ENVIRONMENTAL GEOLOGY
OVERVIEW OF LANDFILLS AND WASTE DISPOSAL

I. TYPES OF WASTE

A. Solid Waste
1. Municipal
a.Waste derived from residential/urban areas
(1) plastics, packaging, paper, cardboard
(2) food wastes
(3) Household Chemicals (paints, oil, cleaners, bathroom)
(4) Lawn wastes

2. Residual
a. Waste derived from industrial processing
(1) a "residuum" left after a particular product is processes

(2) Construction debris, shredded plastics, fly ash in some cases, ashes, industrial sludges, automobile parts

(3) difference between residual and hazardous is one of toxicity and risk to health

3. Hazardous
a. Heavy metals (chromium, lead, fluoride)
b. Organic chemicals/hydrocarbons
c. asbestos/particulates, ashes

B. Liquid Waste
1. Liquid Chemical By-products of Industrial Processing
a. Waste water/cleaners
(1) may be laden with organic chemicals, dissolved heavy metals, salts
b. Degreasers
c. Acids, pickle-liquors, alkali bases

II. WASTE DISPOSAL OPERATIONS
A. Landfilling- burial of wastes in earthen pits
1. Composting- of lawn and organic debris

B. Sludge Ponds, Impoundments, Lagoons- liquid wastes and waste water placed in open lagoons for storage and/or treatment

1. transformation of liquid wastes into solid sludges which are often then taken to landfilling operation

C. Deep Injection Wells- disposing of liquid wastes by pressure injection into disposal wells deep beneath earth's surface

D. Incinceration- burning of solid and liquid wastes

1. includes firing augmentation with other fuels (gas/coal)
2. fly-ash by-product must then be disposed of in landfill
    a. Up to 90% volume reduction of solid waste to fly ash

III. CONTAMINANT PATHWAYS

A. Ground Water Contamination

1. "Leachate" = chemical soup formed by chemical degradation of wastes via percolating water
    a. water source:
        (1) rain/precipitation
        (2) through-flowing ground water
        (3) de-watering of waste itself

2. Leachate leakage into porous/fractured subsurface aquifers
3. Direct seepage of liquid residual and hazardous wastes into ground water system
4. Potential contamination of residential/municipal well fields
    a. Potential contamination of surface waters via contaminated seeps and springs

    b. Toxic effects to plant and animal life, particularly in delicate wet-area ecosystems

    c. Toxic effects to humans via water consumption and direct contact with contaminants

B. Soils Contamination

1. Seepage of contaminants into vadose zone (unsaturated zone) of unconsolidated sediment and soils.
    a. eventual percolation into ground water system
    b. Toxic effects to plant and animal life
    c. Toxic effects to humans via direct contact

C. Direct Surface Water Contamination
1. Direct runoff of leachate/chemical contaminants into surface waters
    a. Toxic effects to plant and animal life
    b. Toxic effects to humans via contact and consumption

2. Sediment erosion= overloading waterways with high suspended sediment loads
    a. detrimental to aquatice life
    b. artificial in-filling of drainages

D. Other Considerations

1. Air Pollution: asthetically offensive fumes and odors emitted from waste areas
    a. Toxic chemical fumes, metals vapors (e.g. mercury), organic chemicals

2. "Fugitive dust" and/or particulates into atmosphere from landfill-excavation operations

a. Respiratory problems

b. Toxic metals and particles entering lungs

3. Methane Generation

a. Methane (CH_4): common gas derived from anerobic microbial decay of municipal waste

b. Methane = an highly explosive gas that is colorless and odorless

c. Methane may escape from landfill area via subsurface pathways (porous material/fractures) (Offsite migration)

(1) gases may travel into basements causing potentially dangerous situation.

IV. ENVIRONMENTAL DESIGN CONSIDERATIONS FOR LANDFILL FACILITIES

A. Permitting Considerations

1. "Environmental Impact Statements"

a. Potential impact to local geology, hydrologic systems, cultural systems

(1) Subsurface geologic conditions, bedrock, stratigraphy, aquifers, water-bearing horizons, aquitards, depth and flow of groundwater, etc.
(2) Pre-existing environental problems (e.g. subsurface mines)
(3) existing ground and surface water quality
(4) Site use history
(5) engineering characteristics of soils
(6) Wetlands/ecosystem delineation

b. Local aquifer delineation, water supply use, surface water uses

c. Climate, rainfall, precipitation

(1) Important for "Help" Modelling of anticipated leachate volumes (see below)
(2) Dictates design and engineering of water treatment facilities

d. Impact to significant archeological/cultural systems

(1) Economic impact
(2) Justification for construction in area
(3) cemetaries, archeological/historic sites, airports, cultural operations, local zoning considerations

B. Environmental Engineering and Design

1. Ground Water Monitoring System

a. Upgradient and Down-gradient Monitoring Well System
    (1) directions of ground water flow
    (2) ground water divides
    (3) ground water levels
    (4) ground water quality monitoring
        (a) organic chemicals
        (b) dissolved metals
        (c) chloride, iron, pH, sodium
    (5) contaminant detection system

b. Assessment and Remedial Action Plan
    (1) What will happen if leakage occurs?

2. Leachate Control and Treatment
    a. Liner System
        (1) Low permeability geosynthetics
        (2) drainage nets
        (3) double lined systems
        (4) clay liners
        (5) impermeable clay soils
        (6) drainage layers

    b. Leachate Catchment and Treatment
        (1) type of treatment system
        (2) sludge management
        (3) "evaporative" spray control

    c. Help Modelling, Leachate Volume Prediction

    d. Treatment Plant Design
        (1) storage ponds, conveyance systems, discharge points
        (2) method of treatment/chemical processing

3. Landfill Gas Control
    a. Methane Detection Probes
        (1) Monitoring Program to detect potential off-site migration
    b. Methane collection stations
        (1) Pumping/vacuum system
    c. Flaring station for burning off methane
        (1) cogeneration of electricity, heat

4. Fugitive Dust Control
    a. Facility plan for dust control

5. Air Pollution Monitoring
    a. sampling and monitoring plan

6. Erosion and sedimentation plan
    a. Preventing disturbed sediment from eroding into surface waters
    b. Sedimentation ponds or catch basins

7. "Vector" control
    a. animals, rodents, birds
    b. daily cover of waste

8. Construction/Soils Engineering
    a. Design of loads, sizing of containment structure
    b. Grading design, slope stability design
    c. soils properties
    d. designation of "borrow areas", storage areas
    e. Blasting Permits/considerations

9. Landfill construction and management plan
    a. bonding, daily operations, waste stream allowances
    b. access roads, transportation considerations
    c. Construction plan, "cell life" projections
    d. Daily cover/mitigation procedures
    e. Waste-fill sequence

10. Landfill Closure and Reclamation Plan
    a. What will happen to land when landfill is completed?
    b. Post-closure monitoring
        (1) gas
        (2) ground water quality
        (3) remedial action plan
        (4) revegetation
        (5) geosynthetic caps/capping procedure
            (a) prevent water percolation, reduce leachate potential