Environment Canada
Conservation and Protection
Pacific and Yukon Region

Recommended Waste Management Practices for the Ready Mix Concrete Industry in British Columbia

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Review Notice

This report has been reviewed by Environmental Protection, Pacific and Yukon Region and approved for publication. Mention of trade names or commercial products does not constitute recommendation or endorsement for use.

Comments

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Table of Contents

List of Figures

List of Tables

1.0 Introduction

1.1 Objective

This document presents recommended practices which are intended to minimize environmental impacts of facilities in the ready mix concrete industry. When the receiving environment supports a federal fisheries resource (for example, salmon), it is the federal government's responsibility to ensure the protection of that resource and its habitat, as mandated by the Fisheries Act. Accordingly, Environment Canada has prepared this document in order to provide guidance to facility operators in British Columbia who wish to operate in an environmentally sound manner. The document will also provide uniform guidance to the B.C. Ministry of Environment as they formulate and administer Waste Management Branch Permits for ready mix concrete facilities.

The recommendations of the document have no binding legal or regulatory status. However, the recommendations have been drafted in consultation with Environment Canada, the B.C. Ministry of Environment, and industry personnel (including the B.C. Ready-Mixed Concrete Association, selected independent facility owners and operators, and chemical suppliers). Accordingly, it is intended that ready mix concrete facility operators will strive to meet the objectives set out in the document. The recommendations generally represent good industrial practice; they are realistic, straight forward and technically and economically achievable. In some circumstances, for example for facilities adjacent to very sensitive waters, more stringent measures may be necessary to protect the fish and fish habitat.

1.2 Background

Environment Canada Regional Program Report 88-03, "Overview of the Ready Mix Concrete Industry in British Columbia, Water and Waste Management Practices (June 1988)" provides detailed information which supports this current "Recommendations" Document. The "Overview" report presents background information and a detailed overview of the industry, including a description of current wastewater treatment and recycling practices. The report is based on a review of the literature and visits to 17 plants in the Greater Vancouver area.

This "Recommendations" document elaborates on the preliminary recommendations presented in Program Report 88-03. These recommendations are supported by additional site visits to 7 ready mix concrete facilities and by discussions with facility operators, industry associations in B.C. and the United States, admixture chemical suppliers, regulatory agency personnel in B.C. as well as the U.S. Environmental Protection Agency.

Prior to finalization, this document was reviewed by Conservation and Protection (Environment Canada), the Habitat Management Division (Department of Fisheries and Oceans), the Waste Management Branch (B.C. Ministry of Environment, Victoria and the Lower Mainland Regional Office), the B.C. Ready-Mixed Concrete Association, and selected independent ready mix plant operators.

1.3 Environmental concerns

In the context of all industrial facilities, ready mix concrete plants do not generally pose significant problems in terms of their environmental impacts. However, concerns may exist at specific facilities, especially where effluent or stormwater runoff is discharged into a water body. As noted in Section 1.1, when the receiving environment supports a federal fisheries resource, the federal government is mandated by the Fisheries Act to ensure the protection of the resource and its habitat.

Table 1 describes the specific concerns about wastewater and storm water discharges from the site of a ready mix concrete facility. The thrust of this document is to recommend design and operating practices which will eliminate or minimize these impacts.

TABLE 1: Environmental concerns: effluents from ready mix concrete facilities

ITEM	CAUSE	CONCERN	LEVEL of CONCERN
pH	Soluble cement constituents in effluent and/or stormwater runoff	• High pH is toxic to fish	• pH 9.0-9.5 likely harmful to salmonid fish (1) • pH > 10 will kill salmonid fish in minutes (1)
Total suspended solids	Cement, sand and fines in effluent and/or stormwater runoff	• Can kill fish/shellfish through abrasive injury or clogging of gills and respiratory passages • May contain leachable toxic substances • Aesthetically displeasing • Screens light, contributes to oxygen depletion • Destroys habitat (e.g., by coating bottom)	
Admixture chemicals	Spills carried off-site in effluent or stormwater runoff	• High concentrations may injure or kill aquatic organisms by causing high chemical oxygen demand (C.O.D.), high pH, and/or aquatic toxicity	• Specific to active ingredients • MSDS's may indicate aquatic toxicity (data not always given)
Oil/grease	Drips from trucks and mechanical equipment carried off-site in effluent or stormwater runoff	• Toxic to aquatic organisms (2) • "Oil/grease" can include gasoline, diesel or lube oil	• Highly variable with species • e.g., crude oil is extremely toxic at 0.3 mg/L (2)

References: 1. D. McLeay and Associates Ltd., Toxicity of Portland Cement to Salmonid Fish, Vancouver, 1983
2. Guidance Document for Effluent Limitations and New Source Performance Standards for the Concrete Products Point Source Category, Effluent Guidelines Div., USEPA, Wash., D.C., Feb., 1978

1.4 Regulation of discharges

Pollution control for the ready mix concrete 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 Ministry staff when issuing effluent permits[1].

Discharges to fish-bearing streams or marine waters are subject to the general provisions of the federal Fisheries Act; Section 36(3) of the Act prohibits the "....deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water". Also, Section 35(1) 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 36(3) 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 B.C. Ministry of Environment is intended to ensure that input and recommendations from the federal agencies are considered during permit preparation.

B.C. ready mix facilities are generally regulated by B.C. Ministry of Environment Waste Management Branch permits. Permits are issued by the Regional Offices of the Waste Management Branch, and the specific terms are determined on a case-by-case basis.

The most detailed and stringent conditions are generally applied to facilities which discharge wastewater effluents to waterbodies. In such cases, a Waste Management Branch permit typically places limitations on effluent characteristics including total flow, total suspended solids (or non-filterable residue), pH, temperature, and oil/grease levels. Regulated parameters and specific limitations are determined on a case-by-case basis, but typical permit

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1 Department of Lands, Forests, and Water Resources, Pollution Control Objectives for Food-Processing, Agriculturally Oriented, and Other Miscellaneous Industries of B.C., 1975.

requirements are as follows:

TSS or NFR[2]	50-125 mg/L
pH	6-10
Temperature	<25-32° C
oil/grease	<5-10 mg/L
toxicity	96 hour LC50 = 100%[3]

Where discharge is to land (e.g., to a recycling pit or basin, or to an infiltration pit), effluent levels are normally not specified. Under these circumstances, permits may require that effluents are "equivalent to or better than typical (comparable) effluents from a ready mix concrete batch plant." In addition, general operating conditions for the settling basin or other works may be stipulated. For example, overflow of the basin may be prohibited, or diversion of uncontaminated stormwater runoff away from the basin may be required.

The disposal of settling basin sludge may be required in permits through statements such as "solids shall be disposed of in a manner approved of by the Regional Waste Manager". Specific disposal conditions are not normally specified in the permit, nor do permittees normally report specific disposal methods or contractors to the Waste Management Branch.

The terms of Waste Management Branch permits include requirements for effluent monitoring and reporting. Generally, monitoring of effluents by the permittee is required at least once quarterly (in some cases monthly) with reporting on a quarterly basis.

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2 TSS = total suspended solids; NFR = non-filterable residue.

3 96 hour LC50 static bioassay on salmonid species expressed as percent by volume of effluent in receiving water which is required to give 50 percent survival over 96 hours.

2.0 Overview of current practices

2.1 Concrete composition

The components and typical composition of concrete are:

TABLE 2: Composition of typical air-entrained concrete

INGREDIENT	TYPICAL COMPOSITION		
	kg/m^3	% by wt. (1)	% by vol.(2)
• aggregate (coarse)	625	48	31-51
• aggregate (fine)	410	31	24-28
• portland cement	174	13	7-15
• water	104	8	14-18
• admixture chemicals (control characteristics such as air entrainment, water:cement ratio, initial set, compressive strength)	0.26-0.28	< 0.01	-
• air	-	-	4-8

References: 1. Guidance Document for Effluent Limitations and New Source Performance Standards for the Concrete Products Point Source Category, Effluent Guidelines Div., USEPA, Wash., D.C., Feb., 1978
2. Can. Portland Cement Ass'n, Design and Control of Concrete Mixtures, 1981

2.2 Process description and waste management practices

A detailed characterization of the ready mix concrete industry is provided in Environment Canada Regional Program Report 88-03. This section summarizes the ready mix process and describes the main components of water use and wastewater generation.

Figure 1 illustrates a typical batch mix plant, which uses the truck drum for mixing the concrete ingredients[4]. The mixing process is controlled by a single operator from a central control room. Solid components are accurately metered by weight and added to the truck from overhead silos. Water and chemical admixtures (liquids) are metered by volume. Truck capacities typically range from 5-12 cubic meters[5].

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[4] Central-mix plants provide an alternative (and generally less common) mixing approach. Central-mix plants use a fixed hopper for mixing ingredients prior to loading the trucks. Since the concrete is mixed before loading, dust control during truck loading is less difficult than with batch-mix plants. Some operators direct a continuous water spray on the rotating truck drum during the loading process to accomplish the exterior wash (eliminating the separate washing step).

[5] The trend in British Columbia is to trucks with capacity in the high end of the range.

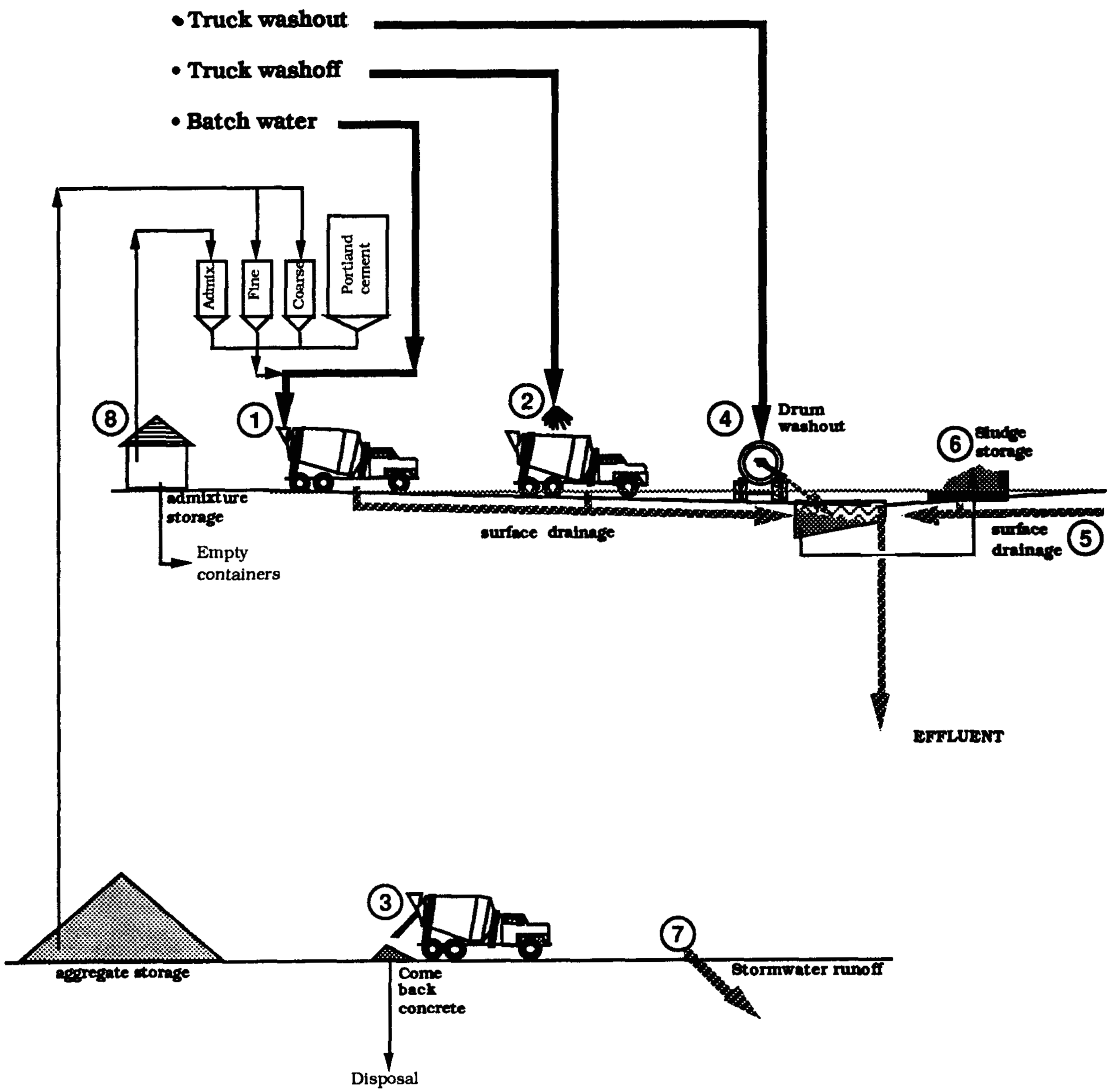


FIGURE 1: Typical components of batch ready mix concrete production

With reference to the numbers shown in Figure 1, the main components of the ready mix batching process are:

(1) CONCRETE MIXING:

Ingredients are added to the truck through a metal chute at the rear of the truck. Solid ingredients are added dry, and a rubber "sock " is normally used to minimize dust losses during loading.

(2) EXTERIOR TRUCK WASH

After loading, the truck moves to a wash area, where overhead sprays or a driver-operated hose is used to wash down the truck exterior. The truck then delivers the concrete load to the customer.

In addition to the routine exterior truck wash described above, weekly (or as required) exterior truck washes are carried out using a dilute muriatic acid solution to remove persistent concrete residues.

(3) DISPOSAL OF RETURNED CONCRETE

Some portion of the concrete load is normally left in the truck following delivery. During operating hours, it is common practice for this residual concrete to remain in the truck drum and to be incorporated into the next concrete load.

Where incorporation in the next load is not possible during operating hours, and at the end of the operating day, returned concrete is discharged from the truck and disposed by one of the following methods:

- production of precast concrete products
  (e.g. highway dividers or blocks for constructing retaining walls)
- on-site use in paving yard surfaces or as site fill
- discharge to ground, drying, breaking and transport to third parties
  (for further size reduction, size classification and use as fill for roadbeds or other suitable applications)

Excess concrete is occasionally discharged to the wash water collection system (described below) when other disposition is not available. In most instances, the insoluble concrete ingredients will settle and be removed for disposal along with washwater sludge. Although mechanical solids reclaim systems are available, they are rarely applied to recover concrete ingredients in B.C. plants. A few plants use mechanical aggregate recovery systems (e.g. drag chains) to provide recovery of coarse aggregate.

(4) DRUM WASH

At the end of the operating day, the truck drum must be washed out to avoid setting of concrete in the drum. This wash is normally completed by the driver, using overhead water racks or hoses. Water is added to the drum, the drum is rotated and discharged to the wash water collection basin.

(5) WASTEWATER MANAGEMENT

Ready mix concrete plants commonly have paved process areas in order to allow collection of contaminated process water and surface runoff from truck loading, truck washoff and drum washout areas. Some plants also provide collection of runoff/leachate from sludge storage and drying piles.

Contaminated water (including drum washings) is usually directed to a sub-grade, concrete settling basin. At most plants, this basin will overflow to a second settling basin; in some cases, additional basins in series are used.

Practices vary with respect to effluent disposition. Removal of suspended solids is principally accomplished through the use of settling basins. None of the visited facilities practice neutralization or pH control of effluent. Most commonly, the final basin will simply overflow to a ditch or surface drainage system. Where there is no receiving waterbody, accumulated or discharged water frequently is dissipated through infiltration. Where there are nearby waterbodies, effluent may ultimately be discharged to the waterbody through surface or subsurface drainage systems. For example, several facilities in the Vancouver area discharge settled process effluent to the Fraser River, Burrard Inlet or False Creek.

Fresh water is normally used for exterior truck washes and for the production of hot water (for winter batching). Settled process water is often used for drum washout. However, reuse of water for batch water is rare because of concerns about the effect of reused water on concrete specifications and acceptability to clients.

(6) SOLID WASTE MANAGEMENT

Most facilities periodically decant water from the collection basins and remove accumulated sludge to an on-site storage area for draining ("drying"). Sludge storage is usually on unpaved ground, in a 3-walled "bin" constructed from large concrete blocks (produced from returned concrete). Less frequently, sludge may be stored in uncontained piles. Returned concrete may be dumped to the ground in adjacent areas and (following setup) is broken up and added to the piles. The sludge and concrete residue is periodically removed by third parties for use as fill or for disposal in an unspecified manner. Although landfill disposal has been used in the past, landfill operators generally will no longer accept concrete sludges.

(7) STORMWATER MANAGEMENT

Practices to control surface runoff vary widely and are often determined by the physical site circumstances (location, natural or evolved topography and drainage). Process areas are usually (not always) paved and sloped to direct process water and stormwater from these areas into the water collection system (as described above). Practices vary with respect to the effectiveness of leachate and runoff collection from sludge storage areas. Some plants provide reasonably effective isolation of surface drainage from other site areas (e.g. aggregate storage areas which are normally on unpaved ground, and parking areas). At other plants, surface drainage is unavoidably collected with runoff from process areas.

(8) CHEMICAL DELIVERY and STORAGE

Admixture chemicals to control concrete characteristics are predominantly supplied as bulk liquids, although some plastic containers (e.g. 5 gallon pails) are still delivered. Admixture chemicals are generally stored in 500-1000 gallon tanks. Steel tanks are commonly used, although some chemicals require storage in plastic tanks and there is a trend to use plastic tanks throughout. The admixture chemical storage area at most facilities is a separate enclosed room (normally a part of the truck loading facility). Chemical storage tanks are usually located on a concrete pad, although tank spill containment is not provided. Exterior storage of admixture chemicals still occurs at some facilities. At most facilities, any spillage of admixture chemicals would flow into the surface water drainage and collection system for the loading area.

Calcium chloride ($CaCl_2$) solution is an admixture chemical which is generally stored in exterior upright cylindrical tanks, normally located adjacent to the admixture storage area.

Concentrated muriatic acid (HCl) is used to prepare dilute acid rinse solutions for periodic exterior truck washes (Item 2, Section 2.2). Muriatic acid is supplied in standard 205 L plastic drums, and is often stored outside, adjacent to other chemical storage or in the truck wash area.

Portland cement is stored in elevated silos (widely varying in size) which are located above the truck loading area. A large main cement silo may be located apart from the loading area and used to feed smaller loading silos. Baghouses are normally used to control cement dust emissions which occur when cement is loaded into the silos.

Aggregates (sand and gravel) are commonly stored in piles on unpaved areas of the site.

2.3 Process effluent management

2.3.1 Water use

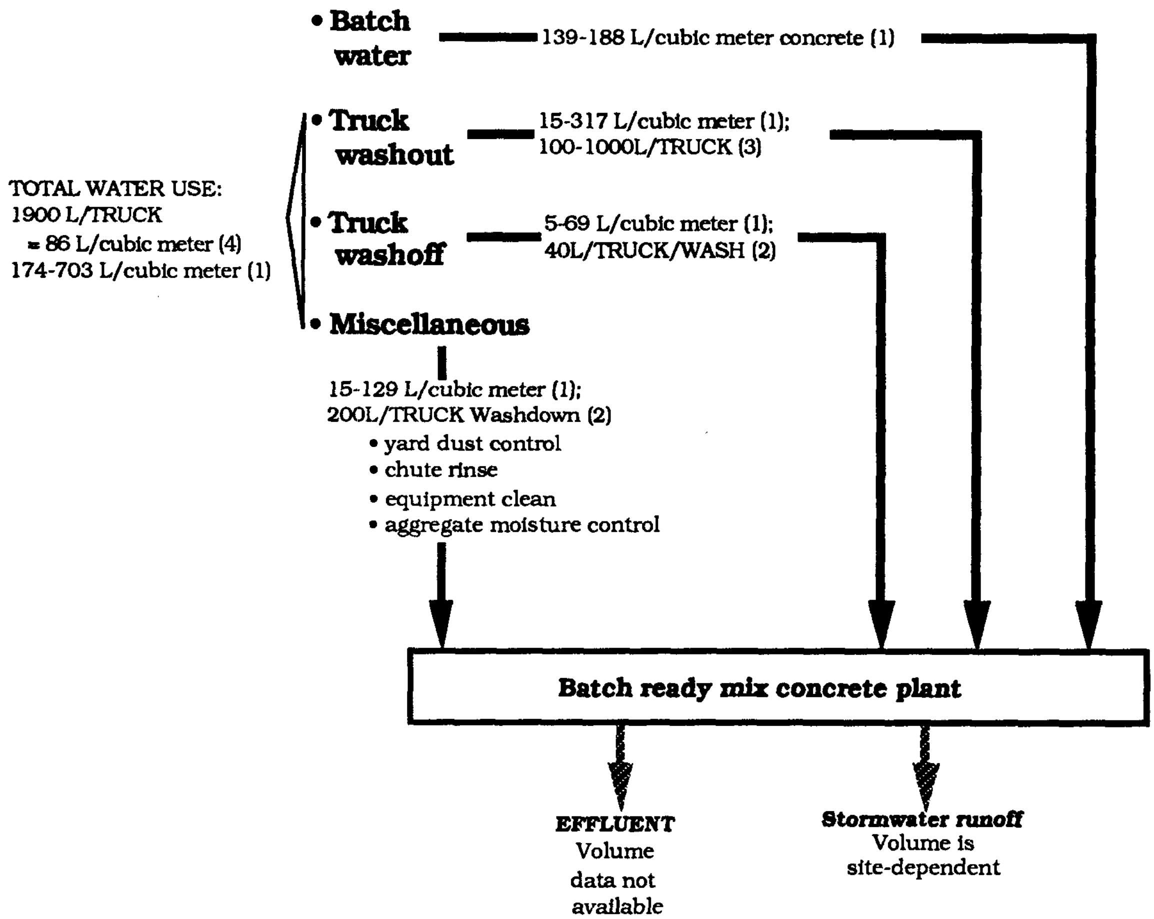
Environment Canada Regional Program Report 88-03 presents information on quantitative water use and wastewater generation in the ready mix industry. Most of these data were gathered in the 1970's (in other jurisdictions), and a subsequent review of current literature and discussion with industry and regulatory personnel indicates that this is the most current information. With the exception of monitoring activities to demonstrate compliance with Permits issued by the Waste Management Branch (B.C. Ministry of Environment), data for the ready mix industry in B.C. have not been compiled.

For easy reference, data representing typical water use in the ready mix industry are summarized in Figure 2. Although there is a high variation in water use from plant to plant, it is clear that batch water (contained in the concrete product) comprises only about 27% of the total plant water use, and drum washout is the unit operation with the highest water demand.

2.3.2 Wastewater generation (volume)

As with water use, there is high variation of wastewater generation from plant to plant. Reuse of process water strongly affects the net discharge of wastewater effluent. The total quantity of effluent discharged by ready mix plants is substantially reduced when settled water is used for drum washout.

Information on the current specific water treatment and reuse practices at B.C. ready mix facilities is not available on an industry-wide basis. Environment Canada's study summarized practices at 17 facilities (November 1987), and this information was updated for 7 facilities which were surveyed for this study. Discussions with B. C. plant operators, chemical suppliers and other industry personnel indicates that reuse of clarified water for drum washout is



Conversions (2):
5.2 cubic meters/Truck; 4.2 trips/day; 22 cubic meters concrete/Truck

References:
1. USEPA, Guidance Document for Effluent Limitation Guidelines and New Source Performance Standards for the Concrete Point Source Category, 1978
2. H.L. Harger, A System for 100% Recycling of Returned Concrete: Equipment, Procedures, and Affects on Product Quality, NRMCA Publication No. 150, 1975
3. R.C. Meninger, Disposal of Truck Mixer Wash Water and Unused Concrete, NRMCA Publication No. 116, 1964
4. USEPA, Wastewater Treatment Studies in Aggregate and Concrete Production, PB-219 670, 1973

FIGURE 2: Summary of water use data for batch ready mix concrete plants

commonly practiced. However, most plants use fresh water for:

- exterior truck washing (to avoid residues),
- batch water (many producers consider that water reuse adversely effects the concrete quality), and
- the production of hot water for winter use (heaters and boilers cannot accommodate the high suspended solids of reused water).

Although zero discharge of effluent is rare in B.C. plants, at least one facility in the Lower Mainland collects all wastewater and surface runoff from the process area of the site and operates with no effluent discharge through most months of the year[6]. The operators of this facility have not experienced product quality problems with total water reuse (although many facility operators have experienced or believe that they would have quality problems or would not be able to get the approval of customers for concrete which uses recycled water for batching).

The maximum allowable volume of process effluents at B.C. ready mix facilities is normally stipulated in Waste Management Branch Permits for facilities which discharge to waterbodies. However, most facilities do not have the capability to accurately monitor wastewater flows, and there do not appear to be reliable data for wastewater volumes generated at B.C. plants.

2.3.3 Wastewater effluent characteristics

pH

Available data for pH in effluent from B.C. ready mix facilities are based on limited monitoring at individual plants. One-time pH determinations made at the time of 1987 site visits to B.C. facilities, indicate that effluent from ready mix plants (as well as runoff from process areas) is frequently strongly alkaline.

The allowable pH of process effluents at B.C. ready mix facilities is normally stipulated in Waste Management Branch Permits for facilities which discharge to waterbodies. Although permits are written on a case-by-case basis, the specified allowable range generally falls within the range of pH 6.0 to 10.0. The Waste Management Branch Permit also normally requires the permittee to monitor the pH of effluent at least once quarterly. However, effluent pH is not correlated with wastewater flow, and monitoring may occur at periods of maximum wastewater dilution.

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6 Some surface runoff must be collected and disposed of off-site during periods of heavy rain.

A survey of permittee monitoring data for ready mix facilities in the Lower Mainland of B.C. indicates that some facilities discharge effluent within the terms for pH imposed by their permit, while others discharge effluent which is well outside allowable levels (with effluent pH levels ranging from 10.6 to 12.6). Discussions with 7 B.C. facility operators during 1989 site visits supporting this document did not identify any facilities which systematically or routinely control the pH of wastewater effluents.

SUSPENDED SOLIDS

No industry-wide data has been compiled on suspended solids in effluents from B.C. ready mix facilities.

The allowable level of suspended solids (or non-filterable residue) in process effluents at B.C. ready mix facilities is normally stipulated in Waste Management Branch Permits for facilities which discharge to waterbodies. Permits are written on a case-by-case basis, and the specified allowable suspended solids range from 50 to 125 mg/L for surveyed permits in Lower Mainland facilities. As with other effluent characteristics, the Waste Management Branch Permit also normally requires the permittee to monitor the suspended solids level of effluent at least once quarterly. However, effluent suspended solids levels are not correlated with wastewater flow, and monitoring may occur at periods of maximum wastewater dilution.

A survey of permittee monitoring data for ready mix facilities in the Lower Mainland of B.C. indicates that some facilities discharge effluent within the terms for suspended solids imposed by their permit, while others discharge effluent which is well outside allowable levels. Measured suspended solids levels range from <5 to 205 mg/L.

2.3.4 Waste solids disposal

Ready mix facilities produce sludges from the cleanout of settling basins, and waste solids from returned concrete. There are no available data for the quantities of sludges or solids generated by B.C. facilities.

Some permits for ready mix facilities specify that waste solids "shall be disposed of to a site" and/or "in a manner approved by the Regional Waste Manager." However, specific solids disposal methods have not been closely monitored and some ready mix facilities have sludge removed by contractors without knowledge of how or where the sludge is disposed.

3.0 Recommended design and operating practices

This document presents recommended practices which are intended to minimize environmental impacts of the ready mix concrete industry. The recommendations are intended as a guide to good operation, and often suggest several possible avenues for meeting the stated objectives. Operators and regulatory authorities should understand that each facility will have its unique operational problems and constraints. These constraints include such factors as facility age, condition, location, topography, subsurface geology, proximity to sensitive water bodies, financial resources, and ability of managers and workers. Existing ready mix plants are obviously constrained by the nature and configuration of the existing physical facilities, and exact compliance with all specific recommendations is not expected. What works well for one facility may not be the best approach for another. Accordingly, the emphasis should be placed on meeting the stated objectives, by whatever means are effective (including innovative measures which may not be identified in the document).

3.1 Process effluent management

3.1.1 Objectives

The primary effluent management objective for ready mix facilities is to minimize the quantity and undesirable characteristics[7] of unavoidable effluent. Tables 3 and 4 present recommended practices for water use and process effluent management. These practices are grouped according to three categories:

1. WATER USE (TABLE 3), which summarizes practices to minimize the net use of fresh water,

2. WASTEWATER GENERATION (TABLE 4), which summarizes practices to maximize process water recycle (within constraints imposed by product quality requirements),

3. WASTEWATER TREATMENT (TABLE 4), which summarizes practices to maximize solids removal and recovery from wastewaters, and indicates the requirement to control effluent pH[8].

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[7] See Section 1.3.Undesirable characteristics include high pH and high suspended solids (the principal concerns), as well as high oil and grease levels and aquatic toxicity resulting from the release (e.g. through spills) of other chemicals which may be used and/or stored on-site.

[8] The need for wastewater treatment may be reduced or eliminated by maximizing recycle, reducing water use, minimizing contaminated stormwater, or discharging to sewer.

3.1.2 Water use for batching

Plant operators should consider the use of recycled water for batch water where possible (see Table 3). Although the use of settled, recycled water for drum washout is common at B.C. plants, reuse of water for batch water is rarely practiced in B.C. This practice is common in other jurisdictions; however, B.C. operators argue that the use of recycled water may influence concrete characteristics and/or the resulting product is unacceptable to customers because of CSA specifications.

In general, the industry believes that the use of recycled water as batch water is practical, but present CSA Concrete Standards prevent wide application of this practice. The B.C. Ready-Mixed Concrete Association should take this issue to the appropriate CSA committee.

3.1.3 Use of admixture stabilizers to eliminate drum washes

Table 4 recommends that plant operators consider the use of chemical stabilizers to eliminate or reduce drum wash water (subject to meeting CSA specifications as noted below). This recommendation is based on the recent official approval of a state department of highways and public transportation for this application[9]. The approved method significantly reduces the water required for drum wash. The method specifies 30 US gallons per drum wash, and enables holding the washwater in the drum overnight and reincorporating the washwater in the first batch of concrete on the following day. No addition of activator chemicals is required, and the procedure is considered to have no adverse effect on the subsequent concrete batches. The procedure has potential for substantial reduction of wastewater and waste solids and should be given serious consideration by ready mix plant operators.

Since the overnight drum wash water generated by this method will contain stabilizer chemicals, the BCRMA has expressed concern that reuse of this water in subsequent concrete batches may not comply with CSA Concrete Standards. Operators may elect to discharge the resulting wash waters to the solids removal system (rather than reusing the stabilized wash water for batching on the following day), and widespread application of the complete procedure may require revision of CSA standards. The B.C. Ready-Mixed Concrete Association should take this issue to the appropriate CSA committee.

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[9] September 25, 1989 approval of the South Carolina Department of Highways and Public Transportation "Policy for Stabilizer Agents and Methods for Mixer Drum Wash Water".

**TABLE 3: WATER USE:
Recommended Practices at Ready Mix Concrete Facilities**

WATER USE	**OBJECTIVE: Minimize contaminated effluent by minimizing net water use**
Minimize the need for wash waters:	Minimize truck exterior contamination by controlling dust losses during loading (Section 3.5) Minimize contamination of surfaces by controlling dust release (Section 3.5) and sludge storage pile drainage (Table 5).
Minimize net water use:	Restrict fresh water uses to: • truck exterior washoff • hot water production • batch water Use recycled process water and stormwater from paved process areas for: • truck drum washout • miscellaneous washdown operations Consider the use of recycled water for batch water (See Section 3.1.2: this reuse application is subject to operational and product quality constraints). Control truck exterior wash volumes (both quantity and effectiveness): • consider continuous spray (during loading) *versus* manual post wash • consider spray *versus* hose wash Install flow controls on freshwater sources • install flow restricting nozzles/spring-loaded triggers at wash stations • eliminate uncontrolled nozzles (continuous or unattended discharge) • consider mechanical control systems (preset volume delivery) Train employees to minimize water use • ensure that workers understand why water use controls are important (to reduce costs and environmental impact) • provide employees with incentives for water minimization • consider factors which may act against effective use of mechanical controls (for example, employees prolonging washout to maximize overtime pay or rushing washout to shorten after-hours cleanup) Provide monitoring/supervision of water use to reinforce the importance of controls and to verify their effectiveness

TABLE 4: EFFLUENT MANAGEMENT :
Recommended Practices at Ready Mix Concrete Facilities

WASTEWATER GENERATION	**OBJECTIVE:** **Minimize wastewater volumes and contaminant loadings**
Minimize contaminant loadings	Minimize contamination of surface runoff (from precipitation and washdown) by controlling dust release and sludge storage pile drainage. Control contaminant dispersal through good housekeeping and by minimizing vehicle traffic on contaminated site surfaces. (Consider at the design stage for new facilities).
Maximize water reuse	Minimize drum washout water • use reclaimed water • use multiple small-volume rinses rather than single large-volume rinses (series rinses are more effective and reduce total rinse volume) • consider the use of stabilizers to minimize washes (see text: Section 3.1.3)
WASTEWATER COLLECTION	**OBJECTIVE:** **Efficiently segregate and collect all contaminated waters**
Collect all wastewaters and contaminated surface runoff for treatment	Pave all site surfaces which are subject to contamination by concrete and ingredients (main plant areas including truck loading, slump racks, washout racks, sludge storage). Aggregate storage areas should not normally require paving. However, surface runoff which is discharged to waterbodies from aggregate storage areas must meet regulatory suspended solids limitations. Curb and grade paved surfaces to collect all wastewaters and contaminated runoff. Direct all contaminated waters to a wastewater collection basin/treatment system. Segregate paved process areas from plant areas not subject to surface contamination (consider potential contamination from both routine operations and spills during chemical delivery or other operations). Segregation can be provided through site layout, grading and curbing, and traffic control. Direct uncontaminated site runoff away from wastewater collection areas. Minimize traffic through contaminated waters by providing segregated drainage channels or by careful layout of traffic areas and collection basin location.
Provide adequate wastewater holding basins	Provide sufficient collection volume for contaminated waters to manage effluent in high precipitation periods. Design and contruct basins to minimize subsurface leakage (except where exfiltration is intended).
WASTEWATER TREATMENT	**OBJECTIVE:** **Treat all contaminated waters to effluent standards**
Treat unavoidable effluents	Provide effective solids removal for collected wastewaters. (For example, use a sloped concrete settling basin overflowing to a second basin). Neutralize discharges to surface waters to meet regulatory requirements for pH. (Provide equipment and training for effective routine pH monitoring). Discharge effluents to sewer rather than directly to the environment, where possible.
Optimize treatment effectiveness	Properly design and operate treatment systems within effective operating limits for hydraulic and solids loading. Regularly maintain treatment systems to ensure efficient operation. Monitor the performance of treatment systems to ensure effectiveness and compliance with regulatory requirements.

3.2 Solid waste management

The disposal of returned concrete and waste solids generated by wastewater settling systems is an expensive and troublesome problem for ready mix plant operators. This is particularly true for facilities located in congested urban areas. Appropriate disposal options are increasingly difficult to find, and the cost of concrete disposal has approached or exceeded the value of the concrete product in some North American areas. The practice of dumping waste concrete in a vacant lot or field is no longer sensible or appropriate.

Table 5 indicates acceptable methods for disposing of returned concrete (with preference for methods which utilize the value of the concrete). In addition, it is recommended that plant operators consider reincorporation of concrete returned at day end in subsequent batches as described below.

3.2.1 Use of stabilizers to allow reuse of returned concrete

Suppliers of admixture chemicals have developed procedures for stopping the set of returned concrete (with chemical stabilizers) to allow holding of the concrete in the truck for several hours. An activator can then be added to the mix to counteract the action of the stabilizer when the concrete is incorporated into the next regular batch. This allows leftover concrete to be reused the following day.

There is controversy about whether or not the quality of subsequent concrete batches is adversely influenced by this procedure and/or the resulting product meets CSA specifications (see also Section 3.1.2). Furthermore, the procedure is sensitive to the quantity and characteristics of the treated concrete, and the successful use of the method requires careful control in implementation.

Although this technique is not known to have official sanction in other jurisdictions, it offers significant potential for the reuse of returned concrete, and is worthy of consideration by plant operators who are prepared to use appropriate care and control in its implementation. However, it is likely that widespread use of the procedure will require acceptance in the CSA Concrete Standards.

3.2.2 Use of mechanical reclaim systems

Commercially available mechanical systems range from simple aggregate recovery to complete solids reclaim units. These systems are in widespread use throughout North America. However, the use of mechanical systems to reclaim aggregate or other solids from wastewaters and returned concrete is rare in B.C.

B.C. ready mix plant operators generally perceive mechanical systems to be expensive and high in maintenance requirements. Also, the slurry that remains after aggregate removal is difficult to manage and cannot currently be reused in concrete batches because of CSA Concrete Standards.

While mechanical systems clearly have a high capital and operating cost, the financial benefit of reclaiming material has not always been given due consideration. With the increasing expense and difficulty of concrete waste solids disposal, plant operators are urged to remain open to consideration of mechanical reclaim systems.

3.2.3 Disposal of other solid wastes

The disposal of concrete solids is the principal solid waste disposal problem at ready mix facilities. However, the disposal of other waste solids, including empty chemical containers and other refuse (such as discarded lead storage batteries) should be given appropriate attention, and Table 5 provides specific recommendations.

TABLE 5: SOLID WASTE MANAGEMENT:
Recommended Practices for Ready Mix Concrete Facilities

Solid waste generation		**OBJECTIVE: Minimize solid waste volumes**
	Disposition of returned concrete	*during daily operation:* Incorporate returned concrete in succeeding batches where consistent with product specifications and quality standards. *at day end:* In order of preference: • Use returned concrete for forming pre-cast concrete products • Recycle returned concrete (dried and ground) as roadbed or other fill • If unavoidable, find approved disposal for returned concrete (see below).
	Minimize waste solids	Eliminate or minimize the discharge of returned concrete to water recovery systems. • Use stabilizers to reduce drum wash waters where specifications permit (see text: Section 3.1.3). • Use stabilizers to eliminate returned concrete disposal where specifications permit (see text: Section 3.2.1). Stabilizers allow dayend returned concrete to be held overnight and incorporated in batches on the following day. • Consider installing mechanical solids removal systems (e.g. aggregate recovery systems) to recover solids from wastewater (Section 3.2.2).
Solid waste handling/storage		**OBJECTIVE: Provide secure storage/handling for waste solids**
	Sludge storage	Contain sludge storage piles from cleanout of settling basins and aggregate recovery systems: • Locate in paved areas with controlled drainage. • Confine sludge piles with retaining walls (for example, walls constructed of pre-cast concrete blocks). • Consider cover (e.g., roofing) to minimize drainage and leachate from piles in regions of high precipitation. Design and operate sludge storage piles to prevent or minimize sludge dispersal by vehicle traffic. Collect leachate and drainage from sludge storage piles and return to process water recycle/treatment systems. Immediately collect and contain spilled solids in ready mix truck loading areas.
Solid waste disposal		**OBJECTIVE: Provide sound, approved disposal for waste solids**
	Disposition of sludge	Use only approved methods of sludge disposition. In order of preference: • Reuse sludge (through recyclers) as roadbed or other fill. • Find approved disposal for unavoidable sludge; do not contract for removal to unknown disposal sites.
	Miscellaneous solid wastes	Obtain regulatory approval for disposal of any residue/sludge from bulk admixture chemical tanks. Consult admixture/chemical suppliers for proper rinsing and disposal of chemical containers (where used). Obtain WMB approval for disposal of admixture chemical containers. Do not discard contaminated chemical containers to conventional solid waste disposal bins without specific WMB approval. Provide proper collection and storage of hazardous and special wastes. For example, lead storage batteries must be contained and recycled (not dumped on-site or discarded to conventional solid waste disposal bins). Provide conventional refuse containers as required to maintain a clean and orderly site.

3.3 Chemical storage and handling

In addition to Portland cement, ready mix facilities use a variety of admixture chemicals as ingredients in concrete. In general, these chemicals are liquids which are supplied in bulk and stored in tanks in the batching area of the plant. Although many of these chemicals present relatively low hazards to the environment and workers, some admixture chemicals do have high aquatic toxicity and/or require worker protection and precautions in the event of spills or direct worker contact. Furthermore, concentrated muriatic (hydrochloric) acid (HCl) is commonly used at facilities for preparing dilute acidic wash solutions. Consequently, careful attention to chemical storage and handling of these chemicals is appropriate.

Table 6 presents recommended design practices for the admixture chemical storage areas at ready mix facilities. The general objective of these recommendations is to provide proactive spill prevention and containment for stored chemicals. The recommendations reflect good practices which are commonly applied (or required) for chemical handling and storage areas at industrial facilities. While these recommendations represent the ideal situation for a new facility, it should be relatively easy and inexpensive to implement many of the recommendations at existing facilities, or to implement measures which fulfill the intent of the objectives.

Table 7 presents recommended operating practices for the admixture chemical storage areas.

TABLE 6: CHEMICAL STORAGE AREAS:
Recommended Design Practices for Ready Mix Concrete Facilities

Design features	OBJECTIVE: To provide proactive spill prevention and spill containment features for stored admixtures
Tanks	• Select strong, corrosion resistant materials of construction (consult with chemical suppliers). • Immediately reinforce or replace bulging or malformed tanks. • Use only undamaged tanks in sound physical condition. • Mount tanks in paved, curbed containment areas (see "Spill Containment" below). • Mount tanks in stable positions and anchor securely. • Locate admixture chemical storage tanks in interior areas (shelter from the weather). • Protect tanks from mechanical impact. • Calibrate tanks and install accurate fluid level indication. ◊ see-through tanks can be calibrated directly on tank surfaces. ◊ If sight gages are installed, provide protection against impact and breakage, and install shutoff valves on gage connections. • Provide safe access for bulk delivery. • Provide good lighting in tank storage areas.
Spill containment	• Tanks should be installed on structurally sound, paved floors. • Provide curbing or diking to create containment areas. • Eliminate floor drains from tank containment areas (to prevent release). • Provide effective, liquid-tight spill containment for the largest tank (in multiple tank areas). • Ensure that incompatible chemicals are not placed in the same containment area. • Ensure that chemical release to a containment area will not damage equipment, tankage or piping. (e.g., release of muriatic acid) • If required, provide protection from freezing for chemical storage tanks.
Piping	• Design according to all applicable codes. • Properly engineer piping systems for sizing and reliability. • Select materials of construction in consultation with chemical suppliers. • Use sound, permanent piping throughout chemical delivery systems. • Provide visible, accessible piping with a simple layout (to facilitate leak detection & repairs). • Avoid buried, sub-floor or concealed piping. • Provide mechanical impact protection for vulnerable piping. • Clearly label piping systems and valves for each chemical. • Ensure that leaks or releases from piping systems will be contained (i.e. captured by the tank storage containment system). • If required, provide protection from freezing for piping.
Spill prevention	• Provide reliable, accurate level indication on all tanks. • Provide mechanical impact protection on glass sight gages (including provision for containing and stopping release from broken gage tubes). • Install shut-off valves on all rupturable lines and tank gages.
Backflow prevention	• Ensure that backflow of chemicals to city water lines cannot occur.
Shelter	• A dry, sound interior location for chemical storage tanks is preferred.
Security	• Provide security precautions to prevent vandalism or access by unauthorized persons. • Install locking valves on all side or bottom drain/fill valves.
Emergency response	• Provide accessible spill response equipment and personnel protection equipment. • If appropriate, advise the local fire department in writing of the location and contents of chemical storage areas. • Train and reherse personel to implement the contingency plan.
Chemical delivery	• Top fill connections are preferred for liquid delivery (to prevent mischievous release). • Provide a curbed, impervious loading pad which drains to a containment area and/or which can be blocked from releasing spills to water collection systems. • Locate chemical loading areas away from high yard vehicle traffic areas. • Restrict access to loading area during chemical delivery. • Provide mechanically secure connections for lines between delivery vehicles and tanks. • Provide good visibility of the delivery system from the point of delivery (to avoid overflow).
Signs	• Provide clear and accurate signing in all chemical storage areas. • Identify the contents of all tanks and indicate hazards. • Prominently display personnel safety practices and first aid procedures. • Prominently display emergency response procedures. • Prominently display emergency telephone numbers for medical aid, facility management, environmental control agencies.

TABLE 7: CHEMICAL STORAGE AREAS:
Recommended Operating Practices for Ready Mix Concrete Facilities

Operating practices:	OBJECTIVE: Use operating practices which protect worker health and the environment
Personnel training	• Provide appropriate training for on-scene supervisors and designated personnel who handle chemicals. Include : ◊ awareness of hazards and concerns for handling each chemical ◊ spill/emergency response procedures • Provide Material Handling Data Sheets for all hazardous chemicals stored and used at the facility. • Provide explicit written safety and handling procedures for chemical storage and handling practices.
Chemical delivery	• Require that chemical delivery is undertaken only by personnel who are trained and qualified in chemical handling and emergency response procedures. • Restrict access to the chemical loading area during chemical transfer operations. Prohibit nearby pedestrian or vehicle traffic. • Require monitoring of all filling and transfer operations (to avoid overfilling)
Chemical access	• Limit access to chemical storage areas to designated, trained personnel.
Housekeeping	• Define and practice good housekeeping practices for keeping the site clean and free of debris. • Require thorough rinsing and proper disposal of empty chemical containers (consult chemical suppliers for recommended procedures). • Identify special wastes (e.g., discarded lead storage batteries) and ensure proper disposal. Do not dump special wastes to ground in refuse piles. • Routinely inspect the chemical storage area for leaks or spills. Daily inspection is recommended. • Immediately contain leaks and and repair the source.
Spill response	• Prepare a written contingency plan for chemical spill response. • Train and rehearse personel to implement the contingency plan. • Ensure that appropriate spill response and personal protection equipment is readily available on-site.
Fire response	• Liaise with the local fire department concerning chemicals in use and appropriate emergency procedures if a fire were to occur in the chemical handling area. • Make advance preparation to prevent or contain chemical release which might occur during firefighting activities.

3.4 Stormwater management

Table 8 presents recommendations for managing stormwater at ready mix facilities. The general objective of stormwater management is to minimize the contamination of stormwater. Where contamination is unavoidable, stormwater should be collected, contained and reused or treated before discharge.

Where aggregate has been washed (generally the case), it is anticipated that stormwater from aggregate storage areas will not contain problem levels of suspended solids. As noted in Table 4, paving of aggregate storage areas is not required. However, operators should take care to ensure that regulatory suspended solids limitations are met if surface runoff from aggregate storage areas is discharged to waterbodies.

The prevention of stormwater contamination (through diversion of precipitation from process areas) is particularly important in areas of heavy rainfall (such as the Lower Mainland of B.C.). Precipitation can generate unmanageable quantities of stormwater on a large site. Furthermore, maximum stormwater generation in these areas occurs during the winter months when hot water use requires fresh water and the potential for water reuse is reduced.

TABLE 8: STORMWATER MANAGEMENT : Recommended Practices for Ready Mix Concrete Facilities

Stormwater management	**OBJECTIVE:** **Minimize stormwater contamination**
Isolate contaminants from stormwaters	• Pave all process areas where concrete ingredients are stored or handled (including truck loading, slump racks, washout racks, sludge storage). • Segregate and collect drainage from the process area (see Table 4). • Prevent or promptly control releases of portland cement, concrete fines, and admixture chemicals to avoid dispersal ◊ minimize spills ◊ promptly clean up spills
Minimize stormwater volume	• Divert uncontaminated stormwater from the process areas of the site • Minimize the area of the process portion of the plant
Contain and control storm-water	• Control drainage (slopes, curbs) to collect contaminated stormwater in a separate, properly-sized settling basin ◊ size basin to provide settling for a maximum 10-year precipitation event • Contain clarified stormwater and recycle • Stormwater pH adjustment is not required for clean, segregated stormwater • An engineered infiltration basin is an alternative to unavoidable discharge of contaminated stormwater off-site

3.5 Control of concrete dust emissions

The presentation of detailed recommendations on the control of air emissions from ready mix facilities is outside the scope of this document. However, dust emissions may be limited by regulatory permit. Furthermore, visual observations during 1989 at 7 ready mix facilities (in support of the current document) indicated that poor control of dust emissions can create a nuisance problem as well as generally contributing to surface dust which eventually finds its way into washdown waters or stormwaters. It is difficult to assess the quantitative significance of air emissions to particulates loading in effluents from ready mix facilities.

The Ministry of Environment normally stipulates 230 milligrams/cubic meter for the allowable level of particulate matter in discharges from baghouses, which are the usual emissions control devices for silos at ready mix facilities. The Ministry also normally requires suppression of fugitive dust to levels 2.9 milligrams/sq. decimeter/day. The Ministry has not generally required air emissions monitoring at ready mix facilities, and quantitative data for B.C. facilities have not been collected. However, normal dustfall levels at one B.C. plant were determined to be <2 milligrams/sq. decimeter/day, and the visual assessments of Ministry personnel indicate that dustfall is not considered to be a compliance problem at most B.C. plants.

Table 9 presents the limited available quantitative information on air emissions from ready mix concrete facilities in other jurisdictions. The only point source of particulate emissions is the transfer of cement to the storage silo; some type of emission control (e.g., venting to a fabric sock or baghouse) may be applied to this emission. All other emissions are from fugitive sources, including sand and aggregate transfer, mixer and/or truck loading operations, vehicular traffic, and wind erosion from sand and aggregate storage piles.

Table 9 indicates that the total uncontrolled particulate emissions from a truck mix facility are of the order of 0.20 pounds of particulates/cubic yard of concrete produced. These emissions would consist of all concrete ingredients (e.g. sand, aggregate and cement). A conservative interpretation of the data (assuming that the composition of emissions from operations handling concrete are in the same proportion as the ingredients of concrete) suggests that emissions of concrete particulates would be 0.08 pounds/cubic yard of concrete produced.

Plant operators should generally strive to reduce dust emissions throughout the facility. This requires consideration of measures including:

- the installation of effective dust removal devices on vents from pneumatic or mechanical transfer operations,
- the use of curtains or socks for truck loading operations, and
- the use of water sprays to remove fugitive emissions from truck loading operations.

It is also recommended that plant operators take measures to prevent dusts or solids from being dispersed throughout the plant site by vehicular traffic. This requires care to prevent dusts or spilled solids from being released to or accumulating on traffic surfaces. This is consistent with recommendations of Sections 3.1 and 3.2 to minimize contamination of surfaces and dispersal (through vehicular traffic) of concrete solids during mixing operations at facilities.

Table 9: Estimated Air Emissions from Ready Mix Concrete Facilities

Source	Estimated emissions to air pounds/cubic yard		
	Sand and aggregate	**Cement**	**Concrete**
Sand and aggregate transfer to elevated bins	0.05		0.05
Cement unloading to elevated storage silo		0.07	0.07
Weigh hopper loading	0.035	0.005	0.04
Truck loading (truck mix)	0.035	0.005	0.04
TOTAL EMISSIONS (Truck Mix)	0.12	0.08	0.20

Based on information in a private communication: R. Rhoads, USEPA to R Morris, NRMCA, 8 April 1985 (Regarding revisions to USEPA Document AP-42, Compilation of Air Pollutant Emission Factors)