Final

# Ash Quantification and Characterization Study — Co-Firing and Dedicated Combution of Waste Tires

## CALIFORNIA INTEGRATED WASTE MANAGEMENT BOARD

January, 1995

R·W·BECK

NOTE: Legislation (SB 63, Strickland, Chapter 21, Statutes of 2009) signed into law by Gov. Arnold Schwarzenegger eliminated the California Integrated Waste Management Board (CIWMB) and its six-member governing board effective Dec. 31, 2009.

CIWMB programs and oversight responsibilities were retained and reorganized effective Jan. 1, 2010, and merged with the beverage container recycling program previously managed by the California Department of Conservation.

The new entity is known as the Department of Resources Recycling and Recovery (CalRecycle) and is part of the California Natural Resources Agency.

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R·W·BECK

January 26, 1995

**Sent via Federal Express**

Mr. Robert Boughton
Manager, Transformation Section
Research and Technology Development Division
8800 Cal Center Drive
Sacramento, CA 95826

**Subject: Report Final**

Dear Mr. Boughton:

Enclosed are 4 bound copies, 1 unbound copy, and a diskette of the Final Report on Ash Quantification and Characterization Study Co-firing and Dedicated Combustion of Waste Tires Report for the California Integrated Waste Management Board.

We enjoyed working with you on this and look forward to future opportunities.

If you have any questions, please feel free to call me at (303) 299-5316.

Sincerely,

R. W. BECK

Benjamin Levie

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Project Manager

/bel

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## ACKNOWLEDGEMENT

This report is based upon work performed pursuant to a contract with the California Integrated Waste Management Board. The contract number and dollar amount are as follows:

[TO COME - BEN LEVIE]



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## DISCLAIMER

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# ASH QUANTIFICATION AND CHARACTERIZATION STUDY

R·W·BECK

# *Ash Quantification and Characterization Study Co-firing and Dedicated Combustion of Waste Tires*

## 1.0 INTRODUCTION

Greater utilization of ash from waste-to-energy facilities is an important objective for the California Integrated Waste Management Board (CIWMB). To this end, the Ash Characterization Study, completed in May 1994, was performed to characterize ash from several different types of biomass, medical waste, and municipal solid waste-to-energy facilities in the state. The information gathered from the first study was intended to be used by the California Department of Transportation (CalTrans) for assessing the adequacy of ash materials for road construction applications, and by the CIWMB for exploring markets and uses for these materials.

The present study was designed to expand upon this work to include a third type of waste feedstock which is prevalent in the state and the country — waste tires. The State of California discarded approximately 29 million used tires in 1994. About 40 percent of these waste tires are disposed in landfills or stockpiles. Other alternatives to this practice include:

- Combustion in a dedicated tire facility;
- Co-fired with other fuels;
- Combustion in cement kilns;
- Pyrolysis and gasification;
- Shredding or grinding the rubber for asphalt roads or embankments; and
- Recycling via retreading or making other products.

The first two alternatives are the subject of this study. A detailed evaluation of ash from these two approaches is the goal of this report.

## 2.0 STUDY OVERVIEW

R. W. Beck sampled ash at two separate facilities: Shasta Energy Signal Wheelabrator (Signal Wheelabrator) and Modesto Energy Limited Partnership (Modesto). Signal Wheelabrator ash was previously sampled in the first ash characterization study while burning only wood waste. In the current study, the Signal Wheelabrator facility co-fired tire chips with wood waste in one of their three boilers during a test trial. At Modesto, whole tires only are incinerated in their twin boilers.

Samples of the Signal Wheelabrator fly and bottom ash were taken for subsequent analysis. At Modesto, only the bottom ash was sampled. Modesto bottom ash was divided on-site into two fractions, the portion which does not pass a No. 4 screen and the portion that does pass. These are referred to as over #4 and under #4, respectively. The ash was sampled according to a protocol developed specifically for these two sites and the requirements for sample size stipulated by the testing laboratories. The protocol is shown in Appendix A.

### 2.1 Material Tests

Material tests were selected to obtain information on physical and chemical properties of the ash which would best serve to characterize each ash and help in determining viable beneficial uses. Information gathered in the first ash study eliminated the need for some physical tests when it was clearly demonstrated that ash had inadequate properties for a given application. In particular, concrete road application testing was eliminated due to the large gap between testing results and CalTrans standards. CIWMB also chose not to have CalTrans tests performed on the Signal Wheelabrator bottom ash because the small amount of tire derived fuel was not believed to be great enough to change its character significantly since the first sampling when tires were not co-fired.

### 2.2 Physical Tests

Table 1 shows the CalTrans tests and specifications for asphalt road and road-base applications. Tests were performed on the Modesto over #4 bottom ash. Two separate composite samples were tested to characterize the ash's potential in road type applications.

**TABLE 1**
**CAL TRANS SPECIFICATIONS FOR VARIOUS APPLICATIONS**

| Material | Specification Requirement for California D.O.T. Test | | | | | | |
|---|---|---|---|---|---|---|---|
| | CT 211 500r Max. | CT213 | CT 217 Min. | CT 229 Min. | CT301 Min. | CT 303 Kc Max. | CT 303 Kf Max. |
| Aggregate Subbase, Class 3 | | | 18 | | 40 | | |
| Aggregate Base | | | 22 | 35 | 78 | | |
| Asphalt Treated Permeable Base | 45% | | | | | | |
| Asphalt Concrete and Asphalt Concrete Base Aggregate, Type 3 | 50% | | 42 | | | 1.7 | 1.7 |

### 2.3 Analytical and Agricultural Tests

Analytical tests were performed on every sample of ash taken. These tests included the USEPA's Toxic Characteristic Leaching Procedure (TCLP), and California's Waste Extraction Test (WET). Agricultural tests were performed on every sample except the Modesto over #4. These tests show macronutrients, micronutrients, and other characteristics important for agricultural applications. Finally, iron oxide tests were performed on both fractions of Modesto ash. This test utilizes x-ray diffraction to determine the total and species of the iron oxide in the ash. Iron oxide may be potentially useful in cement kilns and steel furnace operations.

## 3.0 DATA ANALYSIS

Separate discussions of the data are provided for the two facilities. The discussion includes an analysis of test results and of potential uses of the ash residues. Recommendations for future testing or other activities are listed.

## 3.1 FACILITY OPERATIONS

### 3.1.1 Signal Wheelabrator

Signal Wheelabrator feeds wood waste from lumber operations into three boilers at about 25 tons per hour. Each boiler has its own electrostatic precipitator (ESP). The boilers create three separate streams of ash:

- A bottom ash which consists of heavier ash that drops through the moving grate;
- A heavy fly ash which is deposited upstream of the ESP into hoppers located beneath the boiler tubes and economizer section; and
- A fly ash which is captured by the ESP and deposited into a storage silo.

Currently, the bottom ash is landfilled. The heavy fly ash is screened to produce a sand sized aggregate useful for pipe bedding. Bottom ash also has potential to be used in this way with appropriate screening. The fly ash is marketed to farmers in the region.

The feedstock at the time of our sampling consisted of roughly 77.5 percent wood waste, 12.5 percent natural gas, and 10 percent tires on the basis of heating value. Because tires have a heating value nearly twice that of wood, the tire rate was about 6 percent by weight of the total solid fuel feed rate. The natural gas was employed to ensure that the steam rate would remain constant during the tire co-firing evaluation. Concurrent to our sampling, the Air Resource Board conducted stack emissions tests.

### 3.1.2 Modesto Energy

The Modesto facility is designed and operated to convert whole tires into electricity. Two boilers combust 5 million to 6 million tires per year, and produce about 12 MW of electricity. The tires consist of about 10 percent to 12 percent ash in the form of wire beads, belts, and various inorganic constituents used in rubber manufacture. This material is melted and slagged to varying degrees. Truck tires are apt to produce larger quantities of unslagged metal than the smaller automobile tires due to incomplete combustion and melting of the wire beads. Occasionally, tires will roll over the grate and bypass combustion completely.

At the time of the study, the fly ash was sent to a smelter in Mexico. Bottom ash is currently stockpiled until markets can be identified and pursued. Potential markets include uses in the steel, cement and road building industries.

## 3.2 SAMPLING PROCEDURES

### 3.2.1 Signal Wheelabrator Energy

As defined in the protocol (see Appendix A), the fly and the bottom ash were sampled. Samples were taken as the bottom ash discharged into a receiving bin. A trash can was placed directly under the ash discharge and captured the full stream. Twenty-pound samples were taken hourly, and composited three at a time to yield a morning and an afternoon composite sample. The material was coned and quartered according to ASTM Method C 702-87 to obtain the one-pound samples required for the analytical and agricultural labs.

For the fly ash, samples were taken from the discharge of the ESP inside a small duct. A hand shovel was fabricated from sheet metal to allow samples to be removed from the duct. Two pound samples of fly ash were taken hourly. Three samples of fly ash were mixed together to form a composite which was then thoroughly mixed. One-pound samples were extracted from the composite for the analytical and agricultural labs.

### 3.2.1 Modesto

At Modesto, only the bottom ash was sampled. Samples were taken via a 30-gallon galvanized steel can placed under the ash drag chain discharge. Sample size was maintained at 100 pounds and samples were taken hourly. Each sample was screened with a number 4 screen. This size is commonly used in aggregate production. The under #4 portion was kept segregated and later mixed with like fractions of the next two hourly samples. The same was done with the over #4 fraction. A total of two composite samples for each size fraction was created, representing the three morning and three afternoon hourly samples. The composite samples were coned and quartered until samples of the correct size were reached for the labs. Two, 100-pound samples were required of the over #4 fraction for the material testing. Two one-pound composite samples of the under #4 fraction were sent to the analytical, agricultural, and iron oxide labs.

## 4.0 TEST RESULTS

### 4.1 SAMPLING

The sampling weight breakdowns are shown in Table 2. No over 2" material was found at either facility, with the exception of large pieces of unmelted wire from Modesto. Table 2 shows the weight fractions of ferrous and under #4 (for Modesto only).

**TABLE 2**
**SAMPLING WEIGHT BREAKDOWN**
**SIGNAL Wheelabrator ENERGY SIGNAL WHEELABRATOR AND MODESTO ENERGY FACILITIES**

| Facility | Sample Type | Ferrous | Under #4 |
|---|---|---|---|
| Signal Wheelabrator Energy | Fly | 0 | NA |
| | Bottom | 3% | NA |
| Modesto | Bottom | 3% | 12% |

The Signal Wheelabrator fly ash was black in color and fine in consistency. The bottom ash contained a significant amount of small pieces of wire and occasional nails, but was otherwise fairly consistent in character. The wire presumably originates in the steel belts of tires. Because tires were shredded and debeaded before arriving at Signal Wheelabrator, large pieces of bead (on the sidewall of the tire to keep the tire positioned on the metal wheel of the vehicle) were not seen.

The Modesto ash was quite diverse in its physical appearance. It consisted of large pieces aggregate combined with metal which was magnetic to some extent. In addition, pieces of wire that were partially slagged and a small amount of wire beads that were not slagged were identified. Only the unslagged metal (wire beads) was identified/documented as "ferrous" and was separated from the other sample material during sample preparation. The under #4 fraction was more pea-gravel-like in consistency.

## 4.2 ANALYTICAL RESULTS

Results of the toxicity analyses are shown on Tables 3 and 4. The toxicity analyses shown do not represent the full suite of parameters that were tested. The intent is to present those parameters that are more critical for agricultural applications. The Toxicity Characteristic Leaching Procedure (TCLP) tests and California toxicity test results are given in the Appendix for each of the two facilities sampled. It should be noted that the sampling effort was not designed based on regulatory requirements and hence, the results are invalid from a regulatory standpoint. However the results can be used to help evaluate the likelihood of passing regulatory requirements.

Review of the TCLP test results indicate that the ash byproducts at both facilities were acceptable based upon federal regulatory limits. Total Threshold Limit Concentration (TTLC) values for zinc (5,000 mg/kg) were exceeded for both fly ash samples analyzed from the Signal-Wheelabrator facility (26,200 mg/kg and 26,300 mg/kg). The Soluble Threshold Limit Concentration (STLC) value for zinc (250 mg/L) was also exceeded (486 mg/L) for one sample. One other exceedance of the STLC limit for lead (regulatory limit - 5 mg/L) was identified in one of two bottom ash samples at the Signal-Wheelabrator facility (13.3 mg/L). The samples of ash from Modesto were all within regulatory limits.

## TABLE 3
## SUMMARY OF RESULTS FOR TOTAL THRESHOLD LIMIT CONCENTRATIONS (TTLC) AND SOLUBLE THRESHOLD LIMIT CONCENTRATIONS (STLC)

| Analytical Parameters | Signal-Wheelabrator | | Modesto Tire-to-Energy | | Limit Concentrations for Persistent and Bio-accumulative Substances |
|---|---|---|---|---|---|
| Sample Type | Bottom (2 Samples) | Fly (2 Samples) | Under #4 (2 Samples) | Over #4 (2 Samples) | |
| | TTLC[1] | TTLC[1] | TTLC[1] | TTLC[1] | TTLC (mg/kg) |
| Cadmium | ND/ND | 8.1/8.4 | ND/ND | ND/ND | 100 |
| Chromium | 19.6/20.5 | 54.8/50.9 | 11.3/26.5 | 13.1/18.6 | 500/2,500 |
| Beryllium | ND/ND | ND/ND | ND/ND | ND/ND | 75 |
| Arsenic | 10.3/ND | 51.7/45.4 | 10.9/36.2 | 13.5/ND | 500 |
| Lead | 8.1/23.5 | 213/218 | ND/ND | ND/ND | 1,000 |
| Mercury | ND/ND | 1.9/1.9 | ND/ND | ND/ND | 20 |
| Zinc | 653/684 | 22,200*/26,300* | 1,000/816 | 923/602 | 5,000 |
| | STLC | STLC | STLC | STLC | STLC |
| Cadmium | ND/ND | 0.049/0.595 | ND/ND | ND/ND | 1.0 |
| Chromium | 0.154/0.197 | 1.64/1.33 | 0.634/0.526 | 0.670/840 | 5.0/560 |
| Beryllium | ND/ND | ND/ND | ND/ND | ND/ND | 0.75 |
| Arsenic | ND/ND | ND/ND | ND/ND | ND/ND | 5.0 |
| Lead | 1.64/13.3* | 0.192/0.448 | 0.157/ND | 0.153/0.152 | 5.0 |
| Mercury | ND/ND | 0.0004/0.0006 | ND/ND | ND/ND | 0.2 |
| Zinc | 26.9/33.2 | 12.1/486* | 47.5/40.1 | 25.6/19.7 | 250 |

**Note:**

[1]TTLC reported in milligrams per kilogram (mg/kg); STLC reported in milligrams per liter (mg/L).

ND = not detected.
* = Exceeds respective limit concentration

**TABLE 4**
**TCLP[1] TOXICITY TESTING RESULTS**

| Analytical Parameters (mg/L) | Signal-Wheelabrator | | Modesto Tire-to-Energy | | Regulatory Limit |
|---|---|---|---|---|---|
| Sample Type | Bottom (2 Samples) | Fly (2 Samples) | Under #4 (2 Samples) | Over #4 (2 Samples) | |
| Arsenic | ND | ND | ND/ND | ND/ND | 5.0 |
| Barium | 0.725/0.801 | 0.385/0.313 | 0.314/0.353 | 0.198/0.349 | 100.0 |
| Cadmium | ND | 0.112/0.203 | ND/ND | ND/ND | 1.0 |
| Chromium | ND | ND | ND/ND | ND/ND | 5.0 |
| Lead | ND | ND | ND/ND | ND/ND | 5.0 |
| Mercury | ND | ND | ND/ND | ND/ND | 0.2 |
| Selenium | ND | ND | ND/ND | ND/ND | 1.0 |
| Silver | ND | ND | ND/ND | ND/ND | 5.0 |

[1] Toxicity Characteristic Leaching Procedure

* mg/L = milligrams per liter
ND = not detected

## 4.3 AGRICULTURAL RESULTS

Table 5 shows results for testing of agricultural use characteristics. Most physical and chemical characteristics of the ash byproducts were similar to analyses of ash from biomass-to-energy facilities we sampled in our previous study. In our previous study, we sampled and analyzed bottom ash from Signal Wheelabrator Energy facility. At that time, no tires were being consumed, and fly ash was not sampled. Comparison of the bottom ash data from the Signal Wheelabrator Energy facility when co-firing waste tires, to the previous "wood waste only" analyses, demonstrated a slight decrease in macronutrients when tires were added to the waste stream. Micronutrient values were higher for zinc in the "wood waste/tire" sample, as was the bulk density and acid insoluble ash fraction. The "wood waste only" bottom ash had a higher organic matter and calcium carbonate equivalent.

## 4.4 DISCUSSION

### 4.4.1 Signal Wheelabrator

Fly ash is approximately 50 percent by weight of the ash generated at Signal Wheelabrator. The fly ash from Signal Wheelabrator is currently being marketed successfully to agricultural entities. Thus, it is of interest to Signal Wheelabrator and its fly ash customers that the addition of tires to the wood waste feedstock does not cause the ash to become toxic, or even less beneficial for land application.

Although we did not sample or test the Signal Wheelabrator fly ash in our previous study, we have analyzed fly ash at other facilities that burn wood waste only. Zinc limits for the STLC or TTLC were not exceeded for fly ash when lumber waste wood was the feedstock. It would be expected that this finding would be followed at Signal Wheelabrator when tires are not co-fired with wood. The high zinc values at Signal Wheelabrator are attributed to the tires, which are known to have a significant amount of zinc (part of the rubber in the tire). Since zinc is easily vaporized in a furnace, the zinc condenses on the fly ash particles and is therefore concentrated in the fly ash fraction.

**TABLE 5**
**SUMMARY OF AGRICULTURAL ANALYSIS RESULTS**

| Facility | Signal Wheelabrator Energy Facility | | Modesto Tire-to-Energy |
|---|---|---|---|
| Sample Type | Bottom (2 Samples) | Fly (2 Samples) | Under #4 (2 Samples) |
| **Chemical Characteristics** | | | |
| Macronutrients (%) | | | |
| ▪ Nitrogen | 0.03/0.03 | 0.07/0.07 | 0.04/0.03 |
| ▪ Phosphorus | 0.20/0.19 | 1.51/1.43 | 0.07/0.05 |
| ▪ Potassium | 0.72/0.65 | 3.21/3.28 | 0.07/0.59 |
| ▪ Sulfur | 0.13/0.14 | 2.71/4.17 | 0.77/010 |
| ▪ Magnesium | 0.44/0.40 | 2.64/2.48 | 0.11/0.10 |
| ▪ Calcium | 1.84/1.56 | 13.8/12.4 | 0.55/0.44 |
| Micronutrients (ppm) | | | |
| ▪ Iron | 28,800/26,700 | 26,900/23,300 | 31,100/36,400 |
| ▪ Manganese | 1,090/8,500 | 6,400/5,810 | 1,700/1,910 |
| ▪ Copper | 70/60 | 450/710 | 1,030/1,270 |
| ▪ Zinc | 2,380/1,430 | 3,690/4,110 | 3,250/1,230 |
| Other Characteristics | | | |
| ▪ Aluminum | 21,400/17,600 | 27,100/24,000 | 6,400/6,200 |
| ▪ Sodium | 0.18/0.18 | 0.28/0.28 | 0.11/0.09 |
| ▪ Acid Insoluble Ash (% sand) | 91.03/92 | 5.89/6.14 | 65.9/68.7 |
| ▪ % Organic Matter | 1.9/1.0 | 21.3/21.28 | 15.7/6.7 |
| ▪ Calcium Carbonate Equivalent (CCE) | 5.26/5.53 | 39.81/36.63 | 5.76/5.9 |
| ▪ Chloride (%) | 0.18/0.24 | 3.32/3.24 | 0.04/0.04 |
| **Physical Characteristics** | | | |
| ▪ Bulk Density (gm/cc) | 1.27/1.26 | 0.15/0.15 | 1.87/1.98 |
| ▪ % Moisture (dry basis) | 9.48/9.81 | 0.50/0.54 | 18.32/16.71 |
| ▪ Particle Size (% passing through No. 200 sieve) | 99/99 | 98/97 | 98/98 |

Note: *ppm* = *parts per million*
*gm/cc* = *grams per cubic centimeter*

Zinc was analyzed using agricultural and toxicity testing protocols. It is interesting to note that the results from the agricultural and TTLC tests do not agree. The TTLC tests of the fly ash are far higher than the agricultural test results. Furthermore, the agricultural tests show the bottom ash to have a significant amount of zinc as compared to the fly ash. This trend is not reflected in the TTLC test results, as the fly ash zinc levels are more than 20 times greater than the bottom ash.

To further confuse the issue, the STLC tests varied significantly for the fly ash (12 and 486). These results are unusual as the fly ash appears very consistent and the other chemical and physical properties between the two samples are not nearly as variable. These results should be questioned and more sampling and testing is recommended.

Levels of nutrients are in general very high for the fly ash from Signal Wheelabrator. If the zinc levels could be reduced through some type of ash treatment process, these nutrient concentrations would be beneficial in land application. It may also be possible to get an exemption from the State for use of the ash on agriculture or forestry applications. California is the only state to require the STLC and TTLC testing. The TCLP test, a Federal test, does not include zinc in the list of analytes.

### 4.4.2 Modesto

The Modesto under #4 bottom ash was especially high in micronutrient concentrations. The size distribution of the ash would need to be reduced to a minus 200 mesh before it could be applied. The percent sand in the ash is high, but consistent with bottom ash samples taken from biomass facilities in our previous study. The source of this sand is likely from surrounding soil which has blown into the tires during storage. Sand may be useful for a soil where there is a desire to increase tilth.

In general, the bottom ash has limited value from an agricultural viewpoint. Macronutrients are generally low. The micronutrients are high but generally not as bioavailable as salt forms such as chlorides, and sulfates, which are typically found in fly ash (Eighmy, 1989). The bottom ash generally has metals in an oxidized or elemental form which is not easily solubilized and hence unavailable to plants.

## 4.5 IRON OXIDE RESULTS

Only the Modesto samples were analyzed for iron oxide content. Two samples each of under #4 and over #4 ash were analyzed. The results are shown in Table 6.

The results indicate that the over #4 fraction has a higher average of iron oxide than the under #4 fraction. This is probably due to the metal beads melting into large balls of metal.

**TABLE 6**
**IRON OXIDE RESULTS**
**MODESTO ENERGY FACILITY**

| Analyte | Under #4 | | Over #4 | |
|---|---|---|---|---|
| | Sample 1 (Percent) | Sample 2 (Percent) | Sample 1 (Percent) | Sample 2 (Percent) |
| Magnetite | 32 | 22 | 42 | 43 |
| Wuestitite | 8 | 7 | 7 | 20 |
| Hematite | 12 | 13 | 12 | 8 |
| Goethite | ND | ND | ND | 10 |
| Iron | ND | 2 | ND | 2 |
| Total Iron oxide | 52 | 44 | 61 | 83 |

## 4.6 DISCUSSION

The bottom ash from Modesto is relatively high in iron oxides as compared with bottom ash from non-tire burning facilities. This characteristic may make the ash marketable to the cement or steel making industries.

For steel making, high levels of zinc in the ash are not acceptable. According to industry sources, the acceptable level is approximately 1000 ppm. Modesto's bottom ash may be low enough in zinc to meet this criterion. The size fraction of greatest interest is above 1/2" and less than 2". The above #4 fraction is lower than the 1/2" cut-off, and measures about 0.187".

Theoretically, if the whole tires are completely combusted at high enough temperatures, the zinc will vaporize and end up in the fly ash, where it is marketable. However, at Modesto, truck and car tires are combusted at the same time. This creates an inconsistent burnout of the ash, as is indicated by the difference in organic matter from the agricultural tests of the under #4 ash. The poor burnout results in zinc not being vaporized and transfered to the fly ash stream completely, leaving a larger than desired amount in the bottom ash.

The only other dedicated tire to energy facility in the U.S. is Exeter in Connecticut. There, the bottom ash zinc is apparently low enough to be acceptable for steel manufacture. Exeter procures their waste tires to insure that small car tires are not mixed with larger vehicle tires. The tires of only one size (small or large) are then fed in each boiler. One of the boilers is larger to accommodate larger tires. By controlling the feedstock size, the combustion conditions - such as grate speed and feed rate - can be customized for the size of the tire combusted.

It should be possible, therefore to decrease the zinc in the bottom ash at Modesto by following similar strategies as are followed at Exeter. This may mean sorting the tires by hand. Sources of waste tires should be instructed to keep the tires segregated by size.

Cement manufacture can also make use of the relatively high iron content in the bottom ash. Silicon, aluminum, and calcium are also needed in Type 2 cement. The Modesto ash has a large amount of silicon dioxide (sand), and modest amounts of aluminum and calcium. The iron for the over #4 fraction is fairly high although more tests are needed to calculate the true average. As for the steel industry market, combusting the same size of tires would help to insure a consistent ash which would allow for more precise and predictable results in the ash and the cement.

The ash can be blended with iron ore at up to 1:1 for cement production. While whole or shredded tires could be directly charged in a cement kiln, adding fuel as well as material, obtaining the environmental permits necessary to feed this material is difficult and costly. Changes in operational permits should not be required, however, when ash is used, as the ash is essentially a material feedstock, and the air emissions will not significantly be altered.

## 4.7 MATERIAL RESULTS

The results from testing of the over #4 fraction of the Modesto bottom ash are shown in Table 7. Standards for aggregate in various asphalt applications are shown in Table 1. The testing results indicate that the ash meets minimum requirements for aggregate subbase. The standard for the road base R-value, a measure of stability of the material, was not met.

The material physically has a very high specific gravity compared with other ashes we have tested. Its absorption is quite low, a good property for asphalt. Organic impurities are satisfactory. The durability as indicated by CT229 was very high and the LA Abrasion of CT211 was indicative of low attrition for a bottom ash.

The CT301 testing results of 70 and 71 are less than the standards of 78 set by CALTRANS for base material. However, this can be compensated for by increasing the depth of the road base. A chart for calculating the additional depth is given in the test method.

The asphalt recipe test (CT303) could not be fully performed. However, the material may be mixed with virgin aggregate to meet the requirements for asphalt. Certainly, the low absorption of water by the ash, and high density are good characteristics for asphalt, as less asphalt would be required for the road.

**TABLE 7**
**MODESTO ENERGY FACILITY**
**SUMMARY OF LABORATORY TEST RESULTS**

| Sample | CT202 | CT206 (SG) | CT206 (ABS %) | CT207 (SSD) | CT207 (ABS %) | CT211 (# of Rev.) | CT211 (% Loss) | CT213 | CT217 | CT229 Aggregate Type | CT229 Durability Index | CT301 | CT303 (kf/kc/ABR[%]) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | | 4.74 | 1.26 | 2.76 | 11.2 | 100<br>500 | 14.2<br>45.2 | Satis. | 27 | Fine<br>Coarse | *<br>87 | 71 | >3.0/1.4/* |
| Sample 2 | | 4.71 | 1.40 | 3.03 | 9.5 | 100<br>500 | 13.8<br>44.0 | Satis. | 27 | Fine<br>Coarse | *<br>87 | 70 | >3.0/1.5/* |

* = Unable to determine.

## 4.8 DISCUSSION

The over #4 bottom ash has some impressive qualities necessary for road applications. It is a more consistent ash than MSW or medical waste facilities generate, as compared to our previous study. This is probably due to the homogeneous nature of the feedstock relative to the diverse nature of MSW or medical waste. It is probably also a function of the screening to remove the under #4 fraction, which would normally contain clay, soil, organics, and sand. These constituents, with the exception of sand, would not be beneficial to the overall aggregate properties.

As mentioned in previous discussions of the other tests, the segregation of tires by size before combustion may increase the ash quality. Better control of tire combustion might increase the CT 301 results and allow the ash to meet standards for asphalt paving without mixing with a virgin aggregate.

## 4.9 CONCLUSIONS

### 4.9.1 Signal Wheelabrator Energy Ash

Bottom and fly ash from Signal Wheelabrator were sampled during a waste tire/wood waste co-firing trial run using approximately 6 percent by weight tires. The largest effect from the tires on the ash was seen in the elevated zinc levels of the fly and bottom ash. The total zinc in the fly ash exceeded the California limits which may preclude its use as a fertilizer/soil amendment. Aside from this, the fly ash appears to have higher levels of nutrients, micronutrients, carbon, and calcium carbonate equivalent than most of the fly ashes we have tested at other facilities burning wood and agricultural waste. Therefore, this material might be beneficial for some land applications if the California environmental standards were waived or the tire rate were reduced to a level consistent with complying with the standards for zinc.

Bottom ash does not appear to have agricultural benefits due to its size distribution and low nutrient level. If there were an agricultural market, the pieces of metal remaining in the ash from the tire belts would need to be removed. This would require screening or magnetic recovery.

Bottom ash tests for road applications were undertaken in our previous ash study. Results showed the ash to be acceptable for subbase and base applications. Asphalt concrete aggregate standards were close to being met. This ash has been marketed over the last two years for road base and pipe bed applications.

### 4.9.2 Modesto

The bottom ash from Modesto is among the most unique we have sampled and tested. Its high iron oxide content makes it attractive to both steel and cement markets. The relatively high zinc content would need to be eliminated for the steel market, which has a low tolerance for zinc. This might be accomplished through sorting of the tires by size followed by combustion of only the same sized tires in each boiler. The zinc should vaporize and preferentially end up on the fly ash where it is of the greatest benefit.

For road applications, the over #4 Modesto bottom ash has excellent aggregate properties which make it suitable for road base, subbase, and possibly asphalt concrete (as an additive to virgin aggregate). The under #4 material could be crushed for agricultural application. It is low in many of the macronutrients and high in sand. It may be more likely, given the agricultural testing results, that the under #4 material would be used for landfill cover, as is done at the Exeter tire to energy facility. Pipe bedding markets might also be explored.

## 4.10 RECOMMENDATIONS

Based on the results of this study, we can make a few recommendations for further work. These include further testing, marketing, and demonstration of the ash in various applications. Specifically:

**Signal Wheelabrator**

- More zinc testing of the ash to determine its level with confidence.

- Dialogue with appropriate agencies to determine their position on using the zinc-enriched fly ash on agricultural land.

**Modesto**

- Segregate tires by size before combustion in the Modesto boilers. This may reduce the zinc in the bottom ash and increase zinc in the fly ash. Concurrently, a more consistent ash with less unburned material should be generated.

- Ascertain the specific interest in the Modesto over #4 material among steel and cement manufacturers. Determine the size of the markets, competition, exact specification requirements.

- Demonstrate the Modesto ash's use in road applications. This will entail building a length of road using the Modesto aggregate instead of virgin sources.

- Demonstrate the Modesto under #4 ash use as a landfill daily cover.

Appendix A

# SAMPLING AND TESTING PROTOCOL

R·W·BECK

# *Appendix A*
# *Sampling and Testing Protocol*

R. W. Beck has prepared this protocol to include key steps to effectively perform the ash characterization for the two facilities. These steps are:

- Select the Facilities and Sampling Dates;
- Define the Tests to be Performed;
- Arrange for the Logistical Needs (Equipment/Travel);
- Perform the Sampling;
- Perform the Testing;
- Perform the Test Result Analyses; and
- Prepare the Draft and Final reports.

## STEP 1 — SELECT THE FACILITIES AND SAMPLING DATES

This step involves the selection of the facilities to be visited and the dates for which the ash will actually be sampled.

### Selection

As requested by the California Integrated Waste Management Board (CIWMB), we will perform a one-day sampling event at the Signal Wheelabrator facility in Anderson and a one-day event at the Modesto Tire-to-Energy facility.

### Sampling Dates

We will sample the ash streams at the Signal Wheelabrator on May 25, 1994 to correspond with air emissions sampling conducted by the Air Resources Board. The following day, May 26, we will perform sampling at the Modesto Tire-to-Energy facility. The two days of sampling will be performed by R. W. Beck representatives.

## STEP 2 — DEFINE THE TESTS TO BE PERFORMED

We will be using the same subcontractors as in Phase II of this study to perform the testing of the samples:

- Geofon, Inc. will perform the material tests;
- CKY, Inc. will perform the analytical tests; and
- A&L Laboratories will perform the agricultural amendment tests.

In addition, Geoanalytical will perform iron oxide tests on Modesto ash samples.

As noted, three types of test batteries will be performed: material/physical tests, analytical tests, and agricultural tests, and are described below.

### Material Test Battery

As in Phase II of the Ash Characterization and Quantification Study, the Material Test Battery will be performed by Geofon, Inc. The testing will be performed **only** on two composite samples from the Modesto Tire-to-Energy facility. No samples will be tested from the Signal Wheelabrator Facility. The following battery of tests and the associated costs are shown in Table 1:

**TABLE 1**
**MATERIAL TESTS TO BE PERFORMED**

| Test[1] | Description |
|---|---|
| CT 201 | Soil and Aggregate Sample Preparation |
| CT 202 | Tests for Sieve Analysis of Fine and Course Aggregates |
| CT 206 | Test for Specific Gravity and Absorption of Course Aggregate |
| CT 207 | Test for Specific Gravity and Absorption of Fine Aggregate |
| CT 211 | Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Rattler Machine |
| CT 213 | Test for Organic Impurities in Concrete Sand |
| CT 217 | Test for Sand Equivalent |
| CT 229 | Test for Durability Index (Coarse or Fine) |
| CT 301 | Test for Determination of Resistance of "R" Value of Treated and Untreated Bases, Subbases and Basement Soils by the Stabilimeter |
| CT 303 | Test for Centrifuge Kerosene Equivalent and Approximate Bitumen Ratio (ABR) |

[1]This battery of tests will be performed for samples taken only at the Modesto Tire-to-Energy facility. No samples will be tested from the Signal Wheelabrator facility.

## Analytical Test Battery

As in Phase II of the Ash Characterization and Quantification Study, the Analytical Test Battery will be performed by CKY, Inc. The testing will be performed on four composite samples from the Signal Wheelabrator facility (two fly ash and two bottom ash) and four composite samples from the Modesto Tire-to-Energy facility (under #4 and over #4 screen). Note that the number of tests to be performed has been reduced because of the value received for the cost and the redundancy of performing these tests in light of the Agricultural Test Battery. The following battery of tests and the associated costs are provided in Table 2:

**TABLE 2**
**ANALYTICAL TESTS TO BE PERFORMED**

| Test | Description |
|---|---|
| WET TTLC 3050/6010 | Waste Extraction Test to determine the sample's total threshold limit concentration (TTLC) |
| WET STLC 1311/3010/6010 | Waste Extraction Test to determine the sample's soluble threshold limit concentration (STLC) |
| TCLP 1311 | Toxicity Characterization Leaching Procedure |

### Agricultural Test Battery

As in Phase II of the Ash Characterization and Quantification Study, the Agricultural Test Battery will be performed by A&L Western Agricultural Laboratories. The testing will be performed on four composite samples from the Signal Wheelabrator facility and two composite samples from the Modesto Tire-to-Energy facility. The following battery of tests and the associated costs are provided in Table 3:

**TABLE 3**
**AGRICULTURAL TESTS TO BE PERFORMED**

| Test | Description |
|---|---|
| Manure Analysis | Manure Analysis Report includes Report of Analysis-Percent and Pounds of Nutrients per Ton |
| Acid Soluble Ash | Acid Insoluble Ash |
| Organic Matter | Organic Matter |
| CCE | Calcium Carbonate |
| Chloride | Chloride |
| Bulk Density | Bulk Density |

## STEP 3 — ARRANGE FOR THE LOGISTICAL NEEDS

R. W. Beck will arrange the logistics for the required personnel and equipment at the facilities to perform the sampling events.

This step requires the arrangement of travel for key personnel from Denver to Sacramento, and from Sacramento to Anderson and Modesto, respectively. In addition, the arrangement of the sampling equipment including, but not limited to, safety equipment, a scale, screens, shovels/rakes/brooms, 55 gallon containers, packing/shipping equipment etc., will be required.

A large cargo van will also be needed to transport the personnel and equipment to, from, and between the sampling events.

## STEP 4 — PERFORM THE SAMPLING

Step 4 provides the general guidelines on approaches for the sampling of ash from the Signal Wheelabrator and Modesto Tire-to-Energy facilities. This methodology may differ slightly from the procedures performed in Phase II of this study due to changes in the battery of tests to be run at these facilities as compared to facilities sampled in Phase II.

### Methodology

1. Safety equipment, supplies, and personnel will be transported to each facility by approximately 8:00 a.m. on the designated sampling dates.

2. Upon arriving at the facility and consulting with the facility managers, the most safe and convenient location for sampling will be determined. Accessibility and adequate space for sample preparation will be a priority. The best location for sampling will be at the ash drag chain or conveyor belt head pulley area (discharge point).

3. To facilitate sampling, a 30-gallon metal container will be required to collect the ash from the discharge point.

4. At the discharge point, material (5 pounds per sample for Signal Wheelabrator and 100 pounds per sample for Modesto Tire-to-Energy[1]) will be collected a minimum of six times at hourly intervals over the operation of one normal day. These six samples will be referred to as "daily samples." Note that the fly and bottom ash at the Signal Wheelabrator will be sampled, resulting in 12 daily samples overall. The Modesto

[1]The difference in weight is due to the material testing which needs to be performed on the Modesto samples and not the Signal Wheelabrator samples. Material testing methods require larger/heavier samples.

Tire-to-Energy plant ash is to be screened with a #4 screen, resulting in 6 daily samples over the #4 screen and 6 under the #4 screen.

5. Each daily sample will be screened to remove, weigh, and record:

   (a) Organics,
   (b) Inerts,
   (c) Slag, and
   (d) Ferrous over two-inches in diameter.

   In addition, a magnet will be employed to remove and weigh remaining ferrous metal under two-inches in diameter.

6. As shown in Figure 1, for each day of sampling, two composite samples will be made for each ash sample fraction. One composite will be made from daily samples 1, 2, and 3, and one composite from daily samples 4, 5, and 6. The resulting composite samples will be similar in size and weight.

   In combining the daily samples to produce the composite samples, the material from the three daily samples will be thoroughly mixed and reduced using the coning and quartering method in accordance with ASTM test methods C702-87, Standard Practice for Reducing Field Samples of Aggregate to Testing Size, Method B Quartering.

   In general, the cone and quartering process will involve:

   (a) Forming a cone of equal parts of three daily samples;
   (b) Flattening the cone using a shovel;
   (c) Dividing the flattened cone into four quarters;
   (d) Combining two opposite quarters to obtain one sample;
   (e) Discarding the remaining two quarters;
   (f) Forming a cone with the two sample quarters, and
   (g) Performing Steps (a) through (f) until the sample is reduced to testing size.

7. At the end of each sampling day, composite samples will be double-bagged, identified, dated, and shipped to the laboratories for testing.

   From the Signal Wheelabrator facility, two composite samples each of bottom and fly ash per day will be shipped to the analytical and agricultural laboratories (approximately 1 pound each per composite sample).

   For the Modesto Tire-to-Energy facility, two composite samples of over #4 will be shipped to the material (approximately 150 pounds per composite sample), analytical (approximately 1 pound per composite sample), and iron oxide (approximately 1 pound per composite sample) laboratories. The under #4 composites will be shipped to the analytical, iron oxide, and agricultural laboratories.

8. The laboratories will be notified as to the date the samples are to be shipped, and will proceed to prepare for incoming samples and follow all pre-established procedures for testing.

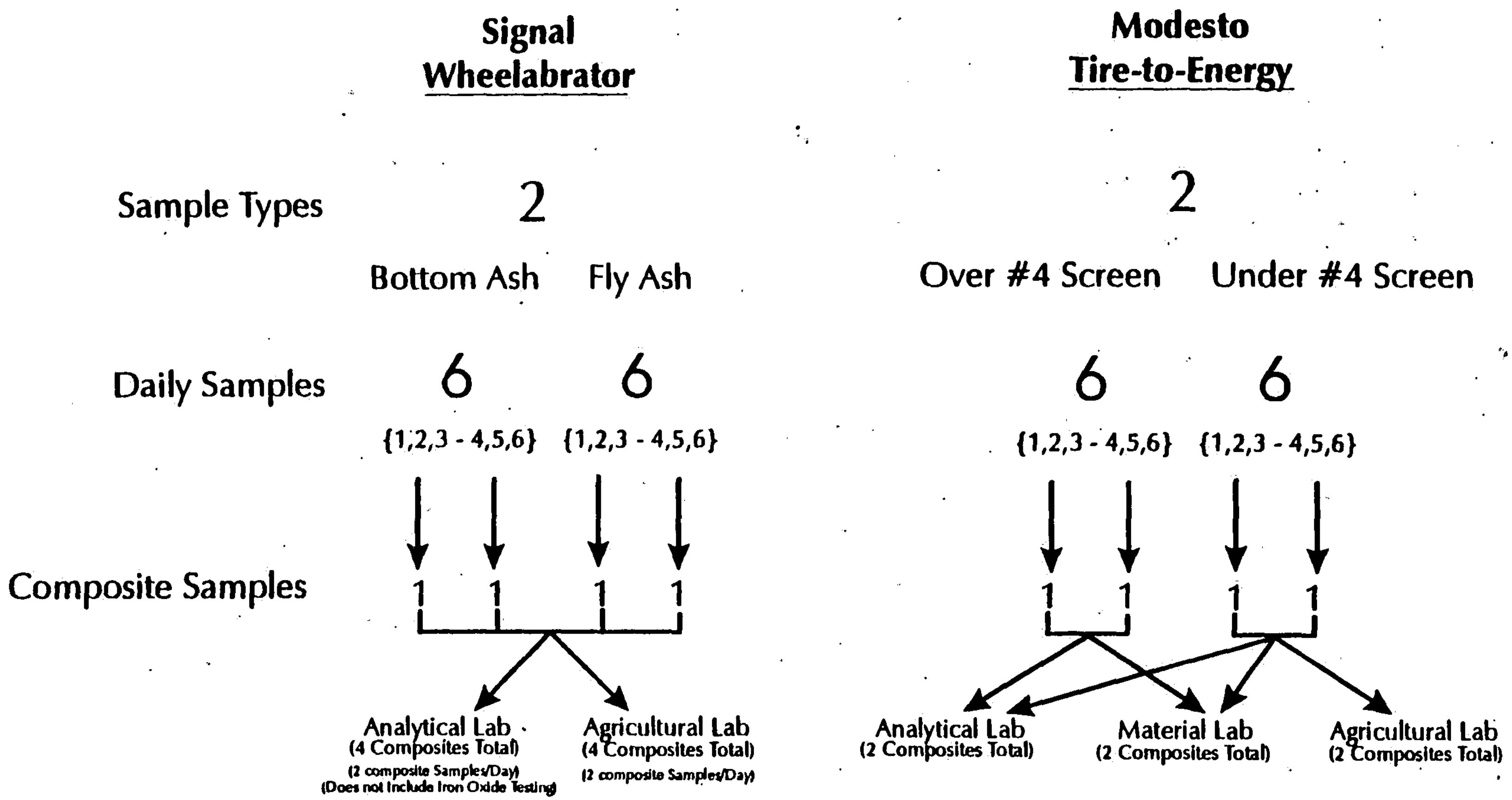
9. All four laboratories will provide an individual report for each of the facilities sampled.

An overview of the sampling program is also shown in Figure 1.

## Sampling Requirements

The performance of the these procedures will require two R. W. Beck personnel and the needed equipment as used in Phase II of this study. Please note that the equipment will need to be gathered and the equipment and personnel will need to be transported to and from both facilities.

# FIGURE 1
## Facility Sampling Program

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## STEP 5 — PERFORM THE TESTING

As indicated earlier, we will be using the same subcontractors as used in Phase II of this study to perform the testing of the samples:

- Geofon, Inc. will perform the material tests;
- CKY, Inc. and Geoanalytical laboratories will perform the analytical tests; and
- A&L Laboratories will perform the agricultural amendment tests.

The test batteries, as outlined in Step 1, will be performed for each of the samples sent to the subcontractors. Each of the subcontractors will require approximately 30 days to perform the tests and provide R. W. Beck with a report of the results.

## STEP 6 — PERFORM THE TEST RESULT ANALYSES

In this step, we will analyze:

- Ash test results from the Signal Wheelabrator and Modesto Tire-to-Energy facilities;
- Potential applications for ashes; and
- Recommendations for use and or ways to improve the usefulness of the material.

Facility reports containing sampling procedures and test results from the individual facilities will be provided as an appendix to the report.

## STEP 7 — PREPARE THE DRAFT AND FINAL REPORTS

Two reports will be submitted to Bob Boughton of the CIWMB — the Draft Report and the Final Report.

As outlined in the Scope's budget and schedule, one draft copy of the report will be provided to the CIWMB for review. The CIWMB will have 30 days to review the draft report and supply one set of comments to R. W. Beck. We will then incorporate CIWMB's comments (collaborating with Bob Boughton), and supply five copies of the Final Report to CIWMB within 30 days of receipt of the comments.

Appendix B

# FACILITY REPORTS

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# MODESTO TIRE-TO-ENERGY FACILITY

## Facility Report

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# *Modesto Tire-to-Energy Facility*

**Facility Description**

This unique facility burns whole tires only to produce electricity. The two boilers have the capacity to receive 6 million tires per year. The boilers generate 100,000 pounds per hour to 140,000 pounds per hour of steam which is used to produce 12.4 MW of electricity. About 370,000 pounds of tires are burned daily. The ash rate was unreported, but fully combusted tires will yield about 10 to 12 percent ash. Unburned organics will increase this number. Modesto does not sort tires before burning by size and therefore tires of a wide range of dimensions and weights are combusted concurrently in the boilers. This will result in different rates of burnout, since the grate speed is kept constant. Occasionally, a tire will come out in the ash unburned due to the tire rolling down the grate rather than being transported by the grate. This happened once to one of the boilers during the day we sampled.

Fly ash from the facility is marketed directly to a zinc smelt in Mexico. Currently, alternatives in the United States are being evaluated. The bottom ash is currently not being utilized and is temporarily being stored on-site until a use can be found or it is moved to an approved landfill.

**Sampling Description**

Sampling of the bottom ash was performed at its discharge into a storage bin. A metal trash can was held under the chute, catching about 50 percent of the discharge stream of ash. Six 100-pound samples were taken at hourly intervals. The samples were first broken up lightly with a shovel and then screened with the 2" screen. All bottom ash fell through the screen with the exception of large ferrous pieces (beads from the tires). Table 1 shows the breakdown of the ash.

The ash was screened a second time using a #4 screen. The two fractions were kept separate and then composited after three samples were taken. This resulted in an over and under 4 sample. The under 4 sample was coned and quartered to yield one-pound samples for analytical, agricultural, and iron oxide testing. The over 4 samples were similarly coned and quartered to yield samples for analytic, metallurgic, and physical (CALTRANS) testing.

**Sample Characteristics**

The under 4 sample was very homogenous and pea-gravel-like. The over 4 ash had a wide particle distribution, but look generally clean after the ferrous was removed. The ash was very brittle over all. The ferrous portion was sometimes wiry in nature and other times had slagged up more into a ball. The more wiry portions only were removed from the sample.

Table 1 shows the complete breakdown of the ash in terms of under 4 material, ferrous, and over 2" material.

**TABLE 1**

**SAMPLE FORM**
**for the**
**ASH QUANTIFICATION AND CHARACTERIZATION STUDY**

Date: May 26, 1994 Facility: Modesto Tire-to-Energy
Location: Westley, CA

| Sample # | Type of Sample | Time of Sample | Ferrous (in pounds) | < #4 (in pounds) | Slag/Inerts >2" | Ash Sample > #4 (in pounds) | TOTAL (in pounds) |
|---|---|---|---|---|---|---|---|
| 1 | Normal | 9:30 a.m. - 9:50 a.m | 6.7 | 16.2 | | 120.59 | 143.49 |
| 2 | Normal | 10:46 a.m. - 10:50 a.m. | 2.7 | 20.0 | | 87.5 | 110.2 |
| 3 | Normal | 11:50 a.m. - 12:00 p.m. | 4.7 | 12.2 | | 74.2 | 91.1 |
| 4 | Normal | | 5.2 | 13.3 | | 104.5 | 123.0 |
| 5 | Normal | | 1.2 | 17.0 | | 109.8 | 128.0 |
| 6 | Normal | 3:00 | 2.3 | 8.8 | | 90.2 | 101.3 |
| 7 | Normal | | | | | | |
| 8 | Normal | | | | | | |
| 9 | Normal | | | | | | |
| 10 | Normal | | | | | | |

EPA METHOD 1311/3010/6010
TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | #1 UNDER #4 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-05 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 314 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

EPA METHOD 1311/3010/6010
TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | #1 OVER #4 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-06 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 198 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

# EPA METHOD 1311/3010/6010
# TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | #2 UNDER #4 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-07 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 353 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

EPA METHOD 1311/3010/6010
TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | #2 OVER #4 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-08 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 349 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | #1 UNDER #4 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-05 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | 10.9 |
| Barium | .5 | 27 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 11.3 |
| Cobalt | .5 | 151 |
| Copper | .5 | 486 |
| Lead | 5 | ND |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | 3.4 |
| Nickel | 1 | 21.8 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | 51.1 |
| Vanadium | .5 | 3 |
| Zinc | 1 | 1000 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | #1 OVER #4 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-06 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | 13.5 |
| Barium | .5 | 35.4 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 13.1 |
| Cobalt | .5 | 153 |
| Copper | .5 | 781 |
| Lead | 5 | ND |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | 3.27 |
| Nickel | 1 | 45.3 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | 61.9 |
| Vanadium | .5 | 3.1 |
| Zinc | 1 | 923 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | #2 UNDER #4 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-07 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | 36.2 |
| Barium | .5 | 28.5 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 26.5 |
| Cobalt | .5 | 173 |
| Copper | .5 | 567 |
| Lead | 5 | ND |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | 5.18 |
| Nickel | 1 | 53 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | 202 |
| Vanadium | .5 | 4.98 |
| Zinc | 1 | 816 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | #2 OVER #4 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-08 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | ND |
| Barium | .5 | 28.3 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 18.6 |
| Cobalt | .5 | 104 |
| Copper | .5 | 434 |
| Lead | 5 | ND |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | 2.69 |
| Nickel | 1 | 29.1 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | 112 |
| Vanadium | .5 | 3.1 |
| Zinc | 1 | 602 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | #1 UNDER #4 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-05 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 1580 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 634 |
| Cobalt | 10 | 4810 |
| Copper | 10 | ND |
| Lead | 100 | 157 |
| Mercury^~ | 0.80 | ND |
| Molybdenum | 50 | 158 |
| Nickel | 20 | 1570 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 207 |
| Zinc | 20 | 47500 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94
~ Dilution Factor : 2

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | #1 OVER #4 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-06 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 1190 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 670 |
| Cobalt | 10 | 3030 |
| Copper | 10 | ND |
| Lead | 100 | 153 |
| Mercury^~ | 0.80 | ND |
| Molybdenum | 50 | 83.2 |
| Nickel | 20 | 1440 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 195 |
| Zinc | 20 | 25600 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94
~ Dilution Factor : 2

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | #2 UNDER #4 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-07 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 1300 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 526 |
| Cobalt | 10 | 4280 |
| Copper | 10 | ND |
| Lead | 100 | ND |
| Mercury^~ | 0.80 | ND |
| Molybdenum | 50 | 106 |
| Nickel | 20 | 1320 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 166 |
| Zinc | 20 | 40100 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94
~ Dilution Factor : 2

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/26/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | #2 OVER #4 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-08 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 876 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 840 |
| Cobalt | 10 | 2470 |
| Copper | 10 | ND |
| Lead | 100 | 152 |
| Mercury^~ | 0.80 | ND |
| Molybdenum | 50 | 110 |
| Nickel | 20 | 1100 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 227 |
| Zinc | 20 | 19700 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94
~ Dilution Factor = 2

REPORT NUMBER

94-153-006

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

Client No: 3084

SEND TO:

R.W. BECK
1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER: MODESTO TIRE TO ENERGY

SAMPLES SUBMITTED BY: MARC TORMEY/BEN LEVIE

LAB NO. 20753 DATE 06/10/94 PAGE 1

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #1 ASH | 0.04 | 0.07 | 0.16 | 0.072 | 0.087 | 0.770 | 0.110 | 0.550 | 0.110 | 31100 | 6400 | 1700 | 1030 | 3250 | | |

### POUNDS OF NUTRIENTS/TON

| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #1 ASH | 0.9 | 1.4 | 3.2 | 1.4 | 1.7 | 15.4 | 2.2 | 11.0 | 2.2 | 62.2 | 12.8 | 3.4 | 2.1 | 6.5 | | |

☐ Reported on an as-received basis Moisture = %

☒ Reported on a dry basis Moisture = 18.32 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

REPORT NUMBER

94-153-006

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

Client No: 3084

SEND TO:

R.W. BECK
1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER: MODESTO TIRE TO ENERGY

SAMPLES SUBMITTED BY: MARC TORMEY/BEN LEVIE

LAB NO. 20754 DATE 06/10/94 PAGE 2

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #2 ASH | 0.03 | 0.05 | 0.11 | 0.059 | 0.071 | 0.490 | 0.100 | 0.440 | 0.090 | 36400 | 6200 | 1910 | 1270 | 1230 | | |

### POUNDS OF NUTRIENTS/TON

| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #2 ASH | 0.7 | 1.0 | 2.3 | 1.2 | 1.4 | 9.8 | 2.0 | 8.8 | 1.8 | 72.8 | 12.4 | 3.8 | 2.5 | 2.5 | | |

☐ Reported on an as-received basis Moisture = %

☒ Reported on a dry basis Moisture = 16.71 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

A & L WESTERN AGRICULTURAL LABORATORIES
1311 Woodland Ave. • Ste. #1 • Modesto, CA 95351 • (209) 529-4080 • FAX (209) 529-4736

REPORT NUMBER
94-153-006

Client No: 3084

June 13, 1994

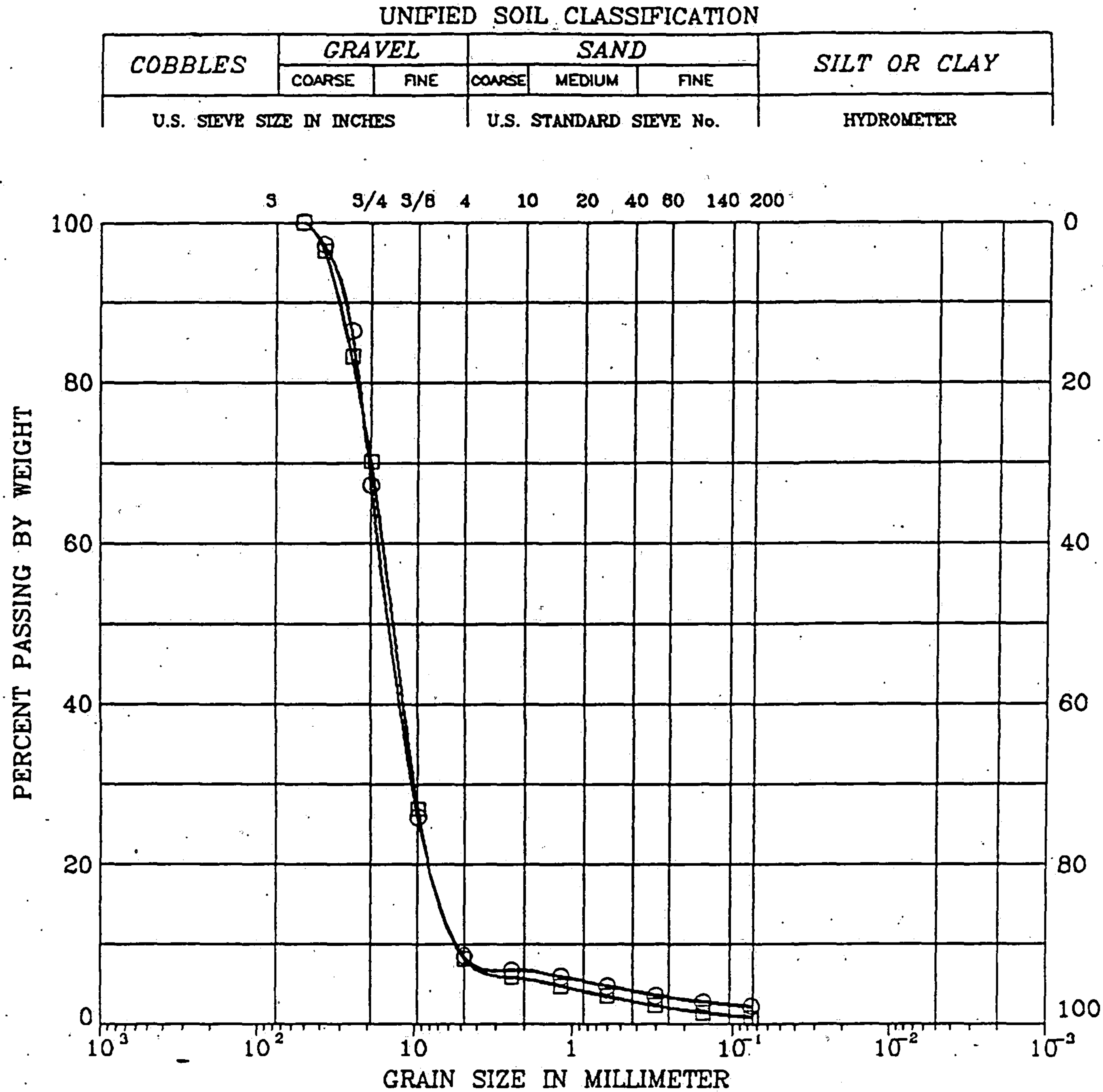
Ben Levy
R.W. BECK
1125 17th Street, Suite 1900
Denver, Colorado 80202

CIWMB Ash Study
Modesto Tire to Energy

| | | | |
|---|---|---|---|
| Lab No | | 20753 | 20754 |
| Sample Id | | Ash #1 | Ash #2 |
| Organic Matter (by combustion) | % | 15.70 | 6.70 |
| Chloride | % | 0.04 | 0.04 |
| CCE | % | 5.76 | 5.88 |
| Acid Insoluble Ash | % | 65.91 | 68.68 |
| Bulk Density | gm/ml | 1.87 | 1.98 |
| #200 Sieve Size (% passing thru) | | 1.60 | 1.78 |

A & L Western Agricultural Laboratories

Robert Butterfield
Laboratory Director




| SYMBOL | BORING | DEPTH (ft) | LL (%) | PI (%) | DESCRIPTION |
|---|---|---|---|---|---|
| O | SAMPLE 1 | | | | |
| □ | SAMPLE 2 | | | | |

Remark : MODESTO

| Project No. 91-330.10 | ASH QUANTIFICATION AND CHARACTERIZATION |
|---|---|
| GEOFON | CT-202 SIEVE ANALYSIS Figure No. B-1 |

# MODESTO
# SUMMARY OF LABORATORY TEST RESULTS

**CT 202 Sieve Analysis of Fine and Coarse Aggregate**

a) Sample No. 1 - (see Figure B-1)
b) Sample No. 2 - (see Figure B-1)

**CT 206 Specific Gravity and Absorption of Coarse Aggregate**

| | Specific Gravity | Absorption (%) |
|---|---|---|
| a) Sample No. 1 | 4.74 | 1.26 |
| b) Sample No. 2 | 4.71 | 1.40 |

**CT 207 Specific Gravity and Absorption of Fine Aggregate**

| | Bulk Specific Gravity (SSD) | Absorption (%) |
|---|---|---|
| a) Sample No. 1 | 2.76 | 11.2 |
| b) Sample No. 2 | 3.03 | 9.5 |

**CT 211 L.A. Abrasion**

| | No. of Revolutions | Percent Loss |
|---|---|---|
| a) Sample No. 1 | 100 | 14.2 |
| | 500 | 45.2 |
| b) Sample No. 2 | 100 | 13.8 |
| | 500 | 44.0 |

**CT 213 Organic Impurities in Concrete Sand**

a) Sample No. 1: Satisfactory
b) Sample No. 2: Satisfactory

**CT 217 Sand Equivalent**

| | Sand Equivalent |
|---|---|
| a) Sample No. 1 | 27 |
| b) Sample No. 2 | 27 |

**CT 229 Durability Index**

| | Aggregate Type | Durability Index |
|---|---|---|
| a) Sample No. 1 | Fine | Unable to determine |
| | Coarse | 87 |
| b) Sample No. 2 | Fine | Unable to determine |
| | Coarse | 87 |

**CT 301 R-Value**

| | R-Value |
|---|---|
| a) Sample No. 1 | 71 |
| b) Sample No. 2 | 70 |

**CT 303 Centrifuge Kerosene Equivalent and Approximate Bitumen Ratio**

| | kf | kc | ABR (%) |
|---|---|---|---|
| a) Sample No. 1 | >3.0 | 1.4 | Unable to determine |
| b) Sample No. 2 | >3.0 | 1.5 | Unalbe to determine |

# GeoAnalytical Laboratories, Inc.

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## CERTIFICATE OF ANALYSIS

Iron Oxide

**Report #** F151-05

R.W. Beck
1125 17th Street #1900
Denver CO 80262

**Date:** 06/20/94
**Date Received:** 05/31/94
**Date Started:** 05/31/94
**Date Completed:** 06/06/94

**Project #**

**Project Name:** CIWMB-Ash Study

**Sample ID:** #1 "Under #4"

**Lab ID:** F10812

| Method | Detection Limit % | Analyte | Results % |
|---|---|---|---|
| XRD | 0.01 | Magnetite($Fe_3O_4$) | 32 |
| XRD | 0.01 | Wuestite(FeO) | 8 |
| XRD | 0.01 | Hematite($Fe_2O_3$) | 12 |
| XRD | 0.01 | Goethite(FeO(OH)) | ND |
| XRD | 0.01 | Iron | ND |

Analyzed by Technology of Materials
Santa Barbara, CA

Certification # E757

Donna Allsup
Laboratory Director

# GeoAnalytical Laboratories, Inc.

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## CERTIFICATE OF ANALYSIS

Iron Oxide

**Report #** F151-05

R.W. Beck
1125 17th Street #1900
Denver CO 80262

**Date:** 06/20/94
**Date Received:** 05/31/94
**Date Started:** 05/31/94
**Date Completed:** 06/06/94

**Project #**

**Project Name:** CIWMB-Ash Study

**Sample ID:** #2 "Under #4"

**Lab ID:** F10814

| Method | Detection Limit % | Analyte | Results % |
|---|---|---|---|
| XRD | 0.01 | Magnetite($Fe_3O_4$) | 22 |
| XRD | 0.01 | Wuestite(FeO) | 7 |
| XRD | 0.01 | Hematite($Fe_2O_3$) | 13 |
| XRD | 0.01 | Goethite(FeO(OH)) | ND |
| XRD | 0.01 | Iron | 2 |

Analyzed by Technology of Materials
Santa Barbara, CA

Certification # E757

Donna Allsup
Donna Allsup
Laboratory Director

# GeoAnalytical Laboratories, Inc.

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## CERTIFICATE OF ANALYSIS

Iron Oxide

**Report #** F151-05

R.W. Beck
1125 17th Street #1900
Denver CO 80262

**Date:** 06/20/94
**Date Received:** 05/31/94
**Date Started:** 05/31/94
**Date Completed:** 06/06/94

**Project #**

**Project Name:** CIWMB-Ash Study

**Sample ID:** #1 "Over #4"

**Lab ID:** F10813

| Method | Detection Limit % | Analyte | Results % |
|---|---|---|---|
| XRD | 0.01 | Magnetite($Fe_3O_4$) | 42 |
| XRD | 0.01 | Wuestite(FeO) | 7 |
| XRD | 0.01 | Hematite($Fe_2O_3$) | 12 |
| XRD | 0.01 | Goethite(FeO(OH)) | ND |
| XRD | 0.01 | Iron | ND |

Analyzed by Technology of Materials
Santa Barbara, CA

Certification # E757

Donna Allsup
Laboratory Director

# GeoAnalytical Laboratories, Inc.

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## CERTIFICATE OF ANALYSIS

Iron Oxide

**Report #** F151-05

R.W. Beck
1125 17th Street #1900
Denver CO 80262

**Date:** 06/20/94
**Date Received:** 05/31/94
**Date Started:** 05/31/94
**Date Completed:** 06/06/94

**Project #**

**Project Name:** CIWMB-Ash Study

**Sample ID:** #2 "Over #4"

**Lab ID:** F10815

| Method | Detection Limit % | Analyte | Results % |
|---|---|---|---|
| XRD | 0.01 | Magnetite($Fe_3O_4$) | 43 |
| XRD | 0.01 | Wuestite(FeO) | 20 |
| XRD | 0.01 | Hematite($Fe_2O_3$) | 8 |
| XRD | 0.01 | Goethite(FeO(OH)) | 10 |
| XRD | 0.01 | Iron | 2 |

Analyzed by Technology of Materials
Santa Barbara, CA

Certification # E757

Donna Allsup
Laboratory Director

# SIGNAL WHEELABRATOR SHASTA ENERGY

## Facility Report

R·W·BECK

# *Signal Wheelabrator Shasta Energy*

**Facility Observations**

During the sampling event, tire chips were fed with wood waste. The feed rate of tires was approximately one ton per hour, into a boiler designed to run at 25 tons per hour of wood. The fuel mix during this cofiring trial was controlled at roughly 12.5 percent natural gas, 10 percent tires, and 77.5 percent wood waste on the basis of heat input to the boiler. The natural gas rate was controlled to keep a constant overall steam rate from the boiler. This was done since the wood heating value changes with moisture and wood type. The boiler was required to keep a constant heat input, since stack emission testing was performed by the California Air Resources Board during this trial.

**Sampling Description**

Samples were taken at the discharge chute for the bottom ash, and the electrostatic precipitator exit duct for the fly ash. The bottom ash samples were taken in a galvanized steel trash can as the ash discharged into a receiving bin. Fly ash samples were removed using a small hand shovel as the ash fell down through the duct feeding a screw conveyor. This conveyor transports the fly ash to a storage bin.

Six, 20-pound samples each were taken of bottom ash and six 2-pound samples were taken of the fly ash at hourly intervals. The first three and last three were composited. The bottom ash was coned and quartered to yield 1-pound samples each for the analytical and agricultural labs. The fly ash was mixed thoroughly in a lined box and one pound was extracted each for the analysis and agricultural labs. This modification of the sampling procedure was done in order to avoid the loss of fly ash due to the wind.

**Sample Characteristics**

The bottom ash sample particles were all less than 2 inches. The ferrous material removed from the ash primarily consisted of small wire pieces which are probably part of the steel belt, since the tires have been de-beaded before shredding. Occasional nails were also seen. Table 1 shows the exact breakdown of the bottom ash.

The fly ash was black in color, indicating a less than complete burnout of the ash. No ferrous organics or slag was seen in these samples.

**TABLE 1**
**SAMPLE FORM**
**for the**
**ASH QUANTIFICATION AND CHARACTERIZATION STUDY**
**Bottom Ash**

Date: May 25, 1994 Facility: **Signal Wheelabrator Shasta Energy**
Location: Anderson, CA

| Sample # | Type of Sample | Time of Sample | Ferrous (in pounds) | < #4 (in pounds) | Slag/Inerts >2" | Ash Sample > #4 (in pounds) | TOTAL (in pounds) |
|---|---|---|---|---|---|---|---|
| 1 | Bottom | 9:10 a.m. - 9:15 a.m | 0.7 | | | 18.0 | 18.7 |
| 2 | Bottom | 9:55 a.m. - 10:00 a.m. | 0.6 | | | 20.8 | 21.4 |
| 3 | Bottom | 10:50 a.m. - 10:56 p.m. | 0.7 | | | 24.4 | 25.1 |
| 4 | Bottom | 11:57 a.m. - 12:04 p.m. | 0.7 | | | 23.6 | 24.3 |
| 5 | Bottom | 12:58 p.m.- 1:05 p.m. | 0.5 | | | 18.9 | 19.4 |
| 6 | Bottom | 1:55 p.m. - 1:58 p.m. | 0.7 | | | 20.7 | 21.4 |
| 7 | Bottom | | | | | | |
| 8 | Bottom | | | | | | |
| 9 | Bottom | | | | | | |
| 10 | Bottom | | | | | | |

**TABLE 2**
**SAMPLE FORM**
**for the**
**ASH QUANTIFICATION AND CHARACTERIZATION STUDY**
**Fly Ash**

Date: May 25, 1994 Facility: Signal Wheelabrator Shasta Energy
Location: Anderson, CA

| Sample # | Type of Sample | Time of Sample | Ferrous (in pounds) | < #4 (in pounds) | Slag/Inerts >2" | Ash Sample > #4 (in pounds) | TOTAL (in pounds) |
|---|---|---|---|---|---|---|---|
| 1 | Fly | 8:18 a.m. - 9:12 a.m | 0 | 0 | 0 | 2.5 | 2.5 |
| 2 | Fly | 9:45 a.m. | 0 | 0 | 0 | 2.0 | 2.0 |
| 3 | Fly | 10:45 a.m. | 0 | 0 | 0 | 2.2 | 2.2 |
| 4 | Fly | 12:00 p.m. | 0 | 0 | 0 | 2.1 | 2.1 |
| 5 | Fly | 1:00 p.m. | 0 | 0 | 0 | 2.4 | 2.4 |
| 6 | Fly | 2:00 p.m. | 0 | 0 | 0 | 2.0 | 2.0 |
| 7 | Fly | | | | | | |
| 8 | Fly | | | | | | |
| 9 | Fly | | | | | | |
| 10 | Fly | | | | | | |

REPORT NUMBER

94-153-005

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

Client No: 3084

SEND TO:

R.W. BECK
1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER

SAMPLES SUBMITTED BY: SIGNAL WHEELABRATOR-ANDERSON

LAB NO. 20749 DATE 06/10/94 PAGE 1

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #1 BOTTOM ASH | 0.03 | 0.20 | 0.46 | 0.720 | 0.867 | 0.130 | 0.440 | 1.840 | 0.180 | 28800 | 21400 | 1090 | 70 | 2380 | | |

### POUNDS OF NUTRIENTS/TON

| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #1 BOTTOM | 0.6 | 4.0 | 9.2 | 14.4 | 17.3 | 2.6 | 8.8 | 36.8 | 3.6 | 57.6 | 42.8 | 2.2 | 0.1 | 4.8 | | |

☐ Reported on an as-received basis Moisture = %

☒ Reported on a dry basis Moisture = 9.48 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

REPORT NUMBER

94-153-005

# A & L WESTERN AGRICULTURAL LABORATORIES

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Client No: 3084

SEND TO:

R.W. BECK
1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER SIGNAL WHEELABRATOR

SAMPLES SUBMITTED BY ANDERSON

LAB NO. 20750 DATE 06/10/94 PAGE 2

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #2 BOTTOM ASH | 0.03 | 0.19 | 0.44 | 0.650 | 0.783 | 0.140 | 0.400 | 1.560 | 0.180 | 26700 | 17600 | 8500 | 60 | 1430 | | |

### POUNDS OF NUTRIENTS/TON

| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #2 BOTTOM | 0.6 | 3.8 | 8.7 | 13.0 | 15.7 | 2.8 | 8.0 | 31.2 | 3.6 | 53.4 | 35.2 | 17.0 | 0.1 | 2.9 | | |

☐ Reported on an as-received basis Moisture = %

☒ Reported on a dry basis Moisture = 9.81 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

REPORT NUMBER

94-153-005

# A & L WESTERN AGRICULTURAL LABORATORIES

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Client No: 3084

SEND TO:

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1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER

SAMPLES SUBMITTED BY: SIGNAL WHEELABRATOR-ANDERSON

LAB NO. 20751 DATE 06/10/94 PAGE 3

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITRO-GEN | P PHOS-PHORUS | $P_2O_5$ PHOS-PHATE | K POTAS-SIUM | $K_2O$ POTASH | S SULFUR | Mg MAG-NESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMI-NUM | Mn MANGA-NESE | Cu COPPER | Zn ZINC | | |
| #1 FLY ASH | 0.07 | 1.51 | 3.46 | 3.210 | 3.867 | 2.710 | 2.640 | 13.800 | 0.280 | 26900 | 27100 | 6400 | 450 | 3690 | | |

### POUNDS OF NUTRIENTS/TON

| SAMPLE NUMBER | N NITRO-GEN | P PHOS-PHORUS | $P_2O_5$ PHOS-PHATE | K POTAS-SIUM | $K_2O$ POTASH | S SULFUR | Mg MAG-NESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMI-NUM | Mn MANGA-NESE | Cu COPPER | Zn ZINC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #1 FLY | 1.3 | 30.2 | 69.2 | 64.2 | 77.3 | 54.2 | 52.8 | 276.0 | 5.6 | 53.8 | 54.2 | 12.8 | 0.9 | 7.4 | | |

☐ Reported on an as-received basis  Moisture = %

☒ Reported on a dry basis  Moisture = 0.50 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

REPORT NUMBER

94-153-005

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

Client No: 3084

SEND TO:

R.W. BECK
1125 17TH STREET, STE. 1900
DENVER, CO 80202-

CUSTOMER

SAMPLES SUBMITTED BY

SIGNAL WHEELABRATOR ANDERSON

LAB NO. 20752 DATE 06/10/94 PAGE 4

## MANURE ANALYSIS REPORT

| | REPORT OF ANALYSIS-PERCENT | | | | | | | | | REPORT OF ANALYSIS-PARTS PER MILLION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #2 FLY ASH | 0.07 | 1.43 | 3.28 | 3.280 | 3.951 | 4.170 | 2.480 | 12.400 | 0.280 | 23300 | 24000 | 5810 | 710 | 4110 | | |

| | POUNDS OF NUTRIENTS/TON | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE NUMBER | N NITROGEN | P PHOSPHORUS | $P_2O_5$ PHOSPHATE | K POTASSIUM | $K_2O$ POTASH | S SULFUR | Mg MAGNESIUM | Ca CALCIUM | Na SODIUM | Fe IRON | Al ALUMINUM | Mn MANGANESE | Cu COPPER | Zn ZINC | | |
| #2 FLY | 1.3 | 28.6 | 65.5 | 65.6 | 79.0 | 83.4 | 49.6 | 248.0 | 5.6 | 46.6 | 48.0 | 11.6 | 1.4 | 8.2 | | |

☐ Reported on an as-received basis Moisture = %

☒ Reported on a dry basis Moisture = 0.54 %

Remarks:

To convert to pounds of nutrients/ton as received, multiply pounds of nutrients/ton as reported by (100 - moisture %)/100.



This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

By ROBERT BUTTERFIELD

# A & L WESTERN AGRICULTURAL LABORATORIES

1311 Woodland Ave. • Ste. #1 • Modesto, CA 95351 • (209) 529-4080 • FAX (209) 529-4736


REPORT NUMBER
94-153-005

Client No: 3084

June 13, 1994

Ben Levy
R.W. BECK
1125 17th Street, Suite 1900
Denver, Colorado 80202

CIWMB Ash Study
Signal Wheelabrator/Anderson

| | | | | | |
|---|---|---|---|---|---|
| Lab No | | 20749 | 20750 | 20751 | 20752 |
| Sample Id | | Bottom Ash #1 | Bottom Ash #2 | Fly Ash #1 | Fly Ash |
| Organic Matter (by combustion) | % | 1.90 | 1.00 | 21.30 | 21.28 |
| Chloride | % | 0.18 | 0.24 | 3.32 | 3.24 |
| CCE | % | 5.26 | 5.53 | 39.81 | 36.63 |
| Acid Insoluble Ash | % | 91.03 | 93.00 | 5.89 | 6.14 |
| Bulk Density | gm/ml | 1.27 | 1.26 | 0.15 | 0.15 |
| #200 Sieve Size (% passing thru) | | 0.46 | 0.46 | 2.16 | 3.30 |

A & L Western Agricultural Laboratories

Robert Butterfield
Laboratory Director

EPA METHOD 1311/3010/6010
TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | BOTTOM ASH #1 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-01 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 725 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

# EPA METHOD 1311/3010/6010
# TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | BOTTOM ASH #2 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-02 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 801 |
| Cadmium | 10 | ND |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

# EPA METHOD 1311/3010/6010
# TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | FLY ASH #1 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-03 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 385 .385 |
| Cadmium | 10 | 112 .112 |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

EPA METHOD 1311/3010/6010
TCLP METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/06/94 |
| SAMPLE ID: | FLY ASH #2 | DATE ANALYZED: | 06/08/94 |
| CONTROL NO.: | F003-04 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Arsenic | 300 | ND |
| Barium | 10 | 313 |
| Cadmium | 10 | 203 .203 |
| Chromium | 10 | ND |
| Lead | 100 | ND |
| Mercury^* | .5 | ND |
| Selenium | 300 | ND |
| Silver | 10 | ND |

^ EPA METHOD 7471
TCLP Extraction Date: 06/02/94
* Date Analyzed, 06/06/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | BOTTOM ASH #1 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-01 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | 10.3 |
| Barium | .5 | 124 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 19.6 |
| Cobalt | .5 | 5.83 |
| Copper | .5 | 25.5 |
| Lead | 5 | 8.11 |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | ND |
| Nickel | 1 | 13.2 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | ND |
| Vanadium | .5 | 30.6 |
| Zinc | 1 | 653 |

^ EPA METHOD 7471, analyzed on 06/22/94

# EPA METHOD 3050/6010
# TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | BOTTOM ASH #2 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-02 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | ND |
| Arsenic | 10 | ND |
| Barium | .5 | 120 |
| Beryllium | .5 | ND |
| Cadmium | .5 | ND |
| Chromium | .5 | 20.5 |
| Cobalt | .5 | 5.51 |
| Copper | .5 | 31.6 |
| Lead | 5 | 23.5 |
| Mercury^ | .05 | ND |
| Molybdenum | 2.5 | ND |
| Nickel | 1 | 16.5 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | ND |
| Vanadium | .5 | 25.8 |
| Zinc | 1 | 684 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | FLY ASH #1 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-03 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | 31.3 |
| Arsenic | 10 | 51.7 |
| Barium | .5 | 1050 |
| Beryllium | .5 | ND |
| Cadmium | .5 | 8.08 |
| Chromium | .5 | 54.8 |
| Cobalt | .5 | 52.2 |
| Copper | .5 | 505 |
| Lead | 5 | 213 |
| Mercury^ | .05 | 1.94 |
| Molybdenum | 2.5 | 36.4 |
| Nickel | 1 | 46.2 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | ND |
| Vanadium | .5 | 44.9 |
| Zinc | 1 | 22200 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD 3050/6010
TTLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/20/94 |
| SAMPLE ID: | FLY ASH #2 | DATE ANALYZED: | 06/21/94 |
| CONTROL NO.: | F003-04 | MATRIX: | ASH |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (mg/kg) | RESULT (mg/kg) |
|---|---|---|
| Antimony | 5 | 51.6 |
| Arsenic | 10 | 45.4 |
| Barium | .5 | 986 |
| Beryllium | .5 | ND |
| Cadmium | .5 | 8.43 |
| Chromium | .5 | 50.9 |
| Cobalt | .5 | 64.7 |
| Copper | .5 | 505 |
| Lead | 5 | 218 |
| Mercury^ | .05 | 1.89 |
| Molybdenum | 2.5 | 41.5 |
| Nickel | 1 | 42.5 |
| Selenium | 10 | ND |
| Silver | .5 | ND |
| Thallium | 20 | ND |
| Vanadium | .5 | 41.2 |
| Zinc | 1 | 26300 |

^ EPA METHOD 7471, analyzed on 06/22/94

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | BOTTOM ASH #1 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-01 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 5280 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 154 |
| Cobalt | 10 | 172 |
| Copper | 10 | 795 |
| Lead | 100 | 1640 |
| Mercury^ | 0.4 | ND |
| Molybdenum | 50 | ND |
| Nickel | 20 | 213 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 636 |
| Zinc | 20 | 26900 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | BOTTOM ASH #2 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-02 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | 2510 |
| Arsenic | 300 | ND |
| Barium | 10 | 6620 |
| Beryllium | 10 | ND |
| Cadmium | 10 | ND |
| Chromium | 10 | 197 |
| Cobalt | 10 | 887 |
| Copper | 10 | 1460 |
| Lead | 100 | 13300 |
| Mercury^ | 0.4 | ND |
| Molybdenum | 50 | ND |
| Nickel | 20 | 416 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 735 |
| Zinc | 20 | 33200 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | FLY ASH #1 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-03 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | ND |
| Arsenic | 300 | ND |
| Barium | 10 | 5260 |
| Beryllium | 10 | ND |
| Cadmium | 10 | 49.4 |
| Chromium | 10 | 1640 |
| Cobalt | 10 | 220 |
| Copper | 10 | 12300 |
| Lead | 100 | 192 |
| Mercury^ | 0.40 | 0.41 |
| Molybdenum | 50 | 947 |
| Nickel | 20 | 33.7 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 499 |
| Zinc | 20 | 12100 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94

EPA METHOD WET/3010/6010
STLC CAM METALS BY ICP

| | | | |
|---|---|---|---|
| CLIENT: | RW Beck & Associates | DATE COLLECTED: | 05/25/94 |
| PROJECT: | CIWMB- Ash Study | DATE RECEIVED: | 06/01/94 |
| BATCH NO.: | 94F003 | DATE EXTRACTED: | 06/09/94 |
| SAMPLE ID: | FLY ASH #2 | DATE ANALYZED: | 06/09/94 |
| CONTROL NO.: | F003-04 | MATRIX: | Ash |
| % MOISTURE: | NA | DILUTION FACTOR: | 1 |

| PARAMETER | DET LIMIT (ug/L) | RESULT (ug/L) |
|---|---|---|
| Antimony | 200 | 766 |
| Arsenic | 300 | ND |
| Barium | 10 | 3600 |
| Beryllium | 10 | ND |
| Cadmium | 10 | 595 |
| Chromium | 10 | 1330 |
| Cobalt | 10 | 573 |
| Copper | 10 | 14200 |
| Lead | 100 | 448 |
| Mercury^ | 0.40 | 0.64 |
| Molybdenum | 50 | 1410 |
| Nickel | 20 | 189 |
| Selenium | 300 | ND |
| Silver | 10 | ND |
| Thallium | 300 | ND |
| Vanadium | 10 | 786 |
| Zinc | 20 | 486000 |

^ EPA METHOD 7471
WET Extraction Date: 06/06/94