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PACIFIC & YUKON REGION
WEST VANCOUVER, BRITISH COLUMBIA

OVERVIEW OF THE READY MIX CONCRETE INDUSTRY

IN BRITISH COLUMBIA

WATER AND WASTE MANAGEMENT PRACTICES

Regional Program Report 88-03

by

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ABSTRACT

Ready mix concrete operations generate high pH and suspended solids wastewaters which are often unacceptable for direct discharge to surface waters. This report presents an overview of the ready mix industry including wastewater treatment and recycling practices, based on a review of the literature and visits to 17 plants in the Greater Vancouver area. Recommendations are made for improved management of process and storm waters, as well as waste solids.

RESUME

Les opérations des centrales à béton génèrent des eaux usées qui sont souvent inacceptables pour décharge directe aux eaux de surface à cause d'un pH et des solides en suspension élevés. Ce rapport présente une vue d'ensemble de l'industrie des centrales à béton incluant le traitement des eaux usées et les pratiques de recyclage, basée sur la revue de la littérature et la visite de 17 usines dans la région du Grand Vancouver. Des recommendations sont faites pour une gestion améliorée des eaux de procédé et de pluie, ainsi que des déchets solides.

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1 INTRODUCTION

The ready mix concrete industry generates large volumes of contaminated process water and stormwater characterized by elevated pH and suspended solids. When the receiving environment supports a federal fisheries resource (e.g. salmon), it is the federal government's responsibility to ensure the protection of that resource and its habitat, as mandated by the federal Fisheries Act.

This report presents an overview of the ready mix industry in British Columbia and includes socio-economic information, an inventory of plants, a summary of process effluent and stormwater characteristics and associated environmental concerns, and recommendations for improving current waste management practices.

1.1 Study Approach

An initial listing of ready mix facilities was obtained through an inventory of industrial effluent discharges maintained by Conservation and Protection. This list was augmented by information provided by the B.C. Ready-Mixed Concrete Association that identified close to 100 facilities province wide, both association members and non-members (Appendix I).

Manual and computerized searches were conducted to locate relevant publications on wastewater treatment practices within this industry sector, but not many publications were found. Several good references, particularly studies by the U.S. Environmental Protection Agency (EPA), were obtained from the American National Ready Mixed Concrete Association.

Site inspections were conducted at seventeen ready mix plants in the Lower Mainland, selected to provide a representative cross section of the industry. Their wastewater and solid waste management practices, including the extent of recycling, were documented. Information was obtained on plant production, truck fleet size, and stockpiles of feedstocks and admixtures.

Based on information in the literature and from site visits, recommendations for improved water, wastewater, and solid waste management are made.

1.2 Legislation

Effluent pollution control for this industry is exercised principally through the British Columbia Waste Management Act and the federal Fisheries Act. In 1975, the B.C. Ministry of Environment published pollution control objectives for this industry that stipulate effluent quality requirements and which provide guidance to the Ministry staff when issuing effluent permits (10). The objectives are presented in Table 1.

TABLE 1: PROVINCIAL EFFLUENT OBJECTIVES FOR READY MIX PLANTS

PARAMETER	UNIT	LEVEL		
		A	B	C
Suspended Solids	lb./100 yd^3 product	0.6	4.2	16.5
Total Solids	lb./100 yd^3 product	21	29	62
pH Range			6.5 to 8.5	

Note: Total Solids is not applicable to discharges to marine waters; pH range is the same for all three levels; reporting frequency is four times per year. Level A applies to new facilities, and to existing facilities after staged upgrading.

Discharges to fish-bearing streams or marine waters are subject to the general provisions of the federal Fisheries Act, specifically Section 33(2) which prohibits the "...deposit of a deleterious substance of any type in water frequented by fish or in any place under any condition where such deleterious substance or any other deleterious substance that results from the deposit of such deleterious substance may enter any such water". Also, Section 31 of this Act states, "No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat", and is applicable due to the high concentrations of settleable solids in many ready mix plant effluents. This Section of the Fisheries Act is administered by the Department of Fisheries and Oceans (DFO) whereas Section 33(2) is co-administered by DFO and Environment Canada.

Federal requirements for wastewater quality are assessed on site-specific environmental considerations. A permit referral process established by the Ministry of Environment and Parks ensures that input and recommendations from the federal agencies are considered during permit preparation.

Permits usually specify effluent concentration limits rather than pounds of solids/yd^3 of product as in the objectives. Permit requirements for selected Lower Mainland ready mix operations are presented in Table 2.

TABLE 2: TYPICAL EFFLUENT PERMIT REQUIREMENTS

PLANT #		MAX. DAILY FLOW (m^3)	T.S.S. (mg/L)	pH RANGE	TEMP. (Celsius)
3		879	50	6.5 - 9.5	N.S.
17	Two	indeterminate	50	6.5 - 8.5	N.S.
17	discharges	indeterminate	160	6.5 - 8.5	N.S.
13		630	100	6.0 - 9.0	25
10		N.S.	125	6.0 - 9.0	N.S.
14		1600	50	6.5 -10.0	N.S.

Note: N.S. - Not Specified.

Plant #3: permitted discharge is stormwater to ditch, which flows to marine waters.
Plant #17: permitted discharge is stormwater to ditch, which flows to marine waters.
Plants #10, #13, #14: permitted discharge is combined stormwater and process water.

2 INDUSTRY OVERVIEW

The ready mix concrete industry is primarily comprised of small- to medium-sized facilities engaged in manufacturing portland cement concrete and delivering it to customers in a plastic (unhardened) state.

2.1 Economic Profile

Table 3 summarizes the latest Statistics Canada economic data for the industry nationally, as well as for B.C. for the period 1980-1985 (15). (More detailed information is presented in Tables 1B and 1C in Appendix 1). In 1985, there were almost 600 ready mix concrete facilities in Canada and 95 in B.C., employing 9210 and 1300, respectively. The value of goods manufactured by the industry in B.C. during 1985 was $135,000,000. During this five-year period, the number of facilities in B.C. and across Canada grew steadily, although the number of employees and value of goods remained constant. It is understandable that the industry did not grow substantially during this recessionary period since it is closely tied to economic activity. The value of goods has likely increased since 1985 as the Canadian and B.C. economies have experienced higher growth rates.

2.2 Manufacturing Process

A typical facility consists of a yard area for the storage of aggregate, a washout station for truck drums with settling facilities, a concrete mix and loading facility including a silo for portland cement, a parking area, a storage area for additives, and an office. When a plant operator receives an order for a specific concrete formulation, the concrete is mixed to specification and discharged (gravity fed) to a truck mixer. The truck drum exterior is washed off before leaving for the job site. Upon returning to the plant, the truck driver may wash out the mixer drum before receiving a new batch of concrete.

Two manufacturing processes are used, dry batching and wet mixing (Figure 1). At batch plants, portland cement and fine and coarse aggregate are individually weighed in hoppers and discharged to the truck drum. Water and admixtures are metered into the drum and the concrete is mixed in the truck drum on route to the job site.

TABLE 3: SUMMARY OF READY MIX CONCRETE INDUSTRY ECONOMIC STATUS

	NO. OF FACILITIES		NO. OF EMPLOYEES		SALARIES & WAGES (MILLIONS OF DOLLARS)		VALUE OF GOODS (MILLIONS OF DOLLARS)	
YEAR	B.C.	CANADA	B.C.	CANADA	B.C.	CANADA	B.C.	CANADA
1980	77	500	1366	9348	34	192	138	898
1981	81	527	1549	10053	43	227	195	1085
1982	87	533	1302	8042	40	200	184	992
1983	85	564	1258	8390	41	216	151	1030
1984	91	584	1357	8801	44	229	154	1061
1985	95	584	1302	9210	43	254	135	1197

Reference: Statistics Canada

At wet mix facilities, the concrete components are delivered to a central mixer for mixing before being discharged to the truck drum. The weighing and metering of separate components in both batch and mix operations is now largely computerized resulting in improved quality control.

Ready mix facilities can be further classified as follows (2):

1) Permanent Plants - these facilities utilize mixer trucks to deliver concrete to customers from a central, permanent batch plant. All facilities inspected during the course of this study were permanent plants.

2) Portable Plants - these are dedicated facilities set up for very large construction projects (e.g. highway or airport runway paving). The concrete is produced in a portable central mixer at the job site and delivered in trucks, or dry batched at a permanent plant and delivered to a portable mixer at the job site.

3) Mobile Plants - these small facilities are capable of measuring and mixing concrete components at the job site. The concrete components are transported to, and stored at, the job site.

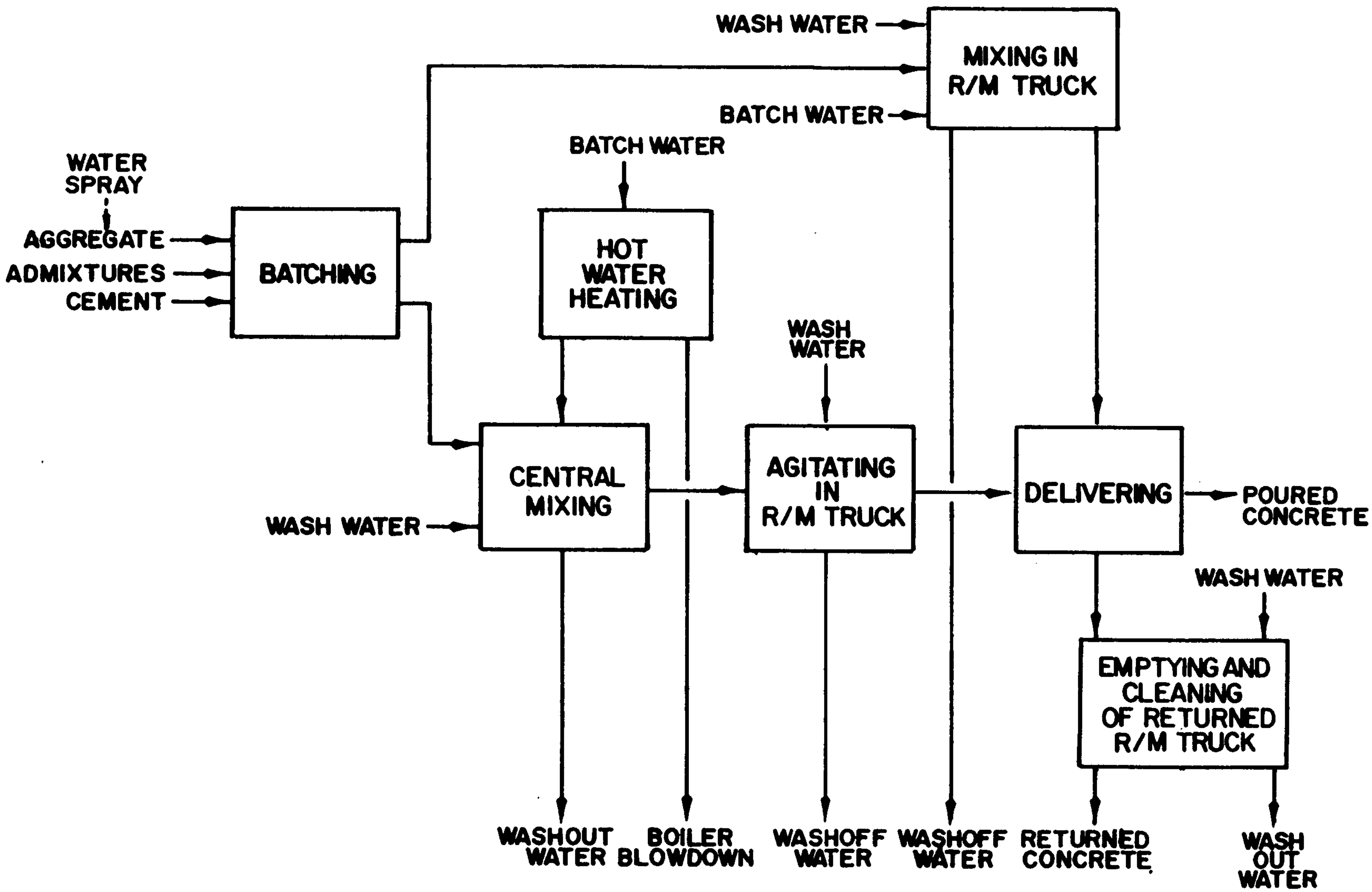

FIGURE 1: SCHEMATIC OF READY MIX CONCRETE PRODUCTION

The three plant types utilize somewhat different equipment and operating procedures, and therefore have different waste generation and disposal considerations. Generally, permanent plants have superior wastewater treatment works due to their permanency and greater land availability.

Production from any given plant can vary widely from day to day depending on product demand. In a survey of medium to large plants, the U.S. Environmental Protection Agency estimated that the average ready mix truck load was 5.2 m^3 and each truck averaged 4.2 trips per day (6). The fluctuation in daily production is illustrated in Table 4.

TABLE 4: VARIATION IN DAILY PRODUCTION

	Production (% of Average Daily)
Average Daily Production*	100
Poor Day (10/yr)	23
Good Day (40-50/yr)	151
Excellent Day (10/yr)	190
Maximum	247

* Average 257 operating days per year, range 200-304 days.

2.3 Concrete Fundamentals

2.3.1 Composition Concrete is a mixture in which a paste of portland cement and water binds materials such as sand and gravel into a rocklike mass. The paste hardens due to chemical reactions between the cement and water (1).

Concrete can be viewed as comprising two principal components, aggregate and paste, with the paste being a mixture of portland cement, water, entrained air, and admixture(s). The aggregate generally occupies 60-80% of concrete by volume, and the paste 20-40%. Table 5 presents the composition of typical concrete, by both mass and volume.

TABLE 5: COMPOSITION OF TYPICAL AIR-ENTRAINED CONCRETE

Component	kg/m^3 (1)	% v/v (2)
fine aggregate	410	24 - 28%
coarse aggregate	625	31 - 51%
portland cement	174	7 - 15%
water	104	14 - 18%
admixture	0.26-0.28	
air	---	4 - 8%

(1) ref.3; (2) ref.1

The density of normal concrete ranges from 2166-2568 kg/m^3, while densities for structural lightweight and insulating concretes are usually between 1364-1846 kg/m^3 and 241-1445 kg/m^3, respectively.

There is some overlap between fine and coarse aggregate sizing, as determined by the Canadian Standards Association (CSA) standards A23.2-2A and A23.2-5A (1). Fine aggregate has a size range between 1.25 mm - 10 mm, while coarse aggregate between 1.25 mm - 112 mm.

Potable water and some non-potable waters are suitable for batching. The water:cement ratio is the main parameter that determines concrete quality. Other factors being equal, a low water:cement ratio will improve a concrete's compressive and flexural strength, watertightness, resistance to weathering and some other characteristics.

2.3.2 **Portland Cement** In 1824, an Englishman Joseph Aspdin obtained a patent for what he called portland cement. He chose this name because the material was similar in colour to the limestone quarries on the Isle of Portland. Canada imported portland cement from England until the first domestic plant was built in Hull, Quebec in 1889. Portland cement was first produced on the west coast at Vancouver in 1893 (1).

Portland cement now refers to a group of hydraulic cements which require water to harden and do not disintegrate in water. The chemical reactions between cement and water are complex. For the purpose of this report, it is sufficient to say the subsequent hardening involves both hydrolysis and hydration of the cement components.

Raw materials required for the manufacture of portland cement include lime, silica, alumina and iron which are found in, among other substances, limestone, sand, clay and iron ore, respectively. Appropriate volumes of each are crushed and blended together, in either a dry or wet process. This mixture is then charged to a kiln and subjected to temperatures between 1400^{0}C and 1650^{0}C where the raw mix is transformed to portland cement clinker. Gypsum is then added to the cooled clinker to regulate setting time and the new mixture is again crushed to produce portland cement.

Portland cement is a mixture of many compounds, but four account for 90% or more by weight: tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite. Varying proportions of these compounds are found in the different portland cements. The CSA Standard CAN3-A5-M77 specifies five types of portland cement as follows (1):

TYPE	DESCRIPTION
10	Normal
20	Moderate
30	High Early Strength
40	Low Heat of Hydration
50	Sulphate Resistant

The two calcium silicates (which account for approximately 75% of portland cement) react with water to form calcium hydroxide and a calcium silicate hydrate (CSH). The CSH primarily determines the concrete's engineering properties, such as setting time, strength development, and dimensional stability.

The acute toxicity of portland cement to fish has been documented. Bioassays conducted in 1983 determined LT_{50} (the time for 50% mortality) values for rainbow trout exposed to portland cement concentrations of 1000, 500 and 300 mg/L to be 29, 45 and 68 minutes, respectively (12). A fish bioassay conducted by Environment Canada in 1986 on No. 10 portland cement determined the LC_{50} (concentration which results in 50% mortality in 96 hours) to be 36 mg/L. The toxicity of portland cement is due to the alkalinity (high pH) of this material.

2.3.3 **Admixtures** Admixtures are compounds added to concrete batches along with portland cement, water, and aggregate. They are primarily liquid formulations designed to impart special characteristics to the concrete. The changes in concrete chemistry that admixtures promote are very complex, and will not be discussed here. Most of these desired characteristics can also be obtained by using specially blended cements, but this requires a prohibitive amount of inventory. Therefore, the industry utilizes admixtures extensively. Most admixtures are mixed according to general formulas, but specific product composition may be proprietary.

Admixtures may contribute contaminants to concrete wastewaters, but since they generally comprise such a small fraction (less than 1% by weight) of the concrete mix, their presence in the wastewater is likely not of concern. Environment Canada conducted fish bioassays on a water-reducing accelerating admixture and an air-entraining admixture in 1986. The 96 hour LC_{50} values for the accelerator and the entrainer were 16432 ppm and 35.4 ppm, respectively. The toxicities of other admixtures are not known. However, based on the entrainer toxicity, spills during transportation or storage could result in significant environmental impacts.

CSA Standard A266.2 (1), Chemical Admixtures for Concrete, specifies admixtures commonly used. Most admixtures enhance or alter more than one concrete characteristic (eg. most water reducing admixtures also act as set retarders), and more than one admixture may be used in a batch. Admixtures are usually categorized in four broad groups as follows:

1) air-entraining
2) chemical
3) pozzolanic-mineral
4) miscellaneous

The B.C. ready mix industry relies heavily on the first three groups of admixtures. In the Lower Mainland admixtures are supplied to ready mix facilities primarily by four companies: Conchem, Master Builders, Pozzolanic International and W.R. Grace & Co.

Air Entraining Admixtures Air entraining admixtures are surfactants that increase the amount of evenly distributed microscopic air bubbles entrained in the concrete. This is desirable for a number of reasons, but primarily to improve the durability of concrete exposed to freeze/thaw cycles. Entrained air also substantially improves a concrete's resistance to surface deterioration caused by deicing salts, and improves it's workability characteristics. In addition, this group of admixtures frequently reduces or eliminates bleeding and segregation between pours, but may lessen concrete strength. The loss in strength may be overcome through the addition of another admixture. Manufacturers' suggested dosage rates for 12 different air entrainers range from 0.2 - 1.95 mL/kg of portland cement (not concrete).

Air entraining admixtures have been catagorized into 7 broad groups as follows (14):

1) Salts of wood resins - primarily neutralized (with NaOH) vinsol resin, a complex mixture of phenolics, carboxylic acids and other substances.

2) Synthetic detergents - alkyl aryl sulphonates; alkyl groups are usually complex petroleum residues reduced with benzene then sulphonated and neutralized.

3) Salts of sulphonated lignin - by-products of the paper industry; utilized more for their water reducing and set retarding effects.

4) Salts of petroleum acids - by-products of petroleum refining; neutralized (with NaOH) water soluble sulphonates from petroleum sludges.

5) Salts of proteinaceous materials - products of animal and hide processing industries; complex mixtures of carboxylic and amino acids; not widely used.

6) Fatty and resinous acids and their salts - produced from various materials; saponification of animal fats, or vegetable oils.

7) Organic salts of sulphonated hydrocarbons - similar to Group 4 above, but neutralized with triethanolamine.

Chemical Admixtures These admixtures may be sub-divided into three broad catagories; water reducers/retarders, set accelerators and strength increasers.

Water Reducers/Retarders: These compounds increase the slump of concrete for a given water content and strength by reducing the water:cement ratio in the concrete batch. Commercial water reducers/retarders can reduce batch water requirements by up to 15% (14). Setting time may be retarded, or accelerated, depending on the particular admixture used. Some brands cause significant increases in drying shrinkage (1).

The active ingredients in a typical water reducer/retarder are water soluble organic compounds, usually divided into the following four groups: salts of lignosulphonic acids containing up to 30% carbohydrates (reducing sugars); hydroxycarboxylic acids primarily gluconic but including citric, tartaric, mucic, malic, salicylic, heptonic, saccharic and tannic acids or triethanolamine salts; carbohydrates such as glucose and sucrose mixed with small amounts of triethanolamine and calcium chloride; and other compounds such as glycerol, polyvinyl alcohol or sulphanilic acid (14).

Accelerators: These compounds increase the initial set and early strength development of concrete, and usually control drying shrinkage. Calcium chloride is the common active ingredient. The amount of calcium chloride added should not exceed 2% by mass of cement to avoid corrosion of steel reinforcing rods (1).

Many other compounds may be utilized as accelerators including: alkali hydroxides, silicates, fluorosilicates, calcium formate, calcium nitrate, calcium thiosulphate, aluminum chloride, potassium carbonate, and sodium chloride (14).

Strength Increasers: These compounds increase the 28-day compressive strength of concrete by 15% to 30%. Strength increasers reduce the cement content required to achieve a given strength which is desirable in large pours, where the heat of hydration may cause setting problems. These admixtures also can retard set time, increase workability, and improve the finishing characteristics of the concrete surface. Strength increasing admixtures are usually mixtures of carbohydrates (1).

Pozzolanic-Mineral Admixtures A pozzolan is defined by CSA Standard A266.3 (1) as "a siliceous or alumino-siliceous material which, in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide released by the hydration of portland cement to form compounds possessing cementitious properties."

Both natural materials (eg. diatomaceous earth, pumicites) and man-made compounds (eg. flyash) are used as pozzolanic-mineral admixtures. These materials are often used to augment cement in batches, due to their low cost, and to reduce the heat of hydration in massive structures. Flyash contains varying amounts of carbon, silica, alkalies, sulphur, and other elements (1). Pozzolans may affect a concrete's water requirements, strength development, shrinkage, heat of hydration, and alkali-aggregate reaction.

Miscellaneous Admixtures These admixtures are not utilized to the same extent as the previous groups. They include workability agents, dampproofing and permeability-reducing agents, grouting agents, and gas forming agents.

Workability Agents: Workability characteristics are important if the concrete is to be placed in heavily reinforced members, is to be pumped, or if it requires a troweled finish. Workability can be improved by increasing the content of cement, fine aggregate, or an air entraining agent.

A superplasticizor may be added to substantially increase product slump for a limited length of time to allow difficult placing. (1).

Dampproofing and Permeability-Reducing Agents: These admixtures are generally water-repellants or pozzolanic materials used to increase the watertightness of concrete.

Concrete permeability is governed by the water:cement ratio and the time of moist curing. A water:cement ratio of 0.45 or less, by weight, will be watertight.

Dampproofing admixtures are used to reduce the capillary flow of moisture through concrete in contact with damp earth or water (1).

2.4 Water Use

Water is used extensively for concrete production and equipment clean up. Specific uses in order of decreasing quantity include: concrete batching, interior truck drum washout, central mixer washout, exterior truck washoff, and miscellaneous uses including aggregate moisture control, yard wash-down, and product slump adjustment.

Water usage varies widely, both daily and from plant to plant. Water consumption depends on daily plant production which in turn is determined by other operational factors, such as the number of operating trucks, frequency of washoff and washout operations, and the volume of miscellaneous water use. It has been estimated that on average, a plant will use 1900 litres/truck/day (6). Table 6 summarizes the results of a study on water usage at several plants in the U.S. (3).

TABLE 6: PROCESS WATER USAGE FOR PERMANENT READY MIX CONCRETE PLANTS (units are litres per cubic meter of production)

Plant	Batch Water	Truck Washout	Truck Washoff	Central Mixer Washout	Miscellaneous
7305	139	99	15	Nil	15
7363*	139	25	15	2	N.A.
7365	139	15	5	Nil	N.A.
7385	149	50	2	3	248
7441	149	89	20	10	N.A.
7451	173	149	25	Nil	N.A.
7452	173	124	25	Nil	N.A.
7487*	129	50	15	Nil	N.A.
7542	168	35	64	Nil	N.A.
7543	168	25	64	Nil	25
7544	168	25	69	Nil	20
7545	168	20	54	5	129
7699	188	25	1	Nil	15
7729*	139	282	35	Nil	N.A.
7731	139	84	10	Nil	N.A.
7732*	139	317	40	Nil	N.A.
7736*	144	45	15	Nil	N.A.
7750	139	74	20	Nil	N.A.
7755	149	64	5	5	N.A.
7757*	149	139	10	Nil	N.A.

* These plants reuse clarified mixer truck washout water for a percentage of batch water.
(Reference 3, pp. 52)

2.4.1 **Batch Water** Batch water is the water added to the cement, aggregate, and admixtures to make the concrete slurry. Potable water has traditionally been used for this purpose. However, water of lesser quality is also acceptable. In order to achieve a zero wastewater discharge, it is essential that treated wastewater be utilized as batch water. Water of questionable suitability can be used for making concrete if mortar cubes made with this water have 28-day strengths equal to at least 90% of companion specimens made with potable water. Mortars should be made and tested in accordance with CSA Standard CAN3-A23.2-M8A (1). Additional tests should be conducted to determine the effect any impurity may have on setting time, colouration and shrinkage, as these factors, and not strength alone, determine a water's suitability for batching. Water with less than 2000 mg/L of total dissolved solids is usually suitable for batch water, as is water with suspended solids concentrations less than 2000 mg/L. Marine water may be used for unreinforced concrete provided the concentration of dissolved salts does not exceed 35,000 mg/L. Alkaline waters with sodium hydroxide concentrations less than 0.5% by mass of concrete, and potassium hydroxide up to 1.2% may be used for some concretes without adversely affecting strength. Oil levels up to about 2% by weight (20,000 ppm), do not normally affect concrete quality. Table 7 summarizes the tolerable concentrations of common pollutants in batch water (13).

As noted, the concept of zero discharge is based on the reuse of wastewater as batch water, which is a relatively new practice in the ready mix industry and raises questions regarding product quality. One expert has suggested this practice may increase the standard deviation of the concrete strength which must be offset by increasing the average strength (7). This can be accomplished by raising the cement content by 15-30 kg/m3, which would increase product price by 2 to 4%. Although contaminants in recycled batch water may, in some instances, adversely affect the appearance, and strength characteristics of concrete, some studies have concluded that reclaimed wastewater may be used as batch water without any harmful effects (13). However, recycled water may not be suitable for some special jobs, such as highway paving, or other placements requiring strict quality control. These jobs only account for a small fraction of total production and do not preclude the use of recycled water for the majority of concrete.

TABLE 7: COMPARISON OF POTABLE WATER QUALITIES WITH TOLERABLE LIMITS FOR CONCRETE BATCH WATER

CONSTITUENTS	TYPICAL POTABLE WATER[1]	TOLERABLE LIMIT[1]
Colour (HU)	<5	--
Turbidity (JTU)	<1	--
BOD_5	--	--
COD	--	--
Free ammonia (as N)	<0.15	--
Nitrite nitrogen (as N)	--	--
Total Hardness (as $CaCO_3$)	30	--
pH	7.5	3.0
Suspended solids	--	2,000
Total solids	50	4,000
Total alkalinity (as $CaCO_3$)	12	1,000
Carbonate	--	1,000
Bicarbonate	--	400
Sulphate	8	1,000
Chloride	14	500
Calcium	12	Combined total <2,000
Sodium	--	
Magnesium	18	
Potassium	--	
Copper	--	500
Lead	--	500
Zinc	--	500
Manganese	--	500

[1] Units are in mg/L except colour, turbidity, and pH.

2.4.2 **Truck Washout** A mixer truck returning to the plant from a job site will usually have unused concrete in the mixing drum. This concrete, if not compatible with the next batch, must be removed.

Washout water is used to bring the residual concrete in the mixer drum into suspension, in order that it may be flushed out. Therefore, potable water is certainly not required for this purpose, and recycled water is suitable.

Truck washout operations usually require a water volume second only to batch water. Water requirements for a single washout vary from 100 to over 1000 litres (5). Total daily washout water demand is highly variable, depending on the number of operating trucks, the number of central mixers (mix plant only), the washout frequency, and the amount of water used per wash. While the first two factors are fixed, the latter two are not. An efficient washout may be accomplished with a single rinse of 950 litres, or a double rinse using 375 litres twice (total of 750 litres), or a triple rinse using 190 litres three times (total of 570 litres) (4).

Washout frequency is determined by the time interval between truck loading, volume of returned concrete, characteristics of the preceding batch, housekeeping practices, and ambient temperature. From a study involving questionaires sent to 25 facilities (5), washout frequency per truck ranged from once per day to after each load; approximately 1/3 of the respondents wash after each load; the majority of the others wash out only at the end of the day, or after a significant mix change. This latter group may also washout after a particularly long haul or a long wait.

2.4.3 **Truck Washoff** The truck exterior is soiled during loading operations, more so at batch plants than mix plants. The truck must then be washed off to prevent cement build up on the truck drum exterior and to improve the truck's appearance during transit. Washoff is usually conducted concurrent to product slump adjustment at batch plants and in the loading bay at mix plants. Potable city water is normally used for washoff operations as recycled water may leave a film or residue on the truck drum exterior, due to solids concentrations. Recycled water could be used for preliminary washoff with clean water utilized for the final rinsing but this may be inconvenient. One study showed that 73 of 430 (17%) plants used recycled water for washoff (3).

The water volume used for washoff operations is also quite variable but the frequency is constant. The volume used is dependent on plant housekeeping practices and driver preference. The average volume has, however, been estimated at 40 litres/truck/washoff (4).

2.4.4 Miscellaneous Miscellaneous water use is highly variable from plant to plant and from day to day. Uses include yard dust control, cement discharge chute rinse-off, and other equipment clean up. Aggregate stockpiles may be sprayed occasionally to maintain a constant moisture content throughout the pile so batch water requirements are constant for every mix. Most miscellaneous water uses can be accomplished with recycled water.

The volume requirements have not been comprehensively quantified but one study estimated it takes about 4000 litres to wash down a 20-truck facility at the end of each day, or about 200 litres per truck (4).

3 WASTE MANAGEMENT PRACTICES

As discussed in Section 2, water is used in the ready mix concrete industry for the production of concrete, for essential truck washout and washoff operations and for other miscellaneous uses such as yard dust control, aggregate moisture control, discharge chute rinse off, and equipment clean up. These uses, except water used for batching, generate a wastewater.

Plant production, which is highly variable, largely determines liquid and solids waste generation rates. Truck mixer washout accounts for the majority of process effluent. Contaminated stormwater from various plant areas may also provide significant volumes of wastewater.

Water availability and cost affects usage. When water is abundant and inexpensive, operators tend to use more which increases the volume requiring treatment. While this reduces the solids concentration, the total solids loading remains the same.

Settling to remove suspended solids is the most common wastewater treatment practised within the industry. The high suspended solids loadings of the waste streams results in the generation of a large volume of waste solids.

3.1 Process Water

For waste management considerations, it is necessary to distinguish process from non-process effluents. Process effluent is water which, during the manufacturing process, comes into direct contact with any raw material, intermediate product, by-product or product used in or resulting from the process. Non-process wastewater is any water that is used for auxilliary operations necessary for the manufacture of a product but not contacting the process materials (eg. non-contact cooling water for pumps and air compressors). By definition, process effluent is therefore comprised of batch water, truck washout and washoff water, and central mixer washout.

Batch water, although defined above as process water, can be ignored as it is incorporated with the product transported off site, and does not generate a waste stream. Wastewater quantity and quality is determined by production, housekeeping and wastewater management practices and is, therefore, highly variable.

Figure 2 presents wastewater volumes generated at ready mix facilities on a litre/m^3 of production basis (3). The data indicates that the mean volume for the 385 plants surveyed is slightly less than 50 litres/m^3. It was estimated that 80% of wastewater volume is made up of washout and washoff effluent.

3.1.1 **Significant Pollutants** The pollutant parameters of concern in ready mix concrete wastewaters include pH, suspended solids, and to a lesser extent, oil and grease and dissolved solids.

pH Technically, pH is the negative logarithm of the hydrogen ion concentration in a given solution. A high or low pH is stressful and may be fatal to some aquatic life. Generally, freshwater solutions with a pH >10 are acutely toxic to young salmonid fish (12). Another important consideration is that the toxicity to aquatic organisms of many compounds dramatically increases when the pH changes (3). Wastewaters from the ready mix concrete industry typically have high pH levels (i.e. >9.0) due to the lime content (60-66% CaO) of portland cement.

Suspended Solids Suspended solids include both settleable and non-settleable solids which are particles that can be extracted from a wastewater by a standard laboratory filtration procedure and may include both organic and inorganic components. Organic solids can exhibit an oxygen demand in receiving waters but are not significant in concrete batch plant effluents. Suspended solids adversely affect aquatic flora and fauna by increasing water turbidity, thereby reducing available sunlight to aquatic plants. In large quantities the settleable fraction can smother bottom-dwelling aquatic life. Also, fish and shellfish may be killed by having their gills or respiratory passages blocked. Wastewaters from this industry are characterized by high suspended solids consisting of portland cement and the fine particle fraction of sand.

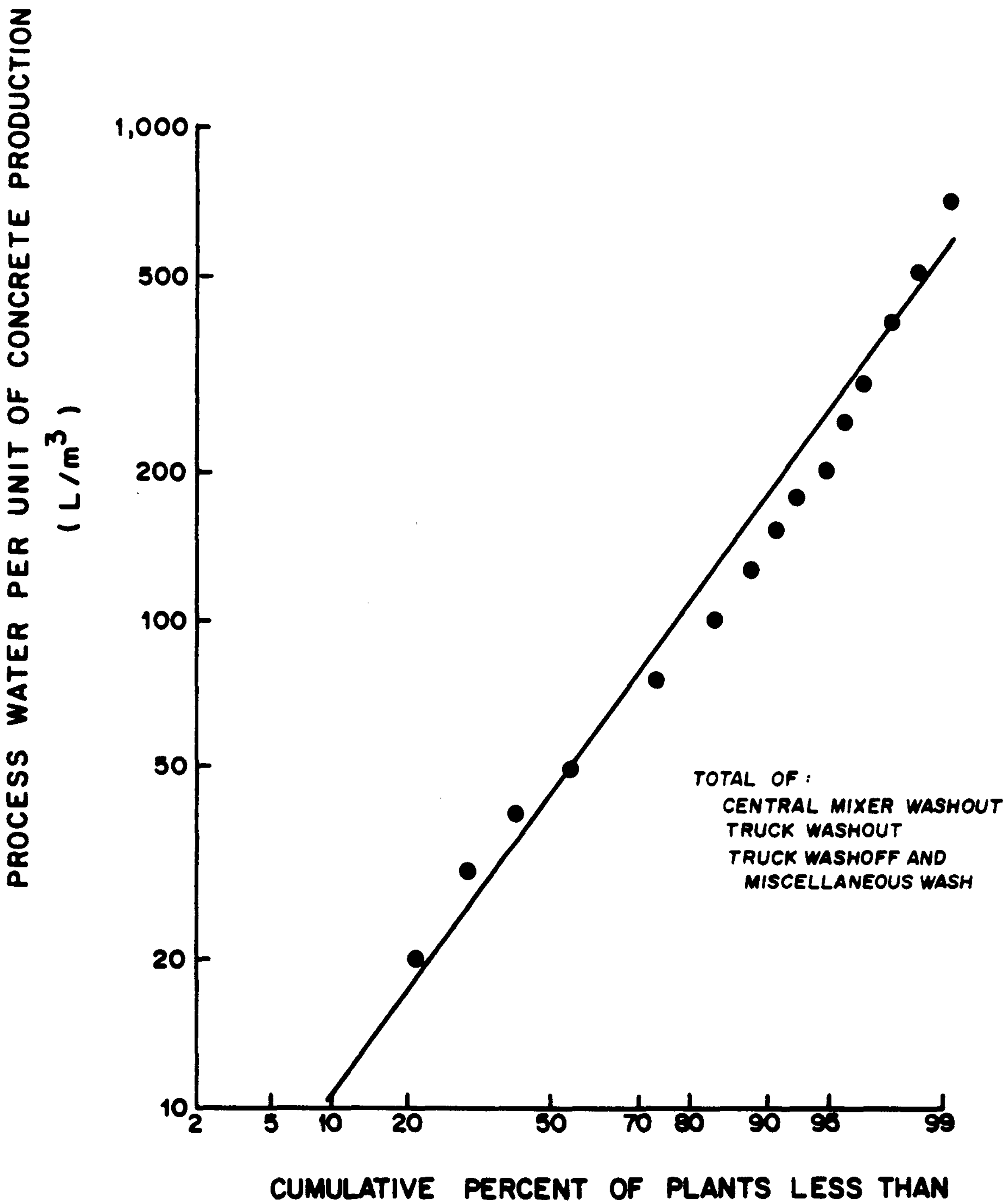

FIGURE 2: DISTRIBUTION OF PROCESS WATER GENERATED AT PERMANENT READY MIX CONCRETE PLANTS

Oil and Grease Oil and grease is a broad category that includes all oily wastes such as light and heavy hydrocarbons, lubricants and cutting fluids. These compounds may settle or float and may be liquid or solid. The lethal concentration to aquatic organisms ranges widely depending on the type of oil and grease, but can be as low as 1 mg/L (1). Even in small quantities, oil and grease can affect taste and cause odor in fish. In the ready mix industry oil and grease originate primarily from trucks and other machinery.

3.1.2 **Treatment** The type and extent of treatment will depend on whether the wastewater is to be recycled or discharged off site. Quality requirements for recycled water are usually not as stringent as are those for discharged water. If the effluent is to be recycled, settling is usually adequate. If the effluent is to be discharged from the plant property, further treatment (e.g. pH adjustment and lower suspended solids) may be required, depending on the uses and resources of the receiving environment. The U.S. EPA has identified various wastewater treatment levels for this industry from no treatment to total wastewater recycle and aggregate recovery (2):

a) no treatment
b) pond settling of suspended solids; no aggregate recovery; no pH adjustment
c) same as (b) plus pH adjustment
d) sloped slab system; aggregate recovery; partial recycle of processed wastewater; no cement fines recovery; no pH adjustment
e) same as (d) plus pH adjustment
f) mechanical clarification; aggregate recovery; partial recycle of processed wastewater; no cement fines recovery; no pH adjustment
g) same as (f) with pH adjustment
h) same as (f) with mechanical evaporation of excess wastewater
i) total recycle of wastewater with recovery and reuse of aggregate and cement

Treatment system costs are determined by: value of land; cost of land development; cost of equipment; cost of operation and maintenance; effect on plant production; cost of water and sewer charges; and cost of meeting regulatory requirements. Most systems are not energy intensive, but some pumping equipment is usually required.

Settling Settling, or sedimentation, facilities include: earth ponds or basins, concrete tanks or ponds, sloped slab basins, mechanical clarification units, or a combination of these. The size of the facility depends on the water quality required and the volume of wastewater to be treated. The removal efficiency is determined by the specific gravity and particle size of the suspended solids. Other parameters being equal, small particles settle more slowly than large particles. Table 8 presents theoretical settling rates for fine sand and cement particles as calculated by Stoke's Law. Note however, that cement probably settles faster than is indicated due to flocculation (5).

TABLE 8: SEDIMENTATION RATES AND CRITICAL HORIZONTAL WATER VELOCITIES

DIAMETER OF PARTICLE (inches)	DESCRIPTION	SPECIFIC GRAVITY	TIME REG'D TO SETTLE (min/ft.)	SETTLING VELOCITY (ft./min.)	ALLOWABLE MAX. HORIZ. VELOCITY (ft./min)
0.01	fine sand	2.65	0.0877	11.4	4.0
0.001	cement	3.15	6.75	0.148	0.4
0.0005	cement	3.15	26.9	0.0372	0.2
0.0001	cement	3.15	675	0.00148	0.04

Figure 3 provides a graphic illustration of observed settling rates for suspended solids in drum washout (3). Particles in a ready mix truck washout slurry vary in size from large coarse aggregate to fine cement. As the graph shows it takes about an hour to reduce the suspended solids by 90% from 1000 to 100 mg/L.

The factors to consider in designing a settling basin include:

a) available land area
b) available equipment
c) local regulations and conditions
d) volume of washout and returned concrete processed daily
e) maximum number of mixers or trucks to be washed at any time
f) water quality desired
g) method of clarified water disposal or reuse
h) frequency of solids removal
i) method of solids removal and disposal or reuse

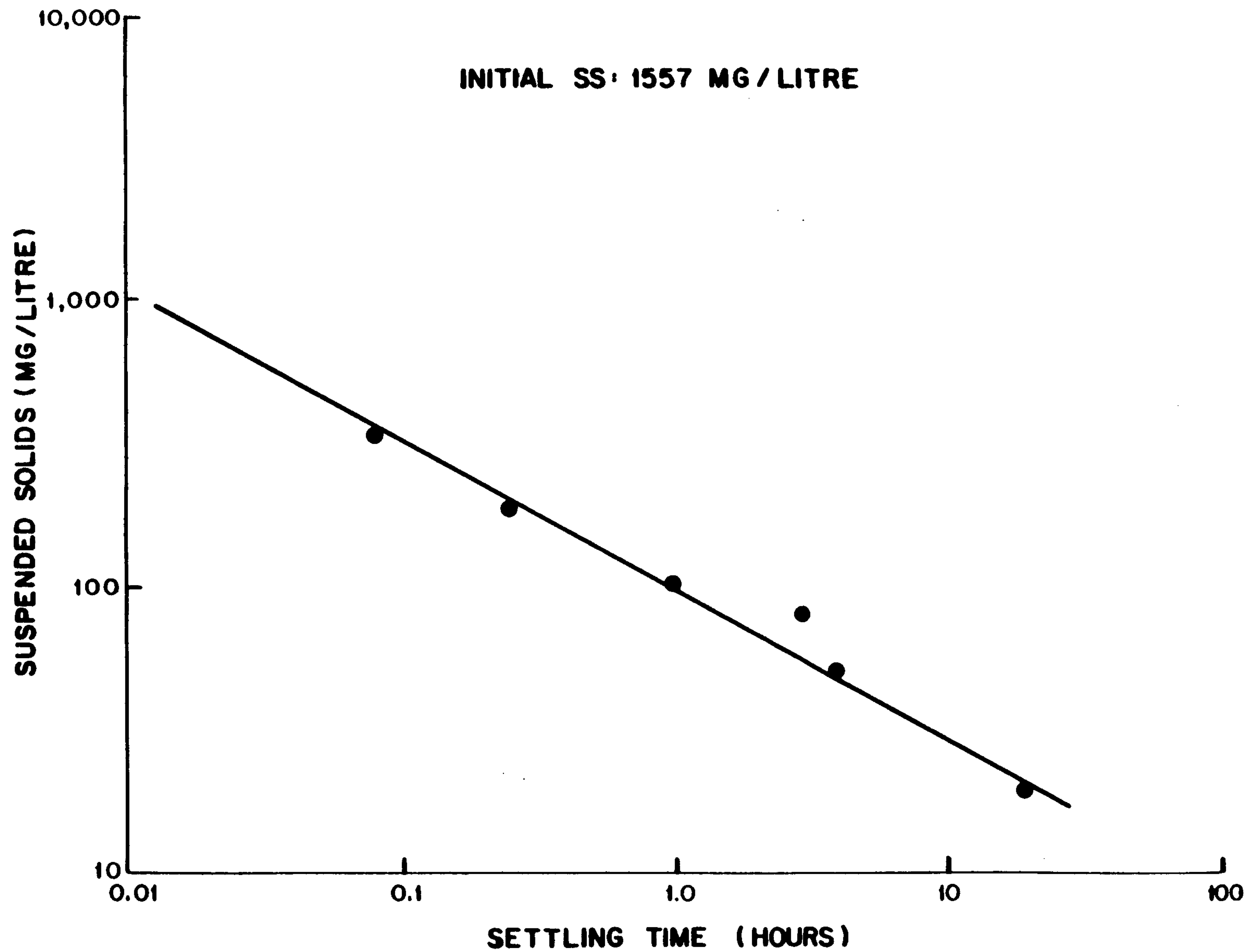

FIGURE 3: SETTLING RATE FOR CONCRETE FINES IN TRUCK WASHOUT

Site conditions determine the location and design of the pond. A concrete basin is usually more expensive, but it is easier to clean and has a superior appearance to that of an earthen basin. Earthen basins can be simply excavated on plant property and as sediment accumulates they can be abandoned or cleaned. Significant infiltration/percolation may occur from earthen ponds. At some sites this may be a problem and in other cases the pond may be designed for this process rather than discharging directly to a surface water.

Settling basins are of two general types - continuous flow or intermittent flow. In continuous flow systems, wastewater is introduced to the basin continuously, and moves in a plug flow manner at low velocity allowing solids to settle; clarified effluent continuously overflows and settled solids are removed continuously, or intermittently. In intermittent systems, the wastewater is introduced as a batch into the basin and retained there until solids have settled; at the end of this period, clarified water is drawn from the top for recycle or discharge. Settled solids are removed as required to maintain an adequate residence time in the basin.

Intermittent flow type settling basins are predominantly used in B.C. as most facilities are batch plants. The basins can be conveniently operated with an overnight retention, producing a clarified water ready to be withdrawn in the morning.

A multiple stage settling system improves the treatment efficiency. The initial stage removes the larger fraction of settleable solids, allowing the final stage(s) enhanced removal of finer solids due to reduced turbulence and solids build-up. The initial stage may have a gently sloping declined apron which retains the coarser aggregate and/or a basin with a short residence time which serves the same purpose. If truck washout is discharged to a declined plane, an estimated 75% of the total solids is retained on the slope and may be easily recovered (3). This eliminates 75% of the sludge that will eventually have to be recovered from the bottom of the basin. The multiple stage system requires more land area for the treatment works than does a simple 2-cell system, and consequently has not been widely adopted by Lower Mainland facilities.

pH Adjustment If wastewater is to be discharged off site, regulatory requirements usually require the pH be controlled (<9) so that the effluent is not acutely toxic to fish or other biota. This can be accomplished with the addition of acid. Figure 4 indicates the volumes of sulphuric acid required to lower the pH of a typical concrete wastewater to 7. Note as the effluent approaches neutral, the pH is rapidly reduced (3).

3.2 **Stormwater** Stormwater can be significantly contaminated depending on the source and housekeeping practices. Because of the highly variable flows, stormwater treatment facilities are difficult to design.

3.2.1 **Sources and Quantity** Stormwater, or yard runoff, must be managed according to it's origin and path of flow both of which determine its quality. Precipitation contacting active plant areas such as truck washout and washoff, truck loading areas, and waste treatment or containment facilities (including sludge drying cells), is likely to have elevated pH and suspended solids levels. Precipitation contacting aggregate stockpile areas may pick up substantial suspended solids but usually has an acceptable pH. The source of the solids is not normally the aggregate, which is delivered to the ready mix facility pre-washed, but solids from the unpaved aggregate stockpile areas and fugitive cement particles from the batching operation.

The extent of stormwater contamination varies with the frequency, duration and intensity of each precipitation event. After the initial rainfall, the solids concentration will drop significantly. Therefore, stormwater may not be contaminated at all times. The concept of zero discharge may not be attainable in high precipitation areas, as more stormwater will be collected than can be recycled as batch or washout water.

Another potential stormwater problem is runoff originating from adjoining properties or adjacent streets. If a facility has been situated in a low-lying area, it may have to deal with a volume of stormwater many times the volume of that originating on its property. Properly situated and constructed interception ditches are usually the best practical method of diverting off-site stormwater.

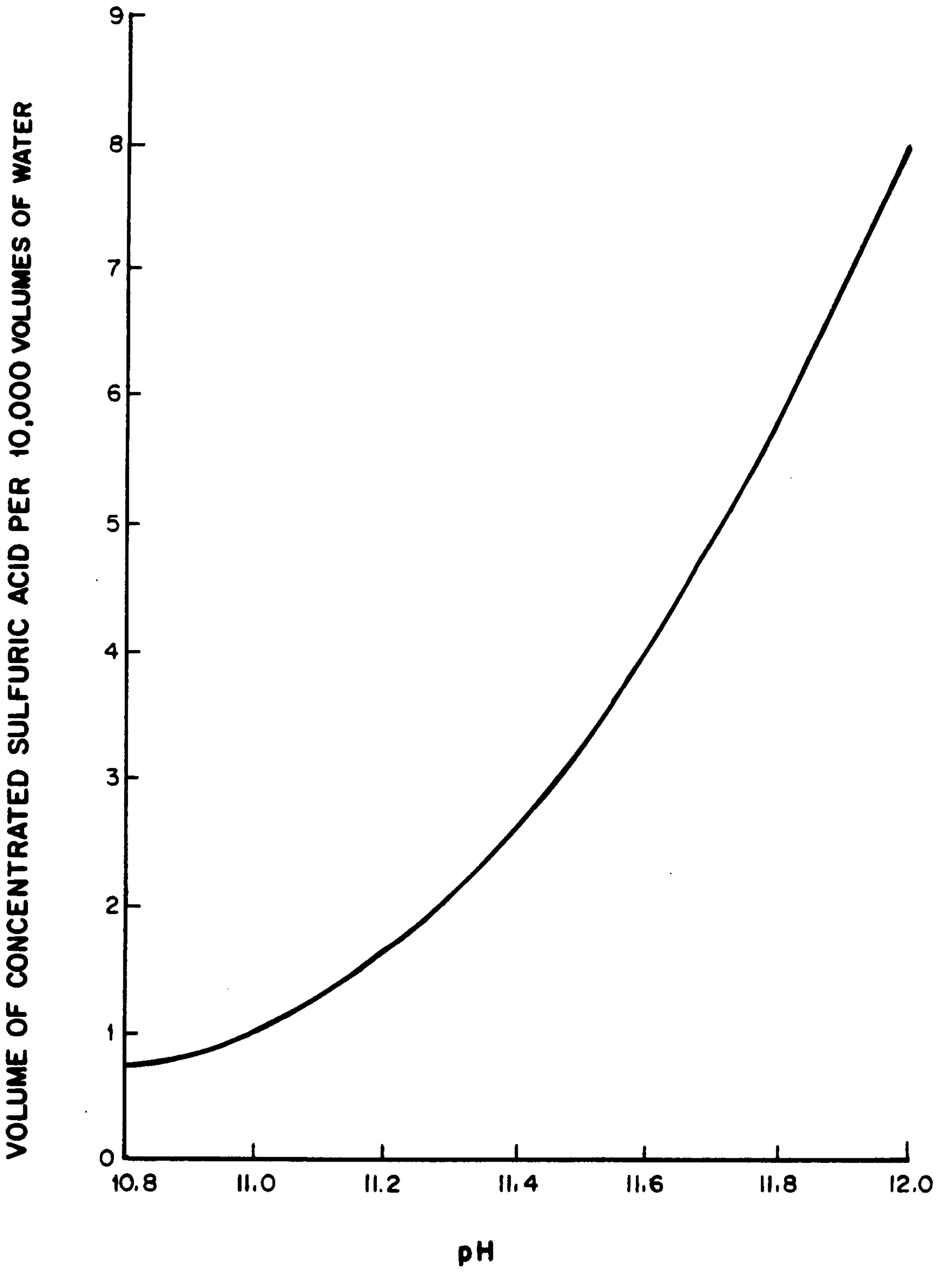

FIGURE 4: AMOUNT OF ACID REQUIRED TO NEUTRALIZE A CONCRETE WASTEWATER TO pH 7

Precipitation, and therefore stormwater, can vary significantly both geographically and seasonally. For example, the mean annual rainfall varies from 1067 mm at the Vancouver airport to 1778 mm in North Vancouver. Similarly, the maximum recorded precipitation in 24 hours varies from about 64 mm to 140 mm depending on location within the Lower Mainland (9).

3.2.2 **Treatment** The design capacity of a stormwater treatment system is determined by the flow rate, suspended solids concentration, solids settling rate and required effluent quality. The flow rate is determined by the runoff area, coefficient of infiltration and precipitation intensity. The appropriate precipitation event for design is debatable. However, it is logical that the system capacity be designed based on at least a maximum 24-hour precipitation event that can occur once in 10 years. While system capacity then has some margin of safety, a precipitation event will eventually occur which will overtax the system. Therefore, treatment systems should be designed to minimize the environmental impact from these infrequent, but unavoidable discharges.

Treated (settled) stormwater should be suitable as batch water and for washout. However, in the Lower Mainland, rainfall does not coincide with production. During periods of prolonged rainfall when stormwater is most abundant, it is likely that plant production and associated water requirements are low. Conversely, when the weather is good (dry) and production requires heavy water usage, sufficient stormwater is not available. One Lower Mainland operator estimated that 90% of his annual production occurs between April and November which coincides with the seasons of relatively low precipitation.

3.3 Waste Solids

Ready mix concrete production generates the following waste solids which must be managed (3):

1) returned concrete - approximately 1%-4% of production

2) solids recovered from settling basins generated by:
   a) central mixer washout - 73 kg/washout/m3 central mixer volume, average of 1 washout/day
   b) truck washout - 59 kg/washout/m3 mixer volume, average of 1.5 washouts/truck/day
   c) truck washoff - variable, but relatively minor compared with other sources

There are several options available which reduce the environmental impact and the management costs of these solid waste streams.

3.3.1 Returned Concrete The general industry practice is to order more concrete than is needed for the job, to ensure there is enough. Therefore, trucks returning to the plant usually contain some concrete that has already been paid for. Unused concrete may be unloaded at the job site, but this is usually unacceptable. In some instances it is given away before the truck returns to the plant.

The volume of returned concrete fluctuates greatly but has been estimated at 1.5-2% of production (4). Another study estimated that between 1-4% of production was returned to the plant (3). If the returned concrete is still of good quality and similar in composition to the formulation of the next batch, it may be incorporated in that batch. The frequency of incorporation is difficult to determine, but one Lower Mainland plant estimated it at 60%, while another smaller plant estimated only 10%. The lower estimate may be biased to avoid questions of concrete quality. Returned concrete is most likely incorporated into the succeeding batch more than 10% of the time. If returned concrete is not suitable for the next batch, it must be used either for an alternative purpose or disposed.

When the returned concrete is not compatible with the next batch, but still of reasonable quality, it may be used to pave the yard (in a variety of applications), or in precast concrete products, both of which are environmentally acceptable waste management practices. There are, however, costs associated with these uses including the time required to pave effectively and the cost and maintenance of the forms, but these costs may be offset by reduced waste solids handling expenses. One Lower Mainland operator estimates that making returned concrete products has reduced his annual solids disposal costs by a factor of 2.5.

Substantial research has been conducted in assessing the feasibility of using all returned concrete in subsequent batches. Conrock, a California company, has developed a system for recycling 100% of returned concrete. Returned concrete is diluted with water at 75 L/m3 of concrete, aggregate is recovered from the slurry, and the slurry is then used as batching water. Any admixture in the slurry is so dilute, it is not believed to cause a compatibility problem (4). A similar system produced by Schwing America Inc. is available through Concrete Systems Inc. in B.C. The major disadvantage of these systems is their capital cost, and therefore they may only be affordable to large plants.

Master Builders has recently developed another system for recycling returned concrete, called the DELVO system. The DELVO system utilizes two chemical compounds, a cement stabilizer which retards hydration and a cement activator. The day's returned concrete is discharged into a large, dedicated central mixer, and mixed with the stabilizer and water. The next day, the activator is added and the slurry is used as a portion of batch water. This system is also expensive. While the DELVO system was developed based on economic considerations, the attendant environmental benefits are obvious when no waste is generated from returned concrete.

One large ready mix company, with several operations in the Lower Mainland, has been using a partial DELVO system since mid-1987. These facilities do not discharge returned concrete to a central mixer, but utilize the DELVO stabilizer to eliminate truck washout at the end of the day. (Apparently the volume and characteristics of the returned concrete rarely prevent this operation from being conducted.) After returned concrete is discharged, water and stabilizer are injected into the drum mixer. The drum is rotated a few times to ensure thorough mixing and the slurry is retained in the mixer overnight for incorporation into the next morning's batch. The system is new, and long-term effects on product quality have not been conclusively determined. However, the company is pleased with performance thus far, and even the partial system eliminates wastes from final washout and reduces water usage.

Some returned concrete with poor cementitious qualities, is no longer suitable for normal concrete applications, and therefore must be otherwise managed. The simplest and lowest cost method is to dump the concrete on the ground, but unless the contaminated runoff is contained and treated this method is usually not environmentally acceptable. Once the concrete has set, it has to be broken up and can be used as fill. Many plants discharge the excess concrete with the drum washout into the settling basin, and therefore it becomes part of the waste solids. However, this increases the solids loading in the settling basin which requires more frequent cleanout.

Returned concrete can be discharged to an aggregate recovery unit in the first stage of the wastewater treatment system. There are two mechanical aggregate recovery systems used in the ready mix industry, sand screws and drag chains, and many variations exist of each. Generally, screw devices are superior to drag chain units as the former has been found to wear better and require less maintenance.

A sand screw (Figure 5) operates as follows: A slurry of returned concrete is introduced to the unit at the bottom of an inclined trough which houses the screw. As the screw rotates, large aggregate is carried up and is discharged over the top, while the smaller fraction is carried back with the flush water. Screens can be used to sort the recovered aggregate.

A drag chain unit, or washer, usually consists of two chambers (Figure 6). Truck washout is discharged into the first chamber, where the larger fraction of the slurry drops out. This sediment is conveyed via a drag chain across the bottom then up and out the end of the unit. The fines settle in the second chamber and are removed by a slower drag chain in a similar manner. These units are quite compact - approximately 6 x 18 x 1 metre deep and can handle washout from approximately 20 trucks/day (3).

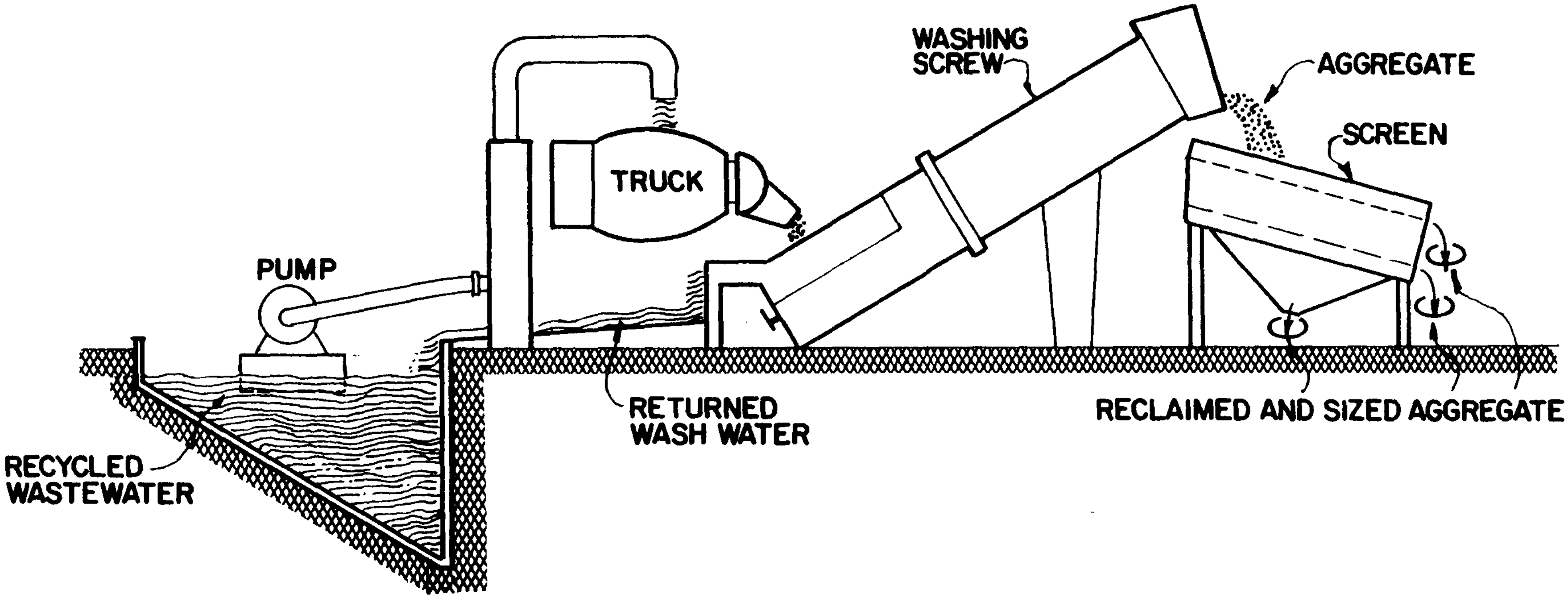

FIGURE 5: SCHEMATIC OF SCREW WASHER AND SCREEN FOR AGGREGATE RECOVERY FROM RETURNED CONCRETE.

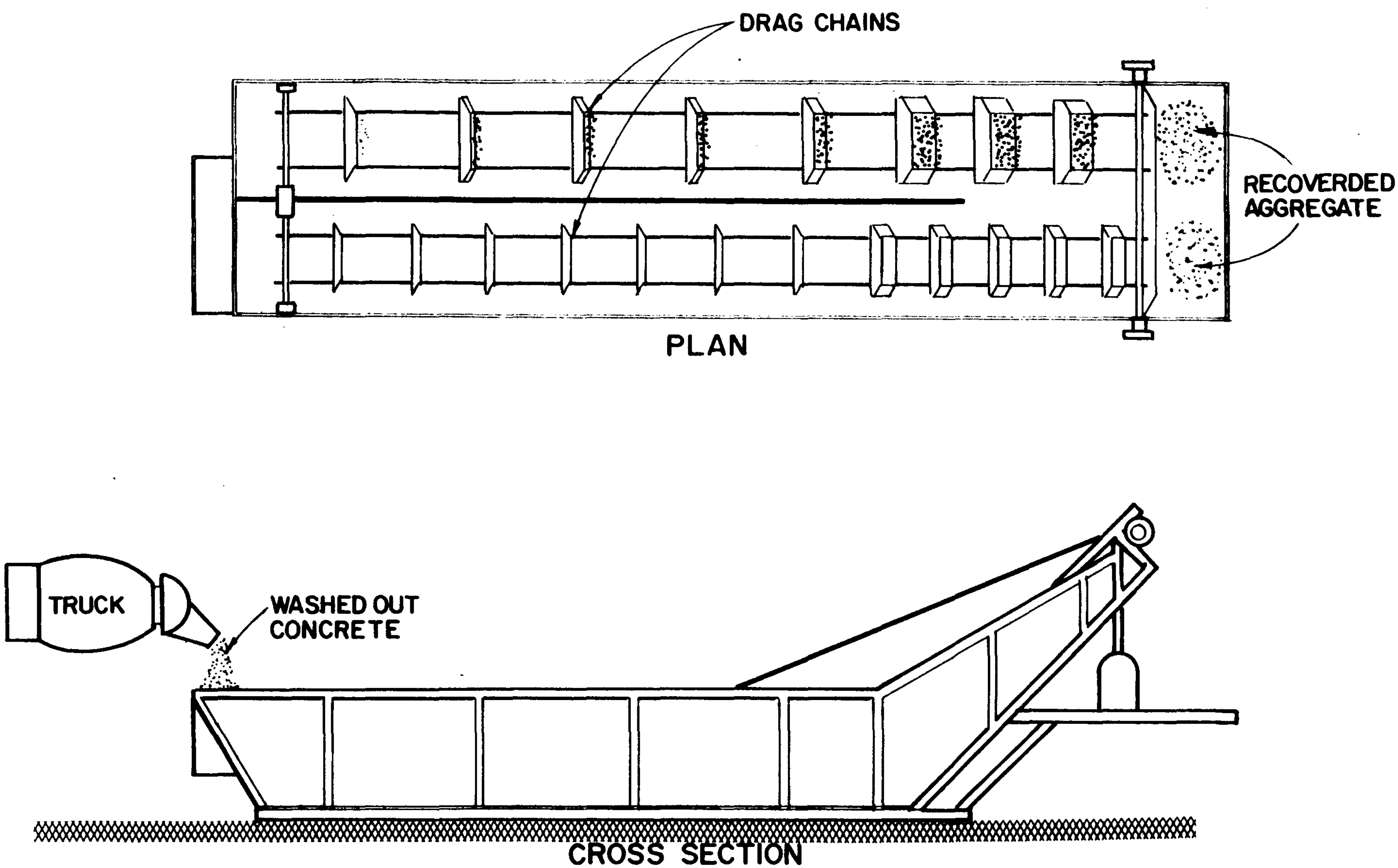

FIGURE 6: SCHEMATIC OF DRAG CHAIN WASHER FOR AGGREGATE RECOVERY FROM RETURNED CONCRETE.

3.3.2 **Recovered Solids** Sludge accumulating in aggregate recovery units as well as wastewater settling basins, must be removed periodically. The sludge composition varies according to the treatment works, but is primarily comprised of sand and cement fines. The recovered sludge has a high moisture content and an elevated pH. The water content is usually reduced by simply piling the recovered sludge on the ground and letting the water drain and evaporate. The leachate must be contained and may need treatment because of the high pH.

Depending on the dry sludge's characteristics, it is sold or given away as pond sand, road base, or back fill. If a client cannot be located for the sludge, it is sometimes landfilled on site, but is usually hauled away to a landfill at substantial cost to the company.

4.0 OVERVIEW OF SELECTED PLANTS IN THE LOWER MAINLAND

Data were obtained during site visits to 17 plants in the Lower Mainland, selected to be representative of the ready mix concrete industry. Table 9 summarizes the information and an inspection report for each site is presented in Appendix 2.

Approximately three-quarters of the facilities are batch type operations, while four plants utilize a central mixer for production. Fleet size varies from 5 to 40 trucks. Rated design capacity and average daily production range from 35 to 300 m^3 per hour, and 45 to 700 m^3 per day, respectively, based on plant operators' estimates.

Some degree of process effluent recycling is practiced by 82% (14 of 17) of the facilities visited (Table 10). One of the three plants not currently recycling, plans to do so starting in 1988. Recycled wastewater is used for truck drum washout at 71% (12 of 17) of the plants, while 53% (9 of 17) use recycled water as makeup to batch water; 41% (7 of 17) use recycled water for both drum washout and batch water.

Process effluent treatment by some type of settling is conducted by all 17 plants: 65% (11 of 17) have concrete sloped slab cell(s) while four of 17 have concrete lined settling basins. Fifty-three percent (9 of 17) employ an infiltration system.

Mechanical aggregate recovery units are used by 5 plants, 3 use sand screws and 2 use drag chain devices. The drag chain at one plant is used only for clarification with no aggregate recovery. One facility adjusts effluent pH by dilution. None of the plants neutralize wastewater by adding acid. Table 11 presents the results of pH measurements taken at various locations at the plant sites. The pH values ranged from 7 to 13 with most effluents about 11. No plants add a flocculating agent or polyelectrolyte to enhance settling of suspended solids.

The process area is usually small, estimated at less than 5% of the total property. Waters contacting process areas generally have elevated pH levels because of spilled cement. This contaminated runoff, generated from either precipitation or washing operations is reasonably well collected and contained in basins at 59% (10 of 17) of the plants, while four plants (24%)

TABLE 9: SUMMARY OF INSPECTED LOWER MAINLAND READY MIX PLANTS

Plant #	Plant Type	Avg. Daily Production (cu. m)	1 Hour Design Capacity (cu. m)	Wastewater Treatment Facilities	Recycled Water Use	Process Area Effluent Containment	WMB Permitted	Surface Water Proximity
1	mix	550	300	B,G,H	WO	good	no	no
2	mix	250	175	C,D	nil	fair	no	1 km
3	batch	125	100	D,E	BW	good	no	1 km
4	batch	400	100	A2,E,F	WO,BW	good	no	no
5	batch	100	50	A3,D	WO,BW	good	no	no
6	batch	80	200	D	BW	good	no	no
7	batch	275	100	A3,B	WO	fair	no	1 km
8	batch	300	120	A3,F	WO,BW	good	no	1 km
9	batch	65	40	C	nil	fair	no	.5 km
10	batch	200	200	A3,C	WO,BW	good	no	50 m
11	batch	185	120	A2,E	WO,BW	poor	no	50 m
12	mix	400	200	A2,B	WO	fair	no	25 m
13	batch	125	85	A2,B,C	WO	good	PE,SW	100 m
14	batch	700	270	D,F,G,I	nil	good	PE,SW	100 m
15	batch	250	100	A3,D	WO,BW	good	SW*	20 m
16	batch	45	35	A2,B	WO,BW	poor	no	20 m
17	mix	125	160	A2,H	WO	poor	SW	10 m

KEY:

Wastewater Treatment Facilites:
Ax - sloped slab basin, "x" indicates no. of cells
B - one or more sumps
C - infiltration pit
D - permanent infiltration lagoon
E - sandscrew aggregate recovery
F - lined pond
G - lined ditch
H - drag chain aggregate recovery
I - dilution

Positive Discharge:
PE - process effluent
SW - stormwater
SW*- uncontained runoff during heavy rain
WMB- Waste Management Branch

Recycled Water Use:
WO - interior truck drum washout
BW - batch water
nil- no recycling

Process Area Effluent Containment:
good - process effluents well contained
fair - process effluents fairly well contained, slight modifications needed
poor - potential procress effluent discharge to surface water

TABLE 10: EFFLUENT TREATMENT PRACTICES AT INSPECTED FACILITIES

Plant	Infiltration Basin	Settling Basin (Impermeable)	Sloped Slab Cell(s)	Mechanical Clarifier	pH Adjust	Reuse of Wastewater
1		X		X		X
2	X					
3	X			X		X
4		X	X	X		X
5	X		X			X
6	X					X
7			X			X
8		X	X			X
9	X					
10	X		X			X
11			X	X		X
12			X			X
13	X		X			X
14	X	X			X*	
15	X		X			X
16			X			X
17			X	X		X
% of plants:	53%	24%	65%	29%	6%	82%

* this plant attempts to neutralize pH by dilution with spring water

TABLE 11: EFFLUENT pH VALUES AT INSPECTED FACILITIES

Site	Truck Loading	Truck Washoff	Truck Washout	Aggregate Storage	Sludge Drying Area
1	10	11	12	N.A.	N.A.
2	11	11	11	N.A.	11
3	11	12	N.A.	9	N.A.
4	11	N.A.	12	N.A.	10.5
5	10	11	11.5	N.A.	N.A.
6	7	N.A.	9	N.A.	N.A.
7	11	11	12.5	7	N.A.
8	11	11	11	N.A.	N.A.
9	11	N.A.	12	9	11.5
10	12	11	N.A.	N.A.	N.A.
11	N.A.	11	13	N.A.	N.A.
12	10	9	12	N.A.	N.A.
13	N.A.	8.5	12.5	7	11
14	N.A.	11.5	11.5	N.A.	N.A.
15	11.5	11.5	12	10	N.A.
16	11	11	11.5	N.A.	N.A.
17	11.5	8.5	11.5	7	12

Note: N.A. = not available

Truck Loading area pH values ranged between 7 - 12, with 93% of 14 measurements recording pH 10 or greater.

Truck Washoff pH values ranged between 8.5 - 12, with 79% of 14 measurements recording pH 10 or greater.

Truck Washout pH values ranged between 9 - 13, with 93% of 15 measurements recording pH 11 or greater.

Sludge Drying Area values ranged between 10.5 - 12, with 100% of 5 measurements recording pH 10.5 or greater.

Aggregate Storage area pH values ranged between 7 - 10, with 83% of 6 measurements recording pH 9 or less.

achieved only partial containment. Three plants have a significant potential for the discharge of contaminated wastewater to surface waters.

As discussed in Section 2.3.3 admixtures are used extensively in the ready mix industry and are of environmental concern due to their potential toxicity. Table 12 summarizes the admixture information for the plants visited, including the container capacities and method of storage.

Treatment of stormwater runoff is practised by only two facilities (12%); one collects most runoff in the plant sewer system and discharges it to an infiltration lagoon, and the other plant directs runoff straight to an infiltration pit.

Zero discharge of process water is accomplished by 76% (13 of 17) of facilities inspected, based on the fact that effluent permits are not required by the province. This does not mean all wastewaters are retained on company property. Stormwater and process effluents in some cases cross property boundaries as runoff and in groundwater migrating from unlined ponding facilities. Settling basins or ponds likely overflow at most plants during periods of high precipitation.

TABLE 12: ADMIXTURE INFORMATION FOR INSPECTED FACILITIES

	STORAGE CAPACITY (thousands of litres)																	
Site:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	# of Users
Admixture																		
Water Reducer	11	3	9	6	-	9	5	14	2	9	5	3	5	1	5	-	6	15
Air Entrainer	1	2	2	-	2	5	2	2	1	2	3	2	2	1	2	2	1	16
Set Retarder	1	2	2	2	2	9	5	2	-	2	1	2	5	3	2	-	2	15
Set Accelerator	1	-	-	6	-	-	9	23	1	9	12	-	-	1	-	2	-	9
CaCl2 (Accel.)	-	13	5	14	-	9	-	-	-	9	-	-	-	9	9	-	9	8
Early Strength	11	-	9	-	5	14	-	-	-	-	-	-	7	-	2	-	-	6
Plasticizor	1	2	-	4	-	-	-	-	-	-	-	6	-	1	-	-	2	6
Total	26	22	27	32	9	46	21	41	4	31	21	13	19	16	20	4	20	
Location	in	in	out	in	in	in	in	out	out	out	in	in	in	in	out	out	in	
Supplier	Con. M.B.	G.	M.B.	G.	Con.	M.B.	Con.	G.	M.B.	M.B.	G. M.B.	G.	Con.	G. M.B.	Con.	G.	G.	

Note: Con. = Conchem
G. = Grace
M.B. = Master Builders

Location refers to inside or outside vessel storage.
11 of 17 facilities (65%) securely store admixtures inside.
8 of 17 facilities (47%) utilize non-corrodible plastic vessels.

5.0 SUMMARY AND RECOMMENDATIONS

The ready mix concrete industry in B.C. has a significant economic role, producing goods worth in excess of $35,000,000 and directly employing more than 1000 people.

Many of the approximate 100 facilities in B.C. are located adjacent to surface waters. Consequently, the periodic or continuous discharge of contaminated process effluent and/or stormwater to the surface waters, can result in acute or chronic toxicity to aquatic biota, and destruction of habitat.

The primary contaminants of concern are pH and suspended solids. Because of the high alkalinity of portland cement, any water contacting it quickly increases in pH. Water with a pH of approximately 10 or more is acutely lethal to fish. Suspended solids result from the washdown of process equipment and stormwater runoff from the site. Suspended solids can directly affect fish by plugging their gills, and adversely affect habitat by reducing light penetration and/or smothering stream or ocean bottoms.

The environmental impacts of the ready mix concrete industry can be significantly reduced or eliminated by employing appropriate waste management practices including water use reduction and recycling, good housekeeping, stormwater segregation and control, effective wastewater treatment systems, and progressive solid waste management techniques. Although each ready mix facility is somewhat unique, combinations of these approaches can be effectively applied.

The primary, and likely easiest and least costly way to minimize, and in most cases eliminate, process effluent is to reduce fresh water usage and recycle process water to the greatest extent possible. Fresh water should be restricted to specific uses such as truck exterior washoff and hot water production. If fresh water is deemed necessary for washoff, flow restricting nozzles with spring-loaded triggers should be installed on hoses, and employees should be trained to use no more water than is absolutely necessary.

Recycled process water and/or stormwater should be used for batch water, truck drum washout, and for washdown activities not requiring clean water. In turn, drum washout water should be minimized, by series rinsing if necessary.

Zero discharge of process water is attainable through sound wastewater management practices which must include the utilization of recycled water as batch water. Research over the past 20 years has demonstrated that good quality concrete can be made using water which is contaminated within certain limits. The tolerable limits for many contaminants have been identified, below which the concrete's strength development and overall quality should not be affected. Many Lower Mainland ready mix producers have accepted this practice. If producers are informed of the benefits of recycling, the reuse of treated wastewater for batching purposes will continue to gain industry acceptance. The only constraint for using recycled process water for batch water is low temperature. Batching requirements dictate a certain temperature be maintained, and during cold months recycled water stored outside may not be suitable. In many instances, this constraint is overcome by combining hot water with the colder recycled water. The recycled water may not be of high enough quality to charge through the heater.

Although the level of contamination in stormwater tends to be lower than in process water, management is more difficult because the frequency and intensity of precipitation events are highly variable. The easiest and least costly method of minimizing stormwater contamination is to prevent contamination in the first place by employing good housekeeping practices. In particular, spills should be minimized and cleaned up as soon as they occur. This applies especially to portland cement because of its high toxicity to fish, but also to other fine materials that can increase the suspended solids in stormwater runoff. Other steps that can minimize stormwater volumes and contamination include: minimize the plant process area, divert offsite stormwater around and away from the plant, pave as much of the yard as is practical, and slope the yard so stormwater is removed as generated and directed to an appropriately sized settling basin. Clarified stormwater should be contained and recycled to supplement recycled process water as necessary.

Process water and stormwater require settling to remove solids. The majority of process water is generated by truck drum washout. If aggregate recovery equipment is not used, settling should be done in a sloped concrete basin which overflows into a second basin for further clarification prior to recycling. These basins should be located so other process streams, such as equipment runoff, will flow to these basins for treatment. Although total recycle is generally feasible for process water, if discharge is necessary, then neutralization will be required in most cases where discharge is to surface waters.

A separate settling basin should be provided for stormwater. The size will depend on several factors including area serviced, infiltration coefficient of unpaved service areas, housekeeping practices, and local precipitation trends. The basin should be sized to provide adequate settling for a precipitation event occuring once in at least 10 years. Discharged stormwater should not need pH adjustment unless housekeeping practices are poor or process water is contaminating the stormwater.

If positive discharge of process effluent or stormwater is unavoidable, a potential alternative to a direct discharge is a properly designed and constructed infiltration basin.

Whenever possible returned concrete should be incorporated in the succeeding batch. Where this is not acceptable for quality control, returned concrete should not be discharged to the treatment works but used for making concrete products (eg., blocks, slabs, curbstones). This practice eliminates liquid and solid waste generation, significantly lowers waste water treatment and sludge disposal costs, and yields useful saleable products.

Periodically sludge from settling basins or aggregate recovery equipment must be removed because its accumulation reduces residence time and therefore suspended solids removal efficiency. This material should be stored where the leachate can be contained, and treated if necessary. At least, the material should be stored so any leachate is directed to the process water treatment system. When dry, the solidified material can be used as fill.

Admixtures are chemicals that are potentially hazardous to human health and/or the environment. Admixture tanks should be located indoors to protect them from the elements and potential damage from mobile equipment. The floor should be sealed and curbed to ensure containment of leaks. Additional toxicity information is required in order to further assess the potential environmental impacts of these materials.

As previously noted each ready mix facility is unique and, therefore, not all of the preceding recommendations will universally apply. However, many of these waste management techniques can be incorporated by all plants and will result in reduced environmental impacts by this industry.

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APPENDIX 1

READY MIX CONCRETE INDUSTRY
ECONOMIC AND INVENTORY INFORMATION

TABLE 1A : LIST OF B.C. READY MIX CONCRETE PLANTS

PLANT	STREET	CITY
AGASSIZ READY-MIX CONCRETE	5383 MCCALLUM RD.	AGASSIZ
ALLIED READY MIX LTD.	13980 MITCHELL RD.	RICHMOND
B.A. CONCRETE LTD.	R.R. #1	KAMLOOPS
BAIRD BROS. LTD.	P.O. BOX 189	ENDERBY
BANNERT READY MIX LTD.	P.O. BOX 543	GRAND FORKS
BAY CONCRETE LTD.	P.O. BOX 640	QUALICUM BEACH
BLACKHAMS CONSTRUCTION		CHILLIWACK
BLUE CANYON CONCRETE LTD.	P.O. BOX 1359	FORT NELSON
BUILDERS CHOICE READY MIX LTD.	P.O. BOX 8	ABBOTSFORD
BUTLER BROS. SUPPLIES LTD.	P.O. BOX 4066 STN. A	VICTORIA
CANNON CONTRACTING		MISSION
CARDINAL CONCRETE LTD.	P.O. BOX 336	SQUAMISH
CARIBOO REDI-MIX & CONTRACTING	P.O. BOX 4129	QUESNEL
CHEHALIS REDI MIX	R.R. #1	AGASSIZ
CHETWYND REDI MIX LTD.	P.O. BOX 1240	CHETWYND
COAST AGGREGATES LTD.	BOX 1098	SQUAMISH
COLUMBIA READY-MIX LTD.	860 ATTREE RD.	VICTORIA
COMOX VALLEY READY MIX LTD.	P.O. BOX 3157	COURTENAY
CONCO HOLDINGS LTD.		VERNON
COQUITLAM CONCRETE PROD. LTD.	1530 PIPELINE RD.	COQUITLAM
COQUITLAM READY MIX		COQUITLAM
DENRAL CONCRETE	P.O. BOX 1710	FERNIE
DOLAN'S CONCRETE LTD.	4747 ROGER ST.	PT. ALBERNI
EAGLE VALLEY CONCRETE CO. LTD.	R.R.#1	SICAMOUS
ECONO MIX LTD		LANGLEY
ECONO MIX LTD.	P.O. BOX 3862	VANCOUVER
ELK VALLEY READY MIX LTD.		ELKFORD
EVER REDI CONCRETE	P.O. BOX 4369	QUESNEL
EVANS REDI-MIX LTD.	P.O. BOX 10	DUNCAN
F.J.H. CONSTRUCTION LTD.	4434 LAKELSE AVE.	TERRACE
FLINTSTONE CONCRETE	P.O. BOX 335	BURNS LAKE
GARRETT READY MIX LTD.	P.O. BOX 10923	SPARWOOD
GATOR REDI MIX	P.O. BOX 816	VANDERHOOF
GENERAL ENTERPRISES LTD.	120 INDUSTRIAL RD.	WHITEHORSE
GIBSONS READY MIX	P.O. BOX 737	GIBSONS
GLACIER CONCRETE LTD.		TERRACE
GLACIER CONCRETE LTD.	P.O. BOX 379	KITIMAT
GLENDALE REDI-MIX LTD.		WILLIAMS LAKE
GOLDEN CONCRETE PRODUCTS	P.O. BOX 2066	GOLDEN
GOOD'S REDI-MIX	1691 FAIRVIEW RD.	PENTICTON
GOODBRAND CONSTRUCTION LTD.		SURREY
GOODBRAND READY MIX		MATSQUI
GRAND FORKS READY-MIX CONCRETE	P.O. BOX 2158	GRAND FORKS
GRAVEL HILL SUPPLIES	1455 COWICHAN BAY RD.	COBBLE HILL
GULF COAST MATERIALS LTD.	RAINBOW RD.	GANGES
H & J READY MIX LTD.	P.O. BOX 1759	REVELSTOKE
H & R REDI-MIX LTD.	23616 RIVER ROAD	MAPLE RIDGE
HASLER'S CONCRETE		KAMLOOPS
HOPE READY MIX LTD.	P.O. BOX 1095	HOPE
INLAND READY MIX LTD.		NAKUSP
ISLAND READY MIX LTD.		COURTENAY
ISLAND READY MIX LTD.		CAMPBELL RIVER
JOPP & SONS REDI-MIX		INVERMERE

KASK BROS. READY MIX LTD.	7500 BARNET	BURNABY
KELOWNA READY MIX INC.	1131 ELLIS ST.	KELOWNA
KETTLE VALLEY READY MIX		KETTLE VALLEY
KITIMAT VALLEY CONCRETE LTD.	P.O. BOX 288	KITIMAT
KON KAST PRODUCTS LTD.		KELOWNA
KORPACK CEMENT PRODUCTS LTD.	154 WELLINGTON ST.	TRAIL
LAFARGE CONCRETE LTD.		NANAIMO
LAFARGE CONCRETE LTD.		NORTH VANCOUVER
LAFARGE CONCRETE LTD.	1051 MAIN ST	VANCOUVER
LAFARGE CONCRETE LTD.		RICHMOND
LAFARGE CONCRETE LTD.		COQUITLAM
LOUIS SALVADOR & SON LTD.	P.O. BOX 583	CRESTON
LOUIS SALVADOR & SON LTD.	P.O. BOX 218	CRANBROOK
M & K READY MIX LTD.	2401-43 ST.	VERNON
MACKENZIE REDI-MIX CO. LTD.	P.O. BOX 29	MACKENZIE
MANNING KUMAGAI JOINT VENTURE	9807 - 196A ST.	LANGLEY
MARC'S U-CART READY MIX LTD.	2250 ROSS RD.	KELOWNA
MAX HELMER CONST. LTD.	P.O. BOX 400	RADIUM HOT SPR.
MAX HELMER CONST. LTD.		ATHALMER
MAX'S READY-MIX LTD.	P.O. BOX 1649	PRINCETON
MAYCO-MIX	1125 FARQUHAR	NANAIMO
MCBRIDE TRANSIT MIX LTD.		MCBRIDE
MCGAULEY READY MIX CONCRETE CO.		ELKFORD
MCGAULEY READY MIX CONCRETE CO.		SPARWOOD
MCGAULEY READY-MIX CONCRETE CO.	P.O. BOX 194	TRAIL
MISSION READY-MIX LTD.	P.O. BOX 3083	MISSION
MOJO ENTERPRISES LTD.	P.O. BOX 50	L.NICOLA VALLEY
MULDER CONCRETE	P.O. BOX 2354	SMITHERS
NECHAKO REDI-MIX LTD.	P.O. BOX 2	VANDERHOOF
NELSON READY-MIX CONCRETE	P.O. BOX 180	NELSON
NEWTON READY MIX LTD.	14744 HYLAND RD.	SURREY
NORGAARD READY-MIX		MERRITT
NORGAARD READY-MIX	P.O. BOX 636	PRINCE RUPERT
O K BUILDERS SUPPLY LTD.		SUMMERLAND
O K BUILDERS SUPPLY LTD.	925 ELLIS ST.	KELOWNA
OCEAN CONST. SUPPLIES LTD.	P.O. BOX 1270	VICTORIA
OCEAN CONST. SUPPLIES LTD.	666 N. NECHAKO RD.	PRINCE GEORGE
OCEAN CONST. SUPPLIES LTD.		KAMLOOPS
OCEAN CONST. SUPPLIES LTD.		NANAIMO
OCEAN CONST. SUPPLIES LTD.		TERRACE
OCEAN CONST. SUPPLIES LTD.	P.O. BOX 2300	VANCOUVER
OLIVER READY MIX LTD.	R.R. #3	OLIVER
OMINICA REDI-MIX LTD.	P.O. BOX. 577	FORT ST. JOHN
OSOYOOS READY MIX LTD.	P.O. BOX 163	OSOYOOS
P.R. TRU MIX LTD.	4520 FRANKLIN AVE.	POWELL RIVER
PACIFIC RIM READY MIX LTD.		PRINCE RUPERT
PACIFIC SITE CONCRETE LTD.	3629 W. 2 AVE.	VANCOUVER
PORT MCNEILL ENTERPRISES	P.O. BOX 459	PORT MCNEILL
PRINCETON REDI MIX LTD.	P.O. BOX 185	PRINCETON
R & J READY MIX		PENTICTON
REBAR REDI MIX LTD.	13611 MITCHELL RD.	RICHMOND
REMPEL BROS. CONCRETE LTD.		COQUITLAM
REMPEL BROS. CONCRETE LTD.	P.O. BOX 187	ABBOTSFORD
REMPEL BROS. CONCRETE LTD.		CHILLIWACK
REMPEL BROS. CONCRETE LTD.		VANCOUVER
REMPEL BROS. CONCRETE LTD.		NORTH VANCOUVER
RESIDENTIAL READY MIX LTD.	376 E. KENT	VANCOUVER
REVELSTOKE CONC. PRODUCTS		REVELSTOKE

REVELSTOKE CONCRETE INC.	10616 - 87 AVE.	FORT ST. JOHN
RIVTOW INDUSTRIES		NELSON
ROCKET REDI-MIX LTD.	P.O. BOX 904	DAWSON CREEK
ROLLING MIX CONCRETE	P.O. BOX 2298	PRINCE GEORGE
ROOSTER READY MIX	R.R. #1	WINLAW
SALMON ARM READY MIX LTD.	P.O. BOX 1317	SALMON ARM
SARDIS READY-MIX LTD.		SARDIS
SKANDIA CONCRETE LTD.	P.O. BOX 2700	INVERMERE
SPEEDWAY CONCRETE SALES LTD.	115 MOUNTAIN HIGHWAY	NORTH VANCOUVER
STRONG ARM CONCRETE	3640 ARTHUR DR.	LADNER
SWANSON'S READY-MIX LTD.		KLEINDALE
SWANSON'S READY-MIX LTD.	P.O. BOX 172	SECHELT
TINSLEY BROS. ENT. LTD.	P.O. BOX 295	VALEMOUNT
TRI LAKE READY MIX LTD.	P.O. BOX 530	CHASE
TRI-B CONCRETE LTD.	P.O. BOX 679	LILLOOET
TRI-MAC CONCRETE LTD.	6245 RIVER RD.	DELTA
TRIO READY-MIX LTD.		SAANICH
TRIO READY-MIX LTD.	773 CORDOVA BAY RD.	VICTORIA
UPLAND READY-MIX LTD.	1920 ANTONELLI RD.	CAMPBELL RIVER
VALLEY RITE-MIX LTD.		CHILLIWACK
VALLEY RITE-MIX LTD.	P.O. BOX 367	ABBOTSFORD
VIEVIRA BROS CONCRETE		OSOYOOS
WEST FRASER CONCRETE LTD.	19685 - 0 AVE.	SURREY
WEST K CONCRETE LTD.	411 - 9 AVE.	CASTLEGAR
WEST ARM CONCRETE LTD.	UPPER JOHNSTONE RD.	NELSON
YARD-AT-A-TIME CONCRETE LTD.	9180 RIVER ROAD	DELTA

TABLE 1B : B.C. READY MIX CONCRETE INDUSTRY PRINCIPAL ECONOMIC STATISTICS 1980 - 1985

		MANUFACTURING ACTIVITY							TOTAL ACTIVITY			
		PRODUCTION & RELATED WORKERS								EMPLOYEES		
Year	# of Facilities	#	1000's Person Hours Paid	Wages	Cost of Fuel & Electricity	Cost of Materials & Supplies	Value of Shipments of Goods of Own Manufacture	Value Added	# of Working Owners & Partners	#	Salaries & Wages	Value Added
				(1000's of Dollars)							(1000's of Dollars)	
1980	77	1070	2169	26640	3989	79764	138268	54698	1	1366	34295	68321
1981	81	1222	2403	34024	6461	109026	195199	80155	2	1549	43287	98078
% change	+5.2	+14.2	+10.8	+27.7	+62.0	+36.7	+41.2	+46.5	+100	+13.4	+26.2	+43 6
1982	87	980	2000	30007	7269	96593	184465	80218	2	1302	40281	91369
% change	+7.4	-19.8	-16.8	-11.8	+12.5	-11.4	-5.5	+0.1	0	-15.9	-6.9	-6.8
1983	85	876	1731	27750	6447	83404	151313	61215	-	1258	40741	73925
% change	-2.3	-10.6	-13.5	-7.5	-11.3	-13.7	-18.0	-23.7	-	-3.4	+1.1	-19.1
1984	91	992	1954	32176	6694	85337	153614	61710	3	1357	44479	76358
% change	+7.1	+13.2	+12.9	+15.9	+3.8	+2.3	+1.5	+0.8	-	+7.9	+9.2	+3.3
1985	95	979	1944	32027	6709	75627	134883	51533	-	1302	43257	62225
% change	+4.4	-1.3	-0.5	-0.5	+0.2	-11.4	-12.2	-16.5	-	-4.1	-2.7	-18.5

Note: "% change" refers to change from previous year.
Reference: Statistics Canada - Industry Division

TABLE 1C : CANADIAN READY MIX CONCRETE INDUSTRY PRINCIPAL ECONOMIC STATISTICS 1980 - 1985

		MANUFACTURING ACTIVITY							TOTAL ACTIVITY			
		PRODUCTION & RELATED WORKERS								EMPLOYEES		
Year	# of Facilities	#	1000's Person Hours Paid	Wages	Cost of Fuel & Electricity	Cost of Materials & Supplies	Value of Shipments of Goods of Own Manufacture	Value Added	# of Working Owners & Partners	#	Salaries & Wages	Value Added
				(1000's of Dollars)							(1000's of Dollars)	
1980	500	7196	15011	147953	31638	537335	898347	332067	10	9348	191703	352414
1981	527	7698	16031	173640	41845	639566	1085326	402313	11	10053	226960	430145
1982	533	6069	12626	148080	45103	575930	992432	368757	12	8042	200125	388905
1983	564	6395	13296	161806	46522	600687	1030390	383494	10	8390	216358	406010
1984	584	6863	14225	174096	49731	639315	1060659	371751	16	8801	229265	397210
1985	584	7599	15672	203311	53281	704361	1196666	437980	-	9210	253874	455336

Reference: Statistics Canada - Industry Division

APPENDIX 2

SITE VISIT REPORTS

Introduction

The following 17 site visits were carried out in November, 1987. Although believed to be reasonably accurate, much of the information is based on estimates by the author or plant personnel. The pH values reported are from one time grab samples taken during the visits.

Plant 1

Operation: Central mix - two central mixers - 6 & 8 cu. m
Fleet Size: 35 trucks, average 10 cu.m/truck
Avg. Daily Production: 550 cu.m
Max. Hour Production: 300 cu.m

Recycled water is used for truck wash-out. Wastewater treatment works utilize mechanical aggregate recovery and five sumps. Operations are summarized as follows:

Truck Loading: Trucks drive into the loading area and are filled with a premixed concrete batch. The batch water is city water. During the filling operation a spray bar cleans the exterior with city water. The loading area is paved to direct runoff(pH 10) from this operation to a concrete ditch running east/west along the south plant boundary. This ditch has sumps at both ends, but effluent runs primarily to the west sump.

The central mixers are washed daily with approx. 1000 L of city water each and some gravel to provide a scouring effect. This effluent is discharged to a truck mixer which then deposits this load in a drag chain washout unit.

Truck Wash-Off: After filling, trucks proceed to the wash rack where they wash off the back of the truck with an estimated 20 L of city water. This area is paved and sloped to the east to direct runoff to a nearby sump (pH 11).

Truck Wash-Out: Come-back concrete is primarily used to make pre-cast blocks or is incorporated in the next batch. It may be dumped near the temporary holding area if it is not suitable for either of the above. If it is dumped it is later broken down with a loader and hauled away. The returning trucks back up to a two trough aggregate recovery unit. An estimated 450 L of recycled water from the #2 trough (pH 12) is used to flush the truck mixer. The resultant slurry is then discharged to the #1 trough. Recovered aggregate is discharged from the end of the #1 unit and sold as fill, while effluent is directed to the #2 trough for recycle.

A small trench around the drag chain washer unit directs runoff to a sump at the west side of the unit. This effluent is pumped on level control to another sump 20 m south on the yard's west boundary. This sump drains to city sewer.

If the drag chain washer unit is down, truck wash-out is discharged to a temporary holding area near the aggregate stockpiles. A 0.5 m sludge berm holds back the larger solids, while leachate runs west to an adjacent sump. The flush water for this operation is city water.

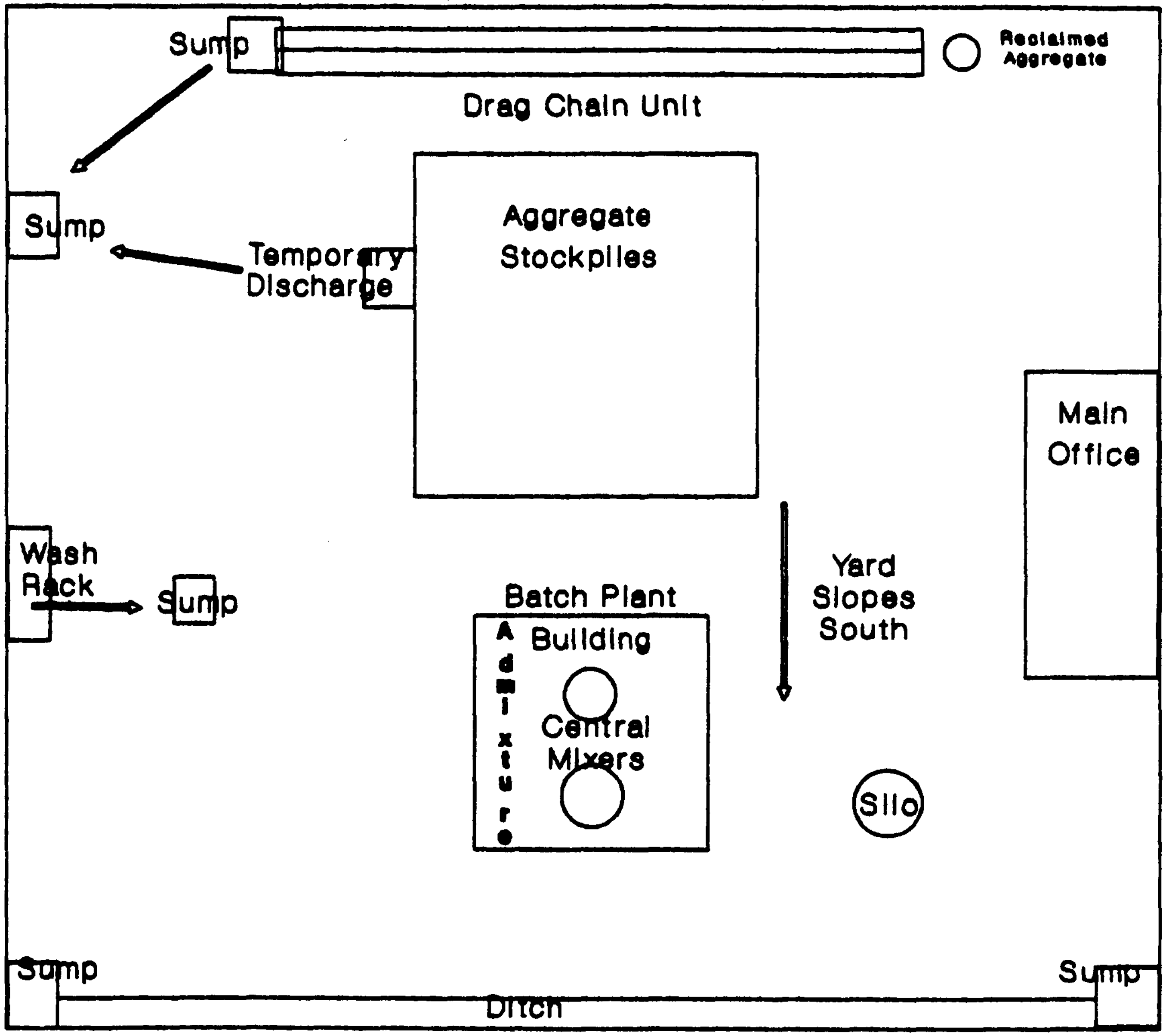
The sumps are cleaned by a loader on a weekly basis; the recovered sludge is hauled away at an estimated cost of $40,000 per year, based on an annual cost of $70,000 for all three operating plants this company owns in the Lower Mainland. The haulage fees would be approximately 2.5 times higher if the company did not produce blocks with come-back concrete.

Stormwater: The lot is effectively paved and sloped predominantly to the south, but specific operation areas may direct runoff to one of five sumps.

Feedstocks: This plant has one silo containing a maximum of 2000 tonnes of type 10 cement. A maximum of 150 tonnes of type 30 cement is kept in a silo above the loading area. Additionally, 80 tonnes each of flyash and lasonite (coloured pozzolan) are kept in pigs (cylindrical steel vessels) beside the loading area.

Admixtures are supplied by Conchem and Master Builders and are securely housed in the elevated batch plant control room:

TYPE	EFFECT	VOLUME(L)	
Procrete-N	water reducer	11000	Conchem
HE-202	early strength pozz.	11000	"
Procrete-R	set retarder	1000	"
AES	air entrainer	1000	M.B.
555-A	non-corrosive accel.	1000	"
PS-847	plastisizor	1000	"
	Total	26000	



Sump
Reclaimed Aggregate
Drag Chain Unit
Sump
Temporary Discharge
Aggregate Stockpiles
Main Office
Wash Rack
Sump
Batch Plant Building
Admixture
Central Mixers
Yard Slopes South
Silo
Sump
Ditch
Sump

PLANT 1

Plant 2

Operation: central mix - 7.5 cu.m
Fleet Size: 10 trucks, average 8.4 cu.m/truck
Avg. Daily Production: 250 cu.m
Max. Hour Production: 175 cu.m

This medium sized operation is located near an industrialized waterfront property; the process area is an estimated 1 km from Burrard Inlet. Water is not currently recycled, but plans have been prepared to utilize recycled water for truck wash-out early in 1988. Wastewater treatment works utilize an infiltration pit and a collection ditch; a mechanical aggregate recovery unit (drag chain type) on site has not worked for a number of years. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with a premixed concrete batch. The batch water is city water. A spray bar cleans the exterior drum during the filling operation with city water. The loading area is paved and most runoff (pH 11) from this operation meanders to a winding ditch (pH 11) approx. 4 X 30 X 2 m deep.

The central mixer is washed out daily with an estimated 1000 L city water and some gravel. This slurry is discharged to a truck mixer and disposed of at the infiltration pit.

Truck Wash-Off: After filling, trucks proceed to the wash rack where they wash off the back end of the truck with city water. This area is paved and sloped to direct runoff (pH 11) to the ditch. The accumulated solids in the ditch are cleaned out approx. once every two years.

Truck Wash-Out: Come-back concrete is used to pave the neighbouring property. The aggregate recovery unit has not been operational for a number of years.

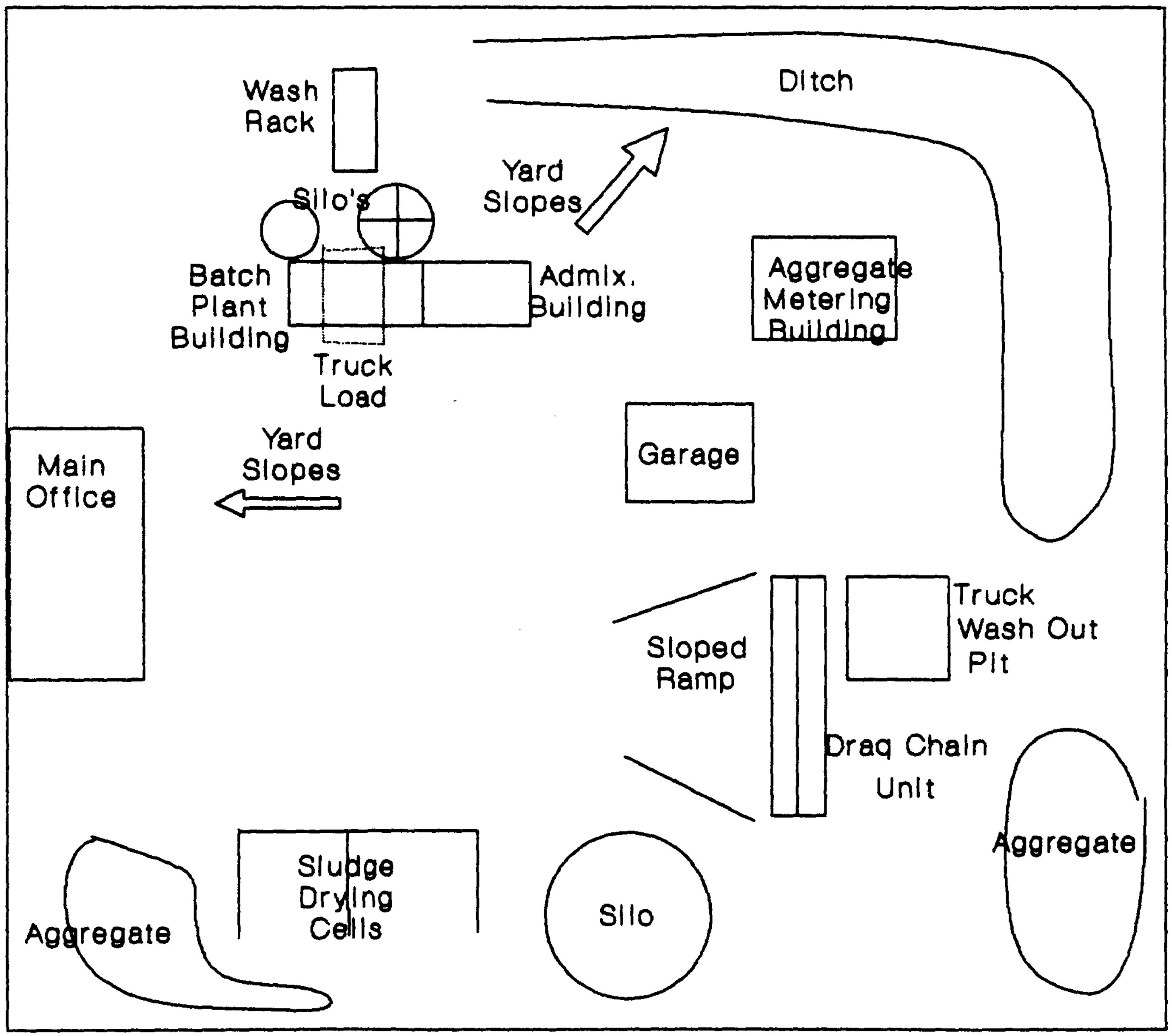
Empty truck mixers are flushed with an estimated 675 L of city water from the wash rack and the slurry is then discharged to an infiltration pit (approx. 6 X 6 X 4 m deep). Sludge is recovered weekly and piled in one of two concrete block holding stalls to dry. A pool of water in this area had a pH of 11. The dried sludge has recently been used as fill at a neighbouring property ; in the absence of this option the sludge is hauled away. Annual haulage fees for the three facilities operated by this company in the Lower Mainland are estimated to be $35,000.

Stormwater: The process area of the lot is paved and runoff drains to the ditch. A small fraction (estimated between 5 and 10%) of runoff contacting a process area may drain into a ditch running along the west plant boundary.

Feedstocks: This plant has one four compartment silo above the loading area which contains a maximum of 40 tonnes each of type 10, 30 and 50 cements and flyash. A very large 800 tonne silo for type 10 cement is located in the aggregate section of the yard.

Admixtures are supplied by Grace and are securely housed in plastic vessels in a room under the batch plant.

TYPE	EFFECT	VOLUME(L)
Daratard-17	set retarder	2400
WRDA-19	superplastisizor	2400
Daravair	air entrainer	2400
WRDA-82	water reducer	3200
CaCl2	set accelerator	13000
	Total	23400


Ditch
Wash Rack
Yard Slopes
Silo's
Batch Plant Building
Admix. Building
Aggregate Metering Building
Truck Load
Yard Slopes
Main Office
Garage
Truck Wash Out Pit
Sloped Ramp
Drag Chain Unit
Aggregate
Sludge Drying Cells
Silo
Aggregate

PLANT 2

Plant 3

Operation: batch plant
Fleet Size: 8 trucks, average 8 cu.m/truck
Avg. Daily Production: 125 cu.m
Max. Hour Production: 100 cu.m

This operation is located in a somewhat undeveloped but industrialized area approx. 1 km from Burrard Inlet. Recycled water is used for batch water, unless hot water is required. Wastewater treatment works include a mechanical aggregate recovery unit (sand screw) and an infiltration lagoon. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. The batch water is recycled water drawn from the lagoon unless hot water is required. A spray bar cleans the drum exterior during the filling operation with city water. The loading area is effectively paved to direct runoff from this operation (pH 11) to the infiltration lagoon (pH 12; 10 X 15 X 5 m deep).

Truck Wash-Off: After filling, trucks proceed to one of two wash/slump racks where they wash off the back end of the truck and adjust the product slump as required with city water. This area is paved and sloped to direct runoff to the settling pond.

Truck Wash-Out: Come-back concrete is usually used to make pre-cast products at a neighboring lumber yard. The company does not charge for the concrete. If the lumber yard is closed the concrete may be discharged to the sand screw. Reclaimed aggregate is discharged at the elevated end of the screw, while effluent drains from the lower end of the device into the pond. Flush water for the screw is recycled water drawn from the pond.

The empty truck mixer receives approximately 100 L of city water and 1 L of Master Builders stabilizer PB-134. This slurry is mixed a couple of times and left in the mixer, to be incorporated with the next day's initial batch. This system does not generate any wastewater during wash-out operations.

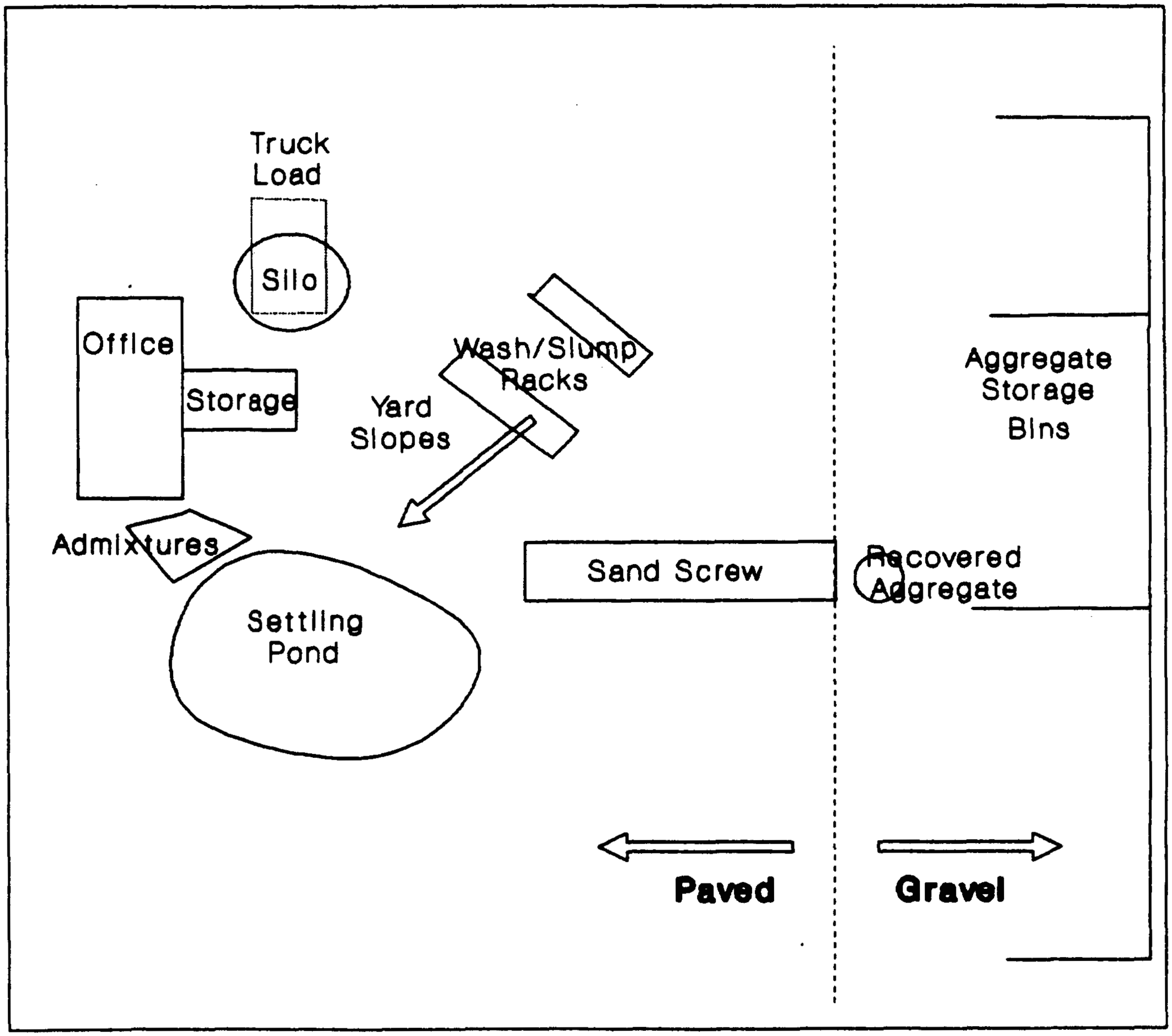
Prior to this system, truck wash-out was discharged to the pond, which then required cleaning twice per month. Now the cleaning frequency has been reduced to every 6 weeks, depending on plant production. Recovered sludge is piled to dry in the aggregate storage area, and is hauled to the company's gravel operation in Chilliwack for landfilling.

Stormwater: The process area of the lot is paved and sloped to drain runoff to the settling pond. The aggregate area of the yard is not paved and stormwater either pools (pH 9) or infiltrates.

Feedstocks: This plant maintains a maximum of 70 tonnes of type 10 cement and 70 tonnes of flyash in a silo above the truck loading area.

Admixtures are supplied by Master Builders, except for $CaCl_2$, and are stored in steel vessels, uncovered beside the loading area.

TYPE	EFFECT	VOLUME(L)
344-N	water reducer	9000
HE-202	early strength	9000
AES	air entrainer	2250
300-N	set retarder	2250
CaCl2	accelerator	4500
	Total	27000


Truck
Load
Silo
Office
Storage
Admixtures
Settling
Pond
Yard
Slopes
Wash/Slump
Racks
Sand Screw
Recovered
Aggregate
Aggregate
Storage
Bins
Paved
Gravel

PLANT 3

Plant 4

Operation: batch plant
Fleet Size: 14 trucks, average 9 cu.m/truck
Avg. Daily Production: 400 cu.m
Max. Hour Production: 100 cu.m

This medium sized plant is located in an industrial park and utilizes recycled water for batch water (unless hot water is required) and for truck wash-out. Effluent treatment works include a two-stage settling basin with associated overflow pond and a mechanical aggregate recovery unit. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with a premeasured concrete components. A spray bar cleans the exterior drum during the filling operations with city water. This area of the lot is paved and effectively directs runoff (pH 11) to an overflow pond (pH 12) formed at the north end of the settling basin. Basin overflow and process and yard runoff contribute to this pond. The pond volume fluctuates with weather conditions and was approx. 10 X 10 X 1 m deep during this inspection.

Truck Wash-Off: After loading, the truck proceeds to the settling basin discharge area where city water is used to clean off the back end of the truck and adjust product slump as required. This runoff is effectively channeled to the overflow pond.

Truck Wash-Out: Come-back concrete is primarily used to make pre-cast blocks or is incorporated in the next batch. It may also be dumped into the sand screw after dilution, for aggregate recovery.

The returning truck backs up an inclined, paved approach to one of two discharge bays at the two-celled settling basin. The slope of the approach effectively directs runoff from this operation to the overflow pond.

Recycled water drawn from either the pond or cell #2 is used to rinse out the drum. The slurry is then discharged to a declined trough (pH 12) where a flush line (recycled water) helps move the slurry toward the sand screw. The inclined sand screw, perpendicular to the trough, accepts the slurry and discharges recovered aggregate from its top end.

Overflow near the bottom of the sand screw passes into cell #1 (approx. 10 X 15 X 5 m deep). A 0.3 m notch in the wall dividing the two settling cells allows supernatant from cell #1 to overflow into cell #2 (approx. 10 X 30 X 8 m deep). Supernatant from cell #2 in turn spills into the overflow pond at the end of the clarification works.

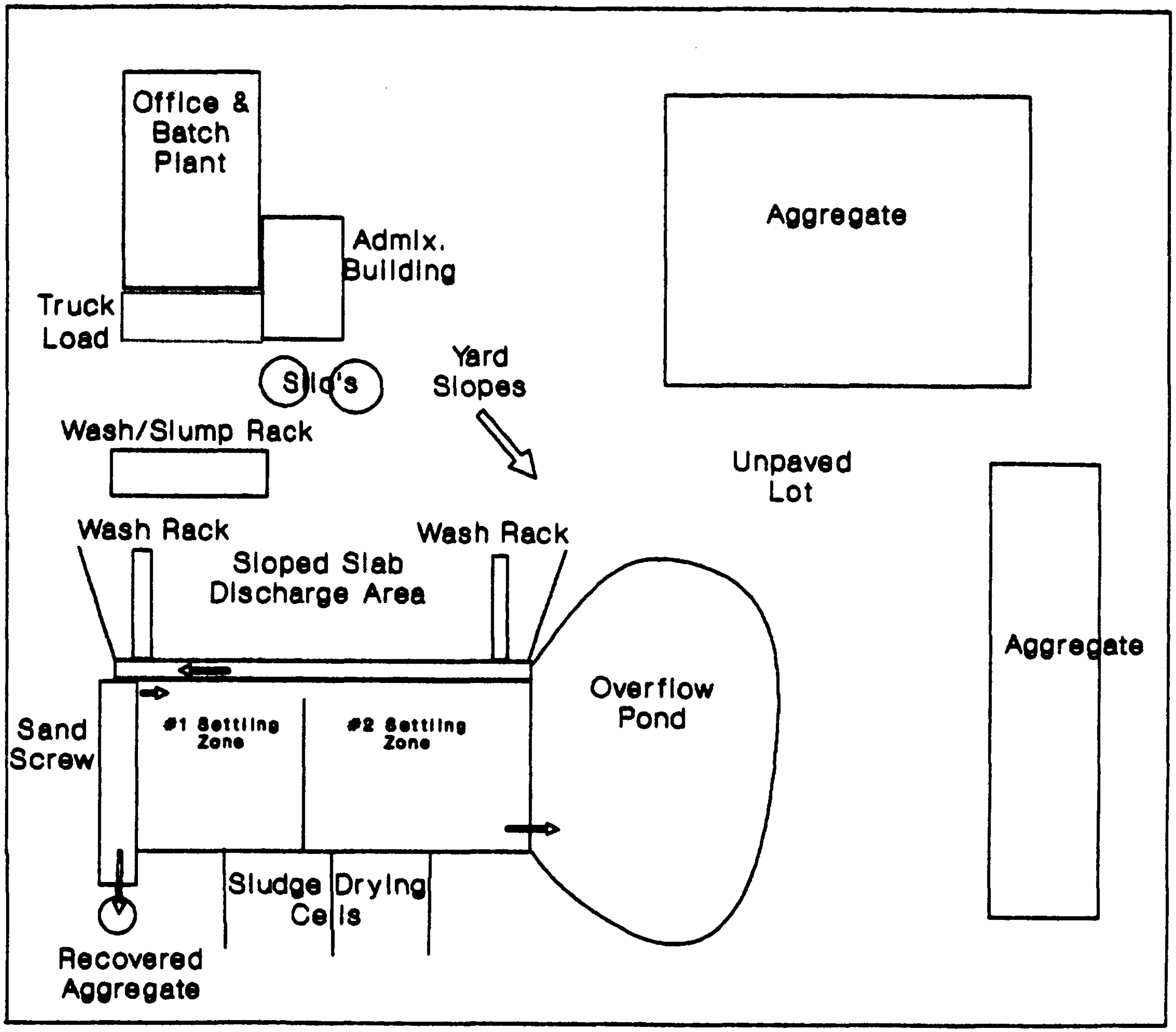
The settling cells are cleaned approx. twice per month, depending on plant production. The recovered sludge is piled to dry behind the settling basin in a three-walled concrete block stall. A puddle in this area had a pH of 10.5. Dried sludge is hauled away at an annual cost of $30,000.

Stormwater: The process areas at this facility are paved and sloped to direct runoff to the overflow pond. The non-process aggregate storage areas are not paved and infiltration occurs.

Feedstocks: This plant maintains a max. of 77 tonnes of type 10 cement and 88 tonnes of flyash in silos above the truck loading area.

Admixtures are supplied by Grace and are kept inside a building beside the batch plant control room, except for CaCl2 and Daraccel, which are located outside the building.

TYPE	EFFECT	VOLUME(L)
WRDA-82	water reducer	6000
Daratard-17	set retarder	2000
Deracem-100	superplasticizor	2000
Dera-700	superplasticizor	2000
Daraccel	water reducing accelerator	6000
CaCl2	set accelerator	13500
	Total	31500



Office & Batch Plant
Admix. Building
Truck Load
Silo's
Yard Slopes
Aggregate
Wash/Slump Rack
Unpaved Lot
Wash Rack
Sloped Slab Discharge Area
Wash Rack
Aggregate
Overflow Pond
Sand Screw
#1 Settling Zone
#2 Settling Zone
Sludge Drying Cells
Recovered Aggregate

PLANT 4

Plant 5

Operation: batch plant
Fleet Size: 12 trucks, average 6 cu.m/truck
Avg. Daily Production: 100 cu.m
Max. Hour Production: 50 cu.m

This medium sized plant is located in an undeveloped area and utilizes recycled water for its batch water, unless hot water is required, and for truck wash-out. Effluent treatment works include a three-celled settling basin and two infiltration pits. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. Batch water is recycled water unless hot water is required. A spray bar (city water) cleans the exterior drum during the filling operations. A fire hose (city water) is used to wash the area down. This process area is concreted and sloped to direct runoff (pH 10) to the three-celled settling basin. The settling basin was formerly used for truck wash-out, but now only receives runoff and wash-off water.

Truck Wash-Off: After loading the truck proceeds to the wash/slump rack to clean the back end of the truck and adjust the product slump as required (city water). This area is paved and sloped to direct runoff (pH 11) to the settling basin.

The three-celled settling basin is positioned such that the declined slab opening to the #1 cell receives runoff from truck loading and wash-off operations and yard runoff from these process areas. Supernatant from cell #1 enters cell #2 via a small V-notch weir. This cell is divided from cell #3 by a half height wall. A board floating on the surface prevents floating debris from reaching the final stage. Recycled water is drawn from the final stage (pH 8).

Sludge is recovered approx. every 6 weeks, depending on plant production, and piled to dry near the wash-out pit.

Truck Wash-Out: Come-back concrete is used to make pre-cast concrete blocks or is incorporated in the next batch. The empty truck backs up to the loading area where it receives an estimated 900 L of recycled water drawn from settling cell #3. The truck then drives approx. 100 m south, and discharges the slurry into a lagoon (approx. 30 X 30 X 5 m, pH 11.5). This lagoon gravity drains into a smaller lagoon (pH 11.5). The second process lagoon in turn drains into the second of a series of four non-process lagoons. All lagoons gravity feed by 2 ft. diameter pipes. The connecting pipes were all visible as the water level was low. The first non-process lagoon had a pH 7, while the second (receiving effluent from the #2 process lagoon) non-process lagoon was pH 9.5. The final non-process lagoon was pH 7.

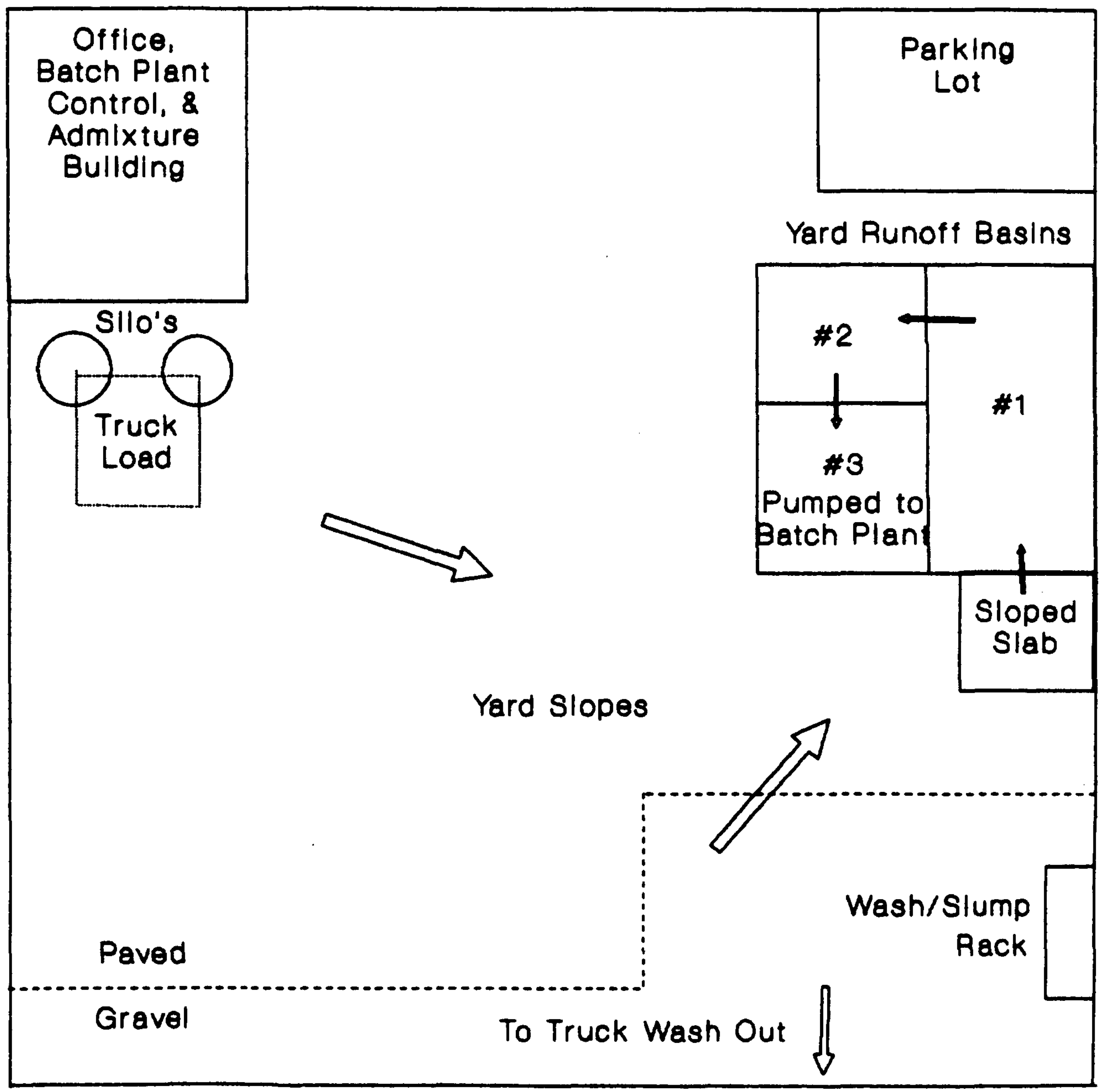
The two process lagoons are cleaned with a front end loader every month; recovered sludge is piled nearby to dry. A sister gravel company adjacent to the ready mix facility stockpiles the dried sludge on site. On occasion, they have been able to sell the dry residue as pond sand.

Stormwater: The loading and wash-off process areas are paved to direct runoff to the settling basin. The truck wash-out lagoon area is not paved and runoff from this area either drains into the lagoons or infiltrates the ground.

Feedstocks: This plant maintains a maximum of 92 tonnes of type 10 cement and 42 tonnes of flyash in silos above the truck loading area.

Admixtures are supplied by Conchem, and are securely stored in steel vessels inside the batch plant control building.

TYPE	EFFECT	VOLUME(L)
AES	air entrainer	2250
HE-202	high early set	4500
Procrete-N	water reducer	4500
Procrete-R	set retarder	2250
	Total	13500


Office,
Batch Plant
Control, &
Admixture
Building
Silo's
Truck
Load
Parking
Lot
Yard Runoff Basins
#2
#1
#3
Pumped to
Batch Plant
Sloped
Slab
Yard Slopes
Wash/Slump
Rack
Paved
Gravel
To Truck Wash Out

PLANT 5

Plant 6

Operation: batch plant
Fleet Size: 5 trucks, average 8 cu.m/truck
Avg. Daily Production: 80 cu.m
Max. Hour Production: 200 cu.m

This small plant is located in an undeveloped area and utilizes recycled water for batch water, unless hot water is required. This operation does not generate any truck wash-out effluent; instead it utilizes a new type of concrete stabilizer. Wastewater treatment works include an infiltration pond. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. A spray bar (city water) cleans the exterior drum during the filling operations. A fire hose provides city water to wash the area down. This process area is concreted and sloped to direct runoff (pH 7) to the lagoon (approx. 15 X 10 X 5 m deep).

The pump intake at the pond is on a lever and is tilted into the water to recover the supernatent batch water.

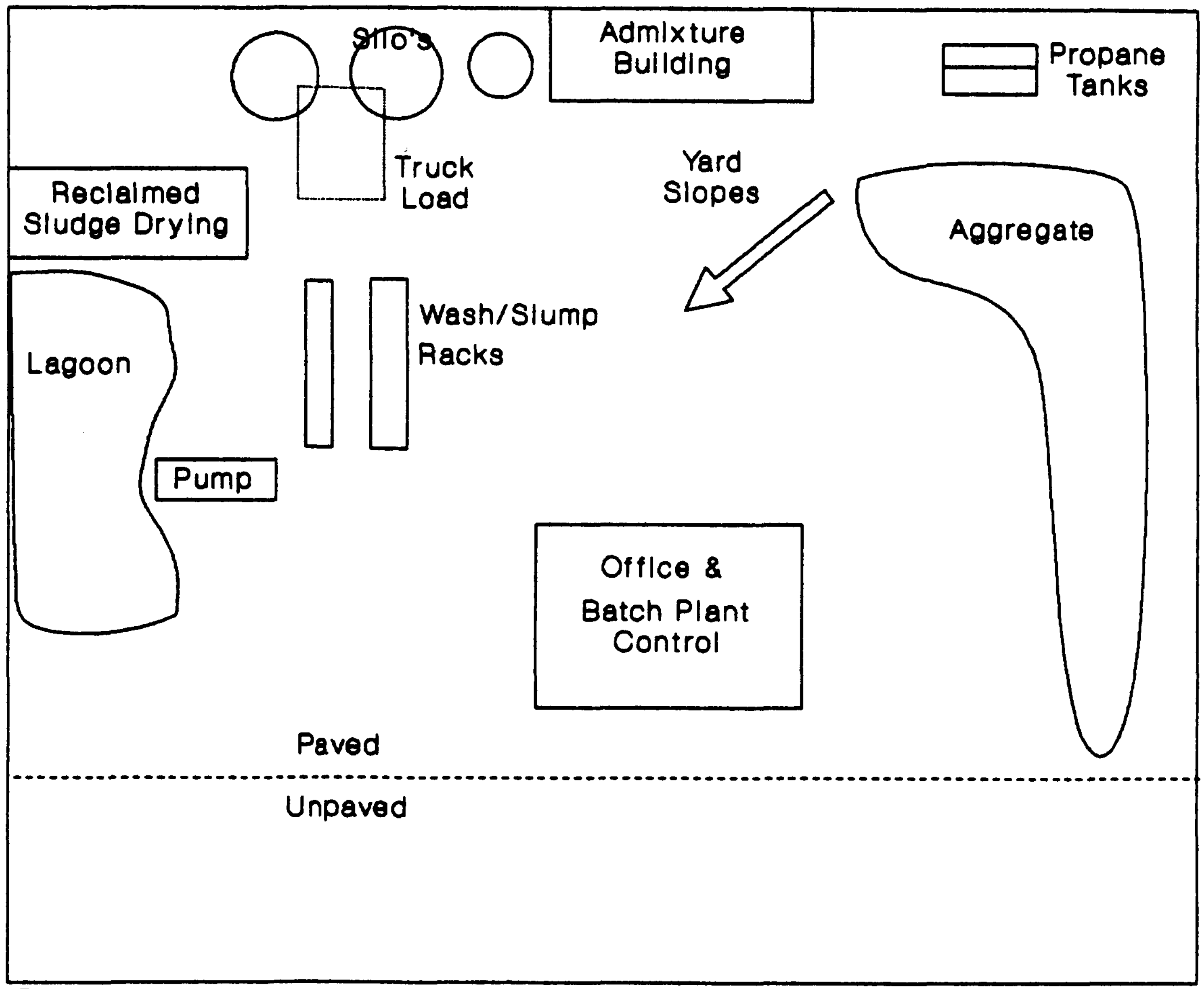
Truck Wash-Off: After filling the truck proceeds straight ahead to one of two wash/slump racks to clean the back end of the truck and adjust the product slump as required with city water. This process area is well paved and sloped to direct runoff (pH 9) into the lagoon.

Truck Wash-Out: Come-back concrete is used to make pre-cast concrete blocks or is incorporated in the next batch. This operation does not generate any process effluent from wash-out operations. A stabilizing admixture and approx. 100 L of city water is added to the truck mixer. The slurry is mixed briefly and left overnight to be incorporated in the next morning's first batch.

Stormwater: The truck loading and wash-off areas are well sloped to direct any yard runoff to the infiltration lagoon (pH 9). With the new system not generating slurry from truck wash-out, the lagoon only requires cleaning on a yearly basis; prior to the new system, it was cleaned 2 or 3 times per year. The recovered sludge is piled beside the lagoon to dry and is later hauled away to the company's gravel operation for landfilling.

Admixtures: This plant maintains a maximum of 200 tonnes of type 10 cement and 70 tonnes of flyash in silos above the loading area. Admixtures are supplied by Master Builders and are securely housed in steel vessels in a building beside the loading area.

TYPE	EFFECT	VOLUME(L)
344-N	water reducer	9000
300-N	set retarder	9000
H.E.	high early	13500
Microair	air entrainer	4500
CaCl2	set accelerator	9000
	Total	45000


Silo's
Admixture Building
Propane Tanks
Truck Load
Yard Slopes
Reclaimed Sludge Drying
Aggregate
Wash/Slump Racks
Lagoon
Pump
Office & Batch Plant Control
Paved
Unpaved

PLANT 6

Plant 7

Operation: batch plant
Fleet Size: 14 trucks, average 7.4 cu.m/truck
Avg. Daily Production: 275 cu.m
Max. Hour Production: 100 cu.m

This medium sized plant is located in an industrial area. Recycled water is used for truck wash-out. Effluent treatment works include a three-celled settling basin and sumps. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. A wash bar provides city water to clean the exterior drum during filling operations. The loading area is paved and somewhat effective in directing runoff to a small infiltration sump (pH 11) approx. 3 X 3 X 2 m deep. This sump requires cleaning every two weeks; the recovered sludge is piled to dry near the settling basin and later hauled away.

Truck Wash-Off: After filling, trucks proceed to the wash/slump rack where city water is used to clean the back end of the truck and to adjust the product slump. Runoff from this operation is effectively collected in a sump (pH 11) approx. 4 X 3 x 1 m deep, which connects to the plant sewer system.

Truck Wash-Out: Come-back concrete is used to pave the yard. A three-celled settling basin is located adjacent to the Fraser River, approx. 70 m south of the truck loading area. While this discharge facility is located in close proximity to the Fraser River (approx. 5 m), effluent appears to be well contained in the basin. Should an overflow occur, the effluent would flood the immediate area, and not spill directly into the Fraser.

The empty truck backs up a paved, inclined slab to one of three wash rack/discharge stalls. The truck drum is flushed with recycled water drawn from cell #3; the resulting slurry is discharged to cell #1 (pH 12.5). The #2 cell (pH 13) is separated from cell #1 by a wall with a small weir which allows supernatant to overflow into #2. The two cells share a common sloped slab which allows access by a front end loader for cleaning. Both cells are approx. 4 X 13 X 6 m deep. Effluent from cell #2 is pumped to cell #3 (approx. 5 X 15 X 3 m deep). The pump intake head is maintained 30 cm above the cell bottom.

The heaviest solids drop out in cell #1, and further settling occurs in cell #2. The supernatant in cell #3 appears relatively free of suspended solids but had a high pH of 12.

Sludge is recovered from the settling basin approximately weekly, depending on plant production. All recovered sludge is piled to dry in a three walled concrete block structure just north of the settling basin. Leachate from the sludge drains back into the basin. The dried sludge is hauled away.

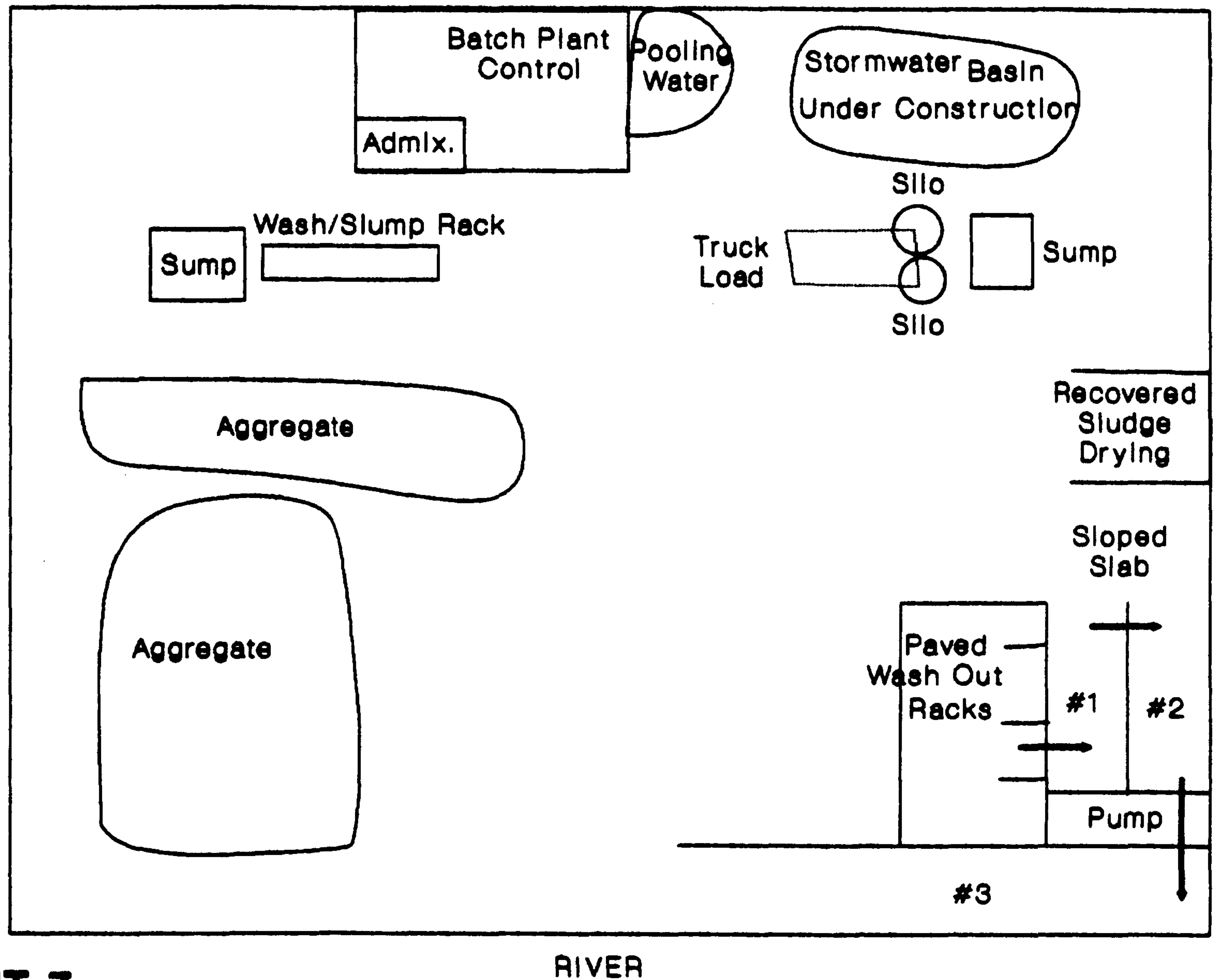
Stormwater: Aside from truck loading and wash-off/slump process areas and the approach to the settling basin, the lot is not paved. The paved areas do not completely channel runoff to either of the available sumps. Consequently yard runoff pools randomly and/or infiltrates. A puddle in the aggregate storage area had a pH of 7.

A stormwater basin (approx. 5 X 5 X 3 m), under construction just north of the loading area sump, will collect runoff from around the batch plant control room.

Feedstocks: This plant maintains a maximum of 60 tonnes of type 10 cement, 60 tonnes of type 30 cement and 75 tonnes of flyash in two silos above the truck load area.

Admixtures supplied by Conchem are securely stored in steel vessels, located inside the control building.

TYPE	EFFECT	VOLUME(L)
Procrete-N	water reducer	4500
HE-202	set accelerator	9000
AES	air entrainer	2250
Procrete-R	set retarder	4500
	Total	20250



Batch Plant Control
Admix.
Pooling Water
Stormwater Basin Under Construction
Silo
Silo
Truck Load
Sump
Wash/Slump Rack
Sump
Aggregate
Aggregate
Recovered Sludge Drying
Sloped Slab
Paved Wash Out Racks
#1
#2
Pump
#3
RIVER

PLANT 7

Plant 8

Operation: batch plant
Fleet Size: 16 trucks, average 9.2 cu.m/truck
Avg. Daily Production: 300 cu.m
Max. Hour Production: 120 cu.m

This large operation is located on an industrial island in the Fraser River. Recycled water is utilized for batch water, unless hot water is required, and for truck wash-out. Effluent treatment works include a three-celled settling basin and a stormwater basin. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. A wash bar cleans the exterior drum with city water during the filling operations. This area of the lot is concreted and runoff is effectively directed to the stormwater basin (pH 11; approx. 10 X 15 X 5 m deep). This basin is cleaned approximately twice per year with the recovered sludge piled to dry, and later sold as roadfill.

Truck Wash-Off: After filling, trucks proceed to the approach of the settling basin where they wash off the back end of the truck and adjust the product slump with city water from a fire hose. This area is paved and runoff is effectively channeled to the stormwater basin.

Truck Wash-Out: Come-back concrete is taken to a neighbouring business and used for pre-cast blocks. The company receives a token payment for providing the concrete.

Empty trucks back up to one of three settling basin discharge stalls and flush the mixer drum with recycled water. The resulting slurry is discharged to cell #1 (pH 11). This cell's north side is open and slopes downward to the south. As the water level rises, partially clarified effluent flows around the open end of #1 and enters cell #2. This effluent entrains the smaller fraction of solids. Both these cells are approximately 15 X 5 X 4 m deep. Effluent from cell #2 is then pumped to a final settling cell (approx. 5 X 5 X 4 m deep) from which the recycled water for batching and truck wash-out is drawn. The pump intake head is fixed approx. 1 m above the cell bottom.

Cell #1 requires cleaning every two weeks, while the stormwater basin is cleaned twice per year. The recovered sludge from these sources is piled to dry in the aggregate storage area, and sold as roadfill.

Cells #2 and #3 are cleaned twice per year at an annual cost of $16,000.

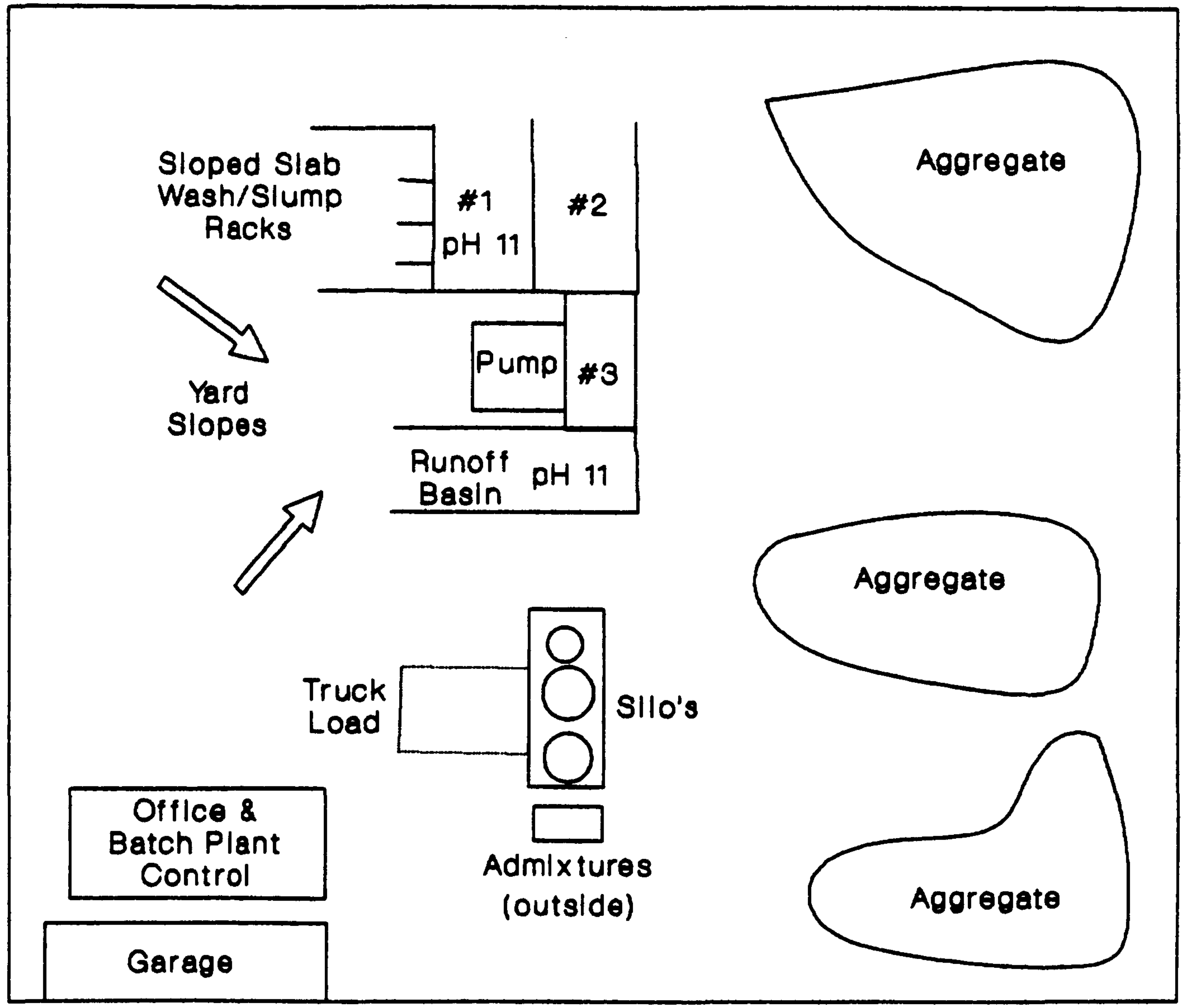
Stormwater: The process areas are paved and sloped to channel runoff to the stormwater basin. The aggregate storage areas are not paved which likely results in some infiltration. Some yard runoff may flow north off plant property via the roadway.

Feedstocks: This plant maintains a maximum of 150 tonnes of type 10 cement (2 X 75 tonnes silos) and 75 tonnes of flyash in silos above the truck load area.

Admixtures are supplied by Grace and are located in steel vessels outside, beside the loading area.

TYPE	EFFECT	VOLUME(L)
WRDA-82	water reducer	13500
Daraccel	set accelerator	22500
Derex AEA	air entrainer	2250
Deratard-17	set retarder	2250
	Total	40500

PLANT 8



Sloped Slab
Wash/Slump
Racks
#1
pH 11
#2
Pump
#3
Yard
Slopes
Runoff
Basin
pH 11
Aggregate
Aggregate
Aggregate
Truck
Load
Silo's
Office &
Batch Plant
Control
Admixtures
(outside)
Garage

Plant 9

Operation: batch plant
Fleet Size: 7 trucks, average 6 cu.m/truck
Avg. Daily Production: 65 cu.m
Max. Hour Production: 40 cu.m

This small operation is located on an industrial island in the Fraser River. Recycled water is not utilized. The process area is approx. 50 m south of the Fraser River; the entire lot slopes gradually to the south. Effluent treatment works include three small infiltration pits in series. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. A fire hose provides city water to clean the back end of the truck and adjust product slump as required. This immediate area of the lot is paved and runoff is channeled to a small infiltration ditch (pH 11). A gasoline/oil slick was visible on the water surface.

Truck Wash-Off: There is no dedicated wash/slump rack at this plant. Trucks are washed and slumped in the loading area and runoff flows to the infiltration ditch, or pools on the ground.

Truck Wash-Out: Come back concrete is used to make pre-cast blocks or is incorporated in the next batch. This plant has three small infiltration pits in series. The pits are small, approximately 4 X 4 X 2 m deep.

The empty truck backs up to the unpaved approach to the first pit where a fire hose supplies fresh water to flush the drum. The resulting slurry is discharged to the first pit. Overflow then enters the second and third pits successively.

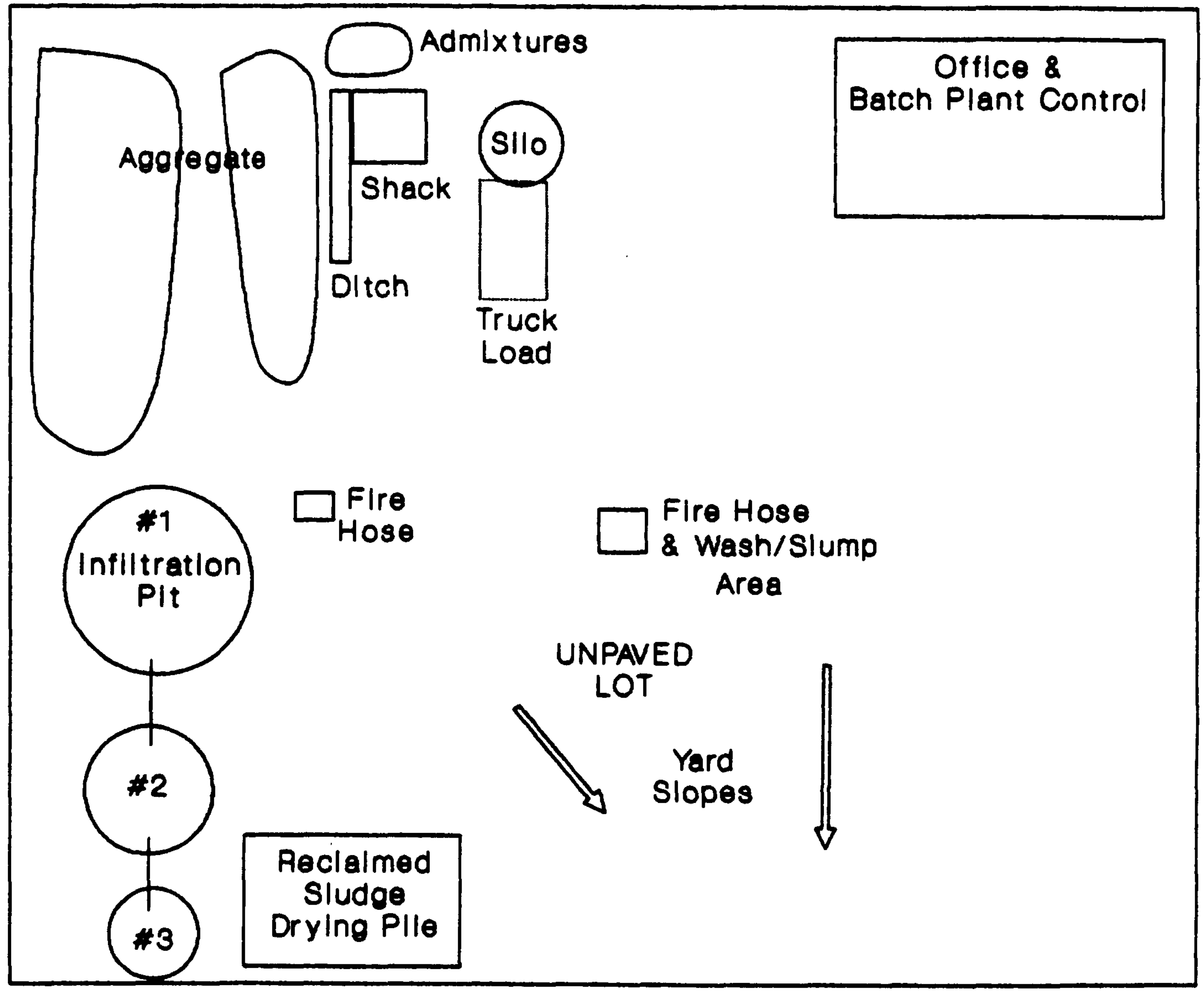
The pits require cleaning out every 2 to 3 weeks. The recovered sludge is piled beside the pits in a concrete block stall to dry. The dry sludge is hauled away at no cost and used for road base. Prior to this, annual haulage costs ranged from $1000 - $2000.

Stormwater: The lot is not paved except for the loading area and stormwater tends to pool (pH 9) or infiltrate. Some yard runoff may flow south off plant property.

Feedstocks: This plant maintains a maximum of 25 tonnes of type 10 cement in a silo above the loading area.

Admixtures supplied by Master Builders are not enclosed, but have overhead cover, and are located beside the loading area.

TYPE	EFFECT	VOLUME(L)
MicroAir	air entrainer	675
344-N	water reducer	1700
H.E.	early set	1125
122-R	set retarder	5
	Total	3505


Admixtures
Office &
Batch Plant Control
Aggregate
Shack
Silo
Ditch
Truck
Load
Fire
Hose
Fire Hose
& Wash/Slump
Area
#1
Infiltration
Pit
UNPAVED
LOT
Yard
Slopes
#2
Reclaimed
Sludge
Drying Pile
#3

PLANT 9

Plant 10

Operation: batch plant
Fleet Size: 8 trucks, average 10 cu.m/truck
Avg. Daily Production: 200 cu.m
Max. Hour Production: 200 cu.m

This small plant is located in an industrial area near the Fraser River. While the property line extends to the river front, the process areas are approx. 50 m north of the river, and well sloped to direct process effluents to the north.

Recycled water is used for batch water, unless hot water is required, product slump adjustment, and truck wash-out. Effluent treatment works include a three-celled settling basin and an infiltration pond. This plant does not generate any effluent during truck wash-out. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. A spray bar cleans the exterior drum during the filling operations with city water. Runoff collects in either a small infiltration sump (pH 12, approx. 2 X 1 X .5 m deep) or cell #1.

Truck Wash-Off: After filling, trucks proceed to one of two wash/slump racks where they wash off the back end of the truck with city water. Product slump is adjusted, as required, with recycled water. All runoff (pH 11) from this operation is effectively channeled to cell #1.

Truck Wash-Out: Come-back concrete is used to produce pre-cast blocks, or is incorporated in the next batch. The empty truck mixer then receives approx. 1 L of PE-134 (a Master Builders cement stabilizer) and 100 L of recycled water. This slurry is left in the truck overnight and incorporated in the first batch on the next day. Before this system was utilized an estimated 500 L of recycled water was required to flush the mixer.

Settling Basin: This settling basin consists of three cells in series. The #1 and #2 cells share a concrete bottom and a sloped slab open to the south which allows a front end loader access for clean out. Both cells slope to the north and are approximately 10 X 4 X 3 m deep. As the water level in cell #1 (pH 10.5) rises, partially clarified effluent flows around the open end into cell #2 (pH 10.5). Supernatant from #2 flows through a small weir into cell #3 (approx. 5 X 8 X 3 m deep). The recycled batch and slump water is drawn from cell #3.

Cells #1 and #2 require cleaning approximately once per month, while #3 is cleaned quarterly. Recovered sludge is piled to dry on site in three walled concrete block stalls. The dry sludge is taken to the company's gravel operation in Chilliwack to be landfilled.

Before the concrete stabilizing system was utilized, truck wash-out was discharged to cell #1 and the cleaning frequency was once per week.

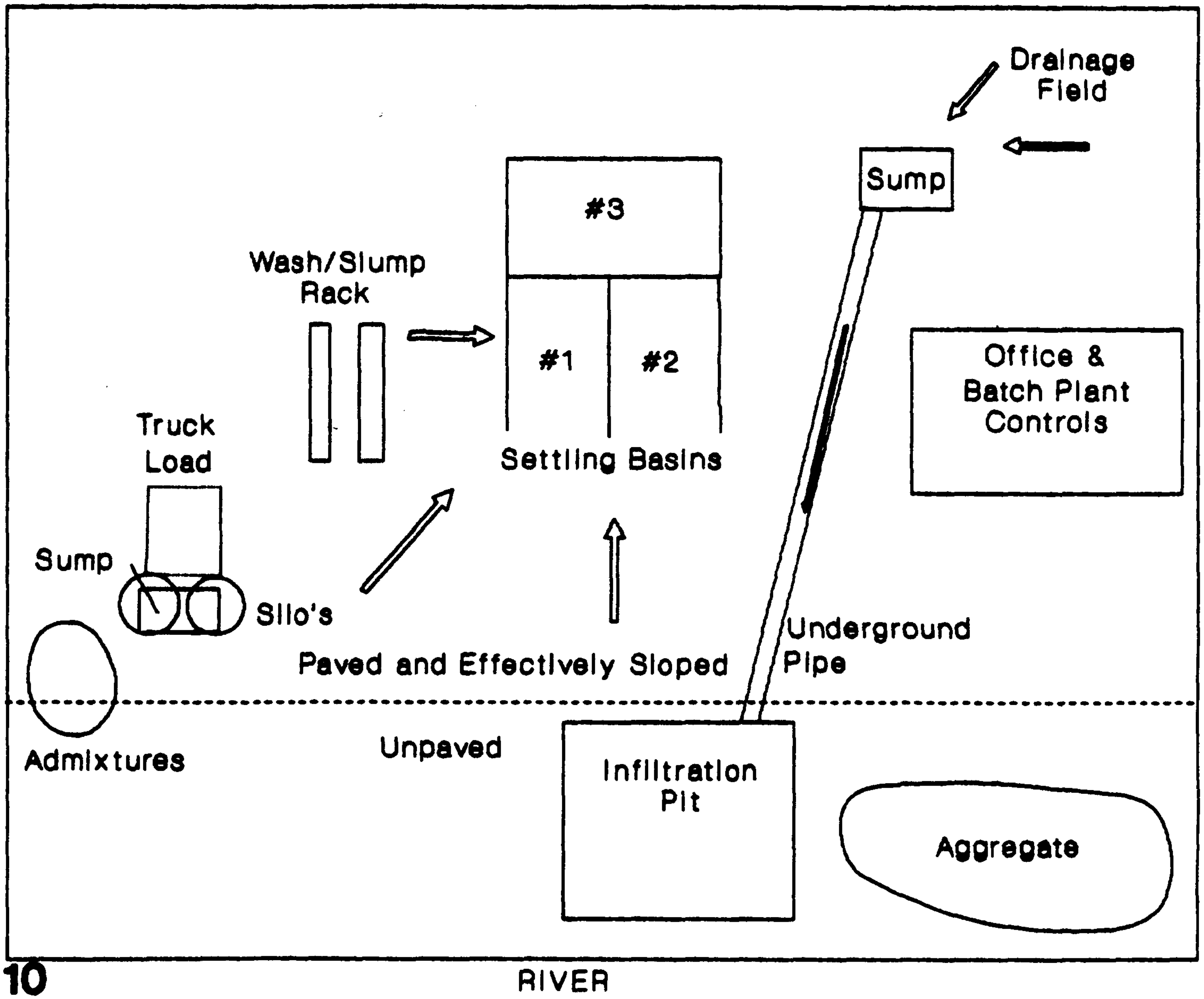
Stormwater: The process area is paved and sloped to channel process effluent and storm runoff to the #1 cell. The aggregate storage areas are not paved and slope moderately toward the river. Non-process yard runoff tends to infiltrate the ground.

To the east of the settling basin and just north of the batch plant control room is a sump. In times of extreme precipitation, cell #3 overflows into this sump. The sump is connected by underground pipe to a large infiltration pit (approx. 8 X 8 X 15 m deep) located south of the process area, near the Fraser River.

Feedstocks: This plant maintains 140 tonnes of type 10 cement and 70 tonnes of flyash in two silos above the loading area.

All admixtures are supplied by Master Builders, except for calcium chloride which comes from Firewater, a Seattle, Wa. company. The admixture vessels are not enclosed and are located to the west of the loading area. The plant has experienced problems in the past with trucks and other machinery hitting the valves of the containers. Should a rupture occur the liquid admixtures would flow towards the settling basin.

TYPE	EFFECT	VOLUME(L)
Microair	air entrainer	2250
344-N	water reducer	9000
300-N	set retarder	2250
HE-133	set accelerator	9000
CaCl2	set accelerator	9000
	Total	31500


Drainage Field
Sump
#3
Wash/Slump Rack
#1
#2
Office & Batch Plant Controls
Truck Load
Settling Basins
Sump
Silo's
Underground Pipe
Paved and Effectively Sloped
Admixtures
Unpaved
Infiltration Pit
Aggregate
RIVER

PLANT 10

Plant 11

Operation: batch plant
Fleet Size: 14 trucks, average 7 cu.m/truck
Avg. Daily Production: 185 cu.m
Max. Hour Production: 120 cu.m

This medium sized operation is located in an industrial area near the Fraser River. Recycled water is mixed with city water for batching, unless hot water is required, and for truck wash-out. Effluent treatment works include mechanical aggregate recovery and a two-celled settling basin. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area, which is paved and sloped, and are filled with premeasured concrete components. A spray bar cleans the exterior drum during the filling operation. This runoff is effectively channeled to cell #2.

Truck Wash-Off: After filling, trucks proceed to the wash/slump rack where they wash off the back end of the truck and adjust the product slump as required with city water. This area is paved and slopes predominantly south and slightly east. The majority of runoff from this operation drains to cell #2 but some may enter a creek/ ditch running along the plant's east boundary. There is no berm to intercept this flow.

Truck Wash-Out: Come-back concrete is used to make pre-cast blocks, is incorporated in the next batch, or is discharged to the sand screw or cell #1.

The empty truck backs up to the sand screw discharge apron which is paved and sloped. It is located approx. 15 m south of the settling ponds. Recycled water is available to flush the drum out and the resulting slurry is discharged to the sand screw. The flush water in the sand screw is also recycled water.

Coarse aggregate in the slurry is drawn up the length of the screw by the auger and is discharged. It is later stockpiled by a loader. The recovered aggregate is sold as fill; it is not suitable for rebatching. Effluent from the screw (pH 13), heavily laden with cement fines and some sand, is discharged to cell #1 via an open 15 cm diameter pipe.

Recycling System: The settling basin consists of two settling cells in series. Truck wash-out from the sand screw, and sometimes directly from the truck (at which time flush water is city water) is discharged to cell #1. A weir in the wall dividing cells #1 and #2 allows supernatant to overflow into cell #2. A hole in cell #1, approximately 1 meter from the top of the eastern side, allows effluent to freely drain to the ditch/creek running along the plant's east boundary. There was little flow in this waterway, but it appeared to be running north (away from the Fraser) toward the city storm sewer. However, the waterway was contaminated with what appeared to be cement residue, and the plant manager informed me that they had arrangements to clean this out on occasion.

Cells #1 and #2 share a common sloped slab which allows a front end loader to clean them out. Both ponds are approx. 5 X 15 X 3 m deep. Recycled water for batching and wash-out operations is drawn from cell #2.

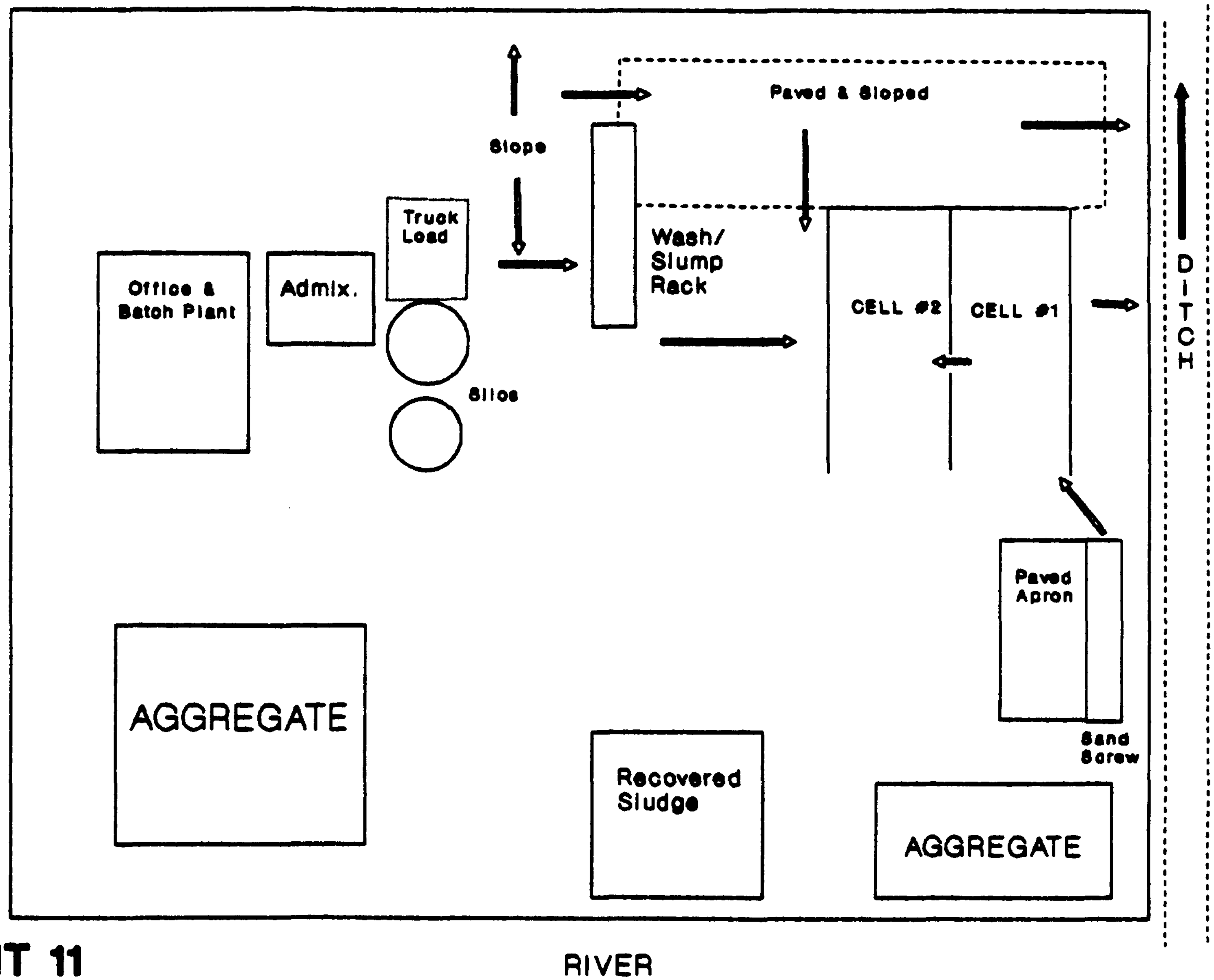
Sludge is recovered from cells #1 and #2 on a monthly basis and is piled to dry in the aggregate storage area. The dried sludge is hauled away at an annual cost of approximately $42,000 per year.

Stormwater: The loading and slump/wash areas of the lot are paved and are somewhat, but not totally, effective in directing runoff to the settling basin. The aggregate storage (non-process) area of the yard is not paved. Some yard runoff may flow north past the plant boundary and enter the city storm drain via the roadway, and some may enter the ditch running along the east plant boundary.

Feedstocks: This plant maintains a maximum of 85 tonnes of type 10 cement and 38 tonnes of flyash in silos above the loading area.

Admixtures are supplied by Grace and Master Builders and are securely stored in a building near the loading area, except for the accelerators, which are isolated from the process area near the batch plant control office.

TYPE	EFFECT	VOLUME(L)	
Darex AEA	air entrainer	2250	Grace
WRDA-82	water reducer	4500	"
WRDA-86	accel./water reducer	200	"
Deratard-17	set retarder	1100	"
Daraccel	accel./water reducer	9000	"
Aeralone	air entrainer	1100	Master
355-N	accel./water reducer	3000	Builders
	Total	21150	


Paved & Sloped
Slope
Truck Load
Wash/ Slump Rack
Office & Batch Plant
Admix.
Silos
CELL #2
CELL #1
DITCH
Paved Apron
Sand Screw
AGGREGATE
Recovered Sludge
AGGREGATE
RIVER

PLANT 11

Plant 12

Operation: central mix - 4.2 and 4.0 cu.m mixers
Fleet Size: 25 trucks, average 8 cu.m/truck
Avg. Daily Production: 400 cu.m
Max. Hour Production: 200 cu.m

This large operation is located on an indusrial island in the Fraser River. The process areas are in close proximity to the Fraser River (30 m). Recycled water is used for truck wash-out. Wastewater treatment works include a two-celled settling basin and sump. Operations are summarized as follows:

Truck Loading: Trucks back into one of two loading bays (one under each central mixer) and are filled with a premixed concrete batch. The batch water is city water. A spray bar cleans the exterior drum with city water during the filling operations. The loading areas are paved. Runoff from the north loading bay is effectively channeled to a sump (pH 10); only about one half of the runoff from the south bay runs to the sump, the remainder pools on the gravel yard. A gasoline/oil slick was visible on the surface of the sump.

The central mixers are washed out daily with approx. 1000 L city water and some gravel. This solution is discharged to a mixing truck and discharged to the #1 settling cell.

Truck Wash-Off: There is no dedicated wash rack at this plant, as central mix plants do not contaminate the back end of the truck mixer to the same extent as batch plants. City water is supplied at the loading bays to clean off the the trucks.

Truck Wash-Out: Come-back concrete is used for pre-cast blocks or is incorporated in the next batch if suitable. Empty trucks back up a sloped slab approach to one of four discharge bays at the settling basin. The approach is inclinded away from the basin and causes runoff to pool there (pH 9).

The two-celled settling basin is approx. 20 X 8 X 4 m deep. Four overhead lines provide recycled water drawn from cell #2 for truck wash-out . The resulting slurry is discharged to cell #1. Effluent in cell #1 (pH 12) is allowed to settle overnight and is pumped to cell #2 (pH 11.5) each morning. The pump intake head is allowed to rest on the cell bottom during pump-over, thus entraining some settled fines. Effluent from the truck loading sump is pumped on level control to cell #2.

The Fraser River is approximately 10 m north of the basin. An effort has been made to build a concrete berm at the plant/river boundary, process runoff does not appear to enter the Fraser, but pools south of the settling basin discharge stalls.

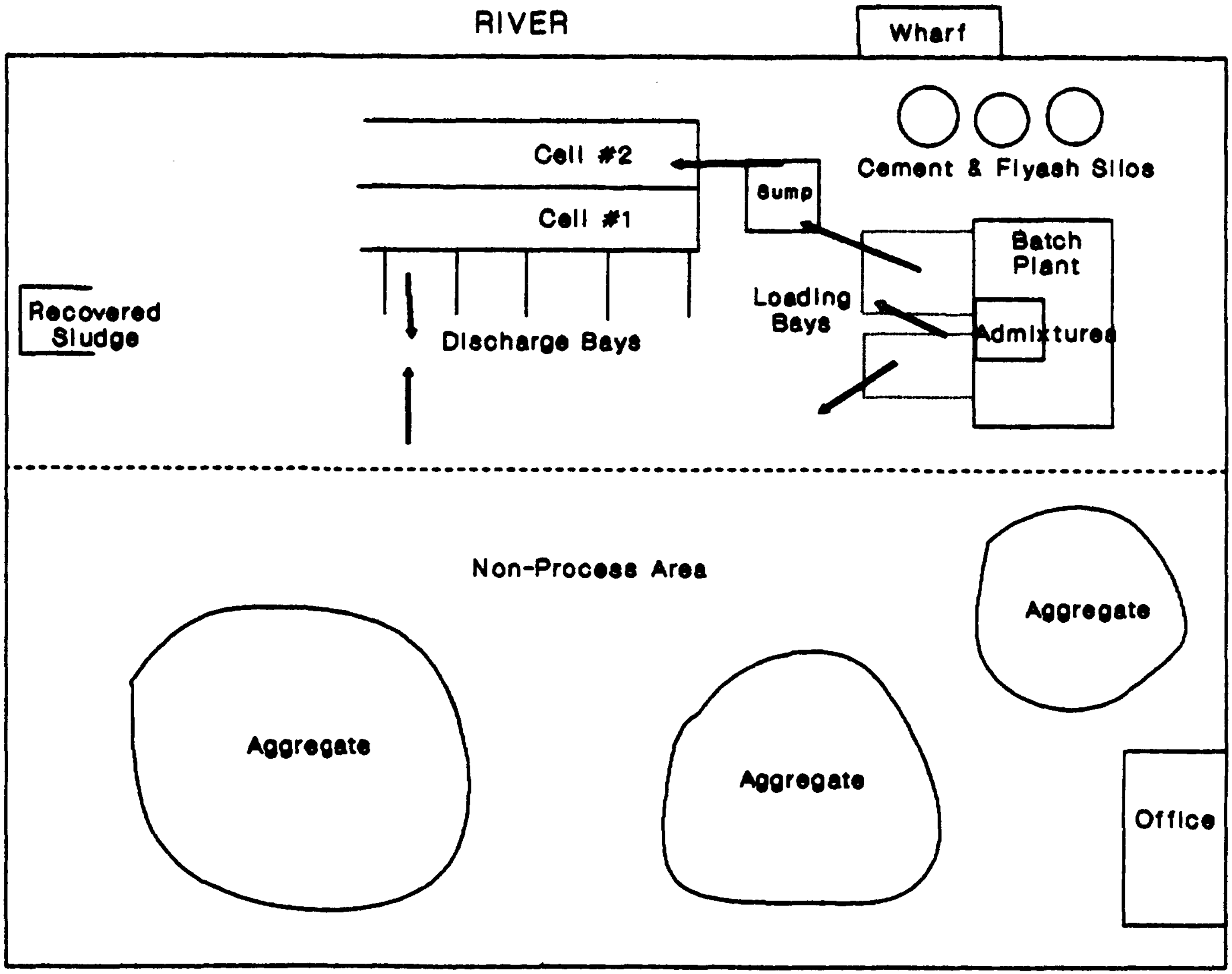
Sludge is recovered from the settling cells approx. twice per month (depending on plant production) and piled to dry in one of two three-walled stalls approx. 10 m south of the river. The leachate from the sludge does not appear to discharge directly into the Fraser. The dried sludge is hauled away.

Stormwater: The process area of the lot is paved but does not effectively direct runoff to the sump or the settling basin. However, runoff from the process areas does not appear to threaten the Fraser River. The aggregate stockpiling areas are not paved and runoff pools and infiltrates.

Feedstocks: This plant maintains a maximum of 800 tonnes of type 10 cement, 300 tonnes of type 30 cement and 300 tonnes of flyash in three large ground level storage silos beside the loading area. Approximately 30 tonnes of type 50 cement are also stored on site.

Admixtures are supplied by Grace and are securely housed in plastic vessels in a building beside the loading area.

TYPE	EFFECT	VOLUME(L)
Daratard-17	set retarder	2400
WRDA-19	superplastisizor	4000
Daravair	air entrainer	2400
WRDA-82	water reducer	3000
Daracem-100	superplasticizor	2400
	Total	14200


RIVER
Wharf
Cement & Flyash Silos
Cell #2
Cell #1
Sump
Batch Plant
Admixtures
Loading Bays
Recovered Sludge
Discharge Bays
Non-Process Area
Aggregate
Aggregate
Aggregate
Office

PLANT 12

Plant 13

Operation: batch
Fleet Size: 7 trucks, average 6 cu.m/truck
Avg. Daily Production: 125 cu.m
Max. Hour Production: 85 cu.m

This small operation is located on North Vancouver's industrialized shoreline. The process areas are approximately 100 m north of Burrard Inlet. Recycled water is used for truck wash-out. Wastewater treatment works include a two-celled settling basin, two sumps and an infiltration pit. Operations are summarized as follows:

Truck Loading: Trucks back into the loading area and are filled with premeasured concrete components. The batch water is city water. This area is paved and effectively sloped to direct runoff to the process area sump (pH 8.5).

Truck Wash-Off: After filling, the truck proceeds to the wash/slump rack where the back end of the truck is cleaned and product slump adjusted as required with city water. This area is paved and sloped to direct runoff (pH 8.5) from this operation to the process sump. This sump is connected via underground pipe to a large (9 X 3 X 6 m deep) runoff sump (pH 7) which collects runoff from unpaved areas of the lot.

The runoff sump is connected via underground pipe to an infiltration pit (3 X 3 X 2 m deep, full of 3/4 inch rock) at the shore of Burrard Inlet. Yard runoff entering this pit from the aggregate area had a pH of 7.5.

It was estimated that approx. 46 L of HCl is used each month to clean concrete build up off the truck drum exterior. No set schedule is followed for this procedure, and the trucks are washed in the wash/slump area.

Truck Wash-Out: Come-back concrete is used for pre-cast blocks. A neighbouring company maintains the forms and is not charged for the concrete.

Empty trucks back up a sloped slab approach to one of three discharge bays at the two-celled settling basin which measures approx. 20 X 6 X 6 m deep overall. Three overhead lines provide recycled wash out water drawn from cell #2. The resulting slurry is discharged to cell #1 (pH 12.5). Effluent in cell #1 is allowed to settle overnight and is pumped to cell #2 (pH 12.5) each morning. The pump intake is a pipe fixed above the cell bottom to prevent entraining settled solids during this operation.

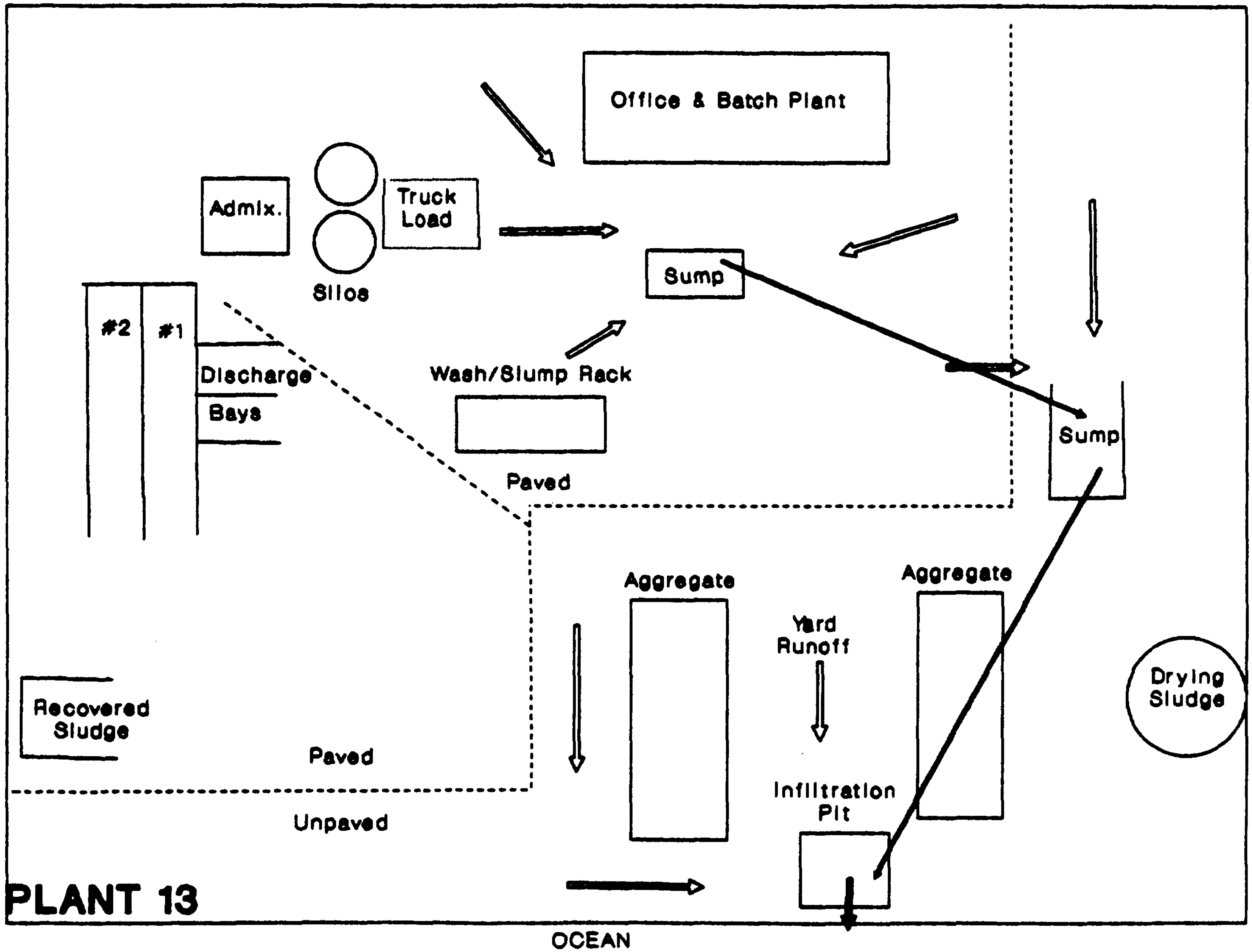
Sludge is recovered daily from the settling cells and piled nearby to dry (pH 11). Partially dried sludge in this pile is in turn transferred to the south east area of the lot for further drying and stockpiling. This sludge is occasionally sold as fill.

Stormwater: The process area of the lot is paved and sloped to direct runoff to either of the available sumps. The yard slopes towards Burrard Inlet and puddles in the aggregate storage area had a pH of 7. Yard runoff either infiltrates the ground or enters the infiltration pit (pH 7.5) at the foreshore.

Feedstocks: This plant maintains a maximum of 800 tonnes of type 10 cement (plus 85 tonnes in a day silo), 22 tonnes of type 30 cement and 85 tonnes of flyash in silos beside the loading area.

Admixtures are supplied by Conchem and are securely housed in a building beside the loading area in steel vessels.

TYPE	EFFECT	VOLUME(L)
Procrete-N	water reducer	4500
Procrete-R	set retarder	4500
HE-202	early strength pozz.	6750
AES	air entrainer	2250
	Total	18000


Office & Batch Plant
Admix.
Truck
Load
Silos
Sump
#2
#1
Discharge
Bays
Wash/Slump Rack
Paved
Sump
Aggregate
Aggregate
Yard
Runoff
Drying
Sludge
Recovered
Sludge
Paved
Unpaved
Infiltration
Pit
PLANT 13
OCEAN

Plant 14

Operation: batch
Fleet Size: 40 trucks, average 6.2 cu.m/truck
Avg. Daily Production: 700 cu.m
Max. Hour Production: 270 cu.m

This large operation is located near Burrard Inlet. Water is not normally recycled for ready mix operations and a positive discharge is directed to Burrard inlet. However, water treatment works utilize two large settling ponds and dilution from existing well water. Operations are summarized as follows:

Truck Loading: Trucks back into one of two loading bays and are filled with premeasured concrete components. The batch water is city water. A spray bar cleans the exterior truck drum during the filling operations with city water. This area is well paved and effectively sloped to channel runoff (pH 10) to the concrete lined #1 lagoon (approx. 45 X 20 X 6 m deep, pH 11.5). Fresh spring water enters through the bottom of the lagoon at approximately three locations.

Truck Wash-Off: After filling, the trucks proceed to one of six wash/slump bays, which are also used for truck wash-out, at the #1 lagoon. The back end of the truck is rinsed off and product slump adjusted as required with city water. This area is paved and sloped to direct runoff to the #1 lagoon.

Truck Wash-Out: Come-back concrete is used for pre-cast products, for paving the yard or is incorporated in the next batch.

Empty trucks back up to one of six wash stalls at the #1 lagoon. This is the same facility used for cleaning after filling operations. City water is used to clean the interior of the drum mixer; the slurry is discharged to the lagoon. If all six bays are occupied, the empty truck may proceed to the concrete-lined #2 lagoon (approx. 20 X 20 X 6 m deep, pH 10) for wash-out. This wash area is supplied with spring water pumped from the #3 lagoon, and is normally utilized by the company's gravel dump trucks. It is paved to direct runoff into the #2 lagoon.

The #1 lagoon receives all process effluent and runoff from the process area. An overflow in the north east corner of the lagoon discharges supernatant via a small V-notch weir to an open 6 inch culvert which connects to the unlined #3 lagoon (approx. 20 X 30 X 10 m deep). Spring water enters from the bottom of this lagoon as well and dilutes the process effluent. The diluted effluent is then discharged to a ditch, which runs into Burrard Inlet.

Another open culvert carrying fresh spring water from the north east corner of the plant runs parallel to the process effluent culvert, but does not enter the #3 lagoon. Instead, this fresh water runs directly to the ditch to further dilute the discharge from the #3 lagoon.

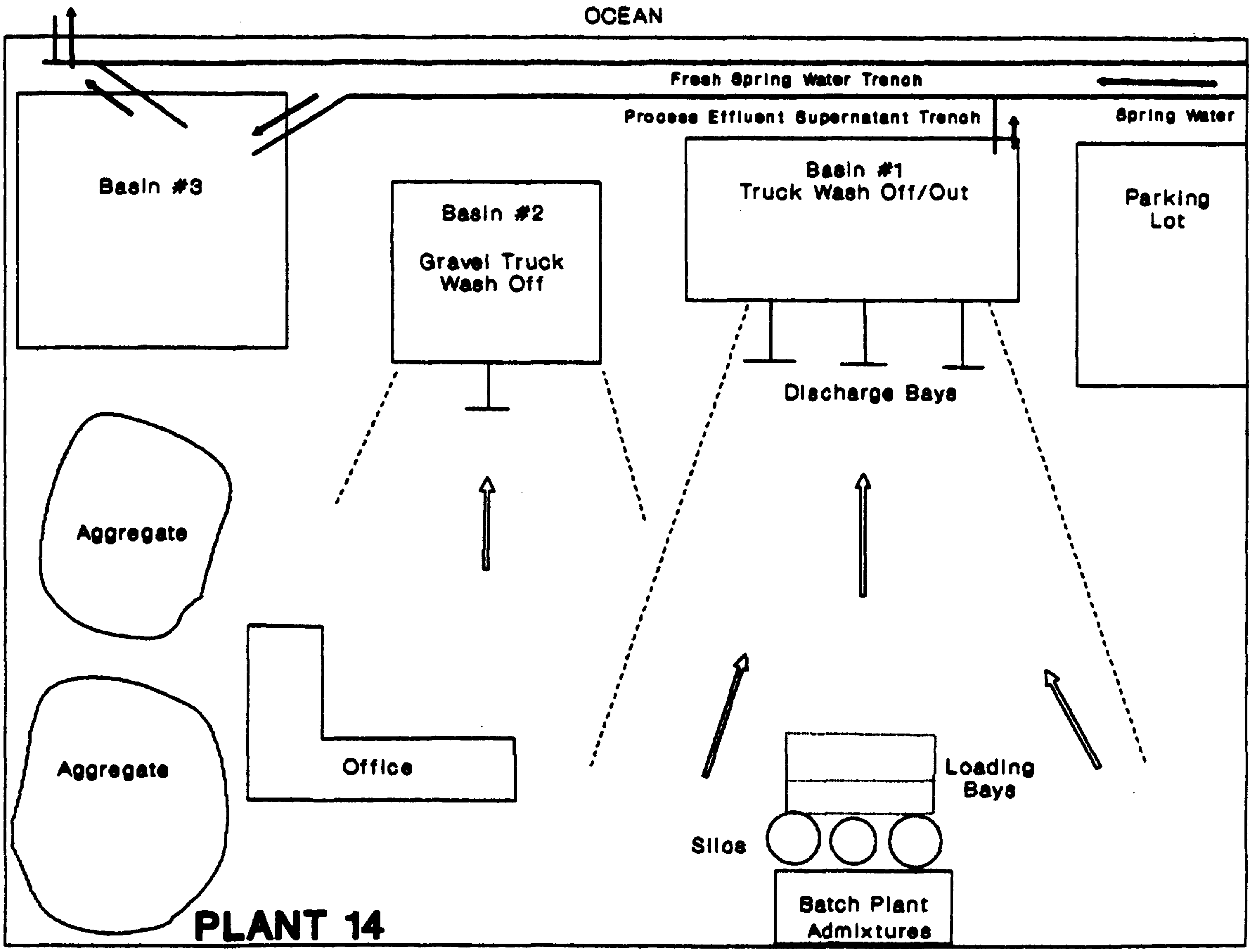
Sludge is recovered from the #1 lagoon twice per year. The larger aggregate located near the wash racks is dried and sold as fill, while the finer fraction in the northern section of the lagoon is dried and buried on site.

Stormwater: The process area of the lot is paved and effectively sloped to direct runoff to the #1 lagoon.

Feedstocks: This plant maintains a maximum of 375 tonnes of type 10 cement total in three silos, and no flyash.

Admixtures are supplied by Grace and Master Builders and stored in steel vessels which are housed in a heated enclosed area under the batch plant control room. $CaCl_2$, supplied by Pozzolanic, is located outside in a steel container.

TYPE	EFFECT	VOLUME(L)	
300-N	set retarder	1350	Master
344-N	water reducer	1350	Builders
122-R	set retarder	1350	"
HE-133	set accelerator	1350	"
Daracem	superplasticizor	1350	Grace
A.E.S.	air entrainer	1350	"
CaCl2	set accelerator	9000	"
	Total	17100	


OCEAN
Fresh Spring Water Trench
Process Effluent Supernatant Trench
Spring Water
Basin #3
Basin #2
Gravel Truck
Wash Off
Basin #1
Truck Wash Off/Out
Parking
Lot
Discharge Bays
Aggregate
Aggregate
Office
Loading
Bays
Silos
Batch Plant
Admixtures

PLANT 14

Plant 15

Operation: batch
Fleet Size: 16 trucks, average 8 cu.m/truck
Avg. Daily Production: 250 cu.m
Max. Hour Production: 100 cu.m

This medium sized operation is located near a fish bearing creek, in a relatively undeveloped area. Recycled water is normally used for batch water and for truck wash-out. A new configuration produces a positive discharge of clarified process water to city sewer. Treatment works include a large infiltration pond and a three-celled settling basin. Operations are summarized as follows:

Truck Loading: Trucks back into the loading bay and are filled with premeasured concrete conponents. Water pumped from the lagoon has been used for batch water for approx 5 years, unless hot water is required. A spray bar cleans the exterior truck drum during the filling operations with city water. This area is paved and effectively sloped to direct runoff (pH 11.5) to a sump which discharges to the lagoon.

Truck Wash-Off: After filling, the truck proceeds to one of the two wash/slump racks located at the three-celled settling basin. Here the back end of the truck is rinsed off and product slump adjusted as required with city water.

This area is quite well paved and sloped to direct runoff (pH 11.5) into cell #1. During wash-off operations water pools beside cell #1 before flowing around and into the open cell end. Additional paving could eliminate this pooling. An oil slick was visible on the pooled water.

Truck Wash-Out: Come-back concrete is used for pre-cast blocks, or is incorporated in the next batch. The company only has 5 block forms and if they are unavailable, the concrete is spread on the sludge pile. The concrete is later broken down and incorporated into the sludge, which actually improves the dried sludge's fill characteristics.

Empty trucks back up to one of two wash-out bays at cell #3 where overhead racks provide recycled wash-out water drawn from cell #2. City water is also provided. The slurry is discharged to the #3 cell. This area is also well paved and sloped to channel runoff (pH 11) from this operation into cell #3.

Stormwater: Approximately 90% of the yard area is paved and effectively directs most non-process yard runoff to the plant sewer system. The plant sewer system discharges to the infiltration lagoon, or may be diverted during heavy rainfall into an adjacent creek. The process areas are also paved to collect process runoff in either the lagoon or settling basin.

Effluent Handling Overview: A series of plant sewers collect yard runoff and discharge it to the infiltration lagoon. Lagoon water is used for batch water. During heavy rainfall events, yard runoff can be diverted from the lagoon and discharged to a nearby creek.

When the lagoon is near capacity, effluent is pumped on level control to the #2 settling basin cell. Previously, this pond flooded over its north west side into an adjacent creek. The company has also sunk concrete blocks in the north west corner of the lagoon to prevent pond seepage into the creek.

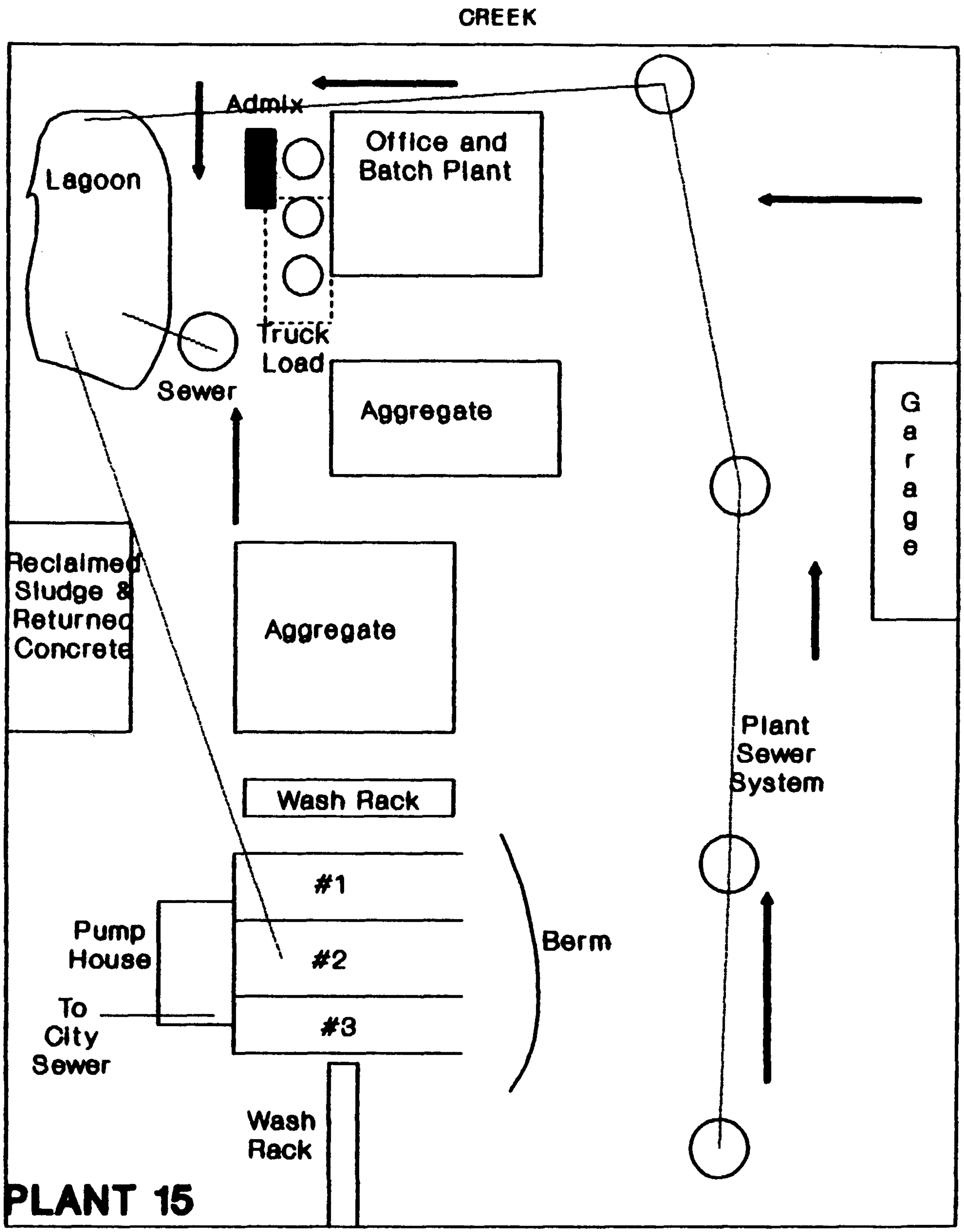
Runoff from the truck loading operations is effectively collected and discharged to the lagoon via plant sewer. Wash-off and wash-out operations are conducted at the three-celled settling basin. Wash-off and wash-out effluents are collected and channeled to cell #1 and #3 respectively. Effluent in #1 and #3 is allowed to settle overnight and in the morning is pumped to cell #2. The pump intake heads in #1 and #3 are tied off and suspended above the cell bottoms to prevent entrainment of solids during pump-over operations. The intake head in #3 is kept off the bottom via a ball float. The recycled cell #2 effluent is used for truck wash-out and for yard wash down. If cell #2 is too full, effluent may be discharged to sewer.

Sludge is reclaimed from the settling basin every two weeks, depending on plant production, and is piled to dry. The company is hoping to sell it as fill.

Feedstocks: This plant maintains a maximum of 175 tonnes of type 10 cement (95 + 80 tonnes) and 40 tonnes of flyash in silos above the truck loading area. Another 50 tonne silo is usually kept empty for a special cement e.g. type 50.

Admixtures are supplied by Conchem, and are located outside near the loading bay in plastic vessels. Old steel admixture vessels from Master Builders are still on site although they are no longer used.

TYPE	EFFECT	VOLUME(L)
MSN	water reducer	4500
Procrete-R	set retarder	2250
HE-202	high early strength	2250
Proair	air entrainer	1800
CaCl2	set accelerator	9000
	Total	19800


CREEK
Admix
Office and Batch Plant
Lagoon
Truck Load
Sewer
Aggregate
Garage
Reclaimed Sludge & Returned Concrete
Aggregate
Plant Sewer System
Wash Rack
#1
Pump House
#2
Berm
#3
To City Sewer
Wash Rack
PLANT 15

Plant 16

Operation: batch
Fleet Size: 4 trucks, average 5.5 cu.m/truck
Avg. Daily Production: 45 cu.m
Max. Hour Production: 35 cu.m

This small operation is located in a small ravine in a relatively undeveloped area. A fish bearing creek roughly disects the operation. This plant is not connected to a municipal water supply; all fresh water is drawn from a well. Recycled water is normally used for batch water and for truck wash-out. Treatment works include a two-celled settling basin. The loading bay acts as a large sump. Operations are summarized as follows:

Truck Loading: Trucks back into the loading bay and are filled with premeasured concrete conponents. A spray bar cleans the exterior truck drum during the filling operations with well water. The loading bay is a concrete lined cell and is very effective in collecting and holding runoff associated with loading operations. Water pooling in this bay (pH 11) is used for batch water. A gasoline/oil slick was visible on the surface.

Truck Wash-Off: After filling, the truck stays in the loading bay. A hose supplied with fresh well water is used to rinse off the back end of the truck and to adjust product as required. All runoff from wash-off operations is held in this bay.

Truck Wash-Out: Come-back concrete is not utilized for any purpose, if it cannot be incorporated in the next batch. The company feels that the cost of preparing the forms outweighs the benefit of such effort. Instead, trucks back up to a two-celled settling basin, south of the creek. The discharge area is paved and sloped to some extent, but chould be improved due to the proximity of the creek (approx. 10 m north). The north side near the creek is bermed to prevent any direct discharge, but effluent may flow around the west side and enter the creek.

Overhead racks provide recycled wash-out water drawn from cell #2, which is used to dilute the come-back concrete in the truck mixer. This requires more water than is needed to wash out a mixer drum that has discharged its come-back concrete. The slurry is then discharged to cell #1 and allowed to settle overnight. In the morning cell #1 effluent is pumped to cell #2. The pump intake head is tied off to prevent settled solids from being entrained with the pumped effluent.

Sludge is usually recovered daily from the 2 cells, and piled to dry in an area just east of the settling basin.

Stormwater: The operation is located in a small valley, so runoff runs toward the creek from the north and south. The truck loading area is north of the creek, and the wash-out discharge area to the south.

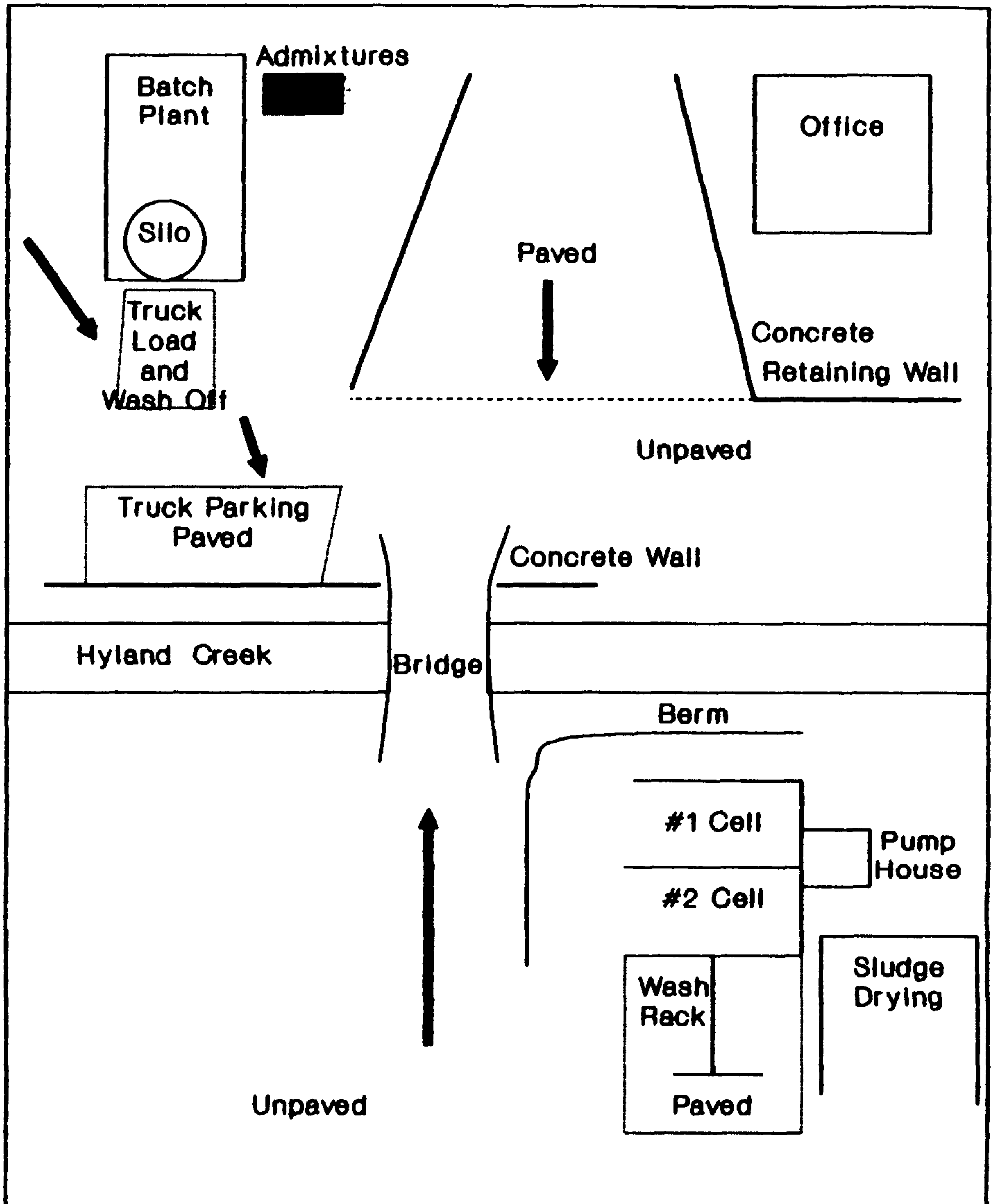
Effluent generated during truck load operations is well contained in the loading bay. The wash-out area is bermed, but is not completely effective in keeping runoff from entering the creek.

Some yard runoff enters the creek directly, but should be free of contamination from the loading operation. Storm runoff originating near or beyond the south plant boundary may flow over the discharge area, thus becoming contaminated, and enter the creek.

Feedstocks: This plant maintains a maximum of 35 tonnes of type 10 cement and 30 tonnes of flyash in two silos above the truck filling area.

Admixtures are supplied by Grace and are kept outside, near the batch plant control room in plastic vessels. They are elevated and out of the way of machinery. Should a vessel rupture, some of the liquid would likely reach the creek, and some would flow into the truck loading cell.

TYPE	EFFECT	VOLUME(L)
Daraccel	water reducing accelerator	2250
Hicol	early strength	2250
Derex AEA	air entrainer	1800
	Total	6300


Admixtures
Batch Plant
Silo
Truck Load and Wash Off
Paved
Office
Concrete Retaining Wall
Unpaved
Truck Parking Paved
Concrete Wall
Hyland Creek
Bridge
Berm
#1 Cell
#2 Cell
Pump House
Wash Rack
Sludge Drying
Paved
Unpaved

PLANT 16

Plant 17

Operation: central mixer (5.5 cu.m)
Fleet Size: 20 trucks, average 7.6 cu.m/truck
Avg. Daily Production: 125 cu.m
Max. Hour Production: 160 cu.m

This large operation is located within downtown Vancouver, adjacent to marine waters. The entire lot is paved and recycled water is used for truck wash-out. Treatment works include a single-celled settling basin and a drag chain mechanical aggregate recovery unit. Operations are summarized as follows:

Truck Loading: Trucks enter the loading bay and are loaded with a premixed concrete batch. A spray bar cleans the exterior truck drum with city water during the filling operations. City water is used for truck wash-off. The loading bay area slopes north (towards the water) and runoff from this operation flows towards the bulk aggregate storage silo bays on the north plant boundary, where it is collected in a sump and discharged with yard runoff to marine waters. While effluent pooling in the loading area had a pH of 11.5, the combined yard and truck loading runoff entering the storage silo sump had a pH of 8.5. A gasoline/oil slick was visible on the surface of the water entering the sump.

Truck Wash-Off: There is no dedicated wash-off rack at this operation. Wash-off, if required, is conducted in the loading bay.

Truck Wash-Out: Come-back concrete is used for pre-cast blocks, is dumped (after dilution) into the settling basin, or is incorporated into the next batch.

Empty trucks back up to one of four discharge stalls at the concrete lined single-celled settling basin (approx. 25 X 4 X 6 m deep). The discharge approach is paved and sloped west to direct runoff into the basin. The basin itself slopes downward towards the north while the south end is open, allowing a front end loader access to clean out settled solids. Four overhead racks provide recycled water (pH 11.5) drawn from the drag chain unit for truck wash-out. The resulting slurry in the truck mixer is discharged to the settling basin and allowed to settle overnight.

In the morning, the clarified basin effluent is pumped into the drag chain unit. The intake head on the pump is tied off to prevent it from resting on the bottom of the settling basin.

The drag chains are used as required (approximately weekly) to recover the entrained fine solids. The recovered material is piled with other recovered sludge. While the unit is designed to recover aggregate, it is primarily used at this facility as a second stage holding tank.

Sludge is recovered from the basin on a weekly basis, depending on plant production, and is piled to dry in a three walled concrete block stall immediately south west of the drag chain unit. Leachate from this sludge flows around the east side of the containment and is directed by a small berm into a covered trench which discharges to the settling basin. The berm prevents the leachate (pH 12) from directly entering the marine water, but if the trench plugs due to solids build up, the leachate will overflow the berm. Immediately east of the berm is a hole in the wharf beside the bulk aggregate storage silos, opening to the receiving water. A gasoline/oil slick was visible on the yard runoff (pH 11) discharging through this opening.

Stormwater: The entire lot is paved and sloped at this facility. A small crest running east/west roughly divides the lot in half, directing half the yard runoff toward the water.

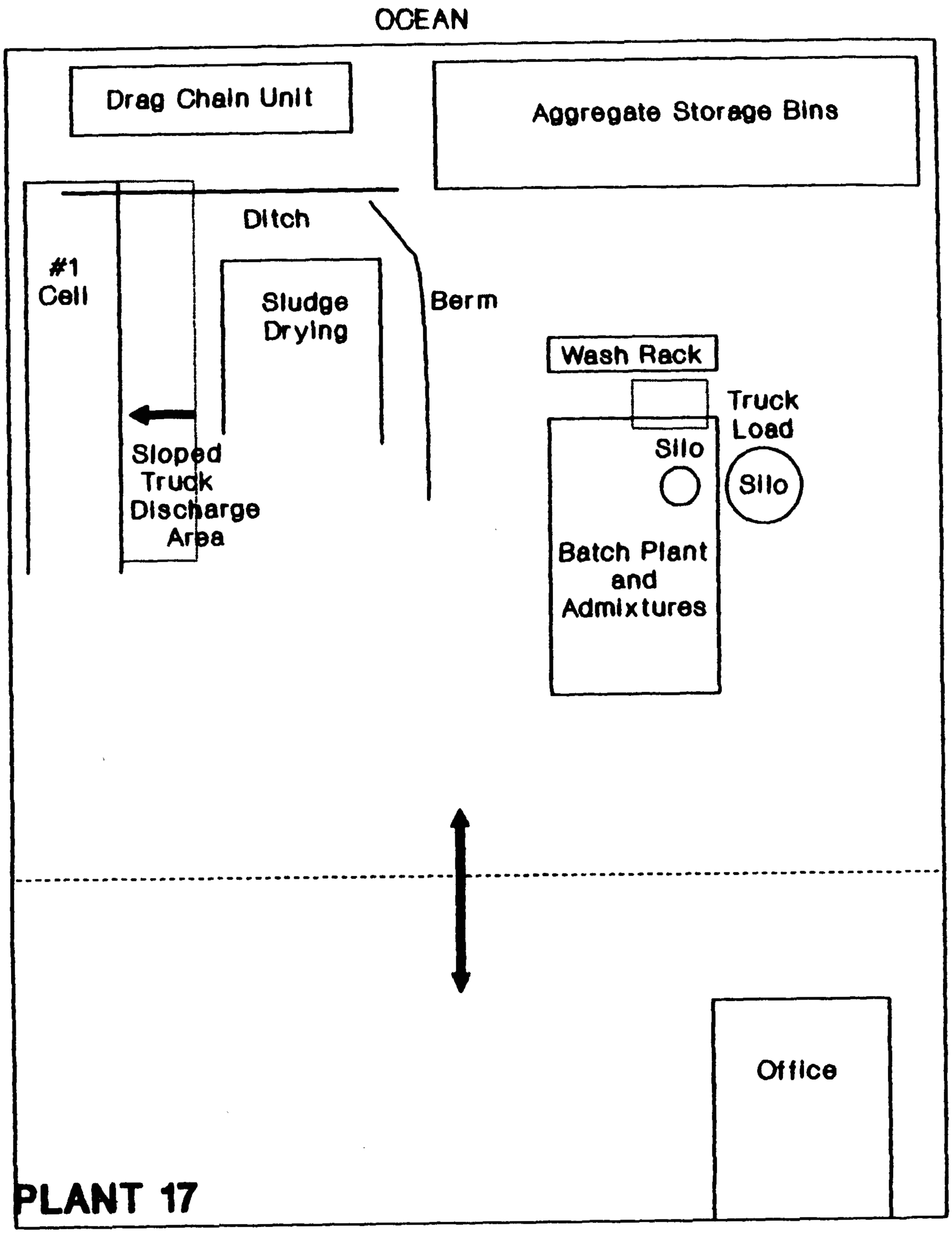
Both process areas (truck loading and discharge) are located in the northern half of the lot. Runoff from the loading area is collected and discharged via collection sumps in the aggregate silo loading bays to marine water, while runoff in the discharge area is directed to the settling basin.

Water pooling in the non-process, southern portion of the lot had a pH of 7 and 8.

Feedstocks: This plant maintains a maximum of 800 tonnes of type 10 cement in a large silo east of the truck loading bay and 75 tonnes of both flyash and type 30 cement in a four compartment silo above the loading bay. The remaining two compartments are usually kept empty to store cement for a specialty order, or for additional capacity.

Admixtures are supplied by Grace and are securely housed in a room beside the loading bay in plastic vessels. Calcium chloride is kept outside in a steel container.

TYPE	EFFECT	VOLUME(L)
Daratard	set retarder	2400
Daravair	air entrainer	1200
WRDA-82	water reducer	6000
WRDA-19	superplastisizor	2400
CaCl2	set accelerator	9000
	Total	21000


OCEAN
Drag Chain Unit
Aggregate Storage Bins
Ditch
#1 Cell
Sludge Drying
Berm
Wash Rack
Truck Load
Silo
Silo
Sloped Truck Discharge Area
Batch Plant and Admixtures
Office
PLANT 17