CIVL 406

PART III

Introduction to Solid Waste Management

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CIVIL 406 — PART III

SOLID WASTE MANAGEMENT

Add. Reference – "Environmental Protection"
2nd Ed, Chanlett, E.
– "Solid Wastes"
by Tchobanoglous et al.

Solid wastes includes: garbage, rubbish, ashes, street-sweepings, dead animals, industrial wastes, etc.

Definitions

Refuse = all putrescible & non-putrescible solid wastes, with the exception of sewage solids

Rubbish = all non-putrescible solid wastes

Garbage = our food reject at any point from growing to final eating

or all putrescible wastes resulting from growing, handling, preparation, cooking and consumption of food

Basic Quantities of Refuse

Available data shows:

- in U.S., total of all sources (municipal, commercial and industrial) exceeds 5 Billion tons/year
- in Canada, about 100 Million tons/yr

Municipal Refuse Only →

U.S. ~ 2.0 kg/day/cap. (4.5 lb/d/cap).

Canada ~ 1.4 kg/day/cap. (3 lb/d/cap).

- basically, urban dweller generates about 1700 lb. per year in U.S. and about 1100 lb. per year in Canada

(see following Table for "select urban centres" globally)

Basic Characteristics of Refuse

Facts – Mixed refuse weighs ~500 lb/yd^3 (300kg/m^3)
– Moisture content of mixed refuse, continent-wide, is 15–25 % (Vancouver ~25-30%)

MUNICIPAL WASTE GENERATION (1989)

	Kg / person / day
Toronto	1.30
New York	1.80
Tokyo	1.35
Paris	1.08
Hong Kong	0.85
Rome	0.69
Manila	0.50
Calcutta	0.50
Canada-wide range	1.30 – 1.80

Canadian Total ≃ 16×10^6 tonnes / yr

Also: Canada generates ≃ 6×10^6 tonnes/yr of hazardous wastes (half in Ontario)

Canada has about 10,000 **known** landfills/dumps.

Source: Can. Geog.

Breakdown

		garbage	rubbish
Volume	—	15-20 %	70-75 %
Weight	—	25-30 %	45-50 %

Remainder = categories of industrial/hazardous wastes, various sundry items and unmentionables, etc.

Components

On a volume basis, largest component is paper or paper products ~ 40-50 % nation wide

(see attached Table for sample numbers)

Cost Breakdown In Handling Municipal Refuse

% Wise ~ 80 % on collection/transportation
20 % on disposal

eg. GVRD in 1988 (last year data available)

- Total cost ~ $45-50/yr/capita
Collection ~ $36-40   Disposal ~ $9-10

TABLE 1 - Solid Waste Components For Selected Municipalities

	PAPER	METALS	GLASS	RUBBER	PLASTICS	(Organic) FOOD WASTES	WOOD	TEXTILES	INERTS	TOTAL
SAN DIEGO	50.74	9.15	9.95	5.13	.32	14.42	8.0	3.84	12.45	100.00
MONTREAL	50.1	8.6	3.9		5.7	18.8			12.9	100.0
CALIFORNIA, L.A.	49.0	10.7	11.7		1.6	8.4			7.6	100.0
CALIFORNIA, S.F.	51.5	7.0	8.0	1.1	1.9	15.5	2.0	4.0	5.0	96.0
JOHNSTON CITY	59.8	15.0	7.0	1.5		22.8	.3	1.3	.6	108.3
GAINSVILLE	53.53	7.55	6.54	2.77		21.85	.13	2.10	5.56	100.03
MOBILE	39.7	8.0	7.0			35.6		.8	8.9	100.0
TORONTO	39.5	5.9	8.0		2.6	38.9	1.1	1.5	2.5	100.0
NEW YORK	40	8				10	7			65
NEW JERSEY	51	8	4			10	4			77
ILLINOIS	42	9	6			14				71
OHIO	42	7	8			28	3			88
ARIZONA	43	10	8			22	2			85
CALIFORNIA	54	7	2			15	2			80
KENTUCKY		9	6			11				26
TENNESSEE	46	11	11			36	1			105
SANTA CLARA COUNTY	50	8	7	1	1	21	2	2	7	99
TOTAL	712.9	148.9	114.1	11.5	13.1	389.2	32.5	15.6	62.5	-
AVG.	47.5	8.7	7.2	2.3	2.2	22.9	2.7	2.2	7.0	102.7
VANCOUVER	36.4	8.2	7.2	.5	1.7	25	14.9	2.5	3.6	100.0

<u>Landfill vs Incinerator Costs</u> (local case)

<u>1976</u> Burn's Bog Landfill

= $3 per ton on disposal at site
plus <u>$9-12</u> per ton on collection

Total = $12-15 per ton

vs Bellingham, Washington Incinerator

Total ≅ $13.50 per ton

∴ Total costs are similar. However, land costs and revenue potential from landfills <u>and</u> incinerators are <u>not</u> factored in.

<u>1984</u> Total costs ~ $55-60/ton @ Burn's Bog.

<u>1992</u> Total costs ~ $75-80/ton @ Burn's Bog.

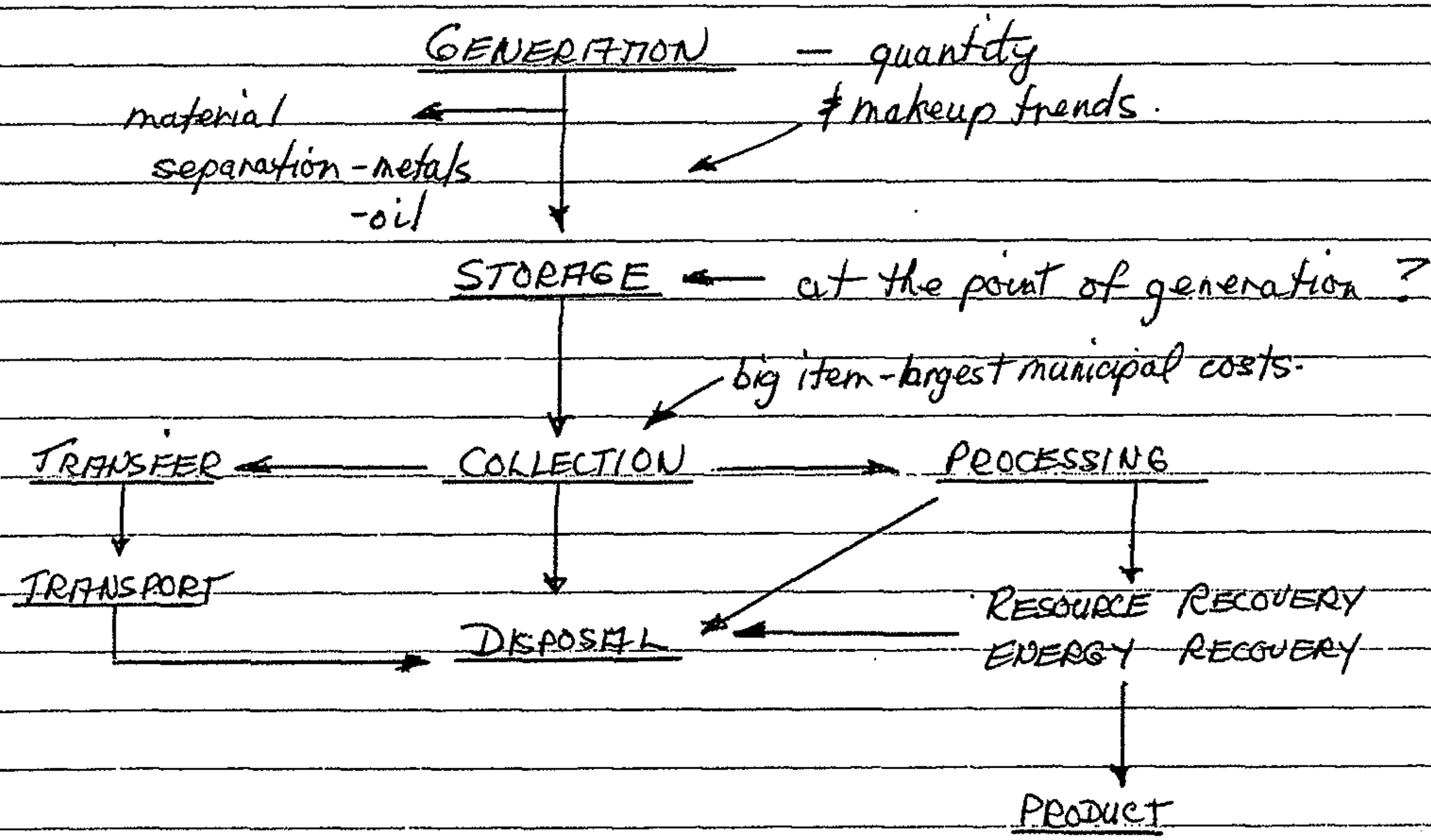
<u>2000</u> Total costs ~ $90-95/ton @ Burn's Bog.

Burnaby Incinerator – 1992 – Charge out = $75/ton
Costs = <u>$55/ton</u>

Difference = Profit!

ENGINEERING MANAGEMENT of SOLID WASTES

The engineering management comes into play following the generation of solid waste: A schematic looks like:



On monetary scale:

– big business → estimate $2 Billion Canada wide
20 " U.S. "

Vancouver ~ 1984, about $12 million/annum for collection and disposal → 3rd largest budget item at municipal level
~ 1990, about $28 million/annum

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4 STEPS IN COLLECTION AND DISPOSAL OF REFUSE

1. Storage

- in house
  - can lead to disease transmission and odours, etc.
  - in plastic/aluminum garbage cans or paper bags
- *in garburators*
  - *will affect frequency of pickup, movement of disease vectors, and sewage plants and sewers*
  - up to 30% of total refuse
  - causes grease problems in treatment plants (clarifiers)
- outside
  - in large plastic cans or "wheelie bins"
  - adequate containers are necessary, especially in warm climates
  - *also have plastic bags (good or bad?)*
  - flies, etc. (health concerns)
- separation
  - organics, paper, glass, metals

2. Collection

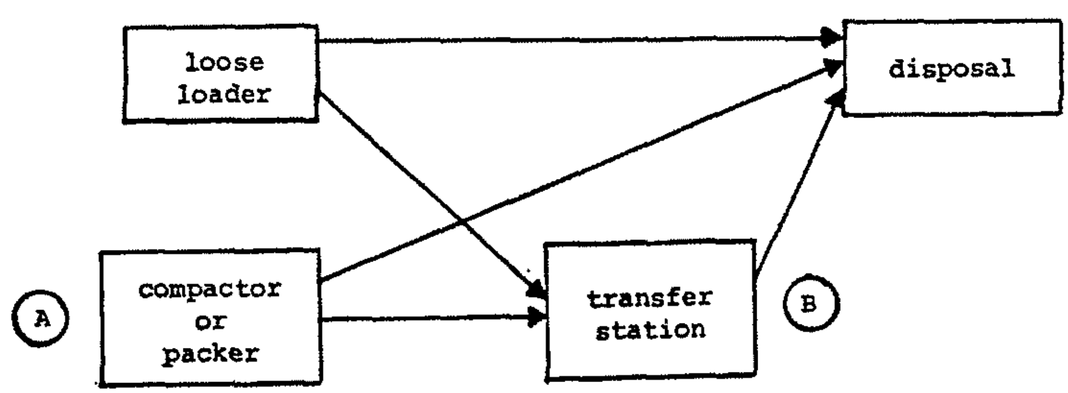
- frequency dependent on community policy and seasons of the year
- usually 1/week in winter and 2/week in summer (except GVRD)
- city usually collects residential refuse and private companies collect commercial
- pickup location → lane, backyard, front, alley?
- truck type → *compactor vs.* loose loader (trailer)

  ↓

  (fewer trips, more maintenance, less mess)
- total privatization?

3. Transportation

- systems analysis required to determine best method - CPM Method



(A)
- if to go direct to disposal site, design truck to take full day's load of refuse
- can release day crew and few drivers put on afternoon shift to ferry loaded trucks to the site

(B)
- usually collect packer loads in large bins
- further compaction and transfer to trailer units or larger haulers for transport to disposal site
- can get 700-1500 lb/yd^3 of compaction here (420-900 kg/m^3)

NOTE: - Vancouver regionally uses version of (A), with tag along empty trucks from holding yard via radio dispatch
- Seattle uses concept (B), with trailer units going from transfer station to the landfill

- rail also used as carrier – Toronto, L.A., etc.
- pipe-lining of refuse also possible in future – now in experimental stage in several large U.S. cities, e.g., Orlando – Walt Disney World; Stockholm, Sweden.

4. Disposal

*(a) Open dumping
*(b) Landfills
*(c) Incineration
*(d) Composting
(e) Salvaging – recovery of usable material
(f) Hog feed – garbage only – cooked for ½ hour
(g) Dumping at sea
(h) Grinding and adding to sewage
(i) Compacting and mixing with cement – building blocks, sea wall, etc. (Japan)

Ontario	in 1968	-	57% open dumping
		-	37% landfills
		-	2% incineration
		-	1% composting
		-	4% rest
	in 1975	-	37% landfills
		-	57% dumping
	by 1980	-	65% landfills
	by 2000	-	about same

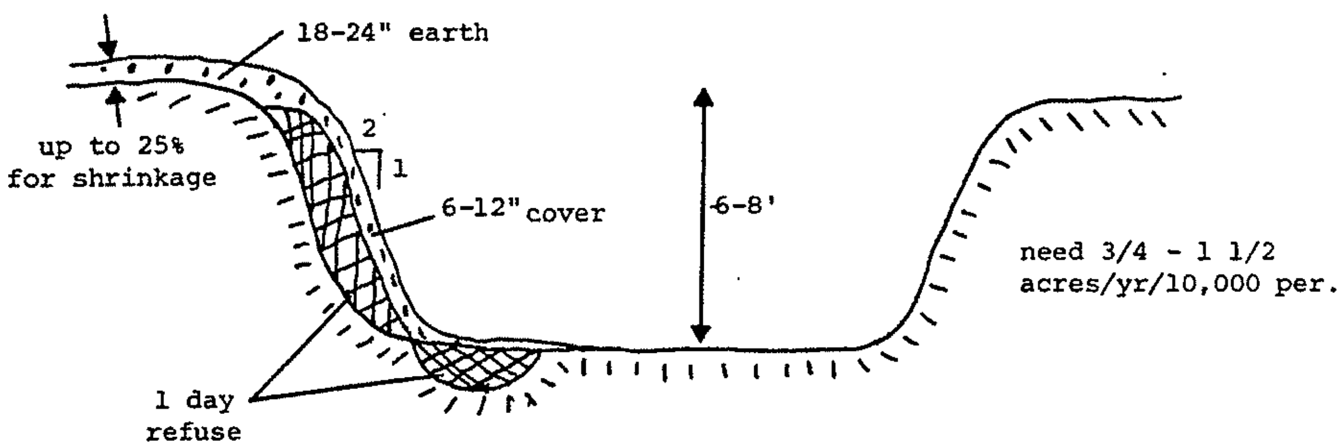
**NOTE*: only (a), (b), (c), and (d) are outlined in the following notes.

(a) Open Pit Dumping

- cheapest method - used by small communities with little tax revenue
- gives rise to nuisance conditions and pollution → blowing papers, flies, rats, fires, air pollution from fires, water pollution from leaching
- should be removed from built-up areas
- lack of compaction results in fast use of space

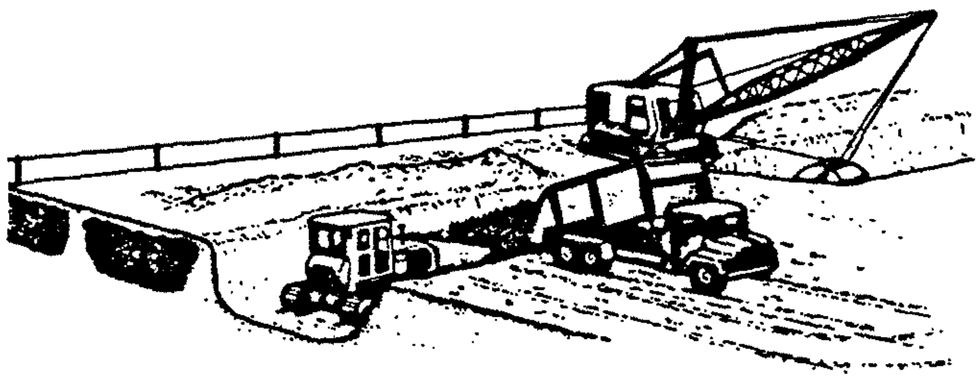
(b) Sanitary Landfills

- can be trench method (Fig. 6-3), ramp method (Fig. 6-4), or area method (see Chanlett, p. 320)
- usually, a combination of trench and ramp method, as such:



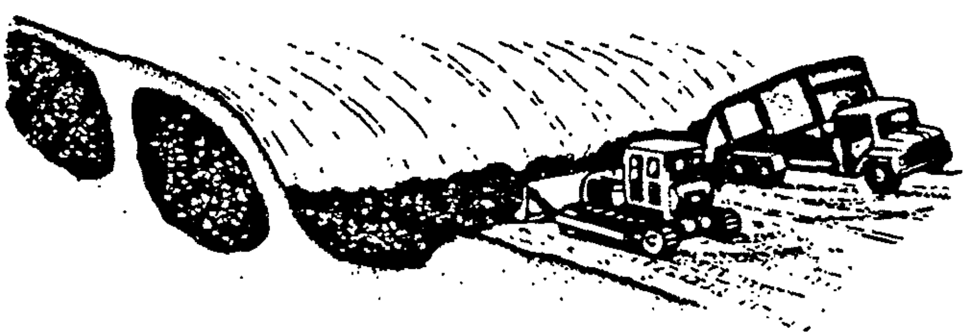
- instead of earth for cover, can use sawdust or hog fuel
- settlement as high as 1.5 ft in 1st 2-3 years
- anaerobic decomposition → H_2, CO_2, CH_4, NH_3, H_2S, acids
- cheap, easy, efficient ? (land can be reclaimed after settlement for parks, airports, etc. but must wait about 10-20 years before construction)
- requires constant supervision to keep it running right
  - force users to dump in right spot
  - ensure proper compaction
  - ensure daily covering
- problems of flies, birds, rodents, fires, wind, groundwater pollution, etc. - e.g., Burns Bog in Delta
- sites selected carefully to prevent pollution of groundwater and nearby streams - can occur from direct leaching or from end products of anaerobic decomposition

→ siting is tricky business - NIMBY syndrome!



The waste collection truck deposits its load into the trench where the bulldozer will spread and compact it. At the end of the day, the dragline will excavate soil from the future trench, and this soil will be used as the daily cover material. Trenches can also be excavated with a front-end loader, bulldozer, or scraper.

FIGURE 6-3
Trench method of sanitary landfill. [*Source*: *Sanitary Landfill Facts*, *U.S. Public Health Serv. Publ.* 1792, 1968, *p.* 6.]



The solid wastes are being spread and compacted on a slope. The daily cell may be covered with earth scraped from the base of the ramp. This variation is used with either the area or trench method.

FIGURE 6-4
Ramp method of sanitary landfill. [*Source*: *Sanitary Landfill Facts*, *U.S. Public Health Serv. Publ.* 1792, 1968, *p.* 6.]

(c) Composting

- should be aerobic decomposition process
- usually add nutrients, N & P, at commercial scale
- sometimes mix garbage and sewage sludge in large-scale operations

In 3-4 days —get—> 140-160° (55-65°C)
└──> 3-4 days —10 to 15 days—> humus matter

- resulting dark humus matter has some fertilizer value and is stable
- must be properly mixed and screened to get rid of glass, metals, plastics, etc. - but how?

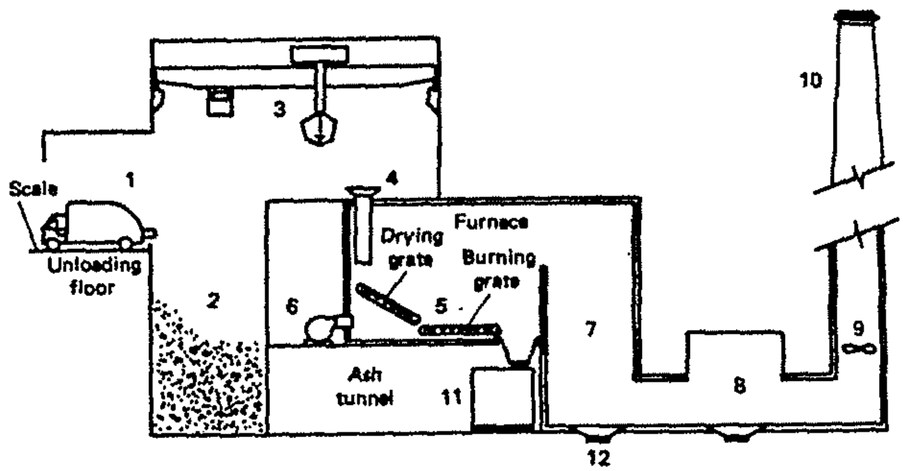
Controlling Factors

1. aerobic - mechanical aeration
2. mixing - turn over every 2-3 days over 20 day composting period - aeration
3. grinding - reduction in size to speed things up
4. temperature - >140°F (55°) - most pathogens die
5. moisture content - 30 to 60% best - can use sprinkler
6. C:N = 30:1
7. pH - 7 to 9

- fast, no odours, fertilizer value
- can be expensive, especially if manual labour used for pre-sorting

(d) Incineration (Ref. flow diagram, Fig. 8-6)

- solid residue (<20% of incoming material) is stable and hence can be used as landfill with no danger of major settlement or leaching problems
- operating temperature of 1300-1800°F are used
- sufficient O_2 also supplied (especially start-up)
- continuous feeding should exist, otherwise start-up daily is expensive (need residual fuels)
- daytime residential incineration and nighttime business incineration
- if refuse not too wet or too high in non-combustibles, may have waste heat available for steam and/or power production

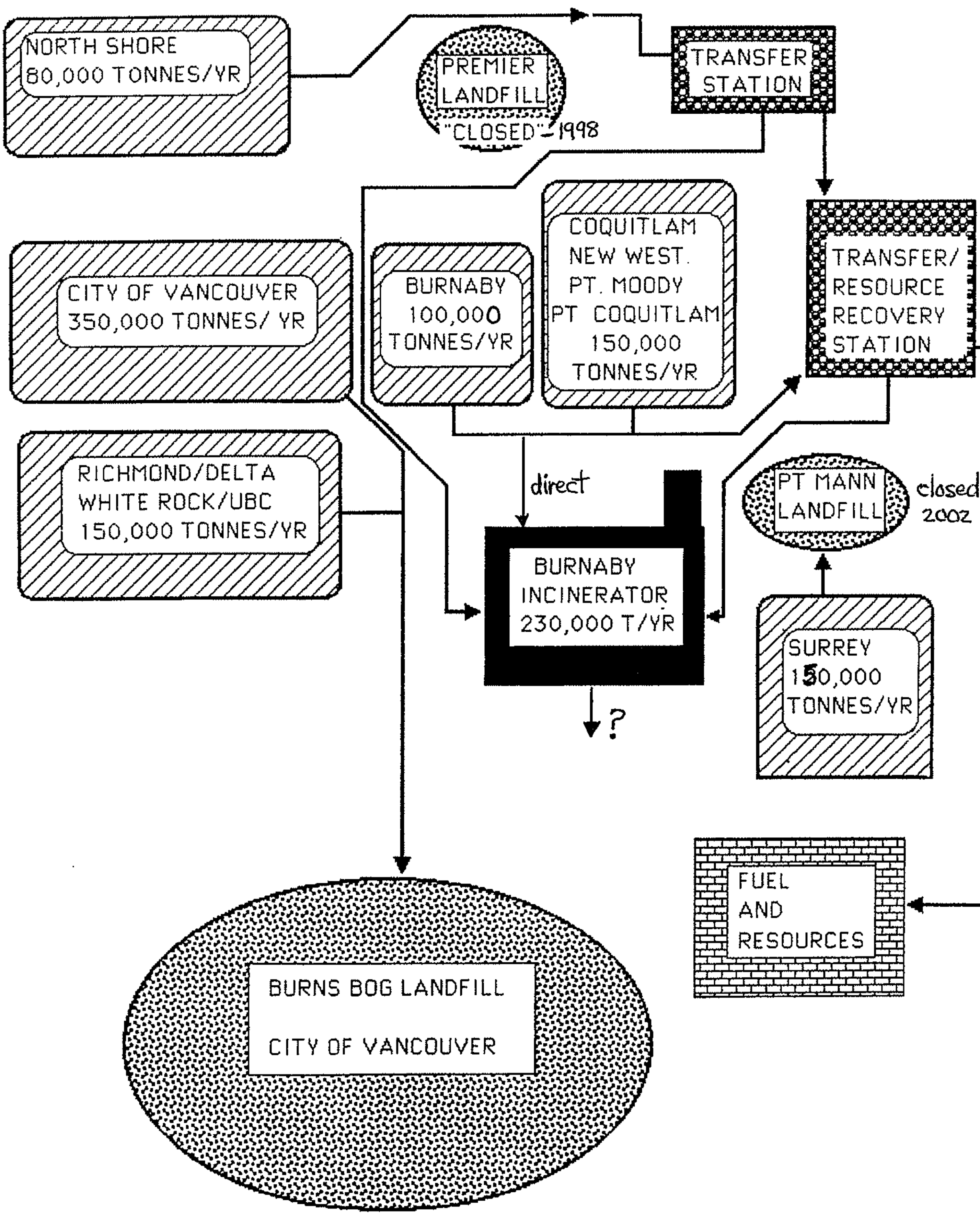


1. Collection truck
2. Storage bin
3. Overhead crane
4. Charging hopper
5. Traveling grate stokers
6. Forced draft fan
7. Combustion chamber
8. Gas cleaning equipment
9. Induced draft fan
10. Stack
11. Residue hopper
12. Flyash sluiceway

FIG. 8-6 Section through a typical continuous-feed mass-fired municipal incinerator.

advantages	-	complete reduction of *combustibles*
	-	hygienic conditions
	-	independent of weather conditions
	-	heat or power as by-product
disadvantages	-	air *pollution/water pollution on site*
	-	high capital and operating cost
	-	need skilled labour
	-	disruption in service to stake holders
	-	can have cans and bottles residuals, etc. left over in ash product
site selection	-	minimum air pollution effect
	-	approach roads - intensity of traffic
	-	availability of utilities
	-	sufficient area for future expansion

→ siting is tricky business - NIMBY syndrome!


NORTH SHORE
80,000 TONNES/YR
PREMIER LANDFILL
"CLOSED"-1998
TRANSFER STATION
CITY OF VANCOUVER
350,000 TONNES/ YR
BURNABY
100,000 TONNES/YR
COQUITLAM
NEW WEST.
PT. MOODY
PT COQUITLAM
150,000 TONNES/YR
TRANSFER/ RESOURCE RECOVERY STATION
RICHMOND/DELTA
WHITE ROCK/UBC
150,000 TONNES/YR
direct
BURNABY INCINERATOR
230,000 T/YR
PT MANN LANDFILL
closed 2002
SURREY
150,000 TONNES/YR
?
FUEL AND RESOURCES
BURNS BOG LANDFILL
CITY OF VANCOUVER

SUMMARY COMMENTS

Open Dumps — usage dropping in N. America (<30%)
— being replaced by Regional Landfills

Composting — myth = profitable market for compost in N. America, based on garbage
— "commercial scale" plants rapidly disappearing in N. America

U.S. eg. - in 1951, 18 plants up and running
- today, only ½ dozen left (45–360 T/day size range)

Canada eg. - only 2-3 large scale plants left, composting both garbage & sewage sludge - Windsor, Niagara Falls, etc

Worldwide - over 100 plants still in operation

Landfills — use of landfills will continue, especially concept of Regional Landfills, but NIMBY Syndrome front-and-centre.
— existing and new landfills will require greater compaction & density
— long term environmental problems have to be addressed, esp. air & water pollution (eg. leachate collection/treatment)

Incineration – becoming popular again, especially with steam heat/energy recovery possible eg. Montreal, Burnaby.
– NIMBY syndrome also front-and-centre
– will require even more sophisticated environmental controls

Salvage / Recovery – subject to 3 R's approach in Europe and now in N. America

eg. U.S. – non ferrous metal recovery focused on copper, lead, zinc, aluminum

– Cu recovery ~40-45 % of total (~80 % of mined output).
– Al recovery ~25 % of demand, with some states (eg. Oregon) up to 80 % recycle

eg. Paper Recovery / Recycle
– Canada / U.S. ~ 45-50 % now
– Japan ~ 50-55 %
– W. Germany ~ 35-40 %
– U.K. ~ 30-35 %

eg. 3RD World Countries – becoming very efficient in recovery / reuse of disposable

eg. e-wastes ??