NAME _____
Student # _____

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATIONS, APRIL 2001

Fourth Year - Programs 1, 3, 5 and 6

CIV543H1S - SOLID WASTE MANAGEMENT

Examiner - P.H. Byer

1	/6
2	/12
3	/12
4	/8
5	/10
6	/18
7	/28
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Instructions:

1. This is a Closed Book examination.
2. Any type of calculator is permitted.
3. Answer all questions, showing your work in the space provided below each question.
4. If more space is needed, continue elsewhere and clearly state where in the space below the question.
5. The precision and clarity of your answers, and the reasonableness of assumptions, will be given significant weight in marking.

PART 1:

(6%) 1. Waste is often characterized by "typical" values. Explain, using a clear example, why the use of these values is not always appropriate in waste management planning.

(12%) 2. Answer any **three** of the following 4 questions. Only 3 questions will be marked. If you attempt to answer more than 3, clearly show which 3 you want marked.

a) List the principle constituents of landfill gases (do not give quantities or percentages) and explain why landfill gases are a concern.

b) What are 3 methods for passive control of landfill gases?

c) Sketch the layers of a modern multilayer landfill liner. Clearly label each layer.

d) What issues should be addressed in a landfill closure plan and in postclosure care?

(12%) 3. Answer any **three** of the following 4 questions. Only 3 questions will be marked. If you attempt to answer more than 3, clearly show which 3 you want marked.

a) Explain the importance of and need for excess air in waste combustion.

b) Explain the difference between mass-fired and a RDF-fired combustion system.

c) Describe the heat balance in an energy-from-waste incinerator.

d) Explain the effect of moisture and exit gas temperature on boiler efficiency.

(8%) 4. Answer either a) or b):

a) Briefly explain the steps of a procedure for facility siting.

b) Explain the Constraint Mapping process for facility siting.

PART 2:
Below is information on solid wastes generated in a small city that is undertaking a 20 year waste management plan.

Waste Generation, Composition and Properties for City
These are not expected to change over time.

Population = 20,000

Waste Generation = 500 kg/cap/year

Composition and Properties (on an as-discarded basis):

Component	% by wt.	Spec. Wt. kg/m^3	% Inert	Energy kJ/kg	Landfill Compaction Factor
Food wastes	20	300	5	5,000	0.3
Paper	30	100	10	15,000	0.2
Ferrous Metals	15	250	100	0	0.4
Plastics	10	70	20	30,000	0.1
Other	25	125	40	10,000	0.5

The current landfill will be closing in the near future. Answer each of the following questions with respect to this planning. You will need to make a number of assumptions; clearly state them and use typical values found in waste management; your mark will be based in part on the reasonableness of your assumptions. Unless otherwise stated or appropriate, work in units of tonnes or tonnes/year.

The city is considering the following four options and combinations of them:

1. At-source waste diversion
2. Landfilling which would require a waste transfer station
3. Centralized MRF for commingled waste
4. Incineration with energy recovery

Assume in all of the questions below that the city will have at-source diversion (option 1) of 40% of its paper waste and 40% of its food waste.

Questions:

5. For option 3 (centralized MRF):

(6%) a) Draw a process flow diagram for a MRF that recovers paper, metals and plastics from commingled wastes without the use of handsorting. Do not show any quantities on the diagram.

(4%) b) Assume that the hourly feed into a binary for metals consists of 100 kg of metals and 150 kg of nonmetal wastes. The separator has the following characteristics:

% Extraction = 90%
% Rejection = 80%

What is the amount of waste per hour in the "extract" from the separator?

6. For option #4 (incineration with energy recovery):

(8%) a) Calculate the amount of electricity that could realistically be recovered annually.

(6%) b) Relative to the volume of waste as-discarded, what would be the % reduction in volume as a result of incineration?

(4%) c) What are the primary concerns with incineration that should be investigated as part of the waste management planning process?

7. For option 2 (landfilling) alone following at-source diversion:

(18%)a) Estimate the required landfill volume and size of the fill area assuming that all of the cover materials must be imported from off the site, that the ground is flat and the height of the fill area will be 30 m.

(10%)b) Draw a layout (plan) view for a typical modern landfill clearly identfying each of the major engineered/design elements.

(6%) 8. If the city chooses a combination of all four options, draw a flow diagram of the material flows through the elements of the waste management system from consumption to disposal. Do not show any quantities on the diagram.