CHAPTER 6 MASTER PLAN OF DEVELOPMENT OF RIVER BASIN INFORMATION SYSTEM

The long-term development plan of the river basin information system (hereinafter referred to as the RBIS), as formulated, includes the objective information of the RBIS, system configuration, project cost, project implementation schedule and project evaluation.

6.1 Objective Information

6.1.1 Objective Information to be Collected by the System

In due consideration of the major issues on present and future river basin management in the Perak river basin, the necessary information to be collected by the system are proposed as given in Table 6-1. Among the proposed information, the field visual information is presently not available. However, the recent multimedia communication technology is going to enable the monitoring of dynamic visual and audible scenes of the remote field on the real-time base. Such information is deemed to be useful for flood and other emergency disaster management.

Likewise, the recent technology on hydrological gauging and telecommunication devices will improve the gauging function as well as the data transmission speed. Examples of such improvement are the radar rainfall gauge and the automatic water quality gauge. These gauging devices would cope with the current issues on the river gauging data which are not adequate in terms of gauging density, particularly, the density of point rainfall gauging stations, and less useful due to the delay of their data transmission. In view of these developed technologies, the radar rainfall gauge and the automatic water quality gauge are proposed as parts of the objective RBIS.

The proposed objective information is classified into the five (5) major categories mentioned below, and will be used as the basic data for the flood management, water resources management, river environmental management and watershed management. The details of the proposed information are as described below:

(1) River Basin Gauging and Monitoring Information

The information includes river basin gauging data (rainfall, river stage/discharge, river suspended load and river water quality data) as well as field visual information. These information are classified into real-time and non-real time information. The

real-time information is in principle used for disaster management such as flood forecasting and warning, and pollutant control. On the other hand, the non-real time information is used to clarify the long-term relationship between the hydrological conditions of the river and the impacts of basin land development (the logging activities in the upper reaches, the urban and industrial development in the basin).

(2) Information on River Works

The information includes all ongoing and proposed flood control works, water supply works, river environmental improvement works and other river works such as sand mining works and bridge construction. The information could be useful as the basic data to facilitate the future river planning.

(3) Information on Field Survey

The information covers the results of major field surveys such as river channel survey, flood damage survey and survey on fauna and flora in the river. The results of the river channel survey are the essential information sources to clarify the river channel flow capacity and, at the same time, to monitor the progress of unfavorable channel conditions such as channel sedimentation, erosion and meandering.

(4) Basin Land Information

The basin land information is given as map information including the land use map, the forest conservation map, the topographic map, the geographic map, the soil map, and the structural plans for urban development and industrial development. Among the map information, the topographic map, the geographic map and the soil map are useful to clarify the basin natural conditions. On the other hand, the land use map, the cadastral map and the structural plans will be useful to evaluate the land development conditions in the river basin and will be used as the essential information for the watershed management.

(5) Basin Census Information

The basin census information will cover the population in the river basin and the designated probable flood inundation area. The information will facilitate the evaluation of flood damage potential or the basin water demand potential and will support the management of land development in the probable flood inundation area and the management of water supply in the basin.

6.1.2 Objective Information to be Disseminated by the System

The items of information to be disseminated and their users are proposed as shown in Table 6-2. The proposed information are classified into the following five (5) categories according to the purposes of river basin management:

(1) The general information covering the features of river basin, the hydrological information, and the river structures;

(2) The information related to flood management covering real-time flood hydrological gauging data as well as the database information such as the existing and proposed flood mitigation schemes, the probable flood inundation area, and the flood damage record;

(3) The information related to water supply and water resources management including the real-time river discharge data as well as the database information about water intake facilities, water resources development facilities and statistics of water demand;

(4) The information related to environmental management including the real-time water quality gauging data and the database information about channel morphology, sand mining, fauna and flora in the river, and ecotourism; and

(5) The database information related to watershed management including the information on logging activities, the map information (land use map, structural plan map, cadastral map, etc.).

As shown in Table 6-2, the above information are also classified into two levels according to the assumed users; i.e., Level 1 for the exclusive use of the government agencies, and Level 2 for information open to the public users. The classification of these uses is based on the following criteria:

(1) All information should be in principle open to public users so that they could understand and cooperate with the ongoing and projected river management works and/or river construction works. Moreover, dissemination of real-time disaster information will facilitate the evacuation and disaster prevention by the public.

(2) However, some information need to be confidential due to regulation/law and the necessity of national security and copyrighting. Moreover, some information may

cause confusion to public users or lead the public users to unfavorable land speculation. Therefore, information such as the topographic map of the river basin, the possible flood inundation area, the logging activities controlled by the Forest Department, and the structural plans in the basin are proposed for the exclusive use of the government agencies.

6.2 System Network

The objective RBIS is composed of sub-systems that have a sequential process of data collection, data transmission, data processing and dissemination. Such an overall system could be established through various components including the system network plan, the system design, and the institutional setup plan. Among these plan components, the system network plan is the most fundamental and important issue for determination of the system.

The centralized network system is proposed as the optimum plan through comparative studies of various alternatives. In the network plan, statistical data and other database information are input at both State and Federal levels, and all of them are collectively transmitted to and processed at the Federal level. On the other hand, all real-time information (i.e., field gauging and monitoring data) are once collected and processed at the State level and then transmitted to the Federal level. Thus, both database information and real time information are finally centralized at the Federal level. The government users could access to the information at the Federal level through the exclusive communication network, while the public users could access through the public telephone network.

The system network plan is oriented to the centralized management at the Federal level to facilitate the future nationwide expansion of the system without dynamic change of system configuration. The effectiveness of the system also can be identified in easy and quick accessibility to the database. On the other hand, the data transmission and access speed largely depends on the network data transfer capability. In this context, the optical fiber system which is being developed throughout Malaysia is emphasized to promise the required data transfer capacity.

6.3 System Device

In recent years, the personal computer has remarkably increased its performance enabling it to process images scanned from maps/drawings and even multimedia information such as the dynamic visual and audible information. The personal computer has also come into wide use due to the remarkable reduction of its price.

The recent communication infrastructures also have the dynamic qualitative improvement and quantitative expansion in Malaysia. As seen in "Multimedia Super Corridor Plan", the high-speed optical fiber communication network is going to be the main communication line in the country. Moreover, the satellite communication system is being made practicable since the Malaysian East Asia Satellite (MESAT-1) was launched in 1996.

In parallel with the development of the personal computer and the communication infrastructures, the field gauging and/observation devices is going to provide the dynamic visual and audible information of the field on real-time base. Such multimedia information will provide the actual images of disaster conditions and to take more prompt and appropriate action on them. The recent technology also enables extensive and systematic river basin gauging works through development of gauging facilities such as radar rainfall gauge and the automatic water quality gauging devices.

In this Master Plan, the futuristic system devices are proposed in due consideration of the potential technological development so as to set up the long-term target of the objective RBIS in Malaysia. The details of the proposed systems are as described below.

6.3.1 Gauging and Monitoring Device

The gauging items for the proposed system includes rainfall, water stage and discharge, river suspended sediment and water quality. In addition to the gauging items, monitoring facilities for the actual visual and audible field conditions are also proposed.

(1) Rainfall Gauge

As described in Subsection 4.1.1, the rainfall stations are scarcely distributed in the upper reaches, but increment of the rainfall stations is judged to be not technically feasible due to the extremely difficult accessibility to the gauging sites located in the deep jungles.

The recent technology enables wide rainfall gauging coverage by the radar rainfall gauge. The effective range of radar wave is about 120 km in radius and, therefore, one radar site could cover the entire watershed of Perak river basin (refer to Fig. 6-1). Thus, the radar could resolve the difficulty in gauging the rainfall in the deep jungles.

The present principal disadvantage of the radar rainfall gauge is the high investment and O/M cost, but a dynamic reduction of cost is expected in the future in view of the present intensive development of technology, data transmission, and computer

processing. The radar rainfall gauge is available both for real-time and non-real time rainfall gauge, and enable to estimate not only the rainfall intensity but also other various factors of rainfall such as the extent, movement direction and speed of rainfall area. Such information are quite useful for flood forecasting and warning and other disaster management.

From the above viewpoints, the radar gauge is proposed as the principal device for rainfall gauging. The radar site needs to be located on a high ground elevation and, therefore, the proposed site in the Perak river basin is preliminarily placed on top of Mt. Soh with an elevation of 1,324 feet (refer to Fig. 6-1). The radar gauge also requires several telemetry point rainfall gauging stations to calibrate the estimated rainfall by radar based on the actual gauged point rainfall. In this connection, the existing eight (8) telemetry point rainfall gauging stations are proposed for the calibration (refer to Fig. 6-1).

(2) Gauge of River Stage, River Discharge and River Suspended Load

The proposed gauging stations are divided into the following five (5) classes:

Class	Gauging Objects	Location
Principal Gauging Station	River Stage, Discharge, Suspended Load and Water Quality	Existing principal stations of DID and the additional two stations downstream of major intake points
Secondary Gauging Station	River State, Discharge and Suspended Sediment	Existing secondary gauging stations of DID for the suspended sediment
Tertiary Gauging Station	River Stage and Discharge	Existing secondary gauging stations of DID other than above
Tidal Gauging Station	River Stage	River mouth

The existing gauging stations of Perak are controlled by DID and rather well distributed in the basin. In due consideration of continuity of gauging data, all of the existing gauging stations of DID are applied as gauging stations for the RBIS. Moreover, the following additional and/or modified gauging points are proposed for the river basin management system:

(a) The water quality sampling points should be placed at the existing principal gauging stations of DID to monitor both the river discharge and water quality;

(b) The existing river stage gauging stations at Parit and Kg. Gajah located downstream of Perak River should be upgraded to principal gauging stations to

gauge the actual water intake volume from the river and the water quality for water intake; and

(c) A new tidal gauging station should be installed at the river mouth.

The location and inventory of the proposed gauging stations are as shown in Fig. 6-2 and Table 6-3, respectively. The RBIS will require a dynamic improvement on the transmission and processing speed of hydrological gauging data to realize a more effective and quick response in the future, and the telemetry system could meet such future requirement. Also, the reliability of data gauged by the telemetry system will certainly improve and could be used even as the basic data for the study and planning works. Moreover, the investment cost of the telemetry system will be made lower in the future and could be competitive with the operation and maintenance cost of the off-line gauging system. In due consideration of such possible future trend of technology, all gauging stations are proposed to be equipped with the telemetry gauging system.

(3) Water Quality Gauge

The RBIS collects all water quality data monitored by DOE as database information. Automatic gauging stations are also proposed at the five (5) principal gauging stations for river discharge to take the real-time water quality data for the sake of quick response to excessive aggravation of water quality. The objective database information collected from DOE includes the following twenty-nine (29) items of water quality index, while the real time information by the automatic gauging stations covers five (5) items (water temperature, electrical conductivity, dissolved oxygen, pH value and turbidity).

Category	Monitoring Items of Water Quality	
Related to Environment of human life	6 items	PH, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Suspended Solids (SS), Ammoniacal-nitrogen (NH_3-N)
Related to Human Health	19 items	Color, Oil and Grease, Detergents or Methylene Blue Active Substance (MBAS), Total Coliforms, Faecal Coliforms, Cadmium (Cd), Arsenic (As), Mercury (Hg), Total Chromium (T-Cr), Lead (Pb), Manganese (Mn), Aluminum (Al), Copper (Cu), Sulphide (S), Cyanide (CN), Nirate (NO_3-N), Total Nitrogen (TN), Phosphate as Phosphorous (Po4-P), Pesticides, Phenolics
For Irrigation	4 items	Sodium (Na), Boron (B), Chloride (Cl), Selenium (Se)

(4) Monitoring on Field Visual Information

The recent multimedia technology enables monitoring of the dynamic visual and audible scenes of the remote field by the industrial television (ITV). The ITV had been initially developed to monitor the industrial production line and therefore called as "Industrial Television". The ITV system consists of a television camera installed at the field sites and optical fiber cable installed between the television camera and the remote office. The optical fiber cable is indispensable for the ITV due to the necessity to transmit the dynamic scene of the field. The major disadvantages of the ITV are such that the monitoring points are fixed at the location of the television camera, and the high investment cost accrues from the installation of the optical fiber cable. The ITV is, however, deemed to be useful in particular to monitor the flood conditions or the unfavorable activities along the river such as dumping of garbage and illegal effluent from the pollutant sources to the river. From these points of view, the ITV system is proposed as a part of the futuristic monitoring system for the RBIS. The number of ITV cameras in the proposed system is assumed at ten (10) spots in the river basin.

The recent technology on the multimedia communications system has also produced the portable information terminal (PIT) that transmits the digital data and images of the field scenes through the public telephone lines from the field to the offices. The PIT could not provide the dynamic scenes of the field unlike the aforesaid ITV, but the cost of PIT is much cheaper than ITV and the PIT could take the field data at flexible points. As an example of possible usage of PIT for the river basin management, a river inspector keeps PIT and connects it to his cellular phone so that he could report the actual field conditions to the management office on real-time base. Such function of PIT is deemed to be useful, and a set of PIT is proposed as the monitoring facility for the RBIS.

6.3.2 Input Devices of Non-real Time Information

The proposed river basin information system will input the non-real time data such as the maps/drawings and the attribute data (the alphabetical and/or numeric data). In view of viability of the updated technologies, the following hardware and software are proposed as input devices of the RBIS.

(1) Input of Maps and Drawings

Conventionally, the digitizer have input maps and drawings. However, the digitizer takes much time and manpower in data input works. Moreover, the input accuracy by the digitizer depends much on the skill of the operator. To minimize such disadvantages, attempts are recently being made to read maps and drawings by scanner and convert them to digital data using the software of raster/vector transformation. Such input measure could contribute to the dynamic improvement in the aspect of less input time, less operation skill and high accuracy of input data. The major disadvantage of the input measure is addressed to the high purchase cost of the scanner and software of transformation, particularly when the system applies a large-scale scanner and a higher quality of software. Such purchase cost is, however, expected to decrease with the intensive demand for map information as seen in the wide use of car navigation and CAD. From these viewpoints, the scanner supported by the software of raster/vector transformation is proposed as the input device for the RBIS.

(2) Attribute Data

To realize less manpower and higher accuracy of input works of the alphabetical and numeric data, the automatic reading method will certainly take over the conventional key-in method in the future. In this connection, the Optical Character Reader (OCR) is proposed as the most eligible hardware for automatic reading. The OCR currently reads more than 90% of alphabetical and numeric data accurately being made practicable.

6.3.3 Data Processing Device

The following software and hardware are proposed to analyze and process the database and real-time information:

(1) Software for Processing of Database Information

The RBIS will process the mapping data as well as the alphabetic and numeric data, and the most eligible software for processing of such information is addressed to the Geographic Information System (GIS). The GIS has both graphic and database functions so as to simultaneously process the mapping information and its attribute information.

Since the GIS could manage various mapping information as separate, independent layers, it will be easy to present various river basin characteristics by overlaying the layers such as land use, topography, flood inundation area and watershed boundary. Through the presentation of various characteristics of the river basin, the GIS can clarify the important interrelations between the river gauging data (river discharge, water quality, etc.) and land development/conservation conditions (urban/industrial development, deforestation, etc.). At the same time, the GIS could display the digitized map information with a desired scale and/or focus on a specific area. The GIS also will enable easy access to the desired map information and to easily update and/or retrieve the information. Thus, the GIS can provide the essential information for the river basin management.

(2) Software for Processing Real-time Information

The RBIS will analyze and process the radar rainfall data, the automatic water quality gauging data and the river stage data. All objective real-time information, in particular, the radar rainfall and water quality gauging data will require expert computer programs to analyze and calibrate the gauged data and to estimate the actual rainfall depth and the water quality value.

Presently, no ready-made application software such as the aforesaid GIS is applicable to such expert programs. Instead, the expert program is set up beforehand by the supplier of the gauging equipment and developed by the users of the equipment according to their own convenience.

(3) Hardware for Processing Database Information

The data processing method is in general classified into the following two items:

(a) The mainframe processing method where all data is managed by the centralized computer; and

(b) The distributed processing method as represented by the client/server system (C/S) where the data are stored by the server machines and distributed to the client machines.

As shown in Table 6-4, the client/server system is superior to the mainframe system in extendibility and in cost efficiency. Such superiority of the C/S is attributed to the

recent dynamic functional improvement and the lower prices of personal computers. Due to such superiority, the C/S is applied to the RBIS.

The private personal computers that are widely prevailing could be used as the client machines. As for the server machine, the UNIX machine is selected as the optimum hardware in due consideration of the following conditions:

(a) Most of the government agencies in Malaysia apply the UNIX machine as the main server.

(b) The machine contains the standard operating system to connect the computer network system.

(c) The machine does not depend on vendors.

(d) Connection between different models is easy.

(e) Most Internet server programs are developed on the premises of the UNIX machine and most Internet servers are running on the UNIX machine.

(f) A large-scale network usually applies the UNIX machine as the server.

The server machines are placed at the Federal and State operation rooms. The data management work is divided into the real-time data management and the database management. The database management is further made separately for flood management, water resources management, river environmental management and watershed management.

The Master Plan proposes several server machines that will have an exclusive task for each of these management works for the future substantial increment of data management works. Such server system could also avoid the concentration of user's access on one server machine, and increase the efficiency of system operation.

The Master Plan also proposes several servers to control the traffic of data supplied from the servers and the Internet information. The number of server machines are as proposed below:

Name of Server	Purpose of Server	Number of Servers
Communication Server	Communication control for information supplied from the servers	2 (one each for federal and state levels)
Web Server	Control of Internet information	2 (one each for federal and state levels)
GIS Server	Supply of mapping data	1 (at federal level)
Flood management Data Server	Supply of non-real time data related to flood management	1 (at federal level)
Water Resources Management Data Server	Supply of non-real time data related to water resources management	1 (at federal level)
River Environmental Management Data Server	Supply of non-real time data related to river environmental management	1 (at federal level)
Audio Control Server	Control of the display data at the system operation rooms	2 (one each for federal and state levels)

(4) Hardware for Processing Real-time Information

The real-time information covers the radar gauge rainfall data, the telemetry data for rainfall, river stage, water quality and the visual field scenes. Among the information, the telemetry river stage data require simple processing such as conversion of river stage to the river discharge so that the UNIX workstation at the state operation room could be applied as the telemetry data sever. The visual information is also processed by the same telemetry data sever. Moreover, the telemetry data server distinguishes the radar gauge rainfall data and the point telemetry rainfall data and transmits them to the exclusive computer machine for radar gauge analysis. Likewise, the server will transmit the telemetry water quality data to its exclusive computer machine for analysis.

The radar gauge rainfall data as well as the telemetry data of water quality require a huge and continuous processing work, and the capacity of the UNIX workstation will not be applicable to such work volume. From these viewpoints, two (2) exclusive computers are placed at the state operation room to analyze and process the radar rainfall gauge and water quality.

6.3.4 Data Dissemination Devices

The dissemination device will distribute various information such as gauging data, sounds and pictures comprehensively according to different types of users. The proposed dissemination devices for these users are as described below:

(1) Display Device in System Operation Rooms

Set-up of the system operation rooms is proposed at the Federal and State levels to manage the objective information. All real-time and database information could be accessed through the client machine placed at the system operation rooms. In addition, the audio machine is proposed to display the visual and sound information of the fields on a large screen. Such audio machine will facilitate the common understanding of all members in the system operation rooms, particularly, on the disastrous conditions of the field and to make an appropriate instruction and/or determination on the disaster management. The proposed audio machine consists of projector, display, recorder and audio control server.

(2) Dissemination to Related Government Agencies

All real-time information as well as database information are transmitted through the Internet to the personal computer at the government offices. Such on-line dissemination will be made through the exclusive optical fiber network so that all information including the dynamic visual scenes of the field could be distributed. The government agencies could also obtain the database information stored by CD-ROM. In case of such off-line dissemination by CD-ROM, particular application software needs to be developed beforehand to access the information stored in CD-ROM and installed in personal computers at the government agencies.

(3) Dissemination to Public Users

The dissemination system is principally the same as the aforesaid exclusive system for the related government agencies. The on-line dissemination is, however, made through the public telephone lines, therefore, dynamic visual information is hardly disseminated. Moreover, some of the information are not open to the public users as described in Subsection 6.1.2, and such communication control will be made by the aforesaid Web Server. Likewise, the public users can obtain information through the CD-ROM, but confidential information against the public users is not stored in the CD-ROM.

6.3.5 Data Transmission Devices

There are various data transmission devices classified into the radio wave lines and the ground cable lines. The radio wave lines include the multiplex radio wave line, the telemetry

line and the satellite lines, while the ground cable lines are the optical fiber lines and the telephone lines. Among these devices, the optical fiber line is selected as the optimum trunk line of data transmission for the system in view of the following points:

(1) Among the transmission devices, the optical fiber line could promise the best quality and reliability of transmitted data.

(2) Only the optical fiber line could transmit the dynamic visual information.

(3) As proposed in Telecommunication Vision 2020, the optical fiber network is going to cover the whole country of Malaysia by the year 2020.

The optical fiber line is a ground cable line, therefore, it has the possibility to be cut off. To cope with any failure of the trunk line, a backup trunk line is required in the futuristic RBIS. In this connection, the satellite communication line is proposed as the optimum back up transmission device in consideration of the following points:

(1) Among the transmission devices, the satellite has the second largest data transmission capacity next to the optical fiber line and could transmit all objective information other than the dynamic visual information; and

(2) The satellite communication system is going to prevail in Malaysia as seen in the Telecommunication Vision 2020 and also in the fact that the Malaysian East Asia Satellite (MEASAT-1) was launched in 1996.

The above trunk line will connect the operation centers at the Federal and State levels as well as the related government agencies. In addition to transmission by this trunk line, the real time gauging data is transmitted through the telemetry radio wave and/or the public telephone line to the server machine. Data dissemination using the Internet will also be made through the public telephone line.

6.3.6 Overall System Devices

In line with the optimum system network described in Section 6.2 and the above proposed system devices, the overall system is designed as shown in Fig. 6-3. In the system, eleven (11) UNIX workstations are installed as the data server and/or interface server. In addition, two (2) computer machines are installed at the state operation room to analyze and process the gauged radar rainfall data and the automatic gauging data of water quality.

Among the eleven (11) workstations, seven (7) are at the fFederal operation center; i.e., four (4) as the database server and three (3) server machines as the interface for communication control. Likewise, four (4) workstations will be placed at the State operation room: one as the real-time data server and the others as interface server.

The exclusive optical fiber network will connect the operation rooms at the Federal and State levels and the related government offices. Public users can also access the system through the Internet. Through this network, both the real time and non-real time information could be transmitted.

6.4 Project Cost

6.4.1 Initial Investment Cost

The initial investment cost of the system is estimated, based on 1997 price level, at about RM 19.6 million as shown in Table 6-5. The estimated initial investment cost does not include the installation cost of the optical fiber line as the data transmission system, which is instead, assumed to be leased from Telekom Malaysia. The major reasons for selecting the leased line are as enumerated below:

(1) Should the optical fiber line be independently installed by the project, it will require an extremely high investment cost.

(2) The existing optical fiber line installed by Telekom Malaysia between Kuala Lumpur and Ipoh could be leased as the trunk communication line for the proposed system.

(3) Telekom Malaysia plans to expand the optical fiber network throughout the country by the year 2020 as described in the Telecommunication Vision 2020.

6.4.2 Annual Operation and Maintenance Cost

The annual operation and maintenance cost consists of (a) cost of maintenance of equipment and purchase of spare parts; (b) cost of manpower for system operation; and, (c) cost of lease of data transmission system. The total cost of these items is estimated at about RM 4.00 million, allocated as follows:

Description	Annual Cost (RM million)
Maintenance of equipment and purchase of spare parts	3.00
Manpower for system operation	0.46
Lease Cost	0.54
Total	4.00

The above cost of maintenance of equipment and purchase of spare parts is assumed as about 15% of the initial investment cost in due consideration of approximate durability of the equipment. The annual cost of manpower for system operation is further estimated based on the staff required for system operation, as follows:

Required Staff	Monthly Rate of Emolument (RM/month)	Required Number of Staff	Annual Emolument (RM/year)
River Engineer	9,000	2	216,000
Network Manager	9,000	1	108,000
Database Manager	4,620	2	110,880
Digitizing Operator	2,200	1	26,400
Total		6	461,280

As for the lease cost for data transmission, the following current lease rates are adopted for estimation: RM 200,000/year for lease of satellite communication and RM 343,200/year for lease of optical fiber communication.

6.5 Project Implementation Schedule

The implementation schedule for development of the RBIS is as shown in Fig. 6-4. In the implementation schedule, the fundamental devices for the system including the hydrological gauging system, the data processing system and the data transmission system are to be established in the next 8th Malaysia Plan. The devices established in the 8th Malaysia Plan will pledge the full operational condition of the entire system. After the devices in the 8th Malaysia Plan, the following futuristic systems are scheduled in the 9th to 11th Malaysia Plans in due consideration of their features.

Automatic water quality gauging system	9th Malaysia Plan
Radar rainfall gauging system	10th Malaysia Plan
ITV system and satellite communication system	11th Malaysia Plan

The backgrounds of the proposed implementation schedules are as described below.

(1) Work Items in the 8th Malaysia Plan (2001 to 2005)

The following items are urgently required to facilitate the river management work. No technical difficulty in implementation is expected.

(a) Improvement of the existing hydrological gauging stations and the related telemetry communication system [refer to Item (2), Subsection 6.3.1];

(b) Installation of database server system and its input/output devices (refer to Subsection 6.3.3);

(c) Establishment of main data transmission system between Kuala Lumpur and Ipoh utilizing the leased optical fiber line; and

(d) Installation of portable information terminal (PIT) [(refer to Item (4), Subsection 6.3.1).

(2) Work Items in the 9th Malaysia Plan

The existing automatic water quality gauging system has technical difficulties in maintenance works and its available monitoring items are limited to temperature, conductivity, pH value, turbidity and dissolved oxygen. Intensive development works are, however, being carried out, and it is anticipated that the present defects of the system will be improved within the 9th Malaysia Plan. Hence, the automatic water quality sensor as well as its related telecommunication and computer systems for the analysis of water quality is scheduled in the 9th Malaysia Plan.

(3) Work Items in the 10th Malaysia Plan

The proposed radar rainfall gauge has a wide gauging range, so that the thirteen (13) radar rainfall gauges could cover the whole country of Malaysia (refer to Fig. 6-5). However, the radar rainfall gauge also requires a high investment cost of about RM 12 million (RM 4.2 million for radar site cost, RM 6.8 million for computer for radar analysis and RM 1.32 million for multiplex radio wave), which takes 60% of the total investment cost. In view of the nationwide gauging coverage as well as the high investment cost, it is deemed necessary that the radar rainfall gauge be developed in line with the nationwide development plan instead of the basin-wide plan. Since the implementation of such nationwide development plan will require a

rather long period, the radar rainfall gauge system is proposed in the 10th Malaysia Plan.

(4) Work Items in the 11th Malaysia Plan

The optical fiber network is likely to cover the Perak river basin during the 11th Malaysia Plan in due consideration of the Telecommunication Vision 2020 formulated by Telekom Malaysia. Such optical fiber network is indispensable for the Industrial Television (ITV) to transmit the dynamic visual information of the field. Therefore, the ITV together with its data transmission system of optical fiber line is assumed to be established in the 11th Malaysia Plan. In addition to the ITV, the satellite communication system is scheduled as the backup of the optical fiber data transmission system.

6.6 Major Improvement and Qualitative Benefit by the Project

The RBIS will facilitate access to more consistent and comprehensive river basin information reducing the time and manpower for river basin management works. At the same time, the RBIS will improve the quality of information and enable the river administrator to have more sound engineering justification on the river basin management works.

The RBIS will also expand the users of the information including the government and non-government users so as to improve mutual understanding and cooperation on the river basin management works. Details of these improvements by RBIS are as described below.

(1) Quick Acquisition of Information

River basin gauging information such as rainfall, river stage/discharge and water quality are the essential information for the river management system. However, it presently takes a long period to obtain such information. Due to the delay of the information, difficulties arise in taking the appropriate and quick measures against adverse effects on the river management works.

The proposed RBIS would get rid of such delay of data acquisition through the dynamic technical improvement utilizing the optical fiber system as data transmission device and the futuristic gauging facilities such as rainfall radar gauge and the automatic water quality gauge.

(2) Easy Access to Information

The river development plans generally require a comprehensive river basin information including map information and database information. Since these information are massive and currently scattered in the various government and/or semi-government agencies without on-line linkage, plenty of time and manpower are spent to access those information.

The State DID of Perak had directly undertaken about twenty (20) river management works and/or plans in 1997. In addition, the State DID is requested to make a technical justification on the numerous projects closely related to river management works such as bridge construction, land development along the river course, and river sand mining works.

According to the interview survey, however, such engineering justification is not always efficiently made due to the difficulty in obtaining the desired basic information. The proposed RBIS will substantially reduce the time and manpower for obtaining the desired information and enable the river administrator to have a more sound engineering justification on the river basin management works.

(3) Qualitative Improvement of Information

The proposed system will improve the quality of information in a wide range as given in Table 6-6. The principal improvements are as enumerated below:

(a) The coverage of gauging data is extended to provide further dynamic visual and audible scenes of the remote field on real-time base which effects the disaster management in particular.

(b) Most of the information stored in the database is supported by map information that enables the river administrator to well clarify the various river basin characteristics.

(c) The proposed system unifies all related information to realize a more consistent river basin management.

(4) Expansion of Users

Most of the existing information related to river basin management are separately stored by the different government agencies and seldom exchanged among them.

The proposed system will integrate the scattered information and distribute them to the related government agencies. Such expansion of government users will provide better and common understanding and cooperation on the river management to the related government agencies and thus facilitate a consistent and comprehensive river basin management.

The cooperation of the public on the river basin management will also be one of the significant benefits of the proposed system. Through opening of the river basin information, the river administrator could disseminate the background and purposes of the river basin management and reflect the public opinions in them, thus intensifying the smooth relationship between the river administrator and the public.

6.7 Economic Evaluation

Among the qualitative improvements by the RBIS described in the Section 6.6, the items containing the tangible economic benefit were selected and, based on them, the economic evaluation on the project was made.

6.7.1 Economic Benefit

The RBIS will disseminate the telemetry hydrological gauging information on real-time base. Such hydrological gauging information could be availed both for water supply management and water flood mitigation.

(1) Economic Benefit in Water Supply Management

As described in Section 9.1, the water deficit in the Perak river basin may possibly occur, as experienced in 1990, with a recurrence probability of 5-year return period. This water deficit is attributed to lack of integrated hydrological monitoring system between DID and TNB.

The RBIS will release the real-time information on river discharge at the downstream from the hydropower dams so that TNB could have more flexible reservoir operation of the existing hydropower dams based on the information and solve the probable water deficit with minimal reduction of power reduction. The water deficit causes reduction of irrigation water supply leading to reduction of paddy production. The annual average value of the production loss is estimated at RM 0.34million that could be regarded as the annual average economic benefit of RBIS (refer to Subsection 9.1.2).

(2) Economic Benefit in Flood Mitigation

Among the existing hydropower dams, the Kenering and Chenderoh dams currently have no flood mitigation effect on the lower reaches from the dams. However, the hydrological information (storm rainfall and flood river flow discharge) by the RBIS could avail the reservoir operation of the two dams for flood mitigation without adverse effect to power generation.

The detailed study on the potential flood mitigation effect by the Kenering and Chenderoh dams are made in Section 6.2. According to the results of the study, the annual flood damage value is estimated at RM 2.6million under the present reservoir operation of the Kenering and Chenderoh dams. On the other hand, the value is reduced to RM 2.0million when RBIS starts to provide the real-time information and Kenering and Chenderoh dams effect the flood mitigation in the lower reaches. The reduced value of RM 0.6million is regarded as an annual average economic benefit of RBIS.

(3) Economic Benefit by Database Information

The reduction of time and manpower is expected, in particular, for the study and/or formulation of river development plans. The annual expenditures as well as their corresponding man-month for the river development plans in 1991 to 1997 were estimated, referring to the State DID Annual Reports, as shown in Table 6-7. Then, the proposed system is assumed to reduce about one-third of the actual expenditures and man-months in 1997 that are judged to be currently spent on average for access and collection of the basic information for the river development plans. This assumption is made according to the interview survey with the State DID and the experience of the Study Team. As a result, the following reductions of expenditures and man-month are estimated as the benefit of the proposed system.

Reduction of annual expenditure	RM 0.5 million
Reduction of annual man-month	
Professional Engineer	17 M/M/year
Assistant Engineer	34 M/M/year
Technician	63 M/M/year
Total	119 M/M/year

Among the work items by DID, river management has recorded the highest increment of expenditure during the recent thirty years and taken more than 50% of the total

expenditure in the Sixth Malaysia Plan (1991-1995). The average growth of the expenditure for river management for these 30 years is estimated at about 91.2% per MP (or 13.8% per year) as given below.

Description	1st MP ('66-70)	2nd MP ('71-75)	3rd MP ('76-80)	4th MP ('81-85)	5th MP ('86-90)	6th MP ('91-95)	Average
Amount (RM million)	22.6	36.9	110.5	243.9	277.7	578.0	211.6
Growth Rate (%)/5years	-	63.2	199.5	120.7	13.9	108.1	91.2

Note: Expenditures are expressed in the 1997's price level.

In line with the above increment of expenditure for river management, the expenditure for the river development plans of the Perak River is going to certainly increase, and that also leads to the increment of the above benefit by the proposed system. In due consideration of these conditions, the annual economic benefit of the project is estimated as below:

(a) The annual benefit as of 1997 will increase in the future with a rate of 13.8% per year, the average growth of expenditure for river management in the recent 30 years.

(b) The increase of the above annual benefit will continue until the year 2020 which is set as the target of the long-term national development plan in Malaysia as described in Malaysia Vision 2020.

(c) A part of the above full benefit will be generated during the implementation of the project. The ratio to full benefit generated during the implementation is assumed as the ratio of accumulated investment cost to the total investment cost.

6.7.2 Economic Cost

The project financial cost as estimated in Section 6.4 is converted into its corresponding economic cost by multiplying the conversion factor of 90% a the result, the economic cost of the RBIS proposed in Master Plan is estimated as below:

Description	Financial Cost	Economic Cost
Investment cost	RM 19.56 million	RM 17.63 million
Annual operation and maintenance cost (full operation)	RM 4.00 million	RM 3.60 million

The annual disbursement of the economic cost is further estimated in the following manner:

(1) The 5-year investment in each Malaysia Plan is made in accordance with the project implementation schedule, as described in Section 6.5.

(2) The annual operation and maintenance cost consists of the maintenance cost of system devices, the manpower cost for system operation, and the lease cost of the communication system (the optical fiber communication system and the satellite communication system). Among them, the annual maintenance cost and the operation cost are allocated according to the accumulated investment cost. The lease cost of the optical fiber system is also allocated throughout the project period, while the lease cost of the satellite communication system is allocated after the year 2015 in accordance with the implementation schedule of the project.

6.7.3 Economic Rate of Return of the Project

The economic evaluation for the project is made based on the economic internal rate of return (EIRR), using the annual flow of economic benefit and cost given in Table 6-8. In the annual flow, project life is assumed to be 10 years after completion of the project in due consideration of durability of the system devices. As the result, the EIRR for the proposed project is estimated at 10.8% and judged to be within the applicable opportunity cost (10 to 12%). Thus, the EIRR shows that the proposed project is economically justifiable.

Moreover, the EIRR is subject to the economic cost estimated from the current market price of system devices. However, the current price, in particular, the price of computers will certainly be reduced in the future due to the expansion of users and the technology improvement and, therefore, the potential EIRR for the project will be higher than the estimated value of 10.8%.

CHAPTER 7 FEASIBILITY STUDY ON THE DEVELOPMENT OF THE OPERATIONAL SYSTEM

The Master Plan in Chapter 6 is proposed as the long-term plan, and it is virtually difficult to immediately establish the RBIS proposed in the Plan. However, the present dynamic basin land development requires the early service of an integrated river basin information to support a consistent and comprehensive river basin management. To make up for such deficiency, a development plan of a pilot system (called hereinafter as "the Operational System") was formulated and, based on the development plan, the Operational System was installed. The Operational System's initial operation was further made during the study period to effect the transfer of technical knowledge on system operation and maintenance.

7.1 Objective Information to be Collected

The Operational System will collect all objective information proposed in the Master Plan other than the following items that are still not made practicable in Malaysia; i.e., the automatic water quality gauging information, the radar rainfall gauging information and the dynamic visual information. Thus, the objective information for the Operational System are mostly available and they are urgently and essentially required for the river basin management in the Perak river basin. The details of the objective information are as described below.

7.1.1 Gauging and Survey Information

The information are classified into the categories of hydrology, water quality, river channel survey, flood damage and faun/flora. The contents of information are as given below:

(1) Hydrology

The objective hydrological information is classified into the real time and non-real time information that are essential for the various aspects of river basin management. As for the real-time information, the Operational System collects the hydrological gauging data (rainfall, river water stage and river flow discharge) as well as the outflow discharge from the Chenderoh Dam (refer to Table 7-1 and Fig. 7-1). The hydrological data is given from the existing telemetry gauging stations, while the outflow discharge is through the telephone line from TNB. Thus, the Operational System applies the existing gauging network, but some revisions were made as enumerated below:

(a) The existing gauging network monitors the rainfall and river stage only during a flood period (October to January) for the sake of flood forecasting and warning. However, the Operational System expands the gauging period for not only floods but also droughts (June to August) to facilitate both flood forecasting and drought management.

(b) The existing system does not monitor the river discharge, while the Operational System has a function to convert the river stage to stream discharge during a drought period so as to clarify whether the river discharge is sufficient as compared with the water intake capacity.

(c) The real-time gauging data is now monitored only by the State DID in Ipoh, while the dam outflow discharge is determined in principle by the National Load Dispatch Center (NLDC) of TNB in Kuala Lumpur. Such conditions cause difficulties in coordinating the control of dam outflow both for flood and drought management between TNB and DID. To retrieve the issues, the Operational System expands the data transmission system from Ipoh to Kuala Lumpur so that both the Federal DID and NLDC could monitor the real-time gauging information and coordinate the control of dam outflow both for flood and drought management.

As for the non-real time information, the Operational System applies the existing DID gauging network as its hydrological data source not involving any new gauging stations in due consideration of the following conditions (refer to Figs. 7-2 to 7-3 and Tables 7-2 to 7-5):

(a) The existing point rainfall gauging stations are scarcely distributed in the upper reaches from the Chenderoh Dam. It is, however, not technically feasible to install new rainfall gauging stations due to the extremely difficult access to the gauging sites in the deep jungle. Moreover, the run-off discharge from the upper reaches from Chenderoh Dam is regulated by the existing four (4) hydropower dams, and the rainfall in the upper reaches has less significance for the river flow regime in the downstream river stretch.

(b) In contrast to the rainfall gauge, the existing stream gauging network is judged to satisfy the minimum requirement for river management of the Perak River as well as its major tributaries.

All hydrological gauging data are currently stored by the "Hydrological Data Bank System" (the Data Bank) at the Hydrology Division of Federal DID in Kuala Lumpur. Moreover, the "Hydrological Information System" (HIS) is now being developed by the DID Hydrology Division to upgrade the operational conditions of the Data Bank. Upon completion of HIS, the hydrological data could be transmitted on-line from the Data Bank to the Operational System. The completion of HIS is, however, still indefinite and, therefore, the ASCII data digitized by the Data Bank will be supplied to the Operational System in the form of floppy diskette and/or zip drive instead of the on-line system.

In addition to the hydrological data stored in the Data Bank, the System will also collect the meteorological data gauged by two (2) MMS principal gauging stations in the Perak river basin (at Ipoh Airport and at Lubok Merbau). Moreover, the tidal data gauged at Bagan Datoh near to the Perak River will be collected by the System. The System will update these objective data once a year.

(2) Water Quality and Water Pollutant Source

The objective information for the Operational System is given as all database information as proposed in the Master Plan. Thus, the Operational System covers the information of water quality (29 indices) currently monitored by DOE at 53 points [refer to Subsection 6.3.1(3)].

However, the current sampling points for water quality do not coincide with the river discharge gauging points causing difficulties in estimating the pollutant loads. To retrieve such unfavorable conditions, the Operational System will provide the substitutive database of discharge to support the water quality at the three (3) key sampling points. The substitutive database discharge is given from the record of the DID stream gauging station nearest to the sampling points. The key sampling points and their corresponding discharge gauging stations are as given below:

River	Sampling Point for Water Quality (Sampling. Point No. of DOE)	Discharge Gauging Point	
		Name of Point	DID Sta. No.
Perak	Sta. No. 4709611	Iskandar Bridge	4809443
Pelus	Sta. No. 4909671	Kg. Lintang	4911445
Kinta	Sta. No. 4410660	Weir G. Tg. Tualang	4310401

DOE recently entrusted a series of water sampling, laboratory test of sampling and digitizing of the results of laboratory test to a private company, ASAM. The Federal

DOE receives the digitized water quality data from ASAM and stores the data in its PC hard disk using the application software "Microsoft Excel" and "Microsoft Access". ASAM makes data renewal three times a year in accordance with a definite schedule.

After consultation between the DOE and the Study Team, it was agreed that the Operational System will collect the digitized water quality data from the Federal DOE in the form of diskette. The data renewal for the Operation System will be made three times a year in accordance with the above definite data renewal schedule.

As described in Subsection 3.2.2(1), DOE had also identified the major point pollutant sources clarifying their location and classification (mining, industry, pig farm, and factory of rubber/palm oil) and, further, as for the industrial pollutant source, clarifying types and operation time of industry (refer to Fig. 3-4). The inventory of major point pollutant sources is essential for river environmental management and the Operational System will collect the non-digital information on the inventory of the major point pollutant sources including the location map from the Federal DOE once a year.

(3) River Channel Survey

As described in Section 4.2, the results of river channel survey are scattered with the districts offices of DID, and it is virtually difficult to collect and use them for the sake of comprehensive river management works. To retrieve such conditions, the field survey works should be undertaken under the control of each DID district office and the results of the survey need to be collected to the State DID, then transmitted to the Federal DID and finally stored in the database of the Operational System. The necessary contents of river channel survey are as given below:

Item	Contents
Information to be Collected	• Accumulated distance of cross-sectional survey points • River bed level, bank level • X-Y coordinates of cross-sections
Stretch of river channel survey	• Perak River: 181 km (river mouth to Iskandar Bridge) • Kinta River: 72 km (Anderson Bridge in Ipoh city proper to confluence with Perak River)
Interval of cross-sectional survey	1 to 2 km
Data Source/Competent Agency	Federal DID
Time interval of survey/data renewal	1 to 2 years

The Operational System will be equipped with the database to store the above contents. The actual data input during the study period was, however, difficult, because the Study Team could not obtain the results of the river channel survey as described above. In this connection, an attempt was made to estimate, the channel longitudinal profile as well as the channel flow capacity based on the results of the previous Study "Tumboh Integrated Rural Development Project, in 1982" (refer to Table 7-6 and Fig. 7-4). The Operational System will initiate the flood management of the Perak River based on the estimated channel flow capacity and then update them by the revised river channel survey to be newly carried out in the future.

(4) Flood Damage

The results of the flood damage survey are adopted as one of the objective information for the Operational System and to be stored in the GIS data base in accordance with the recording format currently adopted by DID. The contents of information to be stored are as enumerated below:

Items	Contents
Information to be Collected	1. Extent of flood inundation area 2. Road and bridge inundated 3. Number of people affected 4. Flood damage in monetary value 5. Agricultural damage 6. Epidemic caused by flood 7. Flood inundation map 8. Photographs of the field
Data Source/Competent Agency	Federal DID
Time interval of survey/data renewal	Immediately after major floods

(5) Fauna and Flora

The Operational System will collect and update the results of survey on fauna and flora based on the GIS database digitized by the Department of Wildlife and Natural Park (refer to Section 4.2). The GIS database is made by the PC-Arc/Info, and the Department agreed to supply the database to the Operational System in the form of the floppy-diskette. The agreement was, however, made for the initial system operation and further coordination on continuous data supply is required to update the data.

7.1.2 Information on River Management

(1) Flood Mitigation

The Operational System will integrate all information related to the existing and proposed flood mitigation facilities and update them whenever the flood mitigation work is newly completed and/or projected. The contents of information to be stored in the data base of the Operational System are as enumerated below:

Item	Contents
Information on River Channel Works to be Collected	(a) Name of flood control scheme (b) Objective river for the scheme (c) Type of flood control works (d) Design flood level (e) Location and/or stretch of the scheme (f) Competent agency to maintain the scheme for the existing scheme or to propose the scheme (g) Completion time of the scheme for the existing scheme or target completion time for the projected scheme
Information on Dam Flood Regulation Effect	(a) Name of dam and structural features of dam reservoir (c) Flood control capacity made by drawing down of the reservoir level and the period of drawing down
Data Source/Competent Agency	State DID and TNB
Time Interval of Survey/Data Renewal	Whenever the flood control work is newly completed and or proposed

(2) Water Supply Management

The Operational System will store comprehensive information on the existing and projected water intakes and provide them to the agencies related to river administration and water supply works. The contents of the information to be stored are as given below:

Item	Contents
Information to be Collected	(a) Location map and inventory of intake facilities (b) Water demand from the river source (c) Location map and inventory of irrigation scheme (d) Location map and inventory of domestic/industrial service area
Data Source/Competent Agency	State DID (for Irrigation Water Supply) Perak Water Board (for Domestic/Industrial Water)
Time Interval of Survey/Data Renewal	Once a year

(3) Ecotourism Management

The major attractions of ecotourism on Perak River includes camping/lodging along the river, boating on the river, sightseeing on the historical monuments along the river and canoe expedition in the lake of dam reservoir (refer to Figs. 7-5 to 7-7). All these attractions other than canoe expedition are currently provided by a private company along the stretch between Pasir Sarak and Kuala Kangsar, while the stretch for the attractions are scheduled to expand to Chenderoh Dam by the year 2005.

The Operational System will collect and update the following items so as to promote ecotourism on the Perak river basin:

(a) Location and contents of camping and lodging facilities;

(b) Contents of boating and canoe expedition; and

(c) Location and photograph of major spots for sightseeing along the river.

The information source for the above items is Yayasan Perak, and updating of the information will be made once in three years.

(4) Other Information Related to River Management

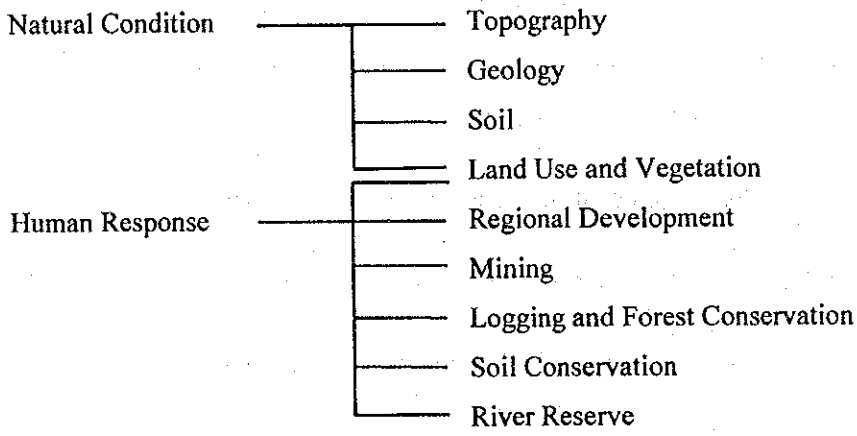
The Operational System will collect the information on bridges and sand mining activities, and the contents of the information to be collected are as given below:

Item	Contents
Items of Information on Bridges	(a) Location of bridges (b) Competent agency for maintenance of bridges (c) Structural features of bridges
Items of Information on Sand Mining Activities	(a) Location of sand mining sites (b) Annual mining volume granted
Data Source/Competent Agency	(a) Department of PWD, PLUS (for bridge information) (b) Department of Land and Mining (for mining information)
Time Interval of Data Renewal	Once a year

7.1.3 Basin Land Information

(1) General

In order to establish an efficient River Basin Information System (RBIS), various kinds of information concerning river basin management should be integrated in the RBIS. These are categorized as follows:



For the proposed RBID, a precise screening of information sources was made through data collection and interview survey of the related agencies, paying attention to the following:

(a) Data availability in the related agency;

(b) Necessity of river basin management;

(c) Progress of computerization in the related agencies; and

(d) Enhancement and facilitation of routine work not only in the Department of Irrigation and Drainage (DID) but also in the related agency.

In due consideration of the above, the appropriate information to be integrated into the RBIS is as proposed herein.

Completion of a fully functioning RBIS needs a lot of time, manpower and budget. The Operational System was developed within the study period as a model for the futuristic RBIS and the information concerning watershed management mainly consists of geographic data such as polygons, lines and points, and their attributes. Likewise, digitizing of information needs much time and budget. Thus, a step-wise

program linking both the operational and future systems is proposed if the database system is not yet established in the agencies and data volume is too large to digitize in a short period.

(2) Topography

Basin Topography

The topography of Perak State is largely governed by the geology of the area. The main mountain ranges consist of extensive masses of granite whose original sedimentary cover has been moved by weathering and erosion. The Titiwangsa mountain range forms the state boundary between Perak and Kelantan.

As a result of the northerly topography in the State of Perak, the drainage of the area can be divided into two systems, the coastal system and the Perak river system, separated by the watershed formed by the Bintang range. Further inland, the Keledang range forms the divide between the valleys of the Perak and Kinta rivers.

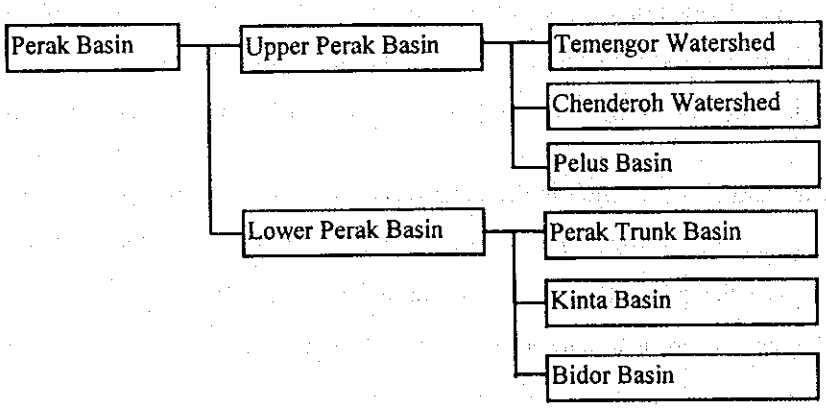
The Perak River which is the largest river on the west coast of Peninsular Malaysia flows along a broadly meandering course. The major tributaries of the Perak River such as the Kinta River and the Bidor River also flow along broadly meandering courses. There is a marked development of flood plains on both sides of the rivers. Meander scars, swamps and marshes abound in the flood plain.

Basin Divide

The Perak river basin can be divided into three parts, upper Perak, lower Perak and major tributaries, from the viewpoint of topographic feature. Further, from the water usage and water storage, the upper Perak can be divided into three parts, Temengor watershed, Chenderoh watershed and remains. The following table summarizes the sub-basin in the entire Perak river basin. The basin divide is also presented in Fig. 7-8.

Major Basin	Sub-Basin	Reference Point	Drainage Area
Upper Perak	Temengor Watershed	Temengor Dam	3,420 km^2
	Chenderoh Watershed	Chenderoh Dam	3,133 km^2
(Major Tributaries)	Pelus River	Confluence with Perak	1,428 km^2
	Remains	-	207 km^2
Sub-Total		Iskandar Bridge	8,188 km^2
Lower Perak	-	Rivermouth	2,345 km^2
Major Tributaries	Kinta River	Confluence with Perak	2,540 km^2
	Bidor River	Confluence with Perak	1,670 km^2
Total Drainage Area			14,743 km^2

The information on the basin divide is stored in the Operational System. As a result, basin information such as logging volume, land use and so on, is easily summed up through the GIS overlay function, based on the following basin structure.



Selection of Base Map

Topographic mapping systems that can cover all of Malaysia are in two map scales: 1:50,000 and 1:500,000. These mapping systems have the same mapping projection of the Rectified Skewed Orthomorphic method as adopted in Malaysia and Brunei.

The basin topography is the most basic information for the RBIS. For the selection of appropriate map scale of the system, the following considerations have been taken into account:

(a) Topographic information is most essential for the establishment of river-related plans and the management of riparian structures and water usage;

(b) For this purpose, accuracy of the 1:50,000 scale is at least necessary for the map information; and

(c) As accuracy increases, the volume of data to be digitized and stored into the computer also increases, resulting in difficulty to input and renew the data.

The following table shows the number of sheets in each map scale that can fully cover the Perak river basin. Based on the interview with private companies in Malaysia, digitizing work costs approx. RM 3,000 per sheet on the average.

Map Scale	Year Surveyed	Number of Sheets
1:50,000	1981-1988	28
1:500,000	Early 1980's	2

Further, digitizing of topographic maps with the scale of 1:50,000 is now being carried out by the Department of Survey and Mapping, Malaysia (DSMM) and will be completed by the year 2002. Considering the accuracy and work volume of map information, the following stepwise program is recommendable:

(a) The limited major elements of the 1:50,000 map, such as contour lines, locations of cities and towns and so on, are digitized for the Operational System because of easy input and cost saving.

(b) After the digitizing work is completed by DSMM, the base map is changed to the 1:50,000 map by obtaining the digital map from DSMM.

(3) Geology

Regional Geology

The Perak river basin is located in the Western Tin Belt of Peninsular Malaysia. Acid intrusives (granitoids) extend widely over the basin. Tin deposits in Peninsular Malaysia are spatially and genetically related to granitoids. Silurian-Ordovician sedimentary rocks distribute, filling up the gaps of granitoids.

Two wide valleys, the Perak Valley and the Kinta Valley, are southerly formed in parallel in the south half of the basin. The bedrock is composed of Carboniferous sedimentary rocks in the Perak Valley, while it is composed of Devonian sedimentary rocks of limestone in the Kinta Valley.

Selection of Geological Information

Geological Survey is being responsibly conducted by the Department of Geological Survey of Malaysia (DGSM). DGSM prepares two kinds of geological map; one is a nationwide geological map with a 1:500,000 scale and the other one is a specific area's geological map with a 1:63,360 scale. The latter one, however, does not fully cover the Perak river basin. Therefore, the former map is selected as a geological information source for the system.

According to the head office of DGSM, they have no plan to digitize the data and to open their digitized data to the public. The data to be integrated into the RBIS consists of polygon, line and their attributes.

The geological map of the Perak river basin is presented in Fig. 7-9. The geological information is mainly based on the work done by DGSM up to the end of 1983.

(4) Soil Cover

Basin Soil Cover

In the Perak river basin, upland soils are generally medium to fine textured. Flood plain soils range from well-drained levee soils to poorly drained heavy clays and peat soils in very poorly drained areas. Most soils are suitable for a wide range of crops.

The only published soil cover information available is the reconnaissance soil map surveyed by the Department of Agriculture in the late 1960's. On this map, the soil cover is mapped mainly as Rengam-Jerangau Association and Serdang-Munchong Association, and areas with slopes greater than 20° (38%) are designated as steep land (tanah churam).

Selection of Soil Cover Information

The Department of Agriculture (DOA) is carrying out a soil survey and storing its result into their database system. So far there are two kinds of soil information in the system. One is based on the work up to 1968 as described above, and the other is now being surveyed. The comparison of them is tabulated in the following table.

Item	Reconnaissance Soil Map	Semi-detailed Soil Map
Completion Date of Field Survey	1968	Still Continuing
Sampling Density	4 km Interval	1 km Interval
Scale of Base Map	1:500,000	1:25,000
Soil Classification	51	More than 300

For the river information system, the reconnaissance soil map was selected as a soil cover information source from the following reasons:

(a) Soil classification on semi-detailed map is over-specialized for the purpose of the river basin management; and

(b) A long time is still necessary for completion of the semi-detailed soil database system.

DOA has already digitized the selected reconnaissance soil map. Further, the urban area, mining area and water surface (the newly created lake) are being updated on the basis of land use in 1990.

Regarding the data structure of soil cover, data consist of polygons classified into 52 categories (including water surface) and their attributes. The soil cover in the Perak river basin is shown in Fig. 7-10.

(5) Land Use and Vegetation Cover

Land Use

The present land use conditions of the Perak river basin are as shown in Fig. 2-2 and Table 2-1 in Chapter 2, based on the land use map edited by the Department of Agriculture (DOA). The forest spreads out in the upper reaches covering 60% of the river basin, while agricultural lands are developed in the Perak Valley and the coastal plain covering 30%. The first major crop area in the basin is the rubber plantation (taking about 13% of the basin), and the second is the palm oil plantation area (about 7% of the basin). Further, there are many ex-mining ponds, particularly in the lower reaches, which cover about 3% of the basin, and some of them are now being used for aqua-culture.

Vegetation Cover

The characteristics of vegetation cover are described in accordance with the topographic classifications, mountains and hills, the Perak Valley, the Kinta Valley and the coastal plain.

(a) Mountains and Hills

Primary inland vegetation consists typically of tropical rain forest, which is also the climax vegetation of the Malay Peninsula. The rain forest consists of a great assortment of plants characterized by the predominance of the family Dipterocarpaceae in the lowlands and hills and Lauraceae and Fagaceae, ferns and mosses in the more elevated areas. Some members of the Dipterocarpaceae like *Dipterocarpus, Shorea* and *Balanops aromatica* provide valuable timber material. Limited cultivation of tapioca and vegetable crops is found along hill slopes.

(b) Perak Valley

In the Perak Valley some lowland forests can be found. The Dipterocarpaceae forms the tree canopy of the lowland forest with a great number of epiphytes, climbers (lianes), shrubs and herbs. Tree cultivation consists essentially of rubber *Hevea braziliensis.* The rubber land is confined inland, generally over hill slopes and undulating ground. Paddy is cultivated in flat ground where irrigation does not present any problem.

(c) Kinta Valley

There is no doubt that before the advent of miners practically all of the area examined was covered by primary jungle of the tropical rain forest. In both lowlands and hills up to 900 or 1,100 m the dominant tree family encountered is that of the *Dipterocarpus* and *Balanocarpus heimii*, frequently making up as much as 30% of the total of large trees present. After the commencement of mining in Kinta the primary jungle began to be cleared rapidly, both to make space for mining operation and to obtain charcoal for the local smelting of tin-ore.

(d) Coastal Plain

The coastal plain, which until as recently as 30 years ago was covered with virgin jungle, has been developed for agriculture. Crops grown are rubber (Sitiawan), oil palm (Teluk Intan) and cocoa under coconut palms (Bagan Datoh). The newly developed area has partly been converted into paddy fields. A narrow fringe along the coast still supports a stand of mangrove.

The mangrove vegetation along the coast consists of evergreen trees and shrubs belonging mainly to the families Rhizophoraceae, Verbenaceae and Lythraceae. Species of *Rhizophora* and *Bruguiera* are used for piling and making charcoal; together they earn more revenue than any other Malayan forest type. Most of the plants in the mangrove swamp are characterized by the presence of aerophores and stilt-roots which are morphological adaptations for survival in soils of high salinity and extremely poor aeration.

Information on Land Use

DOA basically carries out land use survey at 5-year intervals. At present the survey is performed through remote sensing using satellite images. Changes of land use are recognized if land use in an area of more than 20 ha is changed in comparison with the previous one. Mapping scale is 1:50,000 and the latest map is based on the sources in 1990 (refer to Fig. 2-2).

According to the interview with DOA, the land use in 1997 is now being digitized for renewal. On the other hand, the previous one is the 1985 land use map. T his map, however, has not been digitized yet. As of now, historical changes of land use could not be clarified through the GIS system.

(6) Regional Development

Development Framework

The State Government of Perak has formulated the state strategic development plan with four development corridors to develop urban and industrial centers in the state; namely, (1) the East-west corridor; (2) the North corridor; (3) the Central corridor; and (4) the South corridor (refer to Fig. 3-6). This plan keeps step with Vision 2020 (Wawasan 2020).

Among the above development corridors, the East-west corridor is projected in the upper reaches of the Perak river basin, and its land development has a strong influence on the basin runoff discharge and water quality in the lower reaches. The Central and South corridors are also projected along the river course in the lower reaches, and could overlap with the possible flood inundation area. The excessive land development in the Central and South corridors may also increase the flood damage potential in the basin and further reduce the existing natural retarding effect on floods. Thus, the urban and industrial developments in the basin are closely related to the river management works, and the information on the basin development conditions could be one of the important data sources for the river basin management.

Development Details

Among the development components, the following detailed information is essential to the river basin management:

(a) Population Projection

The population projection by District is shown in Table 7-7.

(b) Future Land Use

The Town and Country Planning Department, Perak State prepared the future land use plan based on the structural plan. The future land use plan is shown in Fig. 7-11.

(c) Major Development Schemes

Major development projects are shown in Table 7-8 and Fig. 7-12. They are composed of industrial, multi-sector, trade, tourism, infrastructure and special projects.

As described above, the target of the structural plan is the year 2020. If the economic situation drastically changes, the plan will be adjusted to the new situation. In this case, data renewal work will be necessary.

(7) Mining

Mining History

The Kinta Valley was the world's largest alluvial tin field. Its tin field, discovered in 1880, subsequently became the most important tin-mining area in the world. The deposits consist of rich concentrations of alluvial cassiterite that have accumulated in the wide plain occupied by the Kinta River and its tributaries. In the annual report on the Perak State of 1886 it is stated that mining concessions in Kinta covered about 2,900 ha, of which 1,200 ha had been surveyed. By 1890 this figure had increased to 4,600 ha, by 1895 to 13,500 ha.

In 1892 European miners introduced hydraulic mining. In early 19th century, the steam engine and the bucket dredging were introduced successively. The introduction of new devices resulted in rapid increment of tin production.

The Kinta River, which flows through the mining area, had its course frequently altered due to mining activities. As a result, in particular the lower reaches of the Kinta River had been canalized in the 1950's based on the Kinta River Conservancy Scheme.

The tin-mining activities, however, have rapidly diminished in the recent years due to sharp drop of tin market price and exhaustion of economical mining sites. As of now tin dredges and gravel pumps can be rarely found in the State. The historical changes in number of mine workers employed are given in the following table.

Year	Number of Workers	Remarks
1900	50,728	in Kinta District
1915	76,620	in Kinta District
1950	22,043	in Kinta District
1980	22,600	in Perak State
1995	1,152	in Perak State

As a result of tin mining, a large number of mining ponds (approx. 1,500) occur scattered throughout the previous mining areas. These range from small slime retention ponds to large deep ponds that were left behind after the mining especially when a dredge was used. Some ponds are deep and clear while others are cloudy due to suspended materials.

Information on Mining Activities

From the above-mentioned condition, the effects of tin-mining activities are considered minimal for the river management, although enormous rehabilitation works in the abandoned mining areas still remain. Furthermore, the tin-mining areas are delineated as a tin mining area in the GIS system of land use. Therefore, information on the mining activities is not independently dealt with in the RBIS.

(8) Logging and Forest Conservation

Protection Forest

The present forest area of 9,960 km^2 spreads out in the Perak State, and the area is designated as the protection forest area managed by the Forestry Department (FD). The protection forest is further classified into seven (7) categories: (1) water catchment, (2) soil protection, (3) amenity, (4) education, (5) research, (6) forest sanctuary for wildlife, and (7) VJR [Virgin Jungle Reserve].

These protection forest areas in the State amount to 2,100 km^2, equivalent to 21% of the whole forest area. Among them, the water catchment forest area accounts for 86% of the total protection forest. The water catchment forest is designated as a watershed upstream of an intake for public water supply. Among the protection forest areas, this area is considered essential for the river basin management.

These areas in the State are summarized below.

Protection Forest	Number of Forests	Total Area (ha)
Water Catchment	44	181,981
Soil Protection	4	6,425
Amenity	10	7,798
Education	5	3,254
Research	4	3,059
Forest Sanctuary for Wildlife	8	1,558
VJR	13	5,929
Total	88	210,004

Data Source: Forest Department, Perak

Forest Reserve and Logging Activities

Forest management by FD is conducted following the three (3) hierarchic area classifications:

(a) Forest District: 4 districts in the Perak river basin

(b) Forest Reserve: 25 reserves in the Perak river basin

(c) Forest Compartment: 3,061 compartments in the Perak river basin

Forest management schemes such as logging, reforestation and forest protection are established on the unit of forest compartments. FD is recording the annual activities in each forest compartment.

On the other hand, forest in the forest reserves is classified into three (3) classes in accordance with the allowable activities:

(a) Protection Forest

(b) Virgin Forest: Logging activities are allowed but not yet started

(c) Production Forest: Logging activities are being carried out

These forest classes and forest reserve in the Perak river basin are presented in Fig. 7-13. Intensive logging activities may cause serious sedimentation of the river channel, high turbidity of river water, and hydrological changes of low flow regime and flood discharge. Thus, logging activities are closely related to the river management and the information on the forest reserve conditions is one of the important data sources for the river basin management. Furthermore, the logging activities can be quantified in any sub-basin if the geographic relationship between forest compartment and river sub-basin is established using the GIS system or database system.

Information on Forest Reserve and Logging

So far FD has not digitized the forest compartment boundary. According to the interview with FD, the present status of the GIS system in the Department is now under the experimental stage. A long time is still necessary for completion of the digitizing work over the country. Thus, the following stepwise program is proposed for the river information system.

(a) Operational System

The logging volume in the area will be calculated in the database system by summing up the forest management records with the relational table between forest compartment and river sub-basin. The digitizing work will be limited to the forest reserves.

(b) Future System

Upon receipt of the digitized data of forest compartment from FD, the river information system will calculate the logging volume for any area through the GIS overlay function and the summing-up of the forest management records.

Table 7-9 summarizes the relationship between forest management areas and river sub-basins. The more detailed relational data in each forest compartment will be stored, together with the forest management records in the Operational System. The data items of forest management records based on the "Rancangan Tebangan (Forest Logging Plan)" are as follows. The forest management records compiled in 1997 are tabulated in the Data Book.

Item No.	Data Label
1	Forest District
2	Forest Reserve
3	Forest Compartment Code
4	Area in Ha
5	Logging Year
6	Logging Area by 30-Year Rotation Scheme
7	Logging Area by 55-Year Rotation Scheme
8	Logging Limitation for Dipterocarpaceae
9	Logging Limitation for Non-Dipterocarpaceae
10	Remarks (Protection Scheme, etc.)

Furthermore, if the above data file is owned jointly in the computer of the State Forestry Department as well as DID, the routine works, compilation of the forest management records by the Department and renewal work by DID will be easier.

(9) Soil Conservation

In parallel with forest management, soil conservation works such as contour cultivation and the selection of appropriate crops are also effective against soil erosion. DOA is the responsible agency for this activity. It mainly leads the

small-scale landholders of less than 100 acres (40 ha) to well-soil-conserving cultivation, while it advices the large-scale estate and plantation owners to perform the appropriate measures.

Regarding soil erosion potential, DOA is now calculating the slope factor in the whole of Malaysia, using topographic maps with a 1:25,000 scale. This work will be completed in 1999. The soil erosion potential will be quantified later on. Thus, the information on soil erosion potential has to be integrated into the future system of the RBIS.

(10) River Reserve

Necessity of Geographic Information for River Reserve

The DID guideline on river reserve, "Issues Pertaining to and General Guidelines for the Gazetting of River Reserves, 1991", enumerates the following purposes of river reserves:

Item No.	Purpose
1	As space for future widening and straightening of the river
2	As space for river facilities such as revetment and embankment
3	As space for equipment and housing
4	To act as a flood plain
5	To preserve the stability of the bank
6	To act as a buffer zone against erosion
7	To allow for some erosion of the bank
8	To allow for the propagation of meanders
9	As access for operation and maintenance works
10	As working space for operation and maintenance works
11	As space for spoil dumps
12	As space for beautification works and recreation facilities

The necessary spaces for river reserve are classified in accordance with the river width. According to the guideline the width of reserves in the Perak River falls in the maximum range of 50 m on each bank. In addition to this, the reserves enveloping the well-meandered channel shall be considered in the lower reaches of the Perak River.

In order to enhance the effectiveness of river reserves, as the initial step, DID has to know the current situation of the reserves, such as boundary of a lot, area, landowner,

land use and so on. For this purpose, the cadastral map should be integrated in the RBIS as one of the geographic information items.

Cadastral Mapping System

The Department of Lands and Mines (DOLM) handle land registration. Further, the Perak Water Board (PWB) digitize map information and store them in their computer system by Auto CAD. The Department of Survey and Mapping in Perak State prepared the original map with a scale of 66 feet to the inch (approx. 1:790). The map and attributes are renewed whenever the land registration is changed.

The cadastral map has an index in each sheet with approx. 4,000 by 5,600 m in the exact scale. In addition, the sheet is crosswise, divided into sixty-four (64) pixels (8 x 8). One pixel has dimensions of approx. 500 by 700 m in the exact scale. PWB provides the digitized data at a rate of RM 12 per pixel.

Furthermore, the NaLIS (National Land Information System) is now storing the digital data on cadastral maps and attributes. As of now, this system has not yet covered the Perak State.

Data compatibility between NaLIS and RBIS is essential for convenient data renewal in the future. NaLIS has two types of attributes from different sources. One is based on the land parcel information from DOLM, and the other is from the Local Government Department (LGD). The attributes based on DOLM are considered more useful for the RBIS, because of availability of the items stored in the database. Thus, the data structure of the system will follow the structure of DOLM. The proposed attributes of land parcels are tabulated in Fig. 7-14, and an example of cadastral pixel is also shown in this figure.

Consideration on Usage of Cadastral Map

If the provided digitized data are intended to be utilized as polygon data in the GIS system, data conversion and manual polygon generation works will be necessary. In this case, the data renewal work will be very difficult because enormous manpower is necessary for the work. On the other hand, if the data are utilized as line data without any information, the renewal work will be limited to only conversion work from the Auto CAD system to GIS. The latter case of usage is the same as the present CAD

system handled by PWB. Thus, the latter usage is recommendable from the viewpoint of easy maintenance.

Furthermore, the renewal work in the RBIS should be made as required, because of the following reasons:

(a) Land registration changes are unlikely to frequently occur in the narrow strips of river reserve areas; and

(b) RM 14,400 is needed only for purchasing the renewed data from PWB.

When NaLIS cover the Perak river basin, the maintenance work of the cadastral map will become easier and its cost will be lower because of joint ownership of the information.

Proposed System for River Reserve

The area of river reserve in the Perak river basin has not been actually defined yet. The following two stretches are considered most important from the flood mitigation viewpoint, since the alluvial and coastal plains extend widely in these areas:

(a) Perak River downstream of Iskandar Bridge up to the mouth; and

(b) Kinta River downstream of Anderson Bridge up to the confluence with the Perak River.

These stretches are presented in Fig. 7-15, overlaying the index boundaries of the cadastral map. Based on preliminary estimate, 1,200 pixels are needed to cover the above-defined river reserves.

Considering the progress of digitizing work, the following steps are proposed to establish the system for river reserve management:

(a) Operational System

The digitized data of cadastral maps will be stored in the system by purchasing the digitized data from PWD. The necessary land registration data are collected in the related field office and input into the Operational System.

(b) Future System

After completion of digitizing work of attributes by NaLIS, the renewal work will be made through jointly owning these attributes with NaLIS.

(11) Proposed Geographic Information System

The necessary data and their availability to establish the Operational System for sound watershed management have been discussed in the preceding sections. The information to be stored in the system is composed of geographic data, their attributes and database of the records. Table 7-10 summarizes the result of these discussions, including the future system.

(12) Data Input and Renewal

So far the digitizing of maps enumerated in Table 7-10 has not been completed yet in the related governmental agencies. Besides, the Wide Area Network (WAN) connecting the agencies has not been built yet. Under these circumstances, the data input and renewal work has to be carried out through the following manual procedure:

(a) If the map and its attributes were already digitized by the agencies, their data will be input into the hard disk by copying from the source disk to the data exchange media.

(b) If the data were not digitized, the geographic information will be digitized using digitizer and the attributes will be input manually by typing with the keyboard.

For establishment of the Operational System, the appropriate data input and renewal work is tabulated in Table 7-11, considering the data source conditions. These are summarized below.

Data Input	Map/Table	Data Renewal	
		Item	Interval
Copy of Digitized Data	Soil Map	Urban Area	5 Years
	Land Use Map	Land Use	5 Years
	Cadastral Map	Land Parcel	As needed
Digitizer Input	Topographic Map	Roads, etc.	More than 10 Years
	Geological Map	-	-
	Future Land Use Map	Land Use	Occasion of New Planning
	Major Projects	Project Location	Occasion of New Planning
	Forest Reserve	-	-
Keyboard Input	Population Projection	Population	Occasion of New Projection
	Logging Record	Logging Record	1 Year
	Land Registration	Parcel Data	As needed

7.2 Objective Information to be Disseminated

The objective information is disseminated in either mapping form, tabular form or graphic form. The details of the objective information are as listed in Table 7-12 including the name of information, renewal interval, and agency as data source. As shown in Table 7-12, all objective information are classified in two dissemination level according to the assumed users; i.e., Level 1 for the exclusive use of the government agencies, and Level 2 for information for the public users. The principal criteria of the classification are the same as those in the Master Plan (refer to Subsection 4.2.2). However, some information specified as Level 2 in the Master Plan were provisionally shifted to Level 1 information for the initial operation of the Operational System through a series of discussions with the Government of Malaysia. The following are the major items shifted to Level 1 and the major reasons why such provisional shifting was made:

(1) In the Master Plan it is proposed that all hydrological database will be open to the public so as to promote more active research on the river hydrology. However, a substantial part of hydrological information are originally from the existing database of the DID Hydrology Division, and use of information is currently charged by the Division. Under such conditions, the hydrological database is provisionally dealt with as the information for exclusive use of the government agencies.

(2) In the Master Plan, the real-time hydrological gauging information is also proposed to be open to the public so as to facilitate the evacuation from floods. However, the State DID, the competent agency for the real-time hydrological gauging revealed possible errors in gauging results, and required the time to improve the accuracy of gauging data. Due to the conditions, the information was provisionally dealt with as the information for exclusive use of the government agencies.

(3) Some of the information on the flood management assumed as Level 2 information in the Master Plan are re-classified into Level 1 Information due to uncertainty of their contents. The information classified into Level 1 are the location map and inventory of the projected flood mitigation scheme, the results of river channel survey and the extent of flood inundation area.

The Operational System will disseminate both of the real-time information and non-real time information (i.e., database information). The real-time information contain the hydrological data (rainfall, river water stage and river discharge) transmitted from the existing telemetry gauging stations. As for the non-real time information, it was decided though a series of discussions with the Government of Malaysia that the Operational System will disseminate the objective information through the following seven (7) categories according to the purposes of the river basin management.

(1) General Information, presenting the basin natural conditions and socio-economic conditions to provide the general features of Perak river basin.

(2) Hydrological Information, covering the database on all hydrological gauging data (rainfall, river water stage, river discharge, suspended discharge and tidal data), the meteorological information (temperature, relative humidity, sunshine and evaporation).

(3) Information on River Structures, presenting detailed structural features and the location of bridges, river intake facilities and dams.

(4) Information on Flood Mitigation, presenting flood conditions as well as the existing and proposed flood mitigation facilities so as to support the flood management works.

(5) Information on Water Supply Management, presenting water intake facilities and the statistics on comprehensive water demand so as to support the water supply management.

(6) Information on River Environmental Management, presenting the water quality/water pollutant source, fauna and flora in the river basin, eco-tourism of Perak River and river sand mining to support river environmental management including.

(7) Information on Watershed Management including the information on the urban and industrial development states, the logging activities and the land use states in the river basin to provide the basic information for watershed management.

7.3 System Network

The network plan for the Operational System is oriented to the centralized management at the Federal level as proposed in the Master Plan. That is, both of the database information and the real time information are finally collected to and disseminated from the Federal level. To realize such a centralized system, the network was made through the following four (4) sub-nets (refer to Fig. 7-16):

(1) State DID Sub-Net

This sub-net covers the existing telemetry gauging network operated by State DID. All real-time hydrological gauging information is once collected to this sub-net, and finally transmitted to the Federal DID Sub-Net mentioned below.

(2) ISDN Sub-Net

The Government of Malaysia has leased a dedicated ISDN line of 64 Kbps from Telekom Malaysia to transmit the above hydrological gauging information on real-time base from the State DID to the Federal DID. That is, the State DID in Ipoh once transmits the information through ISDN line to the existing access point of the Agrolink in Kuala Lumpur mentioned below and finally into the Federal DID.

(3) Agrolink Sub-Net

Agrolink is the existing wide area network system established by the Ministry of Agriculture (MOA). This network links all departments of DOA located in Kuala Lumpur including the Federal DID. The IP address for the Operational System is allocated inside Agrolink, and the Agrolink Domain Server manages all information received at and dispatched from the Operational System. The Agrolink Domain Server also manages the global network to open the information from the Web Server in the Federal Sub-Net through the Internet. Thus, Agrolink facilitates the traffic control of all information into and from the Federal Sub-Net. The users can access the Web Homepage of the Operational System through the Internet by the URL address "gis.moa.my."

(4) Federal DID Sub-Net

The information center of the Operational System is placed at the Federal DID in Kuala Lumpur. All system server machines are placed in this Federal DID Sub-Net, and both of the real-time information and the non real-time information are finally collected, processed and disseminated from the Federal DID Sub-Net.

7.4 System Hardware

The Operational System is equipped with various hardware as described hereinafter, and all of them have been installed at either the Federal DID office in Kuala Lumpur or the State DID office of Perak in Ipoh. The inventory of all hardware in the Operational System is as shown in Table 7-13.

7.4.1 Router

The router is the important device to link the sub-nets under the Operational System. In the System, the two new routers were installed at the State DID in Ipoh and the Agrolink Control Center in Kuala Lumpur. Both of the routers check the IP address and ISDN number of external access and ignore the illegal packets (Note: "Packet" is a segment of the digital transmittal data). The routers also check all packets dispatched from the Operational System to external sub-nets, and reject them, unless they are the static routing packets transmitted between the two routers.

7.4.2 Workstation

The Operational System has two units of workstations placed at the Federal DID Sub-Net. The first unit is called "GIS Server" which processes the non-real time information such as geological information and textures the database information and disseminates them through the Internet and/or Intranet. The other unit is the "TM Server" to receive the real-time information transmitted from the State DID and disseminate them to the Internet and/or Intranet. The details of these workstations are as described below:

(1) Hard Disk

The same type of UNIX workstation (HP-UX) is applied to both the "GIS Server" and the "TM Server". The workstation has a total hard disk capacity of 9 GB, which is divided into several partitions and used as Operation System and/or other various applications. Out of the total disk capacity, the largest portion of about 3.6 GB is

allocated to the Operational System database and its associated use. The hard disk also reserves a vacant space of 1 GB for the future system expansion and system swap space.

(2) Device for Network Communication

The workstation contains two network cards, and could work, through the network cards, both for the Intranet communication and the Internet communication. Thus, one workstation can virtually work as if two servers are working. The workstation is equipped with a routing table as a default function in a UNIX system. The routing table controls the communication between the workstation and the external network, and thus protects the workstation from any illegal access.

7.4.3 Peripheral Hardware

In addition to the aforesaid router and workstations, the Operational System contains the following peripheral hardware:

(1) Personnel Computer

Two units of personnel computer (Pentium II/233Mhz) were set as client machines at the State DID and Federal DID sub-nets, respectively. The client machine at the Federal DID Sub-Net will be used as data input and map output controller. The client machine at the State DID Sub-Net will also be used as real-time data transmission controller. The "Windows NT4.0" system is used as the OS (operating system) for these client machines, and the network IP protocol was set up in the OS in accordance with the network design.

(2) Input and Output Devices

One unit of table digitizer of A0 size and one unit of the color Inkjet plotter of A0 size are installed at the Federal DID Sub-Net. The digitizer and the plotter are used as the input device of vector data on geographic information and output device of maps, respectively. Two units of postscript printers are also installed as the output device of documents at the Federal DID Sub-Net and the State DID Sub-Net, respectively.

All of the above input and output devices are directly connected to LAN and could be accessed from either workstations or personnel computers. Thus, the devices could be shared among multi-users.

(3) Power Regulator and Backup Power Supply

Two units of Automatic Voltage Regulator (AVR) and three units of Un-interruptible Power Supply (UPS) are installed to protect the server machine and other hardware from electrical outages. The UPS works for more than one hour as the backup power supply, and the AVR' power rating is more than 600VA.

(4) Backup Device for Database

The Operational System applies two kinds of backup devices; one is a "4mm Type Driver" which is linked directly to the UNIX server machine at the Federal DID Sub-Net, and the other is the CD-R driver linked to the client machine at the Federal DID Sub-Net. The database in the system is protected by these backup devices.

7.5 Operating System

The Operational System applies the following particular operating systems.

(1) Internet Operating System

The "Netscape Enterprise Server" is installed as WWW browser to the "TM Server" and "GIS Server" at the Federal DID Sub-Net. Through this program, the users can access the homepage of the Operational System.

(2) GIS Operating System

A series of software on Geographic Information System (GIS) are installed in the "GIS Server" to manage the database. This software is divided into the three components of "ArcInfo", "ArcView" and "ArcView Internet Map Sever (IMS)". These components of the GIS software have the following functions:

(a) "ArcInfo is the database management software administering all necessary analysis on Geographic Information System.

(b) "ArcView" is used as a viewer to present the GIS data and at the same time used as a software for data input.

(c) "ArcView IMS" is used to dynamically open the GIS data through the Internet.

7.6 Application Software

The following two kinds of application software were developed to support the management of the Operational System: (1) "Telemetry System Application" and "GIS System Application".

(1) Telemetry System Application

This application was developed to support management of the real-time hydrological information gauged by the telemetry gauging stations in the State of Perak. The main functions of this application are as given below:

(a) To collect the gauging data of water stage and rainfall in the Perak river basin on the real-time base;

(b) To collect the outflow discharge from the Chenderoh Dam in the upper reaches of the Perak river basin;

(c) To calculate the discharge data from telemetry water stage data;

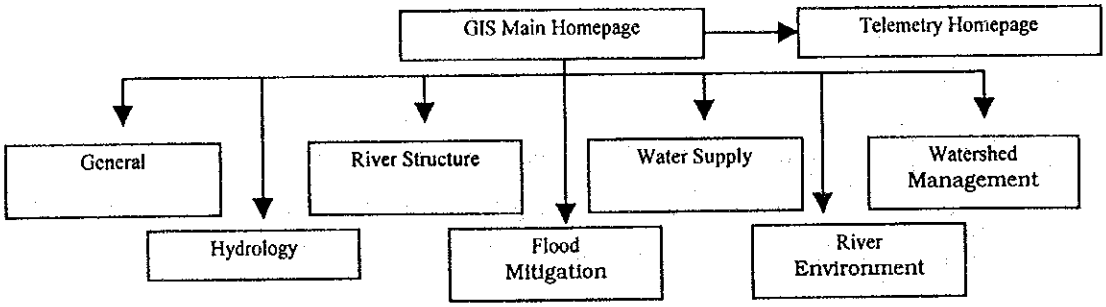
(d) To alarm the flood conditions when the water level exceeds three critical levels; namely, warning level, alert level and danger level; and

(e) To periodically send the above hydrological data to the Web server at the Federal DID Sub-Net and update the web page.

(2) GIS System Application

The database of the Operational System is supported by a series of GIS Operating Systems such as "ArcInfo", "ArcView" and "ArcView IMS". Through these operating systems, the user could process various map information as well as texture data file. A distinct feature of the GIS operation is such that the Operational System could open all database information through the Internet. The "ArcView IMS (Internet Map Server)" in particular could dynamically open the query GIS information through the Internet. To facilitate the operation for "ArcView IMS", the particular frames were developed.

The "GIS WEB Application" was also developed to open the whole web page to the Internet including the aforesaid IMS web page. Through the application, the Operational System opens the main homepage as shown in Fig. 7-17. The main homepage provides the hierarchy of web pages as shown below and, thereby, the users can access any of the categories through the hierarchy.



7.7 Project Implementation Schedule and Project Cost

7.7.1 Project Implementation Schedule

The development of the Operational System was made within one year as shown in Fig. 7-18. In the development period, the system planning and designing by the JICA Study Team took about four (4) months. After the system planning and designing, procurement of hardware and software was made for about three months including tendering, procurement, delivery and installation/adjustment of hardware and software. In the mid-term of delivery of hardware and software, DID completed all necessary preparatory works such as preparation of operation room, power supply, and leased ISDN line for a period of 1.5 months. All data input works and programming works were finally made in six (6) month.

7.7.2 Initial Investment Cost

The initial investment is estimated at RM 2.92 million/year that covers the following four items:

Item	Cost
(1) System planning and designing	RM 1.04 million
(2) Procurement of hardware	RM 0.35 million
(3) Procurement of software	RM 0.47 million
(3) Development of software	RM 0.13 million
(4) Initial data input	RM 0.93 million
Total	RM 2.92 million

(1) System Planning and Designing

The planning and designing of the Operational System was undertaken by JICA Study Team spending about 12 man-months which corresponds to about RM 1.04 million.

(2) Procurement of Hardware and Software

In accordance with the system planning and designing, the necessary hardware and software for the Operational System was procured by JICA through tendering to the local suppliers. As a result, the procurement cost of RM 0.82 million was expended, including RM 0.35 million for hardware and RM 0.47 million for the software ArcInfo, ArcView and ArcView IMS (refer to Table 7-14).

(3) Development of Software

The development of custom-made software for the telemetry system was entrusted to a local consultant at a contact cost of RM 0.13 million (refer to Table 7-15).

(4) Initial Data Input

The Operational System contains various map information and texture/numeric information. A substantial part of the information was not digitized and their digitizing works were entrusted to the local consultant. Such digitizing works amounted to about RM 93 million (refer to Table 7-16).

7.7.3 Annual Operation and Maintenance Cost

The annual operation and maintenance cost consists of (a) cost for maintenance of hardware, (b) cost for manpower for system management, (c) lease cost for ISDN line (64 kbps) and (d) data renewal cost. The total cost of these items is estimated at RM 0.21 million/year that is allocated as below:

Item	Annual Cost
Maintenance of hardware	RM 0.05 million/year
Manpower for system management	RM 0.02 million/year
Lease cost for ISDN line	RM 0.05 million/year
Data renewal	RM 0.09 million/year
Total	RM 0.21 million/year

(1) Maintenance of Hardware

The cost is assumed as 15% of the procurement cost of hardware including the procurement of spare parts in due consideration of durability of the hardware.

(2) Manpower for System Management

The necessary manpower and its annual cost is estimated as below:

Required Staff	Monthly Rate of Emolument (RM/month)	Required Number of Staff	Annual Emolument (RM/year)
River Engineer	9,000	1.0	108,000
Network Manager	9,000	0.3	32,400
Database Manger	4,620	1.0	55,440
Telemetry Engineer	2,200	0.5	13,200
Digitizing Operator	2,200	0.5	13,200
Total		3.3	222,240

7.8 Technical Evaluation

7.8.1 System Expandability

The Operational System deals with the information only for the Perak river basin, and a nationwide expansion of the system will be a significant issue to spread the comprehensive and consistent river basin management in the entire country. At the same time, various government agencies are developing their own information systems, and some of the systems could be useful sources for and/or users of the Operational System. Moreover, the information systems will be linked through the wide area network so as to easily share the information among the government agencies and even the public users. From these viewpoints, the technical evaluation was made on the future nationwide expandability of the Operational System and the system linkage between the Operational System and other related information systems.

The existing Agrolink provides the Operational System with sufficient IP addresses that have a potential capacity of system operation for nationwide river basin management. Moreover, the current workstation of the Operational System reserves the unused hard disk capacity for future system expansion and, at the same time, could easily expand its capacity by increasing of the units of workstations. Thus, the Operational System has a potential to expand the system toward nationwide coverage.

The system's expandability is, however, subject to management of the objective information currently adapted to the Operational System. Should the system manage the futuristic information such as the radar rainfall data and the automatic gauging data on water quality, the data management volume will drastically increase, and the transmission capacity of Agrolink (2MB) is judged to be insufficient for such extensive data volume. Thus, the Agrolink needs to be shifted, in the future, to a permanent wide area network solely dedicated to the Operational System as proposed in the Master Plan.

7.8.2 Linkage with Other Related Information Systems

The DOA has projected to open its land use and soil map information into a wide area network so as to extend and facilitate the use of such information. Likewise, the DID is now developing a system called "Hydrological Information System (HIS)" which could open the hydrological database to the wide area network. The development of both systems by DOA and DID are still under progress, and linkage of the Operational System with those systems have not been made yet. However, the currently intensive multimedia communications development will certainly increase such wide area network information systems as those being developed by DOA and DID. Accordingly, the linkage of the Operational System with the other related information systems will be a significant issue hereafter.

The web server of the Operational System designed under Agrolink facilitates the linkage with other external information systems. The linkage is, however, availed of only when the external information systems are equipped with the wide area network communication system through the following development steps:

(1) The external system sets up a web-server as well as web-application. Should the system intend to open the GIS data, the system also needs to set up the Internet Map Server;

(2) The external system links its web-server to the Internet and/or Intranet, and

(3) The external system opens a network entry to the Operational System.

7.8.3 System Management

The Operational System was developed as an initial information system to support the river basin management in Malaysia, and the sustainable system operation and maintenance in the future will be one of the important issues. In this connection, several particular remarks on the system operation and maintenance were further clarified as described below.

(1) Management of Database

The initial information stored in the database of the Operational System originated from twelve (12) government agencies and two (2) semi-government agencies. The river basin conditions will change from time to time, and the database information need to be periodically updated. The system administrator is required to coordinate with the agencies of information sources and periodically renew the database The system administrator also needs to monitor the updated issues on the river basin management and to vary the contents of database accordingly.

A substantial part of the information are supported by the Geographic Information System (GIS), and their data renewal are made through the particular operating systems of "ArcInfo", "ArcView" and "ArcView Internet Map Server". Although the fundamental management for these operating systems could be made by the government, professional knowledge and/or technique may be occasionally required to solve complicated data errors and other troubles in data management.

The initial data input work for the database of the Operational System was entrusted to the local consulting firm "Landsoft Sdn, Bhd." under the instruction and supervision of the JICA Study Team. The consulting farm has professional knowledge on ArcInfo as well as other GIS operating systems, and further accumulated extensive knowledge on the database of the Operational System. In case of troubles in data management, the system administrator could inquire from the consulting firm.

(2) Management of Real-time Information

The real-time information is managed through a series of software packages of "Telewin Application". All software packages automatically generate the telemetry gauging data on real-time base. During the real-time operation, the only manual work required of the system administrator is to receive the information on dam outflow discharge from the Chenderoh Dam through the public telephone line and input it to the Operational System. Thus, minimal manual work is required during the real-time operation.

The initial data input as well as its periodical renewal is, however, required to activate the real-time operation including input of constants of rating curves for water stage/discharge and the flood alarm water levels. Moreover, the software installed in

the system might still contain programming bugs or cause some inconvenience in operation. Solutions on such professional technical issues could be consulted with the local consulting firm "PowerMatic Sdn. Bhd." The consulting firm is the original designer of the existing flood forecasting and warning system in the State of Perak having sufficient knowledge on real-time information systems. Moreover, the firm was entrusted to develop the particular software applications for the Operational System under instruction and supervision of the JICA Study Team.

(3) System Troubleshooting

The workstations with the UNIX operating system may be damaged due to sudden cutoff of electric power supply. Other hardware may also be damaged accidentally by external forces. In case of such major system failures, the system administrator could inquire from the following suppliers:

(a) Hewlett-Packard Sales (M) Sdn. Bhd for the UNIX workstation and its operating systems;

(b) HI-RAZ Graphic and Peripheras Sdn. Bhd. for all hardware and their operating systems other than UNIX workstation;

(c) Sepakat Computer Consultant Sdn. Bhd. for all GIS operating systems; and

(d) PowerMatic Sdn. Bhd. for the telemetry operating system.

7.9 Economic Evaluation

7.9.1 Economic Benefit

As described in Section 6.7, the RBIS proposed for the Master Plan contains the following three kinds of economic benefit:

(1) Improvement of water deficit by dam reservoir operation that could be realized through the real-time information on the low river flow discharge in the lower reaches;

(2) Reduction of flood damage by dam operation that could be realized through the real-time information on the basin-wide storm rainfall and the flood river flow discharge; and

(3) Reduction of time and manpower for the formulation of river development plans that could be realized by the database information.

The Operational System is equipped with the telemetry river flow gauging system which could have the same function for water supply management as the RBIS proposed in the Master Plan. Accordingly, the Operational System could achieve the same economic benefit for the above Item (1) as the RBIS.

As for Item (2), the RBIS is equipped with the radar rainfall gauge that could enable clarification of the wide area condition of rainfall effecting the objective flood control of the item. However, such radar rainfall gauge is to be installed in line with the long-term development plan and, therefore, has not been installed in the Operational Plan. Due to lack of the radar rainfall gauge, the Operational System could hardly fulfill the above Item (2).

In connection with Item (3), RM 0.5million/year is estimated as the present annual average economic value by the RBIS proposed in the Master Plan. The Operational System is equipped with the comprehensive database information on river basin management and, therefore, could achieve the same economic benefit (RM 0.5million/year) as the RBIS proposed in the Master Plan. It is further assumed that the RBIS proposed in the Master Plan would increase the present economic benefit on Item (3) in the future, as the expenditure for river management increases. However, the Operational System will hardly realize such increment of benefit due to its limited data processing capacity. In due consideration of the above conditions, the annual average economic benefit by the Operational System is estimated as below:

Item	Annual Average Benefit (RM million/year)
(1) Improvement of water deficit by real-time information on low river flow discharge in the lower reaches	0.34
(2) Reduction of flood damage by real-time information on basin-wide storm rainfall and flood river flow discharge	-
(3) Reduction of time and manpower for formulation of river development by database information	0.50
Total	0.84

7.9.2 Economic Cost and Economic Rate of Return of the Project

In the same way as the aforesaid Master Plan, the aforesaid project cost (financial cost) is converted into its corresponding economic cost by multiplying with the conversion factor of 90%. As the result, the economic cost for the Operational System is estimated as below:

Description	Financial Cost (RM million/year)	Economic Cost (RM million/year)
1. Investment cost		
1.1 Procurement of hardware	RM 0.36 million	RM 0.32 million*
1.2 Procurement of software	RM 0.45 million	RM 0.41 million*
1.3 Development of software	RM 0.14 million	RM 0.14 million*
1.4 Initial data input	RM 0.94 million	RM 0.85 million*
1.5 Cost for planning and designing (by JICA Study Team)	RM 1.03 million	RM 1.03 million
Total	RM 2.92 million	RM 2.92 million
2. Annual operation and maintenance cost		
2.1 Manpower cost	RM 0.02 million/year	RM 0.02 million/year*
2.2 Least cost for ISDN line (64kbps)	RM 0.05 million/year	RM 0.05 million/year*
2.3 Maintenance cost of hardware (15% of the Item 1.1)	RM 0.05 million/year	RM 0.05 million/year*
2.4 Data renewal cost (10% of Item 1.4)	RM 0.09 million/year	RM 0.08 million/year*
Total	RM 0.21 million/year	RM 0.21 million/year

* Multiplying with the conversion factor of 0.9

The economic evaluation for the project was made based on the economic internal rate of return (EIRR), using the annual flow of economic benefit and cost given in Table 7-17. In the annual flow, the initial investment cost is disbursed within the first year as made in this study, and the annual operation and maintenance cost accrues from the second year onward. The project period is assumed to be 10 years after completion of the project in due consideration of durability of the system devices. As the result, the EIRR for the proposed project is estimated at 17.1% and judged to be within the applicable opportunity cost (10 to 12%). Thus, the EIRR shows that the proposed project is economically justifiable.