Hoang Thu Minh

1.

(a). It is necessary to increase the supply from local catchment because in 2060 the contract between Johor and Singapore will be expired and there will be no imported water. Hence, the contribution from local catchment needs to be increased to cover for imported water.

. Pratical measures to increase the supply from local catchment:

- Harnessing technology that can treat water of varying salinity from remaining streams and rivulets near the shoreline which could potentially boost Singapore's water catchment area to 90% of land area by 2060.
- Greater reservoir integration to enhance catchment yield
- Increase storage capacity through underground storage caverns to reduce spillage during wet seasons
- Explore the possibility of groundwater from reclaimed land masses, deep groundwater, etc.

(b). Public Education and Publicity Program

. Mandatory installation of water saving devices:

- self-closing delayed action taps
- constant flow regulators
- low capacity flushing cistern

. Fiscal Policy: Pricing water to encourage conservation

- Cover cost
- Water conservation tax

. Water Substitution and Recycling:

- Substitute with NEWater, Industrial water, High Grade Industrial Water and seawater
- Encourage recycling of process water

(c) UFW stands for Unaccounted-for Water. It is the water lost in the network between drinking water treatment plants (water works) and consumers (water usage)

Common measures to reduce UFW:

- Accurate metering:
  - 100% metering will help account for usage
  - good quality meters with accurate output
- Reduce water leakage
  - Leakage control
    - use quality pipes and fittings
    - pipe replacement program for cast iron pipes and galvanised iron connections
    - quick response and rectification of leaks
    - leak detection
  - Proper accounting of water used
  - Strict regulations on illegal draw-offs

(d). Higher temperature increases crop water demand

- Significant changes in rainfall patterns; extreme weather events lead to flooding and droughts
- Coastal areas experience permanent inundation as ocean level rises, which affects coastal ground water resources; salt instrusion
- Flooding of wastewater treatment plants and septic tanks in low-lying areas causes pollution of water sources.

(c) WSUD stands for Water Sensitive Urban Design.
WSUD is an integrated surface water drainage approach that address quantity, quality, and amenity aspects of storm water management.
Four features of WSUD: bioswale, rain garden, green roof, bio-retention swale

2.

(a). Abiotic factors : water, soil
- Biotic factors : flora, fauna
- Social factors : cultural heritage, quality of life

Services provided by the environment:
- Source of materials
- Waste receptor service
- Life support function
- Amenity services

(b) Impact can be defined as changes in physical, chemical, biological, cultural or socio-economic environmental system as a result of activities related to development

- Potential impacts on physical environment:
  - Soil erosion
  - Deterioration of downstream water quality
- Potential impacts on ecology.
  - Loss of forests
  - Loss of wild life habitat
- Potential impacts on human use values
  - Flooding

- Affected fishery along rivers
- Potential impacts on quality of life:
  - Loss of forest tourism and aesthetics
  - Insect vector

(c) • Physical models : small scale models of the environmental system in which experiments are done to predict future changes
• Experimental models: in-situ tracer experiments to monitor changes
• Mathematical models: use mathematical equations to simulate behaviours of environmental system.

3.
(a)

1. Hazard Identification:
   • review documents and processes to identify potential hazards and risks
   • site investigation
   • interview workers on the site or those who handle the processes
2. Risk Evaluation:
   • consider all safe measures in place before rating the level or magnitude of a risk for a hazard
   • study all variables to rate the level of severity and likelihood for each risk. Then, multiply severity and likelihood to get Risk Prioritisation Number (RPN)
   • compare RPN against risk matrix stipulated in Code or Practice on Risk Management to determine the risk level. Actions are taken based on risk level

3. Risk control
   - to eliminate or reduce the risk to an acceptable level
   - Control measures based on hierchy of control:
     1. Elimination
     2. Substitution
     3. Engineering controls
     4. Administrative controls
     5. Personal Protection Equipments

(b) Risk assessments should be reviewed once every 3 years unless:
   - after an incident occurrence (near miss or clangerous situation)
   - there are significant changes in the work process
   - there is new information on Work Safety & Health risk.

4.

(a)

(i) $SF = 0.003\ kg\text{-}d/mg$

$C_e = 1.0\ mg/m^3$

$IR = 1.2\ m^3/h = 28.8\ m^3/d$

$ABS = 50\%$

$AT = 70\ years = 25550\ days$

$BW = 70\ kg$

Lifetime $\rightarrow \frac{EF \times ED}{AT} = 1.0$

$$\text{Lifetime intake} = \frac{(1.0\,mg/m^3)(28.8\,m^3/d)(0.50)}{(70\,kg)}$$

$$= 0.205\ mg/kg\text{-}d$$

Carcinogenic risk : $SF \times I = 0.003 \times 0.205 = 6.15 \times 10^{-4}$

(ii) To reduce the residents' exposure to the carcinogenic risk within a short time, removal and disposal can be used as remedial strategy. This involves excavate and transport contaminated soil for off-site treatment or disposal.

(b)

(i) Volume of contaminated soil in vadose zone
$= 2(68 + 56 + 35) = 318\ m^3$

Mass of contaminated soil
$= 318\ m^3 \times 1800\ kg/m^3 = 572400\ kg = 572.4\ ton$

Volume of contaminated soil to be transported
$= \frac{572400}{1800/1.1} = 350\ m^3$

(ii) Excavation cost : $318\ m^3 \times \$10/m^3 = \$3180$
Transportation cost : $\frac{350}{8} \times \$120 = \$5250$

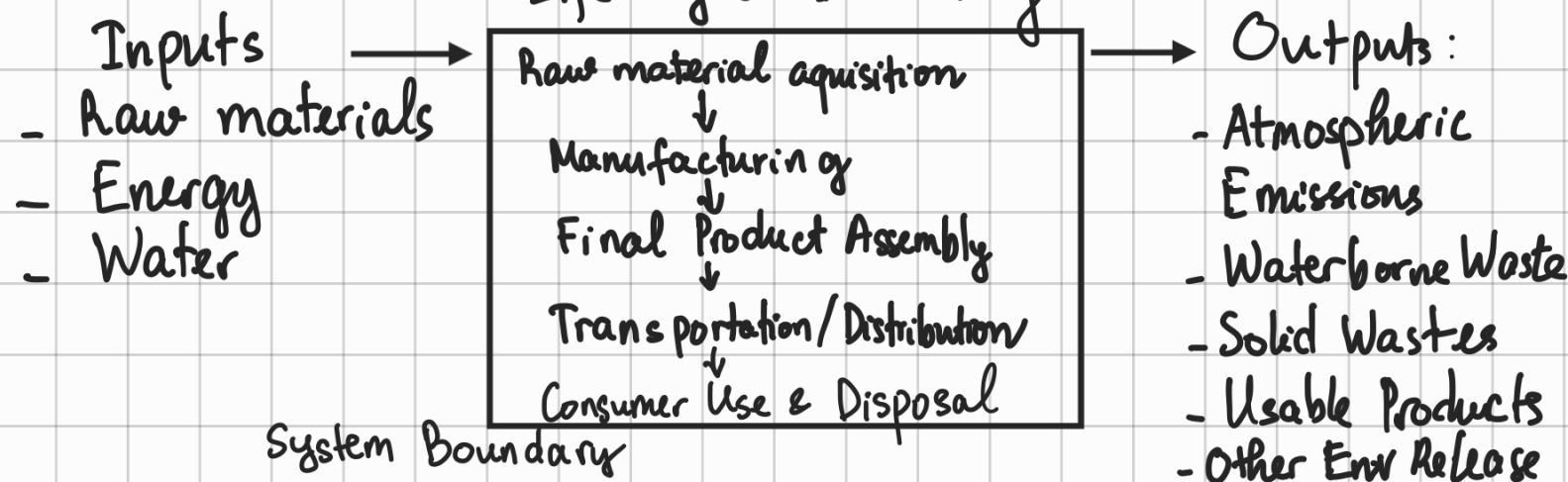
Treatment & disposal cost : $\$200/ton \times 572.4\ ton = \$114480$
Total cost : $\$3180 + \$5250 + \$114480$
$= \$122910$

(c). It is difficult to identify the liable party (polluter): contamination scenarios are too complex, solid evidences are not easy to gather
- The polluters are often unable to pay for the high clean up fee (may cause bankruptcy)
- For old contaminated sites - the responsible party may have moved, merged, or stopped business
- Land disposal was once legal activity - it is not fair to effect the law retrospectively
- When more than one party are the polluters, how to assign the correct portion of liability to each party?
- The toxicological effects of many contaminants are not well known - clean up level can not be justified and so does the cost

5

(a) Three components of LCA:
- Inventory Analysis
- Impact Assessment
- Improvement Assessment

Inventory Analysis:



(b) Less energy and materials are used when recycling is practiced near the end (top) of the material flow chain. This recycling practice will retain embedded utility in the products, which is the total energy and materials used for extraction of materials, transportation, primary and secondary manufacturing, and distribution of the product.
For example, recycling glass bottles to the bottlers only needs cleaning and reusing bottles. On the other hand, returning glass bottles to the glass manufacturers means melting and re-making glass, then the glass is manufactured into bottles.

6.
(a) In the sample:

$$Ni = \frac{(1.2\,mg/L)(2L)}{10\%} = 24\,mg$$

$$Pb = \frac{(2.3\,mg/L)(2L)}{8\%} = 57.5\,mg$$

$$Cu = \frac{(1.1\,mg/L)(2L)}{5\%} = 44\,mg$$

In the ash:

$$Ni = \frac{24\,mg}{100g \times 35\%} \times 100\% = 0.069\%$$

$$Pb = \frac{57.5\,mg}{100g \times 35\%} \times 100\% = 0.164\%$$

$$Cu = \frac{44\,mg}{100g \times 35\%} \times 100\% = 0.126\%$$

(5)

Hazardous wastes are wastes that, in sufficient quantities and concentrations, pose a threat on human health, human life, and the environment if improperly stored, transported, treated or disposed. Other wastes are designated "hazardous" if they have one of the following characteristics:

- Ignitable: combustable under normal conditions
- Corrosive: highly acidic, basic, or capable of corroding metals
- Reactive: unstable under normal condition and capable of creating explosions and/or toxic fumes, gases, vapors when exposed to water.
- Toxic: harmful or fatal when ingested or absorbed

The mixture of hazardous and non-hazardous wastes is labeled hazardous.

The designation of hazardous waste does not include low-level radioactive waste, which is covered under separate state and federal rules.