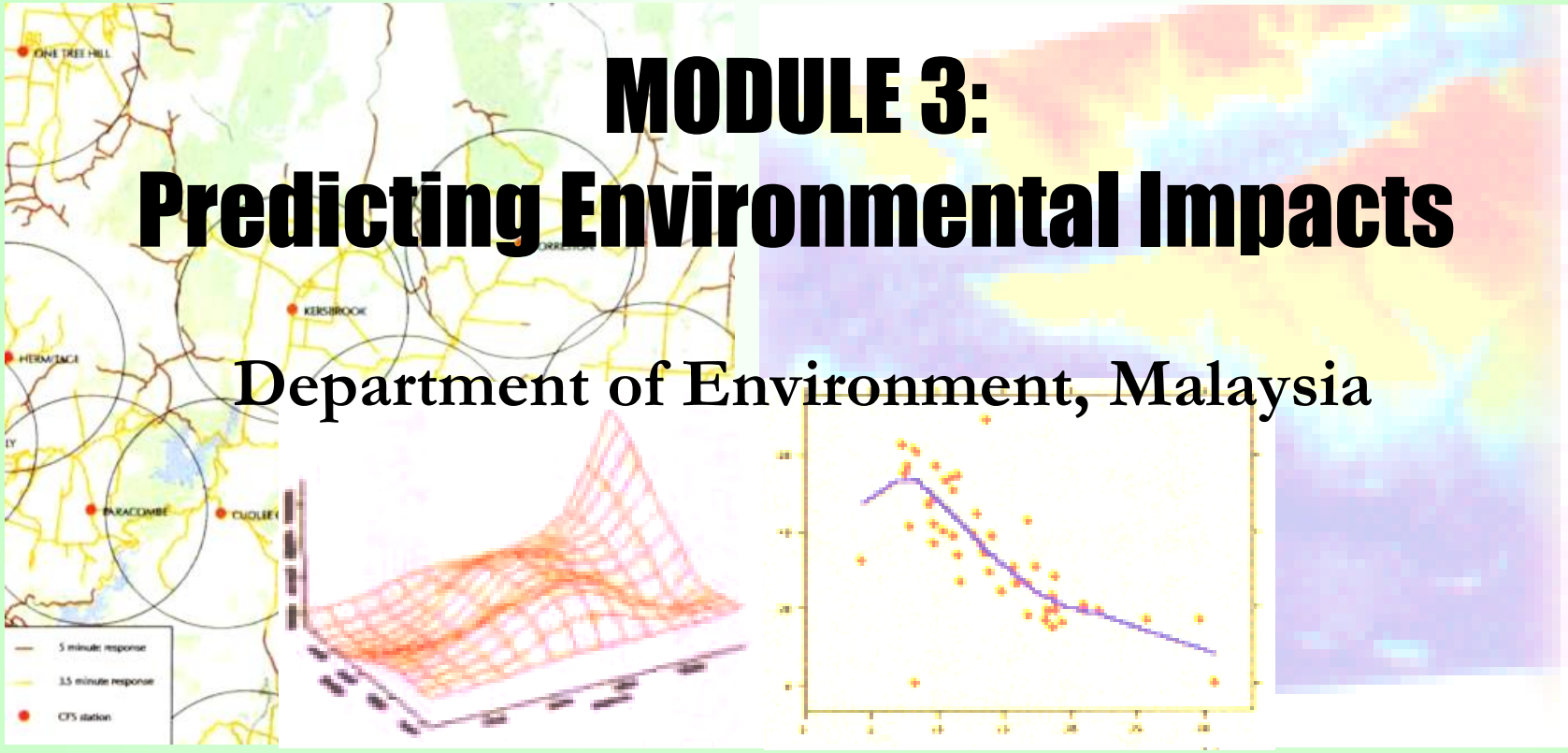
EIA INTENSIVE COURSE



MODULE 3:
Predicting Environmental Impacts

Department of Environment, Malaysia

Objectives

After completing this module, you will be able to:

- understand and apply some of the basic tools available for predicting environmental impacts
- determine which of the tools available for predicting environmental impacts are the most appropriate in a given situation
- assess and review the choice of prediction methods for EIA studies

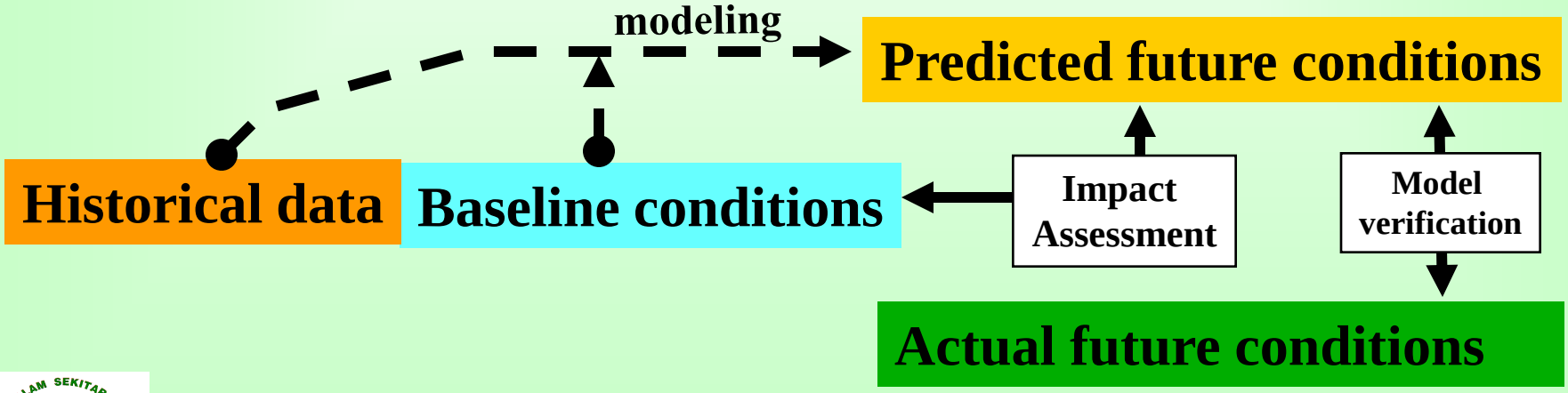
Module Outline

1. Establishing the environmental baseline
2. An introduction to the concept of environmental impact prediction
3. A discussion of the available methodologies for impact prediction
4. How to determine which of the methodologies is the most appropriate for selected examples
5. Practical applications of the skills learned in group exercises

Introduction

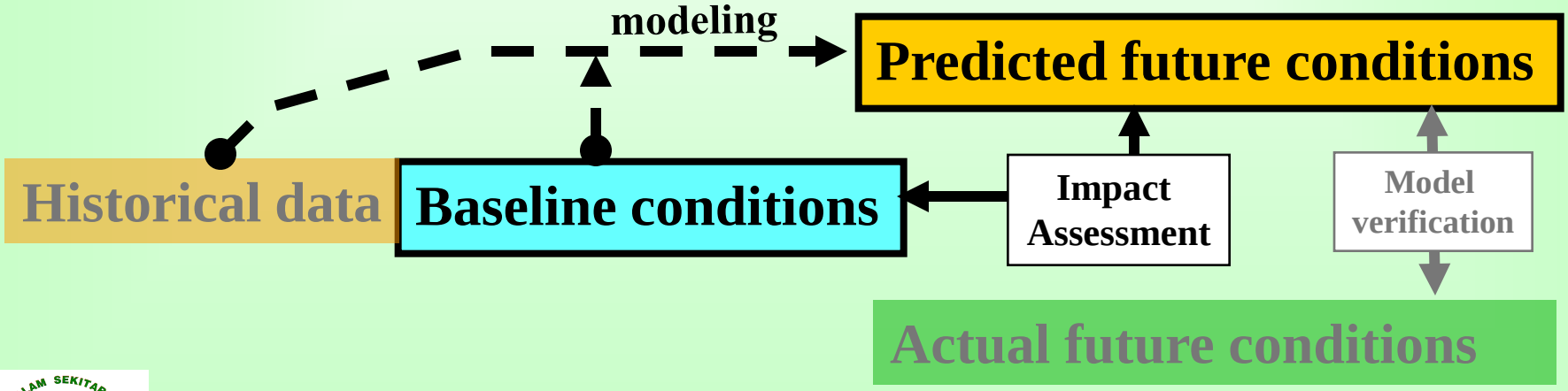
What is PREDICTION?

- A process of quantifying the likely changes in the condition of an area, based on a selected measure that reflects this change.



Objective of establishing Baseline Conditions

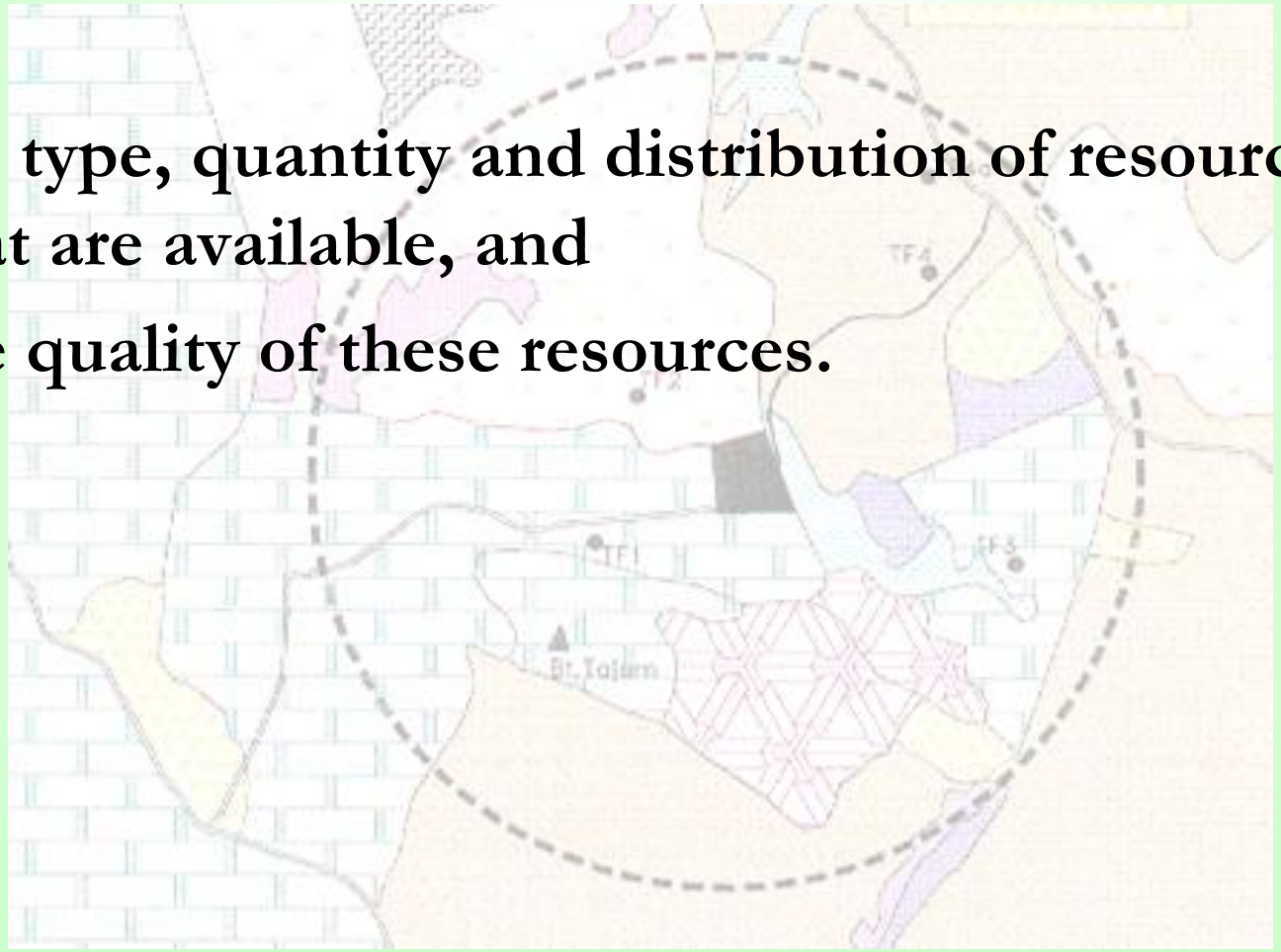
- to determine the condition of the area prior to an activity so as to provide information for the prediction and assessment of impacts



Purpose of Baseline Date

- To provide a description of the status and trends of environmental factors (e.g. air pollutant concentrations) against which predicted changes can be compared and evaluated in terms of importance.
- To provide a means of detecting actual change by monitoring once a project has been initiated.

Baseline Conditions



1. the type, quantity and distribution of resources that are available, and
2. the quality of these resources.

Criteria for Selecting Baseline Information

1. the relative importance of resources that are likely to be affected, for example sensitive fisheries in a river or coastal zone that is affected by discharge of wastewater;
2. If the pollutant is likely to cause a significant change in the quality of the environment, for example, baseline air quality data is required to be collected if the impacts from gaseous emissions of a facility is identified to be significant; and
3. If the data is required for the prediction of impacts, for example meteorological information of wind direction and speed in air quality modelling.

Sources of Baseline Information

1. secondary sources that are maintained by various agencies or authorities, such as population information from the Statistics Department
2. primary data collection from surveys and monitoring studies to be undertaken if secondary data are not available or not adequate

Types of Data

- Quantitative information
  - numerical, indicating a measure of quantity, size or range
- Qualitative information
  - descriptive - e.g. forest that is secondary and sparse..
- Semi-quantitative
  - described relative to a standard or range of 'acceptable' quality.

Evaluation Criteria for Baseline Condition

1. Is the data relevant or important to the study?
2. Is the data adequate to represent the condition of the environment that is described?
3. Is the data in quantitative or semi-quantitative form that is useful for interpretation?
4. Is the data presented in a form that is easily understood or interpreted?
5. Is the data from a reliable source and is this source documented?

Baseline Study

- refers to the collection of background information on the bio-physical, social and economic setting for a proposed development project area
- from secondary sources
- starts right from the period of project inception

Environmental Setting

- the characteristics of the area in which the proposed action would occur
- should be sufficient to convey to readers or reviewers, the precise nature of the natural and human resources potentially affected by the proposed action and alternatives

Environmental Setting (cont.)

- **GEOLOGY**
  - Geological provinces, bedrock formations, history of geological stability or instability.
- **TOPOGRAPHY**
  - General topography of region, specific topography of project area.
- **SOILS**
  - Soil mapping, soil series properties constraints to development.
- **GROUNDWATER RESOURCES**
  - Nature of water bearing formations, recharge rates, sustainable safe yields, locations and depths of existing wells, quality.

Environmental Setting (cont.)

- **SURFACE WATER RESOURCES**
  - Drainage basins and sub-basins, named and unnamed water bodies and water courses, regulatory classification of water bodies, flow regimes, water quality data and evaluation, identification of existing permitted discharges to surface waters.
- **TERRESTRIAL COMMUNITIES**
  - Spatial arrangement of vegetative community types, vegetative species-abundance listings, wildlife species-abundance listings, records of threatened and endangered plant and animal species.

Environmental Setting (cont.)

- **AQUATIC COMMUNITIES**
  - Nature of aquatic habitats, species-abundance listings for aquatic macro-invertebrate and fish communities, ecological indexing of community data.
- **ENVIRONMENTALLY-SENSITIVE AREAS**
  - Identification of wetlands, floodplains, steep slopes, stands of mature vegetation, aquifer recharge areas, areas of high water table, areas of rock outcrop, prime agricultural lands, mines.
- **LAND USE**
  - Existing patterns of land use in the region, regional planning for future use, zoning.

Environmental Setting (cont.)

- **DEMOGRAPHY**
  - Estimated population, recent trends and projections for future population
- **SOUND LEVELS**
  - Existing sound levels, sources of sound.
- **SOCIO-ECONOMIC CHARACTERISTICS**
  - Economic and social structure of communities, tax rates, characteristic types of development.
- **INFRASTRUCTURAL SERVICES**
  - Nature and scope of human services such as police and fire protection, hospitals, schools, utilities.

Environmental Setting (cont.)

- **TRANSPORTATION**
  - Layout and function of existing roadways and airports, existing and projected capacities and demands.
- **CULTURAL RESOURCES**
  - Location and characterisation of identified cultural resources (archaeological, historical, cultural, landmark), potential for unidentified resources to be present in project area.

Exercise 3-1

- Evaluate the quality of the baseline information

Objective of Impact Prediction

- to identify the magnitude and other dimensions of the identified change in the environment as a result of a project activity

Minimum Requirement for Impact Prediction

- **determine the initial reference point (baseline or existing condition)**
- **provide an estimate of the future state of that condition with the proposed project action**
- **provide an estimate of the future state of that condition without the project action**

Impact Prediction Methodology

- **EXTRAPOLATIVE APPROACHES**
  - predictions are made based on present and past trends. These include trend analysis, scenarios, analogies and intuitive forecasting.
- **NORMATIVE METHODS**
  - work backward from desired outcomes in order to assess whether or not the project is able to achieve them

Prediction Models Application

1. **Mechanistic or mathematical models** - for describing cause-effect relationships in the form of charts or mathematical functions, e.g. for predicting economic impacts
2. **Mass balance models** - to establish a mass balance equation for a given defined physical entity, e.g. water flow in a river basin.
3. **Statistical models** - statistical techniques, e.g. regression or principal components analysis to describe relationship between data.

Prediction Models Application (cont.)

4. **Physical, image and architectural models (geographical models)-** illustrative or scale models, e.g. computer graphics
5. **Field and laboratory experimental models -** use existing data inventories supplemented by special surveys to predict impacts on receptors, e.g. testing of a pesticide in an outdoor pond.
6. **Analogue models -** make predictions on analogous situations, e.g. comparing the impacts of a proposed development to a similar development under study.
7. **Expert judgement -** involve asking an acknowledged expert(s) for a brief qualitative opinion

Importance of Model Verification and Sensitivity Analysis

- Undertake simulation of conditions, expected during the project to ensure that the model is applicable.
- Verify constants used
- Monitoring of the residual impacts after project implementation - to verify future assessment using similar models

Predictive Models Used in EIA Studies

- Air quality modelling
- Noise impact modelling
- Surface water quality modelling
- Groundwater and soil quality modelling
- Coastal hydraulic modelling
- Soil erosion modelling
- Ecological modelling

Air Quality Modelling

- to represent the behaviour of pollutants mathematically and determine the resulting impact on air quality

Air Quality Modelling (cont.)

TYPES AND QUANTITIES OF AIR POLLUTION

- Primary and secondary pollutants
- Stable and unstable pollutants
- Mobile and stationary pollutant sources

- Atmospheric interaction
- Meteorology
- Chemical processes

Air Quality Modelling (cont.)

CONSIDERATIONS

- Impact scenarios
  - Most probable impact
  - Worst case impact
- Classification of sources:
  - point
  - line
  - area

Air Quality Modelling (cont.)

SELECTION OF PREDICTION MODELS

- Box model
  - line, area, single or multiple sources uniformly distributed over small areas
  - initial, rough cut estimate
- Dispersion Model
  - Gaussian plume model
  - turbulent dispersion and atmospheric stability
  - Flexible and allows variation in wind speeds and direction

Air Quality Modelling (cont.)

CASE STUDY

- **Steel Mill - Melaka**
- **ISCST2 Model**
- **SO2, NO2, TSP**

Noise Modelling

TYPES & CHARACTERISTICS

- **POINT** - defined by 1 co-ordinate (example, equipment or machinery)
- **LINE** - defined by 2 co-ordinates (example, roads, railway)
- **AREA** - defined by at least 3 co-ordinates (example, parking or commercial lots)

Noise Modelling (cont.)

CONSIDERATION

- Type of noise source
- Sound power level
- Sound pressure level
- Excess attenuation
- Point source - spherical or hemi-spherical
- Line source
- Area source
- Impulse or continuous

Noise Modelling (cont.)

SELECTION OF PREDICTION MODELS

- Point source
- Impulse noise
- Continuous noise
- Line source

Noise Modelling

CASE STUDY

- **Proposed Highway - Pulau Pinang**
- **TNOISE**

Water Quality Modelling

TYPE AND CONSIDERATION

- Physical, chemical and biological processes
- Transport processes
  - advection
  - diffusion
- Transformation processes

Water Quality Modelling (cont.)

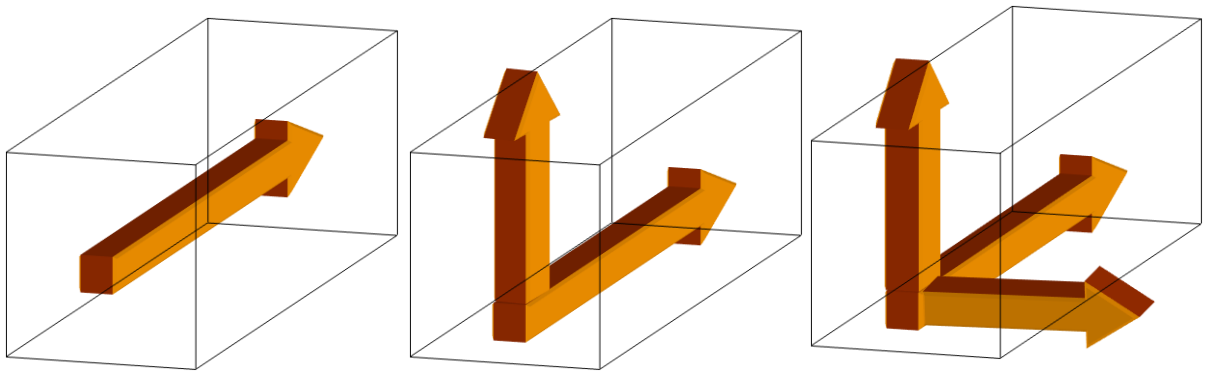
CONSIDERATION

- The characteristic of the water body - whether it is a small stream or large river, swift flowing or slow flowing, stagnant body of water or with a known hydraulic retention time, its catchment and hydrologic characteristics of the water body;
- Flow characteristics of the water body;
- The type of constituent that is to be modelled and its chemical and biological behaviour in water;
- The quantity of constituent existing and introduced into the environment.

Water Quality Modelling (cont.)

TYPES OF MODELS

- One-dimensional model
- Two-dimensional model
- Three-dimensional model



Water Quality Modelling (cont.)

TYPES OF MODELS

- Dynamic models
  - variation in water quality as a function of both distance and time
- Steady-state models
  - no variations exist over time

Water Quality Modelling (cont.)

SELECTION OF PREDICTION MODELS

- Mixing Zone Model
- Streeter-Phelps Model
- Other water quality model :
  - QUAL2E
  - MIKE 11

Water Quality Modelling (cont.)

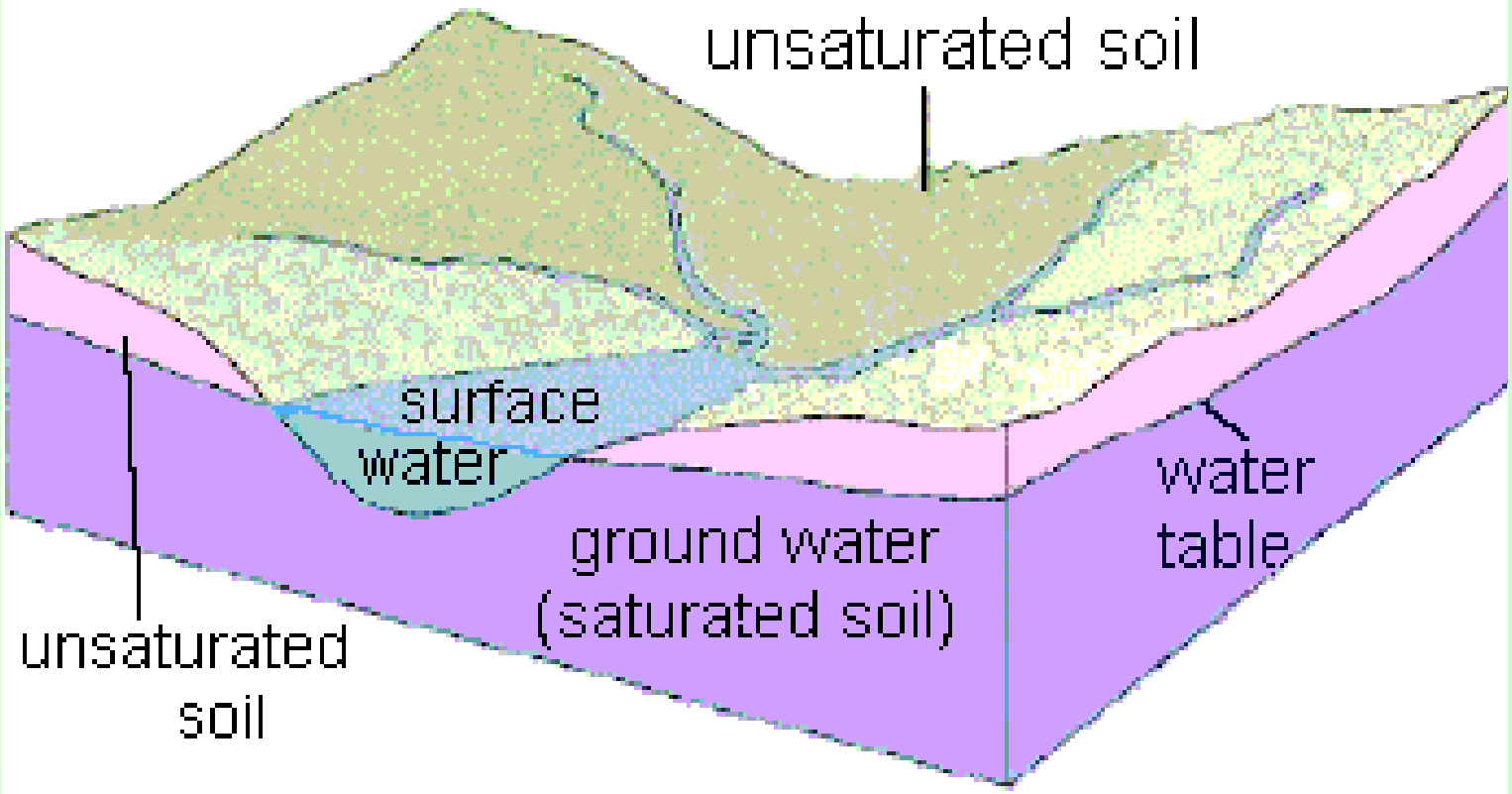
CASE STUDY

- Proposed Sg. Jus Dam, Melaka
- QUAL2E model

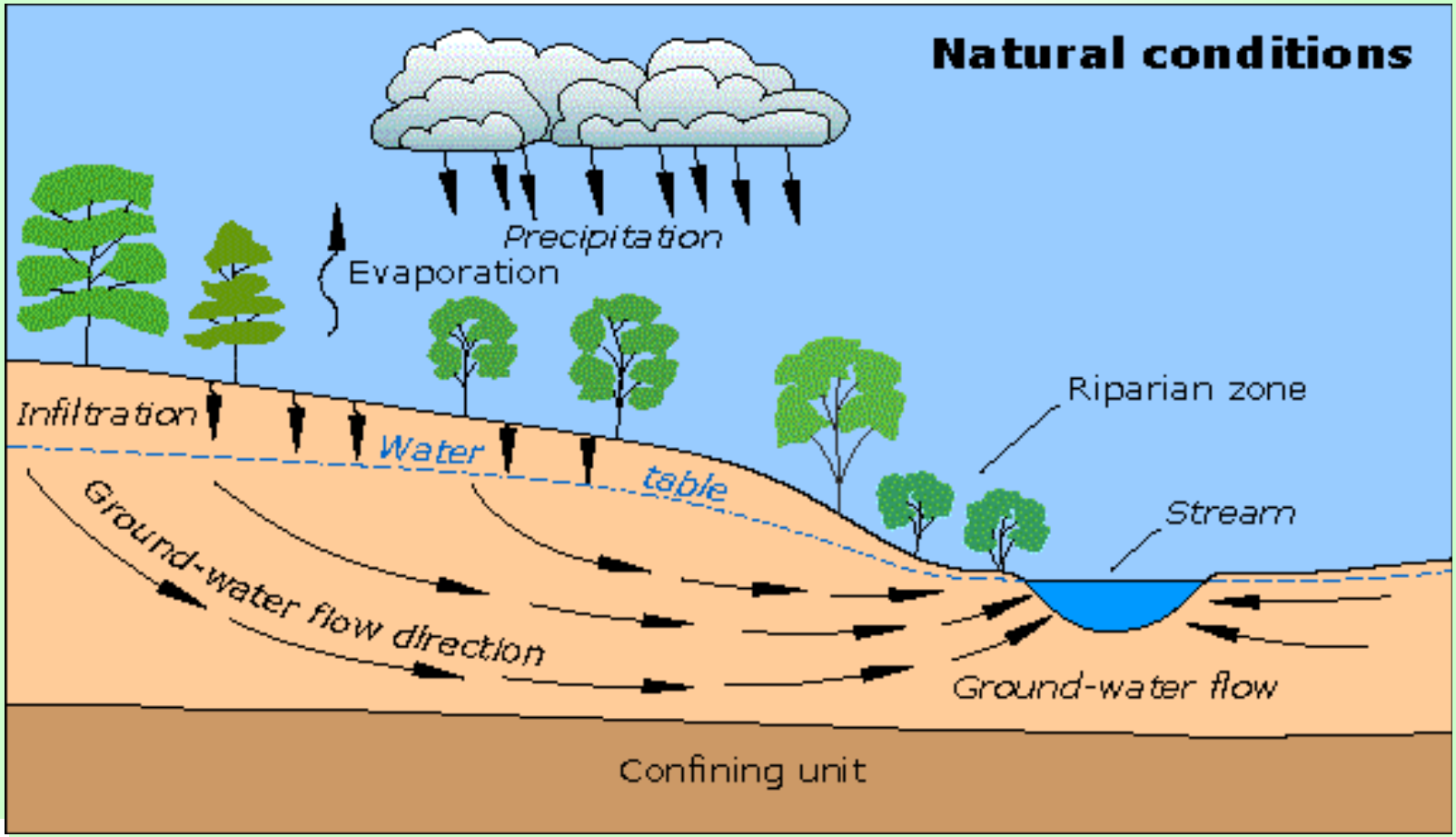
Groundwater Modelling

- Groundwater flow
- Solute transport
- Deformation

Groundwater Modelling (cont.)



Groundwater Modelling (cont.)



Groundwater Modelling (cont.)

CONSIDERATIONS

- Groundwater flow simulation -
  - aquifer properties, inflow and outflow into the system
  - MODFLOW
- Groundwater quality simulation -
  - Vadose zone models
  - MODPATH
  - MOC3D

Groundwater Modelling (cont.)

CASE STUDY

- Groundwater Abstraction in Kuala Langat

Coastal Hydraulic Modelling

- Hydrodynamic modelling
- Wave modelling
- Mud/sand transport modelling
- Advection/dispersion modelling
- Shoreline evolution modelling

Coastal Hydraulic Modelling (cont.)

CONSIDERATIONS

- Model area
- Model set-up
- Calibration
- Verification
- Running

Coastal Hydraulic Modelling (cont.)

SELECTION OF PREDICTION MODELS

- Coastal hydraulics and oceanographic studies
- Environmental hydraulics
  - Advection-dispersion models
  - Water quality
  - Eutrophication
  - Heavy metals
- Sediment Processes
- Waves

Coastal Hydraulic Modelling (cont.)

CASE STUDY

- Proposed Coastal Reclamation, Lekir

Soil Erosion Modelling

- Factors that affect soil loss
- Erosion - a function of the amount and rate of runoff considered in relation to the physical and chemical characteristics of the soil and the biological influence of vegetation on the soil surface.

Soil Erosion Modelling (cont.)

CONSIDERATIONS

- Rainfall duration and intensity;
- Degree and regularity of land slopes;
- Size and shape of the drainage area or watershed;
- Kinds of vegetation and extent of coverage;
- Presence or absence of well defined channels for surface drainage and their hydraulic properties; and
- Permeability of soil and subsoil and the geological substrata

Soil Erosion Modelling (cont.)

Universal Soil Loss Equation

$$A = R.K.LS.C.P$$

A	**= Computed annual soil loss per unit area**
R	**= Rainfall factor**
K	**= Soil erodibility factor**
L	**= Slope length factor**
S	**= Slope gradient factor**
C	**= Crop factor**
P	**= Conservation Practice factor**

Soil Erosion Modelling (cont.)

CASE STUDY

- Proposed Oil Palm Plantation, Sarawak

Uncertainty in Impact Prediction

- Clearly identified
- state clearly the underlying assumptions
- sensitivity analysis - process of trying to identify the sensitivity of an environmental component to changes in the influencing actions.

Exercise 3-2

- Identify and evaluate models used in EIA study

Commonly Used Models in Malaysia

Model	Media	Remarks
EPA ISCST2	Air	From industrial sources
AUSPLUME	Air	Point sources, can be modified for use in fugitive emissions
Box model	Air	For initial assessment
MIKE 11	Water	For surface water
QUAL II	Water	For surface water
Streeter-Phelps Equation	Water	For specific parameters, such as Dissolved Oxygen and Biochemical Oxygen Demand
MIKE 21	Coastal water	Popular Danish model
General equations	Noise	For Traffic, Multiple sources, Single point, Airport - are all different
MODFLOW	Groundwater	More for water flow
USLE	Soil Erosion	A number of modifications might be needed

Risk Assessment

- A scientific process of knowing how risking something is
- A process of collecting and analysing scientific data "to describe the form, dimension, and characteristics of risk"

Risk Assessment

Four analysis steps:

- Identify hazards
- Establish relationship between a dose and response to that dose
- Analyse potential public exposure
- Characterise or describe the risk

Identifying Hazards

- Existing scientific data
- Establish cause and effect relationship
- Primary data from laboratory studies
- Necessary to establish whether data from an affected population could be applied to other populations if secondary data were to be used.

Establishing Relationship between Dose and Response

- Establish the level of dose would cause an observed effect
- Using a known population and its known response to a suspected risk agent
- Also include human exposure information

Analysing Potential Public Exposure

- Other factors
- Potential sources of the cause, concentration, pathways
- Actual measurements, mathematical models, description of people from different groups, etc.

Characterising and Describing Risk

- Information collected should be used to describe or characterise the overall risk
- Analysis involves substantially more information, thought, and judgement than the numbers express