UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: August 2024

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

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

Q1. a) (i) "When implementing a sustainable built environment, prioritizing cleaner technology over end-of-pipe solutions for waste management is essential. This prioritization aligns with several existing environmental management tools, which emphasize prevention and reduction of waste at the source rather than treating or disposing of it after it is generated.". Justify this statement through existing environmental management tools.

[2.0 Marks]

(ii) State two similarities and two differences between 'eco-efficient construction' and 'sustainable construction'.

[2.0 Marks]

(iii) State three construction activities typically undertaken for a water resources development project where tunnelling serves as the principal method for transporting diverted water;
State a source of pollution from each of the activity mentioned above;
State a technological method to mitigate each identified pollution source above.

[2.0 Marks]

b) State two source reduction measures for waste at each of the following stage of any built environment project: pre-construction stage; construction stage and post-construction stage.

[2.0 Marks]

c) Following are the different life cycle stages of an expressway: Raw material extraction; Manufacturing; Construction; Operation and Maintenance; Demolition; and Disposal, Reuse and Recycling. Identify an environmental impact likely to arise at each stage and a mitigatory measure for each impact identified.

[2.0 Marks]

Q2. a) Table Q2 (a) depicts effluent discharge data of an industry.

Table Q2(a): Effluent discharge data of an industry.

Type	Parameter	Flow rate/ Concentration		Charge (Rs/kg or m^3)
		Unit	Value	
	Flow rate	m^3/d	1500	30.00
NHP	Biochemical Oxygen Demand (BOD_5)	mg/L	450	70.00
	Total Suspended Solids (TSS)	mg/L	560	50.00
	Chemical Oxygen Demand (COD)	mg/L	670	
	Total Dissolved Solids (TDS)	mg/L	755	
	Total Kjeldahl Nitrogen (TKN)	mg/L	35	
	Oil & Grease	mg/L	35	
HP	Phenol	$\mu g/L$	20	150.00
	Chromium (Cr^{3+})	$\mu g/L$	150	
	Ferrous (Fe^{2+})	$\mu g/L$	56	
	Led (Pb)	$\mu g/L$	48	
		Management charge (MC)		Rs 50.00 per day

NHP: Non-hazardous pollutants
HP : Hazardous polluants

(i) Develop a suitable formula to calculate the annual effluent discharge fee of this industry.

[2.0 Marks]

(ii) Calculate the **annual** effluent discharge fee using the formula developed in the part (i) above.

[3.0 Marks]

b) (i) Using a sketch diagram, illustrate the appropriate location for placing an equalization tank in a wastewater treatment train that deals with significant fluctuations in the flow rate and organic matter content. Provide justification for the chosen location.

[2.0 Marks]

(ii) Table Q2 (b) shows hourly flow rates of the wastewater discharged by a dairy industry. Design the size of an equalization tank to balance the flow rates. Assume a safety factor of 1.5.

Table Q2 (b): Wastewater flow rates

Time (h)	Average flow rate (m^3/s)
0-1	0.13
1-2	0.28
2-3	0.3
3-4	0.2
4-5	0.1
5-6	0.07
6-7	0.1
7-8	0.32
8-9	0.35
9-10	0.23
10-11	0.3
11-12	0.34

[3.0 Marks]

Q3. A mega-scale project aimed at developing an eco-industrial park is planning to discharge its domestic and construction & demolition wastewater during construction into a nearby stream after on-site treatment. There are two candidate streams, labeled 'A' and 'B', flowing near by the site. The selection of the receiving stream for the treated effluent discharge depends upon minimizing the impact on the chosen stream. Table Q3 (a) provides the effluent data and measurements from each of the stream. Based on these data, which stream would experience the least impact? The saturation dissolved oxygen concentration at 25°C is 8.24 mg/L.

Table Q3 (a) Effluent data and measurements of the streams.

Parameter	Treated Effluent to be Discharged	Stream 'A'	Stream 'B'
Flow rate, m^3/d	5000	35000	40000
Ultimate BOD at 25 ^0C, kg/d	130	-	-
Ultimate BOD at 25 ^0C, mg/L	-	15	18
DO (Dissolved Oxygen) concentration, mg/L	0.8	5	6
Temperature, ^0C	25	25	25
k at 25 ^0C, d^{-1}	0.3	-	-
k_2 at 25 ^0C, d^{-1}	-	0.7	0.7
Velocity, m/d	-	10000	10000

You may use the following equations:

$$D_c = \frac{k}{k_2} L_i e^{-k\theta^*_{tt}}$$

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

$$x_c = \theta_H^* u$$

Where;

D_i = Initial oxygen deficit at the point of waste discharge, *mg/L*

D_c = Critical oxygen deficit, *mg/L*

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

x_c = Critical distance, *m*

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*

u = Velocity of the river, *m/d*

[8.0 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 shortage. The proposed infrastructure of the project includes two weirs, one reservoir, three tunnels and canals. There is a weir at Pitadeniya in Gin River, which will transfer water to Kotapola weir across Kotapola Oya in Nilwala River basin through a tunnel (Pitadeniya tunnel) of the length equal to 12 *km*. Water is then transferred from Kotapola weir through a second tunnel (Kotapola tunnel) of the length equal to 5.5 *km* to another reservoir at Ampanagala 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 (Ampanagala tunnel) of the length equal to 12.5 *km*. The 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 improved (13 *km*) and a new canal of the length equal to 17 *km*. It is planned to accompany the development as separate complexes as follows: Pitadeniya complex; Kotapola complex; Ampanagala complex; Muruthawela complex and Udawalawa-Mau Ara complex (Includes Chandrika wewa and its irrigable area). With this diversion, it is possible to provide drinking and industrial water requirements 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 GNDP. Following questions are based on the Environmental Impact Assessment (EIA) development for the proposed GNDP.

a) In the proposed project above, tunneling will be accomplished using a Tunnel Boring Machine (TBM). The Environmental Impact Assessment (EIA) report for this project necessitates a quantitative analysis of alternative tunneling methods. Develop an outline for a weighting-rating checklist designed to compare potential tunneling methods, including the proposed approach. This checklist should encompass a minimum of five decision factors, assigning an arbitrary weight to each factor and establishing an arbitrary rate for each alternative. A composite index for each alternative should be calculated based on the arbitrary weights and ratings.

[3.0 Marks]

b) Identify an environmental resource factor likely to be affected

(i) during the operational phase in each of the following spatial locations:
the region surrounding Siyabalagoda Oya upstream of the Ampanagala Dam;

the area surrounding Siyabalagoda Oya downstream of the Ampanagala Dam;

the area encompassing the existing 13 km Muruthawela LB Canal; and
the newly constructed 17 km canal.

[2.0 Marks]

(ii) during the construction phase in the vicinity of the Ampanagala Tunnel

[0.5 Marks]

c) State an environmental impact, which will be imposed on each environmental resource factor identified in Q4 (b) during the relevant phase of the project.

[2.0 Marks]

d) Construct a Leopold interaction matrix encompassing the impacts identified in Q4(c).
Assign an imaginary scale ranging from 1 to 4 to denote the magnitude and significance of the impacts imposed on each resource factor.
Proceed to complete the Leopold matrix and provide a quantitative summary.

[3.5 Marks]

e) Construct an Environmental Monitoring Plan (EMP) that encompasses only the impacts identified in Q4(c).

[3.5 Marks]

f) Extend the above EMP into an 'Environmental Management Plan'.

[3.5 Marks]

Q5. 12.2% of the population in a town lacks proper sanitation facilities. The drainage system in the city is polluted with domestic wastewater. During the wet season, cesspools and soakage pits become saturated, causing wastewater to overflow freely into the drainage lines. High population density, a poor drainage system, and frequent sewage overflows into drains have led to health hazards in the area. Therefore, a proper sewage disposal system is necessary to minimize the spread of waterborne diseases in this town.

To address this issue, a project proposing the construction of a wastewater collection, treatment, and disposal system has been put forward. This system will include a collection network, treatment facilities, effluent and sludge disposal systems, as well as operation and maintenance facilities.

The wastewater treatment plant (WWTP) will feature an aerated lagoon system capable of handling 12,000 m^3/d of wastewater, including groundwater infiltration. Sludge accumulated in the secondary sedimentation basin will be composted and sun-dried. The collection network will be laid along the main roads in the town. Adjacent to the proposed WWTP is an estuary, into which treated effluent will be discharged. This estuary is extensively used for fishing, including for shrimp farms, and salt production.

Given the absence of a piped sewerage system in the town, all greywater is currently discharged into surface water drains that lead to the estuary. Both the collection network and the WWTP will be designed to accommodate the town's needs until 2055. Table Q5 (a) depicts the average number of new domestic sewer connections per 5-year period. Table Q5 (b) provides wastewater data for 4 drainage lines that terminate at the estuary.

Table Q5 (a): No. of new domestic sewer connections.

Year	No. of new domestic sewer connections per five-year period
2026-2030	700
2031-2035	1000
2036-2040	1700
2041-2045	2000
2046-2050	2500
2051-2055	3000

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	0.25	0.42	350
C2	0.28	0.13	475
C3	0.34	0.35	505
C4	0.87	0.13	825

a) Name the type of standard applicable to each of the following water quality conditions:

(i) The characteristics of the treated effluent for discharge into an estuary.

(ii) The resultant water quality in the estuary immediately following the disposal of the treated effluent.

[1.0 Mark]

b) Outline a methodology for estimating the ambient water quality in the estuary surrounding the treated effluent discharge point following the discharge of treated effluent during the operational phase of the project.

[3.0 Marks]

c) The methodology described above Q5(b) was employed in the development of the Environmental Impact Assessment (EIA) for the project under consideration. Upon analysis, it was found that the water quality of the estuary fails to meet the applicable ambient water quality standards for certain parameters following the disposal of treated effluent. To rectify this non-compliance issue, propose two recommendations for inclusion in the EIA report.

[2.0 Marks]

d) In conducting an extended cost-benefit analysis, the cost savings from not having to construct on-site facilities are taken as an economic benefits due to this project. Considering the following information, calculate the benefit gained by not having to construct on-site facilities:

- The average investment cost per septic tank disposal system is Rs 150,000/=. This price will remain the same until the design period is over.
- The average installation cost of sewerage connection is Rs 80,000/=. This price will remain the same until the design period is over.
- About 50 % of the residences connected to the network have septic tanks.
- Emptying septic tanks is done every five-year period.
- The cost of pumping out the septage in this town is Rs 20,000. The cost of pumping out septage increases by 5.0 % every five years until 2055.

[4.0 Marks]

e) The implementation of the proposed project is expected to improve the water quality of the estuary 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, 2055. Estimate the net economic benefit gained through the improvement of the water quality due to the implementation of the proposed project in the year 2055. The effluent BOD_5 is 16 mg/L. The shadow price for BOD_5 is Rs. 4.00 per 1 kg of the pollutant load.

[4.0 Marks]

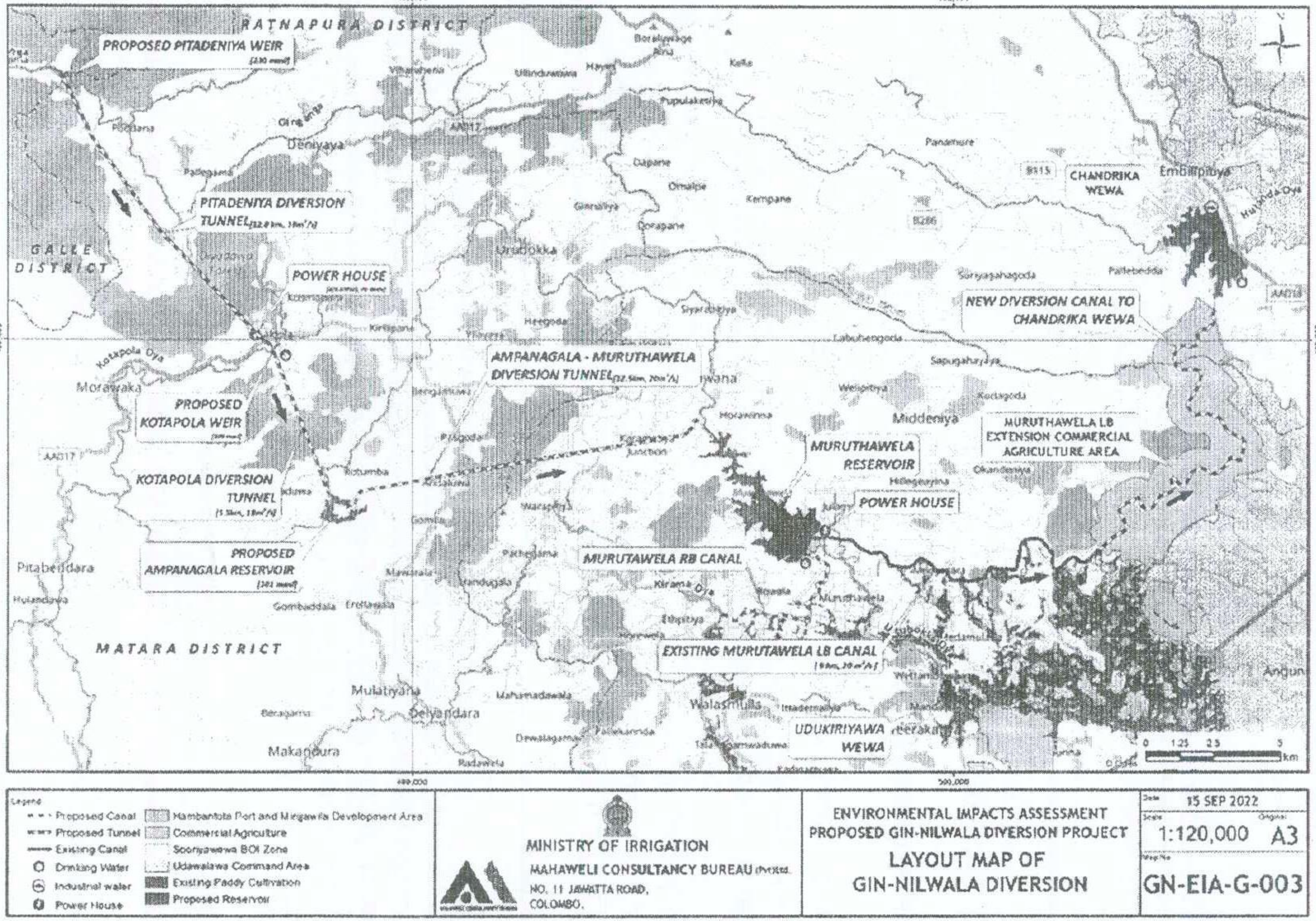

Figure Q4: Locations of the proposed project of GNDP