UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: March 2022

Module Number: CE7303 **Module Name: Construction Environmental Management**

[Answer **all questions**, questions carry **unequal** marks]

Q1. a) (i) "Avoidable wastes produced during construction, wastes generated by the disposal of construction and demolition waste, and excessive energy used to operate construction activities, can be eliminated, or at least reduced through proper use of Life Cycle Assessment (LCA) and implementation of its results". Rationalize this statement with a complete definition for LCA.

[2.0 Marks]

(ii) Environmental-friendly options are preferred as alternatives over traditional methods for road building and restoration. Stabilizing the existing soil to create durable and load-bearing layers is such an environmental-friendly option. This option is preferred to the traditional road-repair and construction methods that involve excavating and transporting the existing substandard soil and importing materials from borrow pits to the road site. Discuss why the former method is considered environmental-friendly compared to the latter.

[2.0 Marks]

(iii) Explain how "Life Cycle Assessment" can be applied to select the best environmental-friendly option in the above case.

[1.0 Marks]

b) Identify 5 pollution hazards sources from construction activities. Specify the construction activity and name a preventive method for each source identified.

[2.0 Marks]

c) Discuss an effective qualitative approach to prevent construction and demolition waste during the pre-construction stage.

[2.0 Marks]

d) Table Q1 gives the pollution and hazard magnitude values per unit time (h_i) for activities associated with foundation and concrete work. Determine which activity produces the highest pollution, using a reasonable method.

Table Q1: h_i values of some construction operations during foundation and concrete work

Activity	Task Name	h_i	Duration (Days)
Foundation work	Prefabricated concrete piles using drop-hammer	0.5	31
	Steel sheet piles using hydraulic piling driver	0.2	57
	Earth work-transportation	0.6	57
	Support system-building	0.3	42
	Support system-demolition	0.7	28
	Foundation construction	0.4	43
Concrete work	RC work-rebar	0.3	155
	RC work-form	0.2	155
	RC work-concrete	0.5	156
	Masonry work	0.5	176
	Structural steel work	0.6	94

[4.0 Marks]

Q2. a) Municipality sewage treatment charges may be determined from (1) the volume of waste (quantity formula); (2) by applying a surcharge for parameters exceeding predetermined concentrations in addition to the charges based on the effluent volume (quantity-quality formula); and (3) by allowing all users to pay the same amount for an 'assessment rupee', after which a surcharge is applied (assessment/surcharge formula), i.e. every user has to pay a fixed amount of money annually to the municipality for sewage treatment (this amount which is called 'annual assessment' is set by the municipality based on an assessment of its wastewater characteristics). Discuss the pros and cons of each of the above three methods from the pollution control standpoint.

[3.0 Marks]

b) An industry has its wastewater treated and disposed of at a central treatment facility by paying sewage treatment charges to a municipal council. The treatment charges are calculated using the assessment/surcharge formula. The industry has been assessed at Rs. 25 million/yr. The average annual residential assessment is Rs. 70 000 per household of 4.5 persons. BOD_5 (Biochemical Oxygen Demand) contribution per household is 150 *g/capita.d*. The operating cost for removing BOD_5 is Rs. 100 per *kg* BOD_5 removed. Assuming that the users are entitled to the same amount of treatment per assessment rupee and the annual

surcharge of this industry is 3 million rupees, what would be the BOD_5 concentration of the wastewater discharged by this industry. The industry daily wastewater generation is 500 m^3/d?

[3.0 Marks]

c) (i) The characteristics of a wastewater out-fall having a varying flow rate is to be investigated. The flow variations exceed ± 15 %. What is the most suitable sampling technique to be used to collect a sample from the above waste stream, justify your selection?

[2.0 Marks]

(ii) An industry operating from 7.00 a.m. to 1:00 p.m. records hourly wastewater generation volumes of 225, 215, 200, 195, 205 and 210 m^3. Two samples for waste composition analysis will be collected using 'fixed volume - fixed time interval composite sampling' and 'flow proportionate composite sampling' techniques. The total volume of each composite sample will be 1556 mL. Estimate the volume of the sample that should be collected every hour for each sampling technique.

[3.0 Marks]

Q3. A mega-scale construction project seeks a potential river to discharge wastewater generated from its construction site. Since this wastewater complies with the discharge standards, the discharge to a river is allowable. There are two streams called 'Stream A' and 'Stream B' situated nearby the site. The decision to which river the wastewater will be discharged, shall be based on which river would be impacted the least due to this discharge. Table Q3 (a) gives measurements of the wastewater generated by the construction site, stream A and stream B. The saturation dissolved oxygen concentration at 24.3 ^0C is 8.29 mg/L.

Table Q3 (a) Measurements of construction industry effluent and stream A and B.

Parameter	Tannery Industry Effluent	Stream A	Stream B
Flow rate, m^3/d	4 000	40 000	50 000
Ultimate BOD at 24.3 ^0C, kg/d	150	-	-
Ultimate BOD at 24.3 ^0C, mg/L	-	20	23
DO (Dissolved Oxygen) concentration, mg/L	0.5	6	6.2
Temperature, ^0C	24.3	24.3	24.3
k at 24.3 ^0C, d^{-1}	0.35	-	-
k_2 at 24.3 ^0C, d^{-1}	-	0.65	0.65

The following equations is applicable:

$$D_c = \frac{k}{k_2} L_i e^{-k\theta_H^*} \qquad \theta_H^* = \frac{1}{(k_2 - k)} \ln \frac{k_2}{k} \left\{ 1 - \frac{D_i (k_2 - k)}{k L_i} \right\}$$

Where;

D_i = Initial dissolved oxygen deficit at the point of waste discharge, *mg/l*.

D_c = Critical dissolved oxygen deficit, *mg/l*.

θ_H^* =Critical hydraulic detention time, *d*

k_2 = Reaeration constant, d^{-1}

k = Carbonaceous organic matter degradation rate constant, d^{-1}

L_i = Ultimate *BOD* at the point of waste discharge, *mg/l*.

a) Which river would be selected by the mega-scale construction site owner?

[6.0 Marks]

b) Estimate the BOD_5 of a sample taken at the critical point of the selected river. Consider the temperature at the critical point is the same as the temperature at which the above BOD_5 value should be determined.

[2.0 Marks]

Q4. Gin-Nilwala Diversion Project (GNDP) is a major development project aiming to divert excess water in the upper reaches of Gin and Nilwala River basins in the wet zone to Hambantota district. Hambantota district suffers from severe water shortages. The proposed infrastructure of the project includes a medium sized reservoir at Madugate (12 MCM) in Gin River and transfer water to Kotapola weir across Kotapola Oya in Nilwala River basin through a tunnel of the length equal to 18 km and from Kotapola weir through a second tunnel of the length equal to 6 km to a another reservoir at Ampanagala (11 km) across Siyabalangoda Oya, which is also in the Nilwala Rver basin. From Amapanagala reservoir, the water will be transferred to Muruthewala reservoir across Urubokka Oya through a third tunnel of the length equal to 13 km. Balance water from Muruthawela reservoir after meeting its irrigation and drinking water demands, will be transferred to Chandrika Wewa in Walawe river basin through Muruthawela existing LB canal, which will be improved (13 km), and a new canal of the length equal to 17 km. With this diversion, it is possible to provide drinking and industrial water requirement of the Greater Hambantota Development area at different key locations in the Udawalawe and Liyangastota schemes. Figure Q4 illustrates the locations of the main components of the proposed project.

a) Identify **five** environmental resource factors likely to be affected during the operational phase of the above project.

[2.0 Marks]

b) State an environmental impact, which will be imposed on each identified environmental resource factor I Q4 (a).

[2.0 Marks]

c) Construct an interaction matrix suitable for an Environmental Impact Assessment (EIA) report for the above project to summarize the environmental impacts during the operational phase. Clearly indicate the environmental resource factors.

(Note: Use the impacts identified in Q4 (a) and consider an imaginary significance level for each impact identified.)

[4.0 Marks]

d) For the above project, construct an outline of a weighting-scaling checklist that could be used to compare three alternative sites to locate the proposed reservoir at Madugate, in developing an Environmental Impact Assessment (EIA) report. One of the alternatives should be the proposed reservoir at Madugate, and the other two alternative sites should be on the up and down stream of the proposed Madugate reservoir, respectively. The checklist should include at least 5 decision factors, an imaginary weight for each decision factor and an imaginary scale for each alternative. A composite index for each alternative must be obtained based on the imaginary weights and scales.

[4.0 Marks]

Q5. Kataragama sacred city is a fast-developing township. The existing wastewater collection, treatment and disposal system (WWCTDS) was completed in 1983. However, the area has been developed rapidly and the demand for sewerage services has subsequently increased. The high population density, improper drainage system, discharge of sewage to the drains etc. have caused health hazards such as dysentery, dengue and viral hepatitis in the Kataragama town area. Because there is no adequate piped sewerage system in the town, all grey water is discharged into surface water drains ending up at Manik River. Therefore, the existing system is incapable of catering the increasing demand. The existing WWCTDS confines to the bus stand and shopping complex areas and to a few pilgrims' restaurants around the shopping complex area. In addition, there are many hotels and pilgrims' restaurants, which do not have connections to the current WWCTDS. Therefore, this wastewater may possibly end up in Menik River without any treatment. To overcome this situation, an upgrading to the existing system has been proposed. The proposed project will cover the entire sacred city area. The proposed augmentation program for the existing wastewater treatment plant (WWTP) will consist of preliminary treatment units and a mechanically aerated flow-through lagoon followed by a maturation pond preceding a chlorination unit. Treated effluent will be ultimately discharged to the Menik River at a place, which is about 1.7 *km* downstream to the Katargama sacred city. The collection network and the WWTP will be designed to cater a total design period until 2047. Table Q5 (a) depicts the average number of new domestic sewer connections per each 5-year period. The value is the same for all the years within each five-year period. Table Q5 (b) shows the wastewater data of 4 drainage lines.

Table Q5 (a): No. of new domestic sewer connections and the total population.

Year	No. of new domestic sewer connections per year	No. of total population
2022	150	8,050
2027	250	9,100
2032	350	10,075
2037	450	10,900
2042	550	11,500
2047	650	12,475

d)

Table Q5 (b) Average wastewater data of 4 drainage lines.

Drainage No	Cross Sectional Area (m^2)	Velocity (ms^{-1})	BOD_5 (mg/L)
C1	0.35	0.45	320
C2	0.25	0.12	400
C3	0.28	0.32	500
C4	0.89	0.15	800

e)

a) Discuss environmental impacts due to 'no action alternative' for the above project.

[2.0 Marks]

b) Develop a methodology to estimate the ambient water quality in Menik River surrounding the treated effluent discharge point, upon the discharge of treated effluent during the operational phase of the above project. Clearly state the parameters and factors to be considered.

[3.0 Marks]

c) In conducting an extended cost-benefit analysis, the avoided cost of medication and gain in productivity as a result of the lower morbidity rate is one beneficial aspect of this proposed project. Health statistics from the Kataragama Base Hospital indicate that the morbidity rate for acute water-borne diseases is about 43 per 1,000 population. These cases represent only those reported in the hospital where patients sought medical treatment. Reported incidences were estimated to represent only about 50% of all cases, therefore, the morbidity rate for non-acute cases was estimated at around 86 per 1,000 population. The survey data likewise indicated that it takes an average of 4 days for a patient suffering from acute water-borne diseases to get fully recovered. The cost of medication is about Rs. 750 per day and for non-acute cases, about one-half of this cost. Although,

most patients are children, about 30% of the patients are adults. The average labor wage in the area is Rs. 300/*d*. The medication cost and wages will increase by 25 % every five-year period. Using a reasonable method, estimate the avoided cost of medication and gain in productivity as a result of the lower morbidity rate. Consider the no. of occupants per a household is 5.

[4.0 Marks]

d) The implementation of the proposed project is expected to improve the water quality by gradually eliminating the pollution load carried by the 4 drainage lines given in Table Q5 (b), as the people will not incline to release untreated wastewater into surface drainage. It is expected that the total pollution load carried by these lines will entirely disappear by the design year, 2047. Estimate the net economic benefit gained through the improvement of the water quality due to the implementation of the proposed project in the year 2047. The effluent BOD_5 is 12 *mg/L*. The shadow price for BOD_5 is Rs. 3.75 per 1 *kg* of the pollutant load.

[4.0 Marks]

e) Name **three** nos. of economic cost aspects and **six** nos. of economic benefit aspects associated with the above project that can be monetized to estimate a benefit-cost ratio for the project. Exclude the economic benefits described in parts 'c' and 'd' above.

[3.0 Marks]

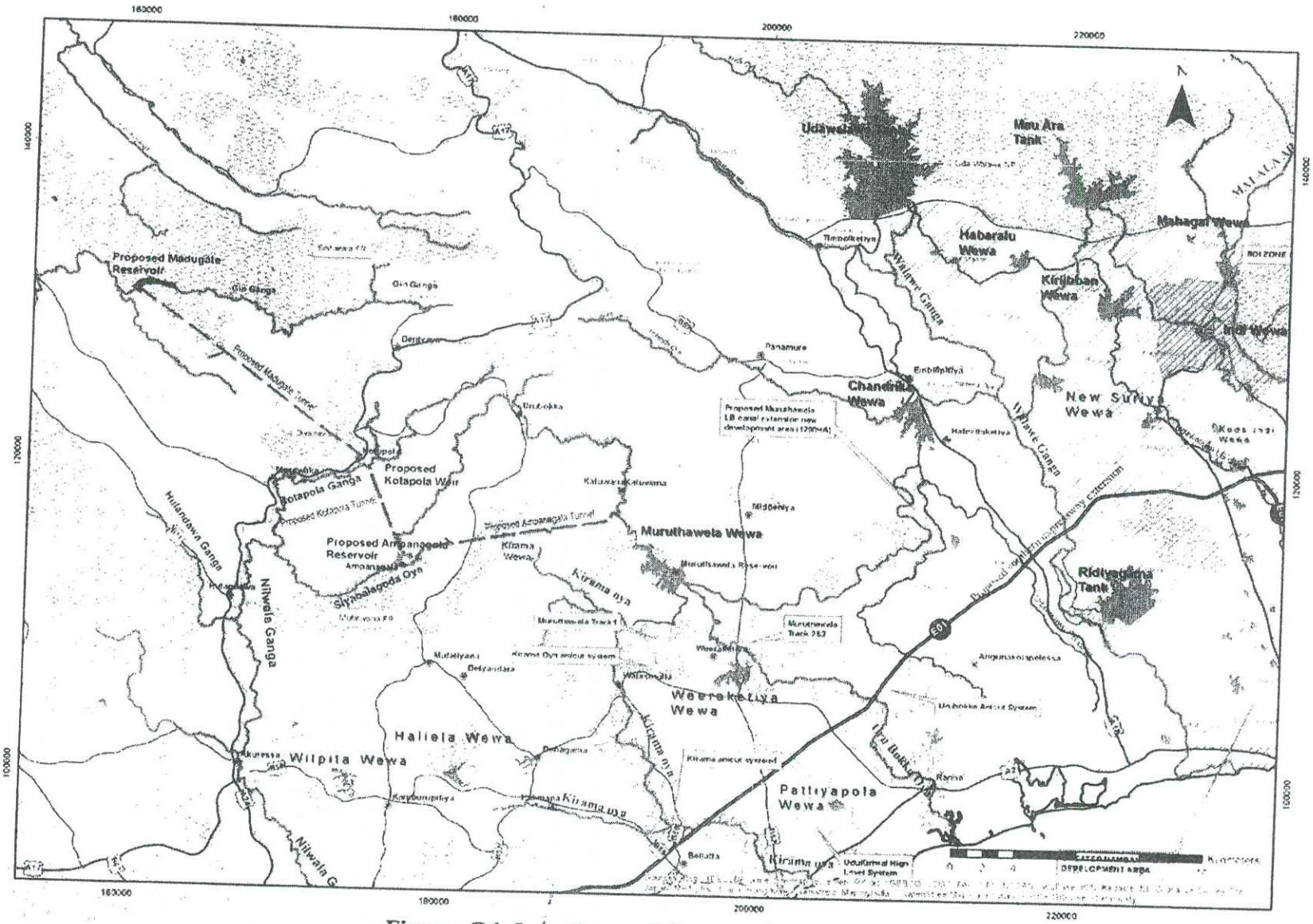

Figure Q4: Locations of the proposed project