

REPORT OF FINDINGS

State-Wide Portland Cement Concrete Waste Supplemental Study

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**CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)
STATE-WIDE PORTLAND CEMENT CONCRETE WASTE SUPPLEMENTAL STUDY
REPORT OF FINDINGS**

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SECTION 1.0

INTRODUCTION

1.0 INTRODUCTION

Bryan A. Stirrat & Associates, Inc. (BAS) has been retained by the California Department of Transportation (Department) to perform an investigation to identify the typical characteristics of Portland Cement Concrete (PCC) wastes generated from Department projects. In the past years, it has become increasingly difficult to find appropriate and logistically feasible disposal locations for PCC waste products. In particular, the Department wished to address specifically the waste generated from pavement grinding, grooving, and saw cutting operations. The waste stream generated from these operations includes both slurry and liquid components.

In order to address these issues, the Department has asked BAS to conduct a field program in order to collect samples for chemical and physical analysis, and to perform statistical data analysis associated with the field program necessary to reasonably characterize the waste stream described above. The field program was conducted in accordance with the *Waste Characterization Work Plan* (BAS, October 13, 2004) and the associated Health and Safety Plan (HSP), both of which were approved by the Department.

1.1 PROJECT BACKGROUND

The Department performs a myriad of construction and repair projects throughout the State of California. Working with PCC in some fashion is almost always a part of these projects, and as a result, PCC related wastes are generated. The type and quantity of waste generated depends on the scale of the project and the activities being performed, such as new concrete pours, surface grinding operations, and saw cutting. However, in general, the wastes are comprised of a slurry component (a solid waste containing fine powder from grinding and saw cutting operations) and a liquid component (potentially high pH water with suspended solids from these same operations).

In the past, the need for disposal of the liquid component of these wastes was mitigated through either evaporation or infiltration into underlying soils in unlined washout pits. However, current practice on Department projects is to line washout pits with plastic sheeting, thereby eliminating infiltration and resulting in a net increase in the quantity of PCC liquid waste generated, unless prior approval to allow infiltration has been obtained from the appropriate Regional Water Quality Control Board. Although it has been the contractors' responsibility on these projects to dispose of both slurry and liquid PCC wastes that are generated, it has become

difficult to find appropriate and logistically feasible disposal locations for PCC waste products associated with construction activities. In addition, certain RWQCBs have expressed¹ concern regarding the potential presence of hexavalent chromium (Cr⁺⁶) in PCC wastes.

In 2003, the Department issued Task Order #1 to BAS to evaluate, through identification and review of available published studies and documents, typical PCC waste product constituent levels and identify disposal sites and methods to meet the needs of construction projects within the Department right of way. Results of that Task Order were summarized in two technical memoranda, the first of which made the following findings and conclusions regarding the characteristics of PCC wastes.

Although there are emerging concerns regarding Cr⁺⁶ in Portland Cement and PCC wastes, there are no existing studies that have shown either material to contain Cr⁺⁶ at concentrations above currently established State or federal hazardous waste levels. As a result, for disposal outside of the right of way, at this time there is no need to consider PCC wastes to be comprised of anything other than:

- Solid PCC Wastes: Typical solid inert PCC construction/demolition debris (e.g., concrete with typical mix additives) free of rebar, wood or other debris, and free of any other outside contamination, which can be re-used, sent to a Class III disposal site or concrete recycling facility;
- Liquid PCC Waste: A high pH, non-hazardous liquid waste, which can be neutralized on-site under DTSC² and RWQCB approvals; be disposed of at a Class II off-site disposal facility, or be treated at an off-site recycling/treatment facility. (This material could also be sent to a Class I facility, however this is not recommended due to the fact that the waste is not considered either a State or Federally defined hazardous waste and disposal at a Class I facility would result in an unnecessary increase in future liability). If on-site treatment is being considered, appropriate NPDES permits and/or site specific waste discharge requirements (WDRs) would have to be negotiated with the local RWQCB on a case by case basis before discharging treated water.
- Slurry PCC Waste: A combination of solid and liquid PCC waste but considered a solid waste, which can be neutralized on-site (if necessary) under DTSC and RWQCB approvals; disposed of at Class II off-site disposal facility, or sent to a permitted recycling facility, which accepts this waste stream. (This material could also be sent to a Class I facility, however this is not recommended due to the fact that the waste is not considered either a State or Federally defined hazardous waste and disposal at a Class I facility would result in an unnecessary increase in future liability). If on-site treatment or disposal is being considered,

¹ Regional Water Quality Control Board

² Department of Toxic Substances Control

site specific WDRs would need to be established with the local RWQCB on a case by case basis. The WDRs would likely include requirements and restrictions on the type and quantity of waste discharged, the drying of the waste prior to disposal, the lining of the disposal pit(s), and the capping of the disposal pit. Because the primary concern with regard to the waste material is pH level, long term monitoring is not likely to be required. However, a long term post-closure maintenance program for the disposal pit will likely need to be developed to ensure its integrity.

The second memorandum prepared under that Task Order identified potential disposal sites for slurry and liquid PCC wastes throughout the state.

Subsequent to completion of Task Order #1, the Department determined that more specific information was required regarding the typical characteristics of both slurry and liquid PCC wastes being generated through concrete grinding operations. As such, under the scope of work outlined in Task Order #8, the Department authorized BAS to proceed with this portion of the project, objectives of which are summarized below.

1.2 PROJECT GOALS

The purpose of this investigation is to determine the typical characteristics of PCC waste from the Department PCC grinding projects through the task specific objectives:

- To collect samples of PCC grinding waste for analysis,
- To perform chemical analyses,
- To perform statistical analysis on the data generated, and
- To report the findings which shall be used as a representative waste characterization for future PCC grinding projects.

1.3 SITE LOCATIONS AND DESCRIPTIONS

In order to achieve the project goals as delineated in Section 1.2 a total of six sampling events were conducted at the following Department right of way locations and dates:

- District 8, on the southbound lanes of Interstate 15, north of Interstate 210 and south of Interstate 215, near the cities of Fontana and Rancho Cucamonga on October 26, 2004. (EA 08-0A4224)
- District 3, on northbound Interstate 5, between State Highway 91 and Interstate 605 in the City of Norwalk, on November 1, 2004. (EA 07-226204)

- District 3, on the northbound lanes of Interstate 5, between Florin Road and Franklin Road in the City of Sacramento, on November 5, 2004. (EA 03-2M0804)
- District 7, on the northbound lanes of State Route 101 between Ventura and Santa Barbara, on November 18, 2004. (EA 07-193004)
- District 7, on the southbound lanes of State Route 101 between Ventura and Santa Barbara, on December 21, 2004. (EA 07-193004)
- District 8, on the westbound lanes of Interstate 10, just west of the intersection of Interstate 15, and Interstate 10, in the City of Ontario, on January 19, 2005. (EA 08-0A1803)

Figures 1 through 6 shows each of the above listed sampling locations. Additional site specific information and observations are included in Section 2.0.

SECTION 2.0

FIELD ACTIVITIES

2.0 FIELD ACTIVITIES

The goal of the field activities was to collect representative PCC grinding residue samples from representative construction sites within Department rights-of-way where pavement rehabilitation and installation projects were ongoing. To determine typical characteristics of waste generated during PCC grinding operations within Department rights-of-way, BAS collected grab samples of typical liquid and slurry waste from six different PCC grinding operations within three Department Districts (Districts 3, 7, and 8) as directed by the Department. Photographs illustrating typical sampling areas, waste material, and other project related activities are included in Appendix A.

Based on site availability and construction scheduling, the Department directed BAS to conduct one sampling event in District 3, three sampling events in District 7, and two events in District 8. Sampling occurred within these Districts on different construction projects with one exception. Two sampling events were conducted along Route 101 in District 7 during the same construction activity, and samples were collected from the same fixed processing facility used for the entire construction. However, sampling events were conducted over one month apart to allow for progression of the grinding operation to an area of potentially different characteristics. To the greatest extent possible, the sites were selected to represent a variety of PCC sources and mix designs throughout the state. During sample collection, both slurry and liquid samples were collected directly from vacuum trucks that collected the waste at the site. As described in further detail below, it was necessary to collect the samples from the discharge of the trucks at the disposal locations and not during waste generation at the sites.

Typical PCC grinding and waste collection machinery is shown in Photograph 1. This orientation, the PCC grinder leading the vacuum truck, was observed at each of the sampling sites. The PCC grinders observed were computer operated and typically guided by a technician who walked with the grinder during operation. The technician makes any necessary adjustments to ensure proper equipment operations and is responsible for any related safety issues. A large water tank, which acts as ballast, is part of the grinder but does not contribute water to the operation. All water required for the grinding operation is provided by the vacuum truck. As the grinder levels the PCC surface, the spent water and PCC waste are pumped into the vacuum truck. This water is reused for grinding operations by recycling it from inside the vacuum truck's holding tank. The water is separated from the solids by passing it through screens and/or bevels separating the internal compartments

within the truck. Fresh water is typically located in the front compartments of the truck prior to grinding and the waste generated is pumped into the rear of the truck via two separate hoses (inlet and outlet) connected from the grinder to the tanker (Photograph 3). The PCC grinding operation continues until the water within the truck becomes too turbid to allow for spraying onto the working surface. One truck is typically capable of approximately two hours of operation before being taken off-line. One to two standby trucks are typically available at the site to ensure that the grinding operation is uninterrupted. Once taken off-line, the trucks typically leave the construction site immediately and transport the waste to a designated disposal or recycling facility.

Initially, attempts were made to collect samples of the waste material directly from the trucks at the construction sites. However, it was determined early in the project that this resulted in undo delays for the transporters, created health and safety concerns at the construction site, and did not result in the collection of truly representative samples. Subsequent attempts to collect the liquid and slurry waste samples from the trucks as they discharged their loads at the designated disposal sites proved to be a more efficient sample collection strategy.

The majority of the sampling activities occurred during night-time hours and in the presence of active operating equipment at often remote disposal sites. Consequently, all sampling activities were conducted by a team of two field personnel. One team member collected the samples while the other took notes and acted as a look-out, monitoring the surrounding field activities to ensure the safety of the sampler. The following sections outline further specifics regarding the protocol that was implemented during field activities. Arrangements for access and sampling were made with the Department's Resident Engineer on each project being sampled prior to arrival at each designated site.

2.1 OVERALL FIELD OBSERVATIONS

Upon arrival at a designated site, BAS field personnel performed a preliminary site survey to determine whether any conditions existed at the site or in the surrounding area that may impact sample collection and/or the analytical results. In particular, BAS field personnel identified on-site or nearby potential contaminant sources (if any) which may have affected the results of the proposed sampling and analyses. In performing each initial site survey and reconnaissance, observations were made regarding the overall site conditions, and the specific waste generation activities being conducted. This information was recorded on preprinted field sampling logs (Appendix B). At a minimum, the following information was noted regarding each sites activities:

- Site location (highway number)
- Project EA
- Department Project Description and Contact Person
- Department Site Construction Manager
- Construction activity generating PCC waste
- Contractor(s) performing this construction activity
- Equipment used to generate PCC waste (make/model/ID#)
- Condition of equipment
- Other activities being performed at the site
- Time of day, temperature, and weather conditions when waste-generating construction activities occurred
- Original PCC source(s), if known
- Original aggregate and cement sources, if known
- Original PCC mix specification(s), if known
- On-site location from which PCC waste was generated
- Type of PCC waste being generated
- Method of PCC waste storage/stockpiling
- On-site location of PCC waste storage and/or stockpiling
- Identification of any on-site or nearby potential contaminant sources
- Estimated rate of water usage (gal/meter²) in the grooving, grinding, or saw-cutting process

2.2 SAMPLE COLLECTION

During the period from October 2004 through January 2005, a total of 27 liquid samples and 27 slurry samples were collected for chemical and physical analyses. The objectives of the analyses were to determine composition of typical PCC grinding liquid and slurry waste. With the exception of the initial sampling event during which sample collection procedures were refined, five (5) liquid and five (5) slurry samples were collected during each sampling event. Slurry and liquid samples were collected from either the discharge piping (Photograph 4) of the truck, or from the top hatch covers of the trucks (Photograph 5) prior to discharge. All sampling equipment was decontaminated prior to use and between samples and sampling events. Decontamination procedures included washing with a non-phosphate detergent

solution followed by a double rinse with de-ionized water. The sampling equipment was allowed to air dry prior to use.

All samples were labeled, placed in zip-lock bags, and stored on ice in coolers immediately upon collection. All sample labels included the following information: sample ID, laboratory analysis, date, project ID, and sample collector name as required by EPA sampling protocol. Chain-of-Custody (COC) forms were filled out for each sampling event and accompanied all samples during transport to the laboratory (Appendix C).

2.2.1 Slurry Sample Collection

In general, slurry samples were collected by placing a clean five-gallon plastic bucket into the discharge stream from the truck outlet piping and then digging directly into the slurry material with a stainless steel and/or disposable polyethylene sampling trowel and transferring the material directly into new clean glass sample jars and/or plastic containers with Teflon lined lids. If liquid samples were collected from the same bucket, solid material was allowed to settle to the bottom of the buckets prior to liquid sample collection. The setting time for each sample collected varied based on field conditions and visual observations.

In order to collect material that was representative of the waste produced, BAS personnel collected approximately 15-gallons of waste material discharge from each truck. Prior to discharge, the truck operator, as part of standard practice, typically "stirred" the tank with pressurized air to ensure the PCC grindings became entrained in solution and to prevent clogging of the discharge piping.

Photograph 6 in Appendix A shows a typical discharge pipe from a vacuum truck used to collect and transport the PCC waste. Photographs 7 and 8 show a typical off-site disposal site where the PCC waste was discharged into lined pits. Photograph 9 shows typical sample collection taking place.

2.2.2 Liquid Sample Collection

Liquid samples were collected prior to slurry samples by submerging the clean, laboratory supplied containers with appropriate preservative(s) below the surface of the liquid waste within the five-gallon buckets. All containers were immediately

labeled and placed in field coolers containing ice. All sample containers were filled completely with no head space to the best extent possible. Most samples were collected with little or no problem. However, in some instances the sample reacted with the preservatives resulting in the unavoidable presence of head space in some containers. This reaction was not determined by the analytical laboratory to have affected or compromised the samples. Samples were transported to the testing laboratory under COC protocol as described above.

2.3 SPECIFIC SITE SAMPLING

In order to accurately characterize the PCC waste, five liquid and five slurry samples were collected from five of the Department designated sites and two liquid and two slurry samples were collected from the sixth site. Frequency of sample collection for any particular site was determined in the field based on the quantity of PCC waste being generated, the disposal/recycling facility conditions, discharge procedures at the disposal/recycling facility, and input from the Department Task Order Manager. In general, sampling procedures were selected to represent the greatest amount of PCC waste being generated at the site. Whenever possible, each truck was sampled from the top entryways prior to discharge. If necessary, samples were collected from the discharge piping.

Site-specific relevant observations for each sample collection site for this study are provided below. Field logs included in Appendix B provide pertinent data taken for each site.

2.3.1 Interstate 15, District 8 – 10/26/2004

This sampling event was the initial field event for this project and knowledge gained was applied to later sampling activities. Specifically, it was determined, through consultation with the Department, that the initial sample collection strategy of collecting samples at the grinding site was not feasible due to the nature of the material. After repeated unsuccessful attempts to collect a representative slurry sample it was decided that sample collection at the grinding site was resulting in undo delays in the transport of the material to the disposal site and that these delays could impact the completion of the grinding project. As a result, a revised sampling strategy was developed where samples were collected from the discharge of the truck at the disposal site. This technique proved more successful. However,

because of the time that was expended in developing this sampling strategy only two samples could be collected during this event.

According to the Department representative on-site, the PCC pavement being ground during the sampling event was approximately twenty-five years old. No nearby potential contamination sources were identified at this location. The PCC grinder emitted some notable steam during the grinding process (Photograph 10) but the roadway was never saturated with water. Photograph 11 illustrates the typical depth and width of the grooves created by the grinding process at this site and is typical of all of the sites.

The slurry waste samples generated at this location were grey in color, slightly viscous, and warm (approximately 70° F). The slurry appeared slightly foamy and resembled dirty water. Sample material was obtained from the rear and side discharge piping from the trucks at the disposal site. Three five-gallon buckets of material were obtained for each sample collected. The liquid samples were collected from the decant of the bucket prior to collection of the slurry samples.

2.3.2 Interstate 5, District 3 – 11/01/2004

According to the Department representative on-site, the PCC pavement being ground at this location was approximately twenty years old. Concrete slab removal work was occurring adjacent to the grinding operation at the time waste was being generated. There were no indications that this work in any way impacted the sample collection efforts and/or could potentially impact the quality of the material being generated or the samples being collected.

The slurry waste samples generated at this location were grey-dark grey color,¹ slightly viscous, and warm (approximately 75° F). Sample material was obtained at the disposal site from hatch covers on the trucks transporting the material. Samples were collected by lowering new clean five-gallon buckets into the truck's holding tanks. The liquid samples were obtained first from the decant water from the bucket. Slurry samples were collected from the material remaining in the bucket following collection of liquid samples.

¹ Note: All color references were made in the field based on the observations of the on-site engineer/geologist and are subjective.

2.3.3 Interstate 5, District 7 – 11/05/2004

According to the contractor's representative on-site, the PCC pavement at this location was approximately 20 years old. No site conditions were observed that would be considered potential contaminant sources. The slurry waste samples generated at this location were grey-dark grey color, slightly viscous, and warm (approximately 80° F). Sample material was obtained from hatch covers on the trucks transporting the material to the disposal site. Three five-gallon buckets were used to obtain representative waste material by lowering the buckets into the holding tanks. The liquid samples were collected from the decant water within the bucket. Slurry samples were collected from the residual material within the bucket.

2.3.4 Route 101, District 7 – 11/18/2004 and 12/21/2004

According to the Department representative on-site, the PCC pavement at this location was approximately ten years old. This site had a fixed (for the duration of the job) on-site PCC waste disposal/recycling unit. Trucks collected waste material and discharged it directly to the unit which was equipped with a large centrifuge that separated the solid and liquid material. The liquid material was then filtered and reused on-site. The solid material was sent through a shaker machine (King Cobra Shaker) to separate the fine and coarse materials. The fine, medium, and coarse material was discharged directly into plastic-lined 20-yard metal open bins. Once the bins were full, they were dumped into piles on-site and spread to accelerate the drying process. The dried material was later collected and used in new concrete batches.

The slurry waste samples generated at this location were light-grey color, semi-viscous, and warmer than other sites (approximately 85-90° F). Sample material was obtained from a truck discharge hose prior to connection to the recycling equipment. Three five-gallon buckets of material were obtained from each truck and samples were pulled from this material. Liquid samples were collected first from the decant water within the buckets. Slurry samples were collected from the residual material within the buckets. Froth and foam was noted in the material being discharged from the trucks. According to the contractor, this was due to additives put into the system to prevent the centrifuge from clogging. When obtaining the liquid samples at this site, it was noted by field personnel that the samples reacted

with preservatives in some of the containers. It is speculated that the clogging prevention additive was the cause for this reaction.

The samples obtained for grain size analysis at this location came from the three soil bins holding the fine, medium, and coarse material. The finer material was soft, gelatinous, plastic-like, and almost dry to the touch. The medium and coarse material was more clayey with a larger grain size.

2.3.5 Interstate 10, District 8 – 1/19/2005

This site represented the final sampling event for the project. According to the Department representative on-site, the PCC pavement at this location was well over 10 years old. The grinding occurred in the High Occupancy Vehicle (HOV) lane of the westbound Interstate 10. No site conditions were noted that may have impacted the quality of the PCC waste or the samples collected. The PCC waste was transported to the Cemex Facility in Riverside, California where it was unloaded into a large plastic lined open pit (Photographs 12, 13, and 14). The PCC waste samples were collected from the trucks prior to dumping into the pit.

The slurry waste samples generated at this location were grey color, and slightly warm (approximately 65° F). Sample material was obtained from the first flush of discharge from the trucks at the disposal site. Three five-gallon buckets of material were obtained and samples were obtained from this material. Liquid samples were collected first from the decant water within the buckets. Slurry samples were collected from the residual material within the buckets.

2.4 ANALYTICAL TESTING

All collected samples were sent to Amerisci Labs of Los Angeles, California, a State certified laboratory, for analytical testing. All testing methods, sample names, sampling dates, and analytes tested for are illustrated in Table 1 for all samples. The testing results and COCs for all analyte testing performed are found within Appendix C. The first slurry and liquid samples at each site location were also analyzed for a supplemental list of analytes.

Representative samples of the liquid PCC waste were analyzed for:

Analytical Testing for Liquid PCC Waste Samples

Standard Analyte List (All Liquid Samples)	Supplemental Analyte List (First Liquid Sample From Each Site)
CAM 17 Metals (EPA 6010/7000) Chrome VI (EPA 218.6) pH (EPA 150.1) TDS (EPA 160.1) Hardness (EPA 130.1) Alkalinity (EPA 310.1) TPH Carbon Chain (EPA 8015M) Oil & Grease (EPA 413.1) VOCs (EPA 8260B) SVOCs (EPA 8270)	Pesticides/PCBs (EPA 8081/8082) Fish Bio-Assay - Haz Waste Screen Total Organic Halides (EPA 9020B) Total Organic Carbon (EPA 415.1) Phenols (EPA 420.1) Chloride (EPA 300.0) Nitrate/nitrite (EPA 300) Sulfate (EPA 300) Sulfide (EPA 376.2) COD (EPA 410.4) TSS (EPA 160.2) Electrical Conductivity (EPA 120.1) Calcium (EPA 6010/200.7) Iron (EPA 6010/200.7) Phosphate (EPA 365.2) Phosphorus (EPA 365.2) Manganese, Magnesium, Potassium, Sodium, and Boron (EPA 6010)

Representative samples of the solid PCC waste were analyzed for:

Analytical Testing for Slurry PCC Waste Samples

Standard Analyte List (All Slurry/Solid Samples)	Supplemental Analyte List (First Slurry/Solid Sample From Each Site)
CAM 17 Metals (EPA 6010/7000) Chrome VI (EPA 7196) pH (EPA 150.1) TPH Carbon Chain (EPA 8015M) Oil & Grease (EPA 9071B) VOCs (EPA 8260B) SVOCs (EPA 8270)	Pesticides/PCBs (EPA 8081/8082) Chloride (EPA 300.0) Nitrate/nitrite (EPA 300) Sulfate (EPA 300) Iron (6010/200.7) Phosphate (EPA 365.2) Aluminum (EPA 6010) Grain Size Analysis (Gravel - Clay, w/ Hydrometer -ASTM D 422)

When necessary, given holding time restrictions, certain samples were analyzed by other state-certified laboratories. In addition to the analytical testing listed above, if a total concentration analytical result yielded a total concentration numerically in excess of ten times its established Soluble Threshold Limit Concentration (STLC)

and/or Toxicity Characteristic Leaching Potential (TCLP), leachability testing was performed. Results of analytical testing are included in Appendix C, and discussed in detail in Section 3.0.

All slurry samples were sent to GeoLogic Associates Laboratory of Diamond Bar, California for grain size analyses using ASTM D 422. Twelve (12) approximately 10-pound bags of solid grinding waste were sent to an independent lab, two (2) bags per sampling site location. All samples obtained for these analyses were obtained as composite samples from all available sources at each site location. Analyses and graphs from these data are included in Appendix E.

SECTION 3.0

SAMPLING RESULTS

3.0 SAMPLING RESULTS

The following sections present the results of the sampling and analysis activities described in Section 2.0. The discussions focus on the results obtained through laboratory analysis of the liquid and slurry samples and statistical analysis of the testing results.

3.1 ANALYTICAL TESTING RESULTS

Chemical laboratory analyses of liquid and slurry samples collected for this study were performed primarily by AmeriSci, a state-certified analytical laboratory, located in Los Angeles, California. In addition, certain analyses were also performed by Sequoia Analytical of Sacramento; Aquatic Bioassay and Consulting Laboratories, Inc. of Ventura; Advanced Technologies Laboratories of Signal Hill; and Associated Laboratories of Orange, California. All of these laboratories are state-certified analytical laboratories. Copies of the chemical analyses laboratory reports are included in Appendix C. Results of chemical analytical testing of the collected samples are summarized in Tables 1, 2 (A and B), and 3 (A and B).

Grain size analyses for slurry samples were performed by GeoLogic Associates, Inc. (GLA). Results of physical analytical testing of composited slurry samples are summarized in Table 4, with complete GLA laboratory reports included in Appendix D.

3.1.1 Liquid Analytical Testing Results

As presented in Table 1, all 27 liquid samples were analyzed for four general chemistry parameters, CAM 17 Metals, hexavalent chromium, petroleum hydrocarbons, and volatile and semi-volatile organics. Results of these primary analyses are presented in Table 2A. In addition, one sample from each sampling event was analyzed for supplemental general chemistry parameters, pesticides and PCBs. Results of the supplemental analyses only are presented in Table 2B.

Primary General Chemistry Parameters

As presented in Table 2A, pH of collected liquid samples ranged from 9.4 to 12.1. Only minor variations in pH levels were measured between samples collected during different sampling events, as well as in between samples collected from the same event. Within samples collected during the same sampling event, the most variation in pH level was measured in the samples collected from District 7, Highway 101, on December 21, 2004. The least variability was observed in samples collected in District 8 on Interstate 15 on October 26, 2004, and in District 3 on Interstate 5 on November 1, 2004.

Hardness of collected liquid samples ranged from 240 mg/L to 2,000 mg/L. Greater variations were observed in hardness levels than in pH levels, both between and within events. Hardness levels calculated for samples collected from District 7 on Highway 101 on December 21, 2004, were significantly elevated compared to levels for other sampling sites, although not statistically¹ different from results of sampling at the same location on November 18, 2004.

It should be noted that results of hardness testing could be greatly affected by the source water used in the grinding process.

Levels of total dissolved solids (TDS) in the collected liquid samples varied from 440 mg/L to 5,400 mg/L. Similar to hardness, significant variations in concentrations were observed, especially for samples collected from different sampling events. TDS levels for samples collected from District 3 on Interstate 5 on November 1, 2004, and District 8 on Interstate 10 on January 10, 2005, are significantly lower than concentrations measured for the rest of the samples.

Among the collected liquid samples, alkalinity concentrations ranged from 48 mg/L to 30,000 mg/L. Even more so than the TDS levels, alkalinity varied greatly between samples collected on the same day, as well as samples collected from different sampling events. Nonetheless, alkalinity levels measured for samples collected in District 7 on Interstate 5 on November 5, 2004, were substantially elevated compared to the rest of the collected samples.

¹ Statistical data evaluation is discussed in Section 3.2

Supplemental General Mineral Parameters

As presented in Table 2B, with the exception of sulfide, which was not detected above its PQL in any of the samples, all other supplemental analytes were detected in at least one sample. Ortho-phosphate and manganese were detected above their respective laboratory practical quantitation limits (PQLs) in only one sample each. With the exception of phenols, the concentrations of which were similar between all samples, the levels of other analytes varied greatly between sampling events.

None of the liquid samples used for fish bio-assay testing resulted in fish mortality.

Metals

No detectable concentrations of silver or beryllium were determined to be present in any of the collected liquid samples. Similarly, with the exception of only two samples (collected from different sites), levels of antimony and thallium were below their respective laboratory PQL in all of the collected liquid samples. Conversely, detectable levels of barium, total chromium, vanadium and zinc were found in all of the collected samples. With only a few exceptions, detectable levels of arsenic, cobalt, copper, nickel, selenium and hexavalent chromium were also present in the majority of liquid samples. The remaining analytes were detected in some, but not a majority of the samples above their respective PQLs.

As with general mineral analytes, metal concentrations varied both between and within sampling events. These variations are considered to be reflective of variations in natural cement composition, as well as variations in the water used in the grinding process.

Relative concentration of hexavalent to total chromium ranged from less than 1% to more than 150% in liquid samples. The latter ratio is considered to be an outlier², without which concentrations of hexavalent chromium reach up to 65% of total chromium levels. In samples collected from District 3 on Interstate 5 on November 1, 2004, and District 7 on Interstate 5 on November 5, 2004, this ratio was less than

² Due to significant differences associated with analytical methodology used for total chromium (acid digestion, ICP analysis) and hexavalent chromium (WET extraction, UV analysis), as well as low levels at which both analytes were detected, a ratio of concentrations greater than 100% is not of concern.

15%, although total chromium levels in the November 1, 2004, samples were somewhat higher than for samples collected during other events. These results indicate that hexavalent chromium concentrations can not be predicted by the total chromium levels.

Organic Constituents

As presented in Table 2A, no detectable concentrations of Total Petroleum Hydrocarbons (TPH) of gasoline, diesel or oil ranges were found in any of the liquid samples. Minor concentrations of Oil & Grease were detected in 18 out of 27 collected samples.

With the exception of several detections of chloroform and 1,2,4-trimethylbenzene (TMB) in several samples, no other VOCs were detected in the majority of collected liquid samples. With one exception, all detections of both chloroform and 1,2,4-TMB were measured in samples collected in District 3 on Interstate 5 on November 1, 2004.

Similar to VOC detections, only a handful of semi-volatile compounds were detected in the collected liquid samples. Benzoic acid was detected in 5 samples, benzyl alcohol in three samples, phenol in two samples, n-nitroso-di-n-propylamine and 2-nitrophenol in one sample each.

As presented in Table 2B, neither organochlorine pesticides nor PCBs were detected in any of the liquid samples analyzed for these parameters.

3.1.2 Slurry Analytical Testing Results

As presented in Table 1, all 27 slurry samples were analyzed for pH, CAM 17 Metals, hexavalent chromium, petroleum hydrocarbons, and volatile and semi-volatile organics. Results of these primary analyses are presented in Table 3A. In addition, one sample from each sampling location was analyzed for supplemental general chemistry parameters, pesticides and PCBs. Results of the supplemental analyses are presented in Table 3B. A slurry composite for each sampling location was analyzed for grain size distribution, results of which are presented in Table 4.

General Chemistry Parameters

As presented in Table 3A, pH of collected slurry samples ranged from 9.3 to 11.8. Similar to liquid samples, only minor variations in pH levels were measured between samples collected during different sampling events, as well as in between samples collected from the same event. With regard to samples collected during the same sampling event, the most variations in pH levels were measured during the event in District 8 on Interstate 10 on January 19, 2005. The least variability was measured in samples collected in District 8, on Interstate 15 on October 26, 2004, and in District 3 on Interstate 5 on November 1, 2004, which is the same as for liquid samples. In general, pH of slurry samples was slightly lower than that of liquid samples.

Similarly to the liquid samples, and as presented in Table 3B, no orthophosphate was detected above its PQL in any of the slurry samples analyzed. With regard to the remaining general mineral parameters, a great variability was measured in all analytes, as was the case with the liquid samples.

Grain Size Analyses

100 percent of all grains tested passed the #4 sieve size with the largest grain size obtained appearing just before the #8 sieve size. The grain size decreases approximately logarithmically at a rate of 0.1 mm per 10 percent decrease. Approximately 5 - 10% (by weight) of the material passes the #200 sieve size. Each sieve test by shaker machine took approximately 1440 minutes (24 hours).

Metals

In general, detections of metal analytes in slurry samples were similar to those detected in liquid samples, although PQLs for some slurry samples were elevated due to significant matrix interferences, such as high buffering capacity of several samples, which affected sample preparation (acid digestion).

As shown on Table 3A, no detectable concentrations of silver or beryllium were determined to be present in any of the collected slurry samples. In addition, cadmium, mercury and thallium were likewise undetected in all of the slurry samples. Also similar to liquid samples, antimony was undetected in all slurry

samples, but one. Unlike the liquid samples, arsenic and selenium, were undetected in a majority of slurry samples, whereas the same analytes were detected in a majority of liquid samples. It is therefore possible that detections of arsenic and selenium in liquid samples are attributable to the water used in the grinding process rather than the PCC itself.

Barium and zinc were found above their respective PQLs in all slurry samples. The remaining analytes were found in the majority of collected samples.

Among all metal analytes, only one sample, PCC-08-010-S-2 collected from District 8 on Interstate 10 on January 19, 2005, exceeded 10-times the STLC³ value for lead. In addition, sample PCC-03-005-S-1 collected from District 3 on Interstate 5 on November 1, 2004 exceeded 10-times the TCLP⁴ value for total chromium. None of the remaining samples exceeded any of the respective TTLC⁵, STLC or TCLP values, as shown in Table 3A. Results of STLC analysis of sample PCC-08-010-S-2 for lead and TCLP analysis of sample PCC-03-005-S-1 for chromium showed no detectable levels of either analyte.

The relative concentration of hexavalent to total chromium in slurry samples ranged from less than 1% to just over 10% in slurry samples. These ratios are significantly lower than for liquid samples. In samples collected from District 7 on Interstate 5 on November 5, 2004, and District 8 on Interstate 15 on October 26, 2004, hexavalent chromium was not detected above the laboratory PQL. These results are consistent with the fact that hexavalent chromium compounds are significantly more soluble than other chromium compounds.

Organic Constituents

As presented in Table 3A, no detectable concentrations of Total Petroleum Hydrocarbons (TPH) of gasoline or diesel ranges were found in any of the slurry samples. Detectable concentrations of TPH-oil were found in several samples, while Oil & Grease was detected in 25 out of 27 collected samples.

³ California Soluble Threshold Limit Concentration

⁴ Federal Toxicity Characteristic Leaching Potential

⁵ California Total Threshold Limit Concentration

With the exception of one detection of 1,3,5-TMB and several of 1,2,4-TMB in several samples, no other VOCs were detected in the majority of collected slurry samples. With one exception, all detections of both TMBs were measured in samples collected from District 3 on Interstate 5 on November 1, 2004, which was also the case for detection of 1,2,4-TMB in liquid samples. Comparison of data sets for liquid and slurry samples collected from the District 3 location on November 1, 2004, indicates that the source of these compounds was most likely water used in the grinding operation.

Minor levels of bis(2-ethylhexyl)phthalate [or di(2-ethylhexyl)phthalate, DEHP] were detected in several slurry samples. A common plasticizer, DEHP could have been derived from PCC components or hosing used in the grinding operation.

As presented in Table 3B, PCBs were not detected in any of the slurry samples analyzed. Minor concentrations of two organochlorine pesticides, 4,4-DDD and d-BHC, were detected in slurry samples collected on December 21, 2004 and January 19, 2005, respectively. Concentration of 4,4-DDD was significantly below the respective TTLC and STLC levels, as shown in Table 3B.

3.2 STATISTICAL DATA EVALUATION

The data described above was reviewed and evaluated for statistical significance. The statistical evaluation was based on the following criteria:

- Statistical evaluations were performed on the complete data set for each target analyte from all sampling events. No calculations were performed for individual sites / sampling events.
- Statistical evaluations were not performed for analytes where all results were reported as non-detected.
- Statistical evaluations were not performed for analytes where less than five (5) samples had detected concentrations.
- For analytes where the data set included both detected and non-detected (i.e. below laboratory PQL) concentrations, the full laboratory PQL value was used in the data evaluation as the analytical result for samples with non-detected results.
- For analytes where the data set included both detected and non-detected (i.e. below laboratory PQL) concentrations, AND the PQL values were significantly

elevated when compared to the actual detected concentrations, the non-detected data points were excluded from the statistical evaluation.

- Statistical evaluations were not performed for analytes that were tested for, or detected in, only a small number of samples AND the range of detected values varied over an order of magnitude between minimum and maximum (Note: this applied mostly to compounds on the extended analyte lists)

As presented in Tables 4A and 4B, the majority of the target analytes from the primary analyte lists for both liquid and slurry samples were subjected to statistical evaluation. However, only a limited number of analytes from the extended lists, for both liquid and slurry samples, were evaluated.

Once the data sets were selected, they were initially evaluated for normality using the Shapiro-Wilk method, as provided by the Analyze-it for Excel software package. The results of this evaluation are provided in Appendix D and summarized in Tables 4A and 4B.

As presented in Appendix D and Tables 4A and 4B, not all of the data sets were determined to configure to a normal distribution. A Shapiro-Wilk coefficient of 0.9 or higher was used as a threshold value in determining whether a data set was normally distributed. As presented in Tables 4A and 4B, the only data sets that met this criterion were the pH data set for both liquid and slurry samples, the cobalt data set for liquid samples, and the sulfate data set for slurry samples.

As a result, the majority of both the liquid and slurry analyte data sets were defined as non-parametric distributions and tested by the Bootstrap method, a variation of the Monte Carlo technique, as provided by the Excel Modeling VBA software set. The results of these evaluations are also provided in Appendix D and summarized in Tables 4A and 4B.

Results of the statistical evaluations determined that the pH of the liquid waste stream from Department PCC grinding operations is anticipated, with 95% confidence, to be between 10.78 and 11.26, with a mean of 11.0. This indicates that, with 95% confidence, liquid PCC waste will not constitute a hazardous waste stream. In addition, the following constituents are anticipated to be present in the liquid waste from Department PCC grinding operations: arsenic, barium, cobalt,

chromium, copper, mercury, molybdenum, nickel, lead, selenium, vanadium, zinc, hexavalent chromium, oil & grease and a variety of other general mineral constituents. The data and statistical evaluations furthermore indicated that the liquid waste from Department PCC grinding operations is not anticipated to contain detectable concentrations of silver, beryllium, cadmium, antimony, thallium, sulfide, ortho-phosphate, petroleum hydrocarbons, VOCs, SVOCs, pesticides or PCBs.

The pH of slurry waste generated during Department PCC grinding operations is predicted, with 95% confidence, to be between 10.48 and 10.92, with a mean of 10.7, which is slightly lower than the liquid waste. Although numerous heavy metal constituents were detected in the slurry samples, only barium, cobalt, chromium, copper, molybdenum, nickel, lead, selenium, vanadium, zinc and hexavalent chromium are anticipated to be consistently detected in the slurry waste from Department PCC grinding operations, and none are anticipated to be present at concentrations in excess of applicable Federal and State hazardous waste standards. In addition to these heavy metals constituents, the slurry waste is anticipated to contain detectable levels of TPH-oil, oil & grease, chloride, nitrate, sulfate, iron and aluminum. The data and statistical evaluations furthermore indicate that slurry waste for Department PCC grinding operations are not anticipated to contain detectable concentrations of silver, arsenic, beryllium, cadmium, antimony, thallium, ortho-phosphate, gasoline or diesel range petroleum hydrocarbons, VOCs, SVOCs, pesticides, or PCBs.

SECTION 4.0
CONCLUSIONS

4.0 CONCLUSIONS

Based on the results of the sampling, testing, and data analysis efforts described in the previous sections, the following conclusions can be made with regard to the nature of PCC waste being generated through Department grinding operations conducted throughout the state:

- The detected concentrations of inorganic parameters in both liquid and slurry samples varied between the locations tested and in some cases within a single grinding project. As a result, it is difficult to predict with certainty the exact inorganic chemistry characteristics that would be typical of the PCC waste. However, generally speaking, both the liquid and slurry waste have pH levels of 10 or higher, which are basic but non-hazardous, and detectable, but non-hazardous levels of heavy metals and other inorganic parameters. The most frequently detected heavy metals in liquid samples were arsenic, barium, chromium, cobalt, copper, nickel, selenium, vanadium, and zinc. Silver, beryllium, cadmium, antimony, and thallium were found in fewer than half of the liquid samples. Heavy metals concentrations in slurry samples were detected but inconclusive due to elevated detection limits for some of the samples. However, the most frequently detected heavy metals in slurry samples were barium, cobalt, chromium, copper, molybdenum, nickel, lead, vanadium, and zinc. Silver, arsenic, beryllium, cadmium, mercury, antimony, selenium, and thallium were detected only sporadically, if at all, in slurry samples.
- Chromium and hexavalent chromium were found to be ubiquitous throughout the liquid samples as well as in many of the slurry samples. None of the detected concentrations were at hazardous levels.
- Total petroleum hydrocarbons as gasoline, diesel and oil were at non-detectable levels in almost all liquid and slurry samples. However, detectable levels of oil & grease were consistently detected. The presence of oil and grease is not unexpected given the source of the PCC grinding waste even though no pronounced staining of the PCC pavement was noted in the field observations.
- Volatile and semi-volatile organic compounds were detected only sporadically and at relatively low concentrations. No discernible trends could be identified in these detections, which are thought to be specific to individual sites and not associated with

PCC waste in general. The most frequently detected semi-volatile compound was bis(2-ethylhexyl)phthalate, which is a common laboratory contaminant.

- Organochlorine pesticides and PCBs were generally at non-detectable levels in both liquid and slurry samples with few exceptions.

Based on these results, PCC waste is not considered hazardous and disposal of these wastes can be done at appropriately licensed non-hazardous waste disposal sites or recycling facilities. Tables 4A and 4B provide a statistical summary of the results of all of the analyses performed as part of this Supplemental Study. The information included in these tables can be provided to Department contractors, sub-contractors, and/or disposal facilities to demonstrate the typical chemical composition of PCC waste from Department grooving or grinding operations.

It should be noted that these results are typical of waste generated within Department rights-of-way where no significant near-site or on-site contaminant sources exist. In cases where a notable potential contaminant source is identified near a grooving or grinding operation, additional sampling may be necessary to eliminate the possibility of impacts related to that condition. Examples of potential contaminant sources that may affect the characteristics of the PCC grinding waste include, but are not limited to, any of the following types of facilities or activities that through their location or orientation may allow for accidental or intentional discharges onto the Department right-of-way where the grinding operations are occurring.

- Industrial facilities that manufacture, store, use, or dispose of significant quantities of chemicals,
- Major petroleum refineries, or processing and storage facilities,
- Major industrial or hazardous waste processing, storage, or disposal facilities,
- Sites currently under investigation and/or subject to clean-up and abatement orders issued by the United States Environmental Protection Agency, the California Environmental Protection Agency, the California Department of Toxic Substances Control, any of the California Regional Water Quality Control Boards, or any local enforcement agency.