NATIONAL UNIVERSITY OF SINGAPORE

FACULTY OF ENGINEERING

EXAMINATION FOR

(Semester I: 2009-2010)

CE5310 - HYDROINFORMATICS

November / December 2009 - Time allowed: 2 hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **FOUR(4)** questions and comprises **FIVE(5)** printed pages.

2. Answer **ALL FOUR (4)** questions.

3. All questions carry equal marks.

.../2

With the completion and closure of Marina Barrage Singapore's catchment area has increased with 10,000 ha, about one-sixth the size of Singapore. Most of the land used in this catchment can be classified as urban. Consequently, managing the water quality in Marina Bay is a complex task, especially during the process of transition from a brackish water system to a freshwater system, which is expected to take about a year. Similarly in the longer term careful water quality management is required to allow the use of the water in Marina Bay for pottable water production. In support of water quality management for Marina Bay a large study has been carried out in which hydraulic, hydrodynamic and water quality models have been developed, an Operational Management System has been built and a water quality management plan for the catchment has been developed.

(Note: for the purpose of this examination some of the information below has been modified from the actual situation)

The project involved the collection and analysis of water quantity and quality data. At four locations (S1, S2, S3 and S4) in Marina Bay the following parameters are continuously monitored at temporal resolution of 10 minutes since the 1st of July 2008:

- Water level (cm)
- Velocity (m/s)
- Temperature (^{0}C)
- Turbidity (NTU)
- Dissolved Oxygen (ppm)
- Salinity (ppt)
- pH
- Rainfall (volume over 10 minute period; mm)

In addition to this, since the 1st of April, 2009 once a week samples have been collected from a boat at three additional, different locations (B1, B2 and B3). These samples are analysed for more than 50 parameters, including:

- Temperature (^{0}C)
- Turbidity (NTU)
- Dissolved Oxygen (ppm)
- Salinity (ppt)
- pH
- Nitrate (mg/L)
- Phosphate (mg/L)
- Chlorophyll-a (μg/L)

.../3

Question 1 [total: 20 marks]

Database Design

(a) State the advantages of storing the measurements data in a database (e.g., MySQL) rather than several spreadsheet (e.g., Microsoft Excel) files. [4 marks]

(b) Design a database for managing the measurements data. List the names of the tables. For each table, list the attributes and their data types (e.g., Varchar, date, time, datetime, int, real).

Hint: you may need to read the next question to help you design a better database that makes queries easy to write.

[6 marks]

SQL queries

(c) Write a create table command for **one** of the tables that you designed in the previous question.

[2 marks]

(d) Write a SQL query that finds out: the water level measurements on Aug 9, 2009.

[2 marks]

(e) Write a SQL query that finds out: the average salinity measured by the boats in August of 2009.

[2 marks]

(f) Suppose that the database also contains a table that keeps the weather information at temporal resolution of one hour, and the structure of the table is:

Table name: WeatherInfo

Attribute	**Data type**	**description**
Day	Date	
Hour	Int	From 0 to 23
Weather	Varchar	Clear, Cloud, Rain

Write a query that finds out the turbidity measurements at the four continuous monitoring locations (S1 to S4) during Rain hours in Aug 2009.

[4 marks]

Question 2 (total: 20 marks)

To manage the water quality in Marina Bay a Geographic Information System needs to be developed to store, analyse and present the spatial data. Describe such GIS using the following topics:

(a) The key components of the GIS [3 marks]

(b) At least five examples of data that could be stored in this system, the data model used and feature types that is most suitable to represent each of the datasets [6 marks]

(c) Some types of spatial analysis that can be used to support the water quality management plan [6 marks]

(d) The way the information could be presented to different types of users / stakeholders (engineers at the Public Utilities Board, decision makers at ministries, general public, etc.) [5 marks]

Hint: think of visualisation technologies or discuss good map design

Question 3 (total: 20 marks)

The basic conservation equations of mass and momentum for fluid flow are usually simplified for hydrodynamics. For numerical modelling some simplifications and issues arise. The following questions require you to discuss some of these simplifications and issues.

(a) Name the two assumptions that allow the basic conservation equations to be simplified for hydrodynamics and describe what how these assumptions affect the physical properties or the basic conservation equations in one or two sentences for each assumption. [8 marks]

(b) When modelling engineering-scale hydrodynamics problems using computers (e.g. using Delft3D-Flow) more assumptions are made to simplify the basic conservation equations. Name at least two of these additional assumptions and describe in one or two sentences for each assumption how they are implemented or how they affect the basic conservation equations. [6 marks]

(c) In addition to these assumptions which may affect the results, issues also arise due to the choice of numerical solution methods. State at least 6 possible issues that may arise due to the choice of numerical solution method.

[6 marks]

Question 4 (total: 20 marks)

(a) Which basic DIMENSIONS will be required to store the data collected in the Marina Barrage case study in a netCDF format (all stations/all parameters in 1 file)? List their attributes and possible values they can take.

[5 marks]

(b) Outline the steps involved in processing/preparing the sampled raw data if it is desired to compare the patterns for Salinity changes during the dry period (May to July) at station B1 and station S2.

[5 marks]

(c) It is proposed to retain only the two of the four Dissolved Oxygen (DO) monitoring instruments at stations S1 to S4 and one of the three weekly monitoring instruments at stations B1 to B3. Explain the possible data analysis approaches that can be used to strategically shortlist the stations, given all the different variables and different sampling rates. List the assumptions made (if any), data analysis/visualization techniques/measures that can be used to support the conclusions.

[10 marks]

- END OF PAPER -