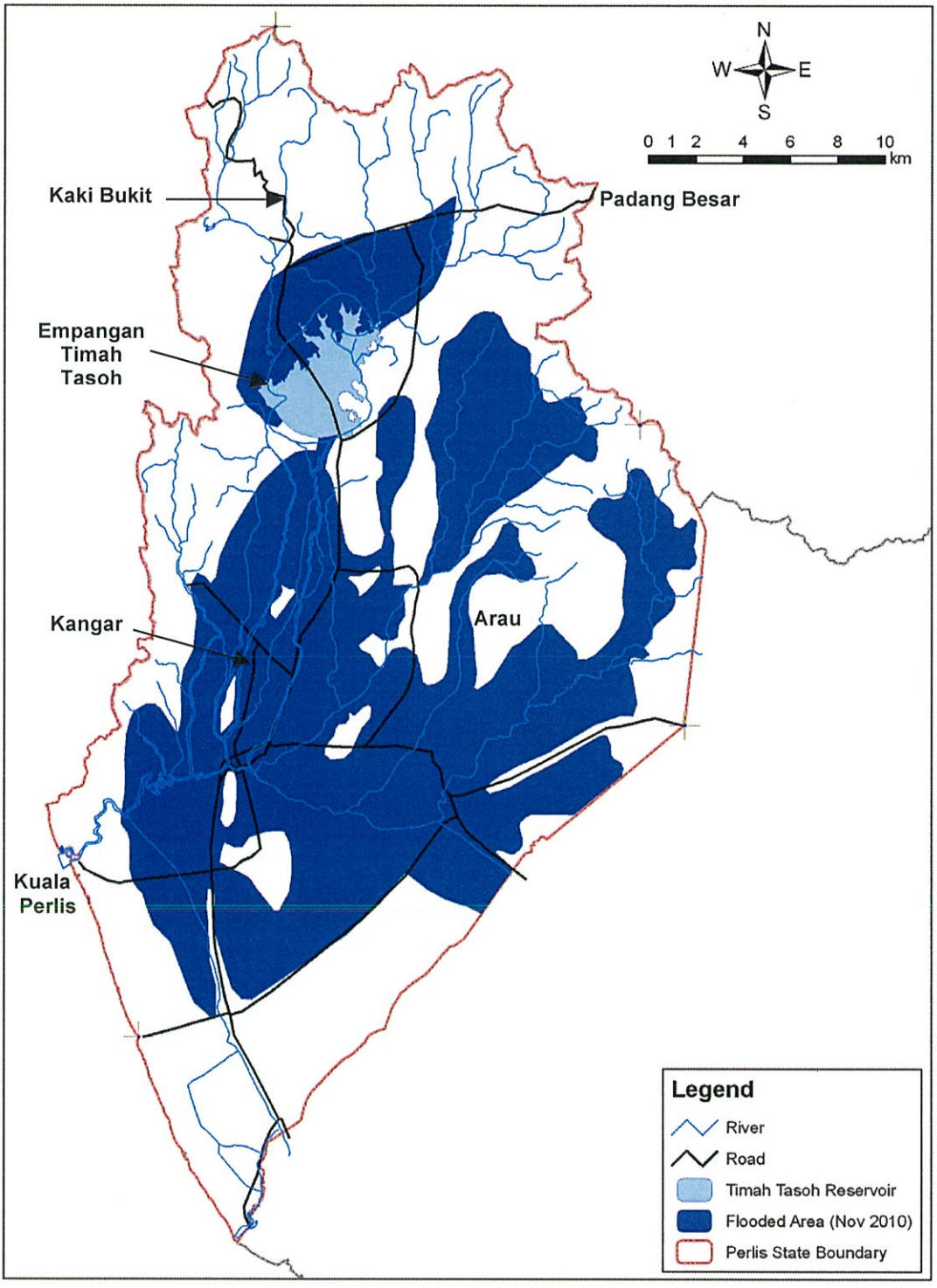
In Perlis, based from the National Register of River Basin Study, 2002 (DID Malaysia), 26 Square kilometres is considered as flood affected area. It consists of 5 Square kilometres from urban, 17 Square kilometres from agriculture, and from others, 4 Square kilometres. Since 2002, there has been a bigger flood occurrences in 2005, 2010 and 2011. The flood in the year 2010 was the worst recorded that happens in Perlis especially to Kangar Town, since the construction of the Timah Tasoh dam and the Kangar flood diversion channel. Arau and Padang Beser were also badly affected. Flood evacuees were recorded at 15,027 people.

12.2 EXISTING AREAS AFFECTED

Table 12.1 shows the total recorded flood prone areas based on State. The table also gives the total flood prone area based on land use. **Figure 12.1** shows the flooded areas during the 2010 flood event in Perlis. It covered the largest flood area ever recorded with two third of Perlis State being flooded.

Table 12.1 - Flood Prone Area with respect to Land Use

State	Flood Prone Area with respect to Land Use				Total flood Affected Area ($Km^{2)}$
	Urban ($Km^{2)}$	Agriculture ($Km^{2)}$	Forest ($Km^{2)}$	Others ($Km^{2)}$	
Perlis	5.12	17.03	0.33	4.26	26.74
Kedah	12.13	180.17	5.77	11.38	209.45
P.Pinang	57.06	129.35	5.32	15.10	206.83
Perak	36.30	429.37	10.10	187.07	662.84
Selangor	95.01	1,133.53	69.58	490.57	1,788.69
Federal Territory	13.16	-	0.01	0.01	13.18
Negeri Sembilan	3.66	75.98	5.68	44.16	129.48
Melaka	3.05	52.67	1.33	23.80	80.85
Johor	51.42	993.77	539.05	782.47	2,366.71
Pahang	69.85	2,303.47	2,560.43	1,337.87	6,271.62
Terengganu	53.66	966.73	463.10	739.38	2,222.87
Kelantan	63.33	1,293.64	67.34	216.07	1,640.38
Sabah	92.65	944.39	899.47	1,347.54	3,284.05
Sarawak	249.33	3,772.46	472.59	6,401.13	10,895.51
TOTAL	**805.73 (2.70%)**	**12,292.56 (41.25%)**	**5,100.10 (17.11%)**	**11,600.81 (38.93%)**	**29,799.20**



*Source: Perlis State DID

Figure 12.1 – Flood area coverage during the 1st to 8th November 2010 flood event in Perlis

12.3 EXISTING FLOOD MITIGATION PROJECTS

List of the major flood mitigation projects that were carried out since the 9th Malaysia Plan are shown in **Table 12.2**. This list will be updated and where possible they can be studied to include extension for any surface water resource development.

Table 12.2 - List of the major flood mitigation projects that were carried out since the 9th Malaysia Plan

Item	Project
1	Rancangan Tebatan Banjir Bandar Kangar - Sistem Saliran Sg Tok Kaya Fasa III
2	Rancangan Tebatan Banjir Bandar Kangar - Sistem Saliran Kangar Alor Marus
3	Rancangan Tebatan Banjir Bandar Arau - Saliran Bandar Arau, Parit Utama Pauh Fasa III
4	Rancangan Tebatan Banjir Bandar Arau - Saliran Sek Keb & Sek Men Fasa IV
5	Rancangan Tebatan Banjir Bandar Kuala Perlis - Sistem saliran Kuala Perlis Fasa 2B
6	Rancangan Tebatan Banjir Bandar Simpang Empat - Sistem Saliran Bandar Simpang 4 Fasa 5
7	Rancangan Tebatan Banjir Bandar Simpang Empat - Pembinaan Rumah Pam

12.4 FLOOD MANAGEMENT STRATEGIES

The flood mitigation strategy looks at solving the current flood problem and then subsequently at ways to prevent future development from creating flood problems. Current flood problems are usually resolved by mainly by provision of structural measures such as channelization, bunding, flood storage and flood diversions.

Residual flood problems that still persist are resolved by other means which would include flood warning, flood proofing etc. To prevent future developments from creating flood problems, non-structural measures such as flood risk mapping and land use zoning, catchment management are proposed so that the flood problem is contained and is manageable. Flood warning, flood management and non-structural flood mitigation measures are given greater emphasis and are reflected in recent flood mitigation master plan studies carried out under JPS.

12.5 STRUCTURAL FLOOD MITIGATION MEASURES

Figure 12.2 shows the various common structural flood mitigation measures.

i) River Channelisation Works

This involves deepening, widening and straightening of inadequate sized rivers. The improved channel is designed to improve the conveyance of river channels so that designed flood event can be contained within the river channel. They may also include lining of the banks and beds of the channel against erosion. River channelization is often the most obvious and least complicated approach to solving

the flood problem but there are impacts, which should be taken into account. The lowering of river bed may jeopardise foundations of bridges and dropping of flood levels may also lead to excessive drop in normal flow levels thereby affecting pumping schemes.

ii) Flood Bunds

Channelisation may not result in lowering flood levels if flooding is not due to inadequate channel conveyance but due to backwater effect of high tides or if the terrain does not have sufficient gradient for channelization to be effective.

In this case flood bunds may be a feasible alternative to flood mitigation.

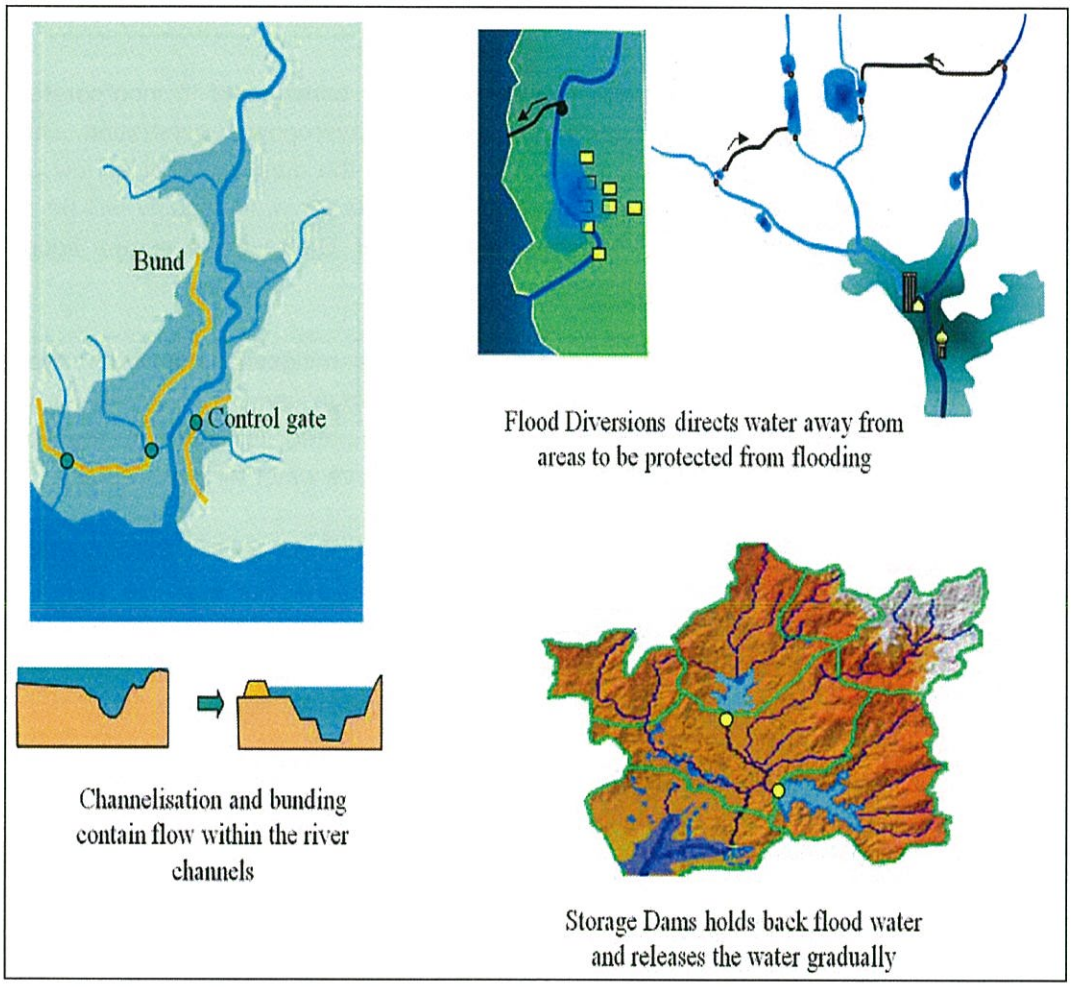


Figure 12.2 - Structural Flood Mitigation Measures

Flood bunds or floodwalls could be constructed to prevent floodwater from entering the low-lying areas. For isolated areas or buildings, constructing ring bunds around the affected areas and provision of pumping system if necessary can provide flood protection.

Where flood bunds are implemented flood control gates must be provided at drainage outlets. During periods of the gate closure, adequate internal drainage storage ponds must be provided to store the internal drainage runoff. If the storage is inadequate then pumps should be provided to drain off the internal runoff.

iii) Flood Detention Dams

The "rapid disposal approach" involving deepening, widening and straightening of river often shifts the flooding problem to the lower reaches. To reduce flood impact to the lower reaches, dams can be proposed upstream of flood prone areas. These flood detention dams hold back and regulate the flood water so that a lesser and controlled amount of stream flow discharge be released to the river downstream of the dam, thus reducing peak flood discharge as well as the peak flood level downstream of the dam.

Multipurpose flood detention dams can be constructed to incorporate other usage such as domestic supply, irrigation and hydropower generation. Dams for flood mitigation are operated such that levels in the dam are kept as low as possible to maximise flood storage volume, while dams for water supply will be maintained at conservation level to maximise stored water. Operation criteria for flood storage and water supply are conflicting.

In a multipurpose dam that provides flood mitigation and water supply, the dam storage volume above a conservation storage level is reserved for flood storage. Under normal condition, the dam is operated to maintain the water level at conservation storage level in order to conserve water for water supply.

It is possible that with proper consideration to flood risks and drought risks to vary the conservative storage level according to seasons. For example, before the onset of the Monsoon season, it may be desirable to set the conservation storage level lower, thereby freeing dam storage for flood mitigation. Conversely before the onset of a draught season, the conservation storage could be set higher.

In Perlis, an example of a multipurpose dam is the Timah Tasoh Dam which was initially constructed for water supply but due to the flooding in Kangar, it was raised to store flood water.

iv) Flood detention ponds and wetlands

The use of existing disused mining pond and wetland storages for flood detention is another means to mitigate floods. These disused mining ponds and swamps/wetland where applicable, could be potentially used to detain the flood water which then could regulate a smaller outlet discharge thus reducing the flood peak discharge, downstream of it.

v) Flood Diversion Channel

A flood diversion redirects partially or completely flows away from the affected areas. The flood diversion channel should be rightfully placed, upstream of the area to be flood protected. In Perlis, the Northern diversion channel is an example in which the flood water from Timah Tasoh dam and part of the Northern catchment area is diverted from entering Kangar Town. Arau canal is another example in Perlis which diverts a part of Arau catchment runoff into this channel to bypass its full flood impact into Kangar Town.

12.6 NON-STRUCTURAL FLOOD MITIGATION MEASURES

The various non-structural flood mitigation measures are:

i) Flood Risk Mapping and Land Use Zoning

Proper planning of development with respect to flood requires knowledge of the location and extent of flood prone area. Hydrological and hydraulic analysis allows an estimate to be made on flood levels and flood prone areas identified based on contours and spot levels shown in topographical maps and levels shown in surveyed cross sections. Development in these areas can then be planned accordingly.

These flood risk maps should be referred to in preparing the development master plans so that development should ideally avoid the very low lying flooded areas. Flood prone areas, if developed, should have platform levels raised above the estimated flood levels. Development should also not isolate flooded areas and sufficient drainage reserve should be provided for floodwaters to flow out to main waterways.

An adequate setback of development from the riverbank would be necessary to prevent aggravating floods upstream. The same principle applies to bunds. While bunds may be used to protect properties from being flooded, locating the bunds too close to the river bank may result in constricting flow and raising flood levels.

The main rivers have through ages achieved the river regime today and it is not recommended that the river sections and alignment be drastically changed. In many reaches where the terrain is flat and the underlying soil is conducive to erosion and deposition, the river has naturally developed meanders. These are zones of uncertain flow path, where the river alignment may change regularly and therefore should be excluded from development. The zoning of land use should be guided by:

- The flood risk maps,
- The recommended green zones,
- Identified river corridor

ii) River Basin Management

The river basin plays an important role in the capture and storage of flood runoff. River basin management is therefore an important part of a holistic approach to overall water resources management which would also include flood management. Proper management and control of development in the river basin will contribute towards flood mitigation, towards sustainable water resources development, environmental enhancement and water quality improvement. Environmental measures, development planning and adoption of proper land use practices are key components of river basin management.

An Integrated River Basin Management Plan needs to be developed for major river basins and this plan should incorporate proper land use planning and the concepts of MSMA for the urbanizing areas.

Enforcement of MSMA concepts for both water quantity and water quality "at-source" control measures would to a great extent improve river basin management.

Complementing this would be identification of regional ponds from existing ponds and wetland areas and gazetting them to prevent them from being developed.

To facilitate integrated river basin management, tools such as a GIS, checklists and procedures for integrated river basin management can be developed.

iii) Flood Monitoring, Warning, Forecasting and Management

In some cases, the provision of a flood forecasting and warning system is a feasible and low-cost measure to minimize flood losses. Where the flood prone areas are not protected or inadequately protected against flooding and the area is of a high risk area (where human lives are at stake), then the community here should be forewarned of any impending floods so that the affected residents and authorities can take necessary action evacuate and to protect or salvage properties against flood damage.

A simple flood warning system installed in many flood prone areas is the siren system. The flood warning sirens will trigger the alarm when the water level reaches a designated threshold level.

Where there is enough lead time, flood forecasting models could be utilised to forecast the flood levels. For this system, it requires the combination of real-time rainfall and water level data, flood forecasting models, and trained forecasters. Increasing lead time increases the potential to lower the level of damages and loss of life. Forecasts must be sufficiently accurate to promote confidence so that the community will respond when warned.

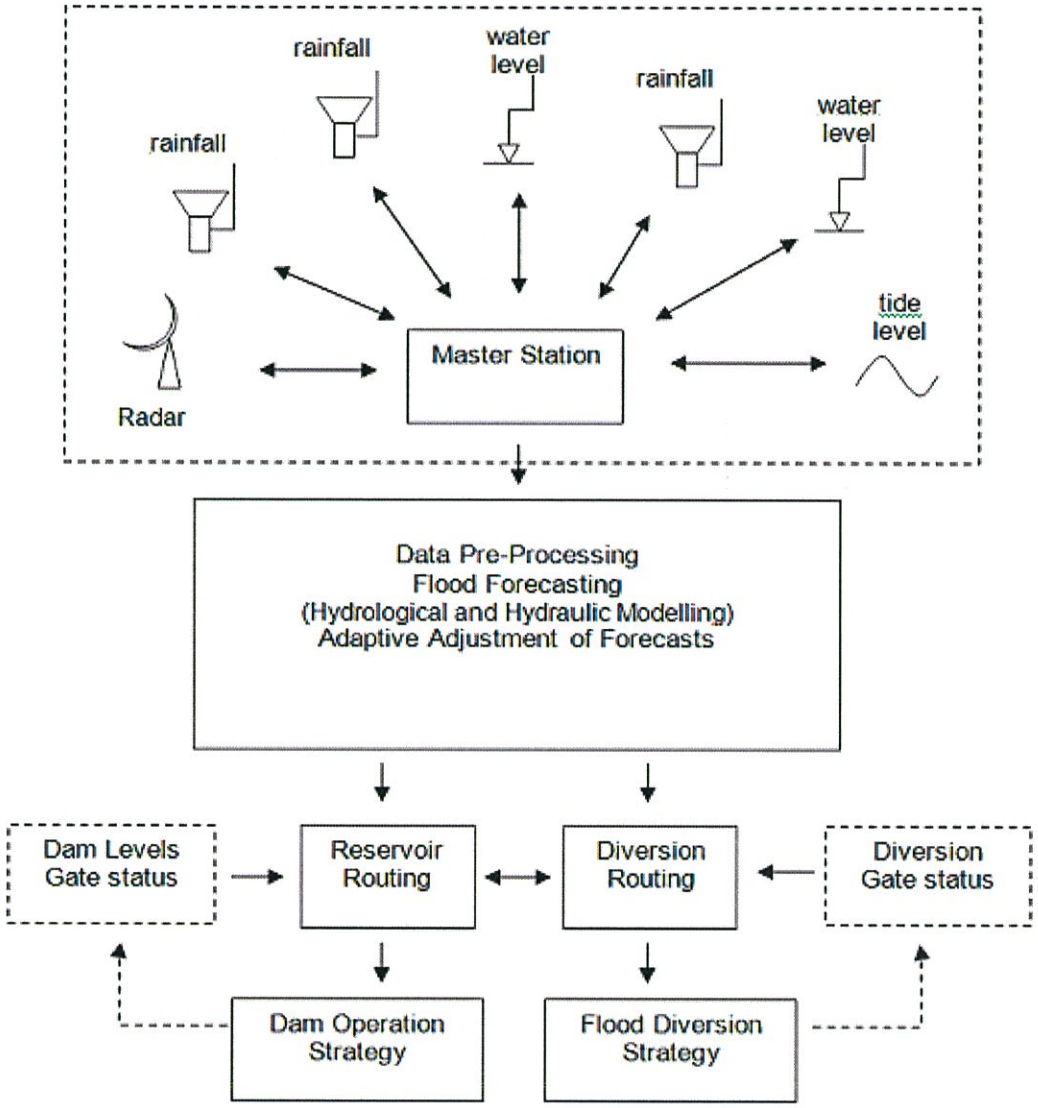


Figure 12.3 - Flood Forecasting and Flood Routing – Concept Flow Chart

Real-time flood management process involves operation of diversions, dam releases and emergency flood evacuation. An automated data acquisition system Supervisory Control and Data Acquisition (SCADA) system for flood monitoring and a real time flood simulation and forecasting system for decision support as shown in **Figure 12.3** is useful.

In flood forecasting the lead time of forecast is important. The lead time of a flood forecast is the time between the prediction of the occurrence of the flood and the actual occurrence of the flood. To improve lead time, information on rainfall should be obtained in real-time and this is made possible through the establishment of telemetric stations and SCADA systems.

The use of the weather radar information from Malaysian Meteorological Service's radar station to provide radar rainfall information would be able to improve the estimation of areal rainfall over the catchment.

12.7 FLOOD MITIGATION AND WATER RESOURCES DEVELOPMENT

Many of the dams constructed and operated for water supply, irrigation or hydropower will also have some degree of flood mitigation. In general, storage dams tend to regulate river flow so that high flows are not excessively high and low flows are not extremely low.

Water supply and hydro-electric dams are best operated with a maximum dam storage possible while conversely flood storage dam is best to be operated with initially zero water storage volume. Since many of flood storage ponds or dams may have water resources development potential, cost-effectiveness of water resources development and trade-offs of such a proposal will need further study.

There is a need to look at various dams to configure better operation procedures. It may be possible to operate water supply dams to cater for flood mitigation and flood mitigation dams and ponds for water supply.

In Perlis, the available dams is the Timah Tasoh Dam which in a multipurpose dam incorporating the functions of irrigation water supply and flood mitigation

12.8 CONCLUSIONS AND RECOMMENDATIONS

An IRBM plan is being prepared for Sg Perlis River Basin. The study will include the flood mitigation as well as the future water resources availability in Perlis.

In the study, the Western flood Bypass and the Eastern Flood bypass had been proposed as a flood mitigation options to protect Kangar Town and Arau Town from flood impacts.

SECTION 13

RIVER SEDIMENTATION

Section 13

RIVER SEDIMENTATION

13.0 RIVER SEDIMENTATION

Sedimentation issues in water bodies are emerging environmental problems of grave concerns. Under natural order that exist since time immemorial, the sediments that are transported and moved along with flows have the least concern and of minimum impacts to the environment in general. River flows with carrying sediments as part of the natural cycles and rhymes.

The sediments comprising primarily sand, silt, and clay are washed down to the streams and rivers from upland and continue to be transported by suspension in the flows or rolling and sliding near the river bed further downstream. In time, under favorable conditions, such as reducing flow velocity and momentum, the sediments could therefore transiently accumulate in the channel or river bottom and waits for such time, conducive hydraulic regime to remobilize and continue their journey down with the flows and settling out at the lake or river mouths or estuaries. In addition, sediments can also be deposited in reservoirs under quiescent condition by the action of gravity. As a result, this reduces their storage capacities. The sedimentation problem also chokes and interferes with the normal hydrological regime of river flow. Mobilization of sediment on land also cause surface (sheet), gully and rill erosion in the upland catchment. In addition, massive land movement such as slumps, landslides, landslides, and mudflows are also probable if massive uncontrolled deforestation and massive land clearance and movement are being taking place in a watershed.

For example, stable land form morphology and regimes exist in the riverine environment and with characteristically low sediment fluxes in the relatively undisturbed upland forested catchment. Most natural river reach are approximately balanced with respect to sediment inflow and outflow. Due to accelerated land clearance and massive infrastructural development and man-made disturbances during the past few decades, sediment fluxes in the river have being gravely increased by many folds.

Consequently, frequent problems of upland soil erosion, overbanks collapses and higher rates of sediment discharges in the river channel begin to surface. It has been estimated that more than 80% of the suspended sediment load in the rivers is caused by human activities in the catchments (Chong, 1985). Most of these sediments will be somehow settled down in the river reaches as they flows downstream to reach the seas. As a result this causes river bed aggradation and with time the river bed is raised, in turn shallow waters run into the risk of overbank floodings and other obstructions and malaise. In addition, high concentration of sediment in the river also affects the natural fauna and flora habitat. High sediment flux affects the gills of the fishes, for instance.

To mitigate the losses of conveyance capacity of the river channel, frequent dredging and desilting program is now almost an indispensable part of river maintenance program. This is perhaps a short-term ad hoc approach as it is merely carried out to keep the river course

clear of siltation. Needless to say the least, these operations incur expensive operational costs.

13.0.1 State of Perlis

There are only five (5) sediment stations are available for analysis. **Table 13.1** below summarizes the results of average SS loadings at the streamflow gauging stations.

Table 13.1 - Average Suspended Sediment Loadings at The Sediment/Streamflow Gauging Stations

Station	CA (km^2)	SS loading (ton/km^2/year)	Estimated concentration (mg/l)
Perlis			
Sg Jerneh @ Titi Tampang	24	22	49
Sg Tasuh @ Titi Baru	126	37	84
Sg Arau @ Ladang Tebu	21	215	417
Sg Pelarit @ Wang Mu	43	153	297
Sg. Jarum @ K Masjid	64	124	n/a

Sg Pelarit @ Wang Mu (6602501, CA=43 km^2) and Sg Tasoh @ Titi Baru (6502252, CA=126 km^2) streamflow stations are located on the tributaries that feed into the existing Timah Tasoh, a shallow reservoir with a relative large surface area, approximately, 13.3 km^2 at FSL and a total capacity of 40 MCM. Another major tributary is Sg Jarum, where a gauging station, Sg Jarum @ Kg Masjid (6602503, CA=64 km^2) is located.

Unfortunately, this is a newly established station with only shorter records starting from 2003 to 2007. The mean annual loading was about 124 ton/km2/year for mostly 50% forested catchment and the rest are agricultural land use with sugar cane plantation.

Sg Arau @ Ladang Tebu FELDA (6503501, CA=21 km2) streamflow station drains predominantly the sugarcane plantation where land use disturbance could be substantial throughout the planting and harvesting seasons. Comparatively mean annual sediment loadings at both Sg Jerneh @ Titi Tampang (6502501, CA=24 km2), and Sg Tasuh @ Titi Baru (6502252, CA=126 km2) streamflow stations are relatively low and this could most likely to be attributed to land use pattern within the predominantly upper rural and forest catchments. The mean sediment loading rates for these two stations are consistent with the sediment export rates of small forested catchments (Lai et al, 1995,1996; Yusop and Suki, 1994).

The sediment records for all stations mostly were not available after 2000 except Sg Jarum @ Kg Masjid (6602503, CA=64 km2), it is therefore difficult to ascertain the current status of the sedimentation in the river basin.

Comparison is also made with the WQI index where Sg Arau @ Ladang Tebu (6503501, CA=21 km2) and Sg Pelarit @ Wang Mu (6602501, CA=43 km2) streamflow station are

classified as class IV, the worst case scenario in terms of sediment water quality status of the river. Whereas, both Sg Jerneh @ Titi Tampang (6502501, CA=24 km2), and Sg Tasuh @ Titi Baru (6502252, CA=126 km2) streamflow stations are of class II suspended solid category. **Figure 13.1** shows the mean annual suspended loading of these four (4) streamflow stations.

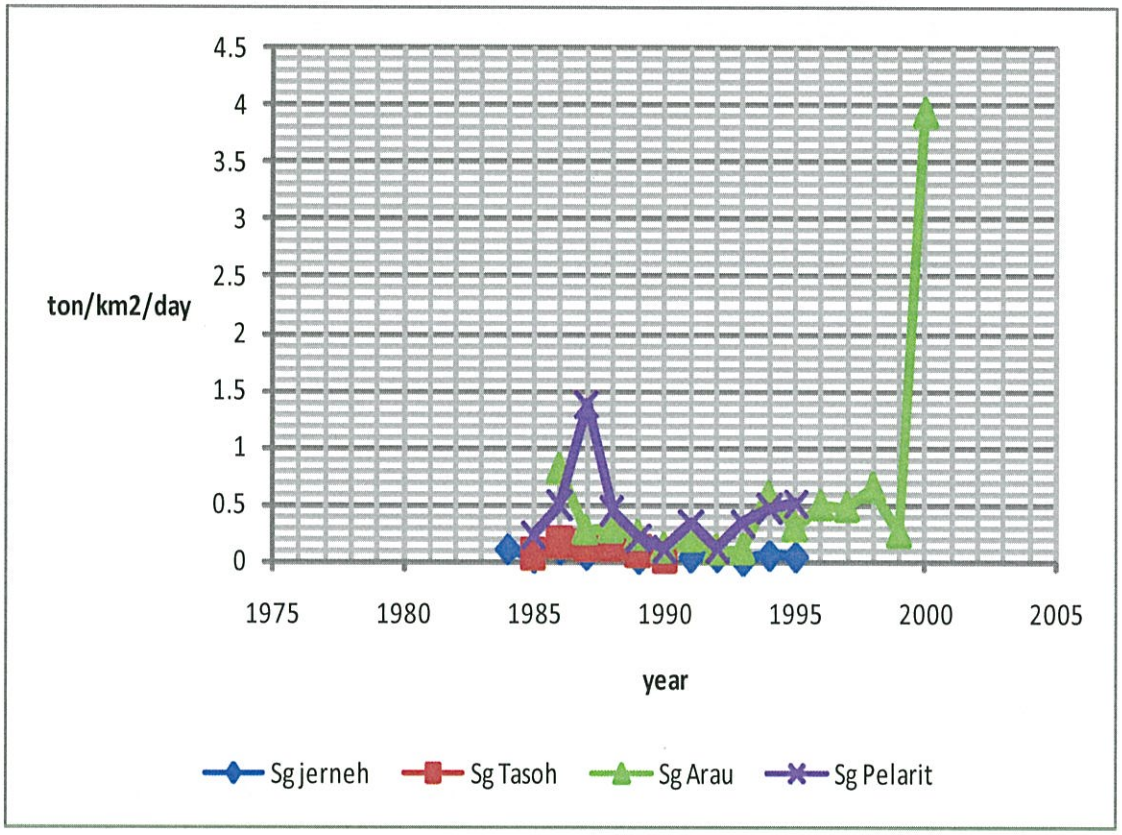


Figure 13.1 - Annual Series of Streamflow Stations in Perlis

13.1 SAND MINING

Sand and gravel have been used for many years as primary ingredients in the construction industry. Virtually all infrastructure construction requires both of them for concrete production. Demand for sand and gravel are continuing to increase in phase and hand-in-hand with the emerging urban renewal and suburban real estate development.

Excessive within the river channel sand-and-gravel mining causes the degradation of rivers. This Instream mining operation lowers the river bed level by incisions and deep down-cutting into the channel bottom, which in turn may lead to worsening bank collapse and erosion and endangers the structural integrity of the river banks.

Besides, sand depletion in the river and estuaries also causes the deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets. It may also lead to saline intrusion further upland with reduced flow as well as sediment fluxes.

The negative effect of mining could also be somewhat compounded by the effect of sea level rise due to imminent global climate warning that causes premature melting of north and south poles icebergs. In general, any volumes of sand that are exported from streambeds and coastal areas are a loss to the system.

Excessive sand mining is also a threat to bridges and other river crossing structures, river banks and ancillary infrastructures in the vicinity. The foundation and piles are weakened when exposed. Scouring of bridge piers are commonly observed if there are uncontrolled and unmitigated mining activities in the vicinity. Mining essentially creates a wider impact of sediment imbalance in the river reaches.

Perhaps it could be perceived as a far more long term impact, sand mining also affects the adjoining ground water system and their utilization is to be severely curtailed. Apart from threatening bridges, sand mining also transforms the riverbeds into large and deep pits; as a result, the adjacent ground water table depletes and leaving the adjacent water wells on the embankments of these rivers dry. The extent of influence of sand mining could possibly extend to a few kilometers inland away from the river banks.

Other than these physical impacts, sand mining operation also results in the destruction of aquatic and riparian fauna and flora habitat through large changes in the channel morphology. These Impacts are degrading channel bottom that scours away the vital habitat of micro-phytes and other living benthic organisms, bed armoring and coarsening that could affect the spawning cycles of vital fish and other aquatic species, lowering water tables near the streambed and decrease ground water nutrient influxes into the river, and channel instability.

In other some minor and indirect impacts, sand mining generates extra vehicle traffic, which negatively impairs the environment. Where access roads cross riparian areas, the local environment may be impacted to a certain extent.

13.2 DEFORESTATION AND LAND CLEARING

Large scale deforestation and massive land clearing are culprits that cause waterway sedimentation. The logging industry and land development has known to be responsible for siltation as well as degradation of water quality in the riverine and lacustrine environments.

Runoff induced erosion from the construction sector is one of the greatest contributors to sedimentation problem in the riverine environment in terms of loading and it therefore is sensible that efforts should be made to mitigate this problem. There are many mitigation plans or they are better known as "best management practices" (BMPs) are available to

achieve the objective of erosion and sediment control. Some of these BMPs are silt fencing, sediment traps and ponds, mulching, hydroseeding, to mention a few.

Most important factor to determine successful implementation of soil erosion and sedimentation control is the practice of a good planning; the very first step in preventing sediments inflow into the water course as this could pose harmful damages to the receiving water ecosystem. However, it is also equally important to ensure erosion and sediment control measures, i.e. BMPs are correctly installed and maintained in situ throughout the duration of construction.

JPS has made the Erosion and Sediment Control Plan (ESCP) as part of the requirements for earthwork applications on new land and housing developments.

The most damaging ecological impact of sedimentation in waterways is the smothering of spawning habitat for fish. Freshwater fish require clear water with clean gravel and sandy beds for reproduction to be successful. And also higher magnitude and frequent number of flash floods in urban areas are often attributed to severe reductions in the capacity of the waterways due to sedimentation and vegetation growth in the channel.

Natural processes do contribute to erosion, however anthropogenic activities of urban development and earthworks accelerate this sedimentation predicaments by many orders of magnitudes.

New stormwater management manual (MSMA; JPS 2001) has been issued to replace the first edition of stormwater management manual in 1976. Other than addressing the stormwater management in urban areas, the new manual also contains comprehensive guidelines on BMPs for erosion and sediment control during construction. Unfortunately on-the-ground practices remain largely unchanged.

In August 2005, Compulsory rule has been made to include ESCP as a prerequisite for new earthwork undertaking of non-agricultural in nature. On the same year, a delegation from Malaysia attended the International Erosion Control Association (IECA) convention in Denver, USA and returned with an agreement to conduct certification examinations from a certification body of IECA called 'Certified Professional in Erosion and Sediment Control' (CPESC).

In October 2010, JPS published ESCP guidelines. A Malaysian body accredited by CPESC, USA is being formed to conduct the examinations and regulate members in future. It is envisioned that ESCPs will be further extended to the agricultural and forestry sectors. This will further strengthen soil erosion and sedimentation control measures. For earthworks and for construction related industry, CPESC certification will be a requirement for professionals charge of preparing ESCPs

13.3 DAM AND STORAGE CAPACITIES

Reservoirs and dams are integral parts of water resources infrastructures in Malaysia. There are 60 existing dams of various functions with several of them currently under construction.

The purpose of the reservoir/dam is to provide raw waters supply in time of need and to augment the low flow regime at the downstream of the river catchments. All in all, the reservoir is the first line of defence against the random, unpredictable vagaries of hydrological cycles. The waters in the reservoir storage are primarily intended for water supply and hydropower production. It also provides ample storage for incoming high flows s a result of major storm events. In other words, reservoirs also provide protection against flooding downstream. By storing water behind the water bodies created by the dam, the downstream outflow could therefore be somewhat moderated and mitigated.

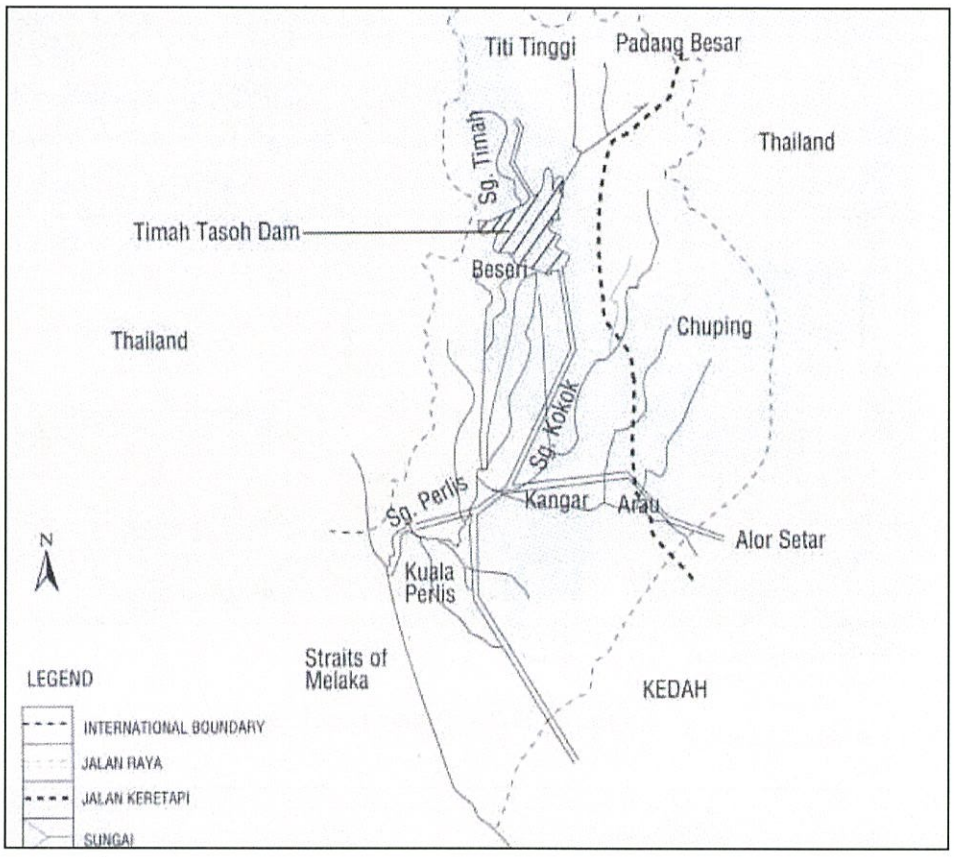
One of the major issues in reservoir management world wide is the siltation or sedimentation (Mahmood, 1987). Loss of storage capacity due to heavy sedimentation is already been evidenced with Sanmenxia reservoir lost its useful storage within a short periods of one year.

All reservoirs formed by dams are subject to some degrees of sediment inflow and deposition even they are from the pristine virgin jungle. Rapid siltation and sedimentation cause enormous economic losses as uncontrolled siltation by inflow sediment from upper watershed into the reservoir. Once they are silted, it would be costly to remedy the problems.

In the common practice of reservoir scheme development, dead storage allocation is adequately specified a priori during the early stages of the dam and reservoir planning. In Malaysia, normally the live of the reservoir is targeted at 100 year. Therefore, allocation of dead storage in the reservoir should also be considered at such. Generally, 200-300 ton/km^2/year of sediment influx are dedicated to dead storage of the proposed reservoir scheme (SMHB, Pahang and Johor water resources master plans; 1992; 1994). This generous allocation is in fact significantly higher than the observed annual sediment inflow of mainly forested and jungle land use.

Only one (1) reservoir scheme currently operates in the state of Perlis (see **Figure 13.2**), Timah Tasoh dam which was constructed at the immediate downstream confluence of both tributaries in 1992. The dam catchment area is 191 km2 with a fairly large lake surface area of about 14 km2.

The purpose of the reservoir is to provide raw water supply for both padi irrigation and domestic water supply to towns in the vicinity. A new upgrading work to raise the dam height and associated works are currently underway. With bigger storage in the reservoir water body, reliable water sources are therefore readily available for both irrigation and domestic water supply.



www.nahrim.gov.my

Figure 13.2- Timah Tasoh Dam and Irrigation Scheme

Figures 13.3 and 13.4 show the birdeye and close up view of Timah Tasoh dam embankment and spillway/off take structure.



www.water.gov.my

Figure 13.3 – Timah Tasoh Dam



www.water.gov.my

Figure 13.4 – Timah Tasoh Dam: Side Spillway

13.4 IMPACT OF CONSTRUCTION OF DAMS, BARRAGES AND OTHER RIVER STRUCTURES

The construction of instream river structures, such as dams, barrages, locks, weirs, and others interferes with the smooth flow of water and sediments. These obstructions generally results in sediment accumulation at the upstream side of the structure. This causes various negative impacts on water courses, such as reduce the efficiency of the water diversion and intakes, hinder the navigation activities, and many others.

Instream structures are integral parts of water resources development and project that serve the function of raising the hydraulic head for smooth diversion at the off take. Due to obstruction to the passage of flow to downstream, sedimentation issues are always prevailed. The most economic as well as least effort way to address the issues of sedimentation is none other than "source control" that prevents the sediment influx at the upper catchment. This non-structural approaches includes stringent landuse control, adoption of effective best management practices for prevention of soil erosion en route to the waterway, etc.

13.5 CONCLUSIONS

Five (5) sediment stations are available for current status of sedimentation assessment in the state of Perlis. Generally, the state is rural with low sedimentation problems except at the instream structures along the major river systems. With the exception of Sg Arau @ Ladang Tebu sediment station, which shows higher annual sediment loading, the records of other stations appear low.

There is no information on the range line or bathymetric survey been carried out for the only reservoir scheme in the state of Perlis. The reservoir has been in operation since the early 1990's. It is therefore prudent to assess the sediment influx within some 20-years of operation. Although the upstream catchment areas are mainly rural but with time, some human activities appears to flourish within the Sg Timah and Sg Tasoh basins.

Instream structures that obstruct the smooth passage of flow normally traps sediments, i.e. silt and clay behind the structure bodies. Maintenance such as dredging is probably the most economical solution for keeping the intake structure functional.

13.5.1 References

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SECTION 14

RIVER TRANSPORTATION

Section 14

RIVER TRANSPORTATION

14.0 RIVER TRANSPORTATION

14.1 INTRODUCTION

Three of the rivers in Perlis are used for navigation; they are Sg Perlis, Sg Baru, and Sg Sanglang. Sg Perlis serves as a commercial centre for ferrying passengers mainly to and from Pulau Langkawi and also as a fishery base where various sizes of boats are moored. Sg Baru and Sg Sanglang are utilized mainly by local fishermen for mooring their boats at private wooden jetties.

Since the early 1980s, Sg Perlis has been plagued with siltation at the river mouth causing access problems for various boats (including fishing vessels) and ferries. Although various maintenance dredging works have been conducted to overcome the problem, heavy sedimentation rates lead to the river mouth quickly silting up. This problem has led to high levels of downtime both for ferry operators and fishermen.

Hence, the windows for vessels operation are limited by insufficient draughts to safely navigate to the passenger and fish-landing jetties. The delays cause grievances for passenger ferry services, and often led to deterioration of fish quality while fishing vessels have to wait for flood tides to safely traverse the river mouth. The problems to fishermen appear greater due to the fact that they have to wait for suitable tides to go out and return, which in turn has left them with less fishing time and longer waiting time to land their catch. This expectedly then leads to higher costs with lower returns.

In Sg Perlis, river transportation is mainly limited only to the fishing villages. The furthest upstream that fishermen are able to travel is approximately between 1.0 to 1.5km from the river mouth. Furthermore, road bridges constructed also limit accessibility upstream within the rivers in Perlis, only allowing the smallest of vessels upstream to access. Smaller crafts for leisure can be seen going upstream as this type of craft has smaller draft and lower headroom requirements and greater ability to manoeuvre compared to fishing vessel or ferry, which generally requires more than a 1 metre riverbed clearance.

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SECTION 15

COASTAL ASPECTS

Section 15

COASTAL ASPECTS

15.0 COASTAL ASPECTS

The coastline of Perlis extends from the Thailand border to Sg Sanglang a distance of approximately 20km.

The previous NWRS (2000) did not deal with this topic in terms of the environmental impacts to water resources. By including this topic in the review, a more comprehensive appreciation of water demand for the country will be realised.

15.1 SHORELINE DESCRIPTION

The shoreline is essentially straight for the entire coastline and is protected to the west and north by Pulau Langkawi and Ko Tarutoa (Thailand) group of islands.

The shoreline consists of soil strata of marine clay with a predominantly littoral material of fine grained sediments formed from the decomposition of clay. Small quantities of calcareous sand collect in pockets along the shore at or about the high water level.

The main net transport rate along the coast is northwards. Although Sg Perlis is discharging some sediment, generally the marine clay seabed is eroding forming a vertical scarp in the clay at the shore where wave energy is concentrated. Accretion results from a deposition of the silt on the mud flats offshore from the scarp. A thin band of mangrove forest remains north of Sg Perlis and Sg Sanglang although it is threatened by erosion.

15.2 COASTAL OUTLETS

The Integrated Water Resources Study for the Northern Region of Peninsula Malaysia of August 2009 reported that there are two major river basins in Perlis, i.e. the Sg Perlis Basin in the north and Sg Arau/Arau Canal Basin in the south.

Apart from Sg Perlis and Sg Arau/Arau Canal basins which constitutes 76% of the Perlis State land area, the remaining area in the State is drained by a number of minor river systems in the interior (such as Sg Mentalon and Sg Melaka) and seven outlet channels discharging directly to the Melaka Strait (from Sg Kurong Tengar in the north to Sg Sanglang in the south).

15.3 IMPACT OF OUTLETS ON SHORELINE ADJACENT TO OUTLETS

Sg Perlis has one (1) dam located upstream of the river basin, i.e. the Timah Tasoh Dam. The Timah Tasoh Dam is the only existing dam in Perlis constructed for irrigation, flood mitigation and water supply purposes that is currently being upgraded to store more water. Except for Sg Perlis, the outlets along the Perlis coastline do not severely affect coastal morphology although they do influence erosion rates. However, at the river mouth of Sg

Perlis constant maintenance dredging has to be carried out to ensure that the water depths are sufficient to cater for the passenger ferry vessels plying the Kuala Perlis – Langkawi route.

Any proposed development works in the river involving water impoundment and regulated river flow either by the construction of dams or barrages will have impacts to the coastal ecosystem (NRC, 1990). The extent of the impact will depend on the percentage of the dam catchments to the overall total river catchments, bed material characteristics, flood discharge and the extent of river sediment contribution to the overall sediment budget.

According to the 2008 Department of Environment (DOE) report on overall water quality Sg Perlis is reported to achieve 92% compliance by the pollution sources based on follow-up actions [Directive Notice, Court or Prohibition Orders] reported. Accordingly river water quality should be able to be maintained and improved over time.

15.4 SALINE INTRUSION

According to the National River Mouths Study in Malaysia (1994) tidal influence at Sg Perlis ranges up to 15km upstream. As such, water abstraction points are mainly located in the upper reaches of the river basin.

For the irrigation outlets saline intrusion is controlled by a tidal gate.

15.4.1 References

(i) Stanley C. 1985. National Coastal Erosion Study

(ii) DOE 2008, Annual Report

(iii) JICA 1994, The National River Mouths Study Vol II

(iv) JICA 1982, National Water Resources Study, Malaysia

(v) SMHB 1999, National Water Resources Study 2000-2050 (Perlis)

(vi) G&P 2009, Integrated Water Resources Study for Northern Region of Peninsula Malaysia

SECTION 16

ENVIRONMENTAL ASPECTS

Section 16 ENVIRONMENTAL ASPECTS

16.0 WATER RESOURCES AND THE ENVIRONMENT

16.1 INTRODUCTION

The governance of water resources in Malaysia has become very complex and more so when the environment is taken into consideration. Any water crisis ranging from a case of there being too little, too much or the water being too polluted is now considered a crisis of governance. At the World Summit on Sustainable Development in 2002 in Johannesburg, Malaysia together with many other countries declared an intent to subscribe to an Integrated Water Resources Management approach (IWRM) and to develop water efficiency plans by 2005[1] to reduce water resource degradation and to achieve integrated management of land, water and living ecosystems whilst strengthening national capacity to overcome any water crisis.

To ensure water security and the optimal use of water resources in the country, the Federal Government is now moving towards encouraging greater focus upon: the conservation of water source areas; integrated management of river basins, i.e. from the source to the sea; tighter control of water pollution; and preservation of biodiversity and the environment. It is looking also at alternative sources of water and water recycling, and encouraging the application of new technologies that can reduce water demand, whilst not forgetting to encourage water savings while preparing the country to better cope with the likely negative effects of climate change.

In light of the above national aspirations, the approach taken in this section is to examine the various components of the environment affected by water resource development with a focus on environmental conservation in the State. It follows a framework of setting the scene, looking at the environmental requirements and limiting factors, and ways to conserve the environment so that water resources may be managed in a more sustainable manner.

This section begins by providing an overview of the current water resource scenario in relation to the environment. In painting this picture, the factors that impinge on water resources such as population, landuse and socio-cultural activities are profiled insofar as they provide information for an assessment of various water demands, competing areas of water requirements and to identify solutions to achieve sustainability.

Within the section of environmental requirements and limiting factors, all salient factors that contribute to water resource sustainability (i.e. forests as water catchment areas, lakes and wetlands as natural water reservoirs, etc.) and impactors, which increase pressures on water resources or degrade its quality (such as aquaculture use of water, sewage and solid waste contributions to water pollution, etc.), are examined.

1 This deadline has since been amended to allow countries to develop the efficiency plans according to their own time schedules.

Finally, to sustain the environment, two key aspects considered are water quality and water quantity. The former provides the "net" or "real" availability of water resources while the latter is essential to sustain all water-dependent ecosystems and habitats, and sustain water availability (quantity) through dilution to counter water pollution. To achieve the goals of water resource sustainability, major recommendations for environmental conservation and management are provided in Section 16.18.

A summary of the approach followed in this Section is shown below.

SETTING THE SCENE
- Background information of Perlis
- Water availability and demand
- Population
- Socio-cultural profile
- Landuse

ENVIRONMENTAL REQUIREMENTS AND LIMITING FACTORS
- Forest ecosystems
- Lake and wetland ecosystem
- Aquatic ecology

ACTIVITIES THAT LIMIT WATER RESOURCE USE
- Commercial inland fisheries and aquaculture
- Recreation and tourism
- Water quality and sources of pollution
- Contributions from sewage
- Contributions from solid waste

SUSTAINING THE ENVIRONMENT
- Environmental flow
- Recommendations for environmental conservation

16.2 BACKGROUND INFORMATION OF PERLIS

Perlis is the smallest northern most State in Peninsular Malaysia. According to the Department of Statistics Malaysia, the total area of the State is 821 km^2. It is divided into three Parliamentary Areas - Arau, Kangar and Padang Besar (**Figure 16.1**).

The State is bordered on the north by Thailand, on the east and south by Kedah and on the west by the Straits of Melaka. The topography is largely flat, less than 61 metres above sea level. High grounds, in excess of 152 metres, are found near the Thai border with the highest point being Gunung China (721 metres).

The climate of the State is tropical monsoon, with a distinct dry spell between the months of January and April. The temperature falls within the range 21°C to 32°C throughout the year. Humidity is consistently high on the lowlands ranging between 82% and 86%. The average

rainfall per year ranges between 1,704 mm and 2,005 mm and the wettest months are from April – May and August – October.

The agriculture in the State is dominated by paddy cultivation but the State is better known for its sugar plantations. There are two large sugar plantations in the Arau Parliamentary Area, one belonging to Felda and the other to Perlis Plantation. The latter may have sold its plantations to the former recently. Some oil palm cultivation is also apparent. Marine coastal and deep-sea fishing is carried out through Kuala Perlis.

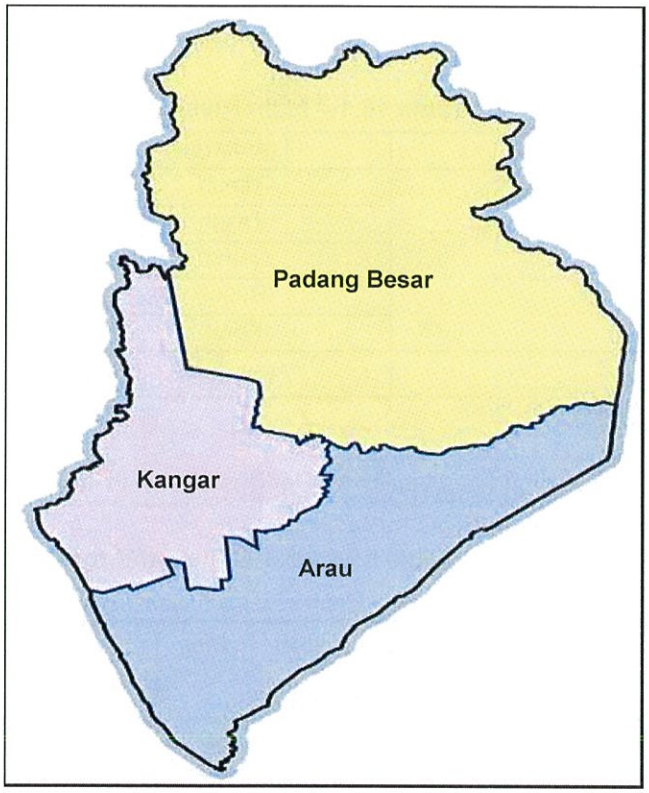


Figure 16.1 – Parliamentary Areas of Perlis

16.3 WATER AVAILABILITY AND DEMAND

A network of rivers in the north of the State flows south to join Sg Perlis, which drains to the Straits of Melaka at the estuary of Kuala Perlis. There are two major river basins in the State, namely, the Sg Perlis Basin in the north and Sg Arau Basin in the south (**Table 16.1**).

The Sg Perlis Basin has a total catchment area of about 527 km^2 comprising the major tributaries of Sg Timah, Sg Tasoh, Sg Jarum, Sg Repoh and Sg Korok. These tributaries flow through the river basin in a southerly and south-westerly direction to join Sg Perlis in close proximity to Kangar. A Northern Diversion Channel has been constructed north of Kangar Town under the Kangar Flood Mitigation Project to divert flood waters to the sea.

Sg Arau Basin has a total catchment area of about 110 km^2 with approximately 16 km^2 of the upper catchment falling within the Changlun area in Kedah. The main river flows in a south-

westerly direction to the Straits of Melaka. This river flows through Arau town, which is located 8 km east of Kangar. Originally, Sg Arau flows into Sg Perlis but it has since been diverted to the Arau Canal to supply water for the MADA irrigation scheme. Water levels along the Arau Canal are regulated by several control structures. The water from the Arau Canal is discharged to the sea at Kuala Sg Baru through tidal gates.

The large man–made lake in Timah Tasoh Dam, was created in 1992 by damming Sg Korok about 2.5 km downstream of the confluence of Sg Timah and Sg Tasoh. The water in the dam is meant for water supply, irrigation and flood mitigation. The major water demands come from domestic, industrial and commercial requirements and for irrigation in the agricultural sector.

Table 16.1 – Main River Basin of Perlis

River Basin	Tributaries	Catchment Area (km^2)
Sg Perlis	Timah	724.4
	Tasoh	
	Jarum	
	Repoh	
	Korok	
Sg Arau	Arau Canal	

Source: Kompendium JPS, 2010

The water demand and availability for Perlis is shown in **Table 16.2 and Table 16.3** below:

Table 16.2 - Water Demand for Perlis

Sectors	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
	Water Demand MCM per year					Water Demand mm rainfall per year				
Potable Water Demand	54.8	61.3	65.3	70.1	75.2	66.7	74.7	79.6	85.4	91.6
Irrigated Paddy	198.0	184.0	165.0	155.0	141.0	241.2	224.1	201.0	188.8	171.7
Non-Paddy Crops	51.9	52.0	52.1	52.2	52.4	63.3	63.3	63.4	63.6	63.8
Livestock	0.9	1.7	3.3	6.5	12.8	1.1	2.1	4.1	8.0	15.6
Total consumptive demand	***305.6***	***299.0***	***285.7***	***283.8***	***281.4***	***372.3***	***364.2***	***348.1***	***345.8***	***342.7***
*Fisheries	9.4	10.4	11.5	12.7	14.1	11.5	12.7	14.0	15.5	17.1
Total demand	**315.0**	**309.4**	**297.2**	**296.5**	**295.5**	**383.8**	**376.9**	**362.1**	**361.3**	**359.8**

* Considered as non-consumptive use

Table 16.3 - Projected Water Availability for Perlis (mm rainfall per year)

Year	Runoff	Estimate % available (15%)	Total consumptive water demand	Deficit
2010	470	70.5	372.3	(301.8)
2020	470	70.5	364.2	(293.7)
2030	470	70.5	348.0	(277.5)
2040	470	70.5	345.5	(275.0)
2050	470	70.5	342.3	(271.8)

16.4 POPULATION

Population is one of the main drivers for water consumption. Apart from direct consumption for survival, health and well-being, water is essential and necessary in all economic activities and development, which may in turn, impact on the quality of water and the environment adversely. Thus, a short review of the current population size and their distribution with projections up to 2050 is a necessary prelude for sound water resources and environmental management.

16.4.1 Current Status on Population, Growth Rates and Density

According to the Department of Statistics, the estimated total population in 2010 stands at 240,100 persons with a density of 292 persons/km^2. Taking account of the small size of the State, it can be considered densely populated. The State recorded a growth of 1.3% during the 2009 to 2010 period (see **Table 16.4**).

Table 16.4 – Basic Population of Perlis, 2010

Districts	Land (km^2)	Population ('000)	Population Density (persons/km^2)	Rate of Population growth (2009-2010) in %
Padang Besar	821	240.1	292	1.3
Kangar				
Arau				

Source: Department of Statistics (2010), Basic Population Characteristics by Districts, 2010.
Note: Low variant as population projection is used. See Table 3.14 in Volume 3.

16.4.2 Population Projection to 2050

The population projection to 2050 is derived from two basic components; natural population increase (births less deaths), and the level of development and urbanisation. The latter depends on many factors, chief amongst which are the proposed and implemented governmental plans and policies that affect the migration patterns of the labour force and therefore the future population distribution and density in State.

One of the main policies of the Government is the development of the Northern Corridor Economic Region or NCER, which stretches from Perlis to northern Perak, covering an area of 17,816 km^2. The developmental focus of the NCER is on agriculture, human capital development, infrastructure, manufacturing and tourism. Because of the high capital

allocation to develop the NCER, and a forecasted generation of 3.1 million jobs, the population projections to the year 2050 will see a tremendous increase in in-migration to Perlis.

The population projection by district is shown in **Table 16.5 and Figure 16.2**. These are derived under three population growth scenarios - high, medium and low variants. For the high variant projection, the trend increases substantially, more than the other two from year 2020 onwards. Based on the projected population growth trend, the current urban and industrial enclaves will see much higher population growth and density and therefore greater demand for water in these areas in the future.

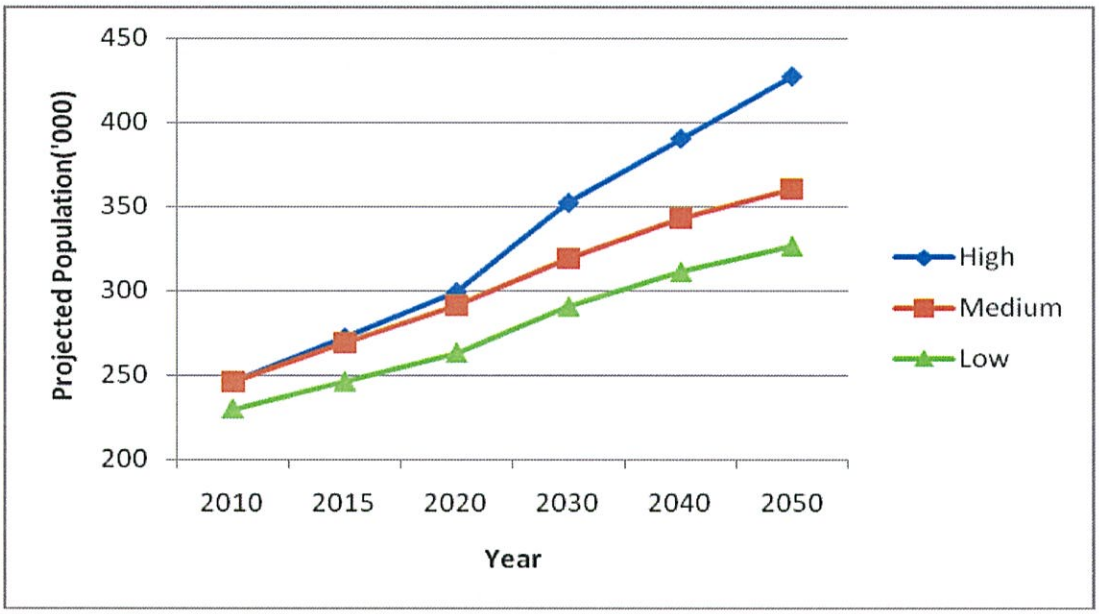


Figure 16.2 - Population Projections for Perlis, 2010-2050

Table 16.5 - Population Projections under High, Medium and Low Variant Assumptions for Perlis

Variant/ Year	2010	2015	2020	2030	2040	2050
High	246	272	299	352	390	427
Medium	246	269	291	319	343	361
Low	230	246	263	291	311	326

Source: Department of Statistics (2008), Population Projection Up to 2050 (presented to LPPKN Second Population Strategic Plan). The 2010 Census is unavailable yet.

16.5 SOCIO-CULTURAL PROFILE

Related to the population are its socio-cultural characteristics where the case for preservation of historical and cultural heritage sites and also the remaining *Orang Asli* tribes has been generally accepted. Therefore, this section provides relevant information on their whereabouts to resource planners to circumvent any development plans, unwittingly resulting in the omissions of these important factors.

16.5.1 Historical and Cultural Heritage

The traditional pattern of population, settlement and landuse described in the section on the socio-cultural aspects of water resources in Malaysia applies as much to the State of Perlis as it does to the larger States of the Peninsula, Sarawak and Sabah.

The population of the State has since early times resided in the lowlands and floodplains of Sg Perlis and that of Sg Arau. Settlement and landuse are spread over the swathe of lowlands enclosed by Sg Perlis, which flows in a southern direction and Sg Arau which flows in a south-westerly direction.

Sg Perlis flows through Kangar, the State's capital while the royal town is at Arau, located upstream of Sg Arau. The estuary of Sg Perlis is at the small river port of Kuala Perlis. Other than Kangar and Arau, traditional villages such as Sena, Beseri, Bukit Keteri, Jejawi, Utan Aji, Kaki Bukit, Cuping and Pauh, still nestle in the midst of wet paddy areas and orchard groves. Strewn amidst the paddy landscapes are limestone outcrops, most with caves and lush overgrowth. The limestones of Perlis must be considered an important landscape heritage in view of their geological, scenic and landscape value.

The upper reaches of Sg Perlis interface with the border of Thailand. The town of Padang Besar is an important rail gateway to the rest of northern Asia, which should be of great historical value.

Archaeological evidence of ancient man has been found in Perlis. Gua Bintong has provided details of Hoabinhian Culture dating back 5,000 years, while pottery and stone tools (axes) from the late Neolithic era were found not only in Gua Bintong, but also during excavation works for the new Kota Kayang Museum. Important but unstratified Neolithic collections have also been discovered in a cave in the limestone massif of Bukit Tengku Lembu, situated in Beseri. A compiled list of archaeological and heritage sites is shown in **Table 16.6**.

Table 16.6 - Archaeological and Heritage Sites in Perlis

No.	Location	No.	Location
1	Gua Bukit Tungku Lembu, Bukit Merah	22	Gua Kelemboi, Bukit Ngulang
2	Bukit Tungku Lembu Rock Shelter	23	Wang Tangga, Kaki Bukit
3	Gua Tok Megat, Bukit Tungku Lembu	24	Gua Tahi Kelawar, Bukit Manik
4	Bukit Batu Hampar, Bukit Cuping	25	Kg Padang Kota
5	Gua Berangin, Bukit Cuping	26	Kota Tok Paduka, Kg Seno
6	Gua Tok Belat, Bukit Cuping	27	Mukim Kg Batang
7	Gua Bintong, Bukit Cuping	28	Gua Gergasi
8	Gua Tembus, Bukit Cuping	29	Gua Lanun
9	Gua Tempah, Bukit Cuping	30	Kg Nasi Sebungkus
10	Gua Tok Janggut, Bukit Cuping	31	Kg Tebing Tinggi
11	Gua Bukit Tok Jawa	32	Gua Che Din, Kg Kelian
12	Gua Bukit Kecil	33	Gua Wang Betong
13	Gua Bukit Kerengga	34	Gua Wang Kunang
14	Gua Tok Kong, Bukit Kerengga	35	Gua Bukit Lentas
15	Bukit Jernih	36	Gua Haji, Kg Payung
16	Kg Kurung Batang	37	Kg Payung
17	Gua Pufur, Bukit Ketri	38	Gua Keleding
18	Bukit Ketri	39	Gua Samah
19	Kg Pangas, Bukit Ketri	40	Sg Arau
20	Gua Berembang, Bukit Ngulang	41	Gua Linggi, Kangar
21	Bukit Merang, Bukit Ngulang	42	Bukit Jurun

Source: Kajian Sumber Air Negara 2000-2050 (Semenanjung Malaysia). Volume 8: Perlis.

16.6 LANDUSE

Landuse directly impinges on the water resources and the environment of the State. Its components, such as forest, lakes, rivers and wetlands, all serve to capture and retain water endowed by the abundant rainfall. Other landuse components, however, serve as indicators for water demand. The current landuse, and projected landuse, set the scene for matching demand with supply for water resources in the State.

16.6.1 Current Landuse

The current landuse was GIS-generated from the DOA 2006 Map and is summarised in **Table 16.7** and illustrated in **Figure 16.3**. The landuse assessment will be based on this Table since it provides a detailed breakdown of the various land covers within the State.

The largest landuse category based on **Figure 16.3** is agriculture with 61,217 ha or almost 75% of the State's land area. Similar to Kedah and Perak, the agricultural landuse of the State has a special relevance to this Study on account of most of it being under irrigated wet paddy cultivation. The whole of the State's paddy land south of Kangar falls into the MADA paddy region. The remaining areas under paddy are in association with traditional villages outside Kangar such as in the Mukims of Jajawi, Utan Aji, Beseri and others. Other than paddy, rubber and sugar cane are also cultivated.

Forests comprise the second most important category with 14,539 ha or approximately 18% of the State's land. This is followed by built-up landuse, which concentrates mainly in the

capital town of Kangar, Arau, Padang Besar, Pauh, Kaki Bukit, Beseri, Mata Air and Kuala Perlis. The smallest landuse category is the water bodies, which is largely represented by the Timah Tasoh Lake.

Table 16.7 - Current Landuse in Perlis (ha)

Land Use (ha)				
Water body	**Forest**	**Agriculture**	**Built-up**	**Total**
1,091	14,540	61,217	5,253	82,101

Source: GIS-Generated from DOA Map 2006

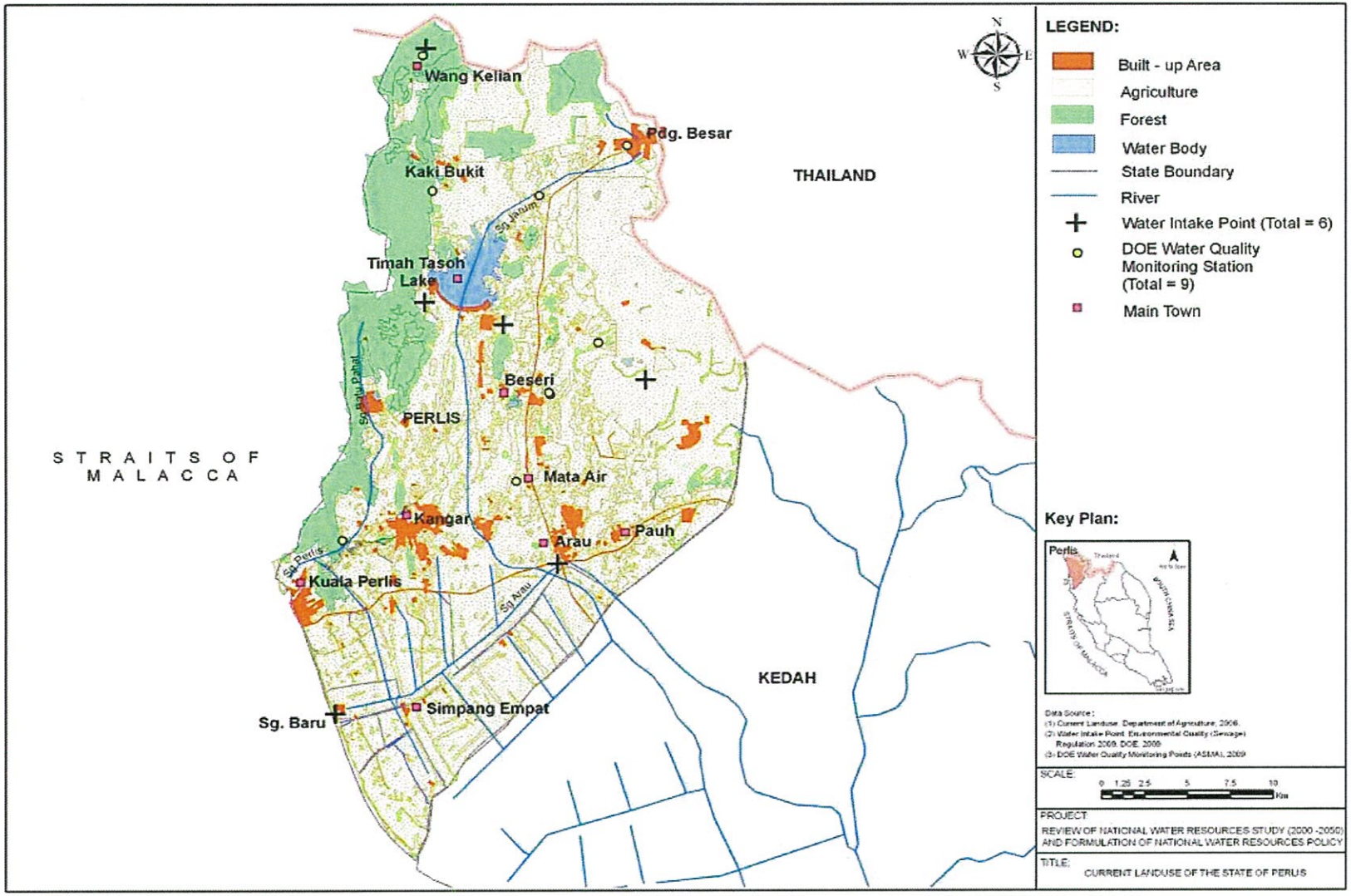


Figure 16.3 - Current Landuse of the State of Perlis

16.6.2 Future Landuse

For the future landuse scenario, it can be summarised that one third of the State, comprising the paddy areas under MADA will remain in status quo. While another third will also remain in status quo by virtue of its status as *Jajaran Pelancongan and Kawasan Pengekalan*, with areas under environmental conservation that includes valuable limestone landscapes and the Timah-Tasoh Lake. The remaining one third, in the north and northeast areas of Kangar town (Jejawi, Mata Air, Chuping, Arau, Pauh and Padang Besar), referred to as a commercial-agricultural development zone, will see active built-up development in the future. The large campus of the University of Perlis in Ulu Pauh and the UiTM campus in Arau are clear pointers in this direction.

Meanwhile, the future industrial landuse segments in the State will comprise the three locations listed in **Table 16.8** and shown in **Figure 16.4**.

Table 16.8 - Future Industrial Locations

Location	Size (ha)	Remarks
Sg Chuchoh	20.2	Herbal and processing of local products
Pauh	202.34	Mixed industries. This will probably be the largest single industrial landuse block in the whole State. The proposed development of a new township at Ulu Pauh and already operational campus of the UNIMAP, University of Perlis, are expected to synergise with this industrial area.
On the proposed reclaimed coastline that will stretch from Kuala Perlis to Kuala Sanglang.	Yet to be determined	Heavy industries and high-technology industries.

Source: JPBD Perlis

16.6.3 The Northern Corridor Economic Region or NCER

Perlis is part of the NCER development region, and its development during the next forty years will be influenced by the strategies for this corridor. The Northern Corridor Implementation Authority will work with the Perlis Economic Development Corporation to develop infrastructure for the Pauh Industrial Zone. Pens Holdings Sdn Bhd has been entrusted with the development works for the area which, once completed, is expected to draw more investment and population to the State (The Star, July 2010).

16.6.4 Environmentally Sensitive Areas

In relation to the future development in the State, the National Physical Plan provides some guidelines on the types of development most appropriate for various categories of the environment. The National Physical Plan requires all States and local authorities to cooperate with the Federal Government to identify and rank environmentally sensitive areas (ESAs) in the country, such as forest lands, marine parks, catchment areas, drainage and recharge areas, erosion risk and elevation into three broad categories; ESA Rank 1, Rank 2 and Rank 3.

In the first category or ESA Rank 1, no development, agriculture or logging is allowed except for low-impact natural tourism, research and education. These include all protected areas,

potential protected areas, wetlands, turtle landing sites, catchment areas of existing and proposed dams, and areas with elevation above 1,000 m above mean sea level (a.m.s.l)

In the second category or ESA Rank 2, no development or agriculture is allowed, but sustainable logging and low impact nature tourism may be permitted subject to local constraints. This category includes all forests, wildlife corridors, buffer zones around ESA Rank 1 areas and areas with elevation between 300 - 1,000 m a.m.s.l.

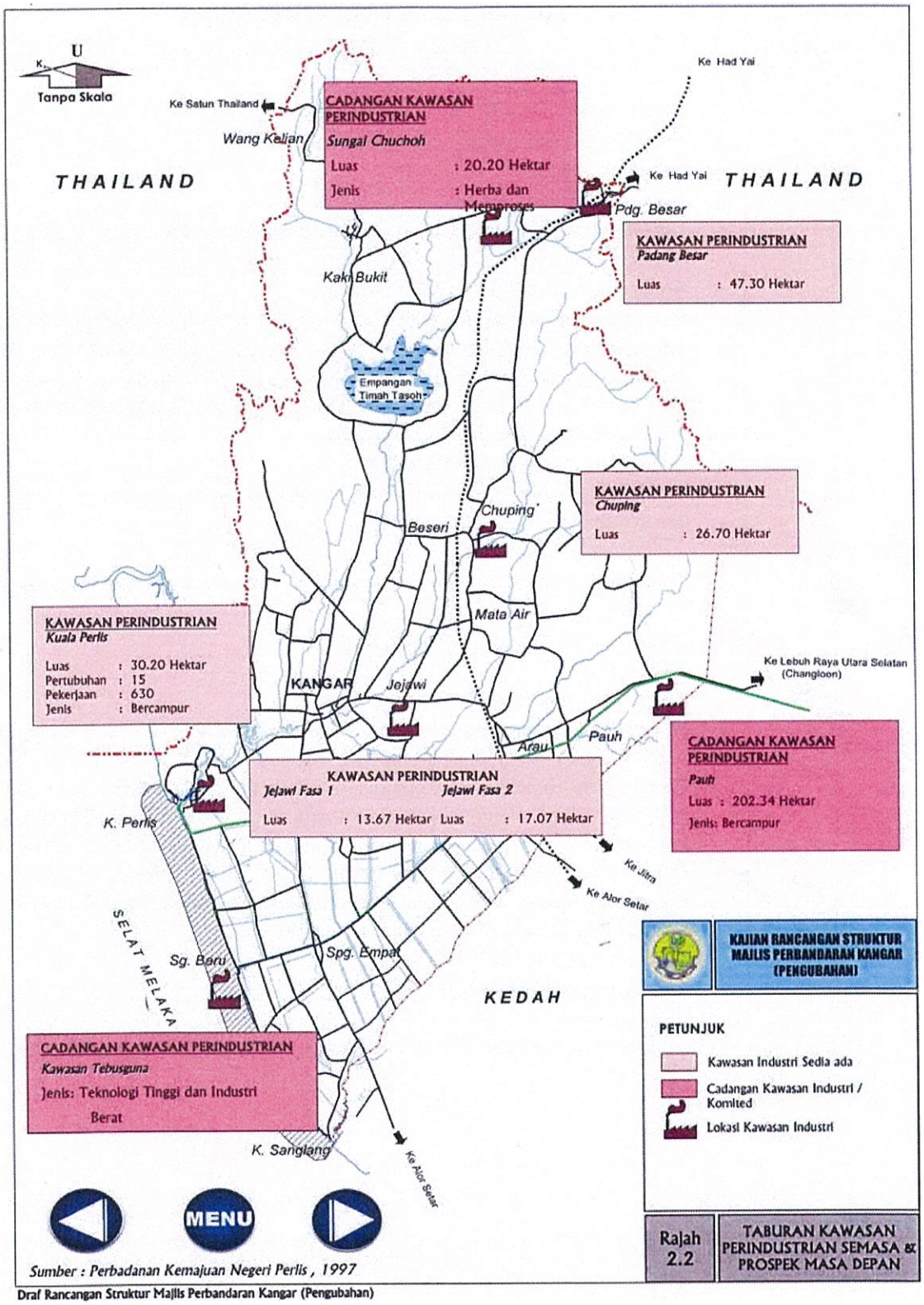
In the third category or ESA Rank 3, only controlled development will be permitted where the type and intensity of the development will be strictly controlled depending on the nature of the constraints. These include all marine park islands, buffer zones around ESA Rank 2 areas, catchment areas for water intakes, areas for ground water extraction (well fields), areas with erosion risk greater than 150 tonnes/ha/year, areas experiencing critical or significant coastal erosion and areas between 150 – 300 m a.m.s.l.

The list of ESAs in Perlis, as provided in the *Laporan Penemuan Rancangan Tempatan Majlis Perbandaran Kangar 2009 – 2020* (JPBD, 2009), has been reproduced in **Table 16.9**. However, it may be noteworthy that there appears little indication of the ranks, size and boundaries of these ESAs, which may lead to future landuse zoning conflicts. Figure 16.5 provides indicative locations of such ESAs in Perlis including other important sensitive areas such as archaeological sites.

Table 16.9 - ESA in the State of Perlis

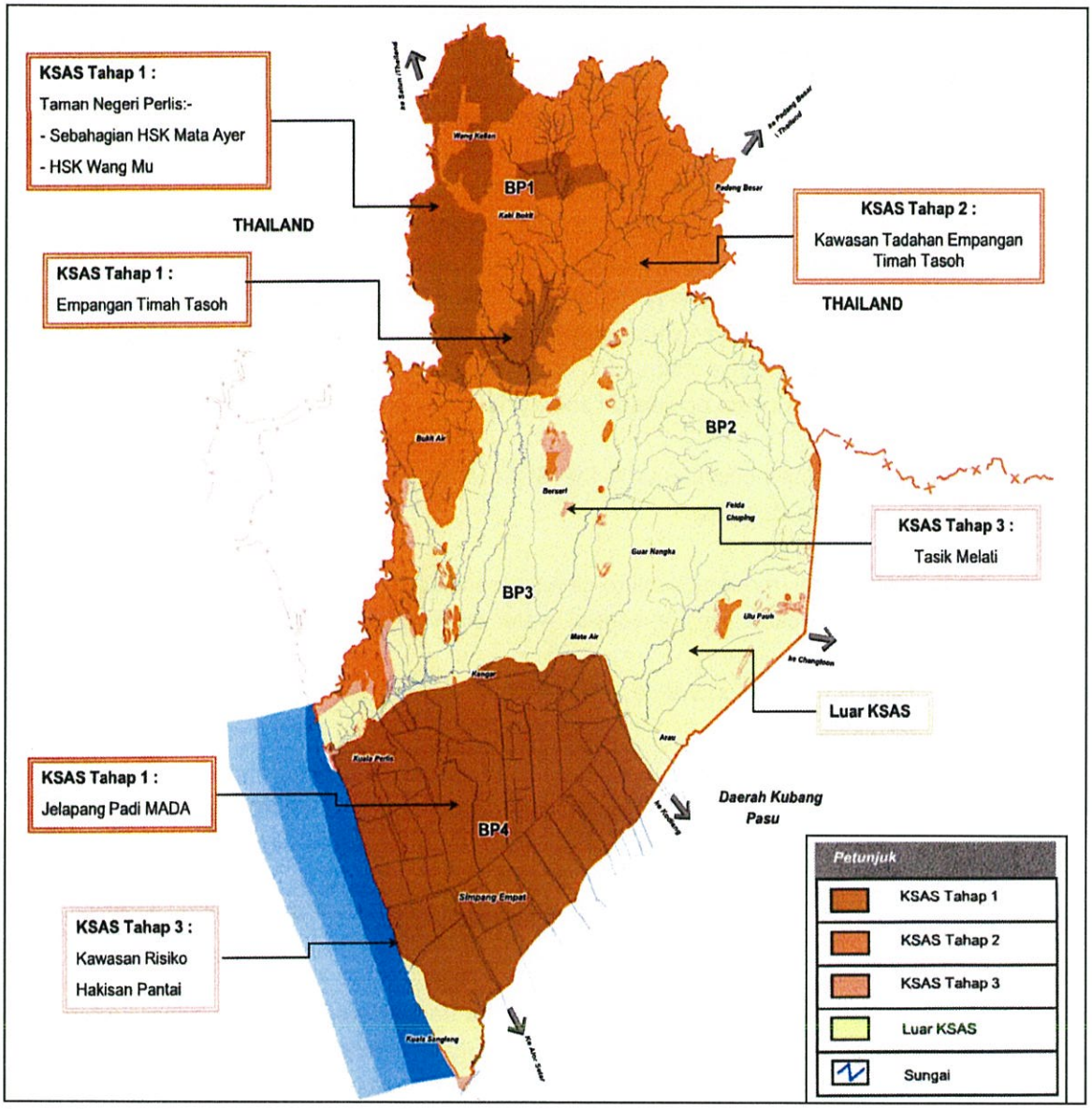
Rank	Environmentally Sensitive Area
1	• Taman Negeri Perlis (HSK Wang Mu, part of HSK Mata Ayer) • Empangan Timah Tasoh • Jelapang padi MADA • Areas with slope > 35° • Limestone caves: Bukit Jernih, Bukit Lagi, Bukit Kubu, Bukit Air
2	• Areas between 300 m – 1,000 m contour • Permanent forest reserves except ESA Rank 1 (HSK Bukit Besi Hangit, HSK Bukit Bintang, HSK Bukit Chabang, HSK Bukit Guar Sami, HSK Bukit Jerneh, HSK Bukit Manek, HSK Bukit Merah, HSK Bukit Merbok, HSK Bukit Namera, HSK Bukit Papan, HSK Tok Seri, HSK Bukit Tung-Tung, HSK Bukit Wang Pisang, HSK Kurong Batang, HSK Rimba Mas-Mas, HSK Tok Panjang). • Buffer zone 300 m around ESA Rank 1 • Catchment areas of Empangan Timah Tasoh (191 km²) • Areas with slope between 25° – 35°
3	• Catchment areas for water intake points and ground water sources of *Skim Perbekalan Air Negeri Perlis* • Areas between 150 m – 300 m contour • Tasik Melati • Areas experiencing critical coastal erosion • Monuments: Gua Kurong Batang (Kangar), Makam Diraja (near Gua Pinang) • Archaeological sites: Bukit Keteri, Kg Pangas, Gua Pufor, Gua Tok Jawa, Gua Bintong, Gua Tempah, Gua Berangin, Gua Tebus, Gua Tok Bulat, Gua Che Din, Gua Haji, Gua Wang Betong, Gua Wang Kunang, Gua Wang Tangga, Gua Wang Pisang, Padang Kota, Sg Arau, Gua Samah, Gua Bentong, Gua Keleding, Gua Tok Kong, Gua Vewah, Bukit Kupang Tiga, Bukit Tengku Lembu, Bukit Junin, Mukim Kurong Batang, Kg Tebing Tinggi, Kampong Nasi Sebungkus, Bukit Batu Hampar. Gua Tahi Kelawar, Bukit Lentas, Gua Beremban, Gua Kelemroi • Areas with erosion risk >150 ton/ha/yr • Areas with slope between 15° – 25° • River reserves

Source: *Laporan Penemuan Rancangan Tempatan Majlis Perbandaran Kangar 2009 – 2020* (JPBD, 2009).
Note: HSK: *Hutan Simpan Kekal*



Source:Rancangan Struktur Majlis Perbandaran Kangar (Pengubahan) 1997 – 2010

Figure 16.4 - Current and Future Industrial Areas in Perlis



Source: *Laporan Penemuan Rancangan Tempatan Majlis Perbandaran Kangar 2009 – 2020* (JPBD, 2009)

Figure 16.5 - ESA in the State of Perlis

16.7 PRIORITY NEEDS OF THE ENVIRONMENT

From an environmental perspective and consequent to the physical, cultural and historical background of Perlis, the environmental needs can be recognised equally alongside domestic, industrial and agricultural demand on water resources. The whole of Perlis can be divided into a number of major ecosystems; namely, the hill and forested ecosystems, the river valleys and riverine ecosystems and the coastal ecosystems. Each of these ecosystems requires water to maintain their natural functions: plants evaporate and transpire water; animals need water to survive; fish and amphibians need water to live in; and wetlands, floodplains and mangroves need water to maintain a natural dynamic diversity of species.

The status and health of these ecosystems provide an indication of the vulnerability and sustainability of water resources in the State. For example, if certain species begin to show signs of decline or excessive population increase not associated with predation or other natural phenomena (normal natural increase rates), this can then be an indication of either water quality or water quantity issues or a combination of both. Variably, the status of ecosystems and biodiversity will provide early indications of the potential environmental concerns particularly if the species or ecosystems are sensitive to environmental change, and more so if the species are robust. If a change is observed in a more robust species, then the concerns on water quality or quantity may be of higher urgency. However, using ecosystems as indicators of water quality/health can only be applied when there is sufficient baseline data outlining the status of various plant and animal populations. This then needs to be supported by continual ecological surveying.

Conservation of the ecosystems in the State is important as they serve and provide many essential functions including:

(i) Regulation (moderate micro-climatic conditions, provide water resources for supply, flood protection, erosion control, water purification, natural pest control);

(ii) Habitat (refuge for wildlife and migratory species, reproduction habitat for harvestable species);

(iii) Production (food, fisheries, raw materials, fertilisers, medicinal resources, ornamental resources such as aquarium fish); and

(iv) Aesthetics/recreation (valued scenery, tourism, cultural and historical value, scientific and educational support).

Although the ecological functions are well-known, ecosystem needs are often prioritised lowly when compared with potable water supply and irrigation needs in most economic planning and decision-making for water resources development and allocations. Most likely, this situation arises because the linkage between ecosystems and water resources is often not fully understood and therefore not adequately appreciated. An appreciation of how ecosystem functions is a logical step in moving towards sustainability as a follow-up from this Study in future.

In Perlis, agriculture, industry and urban areas not only require water resources in large quantities, but they also pollute them in the process, thereby causing devastating impacts on the environment. Agriculture removes a substantial amount of water from the ecosystems' 'water share' through water abstraction and later pollutes it through their return flows. The return flows from urban areas also pollute and degrade the downstream ecosystems through indiscriminate effluent discharges (i.e. sewage, sullage, oil and grease, sediments etc). This is also true in the case of the industrial sector that utilises a substantial amount of water and pollutes the rivers through wastewater discharges. The Timah Tasoh Dam on the other hand affects the downstream ecosystem by changing the water and sediment regimes and obstructing the migratory movements of fishes and amphibians in the river system. In contrast, well-functioning ecosystems can provide many benefits, such as water storage capacities to

sustain and regulate water resources, cleansing of water through wetlands, flood protection capability, and the many economic and business opportunities they endow.

The section below on environmental requirements will profile some of the major ecological resources in the State (i.e. forests, lakes, wetlands, biological resources), to reveal their richness and biodiversity, and to identify areas sensitive to pollution, which affect the overall water resources in the State. It will also elucidate the issues and threats, and the need for conservation of ecosystems and water resources, taking into consideration the physical and socio-cultural background of the State.

16.8 FOREST ECOSYSTEMS

16.8.1 Status and Spatial Coverage

The State is divided into three main physical areas, the coastal alluvial plains, the undulating valleys and the steep hilly areas of the Nakawan Range. The forested area has been logged since 1960s and the remaining forest is categorised as poor quality forest. At the end of 2008, the total forested area in the State was 10,972 ha or about 13.6% of the State's total land area (**Table 16.10**). Out of this total, the permanent reserved forests (PRF) account for 10,586 ha as listed in **Table 16.11** for protection purposes. Besides the PRF, the State kept aside 68 ha and 318 ha of forests for wildlife reserves and Stateland forests, respectively. A map of Perlis on the locations of the PRFs is shown in **Figure 16.6**.

No additional forest reserve was gazetted by the State government in 2008. Instead, a total of 13 ha of PRF was degazetted for other uses. There has since been no new approved project within the forested areas requiring conversion of the same for construction of dams and reservoirs. As of the same year in 2008, the Perlis State Forest Department has identified and gazetted a total of 4,380 ha of PRFs as water catchment forest in the State.

Table 16.10 - Total Forest Areas and Classification of Permanent Reserved Forests in Perlis (2008)

No.	Forest Category & Classification	Area (ha)
1	**Permanent Reserved Forests (PRF)**	**10,586**
1.1	Production Forests	0
1.2	Protection Forests	10,586
	1.2.1 Soil Protection	0
	1.2.2 Soil Reclaimation	0
	1.2.3 Flood Control	0
	1.2.4 Water Catchment	4,380
	1.2.5 Sanctuary for Wildlife	0
	1.2.6 Virgin Jungle Reserves (VJR)	106
	1.2.7 Amenity or Recreational Forests	72
	1.2.8 Education Forests	0
	1.2.9 Research Forests	0
	1.2.10 For Federal Purposes	318
	1.2.11 State Park	5,000
	1.2.12 Unclassified protection forests	710
2	**Wildlife/Other Reserves (outside PRF)**	**68**
3	**Stateland Forests**	**318**
	Total Forested Areas	**10,972**

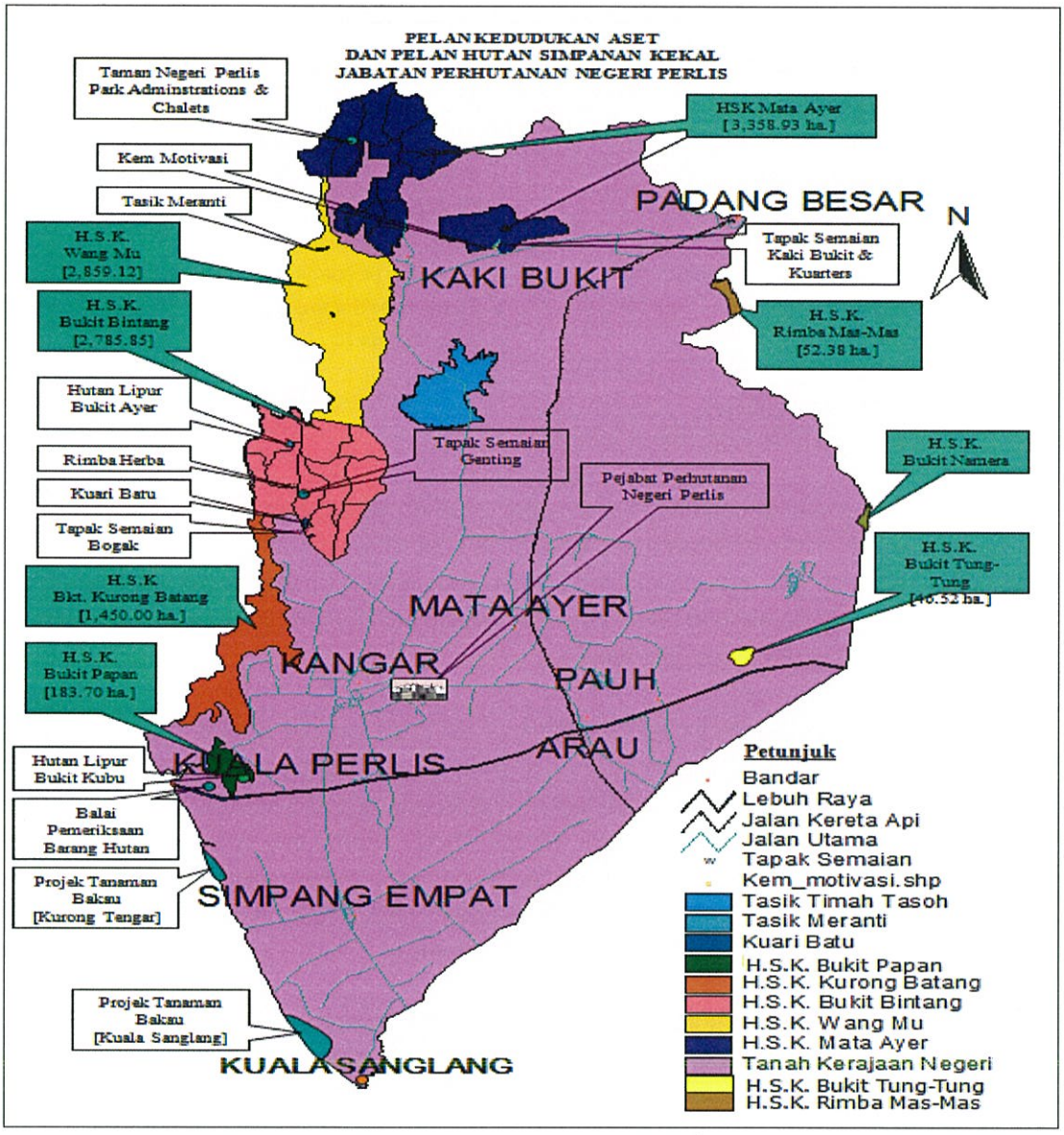
Source: Forest Research Institute Malaysia, 2010

Note: Forest coverage shown in Table 16.10 is some 3,500ha lower than that identified within the State Structure Plan. This is most likely due to a combination of age of data between the two sources, and the way in which forest coverage is defined by the different agencies.

Table 16.11 - List of Permanent and Proposed Reserved Forests (PRF) in Perlis as of 31 December 2008

No	Permanent Reserved Forest	Area (ha)
1.	HS Mata Ayer	3,359
2.	HS Wang Mu	2,859
3.	HS Bukit Bintang	2,786
4.	HS Bukit Kurong Batang	1,450
5.	HS Rimba Mas-Mas	53
6.	HS Bukit Tung-Tung	46
7.	HS Bukit Namera	33
	Total	**10,586**

Source: Jabatan Perhutanan Negeri Perlis, 2009



Source: Jabatan Perhutanan Negeri Perlis, 2009

Figure 16.6 - Forest Areas in Perlis

16.8.2 Ecological Assets

In early 1990s, mammals such as Wild Ox, Sumatran rhinoceros and elephants were roaming within the Perlis State Park (PERHILITAN, 1993). Beruk kentoi (*Macaca arctoides*), the species that was believed to be extinct in Peninsular Malaysia, was found again in the State Park (Sharma, 1992). From the same observation, it was discovered that there were at least 10 mammal orders detected here. In 1993, PERHILITAN made another observation and recorded 8 mammal orders in this same area (**Table 16.12**).

Table 16.12 - Mammals Found in Perlis State Park

Observation by Sharma (1992)	Observation by PERHILITAN (1993)
Rodentia (12 species)	*Rodentia* (8 species)
Scandentia (2 species)	*Scandentia* (1 species)
Insectivora (2 species)	*Insectivora* (1 species)
Dermaptera (1 species)	*Chiroptera* (7 species)
Chiroptera (4 species)	*Perissodactyla* (1 species)
Perissodactyla (3 species)	*Primates* (4 species)
Primates (5 species)	*Carnivora* (3 species)
Pholidota (1 species)	*Artiodactyla* (4 species)
Carnivora (5 species)	
Artiodactyla (3 species)	

Source: PERHILITAN, 1993; Sharma *et al.*, 1992

Scientific research conducted in October 2000 on ecology and biodiversity found at least 10 species of small mammals and 8 species of bats (Shukor, 2002). Among the species found in this research are: ground root rat (*Niviventer cremoriventer*), *cerlah* squirrel (*Sundasciurus tenuis*), black horseshoe bat (*Hipposiderus bicolor*), *benom* bat (*Pipistrellus stenopterus*) and duck wing bat (*Balionycteris malulata*).

Another research conducted by Sharma (1992) discovered a total of 35 species of reptiles from 11 families including 21 species of snakes and 6 species of freshwater tortoises. Among those, 3 species of snake, 4 species of lizards/iguana and 2 species of tortoise were found to be new in the Perlis State Park (**Table 16.13**). From the same research, some wildlife endangered species have also been identified. Among them are kubong (*Cynocephalus* sp.), pangolin (*Manis javanica*), bear (*Helarctos malayanus*), flying red squirrel (*Petaurista petaurista*) and wild goat (*Capricornis sumatrensis*).

Table 16.13 - New Reptiles Species Found in Perlis State Park

Reptile	Species
Snake	*Enhydris plumbea* *Bungarus flaviceps* *Dendrelephis pictus*
Lizard/iguana	*Calotes emma emma* *Draco obscurus* *Gekko gecko* *Gekko monarchus*
Tortoise	*Amyda cartilaginea* *Siebenrockiella crassicollis*

Source: Sharma *et al.*, 2001.

Many flora species from the limestone forest have been recorded in the Perlis State Park (**Table 16.14**). The presence of floral species such as the Slipper Orchid (*Paphiopedilum niveum*) and Large Rattan (*Colaspatha scortechinii*) indicates that the limestone forest is an important wildlife habitat. Several findings that have been recorded within the area such as *Tetrastigma obtectum* (Vitaceae) is new to the Peninsular Malaysia and Perlis, while *Tectaria shahidaniana* is a new finding to science (Faridah-Hanum, 2001).

Table 16.14 - Flora Species in Perlis State Park

Research Areas	Plant Group	Total Record
Tasik Meranti	Bacillariophytes	22
	Bryophytes	74
	Chlorophytes	13
	Chrysophytes	6
	Cyanophytes	10
	Pteridophytes	23
	Pyrrophytes	2
	Spermatophytes	283
Bukit Pelarit	Pteridophytes	8
	Spermatophyte	32
Wang Burma	Pteridophytes	6
	Bryophytes	56
	Pteridophytes	26
	Spermatophyte	40
Kaki Bukit	Pteridophytes	15
Total		**616**

Source: Faridah Hanum, 2001

16.8.3 Important Ecological Site - Perlis State Park

Perlis biological resource locations consist of the Mata Ayer Forest Reserve and Wang Mu Forest Reserve. They both form the Perlis State Park (PSP), which is located on the Nakawan Range bordering with the Thaleban National Park in Thailand (**Figure 16.7**).

According to the Perlis Forestry Department, the total area of PSP is 4,379.81 ha and is situated within the Titi Tinggi and Beseri districts. Nakawan Range is the oldest and longest continuous limestone hill that was created almost 500 million years ago during the Ordovician and Lower Devonian periods. It provides a catchment area for the Timah Tasoh dam at its southwest and supplies natural water resources to the State population.

Geographically, PSP plays an important role in the hydrological cycle, especially because of the arboretum presence there. The water quality here is Class I according to the Department of Environment, Malaysia (Mohd. Kamil *et al,* 2002). The PSP also has a unique forest ecosystem due to its climate and weather conditions and its geographical latitude, which are similar to monsoonal Thailand and Myanmar. The forest types here are classified as Limestone Forest and Lowland Dipterocarp Forest. They provide a stable ecosystem to cater to several special species of flora and fauna's habitats. Among the various habitats that can be found are forest vegetation at the lowland area, limestone area, granolitic hill, wet areas including the surrounding rivers, wetland and freshwater lake (Sharma, 1992). **Table 16.14** lists the flora species that have been recorded from scientific research activities at the PSP area (Faridah-Hanum, 2001). The limestone hills within this area have created the Indo-China and Indo-Malayan unique identities of its own in terms of biodiversity characteristics. The fauna species found shows that the limestones from Setul Formation in Perlis are unique compared to the species that are from other places in Malaysia.

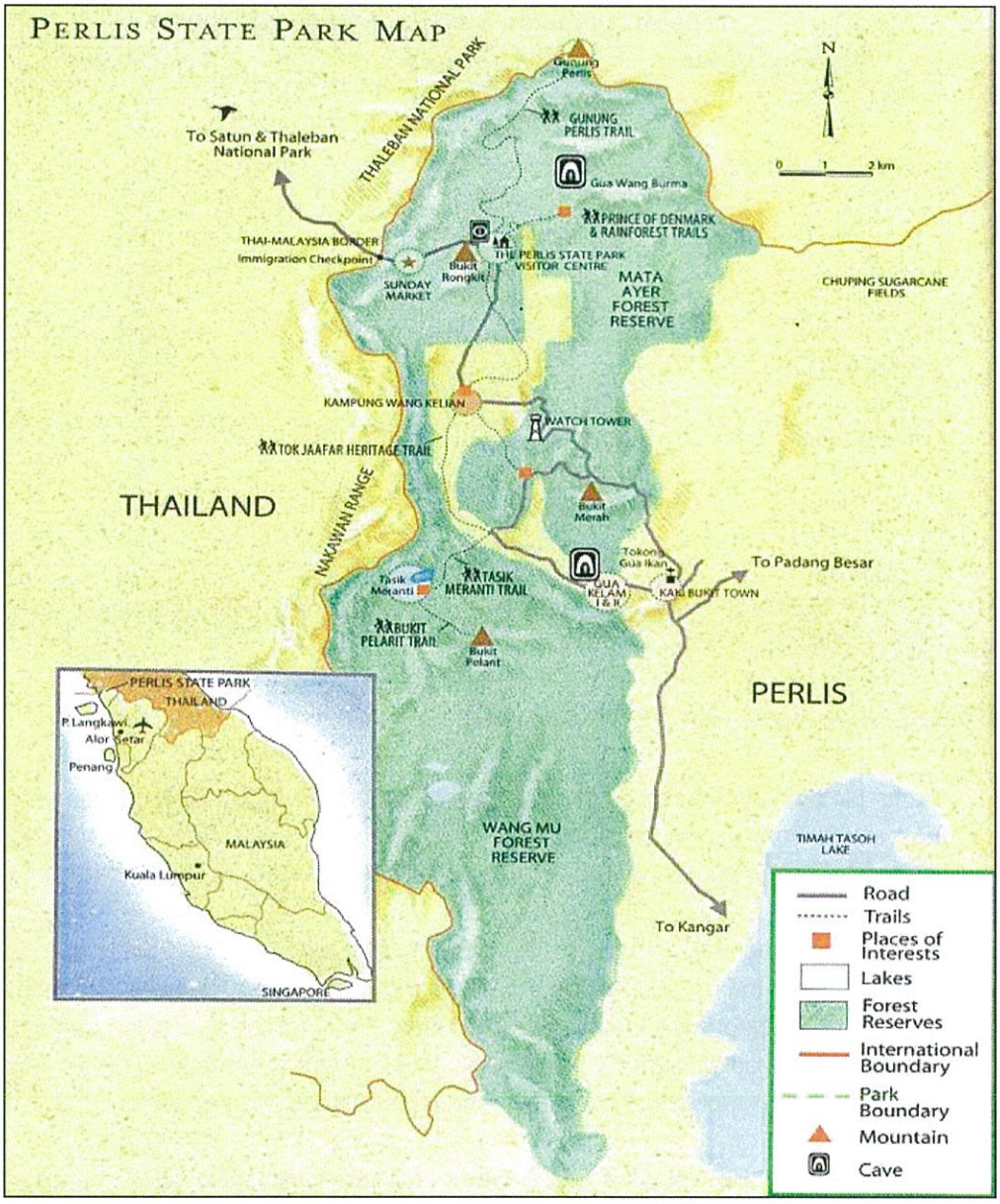


Figure 16.7 - Location of Perlis State Park (PSP)

Bogak (*Cycas clivicola*) is a species of endemic plant found only in this Park, which evolved some 280 million years ago during the Jurassic Age (**Figure 16.8**). It has become one of the significant identities of the Perlis State Park.



Figure 16.8 - Bogak tree (*Cycas clivicola*)

Impacts from human economic activities, in terms of logging and agriculture, have destroyed the once pristine primary forest and replaced by secondary forests such as the Bamboo-Schima Forest and White Meranti-Gerutu Seasonal Forest. These forests are normally found at the northern part of Peninsular Malaysia, which experiences a distinct monsoonal climate. They are unique and are important in terms of ecological and scientific aspect.

16.8.4 Impacts on Water Resources and the Environment

In general, the large spatial coverage of forests, together with the cultivated landuse is a positive point for Perlis in terms of conservation of the natural water resources in the river basin. However, developmental policies and socio-economics in the State dictate that some of the forested areas are to be logged and although this is done on a rotation basis, and following strict enforcements of the logging guidelines put up by the Forestry Department, many impacts are still seen arising from logging activities. Most of the physical impacts are in relation to water and sediment yields affecting the morphology of the river systems and downstream aquatic systems. The major impacts from various studies carried out by FRIM in the country showed that:

(i) Selective logging produces measurable effects on water yield ranging from 70-175 mm per year; the increases in stream flow are proportionate to the amount of forest being removed. The water yield increment tends to reduce after five to seven years following the completion of forest operation. Initial increase in water yield after logging operation largely depends on the amount of rainfall received after the operation.

(ii) Forest conversion to agricultural crops produces greater stream flow increases, up to 800 mm/yr. However after the fifth year, water yield will begin to show a decreasing trend. This reflects the different evaporative characteristics of forest compared to other vegetation. Depending on the magnitude of ground disturbances and method of removal, forest conversion may not necessarily diminish the dry season flow.

(iii) Forest clearance may cause flooding only at local levels and in small watersheds. However, selective logging of up to 40% of standing trees produced no significant effect on peak flow discharges.

(iv) Depending on the extent and location of forest road networks, sediment yield from the road construction may increase by two to ten times. However, the amount of soil erosion from forest roads will reduce drastically after logging operations due to a rapid regeneration and covering up of the exposed surface by undergrowth.

(v) Impairment of water quality through nutrient release from the soil is increasing. Among these are increased Fe, TSS and nutrients occurring immediately after logging or forest clearance.

16.8.5 Conservation Efforts in Forested System

In terms of conservation efforts for forested ecosystems, a major role is played by the Forestry Department and FRIM to create an enabling environment, where the 1977 National Forestry Policy (NFP), the National Forestry Act 1984 (amended 1993) (NFA) and the National Forestry Council (NFC) were put in place. The NFP was revised in 1992 to include aspects of biodiversity conservation and the sustainable utilisation of genetic resources and other environmental issues in forest development. Its key objectives are:

(i) Conserve and manage the nation's forests based on the principles of sustainable management;

(ii) Protect the environment as well as to conserve biological diversity, and enhance research and education;

(iii) In line with the decision of the NFC, State authorities are required to gazette and delineate forest catchment areas in order to protect and conserve sensitive water source areas from future development activities including forest logging;

(iv) The NFA was amended in 1993 to strengthen the provision for safeguarding and protecting the forest resources from encroachment and illegal logging. The penalty for any forest offences was increased from the maximum penalty of RM10,000 or an imprisonment for a term not exceeding three years or both to a maximum penalty of RM500,000 and an imprisonment of at least one year. It also provides for the Police and Armed Forces to undertake surveillance of forestry activities, especially illegal logging, encroachment of forested areas and timber theft.

(v) The National Physical Plan (NPP) maps out the ESAs for Peninsular Malaysia and this applies to Perlis too.

(vi) The Malaysian Criteria and Indicators for Forest Management Certification (MC&I) document is the standards used for assessing forest management practices at Forest Management Unit (FMU) levels for the purpose of certification. It is a result of the collaboration between the Malaysian Timber Certification Council (MTCC) and the

Forest Stewardship Council (FSC). Generally, it addresses the importance of protecting catchments and the hydrological system.

(vii) In Perlis, logging concessionaires have to prepare a Forest Management Plan (FMP) in order to protect the environment, including water resources, which might be impacted on by the forest operations. This includes also the preparation of annual harvesting plans that provide the management of operation procedures to safeguard the environment and hence, water resources. Normally, the FMP is prepared every ten years and supported by an annual operational plan. Guidelines for the preparation of an FMP are specified in the Forestry Manual Vol. III (FDPM, 2005).

16.8.6 Future Conservation Efforts

With increased awareness and recognition of the importance of tropical forests and biodiversity in the global environment, efforts have been made to classify forests and natural areas with unique values or properties in a universally accepted scale. The concept of High Conservation Value Forest (HCVF) Areas has been developed and used to rate areas into 6 High Conservation Value (HCV) classes according to the criteria as shown in **Table 16.15** below.

Table 16.15 - Classes and Criteria of HCVF Areas

Class	Descriptions
HCV1	Globally, regionally or nationally significant concentrations of biodiversity values
HCV2	Globally, regionally or nationally significant large landscape-level forests
HCV3	Forest areas that are in or contain rare, threatened or endangered ecosystems
HCV4	Forest areas that provide basic services of nature in critical situations
HCV5	Forest areas fundamental to meeting the basic needs of local communities
HCV6	Forest areas critical to local communities' traditional cultural identity

Perlis State Forestry Department has not recognised any areas in the State as a HCVF site. However, an endemic species *Canarium perlisanum* can be found in Kaki Bukit, Perlis. This species is listed as vulnerable under category IUCN 2.3 in the 2006 IUCN Red List of Threatened Species. With the existence of this species, the area is eligible as a HCV1 site (WWF-Malaysia, 2010).

In terms of the future conservation efforts for these forested ecosystems, there is a need to adopt, manage and monitor the HCVFs in Perlis in order to comply with Principle 9 in both the FSC and the standards in the Forest Management Certification (MC&I), which is the standard adopted by the National Steering Committee for the certification of natural forests in Malaysia. Some of the guidelines are provided in the *"HCVF Tool Kit for Malaysia: A national guide for identifying, managing and monitoring High Conservation Value Forests"* by WWF (2009).

16.9 LAKES AND WETLANDS ECOSYSTEM

Lakes and wetlands, generally with high water table and location specific, have evolved special and unique ecosystems adapted to the water-related habitats. According to the Department of Statistics and DOA Maps of 2006, the water body landuse for the State of Perlis covers a total area of 1,090.6 ha. However, the NAHRIM Lake Inventory (2009) has indicated that Tasik Timah Tasoh alone already covers an area of 1,338 ha. Therefore, there are some discrepancies in the reports on the spatial coverage of lakes in the State. The term `water body' covers all lakes and wetlands.

16.9.1 Lakes

(i) Registered Lakes

Only two lakes in the State were listed in the NAHRIM Lake Inventory, 2009. They are the man-made Tasik Timah Tasoh and the much smaller natural Tasik Melati (**Table 16.16 and Figure 16.9**). The total surface area of Tasik Timah Tasoh is 13.33km^2 with a volume of 40 Mm^3. Tasik Tasik Melati covers 0.045 km^2 but the volume has not been calculated and reported in any studies thus far, although the depth of its main lake has been reported as 2m (Maisarah et al, 2007).

(ii) Lake Ecology and Assets

Tasik Timah Tasoh was formed from the construction of the Timah Tasoh Dam, which began in 1987 and completed in 1992. It is located at the sub-district of Beseri and Titi Tinggi. The main utilisation of the lake is irrigation, water supply and flood control. The lake is also a source of income for inland fishermen, while the marshes of the lake are a stopover place for migratory birds. It has been reported that from the months of October and November, raptors were seen crossing the Nakawan Range to Sumatra from temperate countries during the northern winter period. The lake has also been identified as a suitable site for aquaculture but farming has been kept to a minimum. Other than that, the lake is also a recreational and famous bird watching site during the months of October till March.

Tasik Melati consists of two main lakes and several sub-lakes. The largest is a natural lake, consisting of natural swamp forest while the smaller lakes are man-made. The lakes also consist of 150 sandbars, which are breeding and foreground areas for birds. Distinct plants in the area, such as the *Alstonia spathulata* trees, are found in the marshy part of the lake ecosystem. Submerged plant species include, the locally named plants, *Lumut Sutera* and *Lumut Ekor Kucing*. The submerged and emergent plants function as pollutant removals that provide services in terms of nutrients cycling, sediment retention, runoff filtration and organic matter transportation. They are also habitat for small fishes. The medicinal *Periuk Kera*, found in the lake, is used by the local people to cure catarrh. The lake is currently being developed by DID to improve its recreational facilities (Maisarah et al, 2007).



Figure 16.9 - Location of Lakes and Wetlands in Perlis

Table 16.16 - Lakes in Perlis

Lake Code	Name	Location	River System	Average Annual Rainfall (mm)	Physical Dimension		Lake Utilisation	Eutrophication Level
					Surface area (km^2)	Volume ($M\ m^3$)		
R02	Tasik Melati	6 ° 47 ' N 100 ° 16 ' E	Sg Perlis	2,000	0.045*	n/a	- Recreation	High
R01	Tasik Timah Tasoh	6 ° 35 ' 4 " N 100 ° 13 '20 " E	Sg Perlis	1,845	13.33	40	- Flood control - Irrigation - Water supply	High
TOTAL					**13.375**	**40**		

Source: Malaysia Lakes Inventory 2009, NAHRIM

Note: * Portal Rasmi Kerajaan Negeri Perlis. Accessed Nov 2010. (http://www.perlis.gov.my/index.php/bm/tarikan/pelancongan/taman-rekreasi-bukit-melati.html)

(iii) Limits on Water Resources

A major constraint in terms of water resources is the quality of the water in the lakes which is reckoned as fair to low. The eutrophication levels of the 2 registered lakes are in the high. For irrigation, this will not be a serious constraint, but for potable supply, advanced treatment of the water will be necessary. For the rich aquatic lifeforms still found in these two lakes, a high level of eutrophication will affect their living, breeding and feeding habitats, and thus their eventual survival.

One of the issues and threats impacting the lake is the polluted surface runoff from the villages, potentially causing an increase in eutrophication and further degradation of the water quality. The nearby paddy fields and use of pesticides are also a concern. Besides that, according to Wan Ruslan (2002), Timah Tasoh is surrounded with many types of landuse activities ranging from urbanisation to agriculture to quarrying. These activities will affect the water quality and present a threat to the ecosystem of the lake.

Tasik Melati faces threats from household and industrial development, which can cause the water quality to degrade further. The development to improve its recreational facilities also poses a loss of habitat and water retention quality of the already small natural peat forest. The unique sandbars of the lake also are under threat by erosion, which can result in the loss of the sandbars and ultimately the presence of migratory birds. Fishing activities is also a disturbance to the lake ecosystem as native fish such as the *ikan tiung* is being wiped out due to the introduction of non-native species such as the carp (Maisarah et al, 2007).

16.9.2 Wetlands

The Malaysian Wetland Directory (1987, PERHILITAN) recorded one wetland site in Perlis, located at Kuala Sanglang (**Table 16.17**). This area is approximately 10 ha now, as opposed to the 100 ha of mangrove forest cover reported in the Directory (Tan C.L, 2005), due to reclamation for aquaculture and paddy fields (**Figure 16.9 and 16.10**).

The wetland which is located at the estuary of Sg Karok Wan Yahya, which borders the State of Kedah, is made up of estuaries, deltas, intertidal mudflats and mangroves. The small wetland area is surrounded by paddy cultivation and is one of the last remaining strands of mangroves in the vicinity of Kuala Perlis. Some 300 species of waders have been recorded since 1986, which consist of the Mangolian Plovers and Curlew Sandpiper. Waterbirds and pond herons have also been spotted at the location (Malaysia Wetlands Directory, 1987, PERHILITAN).

The only mangrove system of Perlis is facing threats from further reclamation for agriculture and aquaculture farming. Most of the inland mangroves ecosystem has already been developed for agriculture and what's left of the then recorded 200 ha (Malaysian Wetland Directory, 1987, PERHILITAN) of wetland in Kuala Sanglang has now been greatly reduced to 10 ha (Tan C.L, 2005).



Source: Google Map, Accessed Sept 2010

Figure 16.10 - Location of Kuala Sanglang Wetland of Perlis

Table 16.17 - List of Wetlands in Perlis

Wetland	Type	Location	Area (ha)	Description
Kuala Sanglang	2,6,7	• Halfway between Kangar, Perlis and Alor Setar Kedah. • Southern tip of Perlis, mouth of Sg Keroh Wan Yahya	490 (half in Perlis, half in Kedah)	• River canalised above estuary, mangrove around estuary mouth with extensive mudflats along adjacent shoreline. • Surroundings are dominated by paddy cultivation.

Source: Malaysian Wetland Directory, 1987, PERHILITAN

Wetland Type Codes

1	Sea bays and straits (under 6 m at low tide)
2	Estuaries, deltas
3	Small offshore islands, islets
4	Rocky sea coasts, sea cliffs
5	Sea beaches (sand, pebbles)
6	Intertidal mudflats, sandflats
7	Mangrove
8	Coastal brackish and saline lagoons and marshes
9	Salt pans (artificial)
10	Aquaculture ponds (a) brackish (b) freshwater
11	Rivers, streams - slow- flowing (lower perennial)
12	Rivers, streams - fast- flowing (upper perennial)
13	Oxbow lakes and riverine marshes (inland drainage systems)
14	Freshwater lakes and associated marshes (lacustrine)
15	Freshwater ponds (under 8 ha), marshes, swamps (palustrine)
16	Salt lakes and saline marshes
17	Water storage reservoirs, dams
18	Seasonally flooded grasslands
19	Paddy field

Wetland Type Codes	
20	Flooded arable land, irrigated land
21	Freshwater swamp forests, temporarily flooded forest
22	Peat bog
23	Peat swamp forest
24	Nipa swamp

16.10 AQUATIC ECOLOGY

Sg Perlis, together with its tributaries, irrigation canals, waterlogged swamps, paddy fields support a rich diversity of fishes. A study in 2000 has produced a list of fish species found in the area (**Table 16.18**). The Department of Fisheries also provided a list of the fish and other aquatic species in Sg Perlis in **Tables 16.19 and 16.20**. These common fishes are not endangered. However, the deterioration of river water quality will have a negative impact on species habitats and their survival, thus threatening their population in the long-term.

Table 16.18 - Freshwater Fish Species Found in Perlis

Common Name	Scientific Name
Bujuk	*Channa lucius*
Haruan	*Channa striatus*
Keli	*Clarias batrachus*
Lee koh	*Cyprinus carpio*
Lampan jawa	*Puntius gonionotus*
Puyu	*Anabas testudineus*
Sebarau	*Hampala microlepidota*
Sepat Siam	*Trichogaster pectoralis*
Sepat Siam	*Trichogaster trichopterus*
Terubul	*Oeteochilus hasselti*
Tilapia	*Tilapia niloticus*
Tilapia Merah	*Tilapia* sp.

Source: SMHB Sdn Bhd, Ranhill Bersekutu Sdn Bhd and Jurutera Perunding Zaaba Sdn Bhd, 2000

Table 16.19 - Fish Species in Sg Perlis

No.	Species
1	Temekong
2	Puyu
3	Haruan
4	Seluang
5	Keli
6	Belida
7	Siakap
8	Lampam Sungai
9	Belanak

Source: Department of Fisheries, 2009

Table 16.20 - Other Aquatic Species in Sg Perlis

No.	Species
1	Udang Harimau
2	Udang Putih
3	Ketam Nipah
4	Siput Belitung

Source: Department of Fisheries, 2009

16.11 OVERALL ECOLOGICAL CONSERVATION STATUS

The bio-ecology of Perlis is host to a variety of terrestrial and aquatic resources of significant importance, which depend heavily on clean and abundant water resources currently available. Over-exploitation of the water resources may lead to serious consequences on these ecological resources, whose conservation is vital.

The Wildlife Conservation Centre at Sg Batu Pahat in Perlis is involved in a breeding programme for ex-situ conservation. The purpose of the programme is to increase the population of wildlife species in captivity. Besides the breeding programme, health-monitoring programmes are also conducted to assist wildlife management in captivity. The species that is currently in the Sg Batu Pahat Conservation Centre are Napuh (*Tragulus napu*), Pelanduk (*Tragulus javanicus*) and Kijang (*Muntiacus muntjac*) (PERHILITAN).

Another notable programme by PERHILITAN, in cooperation with a few NGOs such as WWF and MYCAT, is the Tiger Action Plan (TAC), which is part of the conservation effort to prevent the extinction of tigers.

16.12 COMMERCIAL INLAND FISHERIES AND AQUACULTURE

Commercial inland fisheries and aquaculture require water of acceptable quality as their medium for growth and production. The return flows from these enterprises, however, are often polluted, thus limiting the amount of usable water for potable and recreation purposes. An attempt is made here to assess the aquaculture's demand on the water resources. Marine capture fishery, although contributing a large portion to total food fish production, involves coastal and deep sea fishing, and is unlikely to affect the sea-water quantity or quality significantly. Inland fisheries are also not considered as they contribute only a miniscule quantity to the total fishery production.

16.12.1 Aquaculture Resources

The aquaculture considered here is confined to freshwater and brackish/marine-water farming. These activities draw on the freshwater resources of rivers, lakes, dams, ponds and ground water. The systems of farming are predominantly by pond, with cage and tank cultures used to a much lesser extent. All these forms of aquaculture practices, however, potentially contribute to water pollution.

The Fisheries Department has only one fishery district in this State, based at Kuala Perlis to serve the fishing communities.

16.12.2 Current Aquaculture Production

Perlis produced 521.87 tonnes of aquaculture products in 2008, which rank lowest among the producing States in the country. This is expected due to the size of the State. The production was achieved mainly by pond culture, almost equally contributed by freshwater and brackish/marine-water. Very small amounts were produced under cage, cement and canvas cultures.

Table 16.21 shows the number of aquaculture production units, their total area and production for years 2007 and 2008.

Table 16.21 - Aquaculture Production in 2007 and 2008

	2008			2007		
	No.	Area (ha)	Production (Tonnes)	No.	Area (ha)	Production (Tonnes)
Freshwater						
Ponds	117	26.14	244.08	332	25.27	283.7
Cages	142	1.77	3.2	502	1.47	4.04
Ex-Mining Pools	0	0	0	0	0	0
Cement Tanks	14	0.04	6.23	14	0.06	9.42
Canvas Tanks	190	0.07	0	82	0.05	0
Pen Culture	0	0	0	0	0	0
Sub-Total			**253.51**			**297.16**
Brackish/Marine						
Ponds	12	39.43	252.52	62	39.43	190.88
Cages	1	0.01	15.76	19	0.01	5.68
Tanks	0	0	0	0	0	0
Cockles	0	0	0	0	0	0
Mussels	0	0	0	0	0	0
Oysters	0	0	0	0	0	0
Seaweeds	0	0	0	0	0	0
Sub-Total			**268.27**			**196.56**
Total			**521.78**			**493.72**

Source: Department of Fisheries, 2010

Freshwater ponds produced mostly *keli* or freshwater catfish (57.5%) and red tilapia (40.8%). Cages produced exclusively red tilapia.

The brackish/marine-water ponds produced tiger prawns (80.5%), with *siakap* or barramundi (14.5%) and mud crab making up the rest. The very small amount produced under cage culture was exclusively for mud crabs.

Apart from the normal aquaculture production as described above, the State also produces fish fries and hatchlings (**Table 16.22**) that are necessary and essential to support the aquaculture industry as well as to stock rivers, ponds and lakes. All of these activities place a demand on water. Due to lack of information, the water demand from these minor activities is

not considered further here. Water demand projections will focus only on the primary aquaculture production.

Table 16.22 - Hatcheries Production (no. of individuals) in Perlis, 2007 - 2008

(a) Fish Fries and Hatchlings

Year	Government		Private		Distribution		
	Freshwater	Brackish	Freshwater	Brackish	Public Water	Culturist	Miscellaneous
2008	0	0	3,730,000	0	94,000	210,000	210,000
2007	0	NA	0	0	0	185,844	0

Source: Department of Fisheries, 2010

16.12.3 Water Requirement for Aquaculture

Water is the medium for aquaculture. The quality of the water medium plays a significant role in the growth performance and quality of the aquaculture produce. For intensive aquaculture undertakings, water resources employed should not only be of good quality but of sufficient quantity for frequent flushing and replacement with fresh clean water. Otherwise, the resulting products may be infected with diseases and/or have accumulated heavy metals, and hence be detrimental to consumer health.

Aquaculture in Perlis relies mainly on pond culture. For pond culture to be cost effective, it must be located near a source of water. Water will be pumped into the pond initially to provide the medium for growth and will be pumped out, after harvesting and pond cleaning, to discharge the polluted water. For the duration in between, a continuous supply of fresh clean water is required to replace regularly discharged polluted water. The demand for fresh clean water may therefore be enormous.

To determine the water requirement in aquaculture production, only pond and all forms of tank culture will be considered since future expansion of aquaculture production in the State will most likely use pond and/or tank culture located adjacent to water bodies such as rivers and lakes.

The total area under pond/tank culture in year 2008 is used as the baseline to project growth to year 2050. A growth rate of 1% per annum is assumed, considering the size of the State and its population numbers. **Table 16.23** shows the projected pond/tank area involved in aquaculture production and the water requirement up to year 2050.

Table 16.23 - Projected Area (ha) and Water Requirement (million m^3)

Items	Baseline 2008	2010*[1]	2020	2030	2040	2050
Projected Area (ha)	65.7	72.6	80.2	88.6	97.9	108.1
Water Requirements*[2] (million m^3)	8.5	9.4	10.4	11.5	12.7	14.1

*[1] growth rate of 1.0%

*[2] Assumptions for calculations of water requirements: depth of water in pond/tank to be 1.3m; pond/tank in use for 10 months in the year; and continuous inflow of water to replace initial volume in 30 days.

16.12.4 Issues and Conservation

The moderate to poor quality of water in the rivers of the State is a limiting factor in the growth and expansion of aquaculture production, apart from its small spatial area and population size and hence demands for fishery products.

Aquaculture in the State is limited mainly to pond culture for both freshwater and brackish/marine-water species. The limited cage culture is found mainly in the Tasik Timah Tasoh with very little found elsewhere. At the moment, there is no water quality standard set up particularly for aquaculture farming. An important water quality requirement should be that the water be free from disease-causing pathogens and other microorganisms.

16.13 RECREATION AND TOURISM

Many recreation and tourism activities are water-related, using water and at the same time polluting it. Tourists are very sensitive to water quality, and therefore tourism and recreational sites found besides rivers, lakes, on islands and at the coast, will need to preserve the water quality. Generally, as the water quality of these sites deteriorates, so will the number of tourist arrivals.

Poor and deteriorating water quality in tourism areas could be due to a number of factors, chief among which are activities and developments in and around the sites. Demand for water by tourism and recreational activities come from direct consumption of potable water by tourists and from the need to have clean raw water for tourist sites to operate satisfactorily.

16.13.1 Tourist Consumption

Tourist water consumption obviously depends on the number of tourists. The local tourist consumption would have already been accounted for under the domestic water demand since this is derived from per capita consumption. (see Volume 3 on Water Demand). However, the foreign tourist demand, being an additional demand, is estimated here.

While total tourist arrivals can be obtained for the country as a whole through the various immigration gateways, the individual State arrivals are not readily available. For estimation purpose, the basis adopted is to proportion the national total tourist arrivals to each State according to its available hotel/resort rooms in 2008. Thus, the weight for Perlis is 630/165,739 or 0.004 (630 rooms out of the national total of 165,739). **Table 16.24** provides the individual State hotel rooms for 2008 with which to derive their weights.

Table 16.24 – No. of Hotel Rooms in 2008 by State

State	2008	
	No. Hotels	No. Rooms
FT KL	233	29,730
FT Labuan	25	1,452
FT Putrajaya	5	1,198
Selangor	135	13,386
Perak	181	8,823
Pulau Pinang	126	12,345
Kedah	142	10,271
Perlis	**15**	**630**
Kelantan	81	3,682
Terengganu	157	7,005
Pahang	292	22,337
Johor	265	14,135
Melaka	121	8,046
Negeri Sembilan	87	8,035
Sabah	232	12,383
Sarawak	276	12,281
Total	**2,373**	**165,739**

Table 16.25 presents the projected national total tourist arrivals for 2010 to 2050 in increments of 10 years using the assumed growth rates. The Perlis arrivals are then obtained using the derived weight.

Table 16.25 - Perlis Tourist Arrivals Projected for 2010 to 2050

Items/Year	2010	2020	2030	2040	2050
Assumed Growth Rate (%)	7.5	5.5	3.5	1.5	-
National Tourist Arrivals (million)	24.6	50.7	86.6	122.2	141.8
Arrivals for Perlis (million)	**0.1**	**0.2**	**0.3**	**0.5**	**0.6**

With the derived tourist arrivals and applying the same assumptions as in the national case for average stay and water consumption per tourist per day, the projected water demand per annum over the period are presented in **Table 16.26**.

Table 16.26 - Projected Annual Water Demand by Foreign Visitors to Perlis, 2010-2050

Items/ Year	2010	2020	2030	2040	2050
Tourist Arrivals (millions)	0.1	0.2	0.3	0.5	0.6
Average stay (days)	8.7	9.0	9.5	10.0	10.5
Water Consumption (litres/day)	150	120	110	100	100
Projected Water Demand (m^3)	**130.5**	**216.0**	**313.5**	**500.0**	**630**

16.13.2 Water-Related Tourism Sites

All water-related tourism and recreational sites such as natural and eco-tourism parks, water theme parks, islands, lakes and beaches, require adequate, free-flowing, clean raw water for operational efficiency and sustainability. Generally, water quantity is not a critical factor for most sites. However, seasonal rainfalls bearing too much rain or too low rainfall causing droughts, may deter tourist arrivals. Poor water quality of these water bodies, on the other hand, will definitely discourage the "pull factor" to these sites.

16.14 WATER QUALITY AND POLLUTION

Water pollution is a reflection of the negative consequences of the above activities on the environment. This section provides a summary review of the current water quality status of the major rivers in the State wherever there are available data. Two sets of river water quality data were obtained: data from the Department of Environment (DOE), which was benchmarked against the Malaysian National Water Quality Standards (NWQS), and raw water quality data from the Ministry of Health based on the National Standard for Drinking Water Quality.

The assessment will provide an indication of the level of pollution in the river system where most of the current water resource is derived from for various potable uses. Contamination of the ground water will not be assessed here as there is limited information on the ground water quality, although it is known that contamination by leachates from non-sanitary landfill is a problem. Industrial chemicals are also known to leak and contaminate the soils and ground water especially when they are not properly contained and stored in storage facilities. All these will have an impact on the water resources in the river system.

16.14.1 River Water Quality Assessment based on WQI

DOE started its river water quality monitoring programme in 1978 to establish baselines and to detect changes in river water quality for enforcement purposes. The monitoring stations are usually located downstream of known pollution sources (e.g. industries, major towns, rubber and oil palm plantations, sewage treatment plants etc.). Other stations are positioned to provide baseline or ambient water quality data.

DOE used to maintain a total of nine water quality monitoring stations in Perlis (**Figure 16.3**). However, the monitoring programme at Sg Arau and Sg Peralit was discontinued in 2006 while that at Sg Tasoh has been discontinued in 2008. In 2010, monitoring at three more stations - Sg Serai, Sg Kok Mak and Sg Jernih – were discontinued.

The water quality trend analysis presented in this section is based on the WQI values published in the Malaysia Environmental Quality Report (EQR) 2003 – 2008 (**Table 16.27**).

Table 16.27 - WQI of Rivers in Perlis (2003 – 2008)

State	River Basin	River	WQI					
			2003	2004	2005	2006	2007	2008
Perlis	Perlis	Arau	74	67	62	-	-	-
		Jarum	82	81	81	84	77	83
		Jernih	74	76	77	85	81	87
		Kok Mak	80	79	72	80	68	73
		Ngulang	72	82	76	82	80	76
		Pelarit	89	88	89	91	90	92
		Peralit	-	-	87	-	-	-
		Perlis	67	71	65	68	72	71
		Serai	79	84	78	82	80	78
		Tasoh	80	79	79	93	91	-
		Wang Kelian	-	-	93	93	91	93

Note:
- denotes no information / data

An automated water quality station has been installed at the Timah Tasoh Dam by DID Perlis in January 2009. The WQI is found to fluctuate between Classes II and III for the Timah Tasoh Lake water from then to April 2010. However, the total suspended sediment (TSS) remains high; between Class III and IV levels. The Timah Tasoh Lake is still acceptable as a tourism and recreation site and also for aquaculture farming.

According to DOE Water Quality Monitoring information for 2008, most of the rivers in the State are considered slightly polluted (Class II and III). These rivers identified are Sg Perlis, Serai, Ngulang, Kok Mak and Jarum, all within the Sg Perlis Basin. The causes of pollution can be traced to urbanisation and agricultural production. **Table 16.28** provides the water quality status and major pollutants in the Perlis Basin (see also **Figure 16.11**).

Table 16.28 - Water Quality Status of Sg Perlis Basin in Perlis

Item	River Basin	Description
1.	Perlis Basin	• The water quality for the Perlis Basin was good from 2003-2008 and fell under Class II status except at the more urbanised areas of Kangar, which indicated reduced water quality of Class III. • The results indicate that the pollution sources affecting the quality of water in these rivers are mainly domestic waste discharges from urban areas. • Inadequate treated sewage with high loading has resulted in the degradation of water quality in the rivers. The sugar mills in the upstream reaches of Sg Perlis have also contributed to reduced river water quality. • It is anticipated that with future urbanisation in the State (i.e. Kangar, Arau, Padang Besar and Ulu Pauh), the water quality could further deteriorate. • A pollution control plan for Perlis is essential to ensure the maintenance or improvement of water quality for future use.

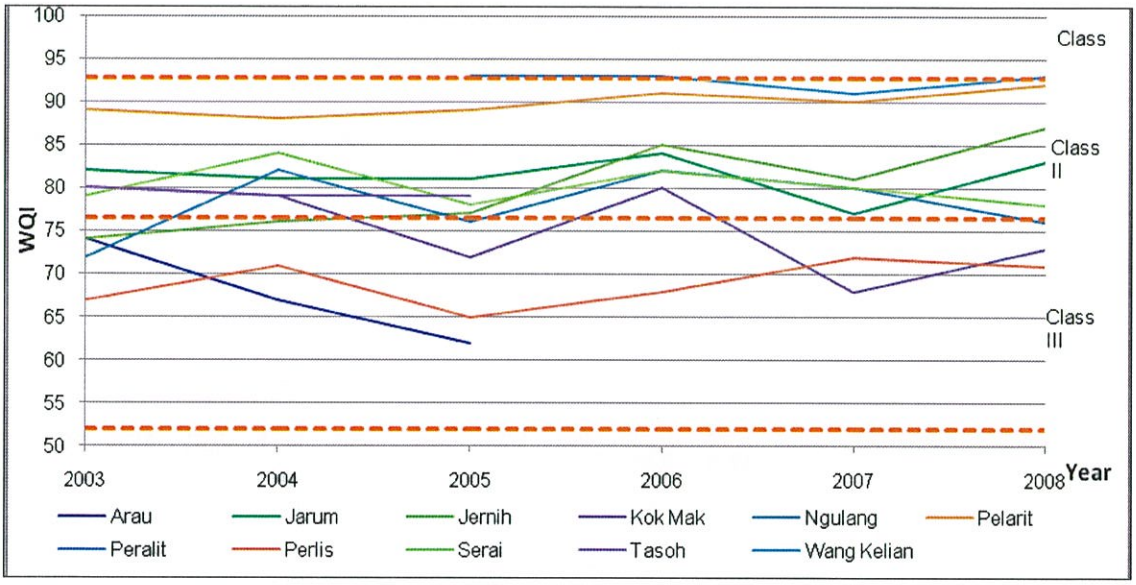


Figure 16.11 - WQI Trends for the Perlis Basin (2003- 2008)

16.14.2 Raw Water Quality Assessment at the Water Abstraction Areas

The Ministry of Health (MOH) administers the National Drinking Water Quality Surveillance Programme (NDWQSP) to ensure the safety and acceptability of drinking water for consumers. This is achieved by reducing the incidence of water-borne communicable diseases, or intoxication of water supplies through effective and long-term surveillance. MOH collects raw water samples at every potable water intake location. The National Standard for Drinking Water Quality prepared by the Engineering Services Division of MOH (MOH, 2004) is the guideline used under the NDWQSP. The standards are different for the raw water abstracted and the treated drinking water.

Raw water quality data over a 12-year period from 1998 to 2009 was requested from MOH for all potable water intake locations in the State. The assessment of the MOH data will provide the percentage of compliance for selected parameters at the water abstraction points. The water quality parameters chosen in this assessment are total coliform, turbidity, BOD, COD, ammonia, nitrate and mercury, based on their general importance in a monitoring programme for drinking water sources as described in Chapman (1992)[2].

The MOH results are shown graphically in **Figures 16.12 – 16.18**. The analyses of MOH data for six water intake points and six water supply schemes in Perlis indicate that the total coliforms in the raw water always exceed the benchmark of 5,000 MPN/100mL (**Figure 16.12**).

Coliform bacteria enter water through poor wastewater management or poor handling of manures, slurry and other farm wastes. Between 5.88% and 57.14% of the samples showed high levels of COD, exceeding the MOH acceptable limit (**Figure 16.15**). Even though BOD

2 Chapman, D. (ed), 1992. *Water Quality Assessments*. Cambridge, UK: Chapman and Hall.

and ammonia levels have exceeded the benchmark values in certain years, their percentage was quite low (**Figure 16.14 and Figure 16.16**).

Zero contaminations (100% compliance) were recorded for both turbidity and **nitrate (Figure 16.13 and Figure 16.17**). High mercury levels were found in 2004, 2005 and 2007 (**Figure 16.18**). Mercury is a naturally occurring element in the earth's crust. Human activity has increased the amount of mercury in the environment through a variety of combustion and industrial processes. Besides, mercury can also leach from flooded area.

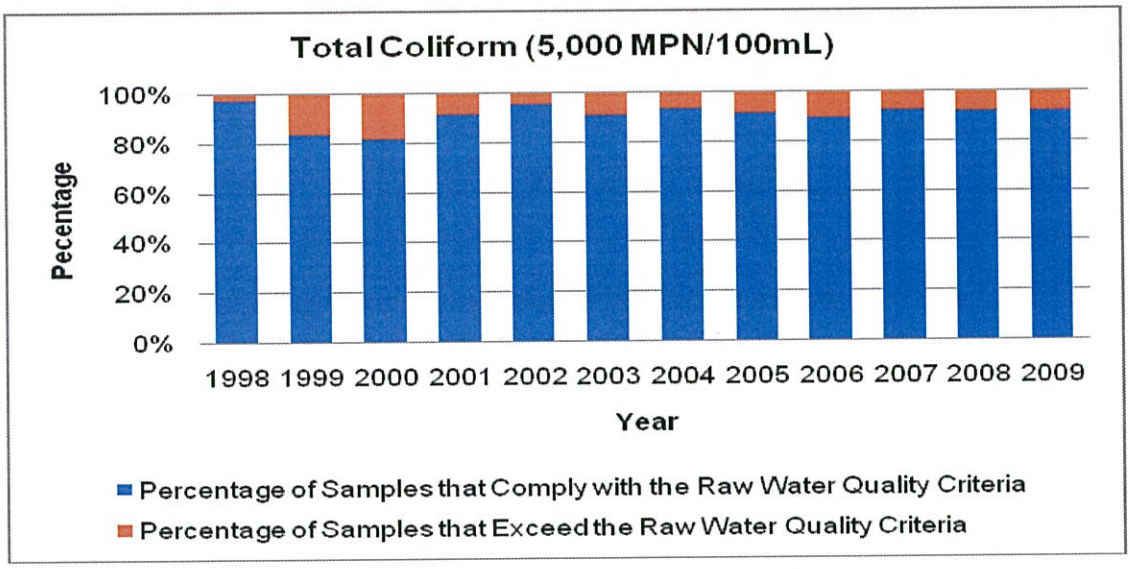


Figure 16.12 - Percentage of Samples that Comply/Exceed the Benchmark for Total Coliform (1998 - 2009)

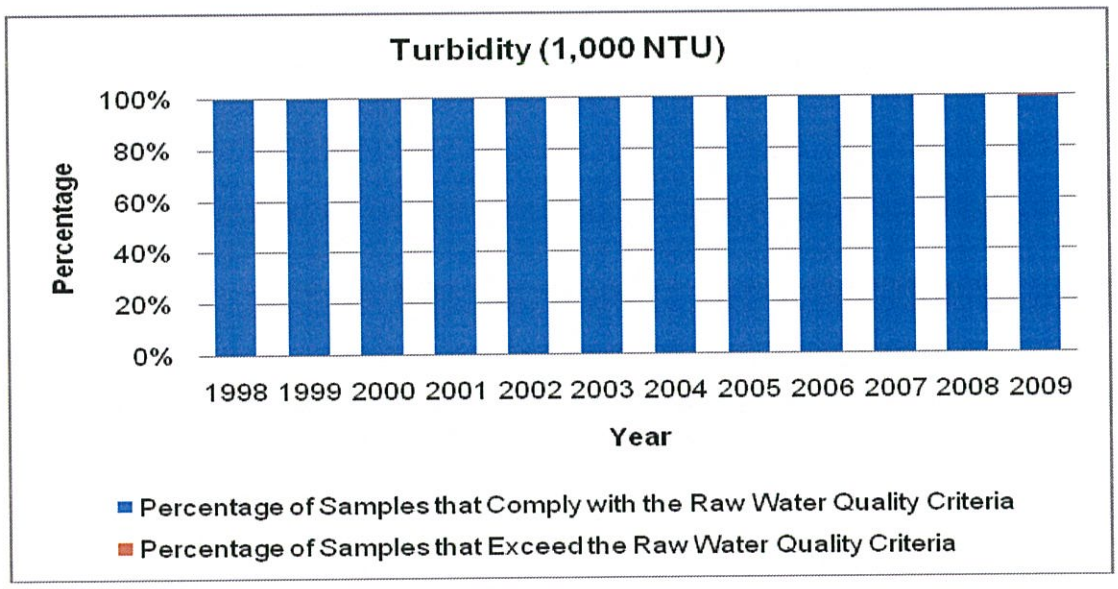


Figure 16.13 - Percentage of Samples that Comply/Exceed the Benchmark for Turbidity (1998 – 2009)

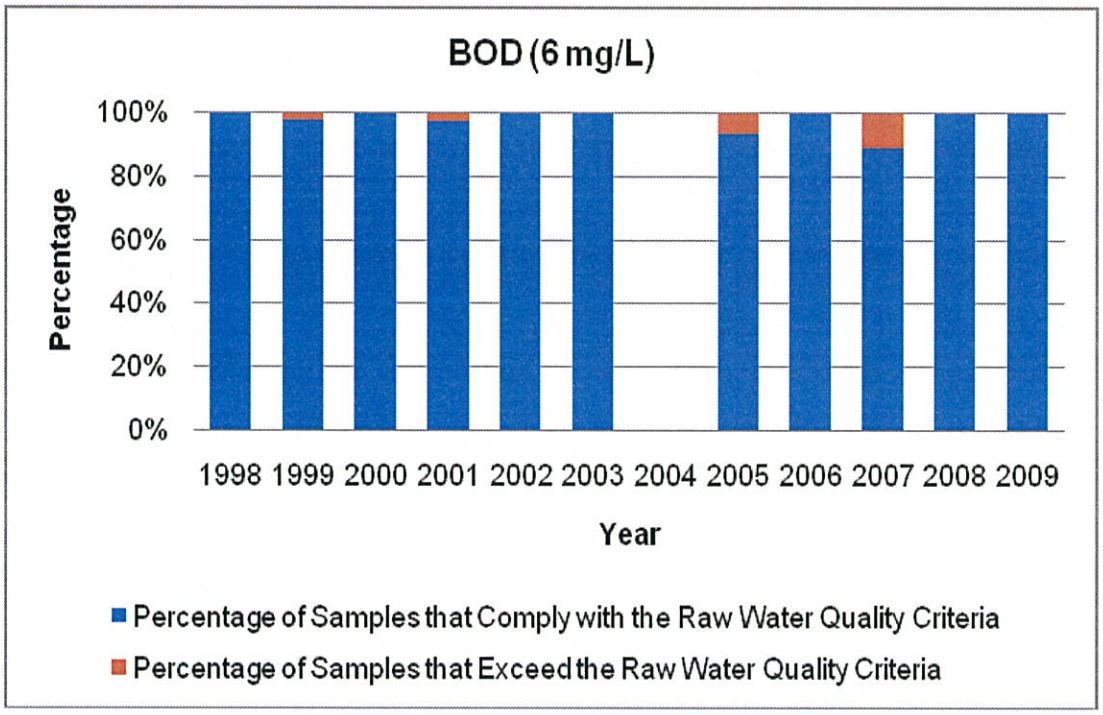


Figure 16.14 - Percentage of Samples that Comply/Exceed the Benchmark for BOD (1998-2009)

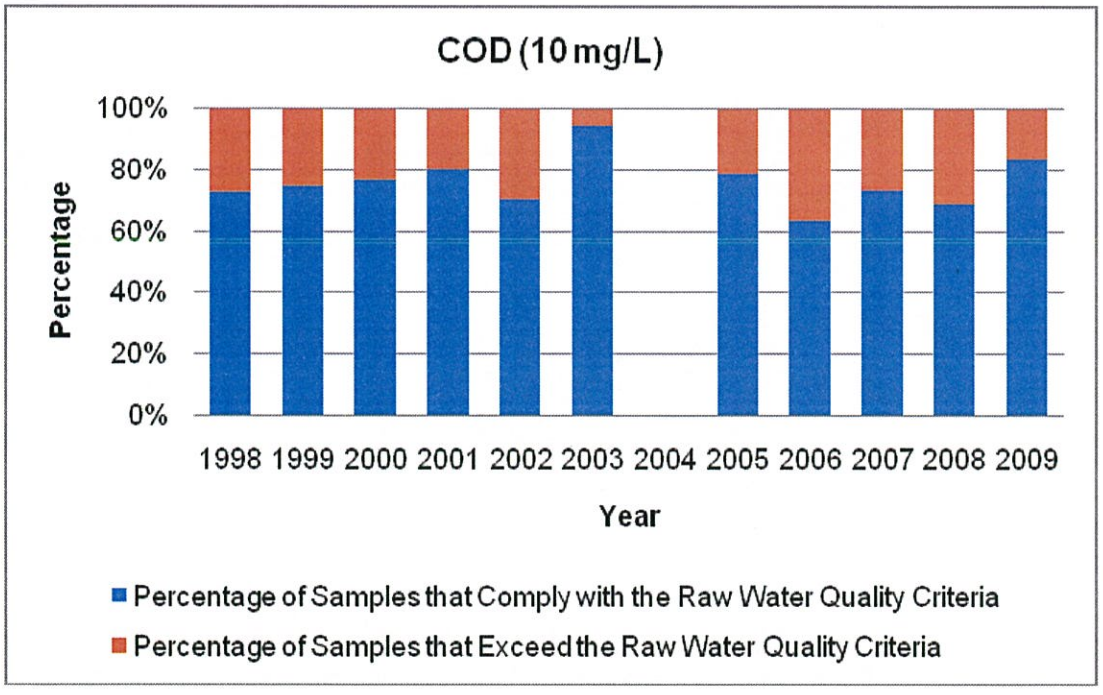


Figure 16.15 - Percentage of Samples that Comply/Exceed the Benchmark for COD (1998 – 2009)

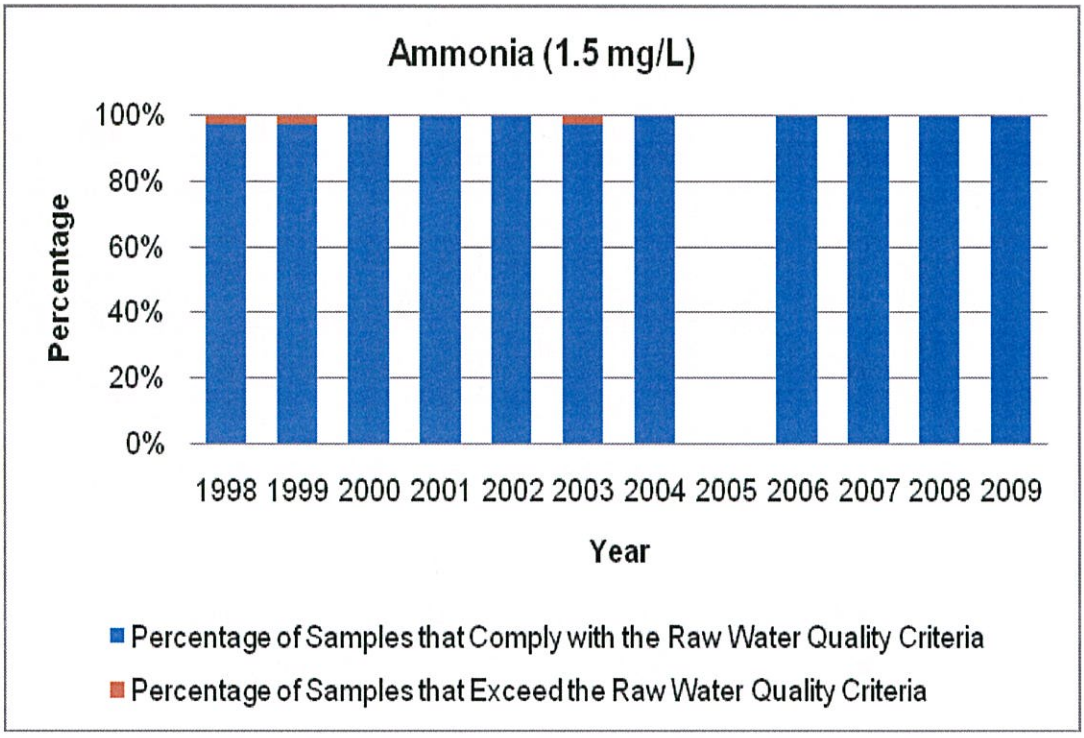


Figure 16.16 - Percentage of Samples that Comply/Exceed the Benchmark for Ammonia (1998 – 2009)

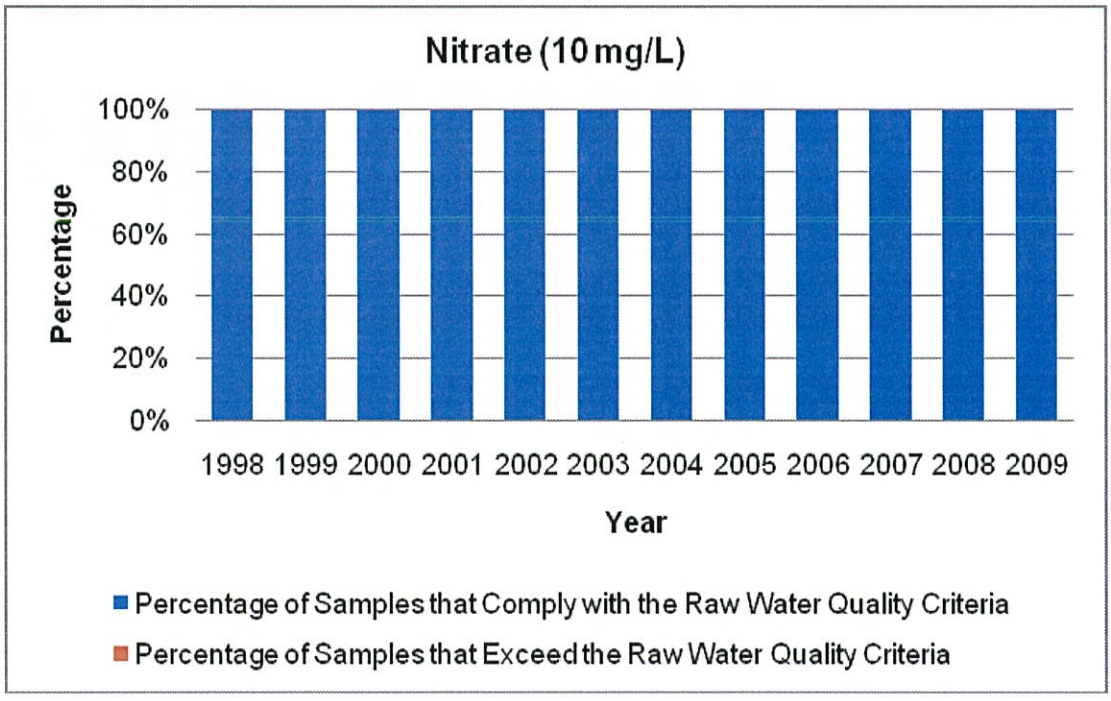


Figure 16.17 - Percentage of Samples that Comply/Exceed the Benchmark for Nitrate (1998 – 2009)

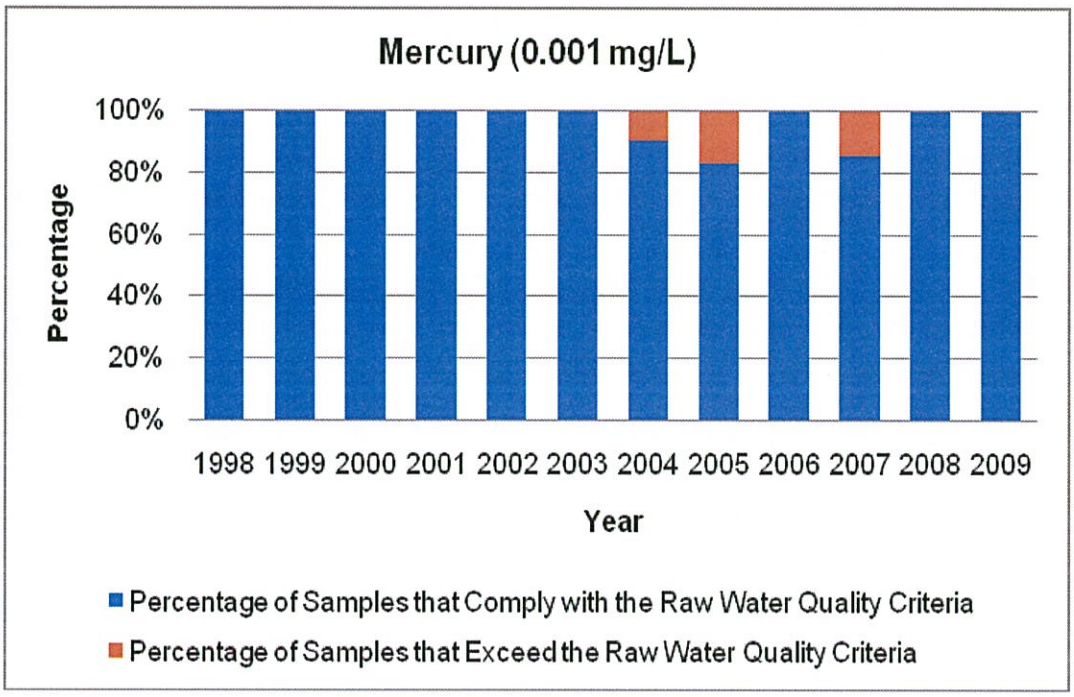


Figure 16.18 - Percentage of Samples that Comply/Exceed the4 Benchmark for Mercury (1998 – 2009)

16.15 CONTRIBUTION FROM SEWAGE

One of the main limiting factors in the water bodies is pollution of water from a number of sources, which include sewage from population and livestock, and wastewater from industries and agriculture.

Sewage in large quantities, untreated or partially treated, will contribute to water pollution in the rivers, and is an important limiting water resource use factor. The sewerage services for most part of the State are rendered by Indah Water Konsortium (IWK), which is now undertaking a rationalisation programme to effectively manage the services. Approximately, 17.7% of Perlis is served by connected services, while ISTs served 30.90% and 51.4% via pour flush systems.

Table 16.18 shows the estimated pollution load (BOD, COD, AN, and TSS) from both IWK and non-IWK sewage treatment facilities. Pollution loads were estimated using total PE of existing plants, measured effluent flow rate and acceptable sewage discharge at Standard B of the Environmental Quality (Sewage) Regulations 2009 of the EQA (1974)

The BOD sewage loads were estimated to be 199 kg/d for IWK plants and 234 kg/d for non-IWK plants. In general, the non-IWK plants would produce loads higher than those from the IWK plants. This is because the non-IWK sewage treatment facilities such as septic tanks may not be able to achieve discharges of even Standard B due to their treatment inefficiencies. Hence, the loadings could actually be higher. However, the estimates in **Table 16.29** serve only as an indication of the potential loadings from the sewage facilities. Actual

data from both the IWK and Non-IWK plants, if available, would serve to provide a better analysis.

Table 16.29 - Total Sewage Loads in Perlis

Facilities	Total PE	No	Standard B Concentration (mg/L)				Effluent Flow Rate (L/d)	Pollutions Load (kg/d)			
			BOD	COD	AN	TSS		BOD	COD	AN	TSS
IWK	17,726	37	50	200	20	100	3,988,350	199	798	80	399
Non-IWK	20,758	416	50	200	20	100	4,670,550	234	934	93	467
Total								433	1,732	173	866

All sewage treatment facilities ranging from the public and private STPs to the less sophisticated septic tanks and pour flush systems can produce large amounts of sludge. Sludge is an active organic compound which can rapidly turn septic if left untreated. Untreated sludge is a significant environmental and public health hazard. However, treated and stabilised sludge has been professed to be inert, stable and safe to use, and many parties in the sewage treatment industry would prefer to utilise treated sludge as a soil conditioner before considering for disposal in a landfill. Facilities to treat and dispose of this sludge are limited. Currently, sewage treatment plants with excess capacity are being used to treat septic tank sludge, and many new sludge treatment and disposal facilities will be needed to manage the large volumes currently being generated.

IWK's preferred solution to sludge management is to construct sludge lagoons that will serve as sludge holding and treatment facilities. These are ideal for short-term use in urban areas as well as long-term use in semi-rural areas. However, for long-term use in urban areas, sludge settling tanks and digesters are required, such as at the Pantai Sewage Treatment Plant in FT Kuala Lumpur.

In the State of Perlis, the estimated sludge generated by public STPs is 5,315 tonne/year whilst those generated by CST, IT and IST facilities contributed to approximately 8,867 tonne/year in 2006. This relates to a contribution of approximately 23% of the total annual solid waste generated by the population of Perlis.

A critical issue is the transport distance from sewage treatment plants to landfills for disposal of sludge, which can often be quite far for some locations. As a result, the sludge disposal procedures tend to be compromised due to the economics of haulage and disposal. Ultimately, the sludge has to be disposed off properly in a landfill or a designated disposal facility. In Perlis, there is no indication as to the designated site for disposal of treated sewage sludge.

Apart from human sewage, animal husbandry is also an important source of water pollution through release of untreated animal waste into the water courses. Animal husbandry has been covered in Section 9, which includes the statistics on water demand. Unfortunately, impacts from such activities on water pollution have not been given due attention in many studies except perhaps for hog farming. The annual report from the Department of Veterinary Services (DVS) focused mainly on disease prevention, meat quality and economic outputs.

Good Animal Husbandry Practice (GAHP) should be implemented to protect the environment and to prevent water pollution. Despite the existence of such a practice, there are no indications of water quality monitoring data or results from DVS Perlis for livestock farms in Perlis. There are also currently no standards for compliance of effluent discharges from livestock farms.

In 1987, the *Enakmen Pengawalan Penternakan Babi* (Control of Pig Farming Enactment) was established in Perlis. This enactment however, was not available for referencing. Hence, reference is made to a similar enactment in Perak, ie. the Perak Control of Pig Farming Enactment 1992 where issues pertaining to the control of water quality of nearby water resources are addressed. For example in Part VI (21), it states that the waste of hog farms cannot be discharged or disposed in:

(i) River, lake or sea
(ii) Public drain
(iii) Pool or pond or land situated outside the boundaries of his pig farm
(iv) Road
(v) Alienated land
(vi) State land
(vii) Reserved inland
(viii) Permanent reserved forest

Any person found discharging the waste into any of these water sources will be penalized accordingly. In addition to that, the Department of Veterinary Services of Malaysia has stated that all discharge from hog farms in the country must ideally comply with the Standard B BOD level, which is 50 mg/L.

16.16 CONTRIBUTIONS FROM SOLID WASTE

Solid waste is generated in all villages and urban areas. In the villages, solid waste is usually dumped illegally into the rivers, by the road side or burnt in their compounds. It poses a problem when it is dumped into the river system causing water pollution, blockages to the flow of river water and localised flooding. Systematic collection of solid waste is mostly carried out in the main urban centres, while high-dense urban and commercial areas in smaller towns generate most of the balance. When the solid waste is dumped in the landfills, which are mainly non-sanitary ones, the leachates from the decomposed solid wastes will contaminate the surface and ground water. The current waste generation rate is shown in **Table 16.30** and the assumptions used to derive these are given in **Figure 16.19**.

Table 16.30 - Waste Generation Rate for Perlis

State	Population (million)	Waste Generation (kg/cap/day)	Waste Generation (tonnage per day)
Perlis	0.25	0.68	170

Source: National Strategic Plan for Solid Waste Management, MHLG

Waste Generation

The waste generation rate being adopted for every State in Year 2002 is shown in following table:

States	LA Township (Urban)	LA Non-Township (Urban)	LA Non-Township (Rural)	Outside LA (Rural)
Perlis	1.0	0.5	0.5	0.3
Kedah	1.2	0.7	0.5	0.3
P. Pinang	1.5	0.7	0.5	0.3
Perak	1.2	0.7	0.5	0.3
Selangor	1.5	0.7	0.5	0.3
W.P. Kuala Lumpur	1.6	0.7	0.5	0.3
W.P. Putrajaya	1.6	0.7	0.5	0.3
Kelantan	1.0	0.5	0.5	0.3
Terengganu	1.0	0.5	0.5	0.3
Pahang	1.0	0.5	0.5	0.3
N. Sembilan	1.2	0.7	0.5	0.3
Melaka	1.2	0.7	0.5	0.3
Johor	1.5	0.7	0.5	0.3

The projection of waste generation rate from Year 2002 to Year 2020 is assuming 1% increase in every year considering higher per capita income and thus higher purchasing power.

Source: National Strategic Plan for Solid Waste Management (August 2005)

Figure 16.19 - Assumptions Used in Waste Generation Projection

The total number of listed landfills in Perlis (refer **Table 16.31**) is 3 (ref. JPSPN, 2009) and all of them are non-sanitary landfills (Level I and II).

Table 16.31 – List of Landfills in Perlis, 2009

State	Total Operational Landfills		Total Closed Landfills		Total
	Sanitary (Level IV)	Non-Sanitary (Level I – III)	Sanitary (Level IV)	Non-Sanitary (Level I – III)	
Perlis	-	1	-	1	2

Source: Jabatan Pengurusan Sisa Pepejal Negara, Sept 2009

16.16.1 Impacts on Water Resources

As all the landfills are non-sanitary ones in Perlis, the leachates from them will pose a threat to the surface water resources and when it infiltrates into the surrounding soil, it will contaminate the ground water. Taking into account the older landfills sited near rivers, the landfilling methods (open dumping and earth cover) and the occurrences of illegal dumping, solid waste will pose a serious water problem that should not be overlooked in water resource management. Landfills located upstream of water intake points need to be monitored more closely due to potential contamination by organic and inorganic matters and their effects on human health. **Figure 16.18** shows the distribution of landfills that are located above water intake points. The list of unsanitary landfills in Perlis is tabulated in **Table 16.32**.

Table 16.32 - Location of Listed Landfills in Perlis

No.	Local Authorities	Site Name	Address	Site Area (ha)	Type of Disposal Site	Status
1	MP Kangar	TP Kuala Perlis	Jalan Wai, Jln Bukit Kubu, 02000, Kuala Perlis	3.0	Non-Sanitary Landfill	Operational
2	MP Kangar	TP Padang Sidang	Mukim Pauh	20.1	Non-Sanitary Landfill	Operational
3	MP Kangar	SP Padang Besar	Padang Besar	n/a	Transfer Station	Operational
4	MP Kangar	TPS Rimba Emas	Mukim Titi Tinggi	n/a	Sanitary Lanfill	To be Built

Source: Jabatan Pengurusan Sisa Pepejal Negara, Sept 2009

Also included in **Annex 16.1** is a case study of Kuala Perlis Landfill (Perlis), located near the mouth of Sg Perlis, which is an unsanitary landfill that is now being proposed for closure, because of the serious environmental problems arising from leachate contamination in surface and underground water.

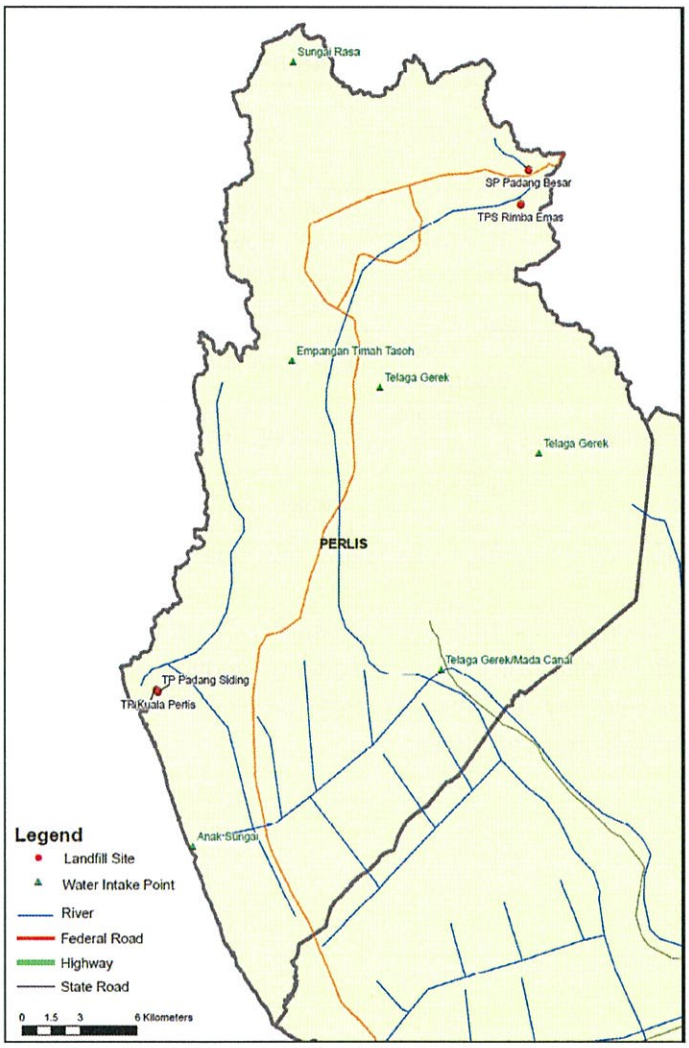


Figure 16.20 - Locations of Landfill Sites in Perlis In Relation to Water Intake Points

16.17 SUSTAINING THE ENVIRONMENT

The above review of the various major activities on the physical and human environments provides an indication of the limits imposed on water resources in the river systems and water bodies. As the trend of these activities increases and imposes greater demand on the amount of relatively 'clean' water, there is a dire need for strategies and actions to sustainably manage the available water resources in the State.

Among the pragmatic measures to manage the quantity and quality of water in the river systems, is to set a range of environmental flow standards for (a) monitoring and enforcement purposes; (b) indicating the status of the water prior to abstraction for potable purposes, and allow comparison with the return flows to determine the level of water pollution; and most importantly (c) sustaining the aquatic ecosystems and their life-forms.

As environmental flows reflect the quantity and quality of the water in the river, an Environmental Flow Index (EFI) can be constructed, based on certain base return intervals vis-à-vis the key critical water quality parameters such as BOD or COD, to categorise rivers

or segments of river as indicators for various beneficial use, the more important being the water-dependent ecosystems. The purpose of the EFI is then to tailor management measures to the specific problems such as from pollution that cause a reduction or even the demise of aquatic fishes and other lifeforms in specific stretches of the rivers and water bodies.

Good water quality in the river systems and water bodies provides an aesthetic value to the environment and landscape, with positive overtones on water-related tourism and recreation activities. It is thus crucial that the environmental flows be included in water resource management practice. The section below provides a review of the importance of environmental flows for various water-dependent uses in the State. The environmental conservation recommendations are also provided as a summary on the need to conserve water resources for the benefit of the environment.

16.17.1 Environmental Flow

As there is limited information on the environmental flow situation for rivers in Perlis, a method was proposed to determine the environmental flow rather than carry out a review of the environmental flow in the State. It is hoped that after this study, the State will adopt the environmental flow as an indicator to measure the health of the ecological and ecosystem conditions in the rivers and water bodies.

Four methods as indicated in **Table 16.33** have been proposed and the details of the method are provided in Volume 4.

Basically, the method adopted should be dependent on the requirements for the river and the availability of data. Of the four methods, Methods 1 and 2 are the easiest to calculate, but they may not fully reflect the ecosystem needs as they are based only on the river hydrological flow conditions. Method 3 has indications of river flows to maintain aquatic habitats, but it is still basically a function of the hydrological conditions.

Method 4 is a more comprehensive method as it takes into consideration the aquatic ecosystem needs, the effects of urbanisation (the cause of pollution) and all the changes in the natural habitat, biota and basic ecosystem functions that have occurred, and/or the presence of intolerant species etc. The results of the four methods are briefly discussed below, while a more detailed discussion on the methods is in Volume 4.

Table 16.33 - Methods Applied to Rivers in Malaysian States

Method No.	Approach/Estimation Method	Description/Comment
1	10% Average Annual Flow (AAF)	NWRS, 1999, applied as "rule-of-thumb value of 10% of the average annual flow has therefore been adopted in the planning of the source works" Data sourced from Hydrological Analysis in This Study.
2	$7Q_1$, $7Q_5$ and $7Q_{50}$ (7-day low flow, for 1, 5 and 50 years)	Results are from the Hydrological Analysis in This Study.
3	Tennant (Montana) Method	This analysis.
4	Smakhtin and Eriyagama Method	This analysis.

16.17.1.1 Method 1: 10% Average Annual Flow (AAF)

This is the most common rule-of-thumb method employed in the past and is still being used for dam projects. This method normally apportions 10% of the average annual river flow (AAF) as the baseflow or compensation flow and is taken as the environmental flow irrespective of the needs of aquatic ecosystem in the river system. It is assumed that this will be sufficient to support the aquatic ecosystem.

As an example, only one station in Perlis is used to demonstrate the flow conditions (**Table 16.34**). The daily flow distribution is given in **Figure 16.21**. From this frequency analysis, it is found that the use of 10% of AAF will result in an extremely low and infrequent flow, less than 4.5% of the time. There is no correlation to the aquatic ecosystem needs or pollution levels, and except for rough hydrological estimation, this method should be used with caution.

Table 16.34 - Water Level Station ID 6503401 in Perlis

State	Station ID	Station Name	River Basin	Catchment Area, sq. km	Record Period	Average Annual Flow (AAF), cumecs	10% AAF, cumecs
Perlis	6503401	Sg Arau at Ldg Tebu Felda	Sg Perlis	20.6	1984 - 2000	0.85	0.085

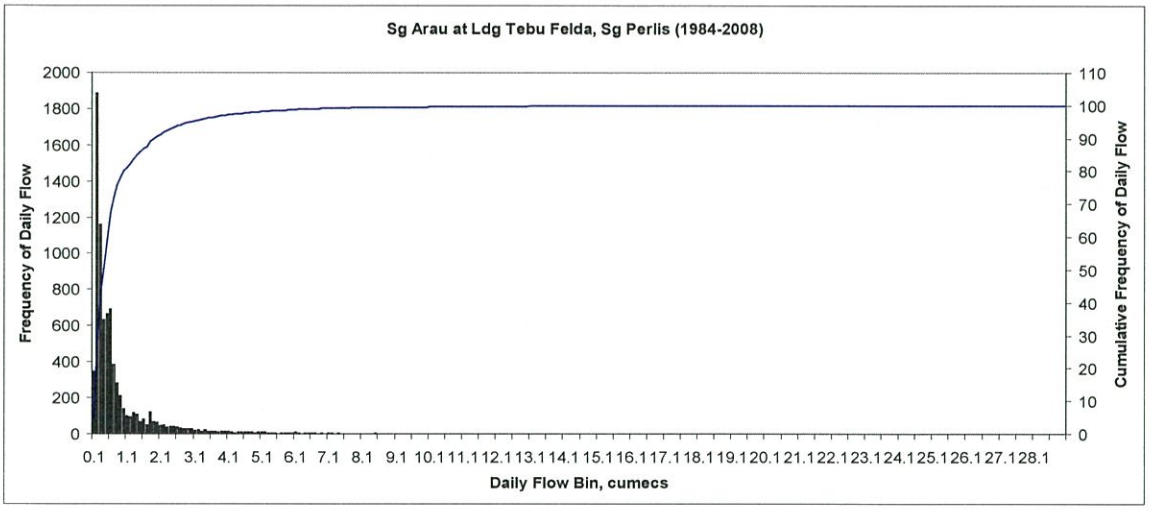


Figure 16.21 - Distribution of Daily Flow at Station ID 6503401

16.17.1.2 Method 2: Low Flow of $7Q_1$, $7Q_5$, $7Q_{50}$

The average of the annual 7-day low flow ($7Q_1$) or the Mean Annual 7-day Minimum flow (MAM7) is used in the United Kingdom for water abstraction licensing (Smakhtin, 2001). In Malaysia, $7Q_{50}$ is used for the design of potable water supply schemes and $7Q_5$ is used for the design of irrigation schemes. **Table 16.35** shows the results of the hydrological analysis of flow data presented in the Hydrological Analysis report. Again this method only provides the flow conditions of specific base return intervals with no indication of the needs for the aquatic lifeforms.

Table 16.35 - 7-day low flow of Perlis Water Level Station Station ID 6503401 for 1, 5 and 50 year Return Periods

State	Station ID	Station Name	River Basin	Catchment Area (km^2)	average 7Q1 (m^3/s)	7Q5 (m^3/s)	7Q50 (m^3/s)
Perlis	6503401	Sg Arau at Ldg Tebu Felda	Sg Perlis	20.6	0.17	0.09	0.04

16.17.1.3 Method 3: Tennant (Montana) Method

The Tennant Method is a refinement of Method 2 which uses eight percentage point values to define the river flow regime for high and low flow seasons. **Table 16.36** gives the percent values used and the estimated flow at Station ID 6503401. It has narrative descriptions to correlate with the aquatic ecosystems needs such as fair or degrading to severe degradation of the water.

Table 16.36 - Flow Regime from Tennant (Montana) Method for Station ID 6503401

Narrative description of general condition of flow for maintaining aquatic habitat	Recommended flow regime (% of AAF) (high flow season)	Recommended flow regime (% of AAF) (low flow season)	Tennant flow regime at Station ID 6503401 (% AAF) cumecs	
Flushing or maximum	200	200	1.70	
Optimum range	60 -100	60-100	0.51	0.85
Outstanding	40	60	0.34	0.51
Excellent	30	50	0.255	0.425
Good	20	40	0.17	0.34
Fair or degrading	10	30	0.085	0.255
Poor or minimum	10	10	0.085	
Severe degradation	< 10	< 10	< 0.085	

16.17.1.4 Method 4: Smakhtin and Eriyagama Method

This method uses the results from the DOE river water quality monitoring for 2008 to categorise the rivers in Perlis into the six Smakhtin and Eriyagama classes based on DOE river basin classifications of polluted, slightly polluted and **clean (Table 16.37**).

The flow duration curve for Station ID 6503401 is shown in **Figure 16.22 and 16.23** to derive the flow duration for each of the River Environmental Management Classes A, B, C, D, E and F. This is for rivers when the management perspective is such that there are:

✓ *"significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation." (Smakhtin and Eriyagama, 2008).*

The results in **Table 16.38** show the likely ecological conditions in the Perlis Rivers as between A to F, depending on the location.

From the management perspective, Perlis is a less developed State. The level of urbanisation indicates that the river environmental management class is C (**Table 16.39 and 16.40**). Therefore, the flow duration curve should not be less than the line labelled as "C" in **Figure 16.21**. Under this class, the most likely ecological condition of the rivers may be described as:

✓ *"The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present."* Smakhtin and Eriyagama, 2008).

Based on the above results, various rehabilitation measures can be planned for the segments of the river or the main rivers to sustain the ecological requirements and functions in the river systems.

In summary, the analysis undertaken to compare the four methods above (of which a sample has been provided here), demonstrates the superiority of Method 4, in that this method provides a more appropriate tool to determine the necessary environmental flows required to maintain water quality and ecosystem integrity (i.e. the living component of the natural environment), both are which are essential outcomes of the IWRM approach.

Table 16.37 - River Management Class Based on Water Quality Conditions in Perlis Rivers (Water Quality and Smakhtin and Eriyagama Classification)

River Status	Smakhtin and Eriyagama Classification
Clean (C)	A, B
Slightly Polluted (SP)	C, D
Polluted (P)	E, F

Table 16.38 - River Management Class Based on Water Quality Conditions in Perlis Rivers (Water Quality and Ecological Class)

State	River Basin	River	WQI 2008	Status	Likely Ecological Class
Perlis	Perlis	Wang Kelian	93	C	A, B
Perlis	Perlis	Pelarit	92	C	A, B
Perlis	Perlis	Jernih	87	C	A, B
Perlis	Perlis	Jarum	83	C	A, B
Perlis	Perlis	Serai	78	SP	C, D
Perlis	Perlis	Ngulang	76	SP	C, D
Perlis	Perlis	Kok Mak	73	SP	C, D
Perlis	Perlis	Perlis	71	SP	C, D

Source: JAS 2008

Table 16.39 - River Management Class Based on State Urbanisation Level (Urbanisation Level and Smakhtin and Eriyagama Classification)

Urbanisation Level, %	Smakhtin and Eriyagama Classification
0-16.6	A
16.7-33.2	B
33.3-49.9	C
50-66.6	D
66.7-83.2	E
83.3-100	F

Table 16.40 - River Management Class Based on State Urbanisation Level (State Level of Urbanisation, 2000)

State	2000 Urbanisation Level, %	Smakhtin and Eriyagama Classification
More developed States		
FTKL	100.0	F
Selangor	88.3	F
P. Pinang	79.5	E
FT Labuan	76.8	E
Melaka	67.3	E
Johor	63.9	D
Perak	59.5	D
N. Sembilan	55.0	D
Less developed States		
Terengganu	49.4	C
Sabah	48.3	C
Sarawak	47.9	C
Pahang	42.1	C
Kedah	38.7	C
Perlis	**33.8**	**C**
Kelantan	33.5	C

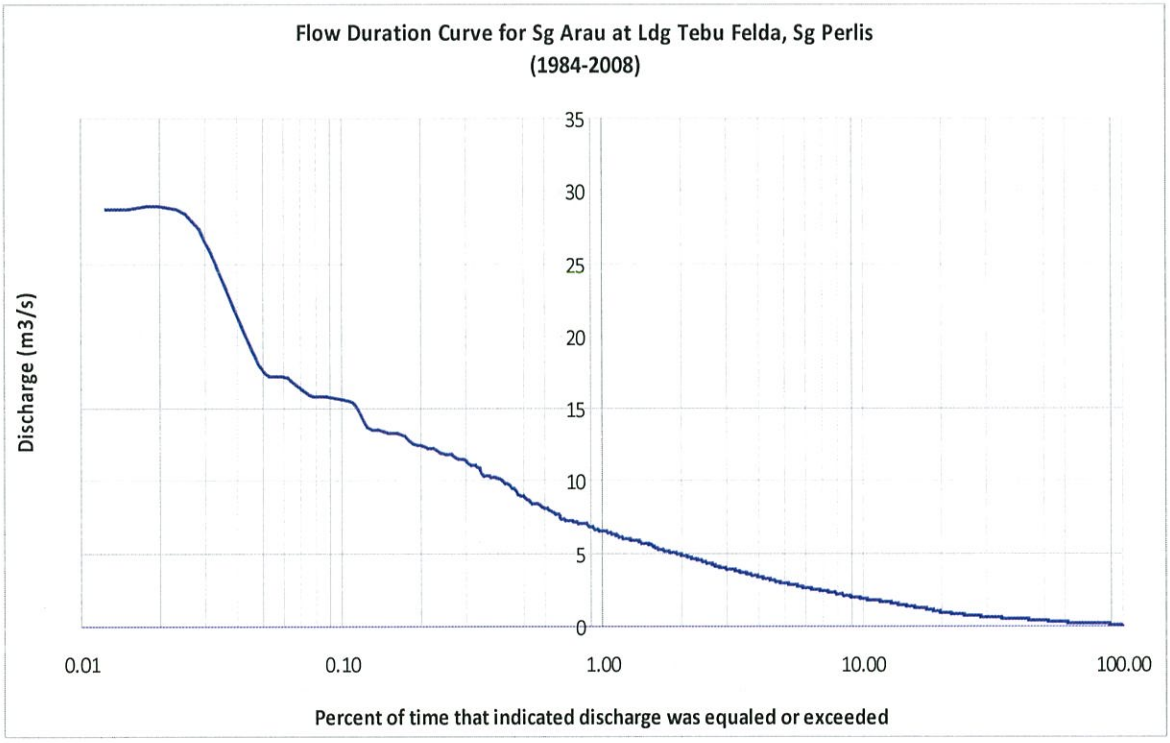


Figure 16.22 - Flow Duration Curves for Station ID 6503401

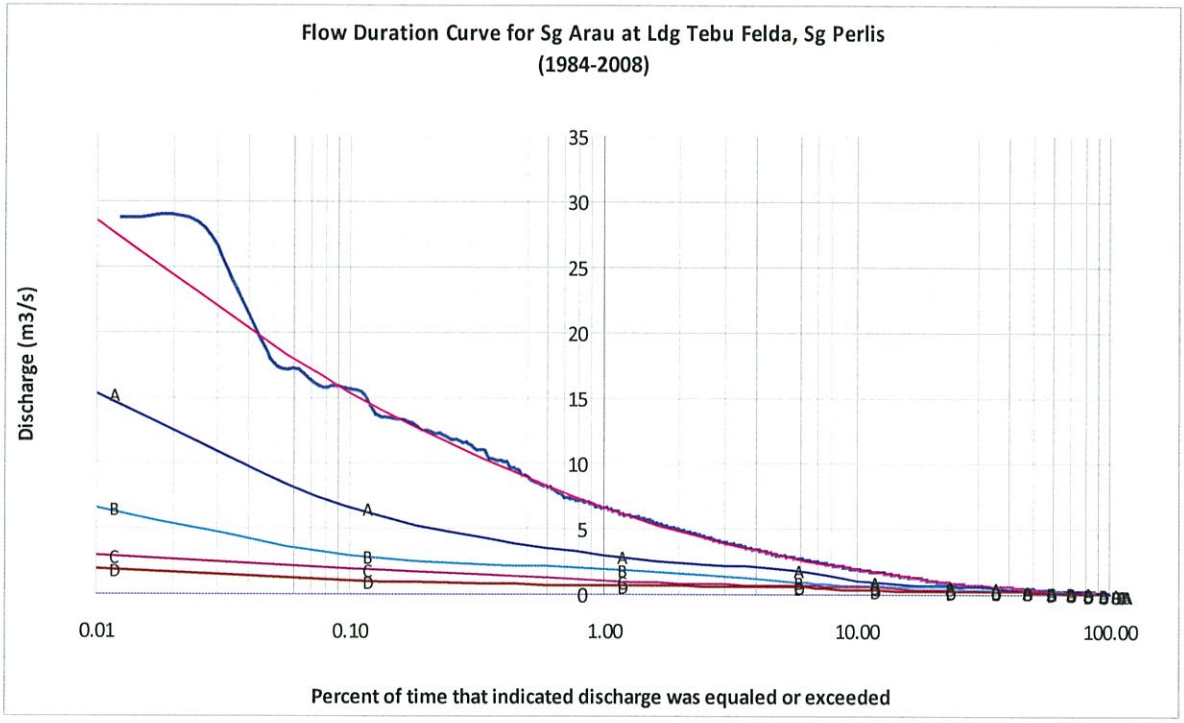


Figure 16.23 - Original Flow Duration Curve including Flow Duration for River Environmental Management Class A, B, C, D, E, F

16.18 RECOMMENDATIONS FOR WATER RESOURCES SECURITY AND SUSTAINABILITY

Environmental conservation is a concept management objective necessary to protect the environment from the negative effects of physical development and use on land and water resources. The National Water Resources Vulnerability Index (NWRVI) has indicated that water resources in the State of Perlis as a whole is at the borderline from being **vulnerable to moderately vulnerable** and therefore there is a need to protect the environment to sustain and protect the water resources (see Volume 4 for details).

The Section below provides the recommendations for future mitigation strategies as well as the need for future detailed studies to ensure that the State will be able to sustain the water resources for all beneficial uses. The recommendations are essentially based on a review of the components as well as the current status of water resources in Perlis for the benefit of the population in the long term.

16.18.1 Recommendation 1 – Protection of Water Source Areas

For water security and sustainability, there is a need to protect and conserve the water source areas or `*water catchment forests'* that it already has gazetted. As of 2009, the State has gazetted 83,344.80 ha as water catchments. A "Water Catchment" refers to a catchment or basin in which forest forms the dominant vegetation cover. In this context, a proposed definition of *water catchment forest* is "*any permanent reserve forest within a river basin together with a river system or watershed that sustains a surface flow originating from rain and having a natural topographical border which can be gazetted*".

The management program should clearly define and delineate the water catchment boundaries through surveys, and the area then registered with the State Government to ensure that the catchment is recognised in a court of law. Buffer zones around the catchment boundary must also be clearly demarcated. Once classified and delineated, a management plan for each water catchment forest will need to be prepared for approval by the State Authority. Such a management plan should include the pertinent forest information and profile, procedures for management and the carrying capacity of the area in terms of water resources. It should also include conservation and rehabilitation measures if needed.

In addition, a Working Committee is recommended in the State to coordinate and supervise the management and development of water catchment forests.

The general priority actions for implementation are:

(i) Conduct a baseline study on the forest catchment areas.

(ii) Initiate awareness programmes at various levels.

(iii) Get endorsement by the State Authority.

(iv) Develop the catchment management and action plans.

(v) Form technical inter-agency committees to standardize and prepare the guidelines for buffer zone management.

(vi) Create buffer zones around catchment forests, ESAs, wetlands and water bodies to prevent encroachment of other landuses.

(vii) Develop and implement guidelines on buffer zone management for water catchment forest and water bodies.

(viii) Standardise the criteria for buffer zones within the forested area other than forest reserves and forest classified under functional classes (Section 10 of the National Forestry Act), as well as ensure the uniformity in terms of regulation among agencies.

(ix) Provide funds to undertake the rehabilitation programmes.

(x) Study the cumulative effects of logging on downstream use in large water catchments.

16.18.2 Recommendation 2 - Integrated Lake Basin Management

Tasik Timah Tasoh is the most important lake entity in Perlis, which must be managed sustainably in order to control the threat of encroaching development. One of the ways is using an Integrated Lake Basin Management (ILBM) approach, which is similar to IWRM,

except it focuses on continuous improvement of governance that integrates institution, policy, participation, science, technology and funding for the lake.

The characteristics and complex response dynamics of lakes are different from flowing rivers and hence, they have differing management implications in terms of the selection of multiple mitigation measures, analyses, sustained actions and involved costs. In general, the non-linear nature of the eutrophication processes and the hysteresis phenomenon inhibit restoration of a degraded lake system (Nakamura, 2007), making it very costly to rehabilitate. Therefore, according to Sharip and Jusoh (2010), due to the lake's location within a micro-scale catchment of major rivers, it would seem easier to manage lakes from the lake basin perspective rather than from the whole river basin.

ILBM needs to be implemented immediately to ensure the sustainable management of the current lakes in Perlis to safeguard their importance for socio-economic well-being, eco-tourism and the sustenance of its biodiversity. This is a priority since the Tasik Timah Tasoh is the only source of water supply, and covers a substantial part of the State and is now under threat from pollution.

16.18.3 Recommendation 3 – Biodiversity Inventory

Perlis is rich in biological diversity but a full inventory of all its aquatic and terrestrial resources is not extensive. In order to understand the importance of the river basins in Perlis as habitats for environmental resources, there is a need to build and continually update the inventory to monitor degradations over time. Cooperation from various stakeholders would be beneficial in implementing such an endeavour.

Ideally, the database should be in GIS format whereby multi-layers of data can be incorporated and analysed to provide management options. The database should be managed by a central agency or custodian with other respective agencies providing the necessary data and inputs. Some pertinent and judicial information should be made available to the public to highlight the importance of sensitive ecosystems in Perlis.

16.18.4 Recommendation 4 – Establish an Environmental Flow Program

Environmental flows are important to maintain the beneficial uses of the river to aquatic organisms and to the associated communities they support. These communities do not include only the flora and fauna along the river banks but also the human communities who are dependent on the aquatic environment for irrigation, fisheries, among other uses. The recommended method to derive the environmental flow is by applying an adaptive management approach. This is a slow process, but it will include the participation of the relevant stakeholders who will decide the best method to use and the best practices to adopt for that particular river based on their local knowledge of the area.

16.18.5 Recommendation 5 – Carry out Capacity Building and Awareness Programs

Different agencies play different roles in ecosystem management relating to water resources. Most State authorities have adopted, implemented and enforced various forestry

enactments, landuse enactments and legislations such as the Water Enactment 1935, Land Conservation Act 1960, Environmental Quality Act 1974, and Protection of Wildlife Act 1972 to ensure effective forest management. However, the lack of capacity and knowledge of these laws among the personnel of these agencies will mar the effectiveness of enforcement efforts on the ground. Capacity building and training of manpower are much needed to strengthen the capacity of agencies to handle environmental and water resources issues.

The concept of HCVF in the certification of responsible forest management in Malaysia is not widely known and there is generally insufficient guidance on its implementation. Forest management agencies and other relevant agencies such as PERHILITAN, the local authority, etc should be trained and equipped with the knowledge in order to promote and implement the concept.

The public is also unaware of the types of legislations pertaining to ecosystem and water resources protection. Such laws should be made readily available to the public through the department's websites or leaflets and training programmes should be provided to the public through forums or the media.

Access to certain judicial data and information including redress and remedy, should be made widely available to the public. This is to facilitate and encourage public awareness and participation to appreciate and protect the environment and its water resources.

16.18.6 Recommendation 6 - Landuse Zoning for Water Source Areas

In the current process of land zoning and application, an EIA is required for prescribed activities. However, for activities that are not prescribed, environmental consideration is often not adequately addressed in the preparation of the land zoning plans, which leads to landuse conflicts and also conflicts between departments after approval of a project or development plan.

ESAs are listed in the local plans, but the exact boundaries are often unclear which leads to disputes during land alienation. Even if such information is available with the Local Authority and Land Office, these are often not made readily available to the public. In 1993, the Department of Environment published a *Guide Book on the ESA in Malaysia,* however, not all the structure plans of States have used it or listed the same locations as in the book. This guide book is essentially just guidelines as the State Government ultimately has the final decision on gazetting these areas.

In terms of native lands, land alienation is further complicated by the fact that such boundaries do not exist as it is a sensitive and subjective issue. All in all, proper landuse planning at an early stage along with the involvement of stakeholder participation would be an ideal solution to minimising landuse conflicts.

16.18.7 Recommendation 8 – Water Quality Improvement and Pollution Prevention Programs

The water quality of surface waters will vary in response to environmental conditions. Large inputs from point and non-point pollution sources will alter the physical, chemical and

biological characteristics of water and water quality will deteriorate. This will reduce the amount of clean water available for drinking, recreation and to sustain a healthy ecosystem. Hence, it is important to control large amounts of pollutants from entering the surface waters. The topic of water quality is multi-faceted that encompasses the management of land and water resources in a river basin context, where inputs and outputs are clearly defined. Therefore, the recommendations are provided by study components for easy reference as provided in **Table 16.41**.

Table 16.41 - Recommendations for Water Quality Improvement and Pollution Prevention

No.	Component	Recommendations
WATER QUALITY		
1	Industrial pollution	• Effluent discharges exceeding 60m^3/day are legally monitored by DOE under the EQA (1974). With DOE's expertise in water quality monitoring, DOE should also be enabled through the amendments in the EQA (1974) to monitor even those that discharge <60 m^3/day. • DOE also need to review the existing contravening licenses in order to assess whether they are still justified. • Monitoring efforts should be intensified especially downstream of industrial activities. • The Standard A imposed through the Environmental Quality (Industrial Effluent) Regulations 2009 should be made more stringent to protect the water resources. • High-risk industries that cause severe pollution either through its normal operations or through malfunctions or failures should only be sited downstream of water intakes. • Stricter standards for effluent discharges from palm oil mills should be imposed to encourage implementation of better treatment methods, recycling practices and zero to minimal discharges. The current BOD_5 limit is 20 mg/L for new plants but according to the Second Schedule of the Environmental Quality (Prescribed Premises) (Crude Palm-Oil) Regulations, 1977 of the EQA (1974), the BOD_3 limit is only 100 mg/L or BOD_5 of 50 mg/L after the year 1984. • Dye pollution from the textile industries is not regulated and there are no standards to comply with. Standards and penalties for dye pollution should be included in the EQA 1974. • All medium or heavy industries, farms and processing factories in agriculture mills should be banned from Timah Tasoh Dam and its surrounding areas.
2	Sewage effluent	• Existing malfunctioning public and private STPs should be upgraded. • Inefficient types of sewage treatments such as pour flush systems should be replaced by other forms of treatments such as septic tanks which should be regularly desludged especially in fishing estuaries • Sewage treatment in rural areas or outside the serviced areas need to be upgraded, perhaps through discharges into gravel filters or an infiltration system as practised in developed countries. • In the case of Tasik Melati, buffer zones with water plants should be created, acting as natural water filters of pollutants in the park. Enforcement to control industrial waste effluents from entering the lake could help minimize the environment hazard.
3	Pollution from animal	• The regulatory framework related to animal husbandry wastes should

No.	Component	Recommendations
	husbandry activities	be improved. The existing legislation on animal husbandry does not address environmental or pollution issues. The DVS advocates "*Good Animal Husbandry Practices*" but these are on voluntary basis rather than regulatory. Therefore, proper legislations to control pollution from animal husbandry activities and guidelines for implementation should be developed. Standards should be developed by DVS for effluent discharges from livestock farms. • DVS personnel should also be trained to be well-versed with the new regulations to aid in enforcement.
4	Pollution from agriculture	• Implement best management practices for: pollution control, vegetable and flower farms, highland farming and management of pesticides near water resources (eg. integrated pesticide management). • DOA's *Malaysian Farm Accreditation Scheme* or "Skim Amalan Ladang Malaysia" (SALM) that incorporates Best Management Practices for participating farms provide the necessary guidelines for agriculture development. • Non-point sources of pollution from agriculture land need to be addressed.
5	Pollution from aquaculture	• The main regulatory instrument in the management and development of aquaculture is the Federal Fisheries Act No. 317 of 1985 (amended in 1993). New regulations should be implemented to control pollution from aquaculture activities especially for licensing of new projects. • The Federal Department of Fisheries should develop new guidelines for the design of appropriate and efficient freshwater aquaculture systems to minimize water usage and pollution potentials. • Sabah has a new Inland Fisheries and Aquaculture Enactment 2003 which the State of Perlis can emulate, but this Enactment has not been enforced. However, this Enactment can provide some Guidelines on sustainable management of inland fisheries activities (capture and aquaculture) that can be used as a good basis for implementation in Perlis in future.
6	Erosion and Sedimentation	• Guidelines on erosion are covered extensively in Volume 3. Generally, the main guidelines to follow are those provided in the "*Urban Stormwater Management Manual for Malaysia (MASMA)*" (DID, 2000) and also the "*Guidelines for the Prevention and Control of Soil Erosion and Siltation in Malaysia*" (DOE, 1996). • ESCP should be made compulsory for any types of land clearing projects and not just those in the urban setting. • Non-point sources of pollution (NPS) from stormwater runoff are also significant contributions to suspended solids and sedimentation in rivers and drainage. Some guidelines for stormwater quality management are provided in MSMA but these should be improved to include non-urban sources. • There are currently no water quality standards for NPS and hence, DID in collaboration with DOE should provide a standardized version for Malaysia.
7	Sullage from urban sources	• Sullage from residential units should be controlled through enforcement especially at the older housing units where sullage is directly discharged into the drains and rivers.

No.	Component	Recommendations
		• Control and conduct strict enforcement on restaurants and commercial areas that discharge sullage and oil and grease into the drainage systems. • Standards for sullage discharges should be developed and included in the EQA (1974) regulations. • Install log booms at selected areas to trap the garbage as a temporary measure. There are currently no log booms in Perlis. • Use concealed urban drainage and treatment for new development (e.g. install gross pollutant traps at strategic locations within the drainage systems; provide ecological treatment of wastewater from wet markets, etc).
8	Solid waste	• Prohibit direct dumping of solid waste into the rivers and extend solid waste collection services to the rural areas with consistent collections. • Close all existing illegal dumpsites and unsanitary landfills. • Consolidate, rehabilitate and upgrade the existing landfills. • Improve sanitary level and monitoring of waste disposal sites. • Impose stricter standards for leachate quality in the EQA (1974). • Develop new sanitary landfills outside of water catchment areas to ensure that leachate will not enter waterways • Ensure proper timing of implementation of existing landfill upgrade, closure and development of news sites in order to avoid a disposal crisis due to no available capacity for disposal of daily generated waste. • Be vigilant in the selection of an operating contractor. Choose only those that have a proven performance record for management of landfills. • Allocate sufficient funds for maintenance and operation of landfills, and for post-closure care and maintenance. • Provide facilities and emergency response plans to cater for natural disasters such as floods and fires at a landfill. • Prepare a transfer disposal site for scheduled waste in Pauh, Perlis before transferring it to Bukit Nenas Waste Management Centre, Negeri Sembilan [*Laporan Penemuan Rancangan Tempatan Majlis Perbandaran Kangar 2009 – 2020* (JPBD, 2009)]
9	Non-point sources of pollution (NPS)	• There are no guidelines for NPS management in Malaysia. Some guidelines for stormwater quality management are provided in MASMA but these should be improved to include non-urban sources. • Develop an inventory of non-point sources in a river basin basis. • Implement research and development initiatives to determine appropriate prediction methods and quantification of loadings for non-point sources of pollution. • Carry out monitoring and enforcement work on all non-point sources of pollution in the basin. • There are currently no water quality standards for NPS and hence, DID in collaboration with DOE should provide a standardized version for Malaysia. • Conduct Stormwater Management Masterplan studies in a river basin basis. • The guidelines pertaining to stormwater can be referred to in the *Water Resources Master Plan Negeri Sabah*, 1994 by the Natural

<table>
<tr><th>No.</th><th>Component</th><th>Recommendations</th></tr>
<tr><td></td><td></td><td>Resources Office, Sabah.</td></tr>
<tr><td>10</td><td>General water quality recommendations</td><td>• Produce a comprehensive inventory list of point and non-point sources of pollution in a river basin basis. This list of pollution sources will form the basis for enforcement and monitoring of all pollution sources in the respective areas.
• Determine the pollutant loadings and carrying capacity of the rivers.
• Increase the monitoring network.
• Create a Community Volunteer Monitoring Programme, which includes volunteers, schools, residences to monitor certain rivers or ponds within their homes so that the community can act as frontline participants and they can discover for themselves how their actions are affecting the river bodies. Water Quality Monitoring Volunteer Manual should be designed and disseminated freely to the communities through the DID website.
• For pristine areas, formulate guidelines to ensure no degradation of the water sources to maintain Class I/II conditions.
• For slightly polluted areas, formulate guidelines to control and minimise the risk of pollution to ensure sustainability of Class II levels.
• For very polluted areas, formulate basin-wide strategies and guidelines to manage the risks and improve the water quality to Class II levels.</td></tr>
<tr><td>11</td><td>River corridor management</td><td>River corridors are important to maintain wildlife diversity and to filter out pollution from entering the surface waters such as lakes and rivers. However, development often encroaches into these important buffers and cause pollution, erosion and sedimentation.
• River corridor management guidelines are provided in MSMA, in "Managing Biodiversity in the Riparian Zone" by MoNRE (2009) and also in the "Guidelines for Rivers and River Reserves (DID, 2001)". This should be used as guidance.
• The guidelines by DID (2001) are shown below.
<table><tr><th>River Width (m)</th><th>Width of river reserve (m) on either side of the bank</th></tr><tr><td>>40</td><td>50</td></tr><tr><td>20 – 40</td><td>54</td></tr><tr><td>10 –20</td><td>20</td></tr><tr><td>5 –10</td><td>10</td></tr><tr><td><5</td><td>5</td></tr></table>The following were extracted from the Stormwater Management and Drainage Master Plan Study for Kangar, Arau and Padang Besar, Perlis (2010):
• Impose building restrictions in the river reserve. This applies to the conversion of future paddy fields to built-up areas.
• Gazette and maintain the existing natural river corridors as riparian reserves to reduce any further encroachment. Local authority should impose planning guidelines and conditions to ensure future development do not encroach into the river reserves.
• Replanting of vegetation to be implemented in all exposed areas to reduce soil erosion and sedimentation.</td></tr>
</table>

ANNEX 16.1- A CASE STUDY: PROPOSED CLOSURE OF THE KUALA PERLIS LANDFILL

ANNEX 16.1 – A CASE STUDY: PROPOSED CLOSURE OF THE KUALA PERLIS LANDFILL

Solid Waste Management activities have a direct impact on water quality, particularly in the discharge of wastewater (leachate) from landfills into surface waterways and ground water. The following case study is on the proposed closure of the existing Kuala Perlis Landfill (Perlis), located near the mouth of Sg Perlis. It provides details of the main environmental issues and impacts of a landfill project on water resources.

(a) Project Feasibility and Critical/Urgent Status

The existing Kuala Perlis Landfill (Perlis) has surpassed its design capacity and is overdue for full closure. It basically functions as a Level 2 landfill (controlled tipping) but lacks treatment facilities and environmental controls to mitigate contamination of surrounding areas. Some of the waste landfilled is exposed to the elements without sufficient earth covering since source of earth is not available at site. Scavenging activities is prevalent and the site is an environmental and safety hazard. Public complaints from neighbouring settlements of odour, vectors, and smoke from frequent landfill fires, as well as the poor condition of the access road, has rendered this site a disposal crisis, warrant immediate full closure to be substituted with an environmentally acceptable disposal facility. Portions of the landfill have been closed, but since waste is still entering the landfill daily, the remaining operating area is becoming more difficult to control in terms of trafficability and safety.



Figure A.1 - View of Kuala Perlis Landfill



Figure A.2 - Location of Kuala Perlis Landfill

(b) Leachate discharge from the waste landfill to nearby surface waterways

Leachate is discharged from the waste landfill via leaching from exposed and uncovered slopes, as well as mixing with stormwater flow if earth cover is insufficient to prevent contamination of surface water. In the case of Kuala Perlis landfill, some uncovered areas have allowed leachate to mix with the stormwater drainage trenches, eventually finding its way to Sg Perlis.

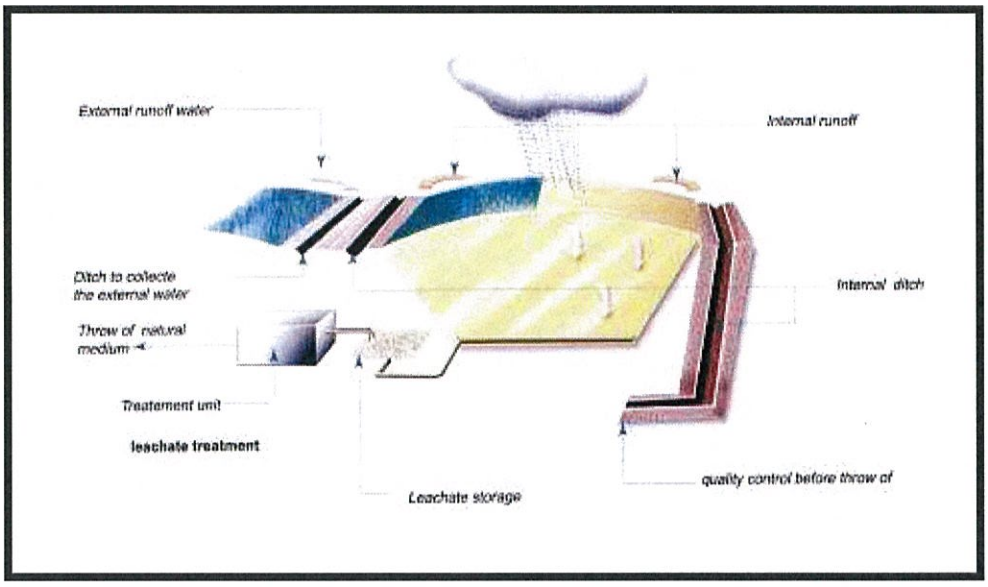


Figure A.3 - Diagram of Potential Leachate Flow from Landfills to Surface Waterways



Figure A.4 - Leachate Flow Paths at Kuala Perlis Landfill

The Kuala Perlis landfill discharges effluent to Sg Perlis and may have an impact on the water quality and usage downstream, even though there are no water intake points downstream.

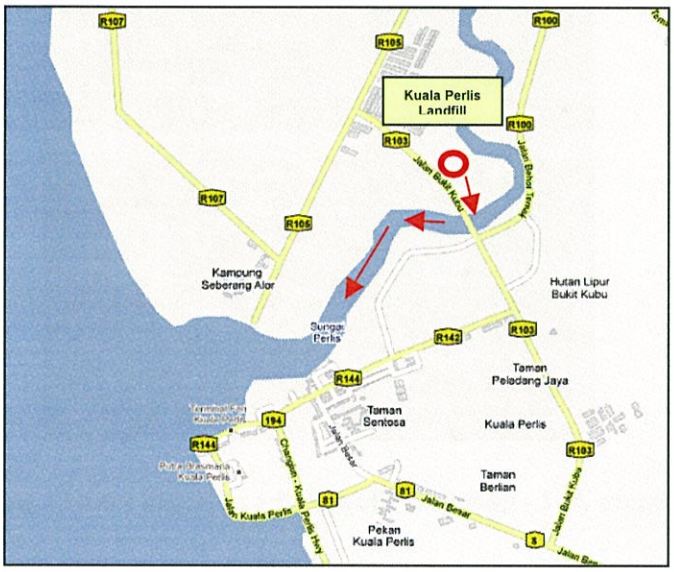


Figure A.5 - Flow of Sg Perlis Downstream of Kuala Perlis Landfill

(c) Leachate discharge from the waste landfill to ground water

Leachate from a waste landfill can travel downward and contaminate ground water if an impermeable liner is not placed underneath the waste.

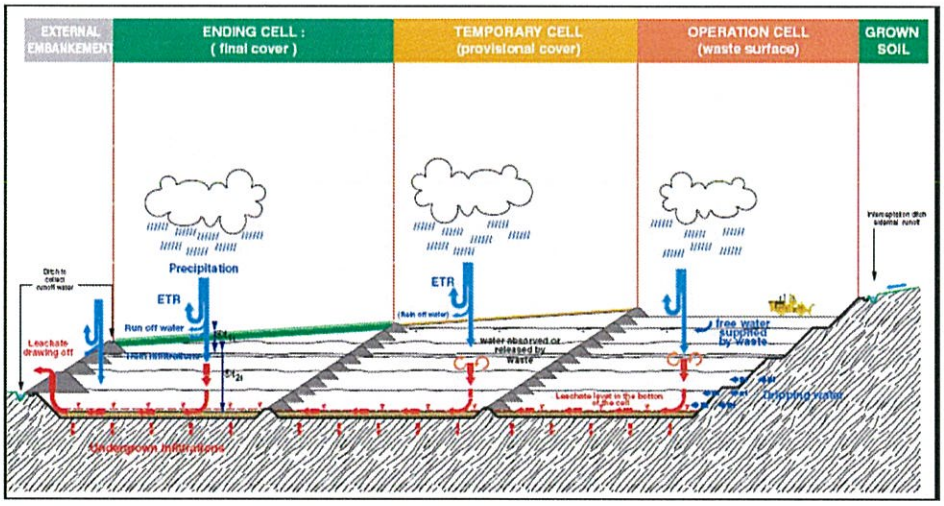


Figure A.6 - Diagram of Leachate Generation and Flow Paths in a Bottom-lined Landfill

Since the Kuala Perlis landfill does not have a bottom liner, leachate from the waste fill has contaminated the ground water. The direction of flow of the ground water within the site appears to be in the direction of Sg Perlis.



Figure A. 7 - Leachate Flow Paths at Kuala Perlis Landfill

(d) Soil Erosion and Siltation of surface waterways from landfill activities

Earthworks related to excavation of earth and capping of a landfill is subject to soil erosion and siltation of surface waterways if erosion control measures such as siltation ponds and turfing or temporary slope cover with plastic sheets are not implemented.

The earth covering works in Kuala Perlis landfill appears to be exposed to rainfall and the potential of erosion and siltation of drainage and surface waterways is at high risk.



Figure A.8 - Erosion and Siltation Risk at Kuala Perlis landfill

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SECTION 17

WATER RESOURCES ANALYSIS

Section 17

WATER RESOURCES ANALYSIS

17.0 WATER RESOURCES ANALYSIS – WATER SOURCE DEVELOPMENT

17.1 BASIS AND CRITERIA

The water resources is provided by the rainfall that translate to surface runoff after losses attributed to evaporation and ground water recharge. A large part of the surface runoff is also loss in the form of floods that necessitates its discharge into the sea. What remains is a fraction of the initial amount and appears as river flows which constitutes the water resource of a river basin's catchment which can be tapped to meet water demands of the various water demand sectors.

The reliable river flows are the low river flows and are very often not sufficient to meet demands. Storage dams are therefore necessary to keep more water resources to be release during the times of low flows.

The Sg Perlis is the major river basin in the state.

The water resources of the state is analysed at the point of interest, defined as the location where the quantity of water is available for use. The point of interest has been suggested to be the respective river basins. However after much study, the point of interest has been chosen in favour of river basin to be at the intake points of WTPs or irrigation headworks due to the following reasons

(i) The river basin is defined as the river where it meets the sea. Deriving the water resource at this point would not reflect the actual water available as the river is saline until the end of the salinity wedge which could be a few kilometres upstream.

(ii) Due to pollution, the river yields would be realisable only up to the point where the water quality is acceptable for use for treatment for potable water or irrigation

(iii) River yields vary along the river reaches and it is only at the intake points that the yields are relevant. To derive a yield at the river mouth would give misleading indication of the actual amount of water resources available.

As such, the point of interest in the water resources simulation is the raw water intake points. For presentation, the intake points will be arranged accordance with the river and the river basin.

The water resources are also defined by the acceptable risk and for water resources purposes it can be considered to comprise 2 parts, namely,

(i) Run of the river flows normally accepted as the 7-day low flow.
(ii) Regulated flow from a storage dam or a series of dams.

Run of the river yields are defined by the 7-day low flows.

Regulated flows yield estimation are normally carried out by computer simulation. Computer simulation for resource studies shall be carried out using HEC_ResSim, a water resources computer simulation model developed by the Hydrologic Engineering Center of the US Army Corps of Engineers to aid engineers and planners performing water resources studies in predicting the behavior of reservoirs and to help reservoir operators plan releases in real-time during day-to-day and emergency operations. Multi reservoirs situations with a single river basin and across river basins for different water uses like potable water supply, irrigation, environmental flows and hydropower generation can be simulated.

Water demands that are taken into consideration in the simulation consist the following:

(i) Potable water which includes domestic, industrial, commercial, institutional and NRW.

(ii) Irrigation water for paddy.

(iii) Agriculture water for all non-paddy crops.

(iv) Animal husbandry uses treated water and thus has been included in the potable water demand.

(v) Environmental flows.

The following simulation scenarios have been adopted for single or multipurpose dam:

(i) Single purpose Irrigation Dam

- 20% 36 month drought series (corresponding to a 1 in 5 year ARI).

(ii) Single purpose Water Supply Dam

- 2% 36 month drought series (corresponding to a 1 in 50 year ARI).

(iii) For multipurpose reservoirs with irrigation and water supply where the designed risks are different the simulation scenarios shall be as follows:

- 2% drought series (corresponds to a 1 in 50 year ARI drought) with water supply alone in the second half of the first year drought. This simulates the condition where the 50 year drought is unexpected and irrigation is already committed for one season (first six months of first year drought).

The assumptions made in the simulation model that have significant bearing on the results are described below:

(i) Monthly time step is adopted in the simulation.

(ii) The reservoir water is at full supply level at the beginning of simulation.

(iii) The plant losses are estimated based on 5% of the designed capacity of the water treatment plant.

(iv) The regulating losses are estimated based on 10% of the raw water demand of the water treatment plant.

(v) Environmental flow / riparian release for preventing of sea water intrusion and maintenance of environment is allowed to flow pass the intakes. The environmental flows are estimated based on 10% of the annual average flow.

(vi) Irrigation water schemes will focus on the granary area and mini granary area. The irrigation water demand for minor irrigation scheme will not be considered in the simulation.

(vii) Under the 1 in 50 year drought and the 2050 scenario, the total developed water source (existing and proposed) shall be able to fully meet the potable water demand. Irrigation demand for the first crop during the first year drought (month 1 to month 6) will be supplied as the drought is unexpected and irrigation is already committed. The supply from the dam for the following second crop (month 7 to month 12) will be ceased.

(viii) Under the 1 in 5 year drought and the 2050 scenario, the total developed water source (existing and proposed) shall be able to meet both potable and irrigation demand.

(ix) The lag time for the water released from the dam to reach the downstream intake has not been considered.

17.2 WATER DEMANDS

Single or multi-reservoirs systems within a single river basin or across river basins by taking into consideration different water uses such as potable water supply, irrigation, agriculture and environmental flows have been simulated.

17.2.1 Potable Water

The potable water demand for Perlis has been projected and discussed in section 6 of this report. **Table 17.1** summarizes the water source required from year 2010 to year 2050.

Table 17.1 - Water Source Requirement

State	Projection (Mld) Median				
	2010	2020	2030	2040	2050
Perlis	150	168	179	192	206
Total	**150**	**168**	**179**	**192**	**206**

17.2.2 Irrigation

The irrigation water demand has been projected and discussed in section 7 of this report. **Table 17.2** summarizes the paddy irrigation water demand projected from year 2010 to year 2050.

Table 17.2 - Irrigation Water Demand Projection in Perlis State

Irrigation Scheme	Projected Annual Irrigation Water Demand (MCM)				
	2010	2020	2030	2040	2050
Mini Granary	133	119	107	97	89
Minor Schemes	65	65	58	58	52
Total	**198**	**184**	**165**	**155**	**141**

17.2.3 Agriculture

The water need for the irrigated agriculture such as fruit, sugar cane, herbs, vegetable, flowers and oil palm has been projected and discussed in Section 8 of this report. **Table 17.3** summarizes the total projected monthly irrigation water demand from year 2010 to year 2050.

Table 17.3 - Projected Agriculture Water Demand

Month	Agriculture Water Demand ('000 cu.m)				
	2010	2020	2030	2040	2050
Jan	18,493	18,505	18,528	18,559	18,613
Feb	17,468	17,479	17,502	17,532	17,586
Mar	7,650	7,657	7,671	7,689	7,721
Apr	2,117	2,120	2,128	2,138	2,156
May	4,437	4,442	4,451	4,463	4,484
Jun	1,508	1,511	1,576	1,524	1,538
Jul	7	7	8	8	9
Aug	95	97	101	106	115
Sep	0	0	0	0	0
Oct	0	0	0	0	0
Nov	48	49	50	53	58
Dec	109	111	116	122	132
Total	**51,932**	**51,978**	**52,069**	**52,195**	**52,412**

17.2.4 Environmental Flows

Environmental flow or compensation water is the water that must be discharged below a dam to compensate riparian interests for the water taken away to supply. In the reservoir simulation, the environmental flow that is allowed to flow through the intake has been estimated as 10% of the annual average flow (AAF).

17.3 RUN OF THE RIVER YIELDS

There is no run of river scheme in Perlis. All WTPs in Perlis are either regulated or from ground water.

17.4 REGULATED YIELD - Simulation Results and Discussion

A local area model for Timah Tasoh Dam has been set up to evaluate the condition of irrigation and potable water supply from Timah Tasoh Dam.

Timah-Tasoh Dam is the only dam located within the State of Perlis. It has a catchment area of 191 km^2, located on Sg Korok about 2.5 km below the confluence of Sg Timah and Sg Tasoh. The dam completed in 1992 which regulates the flows of Sg Korok to provide dependable and adequate potable water supply besides augment water supply to the irrigation requirement. **Figure 17.1** shows the river system, location of the dam and existing water intake points. Catchment area and dam storage of Timah Tasoh Dam is summarized in **Table 17.4**.

Table 17.4 - Summary of Timah Tasoh Dam

Dam	River Basin	Catchment Area (km^2)	Active Storage (MCM)	Gross Storage (MCM)
Timah Tasoh Dam	Sg Perlis	191	33.3	40

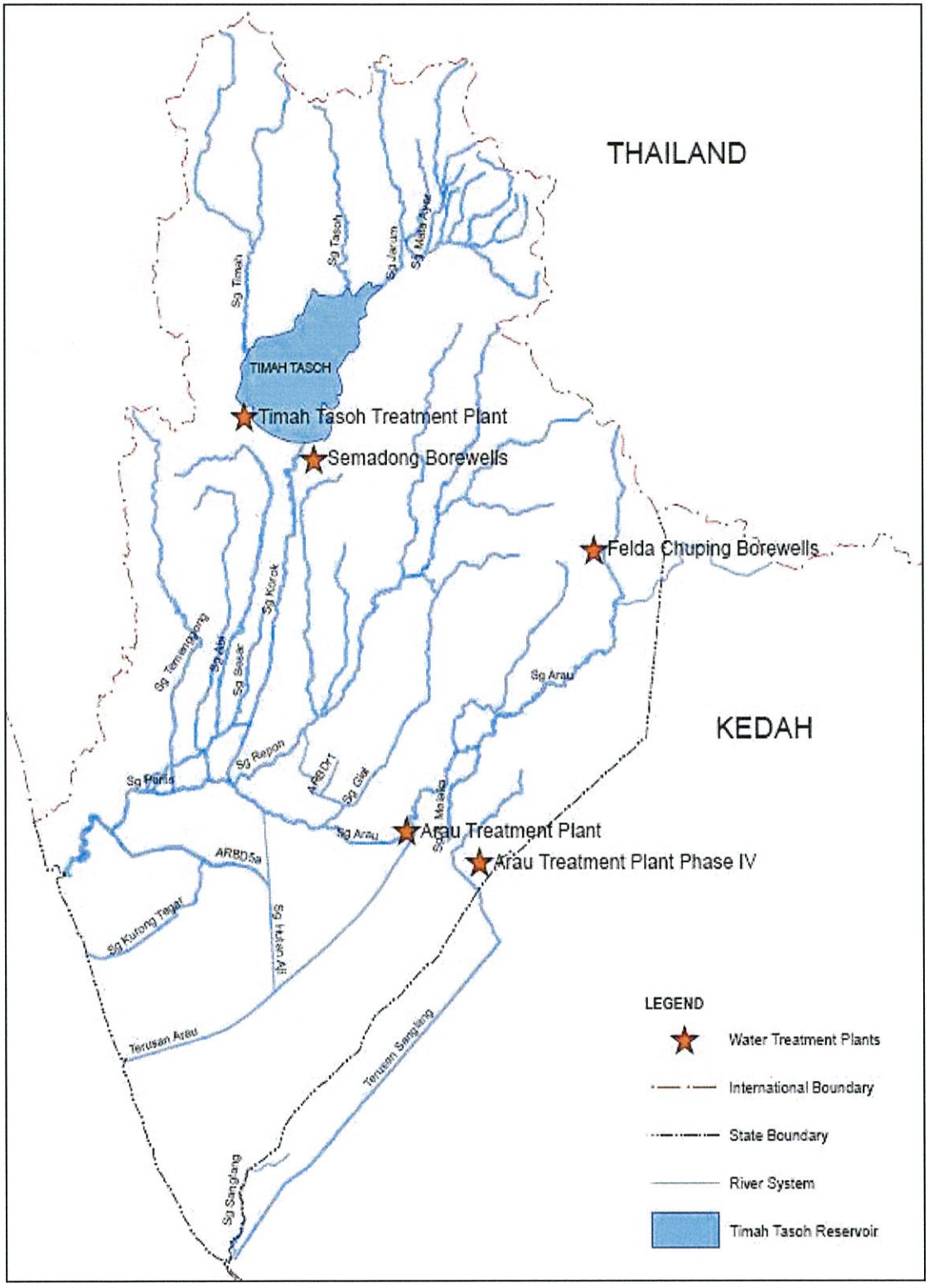
MCM – Million Cubic Meter (x 10^6 m^3)

Figure 17.2 is a schematic diagram of the system. The present irrigation, potable water supply extracting water from Timah Tasoh Dam is included in the model to evaluate the future condition of water supply in Perlis State.

The storage of Timah Tasoh Dam is presently being increased by raising the height of the dam by 3.5 meters, catering for additional flood mitigation storage as well. This will increase the storage capacity of the dam from 33 MCM to 70 MCM. The sufficiency of irrigation water supply from the Timah Tasoh Dam has been assessed using HEC-ResSim. The input data of dam operation and evaporation for the reservoir simulation is shown in **Tables 17.5** and **17.6.**

Tables 17.5 - Reservoir Actual Evaporation (mm)

Dam	Ev Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Timah Tasoh	Padang Katong	157	167	176	153	137	125	128	130	121	119	112	127



Source: IWRSNR 2009

Figure 17.1 - Shows The River System, Location Of The Dam And Existing Water Intake Points

Tables 17.6 - Dam Operation Data

Dam	Maximum/PMF WL (m)	Full Supply Level, FSL (m)	Minimum Operating Level, MOL (m)
Timah Tasoh Dam*	33.6	31.6	25.3

Model for Timah Tasoh Dam has been set up to evaluate the condition of irrigation and potable water supply from Timah Tasoh Dam. The present irrigation, potable water supply extracting water from Timah Tasoh Dam is included in the model to evaluate the future condition of water supply in Perlis State. The system supply irrigation water to about 25 km^2 of mini and minor irrigation schemes in Perlis. Simulations for present and future condition (2050) (see **Table 17.7**) were carried out and presented as below.

Table 17.7 - Simulations For Present And Future Condition (2050)

Sim	Drought ARI	Scenario	Remark
1a	1 in 5-year	Present (2010)	Supply for mini granary, exclude minor scheme
1b	1 in 5-year	Present (2010)	Supply for mini granary's main planting season only, exclude minor scheme
2	1 in 50-year	Present (2010)	Supply for mini granary's main planting season only, exclude minor scheme
3	1 in 5-year	Future (2050)	Supply for mini granary and minor scheme main planting season only
4	1 in 50-year	Future (2050)	Supply for mini granary's main planting season only, exclude minor scheme

Simulation 1a result shows that the reservoir will be drawn down to Minimal Operating Level (MOL) within 3 months, (see **Figure 17.2 to Figure 17.5**). WTP intake will experienced few short period of shortages. Simulated yield at WTP is 40 Mld compared with the plat capacity of 54 Mld. It is also insufficient water to supply to the mini granary, especially during off-seasons.

Simulation 1b result shows that the system is able to supply to both WTP intake and the mini granary for main planting season, (See Figure **17.6 to Figure 17.8**).

Result Simulation 2 shows that the WTP intake will experienced one month shortages during the second dry year. However, this shortage will be overcome when the raising of Timah Tasoh dam completed, (See Figure **17.9 to Figure 17.11**).

Result Simulation 3 shows that the system cannot support both mini and minor scheme. WTP intake will experience few short period of shortages if minor scheme is to be included (see **Figure 17.12 to Figure 17.15**).

Result of Simulation 4 shows that the system is able to supply to both WTP intake and the mini granary for main planting season (See **Figure 17.16 to Figure 17.18**). The simulated yield is 98 Mld. The existing Timah Tasoh WTP with the design capacity of 54 Mld can be upgraded to 79 Mld to meet the 2050 demands (refer Section 18).

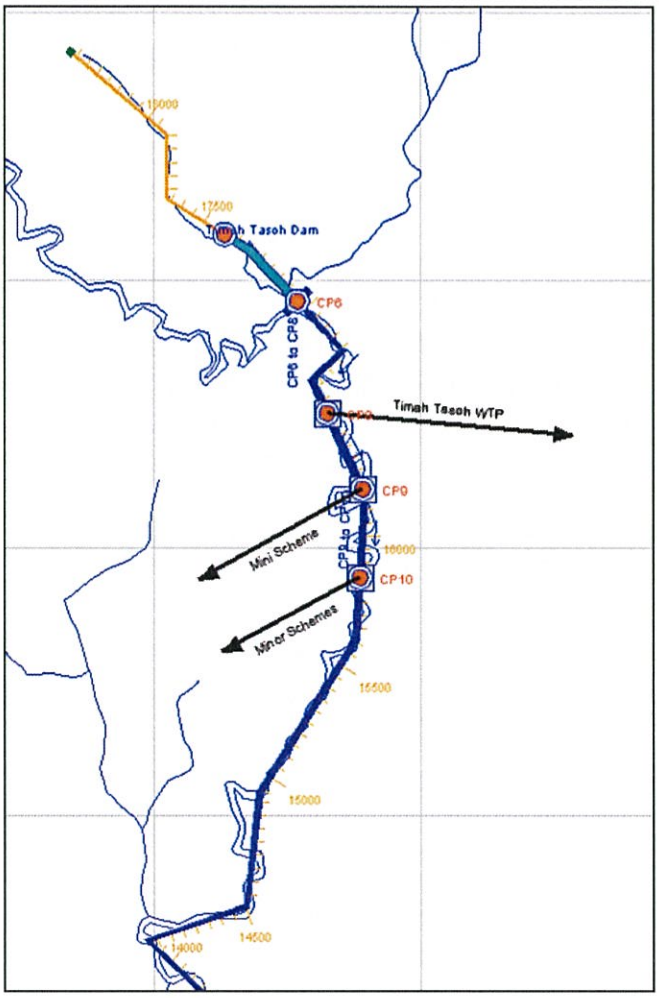


Figure 17.2 - Schematic Model Simulation for Timah Tasoh Dam

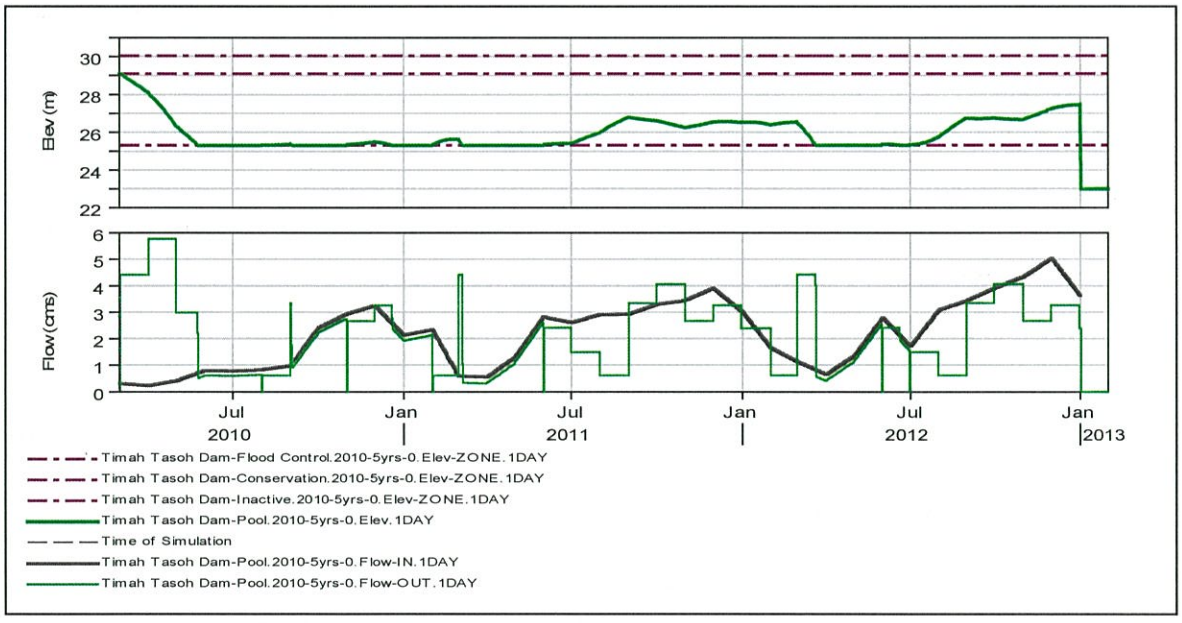


Figure 17.3 - Timah Tasoh Reservoir Water Level, Inflow and Outflow (Sim 1a)

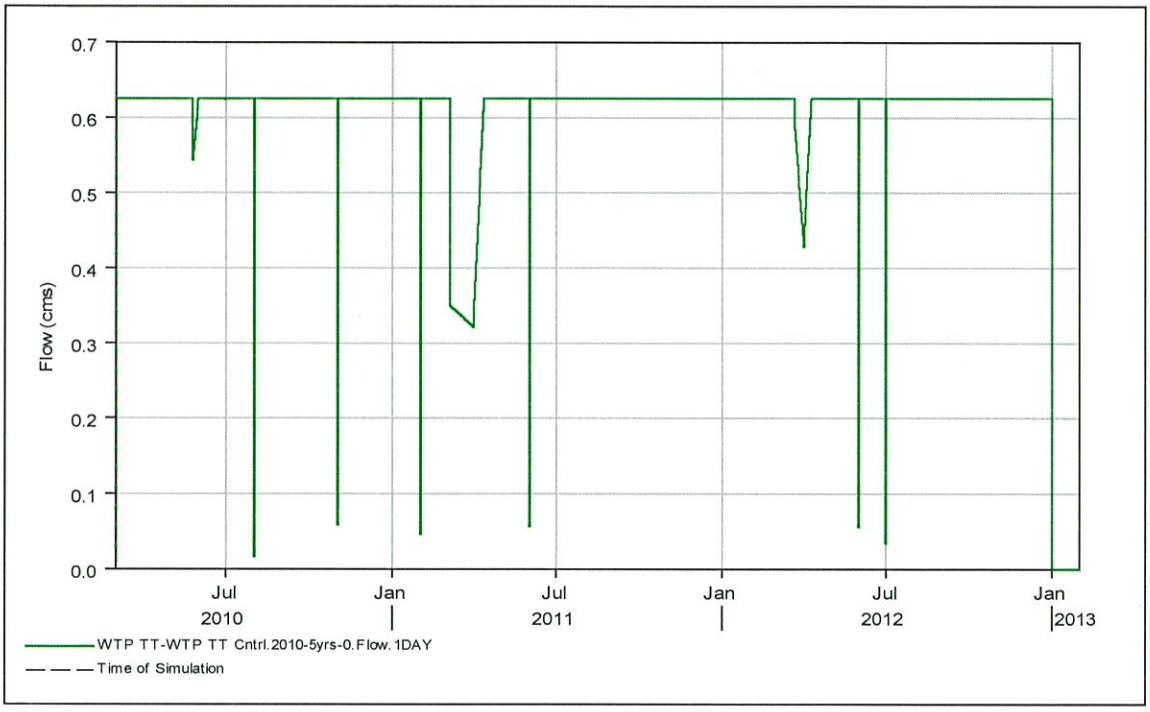
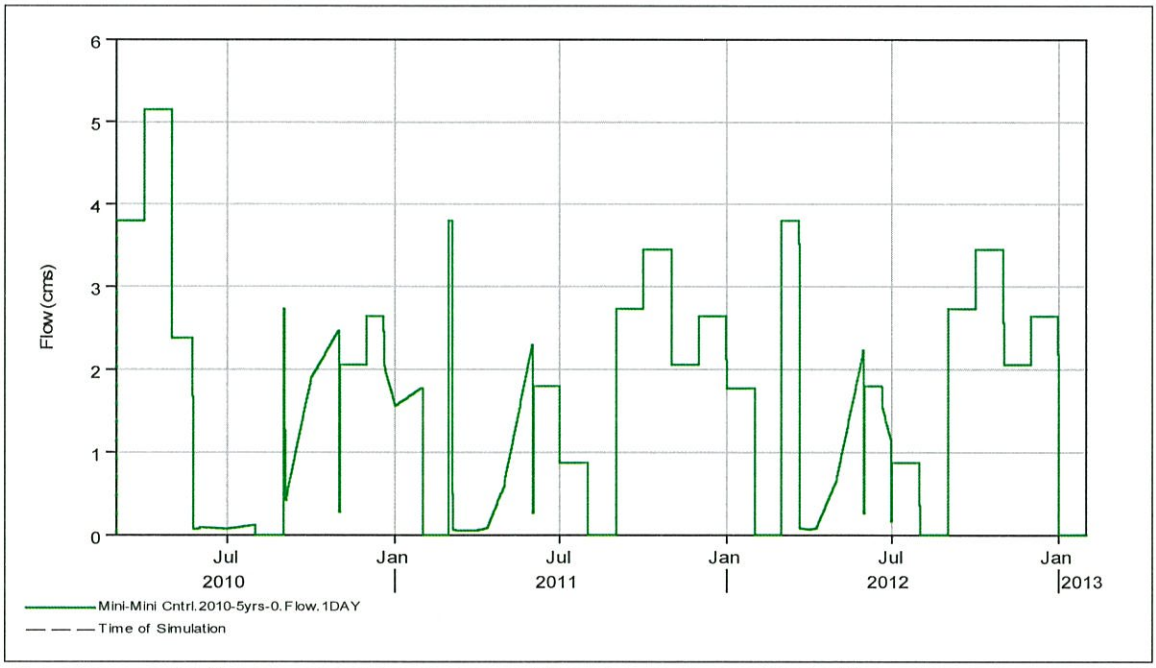


Figure 17.4 - Water Supply to WTP Intake (Sim 1a)



	1st Year		2nd Year		3rd Year	
	Off-Season	Main Season	Off-Season	Main Season	Off-Season	Main Season
Supply	28	25	13	33	17	33
Demand	36	33	36	33	36	33
%	78	75	35	100	47	100

*Supply/Demand in MCM unit

Figure 17.5 - Water Supply to Mini Granary Area (Sim 1a)

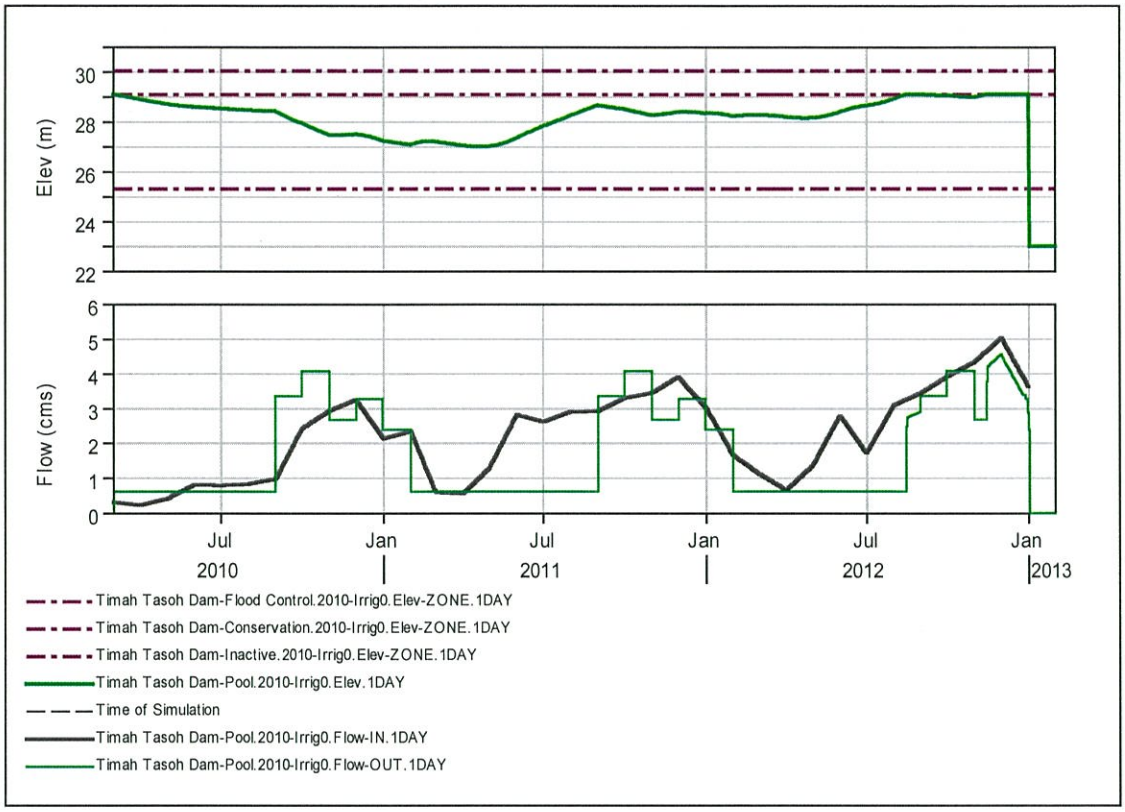


Figure 17.6 - Timah Tasoh Reservoir Water Level, Inflow and Outflow (Sim 1b)

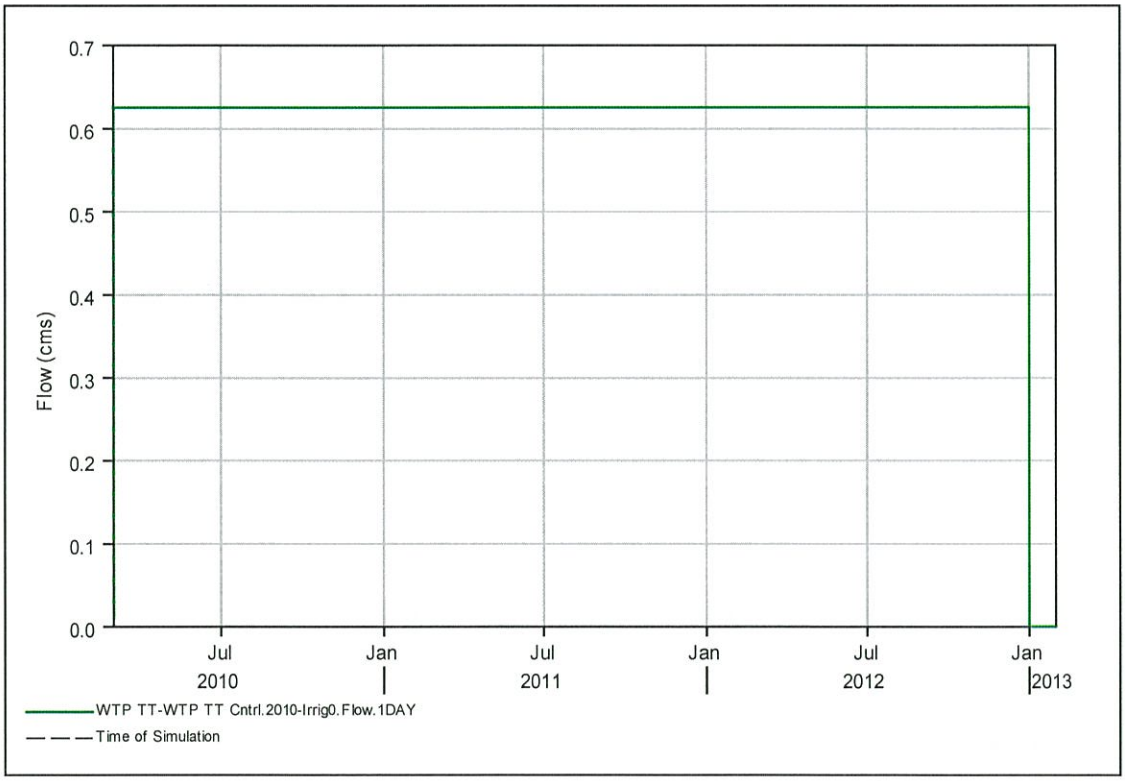
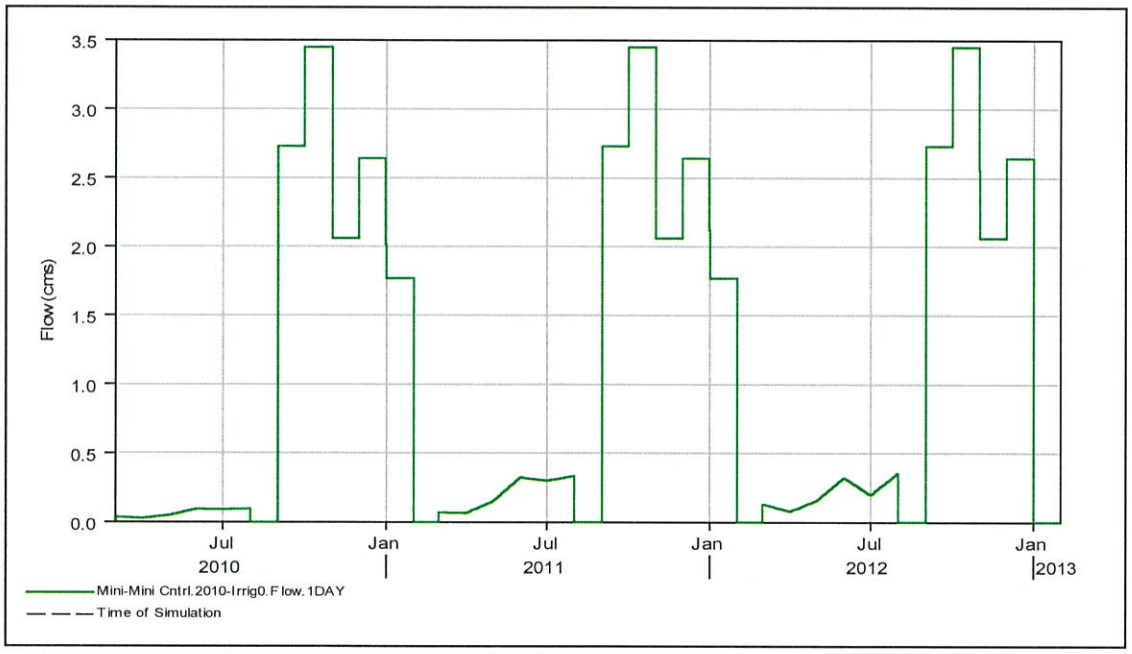


Figure 17.7 - Water Supply to WTP Intake (Sim 1b)



	1st Year		2nd Year		3rd Year	
	Off-Season	Main Season	Off-Season	Main Season	Off-Season	Main Season
Supply	-	33	-	33	-	33
Demand	-	33	-	33	-	33
%	-	100	-	100	-	100

*Supply/Demand in MCM unit

Figure 17.8 - Water Supply to Mini Granary Area (Sim 1b)

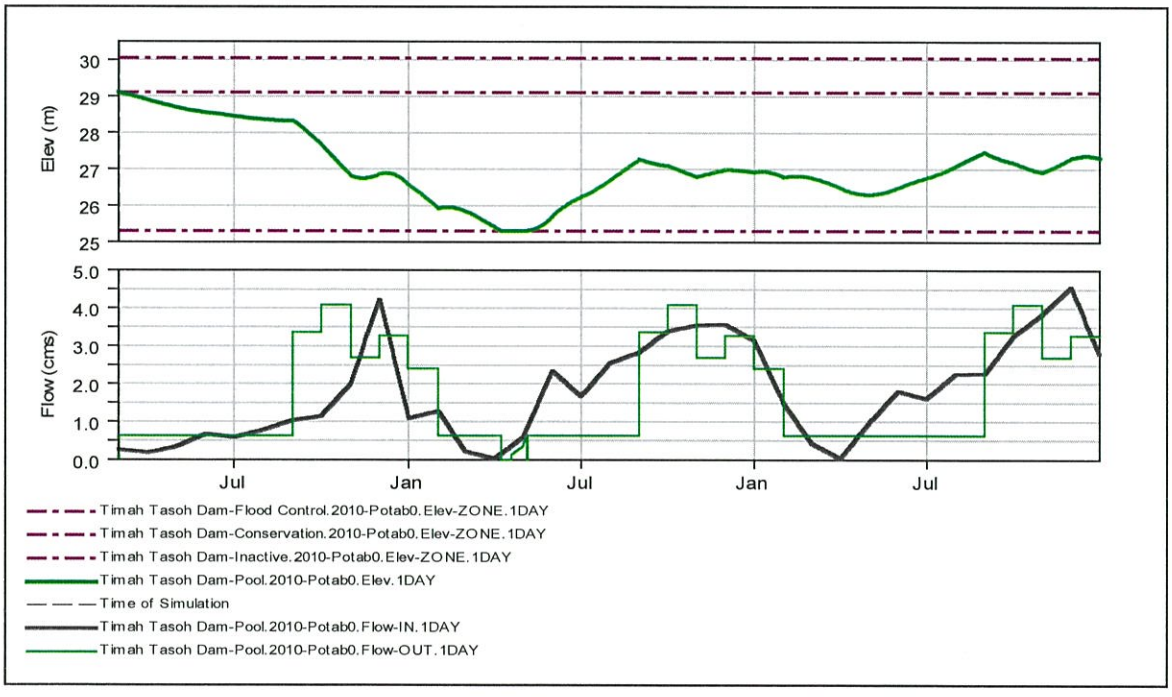


Figure 17.9 - Timah Tasoh Reservoir Water Level, Inflow and Outflow (Sim 2)

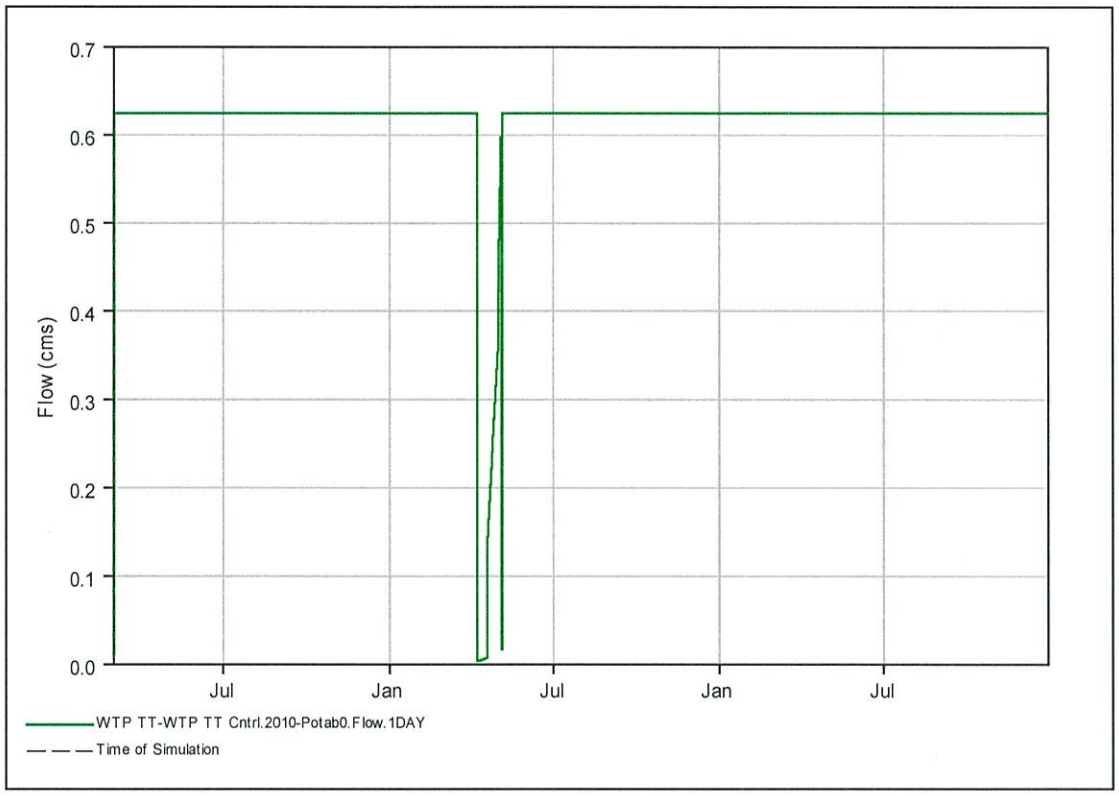


Figure 17.10 - Water Supply to WTP Intake (Sim 2)

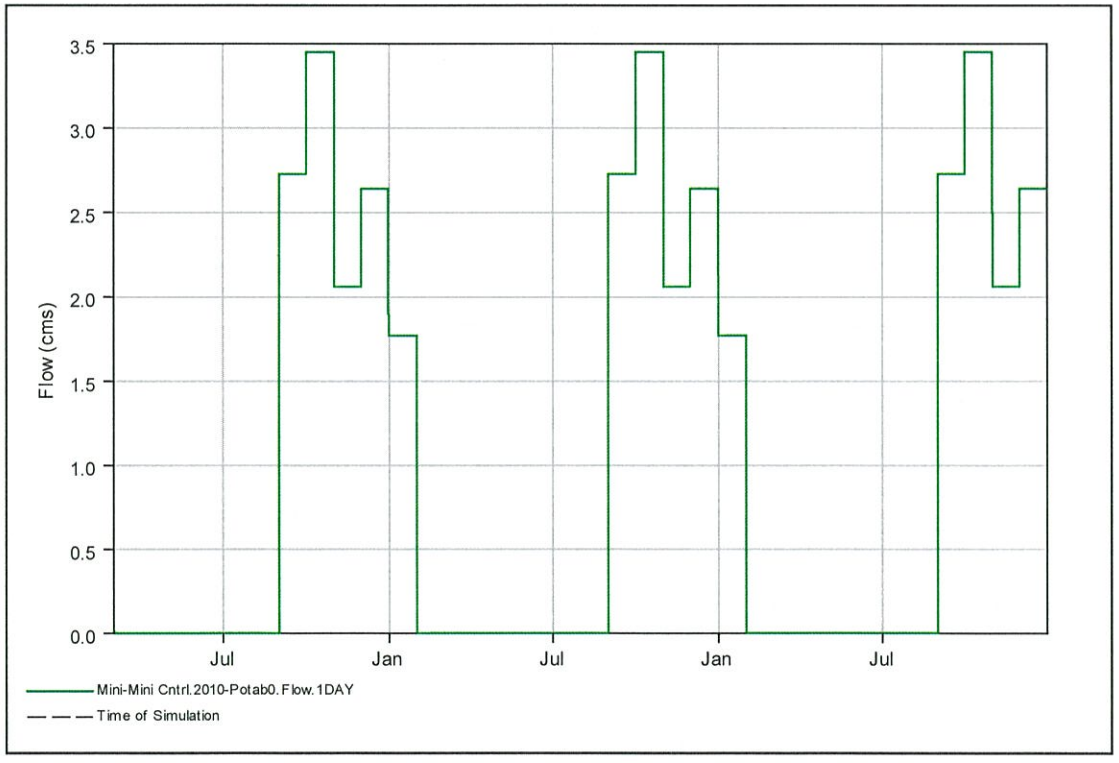


Figure 17.11 - Water Supply to Mini Irrigation Scheme (Sim 2)

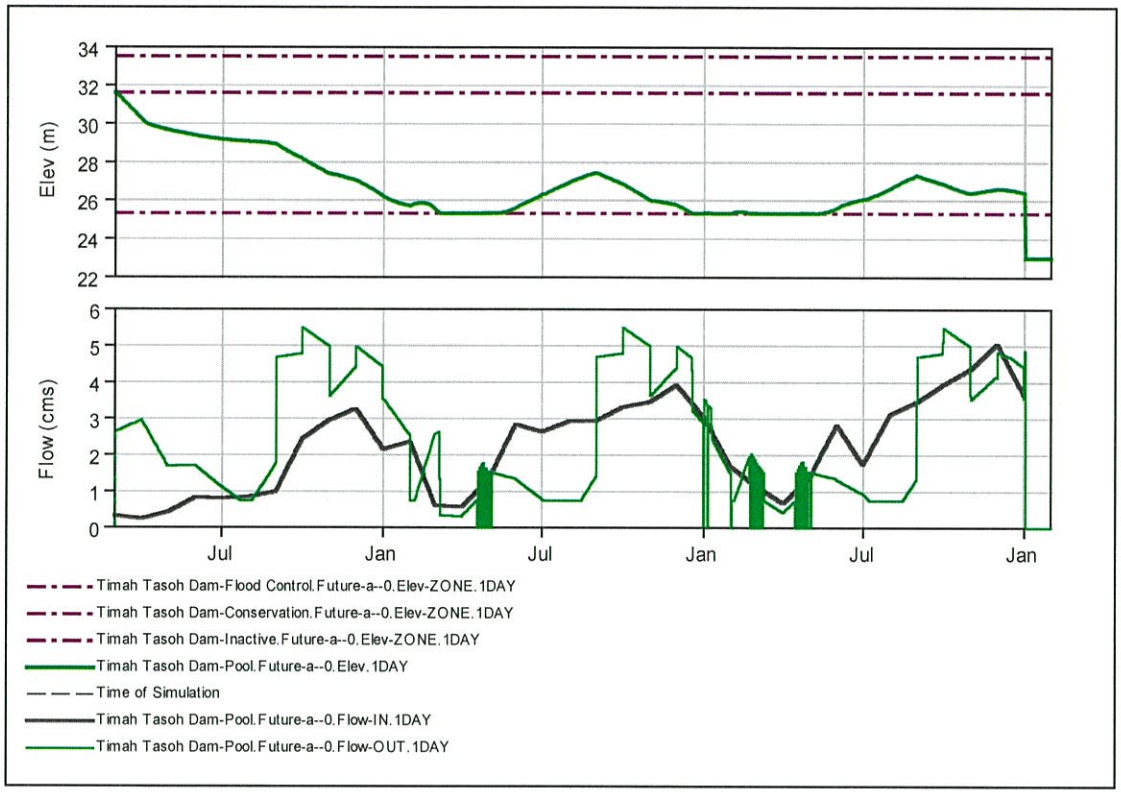


Figure 17.12 - Timah Tasoh Reservoir Water Level, Inflow and Outflow (Sim 3)

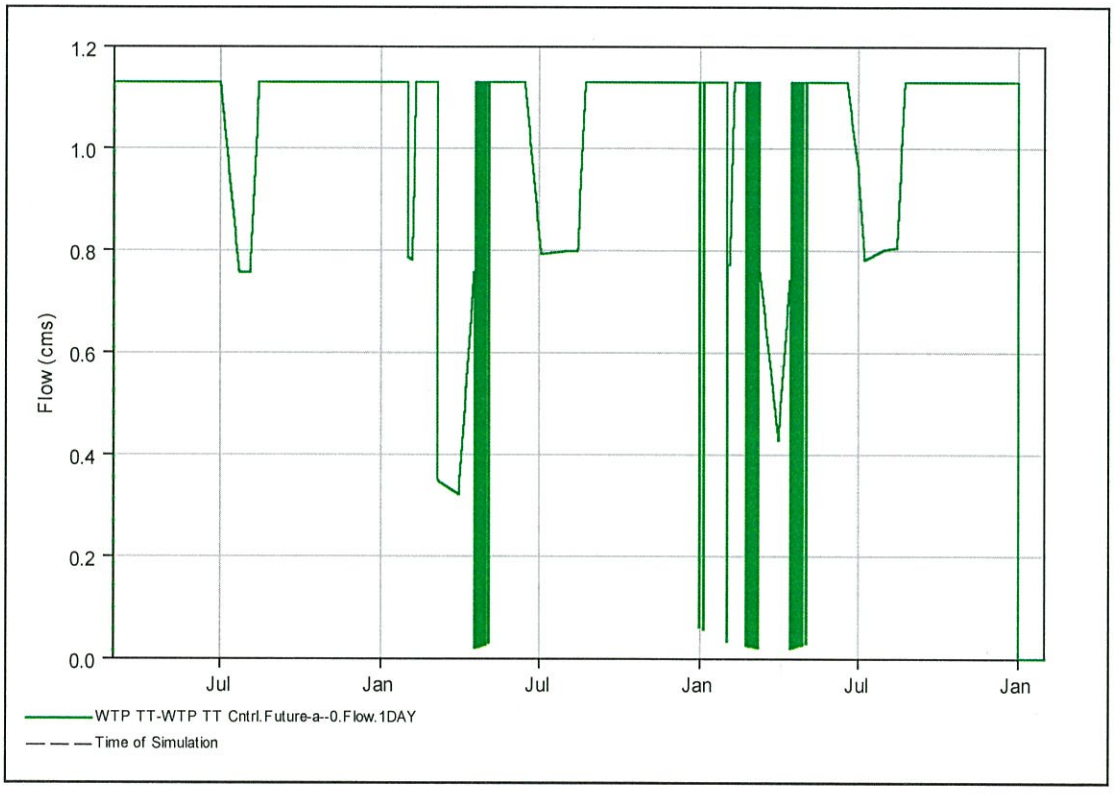


Figure 17.13 - Water Supply to WTP Intake (Sim 3)

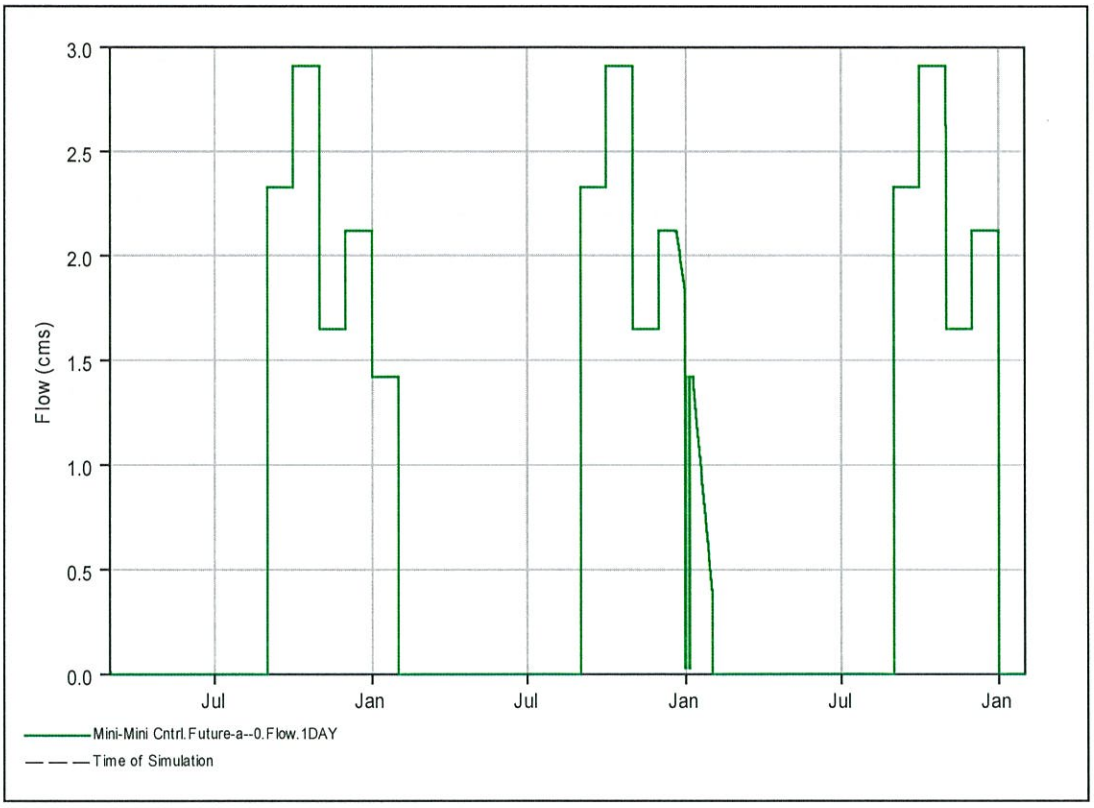


Figure 17.14 - Water Supply to Mini Granary Area (Sim 3)

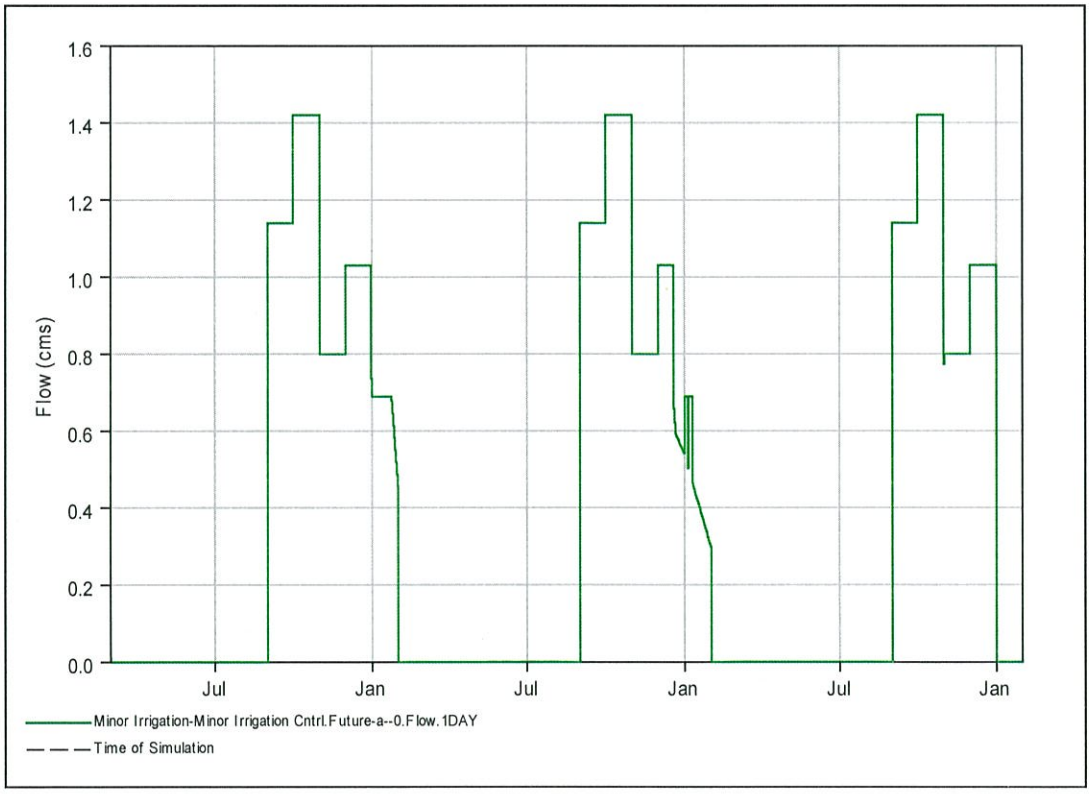


Figure 17.15 - Water Supply to Minor Irrigation Scheme (Sim 3)

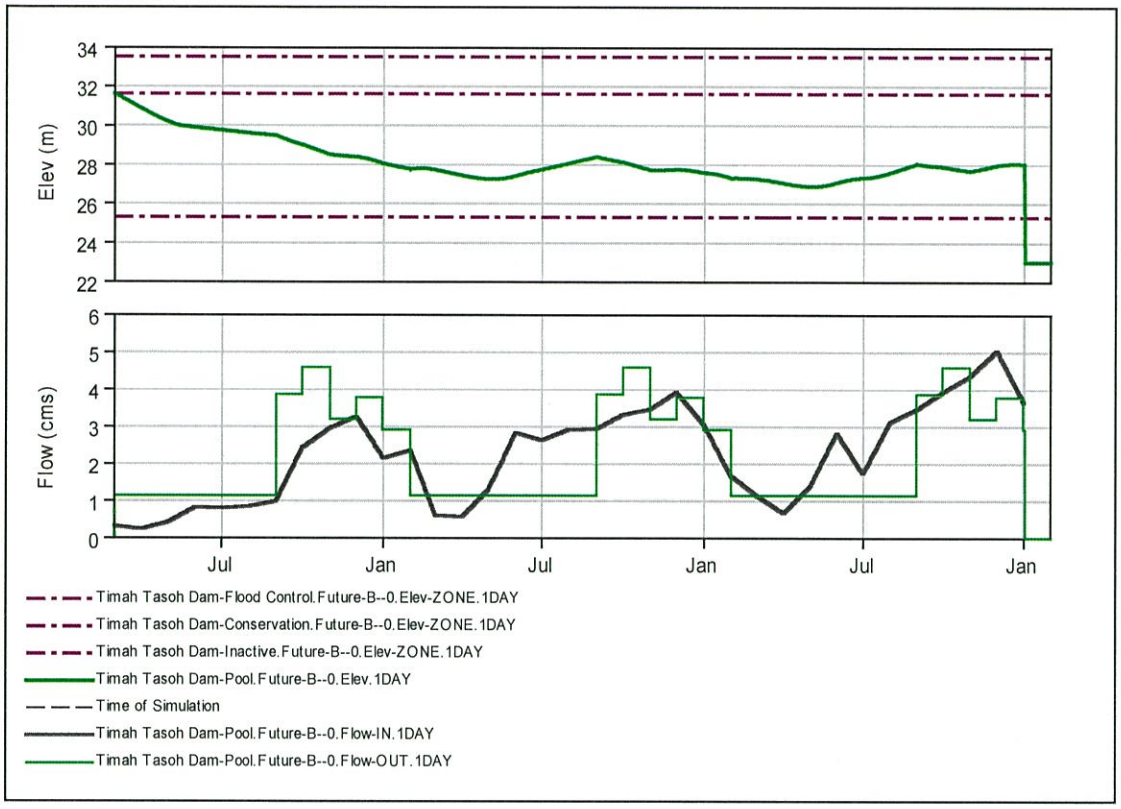


Figure 17.16 - Timah Tasoh Reservoir Water Level, Inflow and Outflow (Sim 4)

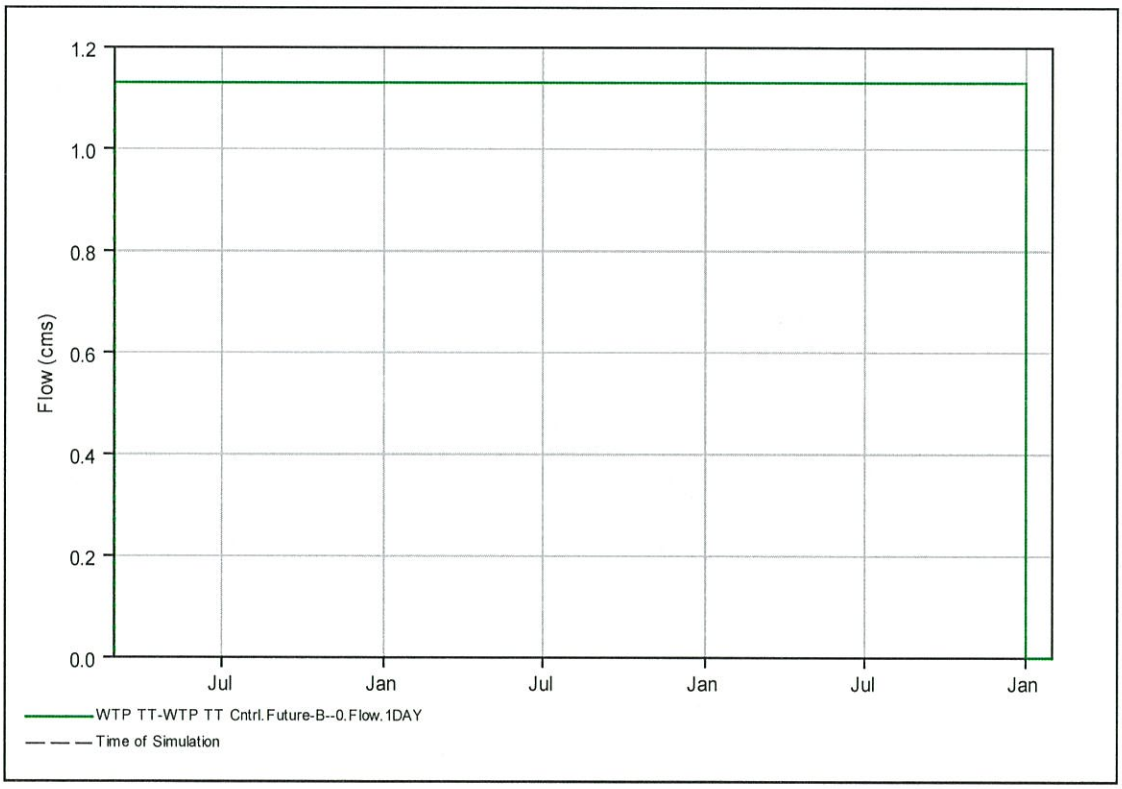


Figure 17.17 - Water Supply to WTP Intake (Sim 4)

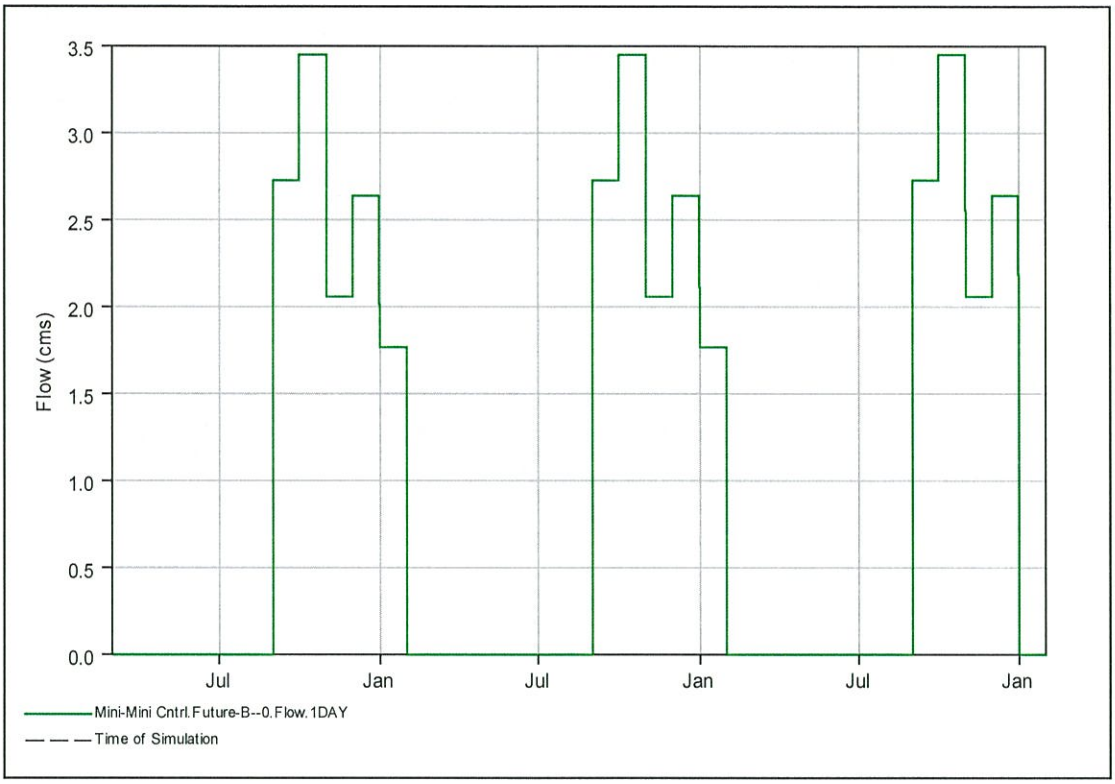


Figure 17.18 - Water Supply to Mini Granary Area (Sim 4)

17.5 SUMMARY

Present raw water resources in Perlis are not able to meet potable and irrigation demand under the design drought condition. Paddy planting is only viable for main planting season. It is insufficient to supply to the mini granary areas, especially during off-seasons. Raising of Timah Tasoh dam is needed to enhance the system.

Water resource from Sg Kedah via Northern Canal will be the main source of water for the future WTP's in Perlis. Due to limited water resources, paddy planting for minor scheme is not recommended.

The projected domestic demand for state of Perlis is estimated at 206 Mld by year 2050. After completion and commissioning of Timah Tasoh Dam raising by 2015, The proposed source works to meet water demand until 2050 is not required, however, raw water in Perlis State is adequate for potable water supply until year 2050 which depends on the interstate raw water scheme, MADA irrigation scheme (Northern Canal) regulated by four dams in Kedah.

The raw water resource for potable water supply is shown in **Table 17.8**.

Table 17.8 - Proposed Water Source Works and Yield

	Existing, On Going and Proposed Source Works	Additional Yield (Mld)	Cumulative Net Reliable Yield (Mld)
1.	Total existing water source *	-	234
2.	Raising of Timah Tasoh Dam	48	282
3.	Arau V (2025)	38	320
4.	Arau VI (2035)	50	370

Note:
1. *Refer Table 18.1
2. Refer Section 18 for detail source work development.
3. Design capacity of the WTP is adopted as the additional yield for the future source work development.

17.5.1 List of Reference

(i) SMHB, Ranhill and JPZ, Unit Perancang Ekonomi Kerajaan Malaysia, 2000 *Kajian Sumber Air Negara 2000 – 2050 (Semenanjung Malaysia).* (NWRS (2000))

(ii) Japan International Cooperation Agency (JICA), 1982. *National Water Resources Study, Malaysia.* Government of Malaysia (JICA 1982).

(iii) Perunding Kejuruteraan Perdana , 2009, *Integrated Water Resources Study For The Northern Region Of Peninsular Malaysia, Department of Irrigation and Drainage, Malaysia* (IWRSNR 2009).

(iv) ACE-RPM, 1996 *Feasibility Study for Raising Timah Tasoh Dam, Perlis.*

(v) SMHB, 2009 *Master Plan Study for Potable Water Supply in Pulau Pinang until Year 2050.*

(vi) MOA, Wiranda and JPZ, *Detailed Environmental Impact Assessment for the Construction of Paya Peda Dam, Besut, Terengganu Draul Iman, Jan 2010.*

SECTION 18

DEVELOPMENT WORKS

Section 18

DEVELOPMENT WORKS

18.0 DEVELOPMENT WORKS

18.1 DEVELOPMENT WORKS - POTABLE WATER SUPPLY

18.1.1 Basis

The State of Perlis with an area of about 821 sq. km is the smallest State located in the northern part of the west cost of Peninsular Malaysia. It supports a population of about 204,000 persons as in the 2000 census. It is estimated that the population in 2010 will reach 245,600 persons.

The Sg Perlis runs through the centre of the State. Sg Timah, Sg Tasoh, Sg Arau, Sg Baru, Sg Terap, Sg Temenggong, Sg Siran are main tributaries of Sg Perlis.

There are total of 2 ground water sources, Felda Chuping and Semadong utilized for water supply.

Paddy cultivation is the largest water consumer in the northern States, the irrigation sectors in Perlis consumes 70% of the water resources.

18.1.2 Existing Potable Water Supply System

18.1.2.1 Existing Source Works and Capacity

Sg Perlis has two main basin, Sg Arau and Timah Tasoh basins. Sg Arau joins the Arau canal of MADA irrigation scheme. The source of water is from Sg Muda system in the Kedah State. The study on Arau dam is technical feasible as reported by WMK Consultant, however the reservoir will inundate the existing sugar plantation. Its catchment areas is about 62 Km^2.

The main two rivers, Sg Timah and Tasoh are draining into Timah Tasoh dam. Its catchment area is 191 Km^2 with active storage of 33.3 MCM. Timah Tasoh dam is the only existing dam in Perlis which constructed for irrigation and water supply purposes. The irrigation scheme depends on the available river flow and the release of water from Timah Tasoh dam.

There are total of 2 ground water sources, Felda Chuping and Semadong utilized for water supply.

18.1.2.2 Treated Water System

Table 18.1 shows the list of existing water treatment plants in Perlis. There are total of 5 Nos of water treatment plants with plant capacity of 234 Mld. **Figure 18.1** shows the existing water treatment location.

Table 18.1 - Existing Water Treatment Plants

Item	Location	Plant Design Capacity (Mld)
1	Loji Air Arau (Phase I, II and III)	52
2	Loji Air Arau (Phase IV)	123
3	Loji Air Timah-Tasoh	54
4	Felda Chuping (ground water)	3.6
5	Semadung (ground water)	1.4
Total		**234**

An assessment has been carried out under the Immediate Water Supply Works which is a sub-component of this study to assess the sufficiency of the present water supply systems to meet demand to 2020 and to recommend schemes to satisfy this demand. Based on this sub-study, the projected water demand for North-West of Perlis (Timah-Tasoh WTP is the only one WTP to supply water to North-West of Perlis) is expected to reach 59.4 mld by 2020. Hence, a shortfall in supply capacity will be experienced.

There is no run of the river system on Perlis State as all the water treatment plants obtain raw water from river which is regulated by Dam.

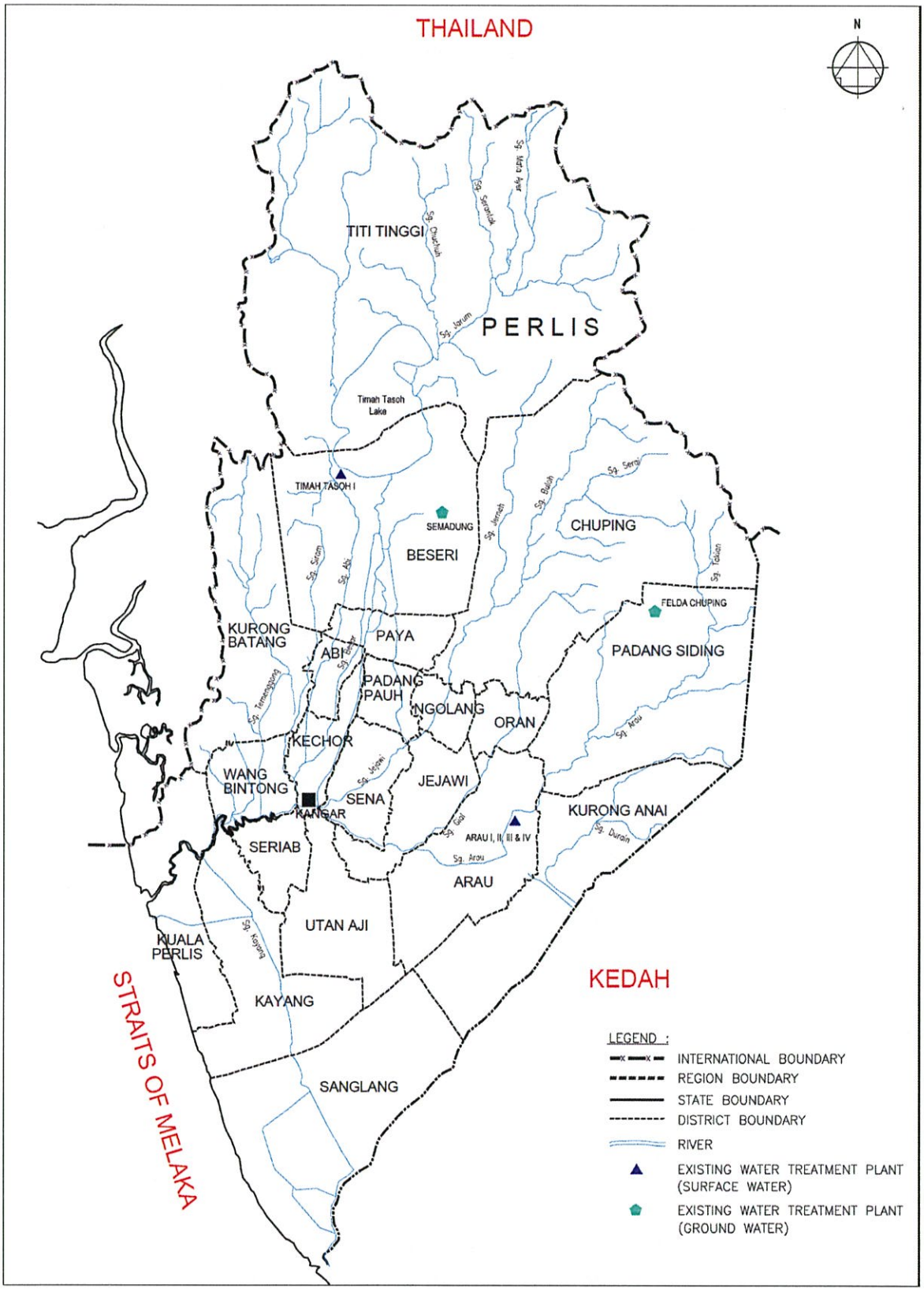


Figure 18.1 - Existing Water Treatment Plants to Meet Short Term Demand

18.1.2.3 Non Revenue Water Status

This is an important factor which has a significant impact on the total water demand The NRW is summarized in **Table 18.2**. The NRW is presently very high being 31.2% and 44.7% for 2008 and 2009 respectively.

Table 18.2 – Non Revenue Water Status

Year	NRW (%)
2000	43.8
2001	39.2
2002	40.0
2003	41.6
2004	32.8
2005	36.3
2006	35.5
2007	34.2
2008	31.2
2009	44.7
2010*	40.7

Source: Jabatan Kerja Raya Negeri Perlis
* based on Jan 10 – June 10 records from JKR Perlis

18.1.2.4Existing Treated Water Supply Networks

The state water supply company typically has a water supply master plan to facilitate the planning of the state's water resource and water supply. The planning horizon of such master plan usually covers a period of approximately 20 to 25 years, and takes into account the followings:

(i) Latest available population data and projection within the planning horizon.

(ii) Water consumption data.

(iii) Anticipated economic scenario and population growth.

(iv) Projected water demand based on the development scenario considered.

(v) Availability of water resource by considering factors such as hydrological yield, terrain, saline intrusion effect, etc.

(vi) Carry out water resource development planning by identifying suitable and feasible projects for the abstraction of raw water, treatment system/capacity and the treated water supply networks to supply water to the consumers.

The master plan is used to guide and aid the water supply authority in the planning of the water resource and supply development for the state. However, the exact timing

for the implementation of the development works depends on the actual growth in the water demand. Periodic review and assessment needs to be carried out (say every 5 to 10 years) to account for any major planning and development that have taken place which have significant impact on the water demand.

In this Study, various water supply planning reports have been reviewed to ascertain both the recommended water resource development projects (intakes, dams, water transfer facilities) and also the proposed works to upgrade the treated water supply networks. The treated water works proposed in this Study are both extensive and exhaustive have been extensively described in relevant chapters of this report and are not be dwelled in further details here. Generally the proposed treated water system upgrading works include the followings:

(i) Construction of a new water treatment plant in conjunction with the upgrading of the raw water intake works

(ii) Provision of new intermediate booster pump stations, if necessary

(iii) Construction of new storage reservoir (either ground or elevated reservoirs)

(iv) Laying and commissioning of new pipelines

(v) Pipeline replacement works to supplant the existing old pipelines to reduce leakage

(vi) Increase pumping capacity of existing pumps e.g. by modification works to the pump impellers

Generally, the treated water supply distribution in the state is satisfactory. Common causes of interruption to the water supply distribution include power supply disruption at the WTPs and pumping stations and damage to the in-line booster pumps.

Some high ground areas especially the northwestern part of Perlis experienced water supply problem. This is largely due to the Timah-Tasoh WTP which serves the northern part of Perlis being currently overloaded. The proposed upgrading of the Timah-Tasoh WTP will help to improve the water supply system in northwestern Perlis.

18.1.2.5 Existing Laboratory Testing Facilities

In general, water treatment plants should be able to produce treated water that complies with the relevant health standard to ensure that the water treated is safe for consumption by the water consumers.

Standard for treated water for drinking for consumption is provided by the Ministry of Health (MoH). For raw water, the main parameters measured include BOD, COD, DO, TSS, turbidity and coliform counts. As for treated water, key treated water quality

parameters based on the standard by MoH are turbidity, colour, pH, iron, manganese and aluminium. Another treated water parameter monitored as a measure of the performance of the treated water services is residual chlorine.

There are three water treatment plants in Perlis with each design treatment capacity of 52 Mld (Arau (Phase I, II and III) WTP), 54 Mld (Timah-Tasoh WTP) and 123 Mld (Arau (Phase IV) WTP).

Generally all the WTPs are equipped with adequate laboratory testing equipment to measure the quality of treated water produced. At the minimal, these WTPs are equipped with laboratory testing equipment to gauge the quality of raw water and treated water produced by the plant. The most common equipment is the jar test equipment. Jar test is a common laboratory procedure used to ascertain the optimum chemicals dosing to be used based on the incoming raw water quality. Jar test simulates the coagulation/flocculation process in a water treatment plant and helps the plant operators determine the right amount of chemical to be used, whether the desired plant performance is achieved or whether further improvement can be. Because it mimics full-scale operation, jar tests can be used to determine which treatment chemical (and dosage) will work best with the respective raw water abstracted. In short, the jar test enables the optimization of the treatment chemicals used, which is the key to an efficient operation of the water treatment plant. However, it was not known whether the equipment are functioning properly, or whether they are utilized in the correct manner.

Difficulties Encountered

Some of the difficulties encountered related to the laboratory testing equipment are:

(i) Lack of monitoring on the status/condition of the equipment (some equipment are no longer functioning and not replaced)

(ii) Insufficient funding for maintenance/repair costs especially due to lack of local maintenance personnel

(iii) Operation and maintenance difficulties due to lack of capable personnel which results in the malfunctioning of the equipment

(iv) Improper recording of water quality results resulting in loss of data for assessment of equipment and plant performance

Improvement Measures

Measures for improvement to ensure the adequacy of laboratory testing equipment in water treatment plants for gauging the treated water quality includes:

(i) Constant monitoring of the conditions of the testing equipment

(ii) Provision of sufficient funding for maintenance of the testing equipment

(iii) Ensure proper training to the plant operator to minimize damage or errors due to mishandling or incorrect use of equipment

(iv) To carry out separate detailed review on all water treatment plants. Obsolete equipment to be replaced

(v) Proper and systematic recording of data collected for review by the engineer and to check the performance of the equipment

(vi) Computer-based data management systems (at the headquarters or divisional/district office level) for effective management, storage, analysis and presentation of water quality data

The various water treatment plants in the state, and the adequacy of the laboratory testing equipment for each respectively plant are as summarized and listed below:

	WTP	Adequacy of Testing Equipment
1	Arau (Phase I, II and III)	Adequate
2	Arau (Phase IV)	Adequate
3	Timah-Tasoh	Adequate

18.1.3 Review Of Development Works In NWRS 2000

18.1.3.1 Status of Development Works Proposed

18.1.3.1.1 Water Source Works

Table 18.3 shows the proposed water source works identified under the NWRS 2000.

Table 18.3 – Proposed Water Source Works under NWRS 2000

Source Works	Yield as stated in NWRS 2000	Year of Commissioning (NWRS 2000)	Current Status
Raising of Timah Tasoh Dam	48 Mld	2009	Under construction

The latest detailed design of the Timah Tasoh Dam is raising the dam by 3.5m. This dam also serves as flood mitigation storage. The dam storage is increased from 33.3 MCM to 70.3 MCM. **Figure 18.2** shows the location of dam site. This dam is expected to be completed before 2015.

18.1.3.1.2 Water Treatment Plants

Table 18.4 shows the WTPs identified under the NWRS 2000 to be constructed by Year 2050. The total plant capacity need to be upgraded is 166 Mld by 2035, as proposed under NWRS 2000. The assessment

indicates that total plant capacity upgraded to-date is 123 Mld, which is about 74% of the plant capacity proposed under NWRS 2000.

Table 18.4 – WTPs Identified Under NWRS 2000

Water Treatment Plants	Proposed WTP capacity	Year of Commissioning (NWRS 2000)	Current Status
Arau IV	30 Mld	2000	Completed at end of 2009 and operating in beginning of 2010.
Timah Tasoh	48 Mld	2009	Not started
Arau V	38 Mld	2025	Not started
Arau VI	50 Mld	2035	Not started

18.1.3.2 Work Developed but Not Proposed under NWRS 2000

There is no works carried out which is not proposed under the NWRS 2000.

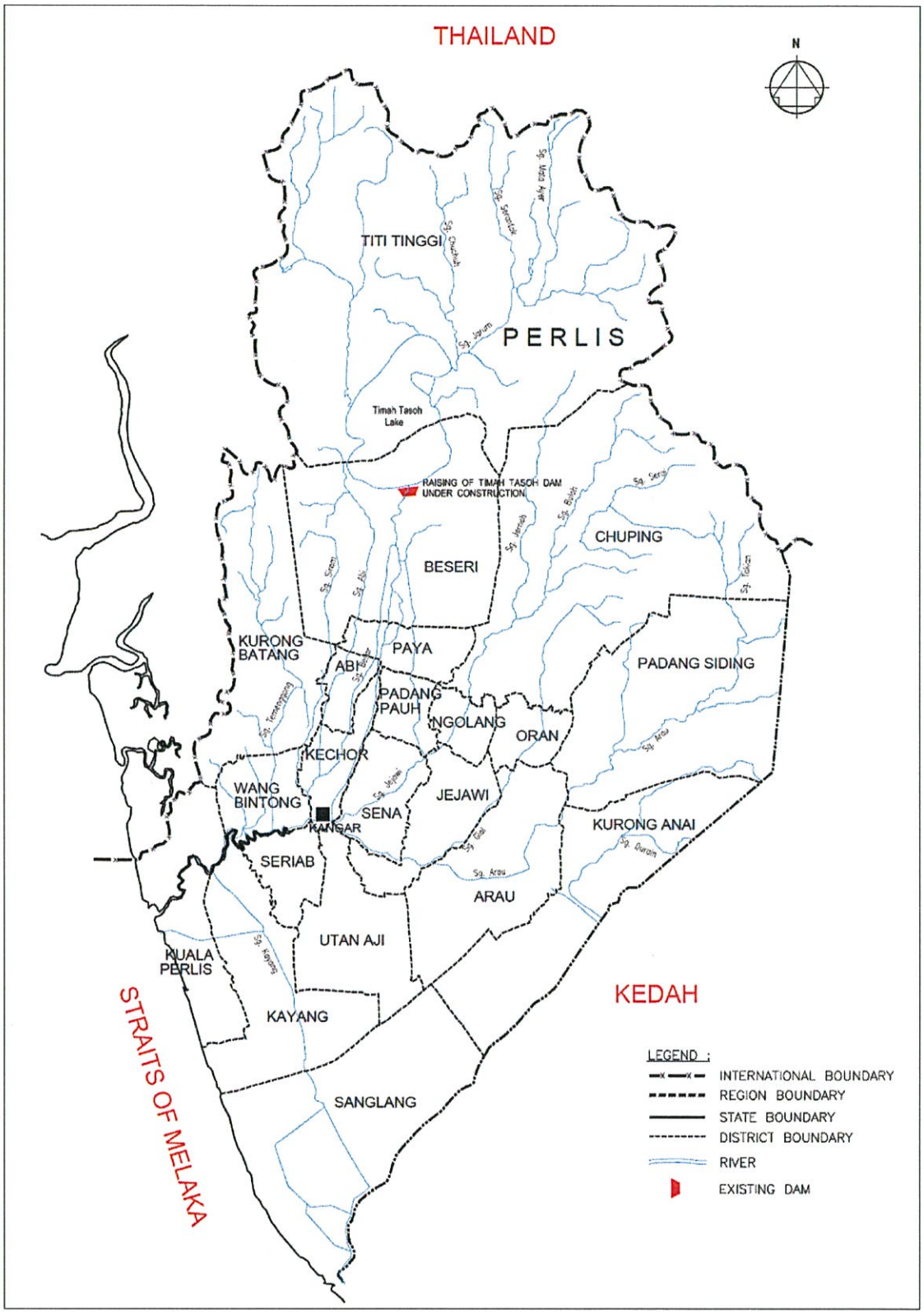


Figure 18.2 – Existing Dam Location

18.1.4 Recommendations for Development Works And Implementation Programme

18.1.4.1 Raw Water

18.1.4.1.1 Dam and Storages

After completion and commissioning of Timah Tasoh Dam raising by 2015, The proposed source works to meet water demand until 2050 is not required.

18.4.1.2 Inter-basin/ Inter-state Raw Water Transfer

Currently, raw water in Perlis State is adequate for potable water supply until year 2050 which Sg Arau basin depends on the interstate raw water scheme, MADA irrigation scheme regulated by four dams in Kedah.

18.1.4.3 Treated Water Supply System

The capacity of the WTPs either singly or collectively should exceed the projected water demand. This is to enable the water system to function when the demand departs from the average annual water demand due to daily variation, outages of WTPs and other operationally problems. A loading over and above the projected annual demand is, therefore, necessary.

The level of loading depends on the operational needs of the water supply system, which in turn is dependent on the following factors:

(i) Daily variation in a year. It has been found that there are seasonal peaks varying from 4% to 7% over the annual average daily rate especially during the festive seasons.

(ii) Actual demand growth rates higher than the projection. There is always a possibility that the economy may perform better than projected resulting in higher industrial water demands and domestic demands brought about by higher immigration labour.

(iii) The risk of water deficit in the daily operation of industries especially those highly dependent on the continuous supply of water for their manufacturing processes which would have to be aborted with heavy financial losses.

(iv) Sudden increase in demand of specific high water using industries may be attracted to the particular area that may put an immediate stress on water supply.

(v) Shutdowns of WTPs due to power interruptions, breakdown of major equipment, schedule maintenance, forced shutdowns due to pollution of raw water that require other WTPs to support.

(vi) Unevenness in water demand across the State or district that does not allow some WTPs to operate to its full designed capacity.

(vii) Delays in commissioning of new WTPs.

(viii) The condition of the water assets.

(ix) The width of coverage.

Should the total capacity of the WTPs in the State equals the projected demand any of the above factors would trigger system failures that may occur several times in the year making the water supply system in the State unreliable for consumers and investors.

It is understood that SPAN is already working on a Key Performance Index (KPI) to determine a minimum buffer to ensure an acceptable level of service and as a guard against a system failure.

The power supply sector is already using a loading of about 25% minimum to ensure reliability of supply. This is an indication of the level of service from the production aspect which should be used as a guide for the security of water supply.

For the potable water supply system loading factor as shown in **Table 18.5** is proposed.

Table 18.5 – Proposed Loading Factor For Water Supply

Aspect	Loading (%)
Daily peaks	7.0
Unaccounted increase in growth rates	1.5
Sudden increased in industrial demand due to high water demand industries	2.0
Scheduled and unscheduled WTP shutdown	4.0
Fluctuation in water demand	3.0
Others	2.5
Total Loading	**20.0**

Hence, for determining the recommended WTP capacity in this study, a buffer of 10% has been allowed over the projected water demand from 2010 – 2015 and 20% buffer from 2020 – 2050.

(i) North-West of Perlis

Timah-Tasoh Water Treatment Plants (54mld) which is the only one WTP to supply the water to the North-West of Perlis State is currently overloaded and need to be upgraded.

Based on **Figure 18.3** below, can be noticed that the present WTP capacity

is not sufficient to meet the water demand until 2012 and Timah-Tasoh WTP will have to be upgraded until 79 mld capacity in order to meet the demand until 2050.

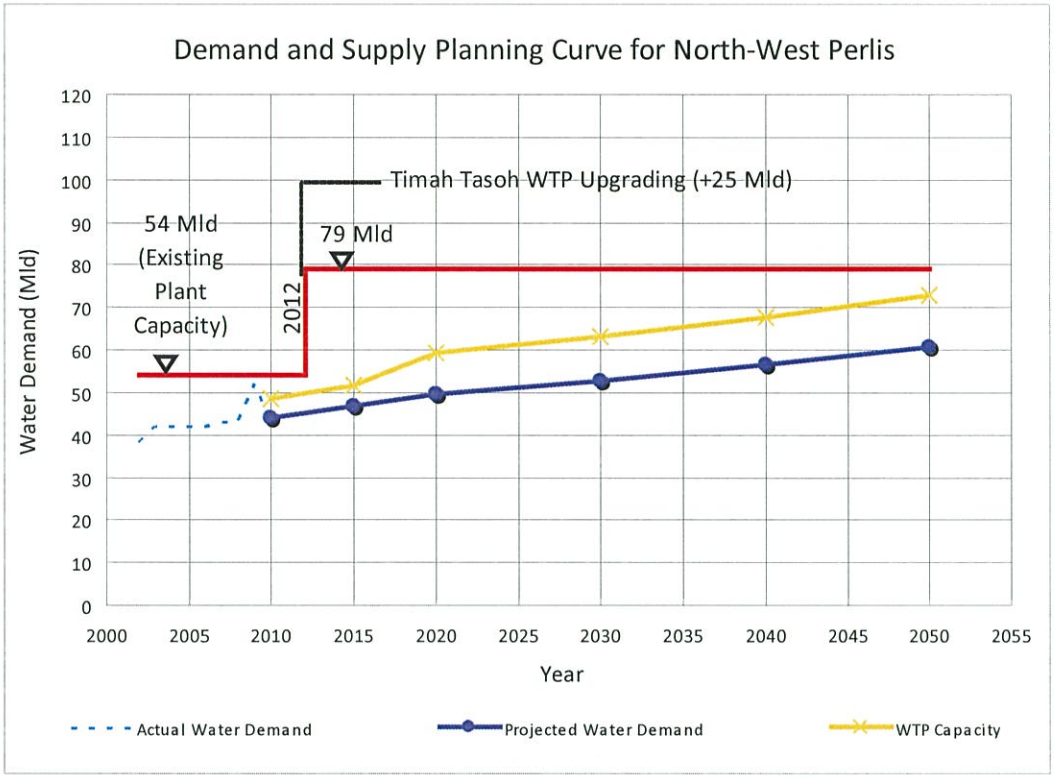


Figure 18.3 – Demand and Supply Planning Curve for North-West Perlis

(ii) South-East of Perlis

The demand and supply planning curve is shown in **Figure 18.4** and the existing WTPs capacity will be adequate to satisfy the demand of south-east of Perlis until 2050. Hence, no immediate works are proposed for south-east of Perlis.

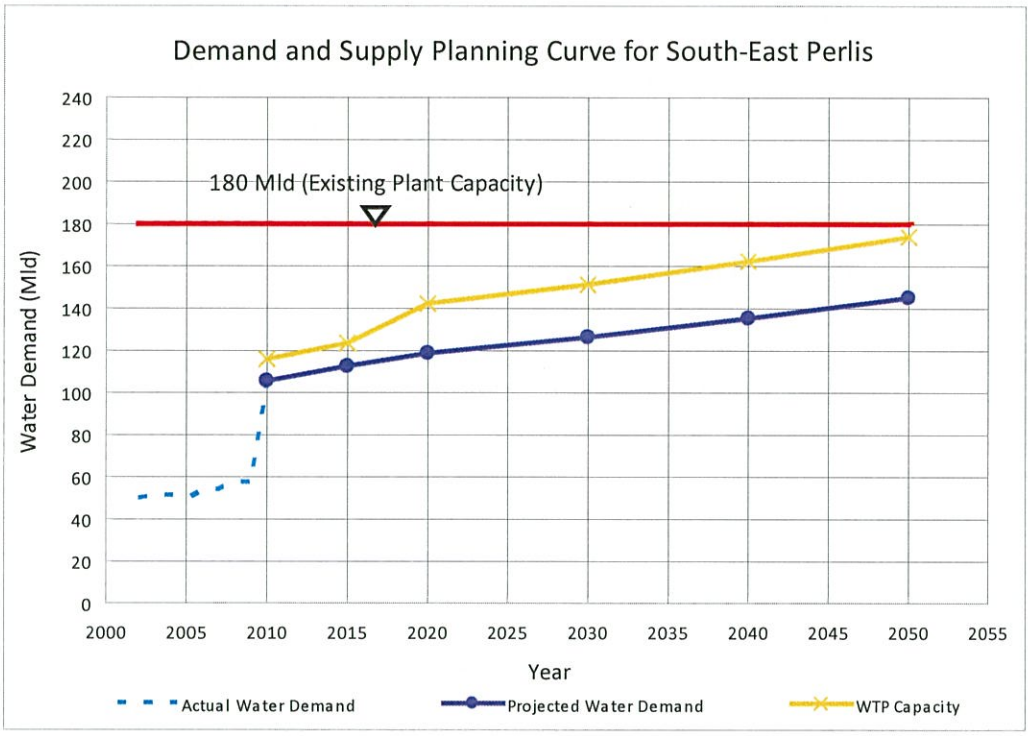


Figure 18.4 – Demand and Supply Planning Curve for South-East Perlis

18.1.4.4 Potential To Export

The water resource in Perlis is limited and there is no potential for Perlis to export raw water to other States.

18.1.5 Costing

The project cost components shall comprise of development of source works and water supply system. These works constitute the CAPEX works necessary to develop the water supply system.

Source works include:

(i) Dams, and/or
(ii) Barrages

Water Supply System shall comprise of:

(i) WTP

This includes the raw water intake, water treatment plant up to the clear water pumps.

(ii) Reservoirs

This includes the balancing reservoirs and other transmission reservoirs up to the terminal reservoirs. This allows for a total storage of the system of transmission reservoirs of 24 hours, the details of which has to be determined in a detailed feasibility study that follows this Master Plan Review.

(iii) Bulk Distribution Works

This constitutes the pipe mains from the clear water pumping station to the terminal reservoir to be developed to transfer water to the demand areas. As such it would exclude any reticulation mains.

It has been noted that the existing water supply system may have a disproportionate development of above three (3) components as their respect development may be phased due to budget constraints and other planning factors.

It is also a practice to have a longer WTP development horizon than that of reservoirs and transmission mains resulting in the capacities of reservoirs and transmission mains lagging in capacity than the WTP. This is because WTP are bulkier structures while the remaining 2 components can be developed in smaller discrete units.

The Master Plan will assume a total development of all 3 components as the scheduling of the 3 components cannot be determined at this stage. A detailed feasibility study would be necessary to determine this aspect.

However, should development of the component lagging downstream of the WTP is identified, it would be proposed then.

NRW works are excluded from the CAPEX works proposed in this Master Plan Development. NRW works are basically operational in nature with the objective to reducing systems leaks so as to optimize on the water supply system. The scope for NRW works involves detail analysis of each individual water system with respect to commercial and physical losses. This demands a more detailed feasibility study of each system in a State and is beyond the scope for any Master Plan Development.

The costing is based on macro costing of major components. There would be variations especially in the transmission mains which have to be sorted out in a detailed feasibility study.

Table 18.6 - Details of Cost Components

Component	Estimated Cost (2010 prices)
WTP	RM 1.25 million per MLD
Reservoir/s	RM 0.6 million per ML
Bulk Distribution Works (20 km)	RM 1.0 million per MLD
Total System	**RM 2.85 million per MLD**

Table 18.7 shows the summary of the estimated cost for water supply system. No source work cost is required. The works need to be commissioned by the year 2012 and hence should be implemented immediately.

Table 18.7 – Project List and Costing for Development Work until 2050

Scheme	WTP Capacity Mld	Year of Commission	Cost (RM million)				
			Source works	Treatment works (RM Million)	Bulk reservoirs (RM Million)	Bulk Distribution works (RM Million)	Total Cost (RM million)
Perlis							
Upgrading Timah Tasoh WTP	25	2012		31.25	15	25	71.25
Total Perlis	25			31.25	15	25	71.25

18.2 DEVELOPMENT WORKS – IRRIGATION

This section describes the development works for irrigation requirement for the State of Perlis. The irrigation development works are derived from the water balance study which has been carried out in the review of irrigation water demand projection and water availability hydrological analyses. The proposed irrigation development works have been simulated by relevant modelling of existing water resources infrastructure in compliance to meet projected future water demand (refer Volume 3 Section 16 – Water Resources Planning).

The major existing irrigation water source is the Timah Tasoh Dam (completed in 1992) with storage capacity of about 33 MCM and catchment area of 191 km^2. The dam supply irrigation water to about 2,500 ha of the non-granary schemes downstream of the dam. The dam is located on Sg Korok about 2.5 km below the confluence of Sg Timah and Sg Tasoh.

The proposed water resources development projects in the previous NWRS Study 2000 have been reviewed. Data regarding irrigation development projects, such as those works currently being planned by the Ministry of Agriculture and Agro-based Industries, have been collected, assessed and presented in this report.

18.2.1 Proposed Development Works

The potential water resources project identified for irrigation in the State of Perlis is the raising of Timah Tasoh Dam. The status of this proposed project is described as follows:

18.2.1.1 Raising of Timah Tasoh Dam

The raising of Timah Tasoh Dam was proposed to be implemented in 2009 by the NWRS Study 2000. The proposed work comprises of the raising of the main dam embankment by 3.5 meter high and the construction of an additional saddle dam. The work is currently under construction and the physical progress is 77% (July 2010). The storage capacity of the dam will be increased from the existing 33 MCM to 70.3 MCM providing additional water storage for irrigation, potable water supply and flood mitigation benefits as well. The construction work is expected to be completed by year 2011.

18.2.2 List of Reference

(i) SMHB, RANHILL AND JPZ, 2000. *Kajian Sumber Air Negara 2000 – 2050 (Semenanjung Malaysia).* Unit Perancang Ekonomi Kerajaan Malaysia (NWRS 2000).

(ii) JAPAN INTERNATIONAL COOPERATION AGENCY (JICA), 1982. *National Water Resources Study, Malaysia.* Government of Malaysia (JICA 1982).

(iii) PERUNDING KEJURUTERAAN PERDANA (PKP), 2009, Integrated Water Resources Study For The Northern Region Of Peninsular Malaysia, Department of Irrigation and Drainage, Malaysia (IWRSNR 2009).

(iv) PERUNDING JASA SDN. BHD., 2009, Sarawak Integrated Water Resources Management Master Plan Study (SIWRM 2009).

18.3 DEVELOPMENT WORKS - GROUND WATER

The sustainable development, management and usage of ground water must take place within the broader context of integrated water resources management. As a pre-condition to effective ground water management, a full assessment of all water resources in Perlis should be conducted. This requires the protection of both ground water quality and quantity and must take into account the interconnection between ground water and surface water systems.

As a start, the limestone bedrock (Chuping Limestone formation), the gravels and sands in sub-alluvial valleys and the upper 3 to 5 metres of coastal alluvium could be explored. The Sg Perlis Basin could also be explored for the construction of horizontal wells (as had been successfully demonstrated in Jeli, Kelantan, for domestic water supply).

18.4 DEVELOPMENT WORKS - FLOOD MITIGATION

18.4.1 Existing Flood Mitigation Schemes with Potential for Surface Water Resource Development

Flood mitigation deals with eliminating flood hazards by removing as much water as possible from the flooded area and discharge them harmlessly into the sea. In this respect, it is virtually taking water out of the system, hence is contradictory to harnessing water resources. However, it is possible to use flood mitigation projects as a means of reclaiming water.

18.4.1.1 Flood Detention Ponds

Just like the flood dam, flood detention ponds are made to store excess floodwater that can then be released after the peak has passed to reduce peak flood flows downstream. Since flood detention ponds are smaller in size than with the flood retention dams, their capacity are generally small. If not supported by pumps, they would be ineffective to cater for larger flood events.

Flood detention ponds may have the potential to be made multipurpose (water supply, recreation, water quality control and silt retention).

18.4.1.2 Disuse mining ponds

Disused mining ponds can be used as flood detention ponds. These ponds can be on-line or off-line. They can also be made into multipurpose use for another source of water supply.

18.4.1.3 Swamps and Wetlands

Swamps and wetlands also have similar concepts with the flood detention ponds. The only difference is that they are naturally formed, and have their own ecological system. Preservation of them can help in reducing the flood problem. They also help to purify the water that flows through it. An inventory of the wetland will be made to asses these requirements in the next line of action. The potential wet land area is at Lake Melawati.

18.4.2 Flood Forecasting

The provision of a flood forecasting and warning system is an important, practical and low-cost measure to minimize flood losses. Where the flood prone areas are not protected or inadequately protected against flooding and the area is of a high risk area (where human lives are at stakes), then the community here should be forewarned of any incoming floods for them to take necessary action to react on the event. The simplest is the installation of flood warning sirens.

The flood warning sirens will trigger the alarm when the water level reaches the critical level which is normally the level that touches the first house or any other level that the community

decides upon. The alarm will initiate the community to assess and react on the situation. Flood warning sirens are especially viable in flash flood prone areas.

Where there is enough lead time, flood forecasting models could be utilised to predict the future flood levels. For this system, it requires the combination of data, forecast tools, and trained forecasters. Increasing lead time increases the potential to lower the level of damages and loss of life. Forecasts must be sufficiently accurate to promote confidence so that the community will respond when warned.

18.4.3 Flood Management

Integrated Flood Management (IFM) is a series of collective activities based upon sustainable development principles, aimed at providing harmony between man and nature, normalizing flood control and operational activities into a rational approach, enhancing self-resilience capacities, and accepting a certain risk in moderation to utilize floodwaters as a resource to help improve the water environment.

The goal of flood management is to minimize loss of life and net damages through both structural and non-structural actions.

The new approach to flood management is to improve the functioning of a river basin as a whole, recognizing that floods can have beneficial impacts but can never be fully controlled (GWP and WMO, 2004c). Such an approach should maximize the productivity of the watershed while minimizing the flooding impact by implementing the various flood mitigation measures (structural and non-structural) over the watershed.

It is financially and physically impossible to provide complete protection from flooding because engineered system such as bunds and dams are constructed to operate within their designed limits. When the event exceeds the designed limit, flooding would be more serious. These flood protection structures, can lead to a false sense of security if communities do not know the limits of that protection.

Any flood control system will have some residual risk, the flood risk beyond that can be controlled by flood management. Due to the fact that flood control capabilities have their limitation, sound flood management practices aims to effectively allocate resources to reduce economic and safety risks.

Flood management policies can be more effective if they account for interdependencies of the entire system as well as changes in land-use, climate and infrastructure (Madani, et al, 2007). Reducing flooding in one place can increase flooding elsewhere. A portfolio of structural and non-structural actions can be an effective and efficient approach to flood management.

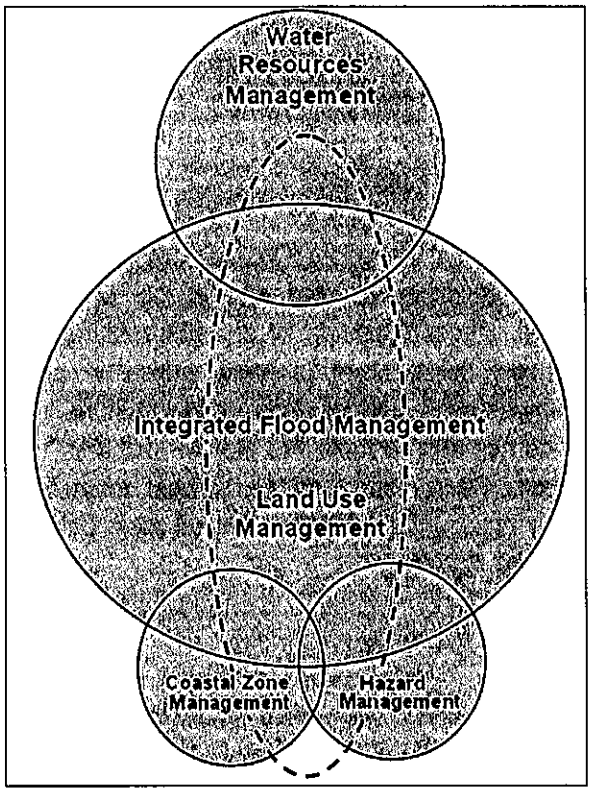
Flood damages are a function of both flood infrastructure and land-use, and both are important for understanding how to focus flood protection efforts.
Component of Integrated Flood Management are:

18.4.3.1 Ensure a Participatory Approach

IFM should be based on a participatory approach involving users, planners and policy-makers at all levels and should be open, transparent, inclusive and communicative. Decentralization of decision-making is necessary, with full public consultation and involvement of stakeholders in planning and implementation. Gender, religious and cultural differences must be taken into consideration. An appropriate combination of both the "bottom-up" and "top-down" approaches needs to be adopted. Coordination at the highest level to promote coordination and cooperation across functional and administrative boundaries needs to be ensured (GWP and WMO, 2004c).

18.4.3.2 Integrate Land and Water Management

Land use planning and water management must be combined in one synthesized plan, through coordination of land and water management authorities to achieve consistency in planning. The three main elements of river basin management (water quantity, water quality, and the processes of erosion and deposition) should be linked in planning (GWP and WMO, 2004c). Effects of land use changes on the various elements of the hydrological cycle need to be taken into consideration. **Figure 18.5** shows the integration of the different types of management.



Source: DID Manual Vol. 1

Figure 18.5 - Integrated Flood Management Model (GWP and WMO, 2004d)

18.4.3.3 Manage the Water Cycle as a Whole

Flood management plans must be intertwined with drought management through the effective use of floodwater and/or by maximizing the "positive" aspects of floods and the need to manage all floods, not just some. For example, how to manage floods greater than the design standard needs to be addressed and so are the need to seek multi-beneficial solutions that serve several different purposes simultaneously (GWP and WMO, 2004c).

18.4.3.4 Adopt a Best-Mix of Strategies

Flood management strategies should involve a combination of complementary options. A layered strategy, appropriate to given socio-economic and geo-climatic conditions and adaptable to changing conditions, should be adopted. An appropriate combination of structural and non-structural measures must be evaluated, adopted and implemented, recognizing the merits and demerits of both types of measures (GWP and WMO, 2004c).

18.4.3.5 Adopt Integrated Hazard Management Approaches

Flood management should be integrated into a wider risk management system of 'all hazard' emergency planning and management. Experts from all sectors, involving different disciplines, should be involved in the implementation of disaster

management plans. Consistency in approaches to natural hazard management in all relevant national or local plans should be ensured. Early warnings and forecasts, that are key inputs for the reduction of the social and economic impact of all natural hazards, including floods, should be strengthened (GWP and WMO, 2004c).

18.4.3.6 Adopt Environmental Enhancement

Drainage of the floodplains is a relatively recent phenomenon (EA, 2003). Many of the natural floodplain have been developed into agriculture and other form of land development. Floodplain behaved like storage and conveyance of water and sediment during high river flow. It is also home to many flora, fauna and habitats including wildlife. The wetland of the floodplains requires protection.

Rivers also including those in the lowland have been physically modified, usually straightened or deepened, with channels often disconnected from their floodplain. Apart from wet grassland, there are habitats that depend on periodic inundation of the floodplain. Raising water level in the rivers can be regarded as a form of environment enhancement to nature taking into account the requirement of flora, fauna and the habitats in the area.

Changes in land-use in floodplains to allow more frequent flooding and or reduced drainage would potentially provide a range of public and private benefits including flood defences for urban areas, biodiversity enhancement, improved water quality, ground water recharge and new business opportunities linked to wetland crops or sustainable outdoor leisure and tourism. Stable natural environments do offer some physical features that work for flood mitigation. These include good temporary storage characteristics and providing room for floods to move within natural boundaries.

18.4.3.7 Integrated Water Resources Management (IWRM)

IWRM is defined by the Global Water Partnership (GWP) as "*a process which promotes the coordinated management and development of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*". This definition is based on the recognition that a single intervention has implications for the system as a whole. More positively, integrating management means multiple benefits may be achieved from a single intervention.

In other words, IFM is a process that promotes an integrated rather than fragmented approach to flood management by integrating land and water resources development in a river basin within the context of IWRM and by aiming at maximizing the net benefits from floodplains while minimizing loss of lives from flooding (GWP and WMO, 2004b).

For flood management to be infused into IWRM, river basins should be considered as integrated systems where socio-economic activities, land-use patterns, hydro-

morphological processes, etc., are constituent parts of the systems. A consistent approach needs therefore to be applied to all forms of possible intervention. For example, the entire hydrological cycle should be considered in the systems, not just differentiating between floods and droughts when planning for water resources development.

SECTION 19

ENVIRONMENTAL EVALUATION OF IDENTIFIED IMMEDIATE WORKS PROJECTS

Section 19 ENVIRONMENTAL EVALUATION OF IDENTIFIED IMMEDIATE WORKS PROJECTS

19.0 ENVIRONMENTAL EVALUATION OF IDENTIFIED IMMEDIATE WORKS PROJECTS

19.1 INTRODUCTION

This section discusses the key environmental issues and impacts which may arise due to the implementation of the proposed immediate water resources schemes for the State. Geographically, the State is endowed with river channels and basins that could provide opportunities for enhanced development of water resources. However, as a result of the analysis undertaken on water supply and demand, this Study observes that for the current and impending water supply infrastructure, only upgrading works (or immediate works) are recommended relating to Water Treatment Plants as shown in **Table 19.1**.

None of the proposed immediate works fall within any of the 19 categories of "Prescribed Activity" under the *Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 1987 (Section 34A), of the Environmental Quality Act 1974 (Act 127).* Hence, the development works shown in the Table below will not require an Environmental Impact Assessment (EIA) based upon the details currently available, and therefore an environmental evaluation of proposed works is not required in this section.

Table 19.1 – Immediate Proposed Source Works

Source Works	Yield as stated in NWRS (2000)	Year of Commissioning (NWRS (2000))	Current Status
Raising of Timah Tasoh Dam	48 Mld	2009	Under construction
Water Treatment Plants	**Proposed WTP capacity**	**Year of Commissioning (NWRS (2000))**	**Current Status**
Arau IV	30 Mld	2000	Completed at end of 2009 and operating in beginning of 2010.
Timah Tasoh	48 Mld	2009	Not started
Arau V	38 Mld	2025	Not started
Arau VI	50 Mld	2035	Not started