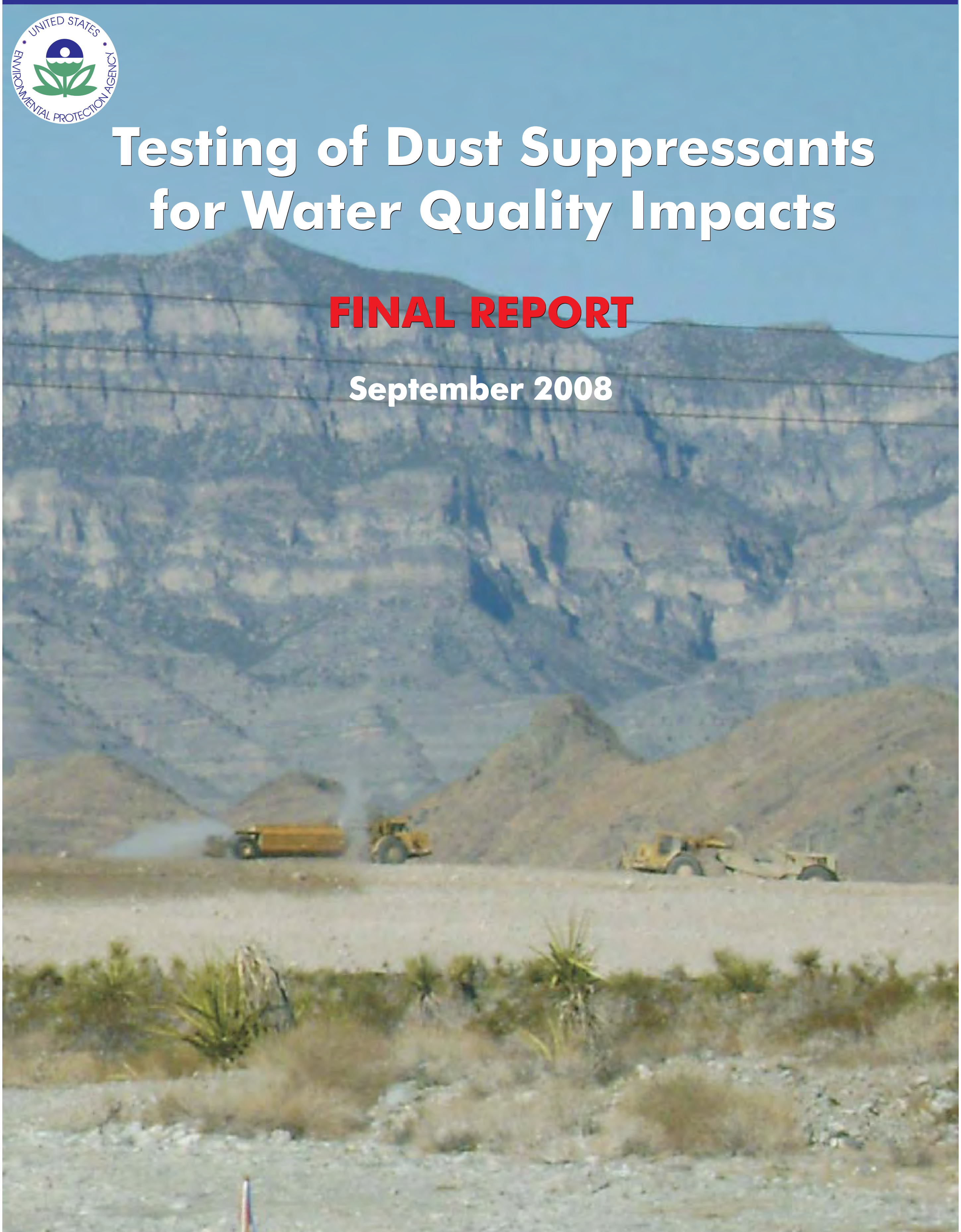
Testing of Dust Suppressants for Water Quality Impacts

FINAL REPORT

September 2008



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EXECUTIVE SUMMARY

The purpose of this research was to identify dust suppressant products with minimal to no adverse impacts on water quality and aquatic life relative to use of water alone. Simulated stormwater runoff from small-scale soil plots treated with six dust suppressant products was evaluated for water quality and aquatic toxicity. The study also evaluated the quality of water leached through soils treated with dust suppressant products.

The study design replicated, to the extent possible, conditions under which dust suppressants are typically applied at construction sites in desert climates. This included use of soils from Arizona and Nevada, a simulated 5-day earthmoving period with soil disturbance and repeated product applications, and heating soils to desert temperatures during the day. Emphasis was placed on dust suppressant applications to control dust during active earthmoving, e.g., rough grading. Surface runoff tests incorporated different combinations of two product application scenarios, three rainfall intensities, and three rainfall time periods (up to 2 months following product application).

Dust suppressant products tested include:

Chem-Loc 101 (surfactant)
Enviro RoadMoisture 2.5 (surfactant)
Durasoil (synthetic organic)
Jet-Dry (surfactant)
Haul Road Dust Control (surfactant)
EnviroKleen (synthetic polymer)

The study analyzed surface runoff and subsurface leaching from soils treated with dust suppressants for nine standard water quality parameters. In addition, surface runoff was tested for toxicity to aquatic life (fish, algae, and invertebrates). Furthermore, pilot tests with soils collected from multiple locations in Arizona and Nevada were conducted to gauge the potential of dust suppressant products to mobilize pre-existing salts and/or metals in soils.

Overall, water quality results for the dust suppressant products were favorable, showing concentrations similar to water-only control tests on untreated soils for the

majority of parameters evaluated. For a subset of parameters and dust suppressant products, average results were higher relative to control tests. However, considerable variation among control sample values warrants conservative data interpretation, particularly in cases where average results for dust suppressant products were only marginally higher.

A trend was observed for Total Suspended Solids (TSS) values in surface runoff from soils treated with Durasoil and EnviroKleen. TSS reflects the quantity of sediments suspended in water and resulting water clarity. TSS concentrations corresponding to these two products were significantly higher relative to control samples (on average, five times higher in Durasoil runoff and twice as high in EnviroKleen runoff). The higher TSS values appear to relate to the products' soil binding characteristics and the tendency for larger dirt clumps to form and be released in surface runoff relative to tests involving untreated or surfactant-treated soils. In a real-world setting, overland runoff typically travels some distance, creating opportunity for heavier dirt clumps to settle out prior to reaching a water body. Also, use of an on-site retention pond as a stormwater best management practice would likely prevent off-site runoff.

Results from the subsurface leaching tests show no potential impact from the dust suppressants on groundwater quality for the parameters evaluated. (While subsurface leaching TSS results from a couple of products were higher than control samples, TSS is generally not a concern for groundwater quality.)

In pilot tests on multiple soil types that examined the water quality of a soil/water/product mixture (as opposed to surface runoff), Total Dissolved Solids (TDS) concentrations for two products -- Enviro RoadMoisture 2.5 and Durasoil -- were significantly higher than control samples. TDS refers to inorganic solids dissolved in water, such as mineral salts. In contrast to these results, TDS values observed in surface runoff tests involving Enviro RoadMoisture 2.5 and Durasoil were not higher relative to control samples. The high TDS pilot test results may be a facet of experimental design rather than an effect that would occur in surface runoff. Additional research could assess the actual potential of the two products to mobilize salts in surface runoff from multiple soil types.

Aquatic toxicity results were also generally favorable. No toxicity to fish was observed in any dust suppressant product runoff. No significant inhibition of algae growth was observed in the two or more samples per dust suppressant product that were successfully tested. A caveat to this favorable outcome is that the algae test protocol required fine filtration of samples that removed significant quantities of sediment to which the dust suppressant products may have adhered.

Toxic effects to the invertebrate *Daphnia magna* were observed in some samples, however, most runoff samples from the surfactants showed no significant impact. For the limited instances when an adverse effect on daphnia survival was observed in surfactant runoff relative to control test runoff, variability among control test results renders the effect inconclusive.

Runoff from Durasoil and EnviroKleen showed a significant impact to *Daphnia magna* survival rates across all tests. This effect was not a classic toxic response but related to physical entrapment of the daphnia in an insoluble product layer. However, the entrapment observed within small laboratory test containers does not represent an effect likely to occur in an open water body, given various potentially mitigating factors. Furthermore, any such effect would likely be localized to a small area. Pure product tests with Durasoil and EnviroKleen showed that the physical entrapment effect does not extend to a smaller invertebrate also commonly used in toxicity testing, *Ceriodaphnia dubia*.

The results of this study should in no way be construed to support the use of substitute dust suppressant products that have not undergone similar testing and may have other and/or more significant potential impacts to water quality or aquatic life than the limited effects observed in this study.

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ACRONYMS

AZ	Arizona
BMPs	Best Management Practices
CL	Chem-Loc 101
CW	Control Water (samples of Region 9 Laboratory water)
DS	Durasoil
AQD	Air Quality Department (Maricopa County)
DAQEM	Department of Air Quality & Environmental Management (Clark County)
DO	Dissolved Oxygen
DQO	Data Quality Objective
EC	Electrical Conductivity
EK	EnviroKleen
ERM	Enviro RoadMoisture 2.5
EQM	Environmental Quality Management
HR	Haul Road Dust Control
JD	Jet-Dry
NV	Nevada
PMSD	Percent Minimum Significant Difference
PM-10	Particulate matter < 10 microns
QAPP	Quality Assurance Project Plan
RC	Runoff Control (from untreated test plots)
RO-Water	Reverse Osmosis Water
SERL	San Diego Soil Erosion Research Laboratory
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

1.1 Background

Fugitive dust accounts for 80% or more of particulate matter less than 10 microns (PM-10) in desert areas such as the Las Vegas Valley (Clark County, Nevada) and the Phoenix Metropolitan Area (Maricopa County, Arizona). USEPA has established a health-based national air quality PM-10 standard of 150 ug/m^3 as a maximum daily concentration. In response to continuing population growth trends in areas such as Clark County and Maricopa County, significant quantities of desert acreage are subject to development, causing soil disturbance and necessitating stringent fugitive dust controls to meet and maintain PM-10 air quality objectives.

Desert soils that tend to resist water have particularly high propensity for creating fugitive dust. These types of soils are prevalent in Clark County, Maricopa County, and other arid areas. The use of dust suppressants other than water[1] can be beneficial, and in some cases necessary, to adequately control fugitive dust at earthmoving/construction sites. They also reduce the quantity of water needed for adequate dust control, thereby contributing to water conservation. Without the use of dust suppressant products, earthmoving of soils with high potential to create fugitive dust in hot temperatures may require constant watering to comply with fugitive dust regulations.

Many dust suppressant products are designed to form a hard crust that can withstand vehicle traffic on unpaved roads or elevated winds on bulk storage piles. Others assist the effectiveness of applying water during active earthmoving, e.g., rough grading, trenching, and digging, so that moisture reaches the depth of cut. Surfactants are non-petroleum based organics which, when added to water, reduce surface tension for better water penetration into subsurface soil layers before or during active earthmoving. Synthetic polymer or organic dust suppressants bind soil particles together. They can be used in lower concentrations to enable soil mobility during earthmoving or in higher concentrations to form a firm, stabilizing crust.

[1] Products added to water or used in lieu of water for dust control.

1.2 Purpose of Study

Construction sites may be located in areas draining to storm water channels, in the immediate vicinity of surface waters, and/or above groundwater resources. Given the benefits for both dust suppression and water savings that dust suppressant products offer, the objective of this study is to identify products with minimal to no adverse impacts on water quality or aquatic life relative to use of water alone.[2]

Many dust suppressant products are advertised as environmentally safe, however, research by independent laboratories/contractors is needed to assess the validity of these claims. Results from this study will help fill an existing data gap.

Most dust suppressant water quality studies have been laboratory tests on product samples that have not come into contact with soil[3] or field research of surface runoff from soil stabilizer products and mulches. First, this study involves dust suppressant application to soils as opposed to laboratory tests on product samples. Second, it examines runoff from soils treated with surfactants, which can be used for dust control during active earthmoving. Furthermore, the study: 1) replicates soil and meteorological conditions that exist in desert environments, since these are the conditions most conducive to generating fugitive dust; 2) simulates soil disturbance and product re-application similar to that which may occur at a typical construction site; 3) evaluates potential impacts to groundwater from sub-surface infiltration of water-dust suppressant product mixtures; and 4) includes tests with multiple soil types to gauge the potential of dust suppressant products to mobilize pre-existing salts and/or metals in soils.

Because a limited number of dust suppressant products are evaluated in this study and discharges to water bodies are heavily influenced by site specific factors, the results should not be used to draw general conclusions about the impacts of dust suppressant product use on water quality. Rather, this study evaluates whether runoff from soils treated with six dust suppressant products could potentially have adverse impacts for

[2] We note that construction sites are subject to general permit stormwater control requirements to implement Best Management Practices (BMPs) to prevent runoff of sediment and contaminants into surface waters. Construction site owners/operators may select from a menu of stormwater BMPs with varying effectiveness depending on the type of BMP, site logistics, and the manner in which the BMPs are implemented and maintained.

[3] Such tests do not consider physical, chemical and microbiological reactions in soils.

water quality and aquatic toxicity *if* dispersed into a water body. The magnitude of any such potential adverse impacts would depend on a variety of factors, such as the amount of acreage on which the dust suppressant product is applied, type and extent of stormwater BMPs implemented, the characteristics of the surface over which runoff travels from a site before reaching a water body, quantity of runoff entering the water body, and the water body's flow dynamics, among others.

1.3 Study Participants

The project team responsible for designing and/or conducting the study consisted of representatives from the following organizations:

- USEPA Region 9, San Francisco, CA
- USEPA Region 9 Laboratory, Richmond, CA
- Environmental Quality Management, Cincinnati, OH
- San Diego State Soil Erosion Research Laboratory, San Diego, CA
- Clark County Department of Air Quality & Environmental Management (DAQEM), Las Vegas, NV
- Maricopa County Air Quality Department (AQD), Phoenix, AZ

Funding was provided by USEPA's Office of Research & Development through allocation of Regional Applied Research Effort funds. Supplemental funding and staff resources were provided by Clark County DAQEM and Maricopa County AQD.

SECTION 2

EXPERIMENTAL PROCEDURE

2.1 Project Summary

This study examined water quality and aquatic toxicity of simulated stormwater runoff from small-scale soil plots treated with dust suppressant products relative to plots on which water alone was applied. The study also evaluated subsurface infiltration (i.e., leaching) of water through soil treated with dust suppressant products and resulting water quality.

The study replicated, to the extent possible, the conditions under which dust suppressant products are typically applied at construction sites in desert climates. This included use of soils from Arizona and Nevada, a simulated 5-day earthmoving period with soil disturbance and repeated product applications, and heating soils to desert temperatures during the day.

Water quality and aquatic toxicity of surface runoff from six dust suppressant products (Table 2-1) was evaluated in a surface runoff experiment and water quality was evaluated in a vertical leaching experiment. In these experiments, half of the dust suppressant products were applied to soil collected from a site in Arizona and the other half to soil collected from a site in Nevada.

Table 2-1. Dust Suppressant Products

Product	Type of Suppressant	Soil for Testing
Chem-Loc 101	Surfactant	AZ
Enviro RoadMoisture 2.5	Surfactant	AZ
Durasoil	Synthetic Organic	AZ
Jet-Dry	Surfactant	NV
Haul Road Dust Control[4]	Surfactant	NV
EnviroKleen	Synthetic Polymer	NV

[4] Despite its name, this product can be used in other applications besides haul roads. In this study, it was tested in a simulated earthmoving application.

In addition, a "pilot" experiment was conducted for all six dust suppressant products on soils collected from multiple locations in Arizona and Nevada. Each of the three experiments is described in more detail below.

I. Surface Runoff Tests

These tests evaluated the potential of runoff from soils treated with dust suppressant products to impact surface water quality and aquatic life. Five cubic yards of soil was collected from a site in Arizona and five cubic yards from a site in Nevada. The soils were transported to San Diego and compacted into 14 by 25 inch wide, 4 inch deep trays. The trays were situated on a tilting mechanism with overhead rainfall simulators. Following dust suppressant application, rainwater was applied, collected at the bottom of the trays, and tested for 9 water quality parameters (pH, Electrical Conductivity, Total Dissolved Solids, Total Suspended Solids, Dissolved Oxygen, Total Organic Carbon, Nitrate, Nitrite, and Phosphate). The experiment included 18 soil trays and corresponding runoff samples for each dust suppressant product by incorporating three rainfall rates, two product application scenarios, and three scenarios ("ages") for timing of rainfall events following product application. In addition, 3 aquatic toxicity tests (fish, algae, and invertebrates) were conducted on the surface runoff samples.[5]

II. Vertical Leaching Tests

These tests evaluated the potential impact to groundwater quality of water infiltrated through soils treated with dust suppressant products. Soil collected from the same locations in Arizona and Nevada as in the surface runoff experiment was compacted in columns to a depth of 15 inches. Following dust suppressant application, rainwater was applied and held at constant volume on top of the soil to ensure infiltration through the soil columns. The infiltrated water was collected and tested for the same 9 water quality parameters as in the surface runoff tests. The experiment included 12 soil columns per dust suppressant product by incorporating two product application scenarios

[5] A total of six surface runoff samples per dust suppressant product were subject to aquatic toxicity tests.

and three ages for timing of rainfall events following product application (plus duplicate columns).

III. Pilot Tests (multiple soils)

The pilot tests evaluated whether dust suppressant products have potential to mobilize salts and/or metals that may pre-exist in typical desert soils. Soils collected from five locations in Arizona and five locations in Nevada were compacted into 4-inch diameter by 2-inch depth cylinders. The ten soils collected represent a general survey of soil types for purposes of determining sensitivity of water quality results to differences in soil chemistry and makeup. Following dust suppressant application, the soil was mixed with 300 ml of rainwater and tested for 3 water quality parameters -- pH, Electrical Conductivity, and Total Dissolved Solids. The experiment included 20 soil cylinders per dust suppressant product as each product was applied on all 10 soil types (plus duplicate cylinders).

All experiments included control tests on which water alone was applied to soil for comparison to dust suppressant product results. Table 2-2 shows the number of tests conducted per experiment in light of the varying study design factors.

Table 2-2. Experimental Factors and No. of Tests*

Factor	Surface Runoff*	Vertical Leaching	Pilot
Soil Types	2	2	10
Dust Suppressants per Soil Type	3	3	6
Rainfall Events	3	1	1
Rainfall Ages	3	3	1
Re-App Scenarios	2	2	1
Duplicate Tests	(1/3 of product tests)	2	2
Total Product Tests	108	72	120
Water Only Tests	18	8	20
Total Tests Producing Runoff Samples	126	80	140
Water Quality Parameters Tested	9	9	3
Total Water Quality Parameter Results	1,134	720	420

* Table excludes aquatic toxicity tests on surface runoff experiment samples

Environmental Quality Management (EQM) supervised the collection and shipment of soils and dust suppressants to San Diego. The San Diego State Soil Erosion Research Laboratory (SERL) conducted the dust suppressant experiments and water quality parameter tests. The USEPA Region 9 Laboratory conducted aquatic toxicity tests. A Quality Assurance Performance Plan (QAPP) was approved by USEPA Region 9 prior to the beginning of the study.

2.2 Soil Collection, Characterization & Homogeneity

The following soils were collected for use in the study:

- Two (2) five cubic yard soil samples -- from one site in Maricopa County, Arizona and one site in Clark County, Nevada
- Ten (10) one gallon soil samples -- from 5 sites in Maricopa County and 5 sites in Clark County

Clark County DAQEM and Maricopa County AQD recommended specific locations for soils collection by reviewing soil maps contained in PM-10 plans and rules for their respective areas. The maps classify soils by texture and corresponding severity of dust-emitting potential.

Soil for the surface runoff and vertical migration experiments was collected “in bulk” from a single site in Maricopa County and a single site in Clark County. Approximately 5 cubic yards was removed from each site by backhoes digging to a depth of 1 foot. Soils for the pilot experiment were collected from five sites in Maricopa County and five sites in Clark County. The ten sites are intended to represent a general survey of random soil types and particulate emissions potential. At each of the ten sites, EQM collected 1-2 quarts of soil to a 1-inch depth.

Appendix A contains maps identifying the locations from which all soils were collected. EQM placed the two bulk soils into Super Sacks and the general survey soils into one-gallon containers. Figures 2-1 and 2-2 show the collection of the Arizona soil bulk sample and a one-gallon sample, respectively.

Figure 2-1. Collection of Arizona Soil Bulk Sample

Figure 2-2. Collection of Arizona Soil One-Gallon Sample

Prior to delivery to SERL, EQM removed 4 ounce samples from the two bulk soils for pre-testing of metals and mercury contamination at Severn Trent Laboratory (Sacramento, California). This step was taken to ensure that the concentrations of metals, including mercury, in the bulk soils are typical for Maricopa County and Clark County. USEPA Region 9 compared the Severn Trent Laboratory test results to those in a United States Geological Survey (USGS) report.[6] The range of metals concentrations in the bulk soil collected from Maricopa County was generally consistent, although somewhat lower than, typical values reported for Maricopa County soil by the USGS.[7] The range of metals concentrations in the bulk soil collected from Clark County was consistent with USGS data reported for Clark County soil. Mercury concentrations in both the Arizona and Nevada bulk soil samples were nondetectable. Appendix B compares the Severn Trent Laboratory results to the USGS report.

Once the soils were delivered to San Diego, SERL re-mixed the two bulk soils to ensure homogeneity for segmenting into individual test trays and columns. SERL placed each bulk soil on a clean tarp, spread into a square approximately 1 foot deep. The soil was then divided into four equal quadrants using stakes and string lines. Next, 30-gallon plastic garbage cans (previously cleaned with reverse osmosis water) were filled with equal parts of soil from each quadrant. The garbage cans were labeled, covered and transferred inside SERL for storage.

SERL also performed particle size analysis on the two bulk soils to determine their size characteristics.[8] Results from this analysis are shown in Figure 2-3.

[6] "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States", U.S. Geological Survey Professional Paper 1270, Hansford T. Shacklette and Josephine G. Boerngen, 1984.

[7] We also note that the USGS data shows significant natural variability in soils metals concentrations for central Arizona, such that it may be difficult to interpret the results of water quality tests with respect to metals concentrations. In particular, data for arsenic, chromium, cobalt, nickel and vanadium is extremely variable for central Arizona.

[8] First, size fractions for particles larger than 0.075 mm were determined using a standard sieve analysis. Second, finer particle fractions were determined using a particle size analyzer.

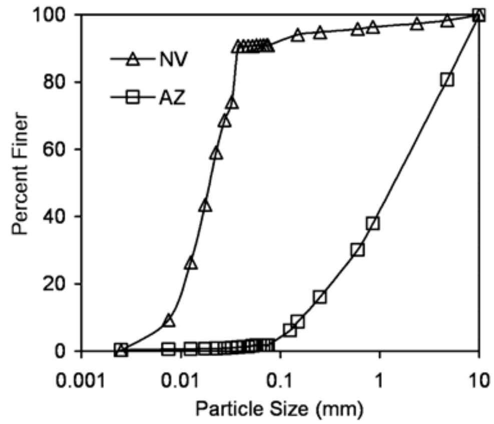

Figure 2-3. Particle Size Distributions for Bulk Soils

Table 2-3 provides a breakdown of the bulk soils by percent sand, silt and clay.

Table 2-3. Bulk Soil Texture Description

Material	**Definition**	**% AZ soil**	**% NV soil**
Sand	0.5 – <2 mm	97.5	6.8
Silt	0.002 – 0.5 mm	2	93.1
Clay	< 0.002 mm	0.5	0.1
Textural Class[9]		Sand	Silt

***** Due to a significant gravel (2 – 64 mm) component in the AZ bulk soil, the textural class name is modified to "gravelly sand".

2.3 Dust Suppressants & Application Scenarios

USEPA Region 9, Clark County DAQEM, Maricopa County AQD, and EQM selected 6 dust suppressant products with good potential for minimal impacts on water quality and aquatic life. Table 2-4 shows the products selected, along with product-to-water ratios and application rates recommended by the manufacturers.[10] Two application rates were provided for Durasoil and EnviroKleen, one in lower quantity appropriate for

[9] Soil is classified according to a United States Department of Agriculture, Natural Resources Conservation Service soil texture calculator: http://soils.usda.gov/technical/aids/investigations/texture/index.html.

[10] For Jet-Dry, the product-to-water ratio and application rate were recommended by a representative of the construction industry.

an earthmoving activity, the other in higher quantity appropriate for soil stabilization. Product manufacturers provided samples of their dust suppressants for use in the study.[11]

Table 2-4. Recommended Product Application Rates

Product	Manufacturer	Suppressant Type	Product-To-Water Ratio	Application Rate
Chem-Loc 101 (CL)	Golden West Industries, Inc.	Surfactant w/ ionic and anionic properties	1.0 gal per 5,000 gal water	4,000 gal per 2 acres
Enviro RoadMoisture 2.5 (ERM)	Envirospecialists Inc.	Surfactant (non-ionic alcohol ethoxylate)	1.0 gal per 2,500 gal water	4,000 gal per 2 acres
Durasoil (DS)	Soilworks, LLC	Synthetic Organic	Product not diluted with water	1 gal/30 ft^2 & 1 gal/185 ft^2
Jet-Dry (JD)	Reckitt Benckiser	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
Haul Road Dust Control (HR)	Midwest Industrial Supply	Surfactant	1.0 gal per 2,000 gal water	4,000 gal per 2 acres
EnviroKleen (EK)	Midwest Industrial Supply	Synthetic Polymer	Product not diluted with water	1 gal per 40 ft^2 & 1 gal per 250 sq. ft^2

SERL downscaled the product application rates in Table 2-4 to the size of the soil containers used in the study and labeled the two application rates for Durasoil and EnviroKleen as (A) and (B).

USEPA Region 9, in consultation with Maricopa County AQD and Clark County DAQEM, designated half of the dust suppressants for testing on the Arizona bulk soil and the other half for testing on the Nevada bulk soil in the surface runoff and vertical migration experiments.

Table 2-5 shows the bulk soils on which each dust suppressant was tested, along with the quantity of product applied to trays in the surface runoff experiment, columns in the vertical leaching experiment, and cylinders in the pilot experiment.

[11] Jet-Dry in liquid form was purchased at a store rather than provided by the manufacturer.

Table 2-5. Dust Suppressant Application Rates Scaled to Study

Dust Suppressant	Bulk Soil	Product to Water Ratio (ml/liter)	Application Rate (liters/m^2)	Applied to Trays (ml)	Applied to Columns (ml)	Applied to Cylinders (ml)
Chem-Loc 101	AZ	0.2	1.8	430	14	15
Enviro Road Moisture 2.5	AZ	0.2	1.8	430	14	15
Durasoil	AZ	NA*	0.22 to 1.4	51 (A), 315 (B)	1.5 (A), 10 (B)	11
Jet-Dry	NV	0.2	1.8	430	14	15
Haul Road Dust Control	NV	0.2	1.8	430	14	15
EnviroKleen	NV	NA*	0.16 to 1.0	38(A), 235(B)	1.2(A), 8(B)	8
Water Only	Both	NA	1.8	430	14	15

* Synthetic products were not mixed with water in this study

(A) = Application Rate A
(B) = Application Rate B

In order for the study to replicate real-world dust suppressant use, Clark County DAQEM and Maricopa County AQD recommended an experimental design to assess the effects of repeated product applications[12] and simulated soil disturbance. A 5-day period was selected as a typical length of time to accomplish rough grading at a construction site. The study design included raking of soil to a 1-inch depth in order to simulate disturbance necessitating product re-application.

Two re-application scenarios for the 5-day period were developed for each dust suppressant product, to which we refer as "Application Scenario A" and "Application Scenario B". Table 2-6 shows the frequency of re-application and soil raking over the 5-day period used in the surface runoff and vertical leaching experiments.

[12] Dust suppressants are typically re-applied at construction sites during the active earthmoving phase in order to account for new soil disturbance and soil re-disturbance.

Table 2-6. Application A and B Scenarios

Dust Suppressant	Day 1	Day 2	Day 3	Day 4	Day 5
Surfactants (A)	1 App & raking	1 App & raking	1 App & raking	1 App & raking	1 App & raking
Surfactants (B)	1 App & raking	-- raking only	1 App & raking	-- raking only	1 App & raking
EnviroKleen and Durasoil (A)	1 App A & raking	1 App A & raking	1 App A & raking	1 App A & raking	1 App A & raking
EnviroKleen and Durasoil (B)	1 App B (no raking)	--	--	--	--
Water only	1 App & raking	1 App & raking	1 App & raking	1 App & raking	1 App & raking

(A) = Application Scenario A
(B) = Application Scenario B

In summary, for the surfactants (all products except EnviroKleen and Durasoil), Application Scenario A involved applying product each day throughout the 5-day period while Application Scenario B involved applying product only on Days 1, 3 and 5. Soil was raked once a day for both application scenarios at approximately 90 degrees relative to the direction of the previous day's raking. For the synthetic products (EnviroKleen and Durasoil), Application Scenario A involved applying a lower quantity of product each day (see Table 2-5) along with soil raking once per day. Application Scenario B involved applying a higher quantity of product (see Table 2-5) in a one-time application and no soil raking.

Prior to conducting the surface runoff experiment, SERL assessed the appropriateness of the product re-application rates to gauge soil saturation characteristics. Based on these pre-tests, SERL did not recommend any changes.

2.4 Surface Runoff Experiment

Test Apparatus

The surface runoff tests were performed on a 3-meter wide by 10-meter long tilting test bed with overhead rainfall simulators (Figures 2-4 and 2-5). The test bed was outfitted with eight platforms designed to hold removable soil trays (i.e., "test plots") 14 inches wide, 25 inches long, and 4 inches deep. The soil trays were suspended in the center of the platforms and, during the experiment, tilted to a 33% slope.

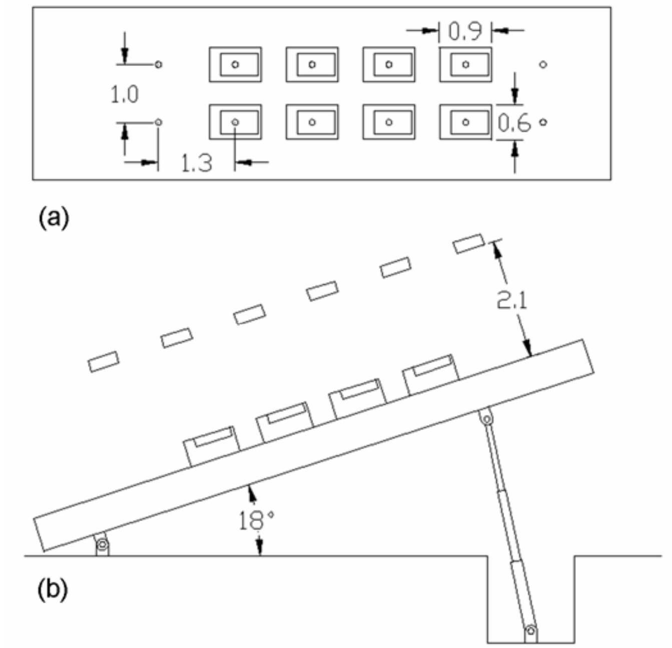

Figure 2-4. SERL's Tilting Bed with Overhead Rainfall Simulators and Soil Test Plots: ***(a) view shows spacing of rainfall simulator spray nozzles (circles), and dimensions of soil boxes in meters (rectangles); and (b) view shows vertical placement of rainfall simulators and soil test plots.***

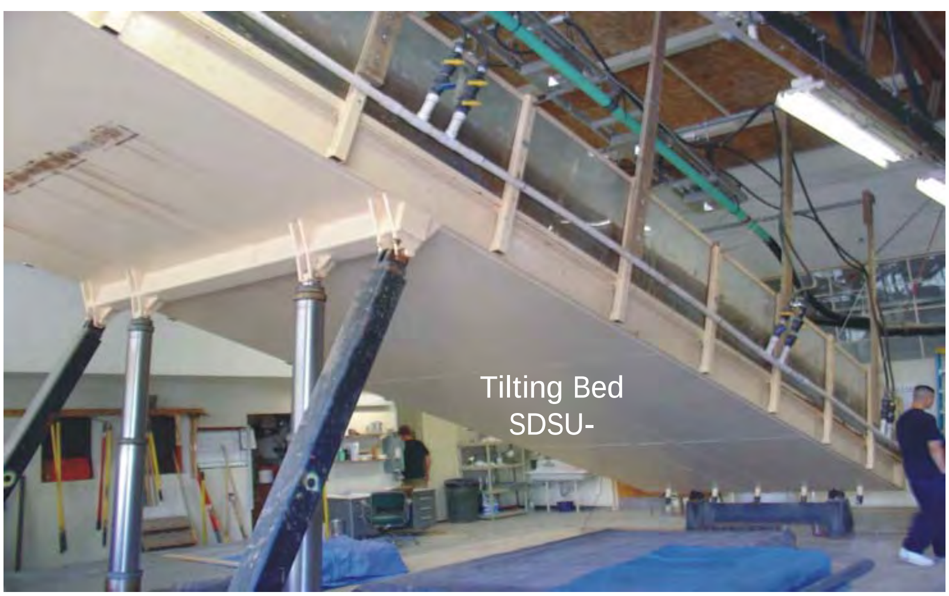

Figure 2-5. Tilting Test Bed (underside view)

Rainwater Description

The rainwater used in the experiment was tap water treated with reverse osmosis, henceforth referred to as "RO-water". SERL used RO-water for three purposes: 1) as artificial rainwater to generate surface runoff from soil test plots; 2) as a dust control alternative applied to soil test plots to represent "untreated" control scenarios; and 3) to dilute products where specified in the dust suppressant application scenarios.

SERL's water treatment system consists of a reverse osmosis unit, preceded by one activated carbon vessel and two softening vessels arranged in series (i.e., carbon/softener/softener). The system includes a pre-filter to remove particulates greater than 5 microns in size that may escape the service vessels. Treated water is stored in a 1,000 gallon polyethylene tank. Water is delivered to the rainfall simulators positioned above the soil test bed by a pump attached to hard plumbing and flexible hoses.

Rainwater was applied to the soil trays using a Norton Ladder Rainfall Simulator, developed at the USDA-ARS National Soil Erosion Research Laboratory. Nozzles are spaced 1.1 meters apart and at least 2.5 meters above the soil surface. For uniform intensity across a given test plot, the center of spray patterns from two laterally adjacent nozzles meet at the plot surface. This provides a 0.09 inch median drop size, a nozzle exit velocity of 6.8 meters per second, and a spherical drop with a soil surface impact velocity approximately equal to that of natural rainstorm drops. A full range of rainfall intensities can be achieved by adjusting either the number of sweeps per minute of the spray nozzles or the water pressure within the supply system. Unused water from within the simulators is returned to the holding tank for reuse. Flexible plumbing is installed to accommodate this return flow.

Soil Tray Preparation

First, SERL installed an overflow weir for each tray at a depth of 4 inches. Second, the trays were washed with RO-water, and the required amount of soil and water were mixed together using a concrete mixer and added to the tray in four equal intervals.[13] Each layer was compacted using a hand compactor until the soil was

[13] The bulk Arizona and Nevada soils were covered and stored at approximately 8 and 3% moisture content (by mass), respectively. Based on the moisture contents of the bulk soils, the dimensions of the trays, and the desired soil densities at final compaction, the required mass of soil and volume to water for optimal

compacted to a 4-inch depth. The soil trays were then covered and stored until dust suppressants were applied according to the two application scenarios in Table 2-6. Figures 2-6 and 2-7 show typical trays of Arizona and Nevada soils, respectively.

Rainfall Events

The surface runoff experiment involved 3 simulated rainfall events representing a range of desert climate precipitation capable of creating stormwater runoff. The initial rainfall event scenarios proposed by Clark County DAQEM and Maricopa County AQD were ultimately adjusted by SERL to ensure adequate runoff volume for the experiment. Only minor changes were made to the proposed rainfall intensities. When presented with the revised rainfall event scenarios, Clark County DAQEM and Maricopa County AQD indicated that they still adequately represent desert climate precipitation. Table 2-7 indicates the differences between the proposed and final rainfall event scenarios.

Table 2-7. Rainfall Events for Surface Runoff Experiment

	Proposed Rainfall Events			**Final Rainfall Events**		
Rainfall Event	Duration (min)	Rate (in/hr)	Depth (in)	Duration (min)	Rate (in/hr)	Depth (in)
1	80	0.75	1.0	150	0.7	1.75
2	40	1.5	1.0	80	1.3	1.75
3	26.6	2.25	1.0	44	2.4	1.75

Timing of Rainfall Events

The rainfall events were timed to occur at three different periods, i.e., “ages”, following dust suppressant application.

AGE 0 - immediately following the 5-day application period
AGE 1 - one month following the 5-day application period
AGE 2 - two months following the 5-day application period

compaction were determined. To achieve approximately 85% compaction according to the proctor compaction test with a depth of 10 cm, Arizona soil trays were filled with a mixture of 41 kg of soil and 1140 ml of RO-water. The Nevada soil trays were filled with 35 kg of soil and 4410 ml of RO-water.

Figure 2-6. Typical AZ Soil Tray Before Product Application and Raking

Figure 2-7. Typical NV Soil Tray Before Product Application and Raking

The purpose of including rainfall event scenarios one or two months following product application was to capture any biodegradation effects that may occur over time.[14]

Heating of Soils

All soils in the test trays were heated during the day to mimic desert conditions. This was done with appropriately spaced heat lamps to increase the temperature of the soils to approximately 86-104 degrees Fahrenheit for 12 hours each day. Soils were heated during both the 5-day dust suppressant application period and throughout the aging periods (up to 2 months). The test trays were stored in an enclosed greenhouse during both the application and aging periods (Figure 2-8). As needed, trays and columns aged in the greenhouse were covered and transported to the tilting test bed for rainfall simulation.

Surface Runoff Simulations

Following application of dust suppressants according to either Application Scenario A or B, the soil trays were placed on the tilting test bed to undergo one of the three simulated rainfall events at one of the three aging cycles (immediate, 1-month or 2-month). Given the combination of the various test parameters, SERL prepared a total of 126 soil trays -- 18 for each of the six dust suppressants plus 18 untreated (RO-water alone applied). The untreated soil trays were subject to the same experimental parameters as soil trays treated with dust suppressants. Figures 2-9 and 2-10 show close-ups of the Arizona and Nevada treated soils, respectively. Figure 2-11 shows the soil test boxes on the tilting soil bed.

Surface runoff from each soil tray was directed into a plastic flume discharging into a 4 liter, wide-mouth sample bottle.[15] Thus, a water runoff sample was generated for each of the 126 trays.[16] When a sample bottle was nearly full or the simulated rainfall

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[14] Application Scenario A tests were conducted for AGE 0 and AGE 1 only while Application Scenario B tests were conducted for AGE 1 and AGE 2 only.

[15] The discharge pipe and sample bottles were covered to prevent direct rainfall and splash from entering the sample bottles.

[16] A total of 36 out of 108 trays (6 per dust suppressant product) were duplicate tests with the same experimental parameters.

Figure 2-8. Greenhouse (AZ soils on the left, NV soils on the right) under heat lamps

had concluded, the lid was placed on the bottle and it was immediately transported to SERL's analytical laboratory for water quality analysis as specified in the QAPP.

A portion of the generated runoff was extracted, chilled to 4 degrees Celsius, and shipped on ice to USEPA's Region 9 laboratory in Richmond, California for aquatic toxicity testing. In order to have sufficient quantity for toxicity testing, SERL combined runoff generated from same-product test plots for the 3 rainfall event scenarios (runoff from product test plots subject to different application rates or aging was not combined for toxicity testing).

SERL took steps to homogenize runoff samples which were divided for either conducting replicate tests or aquatic toxicity tests. First, the contents of multiple bottles used to collect the entire volume of runoff from an individual test tray were combined into a single large container. Second, the runoff in the container was stirred prior to

Figure 2-9. Treated Arizona Soil Trays Under the Heat Lamps

Figure 2-10. Treated Nevada Soil Trays Under the Heat Lamps

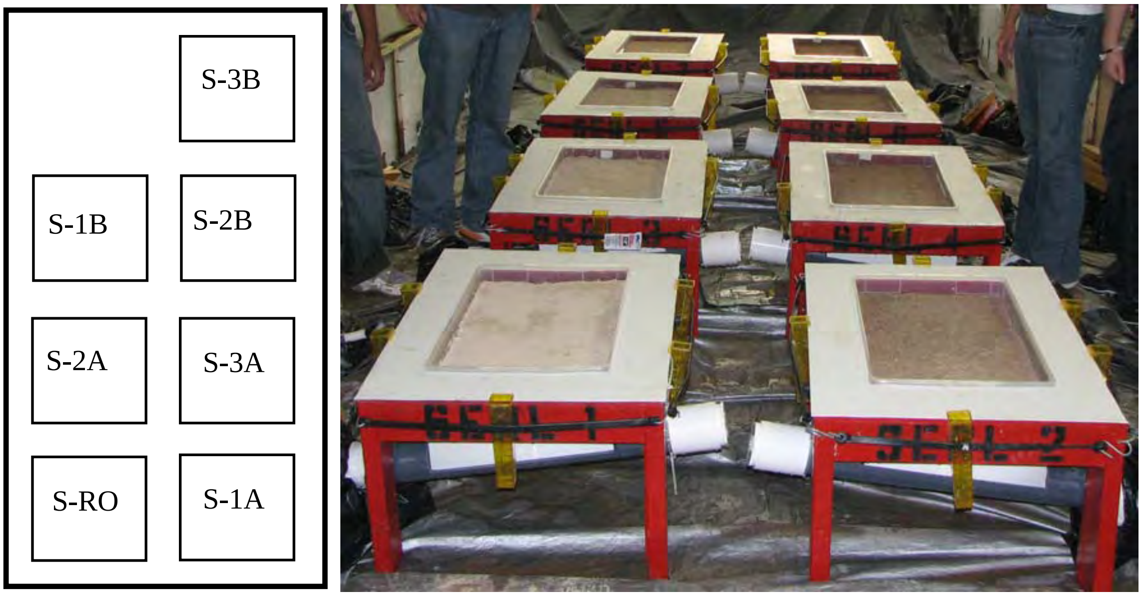

Figure 2-11. Plan view of tilting soil bed with approximate location of soil test boxes; drawing not to scale, where *S* is soil type; 1, 2, 3 are products; *A* and *B* are product application scenarios.

transfer into separate, smaller containers in order to ensure an approximately equivalent quantity of sediment in each container.

Water Quality Parameter Tests

SERL conducted an array of general chemistry water quality parameter tests (i.e., sample analyses) on runoff from the soil test plots. These sample analyses tests included pH, Electrical Conductivity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen, Total Organic Carbon, Nitrate, Nitrite, and Total Phosphorus. Appendix C contains a table showing the methods SERL used for water quality analysis.

Toxicity Tests

USEPA’s Region 9 Laboratory in Richmond, California, performed three types of aquatic toxicity tests on water runoff samples delivered by SERL:

1. Fish (*Pimephales promelas*, i.e., fathead minnow) - Acute
2. Algae (*Selenastrum capricornutum*) - Chronic
3. Invertebrate (*Dapnia magna*) – Acute

A detailed description of the toxicity tests and results are provided in Section 5 of this report.

2.5 Vertical Leaching Experiment

Test Apparatus

The vertical leaching tests were conducting using 4-inch diameter vertical flow columns. Each column was composed of a high-density polypropylene pipe, a bottom polypropylene coupling, which also serves as a plate, and an elliptical plastic fitting held in place by a removable rubber coupling equipped with a standard clamp. The input flow tube (0.25 inch diameter) was embedded in the top plastic fitting, and an output flow tube of the same size was embedded in the bottom coupling, as shown in Figure 2-12.

Soil Column Preparation

First, the pipe, couplings, and peripherals were cleaned, dried, and the bottom coupling was attached to the vertical pipe. Second, a washed-and-dried layer of gravel (layer thickness ≈ 0.98 in) was placed into the column, such that it rested on the bottom. The inside end of the output tubing was held within the gravel layer. Third, a layer of washed-and-dried well-graded fines-free sand (layer thickness ≈ 0.98 in) was then placed above the gravel layer to create a filtration zone (the gravel filters the sand; in turn, the sand layer filters the bulk soil).[17] Four, the bulk soil was placed inside the columns and compacted in layers to a depth of 15 inches to a pre-determined unit weight and moisture content.[18] The soil columns were then covered and stored until dust suppressants were applied.

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[17] The sand and gravel layer was added in order to prevent clogging. Since the pores of the sand and gravel were larger relative to the bulk soil above it, the sand and gravel layer would not have unduly influenced results by trapping contaminants.

[18] The bulk Arizona and Nevada soils were covered and stored at approximately 8 and 3% moisture content (by mass), respectively. Based on the moisture contents of the bulk soils, the dimensions of the columns, and the desired soil densities at final compaction, the required mass of soil and volume to water for optimal compaction were determined. To achieve the desired compaction of 70% proctor, AZ soil columns were filled with a mixture of 4.0 kg of soil and 110 ml of RO-water and the NV columns were filled with 3.5 kg of soil and 435 ml of RO-water.

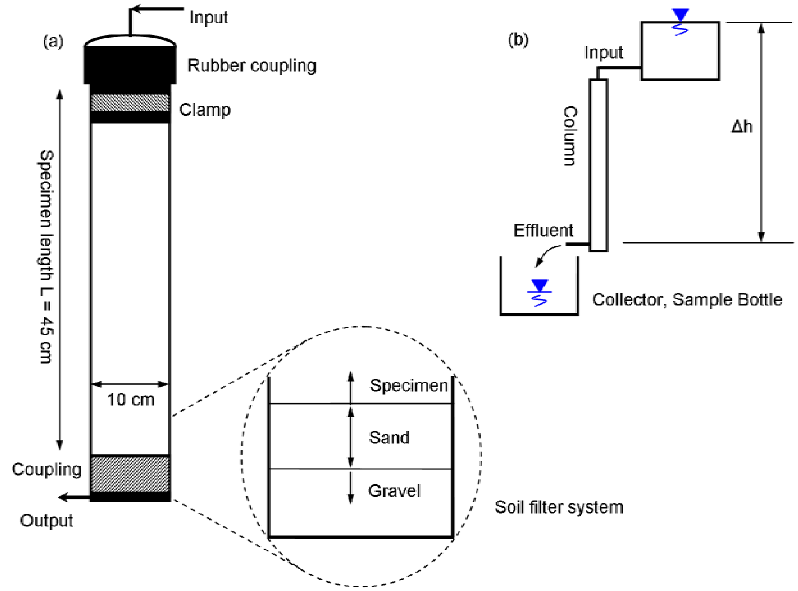

Figure 2-12. Vertical Leaching Experiment: (a) column design and (b) experimental setup

Infiltration Simulation

The vertical leaching tests were conducted using the same 5-day application scenarios as in the surface runoff tests (including dust suppressant re-application, soil raking, and soil heating), except dust suppressants were applied in lower quantity as shown in Table 2-5 due to the smaller container size (Figure 2-13). Another difference was that RO-water was applied to the top of each soil column and held at constant head. This simulates a circumstance in which rainwater has collected into a puddle or pond and gradually infiltrates.

Flow was imposed to soil columns by a constant gradient flow system. Each column was attached to a separate input tank containing RO-water. At the beginning of each test, a gradient $i = \Delta h / L$ of unity ($i = 1$) was imposed on each column. For most columns (~80%), this gradient was sufficient to produce approximately 3 to 4 liters of effluent in 2 to 3 days. The remainder of the columns either: (a) produced the desired amount of effluent in > 4 days; or (b) were subjected to a gradient increase ($i = 1$ to $i = 3$) if the effluent flow rate was small or minimal after 7 days. Where gradient increase was necessary, this may be attributable to the dust suppressant products clogging the effluent tube.

Figure 2-13. Typical AZ (left) and NV (right) soil columns before and after product application and raking

SERL prepared a total of 80 soil columns -- 12 for each of the six dust suppressant products plus 8 untreated columns (RO-water alone applied). The vertical leaching experiments were conducted in duplicate as part of quality assurance procedures. Untreated (water only) soil columns were subject to the same experimental design parameters as soil columns treated with dust suppressant products.

Effluent from the bottom of each soil column was collected in 4-liter, wide-mouth sample bottles. When a sample bottle was almost full or the experiment had concluded, the lid was placed on the bottle and it was immediately transported to the analytical laboratory for water quality analysis.

Water Quality Parameter Tests

Samples from the vertical leaching experiment were analyzed for pH, Electrical Conductivity, Total Suspended Solids, Total Dissolved Solids, Dissolved Oxygen, Total Organic Carbon, Nitrate, Nitrite, and Total Phosphorus. Appendix C contains a table showing the methods SERL used for water quality analysis.

2.6 Pilot Experiment

For the pilot tests, 1-2 quarts of soil collected from five locations in Arizona and from five locations in Nevada were placed into 4-inch diameter by 2-inch depth cylinders.[19] The intent of these tests was to evaluate sensitivity of select water quality parameters to differences in soil chemistry to gauge the potential of dust suppressant products to mobilize salts and/or metals that may pre-exist in soils.

Dust suppressants were applied to the soil cylinders in the quantities shown in Table 2-5. Following this one-time application, the cylinders were stored for 24 hours. Next, 300 ml of RO-water was applied to each cylinder and the entire soil-water mixture was transferred to a 1-liter sample bottle. The soil-water mixture was then transported to the SERL laboratory for water quality analysis of pH, Electrical Conductivity, and Total Dissolved Solids.

[19] To ensure uniformity between tests, each of the 10 soil samples was separated into 14 sub-samples weighing 12.3 ounces.

All six dust suppressant products plus water-only control tests were evaluated on all 10 soil samples. Also, the pilot tests were conducted in duplicate for quality assurance purposes. The pilot experiment generated a total of 140 results for each of the 3 water quality parameters tested.

SECTION 3

WATER QUALITY AND AQUATIC TOXICITY BENCHMARKS

3.1 Water Quality Parameters

Nine general water quality parameters[20] are used to assess the quality of water running off or infiltrating through soils on which dust suppressants were applied:

- pH
- Total Dissolved Solids (TDS)
- Electrical Conductivity (EC)
- Dissolved Oxygen (DO)
- Total Organic Carbon (TOC)
- Total Suspended Solids (TSS)
- Nitrate
- Nitrite
- Phosphate

pH, Total Dissolved Solids, and Electrical Conductivity

pH is a quantitative measure of acidity; a lower pH value corresponds to higher acidity. Typical surface waters have pH ranging from 6.5 to 9.

TDS refers to all inorganic solids (usually mineral salts) that are dissolved in water. TDS is measured by the weight of solids left behind once a water sample has evaporated. TDS is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. As examples of TDS values, 500 milligrams per liter is a secondary drinking water standard and salinity standards for the Colorado River range from 723 – 879 mg/L.

EC is closely related to TDS and is a measure of the ionic activity of a solution in terms of its capacity to transmit electrical current. The more salts dissolved in water (i.e.,

[20] While the study included nine standard water quality parameters, they represent a subset of parameters that can be used to evaluate water quality.

resulting in high TDS), the higher the EC. EC is measured using a conductivity probe that detects the presence of ions in water. In a dilute solution, TDS and EC are reasonably comparable and the TDS of a water sample based on the measured EC value can typically be calculated using the following equation:

$$\text{TDS (mg/l)} = 0.7 \times \text{EC (micromhos per centimeter)}$$

At high values of TDS and EC (a TDS of > 1,000 mg/l or EC > 2,000 (µS/cm)), then the relationship tends towards TDS = 0.9 x EC and TDS and EC of the sample should be measured separately. These equations may not always apply, e.g., where particles are too small (< 1 micron) to remain in solution or are not conductive. In these cases, only the TDS test would capture their effects.

pH and TDS can be evaluated together to determine whether one or more pre-existing metals in a soil is being mobilized by a dust suppressant product relative to water alone. If use of a dust suppressant on soils low in organic matter (as is typical of desert soils) does <u>not</u> lower pH, the dust suppressant will not likely mobilize heavy metals.

<u>Dissolved Oxygen</u>

DO is the amount of oxygen freely available in water and necessary for aquatic life and the oxidation of organic materials. DO concentrations can vary from 0 mg/L to 15 mg/L. A minimum DO of 5 mg/L is typically needed to sustain warm water fish and minimum of 7 mg/L to sustain cold water fish. Expressing DO in terms of percent saturation is useful because it takes into account factors such as water temperature.

<u>Total Organic Carbon</u>

TOC is a quantitative measure of organic carbon, which has bearing on oxygen demand. A high TOC reflects that oxygen has been extracted from the water, leaving a lower DO which could adversely affect plant growth. TOC is expressed in mg/L and there is no specific criteria threshold.

Total Suspended Solids

TSS provides a quantitative value of sediments that are suspended in water, which affect water clarity. Relative to TDS which measures the portion of total solids that pass through a container, TSS measures the portion of total solids retained by a filter. High TSS concentrations can pose problems for aquatic life health, e.g., by blocking light from submerged vegetation and lowering dissolved oxygen available to fish. When water flow slows down, suspended solids settle to the bottom. Increased fine sediment loads can adversely impact aquatic organism habitat, reproductive capability, and ultimate survival.

There are no numeric criteria for TSS, however, Arizona and Nevada have adopted standards for Suspended Sediment Concentration (SSC) for some water bodies. While directly correlating TSS and SSC is difficult, generally, the TSS value for a water sample will typically be lower relative to the comparable SSC value. Arizona and Nevada have established a SSC standard of either 25 or 80 mg/L to specifically identified streams and rivers (in Arizona, to those that support aquatic and wildlife uses). Arizona's SSC standard only applies during normal flow conditions, as opposed to stormflow.

Nitrate, Nitrite, and Phosphate

Nitrate, nitrite, and phosphate are nutrients that are necessary for aquatic plant and algae growth. However, high concentrations can over-stimulate aquatic plant and algae growth, resulting in high DO consumption and reduced ecosystem stability with adverse effects to aquatic life. Different surface water bodies have different capacities for nutrients depending on their use and existing water quality.

As examples of nutrient values, some rivers and lakes in Arizona have numeric limits on total phosphorous ranging from 0.10 – 0.2 mg/L (annual mean) and on total nitrogen ranging from 0.3 – 1 mg/L (annual mean).

3.2 Aquatic Toxicity Tests

Toxicity is the inherent potential or capacity of a material to cause adverse effects on living organisms. Three aquatic toxicity tests are used to gauge potential toxicity of surface runoff from soils treated with dust suppressant products.[21] These include:

1. Fish (*Pimephales promelas*, i.e., fathead minnow) – Acute
2. Algae (*Selenastrum capricornutum*) - Chronic
3. Invertebrate (*Dapnia magna*) - Acute

The fathead minnow is a member of the fish family Cyprinidae, the largest family of fish with more than 2,000 species worldwide and nearly 300 extant in North America. The fathead minnow is often used in toxicological research regarding the effects of pollution on freshwater resources as its tolerance of adverse conditions and ease of spawning make it ideal for laboratory culture. The method employed in this study measures acute, short-term adverse effects during a 48 hour static exposure with an endpoint of mortality.

The freshwater algae test measures inhibition of algae growth. Algae play an important role in the equilibrium of aquatic ecosystems for producing organics and oxygen. The method used in this study measures short-term adverse effects of potentially contaminated freshwater solutions during a static chronic 4-day exposure with an endpoint of mean cell density.

Daphnia magna are freshwater fleas and a source of food for other aquatic organisms. The method used in this study measures acute adverse effects during a 48-hour static exposure with an endpoint of mortality.

3.3 Data Quality Objectives

Data quality objectives (DQOs) are criteria intended to gauge whether each dust suppressant tested has minimal potential for adverse water quality impacts. Where the

[21] These toxicity tests are a subset of bioassessment tests that can be used to assess the health of aquatic organisms.

DQO for a particular parameter is not met, this indicates some potential for adverse impact.

DQOs developed for this study are provided in Table 3-1. The DQOs largely compare results from dust suppressant product tests to control tests in which water alone was applied to soil. This is done in recognition that applying water for dust control may have some potential for adverse impact with respect to one or more water quality parameters that should not be attributed to the dust suppressant products.

Table 3-1. Data Quality Objectives (DQOs)

Parameter	DQO	Comments
pH	1. If outside of the 6.5 to 9 range… 2. If pH is $\leq$90% control sample…	1. potential for adverse impact 2. product could be mobilizing salts, metals or both. Look at degree of difference between results.
TDS	If TDS is $\geq$ 25% control sample…	…product could be mobilizing salts, metals or both. Look at degree of difference between results.
EC	If EC is +/- 25% control sample …	…indicates the presence of a chemical species not in the control sample.
DO (% saturation)[22]	1. If DO is < 60% compared to a control sample value that is > 60%... 2. If DO is < the control sample value but between 60%-79%... 3. If DO is 90% or higher…	1. potential for adverse impact 2. DO levels acceptable albeit affected 3. a particularly good result
TOC	If TOC is $\geq$50% control sample…	…could indicate lower oxygen levels.
TSS	If TSS is $\geq$25% control sample…	…potential for adverse impact
Nitrate, Nitrite, Phosphate	1. If higher than control sample… 2. If value is $\geq$ 25% control sample… 3. If nitrate < 10 mg/L; nitrite < 1 mg/L; phosphate $\leq$ 0.2 mg/L	1. nutrients are being mobilized/added 2. potential for adverse impact 3. a particularly good result
Aquatic Toxicity Tests (Fish, Algae, Invertebrate)	1. If product test result is statistically significantly different than control sample… 2. If no acute effects observed in any of the 3 tests…	1. potential for toxic effects on aquatic organisms 2. low potential for toxic effects on aquatic organisms

[22] Percent saturation is the DO value in mg/L divided by the 100% DO value for water at the same temperature and air pressure.

SECTION 4

WATER QUALITY RESULTS

4.1 Summary

Overall, water quality results for the dust suppressant products are positive. For all six products tested in the surface runoff experiment, average results meet the study's benchmarks for five of the nine parameters evaluated -- pH, TDS, TOC, DO and Nitrate.[23] For the remaining four parameters – EC, TSS, Nitrite, and Phosphate – average results for at least one dust suppressant product for one or more of the parameters are not consistent with the DQOs. Most of these results are not necessarily cause for concern for reasons forthcoming. The most significant effect observed in the surface runoff experiment concerns high TSS values in runoff from soils treated with Durasoil and EnviroKleen relative to control tests with water alone.

In a cross-comparison of surface runoff results from tests conducted on Arizona soil versus Nevada soil, runoff from Arizona soil typically had higher Conductivity, TDS, TOC, Nitrate, Nitrite, and Phosphate, while runoff from Nevada soil had higher pH and TSS. DO was similar in runoff from both soils.

Table 4-1 shows average results for each dust suppressant product. Results from all individual tests in the surface runoff experiment are provided in Appendix D.

[23] We rely on average results of multiple tests corresponding to each dust suppressant product to gauge success in meeting the study's DQOs. This accounts for inherent variability observed when comparing results from individual tests, including control tests in which water alone was applied.

Table 4-1. Surface Runoff Experiment Results

Soil Type	Dust Supp	Statistic	pH	Conductivity µmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	DO % Sat	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	Phosphate mg/l
AZ	Water	Avg	8.17	604	2,650	1,050	6.99	78	20.9	2.24	0.10	1.03
		Std Dev	0.60	481	2,570	945	1.04	1.04	27.4	3.76	0.12	0.97
	CL	Avg	8.26	758	2,940	600	7.53	84	13.8	1.32	0.10	1.34
		Std Dev	0.54	595	2,190	459	0.61	0.61	14.5	2.11	0.11	1.55
	ERM	Avg	8.65	449	4,060	469	7.21	81	10.1	1.48	0.13	1.30
		Std Dev	0.44	516	2,650	332	1.13	1.13	13.7	1.85	0.12	1.26
	DS	Avg	8.64	193	12,700	195	7.42	83	3.57	0.79	0.11	1.36
		Std Dev	0.23	183	6,620	131	1.15	1.15	1.54	0.63	0.13	1.37
NV	Water	Avg	8.53	290	11,700	234	7.21	81	1.64	0.39	0.08	0.50
		Std Dev	0.64	169	13,400	108	1.12	1.12	1.13	0.11	0.08	0.29
	JD	Avg	8.86	236	11,700	182	7.37	82	1.10	0.41	0.06	0.46
		Std Dev	0.33	169	11,300	145	1.37	1.37	0.31	0.15	0.05	0.25
	HR	Avg	8.80	268	13,200	267	7.12	80	1.38	0.34	0.03	0.46
		Std Dev	0.35	156	9,660	224	1.04	1.04	0.79	0.12	0.01	0.53
	EK	Avg	8.87	244	26,500	192	7.15	80	1.17	0.36	0.04	0.92
		Std Dev	0.21	42.8	17,200	54.3	1.06	1.06	0.21	0.19	0.02	1.08

* Includes results from 126 tests (18 per dust suppressant product, 18 water only)

In the vertical leaching experiment, average results by product for eight of the nine water quality parameters tested meet the DQOs. While TSS results corresponding to two dust suppressant products are higher relative to control samples from untreated soils, these results do not represent a potential impact as TSS is generally not a concern for groundwater quality.

Table 4-2 shows average results for each dust suppressant product. Results from all individual tests in the vertical leaching experiment are provided in Appendix E.

Table 4-2. Vertical Leaching Experiment Results

Soil Type	Dust Supp	Statistic	pH	Conductivity µmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	DO % Sat	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	Phosphate mg/l
AZ	Water	Avg	7.80	1,890	ND	1,510	8.05	90	32.3	4.26	0.55	1.73
		Std Dev	0.11	617	ND	610	0.86	0.86	10.1	1.75	0.78	1.44
	CL	Avg	7.83	1,740	66.0	1,350	8.14	91	36.5	3.83	0.10	1.94
		Std Dev	0.25	729	126	577	0.79	0.79	18.3	2.03	0.09	1.87
	ERM	Avg	7.81	1,770	1.00	1,450	8.21	92	39.5	4.08	0.09	1.23
		Std Dev	0.17	365	0.00	327	0.91	0.91	18.5	1.61	0.06	0.88
	DS	Avg	7.94	1,850	14.0	1,390	8.39	94	39.1	3.98	0.10	0.94
		Std Dev	0.12	535	21.4	517	0.53	0.53	16.5	1.35	0.10	0.27
NV	Water	Avg	7.88	4,610	28.0	5,450	7.65	86	4.41	3.56	0.16	2.31
		Std Dev	0.06	584	37.2	531	0.18	0.18	1.11	1.21	0.13	1.88
	JD	Avg	7.77	4,140	22.7	4,950	7.61	85	3.94	2.76	0.18	1.01
		Std Dev	0.20	593	35.6	1,230	0.76	0.76	1.46	1.09	0.18	0.50
	HR	Avg	7.58	3,750	8.75	6,400	6.96	78	3.65	2.92	0.12	1.38
		Std Dev	0.09	243	10.5	7,020	1.14	1.14	0.94	0.63	0.08	1.47
	EK	Avg	7.67	3,950	12.5	3,810	7.69	86	4.31	3.75	0.12	1.45
		Std Dev	0.12	544	14.2	1,310	0.64	0.64	1.11	1.53	0.10	1.12

* Includes results from 80 tests (12 per dust suppressant product, 8 water only)

With respect to the pilot experiment, average results meet the study's DQOs for pH for all six products. While average Conductivity for half of the dust suppressant products is higher relative to control tests, this effect is observed exclusively in tests on Arizona soil. TDS values for two dust suppressant products – Enviro RoadMoisture 2.5 and Durasoil – are significantly higher relative to control tests, however, the pilot test results may not represent a typical runoff exposure scenario.

Table 4-3 shows average results for each dust suppressant product. Results from all individual tests in the pilot experiment are provided in Appendix F.

Table 4-3. Pilot Experiment Results (combined for tests conducted on 5 AZ soils vs. tests conducted on 5 NV soils)

Soil Samples	Dust Supp	Statistic	pH	Conductivity µmhos/cm	TDS mg/l
AZ 1-5	Water	Avg	8.52	201	826
		Std Dev	0.22	57	990
	CL	Avg	8.49	184	567
		Std Dev	0.19	55	484
	ERM	Avg	8.35	210	4,780
		Std Dev	0.36	51	2,500
	DS	Avg	8.52	305	1,270
		Std Dev	0.20	52	1,080
	JD	Avg	8.41	247	639
		Std Dev	0.24	65	672
	HR	Avg	8.07	324	450
		Std Dev	0.28	35	232
	EK	Avg	8.36	293	606
		Std Dev	0.24	46	564
NV 1-5	Water	Avg	8.63	173	318
		Std Dev	0.13	12	247
	CL	Avg	8.83	131	215
		Std Dev	0.08	26	127
	ERM	Avg	8.87	145	8,260
		Std Dev	0.09	21	5,450
	DS	Avg	8.74	164	2,870
		Std Dev	0.14	39	2,640
	JD	Avg	8.66	169	242
		Std Dev	0.18	29	57
	HR	Avg	8.87	139	200
		Std Dev	0.06	25	44
	EK	Avg	8.62	175	233
		Std Dev	0.17	23	93

***** Includes results from 140 tests (20 per dust suppressant product, 10 water only)

4.2 Observed Effects

Table 4-4 shows the four water quality parameters for which an effect is observed[24] in average results for one or more dust suppressant products in the surface runoff experiment.

Table 4-4. Surface Runoff Experiment Observed Effects

Dust Supp Product	**Bulk Soil Type**	**Parameter for which effect outside of DQO observed**	**Effect observed in both product application scenarios?**	**Effect observed at all 3 rainfall ages?[25]**	**Magnitude difference of avg results relative to control**
CL	AZ	Conductivity Phosphate	No (A only) No (B only)	No (Age 0) No (Age 1)	1.26X higher 1.3X higher
ERM	AZ	Conductivity Phosphate TSS Nitrite	No (B only) No (B only)[26] No (A only) No (A only)	Yes (all 3 Ages)[27] No (Age 1 & 2) No (Age 1 & 2) No (Age 1 & 2)	1.34X lower 1.3X higher 1.53X higher 1.3X higher
DS	AZ	Conductivity Phosphate TSS	Yes (A & B) No (B only) Yes (A & B)	No (Age 1 & 2) No (Age 1 & 2) Yes (all 3 Ages)	*****3X lower 1.4X higher *4.79X higher
JD	NV	None	--	--	--
HR	NV	None	--	--	--
EK	NV	TSS Phosphate	Yes (A & B) No (B only)	Yes (all 3 Ages) No (Age 1 & 2)	*2.26X higher 1.84X higher

* signifies a particularly high or low average value relative to the control average value.

Conductivity effects are only observed for the three dust suppressant products tested on Arizona soil. Conductivity values for Arizona soil control samples in the surface leaching experiment vary significantly depending on rainfall rate (from an

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[24] "Effect observed" means the water quality parameter result does not meet the relevant DQO in Table 3-1.

[25] For this assessment, average results by product age are compared to average results by age for control samples.

[26] Higher values occurred in some Application A Scenario samples but when averaged, the Application A Scenarios do not show an effect.

[27] For Age 0 samples, product results are higher in Conductivity relative to control samples. In contrast, Conductivity results for Ages 1 and 2 are lower than control samples.

average low of 134 umhos/cm at 2.4 in/hr to an average high of 1,030 umhos/cm at 0.7 in/hr). In contrast, the average range of Conductivity values by rainfall rate in control samples for NV soils is much less (155 - 463 umhos/cm). We also note that several control sample pairings of Conductivity and TDS values (for both soil types) do not follow the standard relationship, thus Conductivity is not a good surrogate for TDS.

The observed Phosphate effects for four dust suppressant products are generally not much greater in magnitude relative to control samples. In each case, the observed effect is attributable to 2 or 3 relatively high values within the 18 sample dataset.

Regarding the observed TSS and nitrite effects in ERM runoff, the magnitude of the effects are not particularly high relative to control samples nor are they observed at both product application scenarios and at all rainfall ages. TSS for Arizona soil control samples ranged from 418-8,982 mg/l and TSS for ERM runoff ranged from 138-9,130 mg/l.

A more distinct trend can be seen in TSS results for DS and EK in that effects are observed across application scenarios and ages with values that are, on average, much higher than control samples (Table 4-5). For example, 16 out of 18 (89%) of TSS values for DS and EK are greater than 5,000 mg/l in contrast to 1 out of 9 (11%) for Arizona soil control samples and 4 out of 9 (44%) for Nevada soil control samples. This observed effect likely relates to the products' soil crusting characteristics and the tendency for solid chunks to break off when flushed with water, increasing TSS in the runoff. In conducting the surface runoff experiments, SERL observed clumps of larger mass in runoff from the DS and EK test plots relative to the control plots and other product plots.

Table 4-5. TSS Surface Runoff Experiment Results for DS and EK

Dust Suppressant	Soil	TSS mg/l (range)	TSS mg/l (avg.)
Water (runoff control)	AZ	418-8,982	2,646
Durasoil	AZ	904-30,298	12,674
			4.79X control
Water (runoff control)	NV	298-45,202	11,745
EnviroKleen	NV	446-74,933	26,544
			2.26X control

With respect to the vertical leaching experiment, an average effect is observed for only one parameter -- TSS -- for two products (CL and DS). Average TSS for CL is twice as high relative to control samples and average TSS for DS is 1.4 times higher than control samples. However, TSS is generally not a concern for groundwater quality. Most solids are eventually removed during percolation through the vadose zone.[28] One exception may be circumstances of shallow groundwater and highly transmissive vadose zones, however, a filter can remove TSS for drinking water purposes. Therefore, we do not interpret these results as representing a potential adverse impact.

In the pilot experiment, effects are observed for Conductivity in results for three dust suppressant products and for TDS in results for two dust suppressant products. Similar to the surface leaching experiment, the Conductivity effects in the pilot experiment are only observed in tests involving Arizona soil as shown below. Average Conductivity results for these same products tested on Nevada soils do <u>not</u> show an effect.

DS (AZ soil) – average result 1.5X above control
HR (AZ soil) – average result 1.6X above control
EK (AZ soil) – average result 1.5X above control

Table 4-6 shows the high TDS values for ERM and DS relative to control samples. Since pH values in the pilot experiment are not significantly different relative to control samples, the observed effect in TDS values likely relates to the propensity of the dust suppressant products to move salts as opposed to metals.[29]

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[28] The vadose zone extends from the top of the ground surface to the water table.

[29] Since it is unknown whether the soils in the pilot experiment contained metals, we cannot conclude that the products have no propensity to mobilize metals. Rather, for the soils used in the experiment, no effect on pH is observed that would indicate metals mobilization.

Table 4-6. Pilot Experiment TDS Values for ERM and DS

Soil Type	TDS – water mg/l	TDS - ERM mg/l	TDS – DS mg/l
AZ1	266	10,628	4,282
AZ1 (duplicate)	274	4,030	684
AZ2	578	4,978	588
AZ2 (duplicate)	448	5,094	684
AZ3	2212	6,676	1,480
AZ3 (duplicate)	3266	5,738	1,236
AZ4	272	1,812	1,330
AZ4 (duplicate)	198	4,542	1,493
AZ5	350	2,392	628
AZ5 (duplicate)	398	1,824	334
magnitude above control	**--**	**5.8X**	**1.54X**
NV1	146	7,910	178
NV1 (duplicate)	109	690	1,106
NV2	452	3,358	5,610
NV2 (duplicate)	950	9,238	1,864
NV3	486	8,384	776
NV3 (duplicate)	230	1,850	6,542
NV4	148	8,320	3,532
NV4 (duplicate)	132	9,512	1,192
NV5	180	12,816	248
NV5 (duplicate)	344	20,570	7,640
magnitude above control	**--**	**26X**	**9X**

Duplicate = same soil type distributed into separate test containers

The observed TDS effect in ERM results can be seen with all 10 soils on which the product was applied. For DS, the observed TDS effect is observed with all 5 Nevada soils and in 2 out of the 5 Arizona soils on which the product was applied. In contrast, TDS results in the surface runoff experiment for ERM and DS (as well as the other dust suppressant products) are not significantly higher relative to control samples. This could be attributable to one of two main differences between the surface runoff experiment and the pilot experiment: 1) different soils. The bulk Arizona soil used in the surface runoff experiment was not used in the pilot experiment; or 2) different experimental design. In the pilot experiment, all soil used in each test (12.3 oz), along with the top soil layer treated with dust suppressant product, was mixed with water prior to TDS analysis. Thus, each pilot test sample contained the entire quantity of dust suppressant product applied. In the surface runoff experiment, samples tested for TDS analysis contained only the portion of sediment and product released in simulated rainfall as runoff. Because a similar effect on TDS values is observed across the 10 soil types for ERM and most soil types for DS, it's likely that experimental design and not the bulk soil used in the surface runoff experiment is the influencing factor for the pilot test results.

4.3 Sensitivity of Results to Varying Factors (product quantity, rainfall event, rainfall age)

With some exceptions, average values for Conductivity, TOC, Nitrate and Nitrite in the surface runoff experiment are higher in runoff from the higher-quantity product application (i.e., Application Scenario A for surfactants and Application Scenario B for EK and DS.) Phosphate values are higher for the lower-quantity application of surfactants, a trend which did not extend to runoff from EK and DS treated soils.

TDS values for only three of the dust suppressant products are higher in runoff from the higher-quantity product application (CL, ERM, and EK).

TSS values for EK and DS are somewhat higher for Application Scenario A, most likely due to the fact that soils were disturbed during the 5-day product application period, as opposed to Application Scenario B in which soil was left undisturbed following product application. However, Application Scenario B TSS values are still much higher relative to control values (4.6 times higher for DS and 1.7 times higher for EK), so soil disturbance associated with Application A Scenarios does not explain the observed effect.

In terms of rainfall rates, a consistent pattern is seen for Conductivity and TDS in that these parameters decrease as rainfall rate increases. In other words, rainfall events of lower intensity generate higher Conductivity and TDS values, including control scenarios with water alone. This also applies with respect to TOC values in runoff from Arizona soils.

TSS tends to increase with rainfall rate for tests conducted on Arizona soil, whereas this trend does not apply to Nevada soil tests in which some of the highest TSS values correspond to the least intense rainfall rate. A trend based on rainfall rate is not apparent for the remaining water quality parameters.

With the exception of TSS and DO, no trends are apparent from the effects of product biodegradation on water quality parameters measured at the three ages of rainfall simulation. DO generally improves in runoff samples generated from soil plots aged 1 or

2 months prior to a rain event relative to DO measured in runoff immediately following the 5-day application period. TSS tends to decrease with rainfall event age, therefore, we can assume that, generally, rain events occurring a couple of months following product application will generate lower TSS values relative to rainfall events that occur sooner.

Variability in control samples results might explain why more patterns are not readily apparent in results sorted by product quantity, rainfall intensity, and rainfall event age. Tables 4-7 and 4-8 provide the range of values observed in control samples, along with the rainfall event age and intensity associated with the lowest and highest values for each water quality parameter.

Table 4-7. AZ Soil Runoff Control Sample Variability

WQ parameter	Lowest Value	Rain Event Age	Rain Event	Highest Value	Rain Event Age	Rain Event
pH	7.17	2	1	9.09	0	3
EC (umhos/cm)	61	0	3	1,394	2	1
TSS (mg/l)	418	2	1	8,982	0	3
TDS (mg/l)	284	2	1	2,864	0	2
DO (mg/l)	4.6	0	1	7.9	0	3
TOC (mg/l)	2.18	1	3	96.1	0	1
Nitrate (mg/l)	0.05	1	2	11.71	0	1
Nitrite (mg/l)	0.01	M	M	0.38	0	3
Phosphate (mg/l)	0.27	M	1	3.27	1	3

M = the value was observed in more than one sample corresponding to different rain events or ages.

Table 4-8. NV Soil Runoff Control Sample Variability

WQ parameter	Lowest Value	Rain Event Age	Rain Event	Highest Value	Rain Event Age	Rain Event
pH	7.16	2	2	9.17	2	3
EC (umhos/cm)	147	M	3	556	0	1
TSS (mg/l)	298	2	1	45,202	0	1
TDS (mg/l)	72	0	3	410	0	1
DO (mg/l)	5.2	0	2	8.7	1	2
TOC (mg/l)	0.84	0	1	4,783	2	1
Nitrate (mg/l)	ND	2	3	0.52	1	1
Nitrite (mg/l)	ND	2	M	0.22	0	2
Phosphate (mg/l)	ND	2	3	0.96	0	3

ND = non-detect
M = the value was observed in more than one sample corresponding to different rain events or ages.

Due to the variability of control sample values, we place greater confidence in results for dust suppressant products that demonstrate a trend across the dataset. Hence, greater weight is given to average results for the water quality parameter tests, which captures the effect of multiple values outside of the DQOs.

The only clear trend in terms of rainfall ages and intensities for control samples is that most of the high end values in runoff from Arizona soil occurred as a result of Age 0 rain events. This inherent variability in the control sample dataset limits the conclusions that can be drawn from evaluating dust suppressant product results according to differing experimental factors.

4.4 Conclusions

Average results show that the majority of water quality parameters evaluated are consistent with the study's DQOs. Where this is not the case, most of the results do not pose a concern for water quality (e.g., TSS values in the vertical leaching test), are not substantially higher relative to control samples, or may not represent a potential problem when viewed in a broader context, as discussed below.

Because the Conductivity effects observed for some products are limited to tests conducted on Arizona soil,[30] are often not consistent with parallel TDS values, and may be higher or lower than control samples without explanation, we find them inconclusive in terms of showing a potential impact directly attributable to the dust suppressant products.

The observed effects on Phosphate values for four dust suppressant products are attributable to a few outliers in the dataset. The effects observed in TSS and Nitrite values in runoff from ERM-treated soils are limited in magnitude above control samples and not consistently observed across the dataset.

While TSS values in surface runoff from DS and EK are well above control samples, this is likely due to the products' soil crusting characteristics, causing dirt clumps greater in mass relative to control test plots to be transported in runoff. Because the runoff from the test plots only traveled a short distance (25 inches) at a 33 degree angle slope, the TSS values measured do not generally represent TSS levels in overland

[30] The Arizona soil control samples show considerable variability in Conductivity results.

runoff that would enter a water body, except for one immediately adjacent to a soil surface with a similar or steeper gradient on which the product had been applied. Rather, stormwater runoff typically travels overland for some distance prior to entering a water body, creating opportunity for larger dirt clumps to settle out along the way.

TDS values for two products in the pilot experiment – ERM and DS – are significantly higher relative to control samples, however, these results may not represent TDS in a typical runoff scenario. The pilot experiment results show that these two products have potential to generate high TDS values when tested in a soil/product/water mixture. However, when tested in a simulated surface runoff experiment, runoff from the products did not show elevated TDS values relative to control samples. It’s possible that the pilot experiment captured the full capability of ERM and DS to dissolve in water, given that the entire quantity of product applied resided in the test containers subject to water quality analyses. In contrast, runoff samples from the surface runoff experiment only contained the quantity of product that adhered to sediment released in runoff from simulated rainfall. Additional research could be conducted with multiple soil types to assess the actual potential of the two products to mobilize salts in surface runoff circumstances, since the products were applied to only one soil type in the surface runoff tests.

SECTION 5

AQUATIC TOXICITY TESTS AND RESULTS

5.1 Summary

EPA's Region 9 Laboratory in Richmond, California, performed three types of aquatic toxicity tests[31] on water runoff samples delivered by SERL:

1. Fish (*Pimephales promelas*, i.e., fathead minnow) - Acute
2. Algae (*Selenastrum capricornutum*) - Chronic
3. Invertebrate (*Dapnia magna*) - Acute

Samples for toxicity testing were collected as part of SERL's surface runoff experiment, which involved simulated rain events on soil test plots treated with dust suppressant products along with soil test plots on which water alone was applied.

5.2 Sample Description

Runoff samples were delivered to USEPA's Region 9 Laboratory at different times corresponding to the 3 ages of rainfall events in the surface runoff experiment. SERL provided a total of 6 runoff samples per dust suppressant for toxicity testing, as shown in Table 5-1.

[31] Toxicity tests were conducted according to Standard Operating Procedure (SOP) 1030 for fathead minnow and SOP 1032 for daphnia magna. These methods have been written following the EPA method manual "*Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*", Fifth Edition, EPA-821-R-02-012, October 2002. Toxicity tests for green algae were conducted according to SOP 1022, which was written following EPA method 1003.0 from the manual "*Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*", Fourth Edition, EPA-821-R-02-013, October 2002.

Table 5-1. Samples from SERL Tested for Aquatic Toxicity

Runoff samples per product[32]	Application scenario[33]	Rainfall event age	Month tested for aquatic toxicity
1	A	0	November '06
2			
3	A	1	December '06
4	B		
5	B	2	January '07
6			

Toxicity testing at the Region 9 Laboratory took place on the following dates for products tested on the bulk soil from Arizona versus the bulk soil from Nevada.

November 14, 2006 – runoff samples from Nevada soil and Arizona soil
December 12, 2006 – runoff samples from Nevada soil
December 14, 2006 – runoff samples from Arizona soil
January 18, 2007 – runoff samples from Nevada soil
January 19, 2007 – runoff samples from Arizona soil

Each sample was a composite of runoff from three same-product soil trays subjected to different rainfall events (see Table 2-7). The Region 9 Laboratory conducted undiluted toxicity tests (100% samples) designed to determine if any observable toxicity is present, not the magnitude of the toxic effect in dilution. Therefore, combining runoff samples from test plots subject to different rainfall events means that the results represent an average effect under various precipitation scenarios.

In addition to providing water runoff samples from soil test plots treated with dust suppressants, SERL delivered to the Region 9 Laboratory six water runoff samples from untreated test plots in which RO-Water only was applied (3 samples from Arizona soil test plots and 3 samples from Nevada soil test plots). These samples were also composites of the three rainfall events. We refer to samples of runoff collected from untreated soil test plots as "runoff control" (RC) samples.

[32] Samples 1 & 2 and samples 5 & 6 are from trays with duplicate test parameters used in the surface runoff experiment.

[33] For surfactants, a total of 2,150 mL of product was applied under Application Rate A and 1,290 mL under Application Rate B. For EnviroKleen, a total of 190 mL of product was applied under Application Rate A and 235 mL under Application Rate B. For Durasoil, a total of 255 mL of product was applied under Application Rate A and 315 mL under Application Rate B.

SERL also provided samples of the RO-water used in the experiment that had not been applied to any soil test plots. We refer to these samples as "RO-Water Blanks".

Furthermore, the Region 9 Laboratory prepared control water (CW) samples by which to gauge organism health and response in the toxicity tests.

Appendix G, Tables G-1 and G-2, contain "EPA Toxic Sample Information" identification numbers corresponding to all samples delivered by SERL for both treated and untreated soil test plots. RC samples for Nevada are numbered T-NV-T-1, T-NV-T-4,[34] and T-NV-T-3 and RC samples for Arizona are numbered T-AZ-T-1, T-AZ-T-2, and T-AZ-T-3.

The Region 9 Laboratory conducted toxicity tests without prior knowledge of which sample identification numbers correspond to which soil test plots (including untreated test plots). This information was provided by SERL in July 2007 for evaluation of results.

5.3 Sample Preparation

The runoff samples were chilled to $4^{o}C$ and shipped on ice to the Region 9 Laboratory. All samples were tested for toxicity on the day of receipt.

Samples tested on 11/14/2006 and 12/12/2006 arrived at the Region 9 laboratory after the method prescribed 36 hour hold time.[35] These samples are flagged with an A3 qualifier and the effect of the time delay on the sample analysis is unknown. Samples tested on 12/14/2006, 1/18/2007 and 1/19/2007 were tested within a 36 hour hold time.

Well-mixed aliquots of each sample were placed directly in test containers for testing with the fish, *Pimephales promelas*, and the invertebrate, *Daphnia magna*. Containers 30 milliliters in size were used for the *Daphnia magna* test.

Aliquots for testing with the algae, *Selenastrum capricornatum*, were filtered through a 0.45 micron filter prior to testing. In addition, for the algal tests, nutrients were

[34] The untreated runoff control sample numbered T-NV-T-2 in Table G-1 was submitted to the Region 9 Laboratory as T-NV-T-4 for the samples received on December 12, 2006. This is the RC sample and was used for all statistical comparisons for that group of samples.

[35] The runoff samples tested on 11/14/2006 were collected by SERL on 11/08/2006 (Nevada soils) and on 11/10/2006 (Arizona soils). The Nevada soil runoff samples tested on 12/12/2006 were collected by SERL on 12/8/2006.

added to each sample to provide a level of nutrients equal to the control solutions. Successful algae testing required fine filtration of the samples as this preparation step is required to test and measure the endpoints with single-celled algae. A significant quantity of fine sediment present in the samples was removed prior to testing. Given the nature of the products tested (i.e., surfactants, coagulants, made-to-bind solids) it is very likely that the products adhered to particles which were filtered out by the preparation step. Therefore, algae test results could underestimate potential toxicity associated with particles or other materials removed by the preparation step.

5.4 Test Conditions

The invertebrate tests performed were 48 hour exposures starting with < 24 hour old neonates with an endpoint of mortality. The fish tests performed were 48 hour exposures starting with larvae < 14 days old with an endpoint of mortality. The algae tests performed were 96 hour exposures starting with growth phase algal cultures. The endpoint was mean cell density as measured with a particle counter.

All of the samples were tested as 100% concentrations only. Four replicates of each sample were tested. All tests were performed at 25^{o}C. The algae were exposed to continuous light and the fish and daphnids were exposed to a 16:8 light:dark photoperiod. The water quality of the tests was monitored on a daily basis. Parameters measured included dissolved oxygen, pH, temperature and conductivity.

5.5 Quality Control

A reference toxicant test was performed each month with each organism tested. All of the results of the reference tests performed were within the acceptable control criteria for the Region 9 Laboratory (+/- 2 standard deviations of the mean of the most recent $\leq$20 tests). RO-Water Blanks and CW sample tests were also performed for each testing day.

For the fish and daphnia tests, the acceptability criterion for control sample survival is $\geq$90%. All of the CW samples for the fish tests met this criterion. The CW survival for daphnia tests run on 12/14/2006 was 80% at both 24 and 48 hours. The CW survival for daphnia tests run on 1/19/2006 was 100% at 24 hours and 85% at 48 hours.

Since the CW samples did not meet method criteria for these tests, the corresponding results have been flagged with a “J” and are considered estimates. The actual effect on the results is unknown.

Based on quality control considerations, algae toxicity tests were only successfully completed for a limited set of samples including Nevada soil runoff samples tested on 12/12/2006 and 1/18/2007 and Arizona soil runoff samples tested on 1/19/2007 for reasons discussed below.

The test acceptability criteria for algal tests include a mean algal cell density in the controls of $>1 \times 10^6$ cells/mL. The control variability among control replicates must be $\leq$ 20%. Due to excessive variability in the controls, the algal results for the samples tested on 11/14/2006 are not reported. Also, nutrients were not added to the sample algal tests performed on 12/14/2006 due to analyst error; while control performance was acceptable, a comparison of controls with runoff samples cannot be made and results are not reported. The mean cell density in the controls for tests performed on 1/19/2007 was 7.8×10^5, which is less than the required criteria. As a result, the comparison of samples to CW shows no effect and the comparisons are not valid. However, the response of the RO-Water Blanks did meet control test requirements, therefore RC samples for 1/19/2007 are evaluated for toxicity against the RO-Water Blanks.

Since the sample volumes provided by SERL were minimally adequate for the tests performed, no re-analysis was possible where quality control did not meet method criteria.

5.6 Evaluation Method

Test results were statistically evaluated following the methods recommended in EPA’s flowchart for statistical analysis of toxicity test data.

The directly relevant and critical comparison for evaluating toxicity of runoff from a soil test plot treated with dust suppressant is toxicity of runoff from an equivalent untreated soil test plot (RC samples). This comparison captures toxic impacts attributable to applying dust suppressant products to soils versus the alternative of applying water alone. As additional information, results from RO-Water Blanks speak to whether the reverse osmosis water itself that was used in SERL's experiments has a toxic impact on the aquatic life studied.

5.7 Results

No toxicity to fish (fathead minnow) was observed on any date or in any sample tested. The tests were all successfully completed.

For the algae tests successfully completed (samples tested on 12/12/06, 1/18/07, and 1/19/07), no statistically significant inhibition of the algae (i.e., toxic impact) was observed from any dust suppressant runoff samples relative to RC samples. These results should be interpreted with caution because they could underestimate potential toxicity of particles or other materials that were removed from the samples in accordance with test protocol.

A statistically significant toxic effect was observed for some samples in the *Daphnia magna* invertebrate tests, which we discuss in detail in the subsequent section. *Daphnia magna* are freshwater fleas, a source of food for fish and other aquatic organisms.

Results from toxicity tests that were successfully completed can be found in Appendix H, Tables H-1, H-2, H-3 and H-4. For each test performed, both the raw data and results of the statistical comparisons are tabulated.[36]

Table H-1 contains the algae test results and provides additional data on the actual cell densities measured in runoff samples from dust suppressant product test plots relative to RC samples, RO-Water Blanks, and CW samples. A response of 100% means the samples being compared contained equal densities of algal cells. Values < 100% represent algal inhibition and values >100 % represent algal stimulation.

Tables H-2 through H-4 contain results for the fish and invertebrate tests. Both the 24 hour and 48 hour survival results and data analyses for the fish and daphnia tests are reported.

The complete raw data sheets, statistical data analysis reports, and reference toxicant tests are contained in a data package on file at the Region 9 Laboratory.

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[36] Since only 100% sample concentrations were tested, an X in the table denotes that the 100% sample result is statistically significantly less than the relevant control (RC, CW, and RO-Water Blanks).

5.8 Invertebrate (*Daphnia magna*) Results

As background to understanding the *Daphnia magna* test results, we first discuss the mixed toxicity results observed in control samples, including both the RO-Water Blanks and RC samples. The RO-Water Blanks were toxic to the daphnia at 48 hours with one exception (Dec. 12, 2006). These results might be explained by lack of a minimal amount of nutrients in the RO-Water that daphnia need to thrive; rainwater that has not come into contact with soil is generally not an adequate medium for these organisms. The 48-hour daphnia survival rate was better in 4 out of 6 RC samples compared to the RO-Water Blanks, potentially due to nutrients in the soil that may have been transferred to the runoff. Notwithstanding, 3 out of 6 RC samples were toxic to the daphnia at 48 hours. Furthermore, the RC sample results from the three test cycles have considerable variability even among the same soil type.

The variable results from the RC samples do not invalidate the *Daphnia magna* toxicity tests. Rather, they reflect the limitations of the small-scale test setup in replicating conditions under which runoff typically reaches water bodies. Also, some of the variability could reflect differences in soils distributed into different test plots, despite the steps taken by SERL to homogenize soils. Since SERL's experiments held other factors constant, the variable nature of the RC sample results does not preclude evaluation of whether runoff from dust suppressant treated soils have an even more toxic effect than comparable RC samples. However, to account for the inherent variability observed, we do not rely on single sample comparisons of untreated vs. treated soil runoff results to draw conclusions. Furthermore, we attribute greater certainty to results that show a substantially larger adverse effect relative to the RC samples.

Thus, the main focus in evaluating results for dust suppressant treated runoff samples is whether the daphnia survival rate is statistically significantly less than the comparable RC sample survival rate. Where this is the case, the variable nature of results among the RC samples, as well as in relation to RO-Water Blanks, creates some uncertainty as to how much of the impact is due to the RO-Water itself, a soil-related factor, or a product-related factor.

Table 5-2 summarizes daphnia test results by product type in terms of whether a significant effect was observed relative to the untreated test plot sample. It also shows at which rainfall event age the effect was observed – immediately, 1 month, or 2 months following the 5-day product application period.

Table 5-2. *Daphnia magna* Results – Runoff from Treated vs. Untreated Plots

SOIL	PRODUCT	24 HOUR EFFECT *	48 HOUR EFFECT *
NV	Jet-Dry	0 of 6	1 of 6 (Age 0)
NV	Haul Road Dust Control	0 of 6	1 of 6 (Age 0)
NV	EnviroKleen	3 of 6 (Ages 0 & 1)	6 of 6 (all Ages)
AZ	Chem-Loc 101	0 of 6	1 of 6 (Age 0)
AZ	Enviro RoadMoisture 2.5	1 of 6 (Age 2)	2 of 6 (Ages 0 & 2)
AZ	Durasoil	5 of 6 (all Ages)	6 of 6 (all Ages)

* Effect means daphnia survival in runoff from the treated test plot was significantly less than survival in runoff from the RC sample.

For products applied to Nevada soil, Jet-Dry and Haul Road Dust Control each showed an effect at 48 hours in 1 sample. EnviroKleen showed an effect in 3 of 6 samples at 24 hours and in all samples at 48 hours.

For products applied to Arizona soil, Chem-Loc 101 showed an effect at 48 hours in 1 sample. Enviro RoadMoisture 2.5 showed an effect in 1 sample at 24 hours and in 2 of 6 samples at 48 hours. Durasoil showed an effect in 5 out of 6 samples at 24 hours and in all samples at 48 hours.

Only runoff from the EnviroKleen and Durasoil test plots had a consistently adverse effect on the daphnia; the magnitude and response by the organisms was similar throughout the three test cycles. Whereas 48-hour survival rates for RC samples ranged from 40% to 95% in the six tests, 48-hour survival rates for EnviroKleen and Durasoil runoff samples ranged from 0% to 15% and 0% to 10%, respectively. Notably, for the December '06 tests in which the RC samples showed no statistically significant toxic impact, the survival rate of daphnia at both 24 hours and 48 hours was either zero or marginal in runoff from EnviroKleen and Durasoil test plots.

Region 9 Laboratory staff observed that runoff samples corresponding to these two products caused the daphnids to be trapped at the test container's surface; they could not easily be physically re-submerged. From a visual standpoint, the runoff from the EnviroKleen and Durasoil products contained a visible sheen on the surface in which the daphnia became trapped. In contrast, in samples of runoff from surfactant test plots, daphnids occasionally found on the surface could move freely back into the water column which enabled their survival.

5.9 Additional Testing of EnviroKleen and Durasoil with Invertebrates

Purpose and Description

As a follow-up to the initial toxicity testing completed between November 2006 and January 2007, the Region 9 Laboratory conducted additional tests on product samples of EnviroKleen and Durasoil. These additional tests did not involve runoff generated by SERL, and thus do not represent field application runoff scenarios. The purpose of the additional tests was to investigate whether the toxic effect observed on *Daphnia magna* can be replicated using pure product samples and culture water conducive to daphnia survival. Furthermore, the additional tests address the question of whether a similar effect is observed with a smaller invertebrate commonly used in toxicity testing, *Ceriodaphnia dubia* (also a water flea).

The Region 9 Laboratory received samples of EnviroKleen and Durasoil directly from the product manufacturers. The product samples were used to perform 48-hour acute toxicity tests in September 2007 with both *Daphnia magna* and *Ceriodaphnia dubia*.

Testing was conducted at product concentrations of 0, 62.5, 125, 250, 500, and 1000 mg/L. Hard, reconstituted water was used in the *Daphnia magna* tests for dilution and control water while moderately-hard, reconstituted water was used in the *Ceriodaphnia dubia* tests. Well-mixed aliquots of the samples at each concentration were distributed to four replicate containers. The *Daphnia magna* and *Ceriodaphnia dubia* were placed in the test containers below the surface of the water.

Results

Appendix I, Figures I-1 and I-2 provide the daphnia survival rates at various product concentrations tested.

Since EnviroKleen and Durasoil are virtually insoluble in water, they formed a visible layer on top of the sample in the test cups. Similar to effects observed in the

SERL runoff samples, the *Daphnia magna* were often trapped in the surface layer during the first 24 hour exposure period. At 24 hours, the Region 9 Laboratory staff re-immersed all trapped daphnids in the solutions using a dropper. At 48 hours, the daphnids that died were all stuck to the product at the surface or on the sides of the test containers. Those remaining in the water column usually survived. As a result, the variability seen across tests was significant, depending on the number of organisms that remained in the water column.

Correspondingly, the within-test variability of individual test dose responses was high, e.g., greater than 40% for all Durasoil concentrations. Percent Minimum Significant Difference (PMSD), or the decrease relative to the control sample needed to identify an effect as significant, was 33.2% for EnviroKleen and 39.9% for Durasoil. The level of effect noted was similar across all concentrations tested. The effect was more a measure of entrapment in the product layer than a classic toxic response. Since the survival of the daphnia in the Durasoil sample was slightly lower than in EnviroKleen, (35 - 55% vs. 50 - 80%), the statistical evaluation identified a significant effect in the Durasoil sample, but not in the EnviroKleen sample. While daphnia survival in the lowest two concentrations of EnviroKleen was significantly less than control, this was not the case for the top three concentrations so no significant effect was noted.

For both products, dose response results were not continuous with product concentrations. In fact, the dose response curves were unusual, therefore, the specific results for the daphnia tests should be interpreted with caution. For example, daphnia survival rates in EnviroKleen samples were lower at lower product concentrations. For Durasoil samples, no apparent pattern of daphnia survival was observed as product concentration increased.

The *Ceriodaphnia dubia* did not experience the same problem, showing no adverse effects with the same test materials at the same concentrations. In contrast to the *Daphnia magna* tests, the PMSD for the *Ceriodaphnia dubia* tests was lower -- 13.1% for EnviroKleen and 19.2% for Durasoil. Despite the more sensitive analysis endpoint, no effects were observed. This result appears to be attributable to the fact that the *Ceriodaphnia dubia* rarely entered the surface layer, remaining in the water column.

5.10 Conclusions

None of the runoff samples from dust suppressant treated soils showed toxic effects on fish or algae. The algae results should be interpreted with caution because they could underestimate potential toxicity of particles or other materials that were removed from the samples in accordance with test protocol.

In the *Daphnia magna* tests, runoff from three of the surfactants – Jet-Dry, Haul Road Dust Control, and Chem-Loc 101 – showed no toxic effect in all but one AGE 0 sample relative to the untreated test plot samples. Runoff from the surfactant Enviro RoadMoisture 2.5 showed no toxic effect in four of the six samples relative to the untreated test plot samples. Overall, these results are positive and do not generate cause for concern.

Runoff samples corresponding to EnviroKleen and Durasoil test plots showed a potential impact on *Daphnia magna*, at least with respect to the small laboratory containers in which the tests were conducted. Runoff from these two products displayed a consistently quicker and more severe effect on daphnia survival relative to runoff from the surfactants and with a significantly stronger effect than corresponding untreated test plot runoff samples. This effect appeared to be related to a physical trapping of the daphnia, as opposed to a classic toxic dose response.

Additional laboratory tests of EnviroKleen and Durasoil product samples confirmed that *Daphnia magna* can be physically trapped in the product at the surface of small test containers, unable to re-enter the water column. This effect was observed to some degree in all product test samples irrespective of concentration levels. No adverse effect was observed on *Ceriodaphnia dubia*.

Daphnia magna are a source of food for other aquatic organisms, thus their survival rates could have implications on larger species. Also, the same physical entrapment effect could extend to other small organisms that abide at the surface level of a water body.

However, the entrapment of *Daphnia magna* observed took place within 30-milliliter laboratory test containers. This does not likely represent what would occur on an open water body. The real-world potential for physical trapping of surface level invertebrates in runoff from these products would depend on several factors, including:

- whether runoff is prevented from reaching receiving waters through best management practices;[37]
- the species and distribution of invertebrates in receiving waters;
- flow and wind dynamics affecting surface layer motion of receiving waters, such that runoff from the product may not remain in a single location for a 24-hour or 48-hour period, unlike the laboratory tests;
- the size of receiving surface water area exposed to the runoff, which affects the quantity of daphnids and similar organisms that actually encounter the product; and
- distribution of the product layer on the receiving water's surface (whether evenly or with openings enabling daphnids to re-enter the water column).

In conclusion, we do not interpret the physical entrapment effect observed with *Daphnia magna* in the laboratory test samples of EnviroKleen and Durasoil as representing a probable adverse impact on surface layer invertebrate communities in open water bodies. To the contrary, any potential impact on *Daphnia magna* in open water bodies would most likely be localized to a small area and could be influenced and/or mitigated by a variety of factors.

Monitoring of invertebrate communities near product applications would be the best measure of potential real-world effects, for example, gauging the health of various surface layer invertebrates upstream and downstream of product applications following rain events. Also, such research could consider longer timeframes for runoff testing beyond two months following product application to further assess biodegradation potential.

[37] Region 9 Laboratory staff observed a very fast setting rate of solids (1-2 hours) during the toxicity tests for EnviroKleen and Durasoil runoff, as well as for surfactant runoff. Thus, use of an on-site retention pond would likely prevent off-site movement of solids and attached/adhered dust suppressants.

SECTION 6

RESULTS BY DUST SUPPRESSANT PRODUCT

Chem-Loc 101

Average results for CL met the objectives for all but two water quality parameters evaluated in the surface runoff experiment – Conductivity and Phosphate. However, the effects for Conductivity and Phosphate were not consistently observed across the dataset and not particularly high in magnitude relative to control tests. The Conductivity results may be influenced by the propensity of Arizona soils to generate a wide range of Conductivity values even among control samples.

In the pilot experiment, CL met all water quality parameters. In the vertical leaching experiment, an effect was observed for TSS, however, TSS is generally not a concern for groundwater quality.

No significant aquatic toxicity effects were observed in the tests conducted, with the exception of a single sample on the invertebrate species tested.

Enviro RoadMoisture 2.5

Average results for ERM met the objectives for five water quality parameters evaluated in the surface runoff experiment, showing an effect for four parameters – Conductivity, Phosphate, TSS, and Nitrite. The Phosphate, TSS, and Nitrite effects were not consistently observed across the dataset and not particularly high in magnitude relative to control tests. Average Conductivity results were not particularly low in magnitude relative to control tests. The Conductivity results may be influenced by the propensity of Arizona soils to generate a wide range of Conductivity values even among control samples.

In the pilot experiment, ERM met the Conductivity and pH objectives but showed an effect on TDS values, with results significantly higher relative to control for tests conducted on both Arizona and Nevada soils. In contrast, no effect on TDS values was observed in the surface runoff experiment. The pilot experiment results may not represent TDS values that would occur in a real-world runoff scenario. ERM met all water quality parameters in the vertical leaching experiment.

No significant aquatic toxicity effects were observed in the tests conducted, with the exception of two samples on the invertebrate species tested.

Durasoil

Average results for DS met six water quality parameters evaluated in the surface runoff experiment, showing an effect for three parameters – Conductivity, Phosphate, and TSS. While DS results for Conductivity were notably lower relative to control samples, these results may be influenced by the propensity of Arizona soils to generate a wide range of Conductivity values even among control samples. Curiously, the opposite effect was observed in the pilot experiment in which Conductivity values for DS were higher relative to control. The Phosphate results were not consistently observed across the dataset and not particularly high in magnitude relative to control tests. TSS results for DS were significantly higher relative to control values across the dataset. The higher TSS values appear to relate to the product's soil binding characteristics and the tendency for larger dirt clumps to form and be released in surface runoff relative to tests involving untreated or surfactant-treated soils. In a real-world setting, overland runoff typically travels some distance, creating opportunity for heavier dirt clumps to settle out prior to reaching a water body.

In the pilot experiment, DS met the objectives for pH but showed an effect on TDS values in addition to Conductivity. TDS results were significantly higher relative to control for tests conducted on both Arizona and Nevada soils. In contrast, no effect on TDS values was observed in the surface runoff experiment. The pilot experiment results may not represent TDS values that would occur in a real-world runoff scenario.

In the vertical leaching experiment, an effect was observed for TSS, however, TSS is generally not a concern for groundwater quality.

With respect to aquatic toxicity tests, DS showed potential for adverse effects on *daphnia magna* survival, an invertebrate species, due to physical entrapment in the product. However, the entrapment was observed in small test containers and does not represent an effect likely to occur in an open water body.

Jet-Dry

Average results for JD met the objectives for all water quality parameters evaluated in the surface runoff, vertical leaching, and pilot experiments. No significant aquatic toxicity effects were observed in the tests conducted, with the exception of a single sample on the invertebrate species tested.

Haul Road Dust Control

Average results for HR met the objectives for all water quality parameters evaluated in the surface runoff and vertical leaching experiments. In the pilot experiment, HR met the objectives for pH and TDS but not for Conductivity, in which average results were higher relative to control tests. Conductivity results may be influenced by the propensity of Arizona soils to generate a wide range of Conductivity values even among control samples.

No significant aquatic toxicity effects were observed in the tests conducted, with the exception of a single sample on the invertebrate species tested.

EnviroKleen

Average results for EK met the objectives for all but two water quality parameters evaluated in the surface runoff experiment – Phosphate and TSS. The Phosphate effects were not consistently observed across the dataset. TSS results for EK were significantly higher relative to control values across the dataset. The higher TSS values appear to relate to the product's soil binding characteristics and the tendency for larger dirt clumps to form and be released in surface runoff relative to tests involving untreated or surfactant-treated soils. In a real-world setting, overland runoff typically travels some distance, creating opportunity for heavier dirt clumps to settle out prior to reaching a water body.

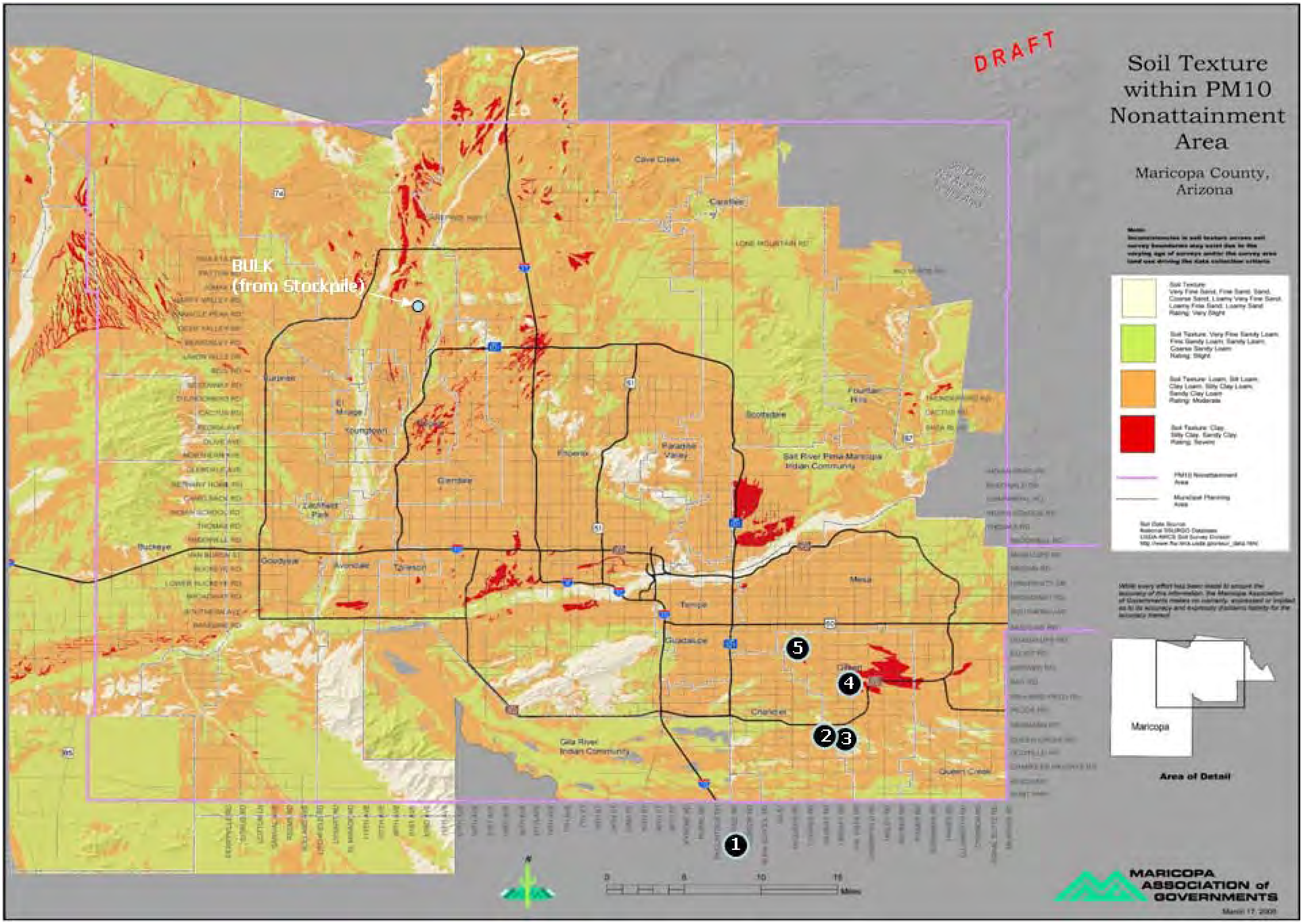
EK met all water quality parameters in the vertical leaching experiment. In the pilot experiment, EK met the water quality parameters for pH and TDS but not for Conductivity, in which average results were higher relative to control tests. Conductivity results may be influenced by the propensity of Arizona soils to generate a wide range of Conductivity values even among control samples.

With respect to aquatic toxicity tests, EK showed potential for adverse effects on *daphnia magna* survival, an invertebrate species, due to physical entrapment in the product. However, the entrapment was observed in small test containers and does not represent an effect likely to occur in an open water body.

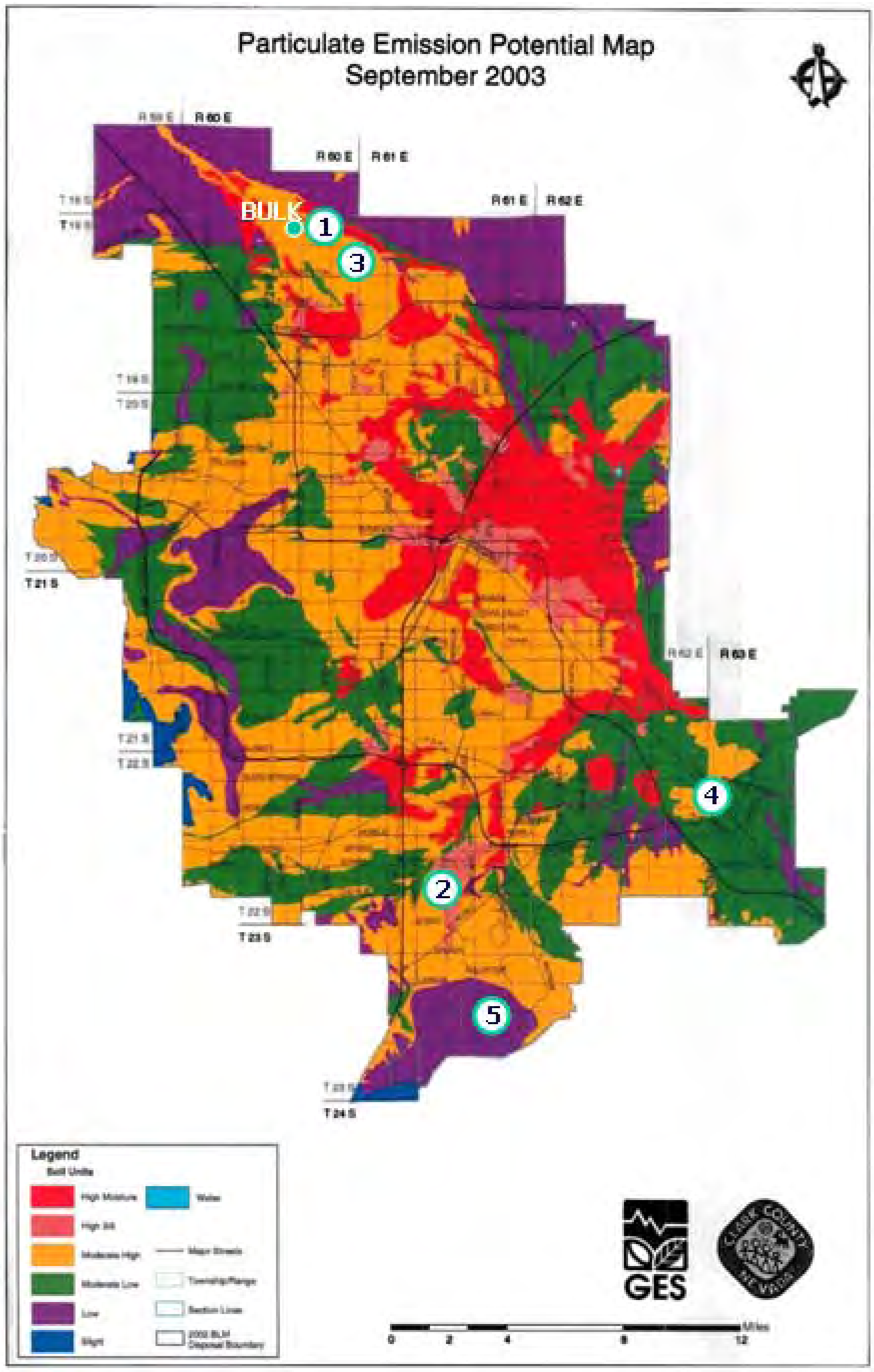
APPENDIX A

Maricopa County Soil Map

Clark County Soil Map



Soil Collection Locations in Maricopa County



Soil Collection Locations in Clark County

APPENDIX B

Table B-1. Concentrations of Metals in NV and AZ Bulk Soil Samples

Metal	Concentration of Metals in Soils, mg/kg			
	Clark County		Maricopa County	
	Typical Range*	Bulk Soil Sample	Typical Range*	Bulk Soil Sample
Antimony	<1	ND (2.0)	<1	ND (2.0)
Arsenic	3 to 7	4	3 to 60	5.5
Barium	<300	130	<700	180
Beryllium	<1	0.69	<1.5	ND (0.5)
Cadmium	NDA	ND (0.51)	NDA	ND (0.50)
Chromium	<30	18	<70	14
Cobalt	<7	4.7	<30	6.1
Copper	<15	9.7	20 to 50	16
Lead	<10	6.4	<20	11
Molybdenum	<3	1.1	<3	ND (1.0)
Nickel	<15	13	15 to 100	15
Selenium	<0.3	ND (2.0)	<2	ND (2.0)
Silver	NDA	ND (1.0)	NDA	ND (1.0)
Thallium	NDA	ND (1.0)	NDA	ND (1.0)
Vanadium	20 to 70	17	30 to 100	23
Zinc	30 to 70	39	45 to 200	27
Mercury	<0.1	ND (0.050)	<1.3	ND (0.051)

NDA - No data available
ND - Non detectable

*Reference for typical ranges: “Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States”, U.S. Geological Survey Professional Paper 1270, Hansford T. Shacklette and Josephine G. Boerngen, 1984.

APPENDIX C

Table C-1. SERL Methods for Water Quality Analyses

Water Quality Parameters	Method	Reference*	Units	Detection Limit	Method Range	Precision RSD (%)	Bias (% Recovery)	Project Hold Times
pH	pH Meter	4500-H-B	pH units	0.01	0.01 unit	< 1	10	Immediately
Electrical Conductivity (EC)	Conductivity meter	2510-B	µmho/cm	10	10-20,000	1	95	Immediately
Nitrate Nitrogen	TOC Analyzer	4500-NO3-E	mg/l	0.01	0.01-1	14	96-99	48 hours
Nitrite Nitrogen	Cadmium reduction/ colorimetric	4500-NO2-B	mg-N/l	0.005	0.01-1	14	102	48 hours
Phosphate	Azo dye/ colorimetric	4500-P-E	mg-P/l	0.01	0.01-6	9	95	48 hours
Dissolved Oxygen (DO)	Ascorbic acid	4500-O-G	mg/l	0.1	0.1-15	10	95	Immediately
Total Suspended Solids (TSS)	Membrane Electrode	2540-D	mg/l	4	4–20,000	4	98	3-5 days
Total Dissolved Solids (TDS)	Gravimetric	2540-C	mg/l	4	4–20,000	4	98	3-5 days
Total Organic Carbon (TOC)	Gravimetric	5310-B	mg/l	0.005	0.005-35	8	97-101	2 days**

* Standard Methods for Examination of Water and Wastewaters, APHA, AWWA, WEF, 20th ed., 1999.

** Preserved with sulfuric acid at pH < 2

APPENDIX D

Table D-1. Results from Individual Tests in the Surface Runoff Experiment

															Replicates									
Tray No.	Soil Type	Product	Aged (Month)	Rain Rate	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l
T-AZ-1	AZ	RO	0	1	T-AZ-A-1	7.76	307	860	2,690	4.6	96.06	11.71	0.16	0.36	T-AZ-B-1									
T-AZ-2	AZ	RO	0	2	T-AZ-A-2	8.33	469	3,248	2,864	7.8	9.46	1.31	0.04	0.39	T-AZ-B-2						9.17			
T-AZ-3	AZ	RO	0	3	T-AZ-A-3	9.09	61.1	8,982	406	7.9	3.49	0.34	0.38	2.12	T-AZ-B-3			8,862	418					
T-AZ-4	AZ	RO	1	1	T-AZ-A-4	8.11	1388	827	1,078	7.7	19.21	0.09	0.01	0.27	T-AZ-B-4	8.1	1386			7.8	18.96			
T-AZ-5	AZ	RO	1	2	T-AZ-A-5	8.18	662	2,605	492	7.5	13.06	0.05	0.01	0.56	T-AZ-B-5	8.18	663			7.5	12.80		0.01	0.53
T-AZ-6	AZ	RO	1	3	T-AZ-A-6	9.07	81.9	4,492	642	6.0	2.18	5.74	0.22	3.27	T-AZ-B-6	9.08	82.0	4,367	664	6.0				
T-AZ-7	AZ	RO	2	1	T-AZ-A-7	7.17	1394	418	284	6.6	22.90	0.22	0.01	0.27	T-AZ-B-7						22.72			
T-AZ-8	AZ	RO	2	2	T-AZ-A-8	7.58	816	1,342	580	7.0	16.00	0.24	0.01	1.26	T-AZ-B-8			1,381	562					
T-AZ-9	AZ	RO	2	3	T-AZ-A-9	8.27	260	1,042	448	7.8	5.87	0.42	0.08	0.81	T-AZ-B-9									
T-AZ-10	AZ	CL(A)	0	1	T-AZ-A-10	7.89	1167	1,155	1,486	7.3	64.52	8.26	0.09	0.11	T-AZ-B-10			1,195	1,440		62.44			
T-AZ-11	AZ	CL(A)	0	2	T-AZ-A-11	7.90	697	2,762	472	7.9	12.65	3.36	0.06	0.21	T-AZ-B-11									
T-AZ-12	AZ	CL(A)	0	3	T-AZ-A-12	9.00	73.3	4,547	372	8.0	3.33	0.90	0.24	0.92	T-AZ-B-12									
T-AZ-13	AZ	CL(A)	0	1	T-AZ-A-13	8.11	1620	5,392	290	5.7	2.84	0.40	0.23	0.98	T-AZ-B-13									
T-AZ-14	AZ	CL(A)	0	2	T-AZ-A-14	8.26	833	6,661	378	7.9	13.83	5.28	0.08	0.24	T-AZ-B-14							4.98	0.08	0.26
T-AZ-15	AZ	CL(A)	0	3	T-AZ-A-15	9.06	76.1	3,828	332	7.8	3.53	0.40	0.23	1.05	T-AZ-B-15									
T-AZ-16	AZ	CL(A)	1	1	T-AZ-A-16	7.99	1917	6,125	1,692	7.6	14.99	0.26	0.02	0.33	T-AZ-B-16	7.99	1919			7.8				
T-AZ-17	AZ	CL(A)	1	2	T-AZ-A-17	7.95	1279	1,167	878	7.4	21.04	0.14	0.01	0.35	T-AZ-B-17	7.95	1280			7.5				
T-AZ-18	AZ	CL(A)	1	3	T-AZ-A-18	8.94	127.9	3,780	250	7.7	2.92	0.68	0.21	1.21	T-AZ-B-18	8.95	128.0			7.9				
T-AZ-19	AZ	CL(B)	1	1	T-AZ-A-19	8.09	1479	1,940	1,104	7.8	24.26	0.24	0.01	2.78	T-AZ-B-19	8.09	1478			7.9				
T-AZ-20	AZ	CL(B)	1	2	T-AZ-A-20	8.88	161.0	2,386	186	7.7	3.50	0.85	0.07	4.50	T-AZ-B-20	8.89	161.1	2,293	181	7.5				
T-AZ-21	AZ	CL(B)	1	3	T-AZ-A-21	9.11	79.5	7,456	408	7.3	1.50	1.22	0.40	5.82	T-AZ-B-21	9.11	79.4			7.2				
T-AZ-22	AZ	CL(B)	2	1	T-AZ-A-22	7.35	1238	423	992	8.4	18.58	0.19	0.01	1.03	T-AZ-B-22									
T-AZ-23	AZ	CL(B)	2	2	T-AZ-A-23	7.98	374	1,101	242	8.4	7.50	0.30	0.05	0.79	T-AZ-B-23									
T-AZ-24	AZ	CL(B)	2	3	T-AZ-A-24	8.44	238	1,338	140	7.4	6.68	0.36	0.04	0.49	T-AZ-B-24									
T-AZ-25	AZ	CL(B)	2	1	T-AZ-A-25	7.57	1139	1,138	944	7.6	22.85	0.25	0.01	0.36	T-AZ-B-25									
T-AZ-26	AZ	CL(B)	2	2	T-AZ-A-26	7.53	964	696	542	7.0	20.23	0.18	0.02	2.57	T-AZ-B-26									
T-AZ-27	AZ	CL(B)	2	3	T-AZ-A-27	8.63	175.0	1,056	90	6.7	3.43	0.53	0.08	0.32	T-AZ-B-27									
T-AZ-28	AZ	ERM(A)	0	1	T-AZ-A-28	8.15	1267	2,702	1,026	4.8	42.69	5.06	0.12	0.05	T-AZ-B-28									
T-AZ-29	AZ	ERM(A)	0	2	T-AZ-A-29	8.85	85.3	2,922	296	7.0	4.49	0.33	0.28	1.40	T-AZ-B-29	8.85	85.9			7.1	4.58	0.35	0.30	1.50
T-AZ-30	AZ	ERM(A)	0	3	T-AZ-A-30	8.96	89.6	4,533	274	7.8	2.98	0.58	0.20	0.81	T-AZ-B-30							0.60	0.21	0.76
T-AZ-31	AZ	ERM(A)	0	1	T-AZ-A-31	8.13	1365	3,504	1,080	4.2	47.74	6.33	0.14	0.12	T-AZ-B-31									
T-AZ-32	AZ	ERM(A)	0	2	T-AZ-A-32	8.71	181.0	9,130	98	7.7	3.78	0.92	0.05	0.23	T-AZ-B-32	8.71	183			7.6				
T-AZ-33	AZ	ERM(A)	0	3	T-AZ-A-33	8.59	332	7,753	168	8.0	5.05	1.05	0.04	0.07	T-AZ-B-33									
T-AZ-34	AZ	ERM(A)	1	1	T-AZ-A-34	8.33	933	2,791	746	6.9	13.63	0.09	0.03	4.22	T-AZ-B-34	8.35	935	2,818	768	7.0	14.17			
T-AZ-35	AZ	ERM(A)	1	2	T-AZ-A-35	9.05	77.0	6,454	324	6.8	1.34	0.76	0.28	2.01	T-AZ-B-35	9.06	77.1			6.9				
T-AZ-36	AZ	ERM(A)	1	3	T-AZ-A-36	9.09	74.9	8,123	302	6.9	1.44	0.39	0.17	1.99	T-AZ-B-36	9.09	75.0			6.8				
T-AZ-37	AZ	ERM(B)	1	1	T-AZ-A-37	8.33	1027	2,651	738	7.7	14.99	5.09	0.02	0.52	T-AZ-B-37	8.34	1029			7.5				
T-AZ-38	AZ	ERM(B)	1	2	T-AZ-A-38	8.65	319	4,356	170	6.8	6.80	1.65	0.03	0.28	T-AZ-B-38	8.65	320			6.9				
T-AZ-39	AZ	ERM(B)	1	3	T-AZ-A-39	9.05	85.2	7,711	358	7.0	1.36	1.32	0.39	1.77	T-AZ-B-39	9.06	85.4			7.2				
T-AZ-40	AZ	ERM(B)	2	1	T-AZ-A-40	8.77	140.5	2,399	844	7.2	1.53	0.29	0.01	0.93	T-AZ-B-40									
T-AZ-41	AZ	ERM(B)	2	2	T-AZ-A-41	8.74	152.0	556	172	9.0	3.76	0.62	0.09	0.54	T-AZ-B-41							0.68	0.08	0.51
T-AZ-42	AZ	ERM(B)	2	3	T-AZ-A-42	9.01	95.0	4,158	84	7.6	1.93	1.11	0.02	4.36	T-AZ-B-42									
T-AZ-43	AZ	ERM(B)	2	1	T-AZ-A-43	7.36	1632	910	994	8.4	23.97	0.30	0.02	1.35	T-AZ-B-43			932	955			0.34	0.02	1.34
T-AZ-44	AZ	ERM(B)	2	2	T-AZ-A-44	8.73	135.4	2,231	244	7.8	3.26	0.19	0.26	0.60	T-AZ-B-44									
T-AZ-45	AZ	ERM(B)	2	3	T-AZ-A-45	9.14	89.1	138	522	8.1	1.82	0.56	0.27	2.19	T-AZ-B-45									
T-AZ-46	AZ	DS(A)	0	1	T-AZ-A-46	8.66	169.4	7,534	74	4.8	2.76	0.64	0.15	0.79	T-AZ-B-46									
T-AZ-47	AZ	DS(A)	0	2	T-AZ-A-47	8.62	182.0	11,262	114	7.5	2.67	1.02	0.05	0.53	T-AZ-B-47	8.63	184			7.7				
T-AZ-48	AZ	DS(A)	0	3	T-AZ-A-48	8.95	68.8	15,391	262	7.9	1.88	0.49	0.27	1.42	T-AZ-B-48									
T-AZ-49	AZ	DS(A)	0	1	T-AZ-A-49	8.40	919	10,346	270	5.0	5.51	2.42	0.04	0.14	T-AZ-B-49						5.63			
T-AZ-50	AZ	DS(A)	0	2	T-AZ-A-50	8.57	209	11,755	110	7.5	3.24	1.10	0.03	0.29	T-AZ-B-50	8.58	205	11,402	113	7.4		1.10	0.03	0.33
T-AZ-51	AZ	DS(A)	0	3	T-AZ-A-51	8.72	105.3	14,874	298	7.9	1.92	0.47	0.36	1.52	T-AZ-B-51									
T-AZ-52	AZ	DS(A)	1	1	T-AZ-A-52	8.73	287	12,115	174	7.4	4.02	1.79	0.03	0.39	T-AZ-B-52	8.74	287	12,599	182	7.5				
T-AZ-53	AZ	DS(A)	1	2	T-AZ-A-53	9.05	93.7	15,645	612	7.6	1.66	1.28	0.48	3.16	T-AZ-B-53	9.04	93.8			7.4				

Results from Individual Tests in the Surface Runoff Experiment (continued)

															Replicates									
Tray No.	Soil Type	Product	Aged (Month)	Rain Rate	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l
T-AZ-54	AZ	DS(A)	1	3	T-AZ-A-54	8.90	134.9	18,953	264	7.1	2.14	1.35	0.24	1.40	T-AZ-B-54	8.91	135.0			7.2				
T-AZ-55	AZ	DS(B)	1	1	T-AZ-A-55	8.81	101.9	14,526	116	6.9	2.01	0.58	0.12	5.61	T-AZ-B-55	8.82	101.8			7.0				
T-AZ-56	AZ	DS(B)	1	2	T-AZ-A-56	8.86	124.5	22,983	166	7.4	3.21	0.51	0.09	0.99	T-AZ-B-56	8.87	124.6			7.5	3.07			
T-AZ-57	AZ	DS(B)	1	3	T-AZ-A-57	8.66	194.0	30,298	122	6.2	5.22	1.38	0.04	0.49	T-AZ-B-57	8.68	194.1			6.3				
T-AZ-58	AZ	DS(B)	2	1	T-AZ-A-58	8.63	86.7	9,787	262	9.5	3.01	0.25	0.04	1.63	T-AZ-B-58			10,129	272		3.04			
T-AZ-59	AZ	DS(B)	2	2	T-AZ-A-59	8.57	138.7	6,859	24	8.5	4.59	0.18	0.03	0.36	T-AZ-B-59							0.17	0.03	0.33
T-AZ-60	AZ	DS(B)	2	3	T-AZ-A-60	8.13	181.6	3,922	306	9.0	6.28	0.10	0.01	3.31	T-AZ-B-60									
T-AZ-61	AZ	DS(B)	2	1	T-AZ-A-61	8.25	152.2	8,613	78	7.6	2.42	0.21	0.03	0.37	T-AZ-B-61						2.78			
T-AZ-62	AZ	DS(B)	2	2	T-AZ-A-62	8.53	148.0	904	146	7.7	5.67	0.25	0.01	1.65	T-AZ-B-62									
T-AZ-63	AZ	DS(B)	2	3	T-AZ-A-63	8.56	173.4	12,140	120	8.1	6.05	0.22	0.03	0.47	T-AZ-B-63									
T-NV-1	NV	RO	0	1	T-NV-A-1	8.38	556	45,202	410	5.4	0.838	0.38	0.03	0.20	T-NV-B-1						0.854			
T-NV-2	NV	RO	0	2	T-NV-A-2	8.89	154	13,331	258	5.2	1.355	0.33	0.22	0.88	T-NV-B-2			12,513	271					
T-NV-3	NV	RO	0	3	T-NV-A-3	8.95	147	17,011	72	8.0	1.297	0.16	0.21	0.96	T-NV-B-3	8.96	147			7.8				
T-NV-4	NV	RO	1	1	T-NV-A-4	8.63	549	17,689	390	6.8	1.332	0.52	0.02	0.32	T-NV-B-4	8.62	547			7				
T-NV-5	NV	RO	1	2	T-NV-A-5	8.72	449	1,150	282	8.7	1.471	0.47	0.03	0.59	T-NV-B-5	8.73	449			8.7				
T-NV-6	NV	RO	1	3	T-NV-A-6	9.15	147	2,563	148	7.7	1.195	0.49	0.03	0.33	T-NV-B-6	9.16	146			7.8				
T-NV-7	NV	RO	2	1	T-NV-A-7	7.73	285	298	231	7.8	4.783		ND	0.57	T-NV-B-7									
T-NV-8	NV	RO	2	2	T-NV-A-8	7.16	149.7	4,679	183	7.8	1.406	0.35	0.03	0.12	T-NV-B-8							0.36	0.03	0.11
T-NV-9	NV	RO	2	3	T-NV-A-9	9.17	170.1	3,781	128	7.5	1.038	ND	ND	ND	T-NV-B-9									
T-NV-10	NV	JD(A)	0	1	T-NV-A-10	8.62	233	27,873	136	5.5	0.788	ND	0.06	0.13	T-NV-B-10			28,600	146					
T-NV-11	NV	JD(A)	0	2	T-NV-A-11	8.79	173	13,666	100	4.9	0.968	ND	0.13	0.79	T-NV-B-11			13,152	98					
T-NV-12	NV	JD(A)	0	3	T-NV-A-12	8.90	145	18,082	70	7.6	1.026	ND	0.07	0.13	T-NV-B-12	8.90	143							
T-NV-13	NV	JD(A)	0	1	T-NV-A-13	8.61	270	44,838	154	5.1	0.922	ND	0.02	ND	T-NV-B-13						0.897	ND	0.02	ND
T-NV-14	NV	JD(A)	0	2	T-NV-A-14	8.82	169	14,611	70	5.4	0.919	ND	0.18	0.71	T-NV-B-14				7.4			ND	0.17	0.67
T-NV-15	NV	JD(A)	0	3	T-NV-A-15	9.00	132	13,521	194	7.8	1.023	ND	0.18	0.66	T-NV-B-15	9.01	131.7							
T-NV-16	NV	JD(A)	1	1	T-NV-A-16	8.33	872	1,345	582	6.9	1.213	0.53	0.02	0.43	T-NV-B-16	8.31	871			6.9				
T-NV-17	NV	JD(A)	1	2	T-NV-A-17	8.90	278	25,520	160	7.1	0.857	0.45	0.02	0.64	T-NV-B-17	8.92	278		7.7	7.1				
T-NV-18	NV	JD(A)	1	3	T-NV-A-18	9.19	166	3,533	128	7.5	0.995	0.55	0.04	0.69	T-NV-B-18	9.20	165			7.5				
T-NV-19	NV	JD(B)	1	1	T-NV-A-19	8.72	404	4,567	144	7.3	0.944	0.52	0.04	0.42	T-NV-B-19	8.72	404			7.2				
T-NV-20	NV	JD(B)	1	2	T-NV-A-20	8.91	290	7,021	124	6.9	1.184	0.47	0.02	0.31	T-NV-B-20	8.93	291			6.7				
T-NV-21	NV	JD(B)	1	3	T-NV-A-21	9.19	168	15,958	126	7.5	1.026	0.54	0.05	0.43	T-NV-B-21	9.16	167			7.4		0.58	0.05	0.43
T-NV-22	NV	JD(B)	2	1	T-NV-A-22	7.91	133.5	450	188	8.9	1.843	0.11	0.04	0.85	T-NV-B-22			440	176					
T-NV-23	NV	JD(B)	2	2	T-NV-A-23	9.15	164.3	6,556	580	9.3	1.175	0.29	0.03	0.08	T-NV-B-23									
T-NV-24	NV	JD(B)	2	3	T-NV-A-24	9.03	189.9	5,877	120	9.1	0.961	0.16	ND	0.07	T-NV-B-24									
T-NV-25	NV	JD(B)	2	1	T-NV-A-25	8.89	154.3	3,335	158	8.7	1.733		ND	0.38	T-NV-B-25									
T-NV-26	NV	JD(B)	2	2	T-NV-A-26	9.30	132.7	1,706	142	8.1	1.619	0.51	0.08	0.32	T-NV-B-26									
T-NV-27	NV	JD(B)	2	3	T-NV-A-27	9.19	168.1	2,236	94	9.1	0.625	0.38	0.03	0.76	T-NV-B-27									
T-NV-28	NV	HR(A)	0	1	T-NV-A-28	8.64	225	23,735	924	5.3	0.891	0.49	0.03	0.05	T-NV-B-28			24,209	887					
T-NV-29	NV	HR(A)	0	2	T-NV-A-29	8.88	159	11,641	250	5.1	4.152	0.28	0.04	0.03	T-NV-B-29									
T-NV-30	NV	HR(A)	0	3	T-NV-A-30	8.92	172	14,272	102	7.7	2.333	0.42	0.04	0.13	T-NV-B-30	8.91	173			7.5	2.244			
T-NV-31	NV	HR(A)	0	1	T-NV-A-31	8.60	283	34,605	234	5.6	1.658	0.24	0.02	0.02	T-NV-B-31									
T-NV-32	NV	HR(A)	0	2	T-NV-A-32	8.79	169	12,516	126	5.6	1.366	0.35	0.03	ND	T-NV-B-32									
T-NV-33	NV	HR(A)	0	3	T-NV-A-33	8.97	146	17,602	170	7.7	1.159	0.31	0.03	0.14	T-NV-B-33	8.95	147	16,984	181	7.6	1.184	0.32	0.03	0.15
T-NV-34	NV	HR(A)	1	1	T-NV-A-34	8.80	373	9,409	216	7.2	1.005	0.36	0.01	0.37	T-NV-B-34	8.78	373			7.1				
T-NV-35	NV	HR(A)	1	2	T-NV-A-35	8.80	372	31,134	158	6.8	0.692	0.38	0.02	0.45	T-NV-B-35	8.82	372			6.9	0.680			
T-NV-36	NV	HR(A)	1	3	T-NV-A-36	9.11	170	27,746	120	7.8	1.122	0.55	0.04	0.44	T-NV-B-36	9.12	169			7.8				
T-NV-37	NV	HR(B)	1	1	T-NV-A-37	8.70	365	5,631	210	7.2	0.521	0.47	0.05	0.47	T-NV-B-37	8.70	364			7.3				
T-NV-38	NV	HR(B)	1	2	T-NV-A-38	9.01	230	8,946	136	6.9	0.870	0.31	0.02	0.47	T-NV-B-38	9.02	230			6.9				
T-NV-39	NV	HR(B)	1	3	T-NV-A-39	9.11	173	4,611	158	7.7	1.048	0.39	0.01	0.31	T-NV-B-39	9.13	171			7.7	1.099	0.41	0.02	0.33
T-NV-40	NV	HR(B)	2	1	T-NV-A-40	7.85	231	8,840	664	7.2	1.731	0.16	0.02	0.27	T-NV-B-40									
T-NV-41	NV	HR(B)	2	2	T-NV-A-41	9.08	185.5	3,394	164	7.7	1.124	0.12	0.02	2.30	T-NV-B-41			3,597	155					
T-NV-42	NV	HR(B)	2	3	T-NV-A-42	8.94	315	10,280	180	7.5	1.198	ND	ND	0.97	T-NV-B-42									
T-NV-43	NV	HR(B)	2	1	T-NV-A-43	8.01	835	9,418	654	8.9	1.763	0.24	0.04	0.32	T-NV-B-43						1.627	0.23	0.04	0.34
T-NV-44	NV	HR(B)	2	2	T-NV-A-44	9.14	179.6	746	202	7.7	1.021		ND	0.56	T-NV-B-44									
T-NV-45	NV	HR(B)	2	3	T-NV-A-45	9.09	238	3,398	134	8.5	1.162	ND	ND	ND	T-NV-B-45									
T-NV-46	NV	EK(A)	0	1	T-NV-A-46	8.59	247	26,069	186	4.6	0.859	0.32	0.09	0.61	T-NV-B-46									
T-NV-47	NV	EK(A)	0	2	T-NV-A-47	8.69	220	26,665	162	7.1	1.497	0.37	0.08	0.38	T-NV-B-47									

Results from Individual Tests in the Surface Runoff Experiment (continued)

															Replicates										
Tray No.	Soil Type	Product	Aged (Month)	Rain Rate	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l
T-NV-48	NV	EK(A)	0	3	T-NV-A-48	8.81	217	35,097	164	7.7	0.856	0.41	0.08	0.27	T-NV-B-48	8.79	216			7.8				
T-NV-49	NV	EK(A)	0	1	T-NV-A-49	8.55	286	44,814	212	5.0	0.865	0.24	0.02	0.32	T-NV-B-49			40,814	228					
T-NV-50	NV	EK(A)	0	2	T-NV-A-50	8.67	242	26,904	170	6.1	0.933	0.30	0.03	ND	T-NV-B-50									
T-NV-51	NV	EK(A)	0	3	T-NV-A-51	8.81	209	44,487	190	7.3	1.170	0.36	0.02	0.82	T-NV-B-51	8.80	209			7.3	1.140	0.38	0.02	0.87
T-NV-52	NV	EK(A)	1	1	T-NV-A-52	9.03	175	27,382	140	6.8	1.408	0.45	0.04	0.60	T-NV-B-52	9.04	176			6.7				
T-NV-53	NV	EK(A)	1	2	T-NV-A-53	9.03	218	33,124	106	6.9	0.885	0.35	0.04	0.35	T-NV-B-53	9.02	217			7.1				
T-NV-54	NV	EK(A)	1	3	T-NV-A-54	9.02	213	28,066	220	7.7	1.309	0.53	0.02	0.81	T-NV-B-54	9.03	215			7.7				
T-NV-55	NV	EK(B)	1	1	T-NV-A-55	9.05	227	23,118	336	6.8	1.059	0.32	0.03	0.39	T-NV-B-55	9.06	228			6.7				
T-NV-56	NV	EK(B)	1	2	T-NV-A-56	8.91	348	74,933	220	6.8	1.126	0.33	0.03	0.57	T-NV-B-56	8.92	351			6.8				
T-NV-57	NV	EK(B)	1	3	T-NV-A-57	9.02	318	13,895	192	7.6	1.277	0.55	0.03	0.67	T-NV-B-57	9.03	315			7.5				
T-NV-58	NV	EK(B)	2	1	T-NV-A-58	8.59	244	33,188	306	8.1	1.451	0.20	0.02	0.48	T-NV-B-58						1.337			
T-NV-59	NV	EK(B)	2	2	T-NV-A-59	9.03	263	18,282	170	9.3	1.264	0.86	0.07	0.64	T-NV-B-59									
T-NV-60	NV	EK(B)	2	3	T-NV-A-60	9.09	292	10,329	160	7.8	1.235	ND	ND	3.68	T-NV-B-60			10,657	155					
T-NV-61	NV	EK(B)	2	1	T-NV-A-61	8.52	191.1	446	182	7.5	1.278	0.49	0.02	0.32	T-NV-B-61						1.286			
T-NV-62	NV	EK(B)	2	2	T-NV-A-62	9.06	254	6,740	201	7.8	1.168	0.07	0.02	3.98	T-NV-B-62								0.02	4.17
T-NV-63	NV	EK(B)	2	3	T-NV-A-63	9.16	232	2,841	134	7.8	1.412	0.03	0.01	0.71	T-NV-B-63									

APPENDIX E

Table E.1. Results From Individual Tests in the Vertical Leaching Experiment

														Replicates								
Column No.	Soil Type	Product	Aged (Month)	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l
C-AZ-1	AZ	RO	0	III-C-AZ-1	7.83	1835	ND	1,486	6.7	33.74	4.95	0.01	1.33	7.83	1833	ND	1530	6.8				
C-AZ-2	AZ	RO	0	IV-C-AZ-2	7.96	1520	ND	1,214	8.3	25.24	3.59	1.89	0.90	7.96	1518			8.4				
C-AZ-3	AZ	RO	1	V-C-AZ-3	7.67	1305	ND	856	8.1	22.13	1.87	0.13	0.52						22.89		0.14	
C-AZ-4	AZ	RO	2	C-AZ-4	7.74	2910	ND	2,496	9.1	48.16	6.62	0.15	4.17	7.74	2940			8.9		6.58		4.15
C-AZ-5	AZ	CL(A)	0	III-C-AZ-5	7.81	1887	ND	1,294	7.7	36.43	4.27	0.02	7.51	7.82	1886			7.7				
C-AZ-6	AZ	CL(A)	0	IV-C-AZ-6	8.34	279	ND	238	6.4	6.88	0.86	0.09	0.38	8.34	277	ND	245	6.5		0.81	0.09	0.39
C-AZ-7	AZ	CL(A)	1	V-C-AZ-7	7.82	1283	ND	1,012	7.9	20.88	2.05	0.05	0.34						21.61			
C-AZ-8	AZ	CL(A)	1	V-C-AZ-8	8.14	1022	ND	808	8.2	23.20	1.03	0.36	2.48						22.28			
C-AZ-9	AZ	CL(A)	2	C-AZ-9	7.94	2270	317	1,760	8.8	34.45	5.61	0.12	2.77	7.93	2250			8.7				
C-AZ-10	AZ	CL(A)	2	C-AZ-10	7.89	3230	4	2,520	9.0	53.19	6.58	0.10	2.11	7.87	3200			9.0		6.51	0.10	2.13
C-AZ-11	AZ	CL(B)	0	III-C-AZ-11	7.70	1589	ND	1,176	6.9	28.36	5.57	0.01	1.89	7.69	1591			7.0				
C-AZ-12	AZ	CL(B)	0	IV-C-AZ-12	7.81	1324	ND	984	8.3	79.76	3.88	0.03	0.37	7.82	1323			8.4		3.86	0.03	0.39
C-AZ-13	AZ	CL(B)	1	V-C-AZ-13	7.80	1514	ND	1,162	8.0	23.24	0.73	0.09	0.58			ND	1075		24.47			
C-AZ-14	AZ	CL(B)	1	V-C-AZ-14	7.38	2380	2	1,908	8.9	41.24	4.48	0.14	1.94	7.40	2450			9.0				
C-AZ-15	AZ	CL(B)	2	C-AZ-15	7.92	1732	4	1,420	8.6	53.70	4.87	0.11	1.62	7.92	1717			8.5				
C-AZ-16	AZ	CL(B)	2	C-AZ-16	7.41	2320	3	1,888	9.0	37.15	5.99	0.12	1.33	7.42	2310			8.9				
C-AZ-17	AZ	ERM(A)	0	III-C-AZ-17	7.83	1870	ND	1,554	7.4	34.49	4.86	0.01	0.67	7.84	1871			7.5				
C-AZ-18	AZ	ERM(A)	0	IV-C-AZ-18	7.92	1478	1	1,130	8.9	83.55	3.40	0.03	0.74	7.93	1479			9.0				
C-AZ-19	AZ	ERM(A)	1	C-AZ-19	7.95	1460	ND	1,165	7.8	37.83	3.52	0.11	0.93									
C-AZ-20	AZ	ERM(A)	1	V-C-AZ-20	7.92	1419	ND	1,200	8.2	23.28	2.23	0.12	0.87									
C-AZ-21	AZ	ERM(A)	2	C-AZ-21	7.29	2520	ND	1,974	8.7	39.66	6.23	0.01	1.28	7.30	2470			8.8		6.20	ND	1.27
C-AZ-22	AZ	ERM(A)	2	C-AZ-22	7.92	1930	ND	1,680	9.6	35.05	4.60	0.14	3.68	7.93	1910			9.7				
C-AZ-23	AZ	ERM(B)	0	III-C-AZ-23	7.91	1878	ND	1,498	7.1	35.28	4.15	0.01	0.50	7.92	1879			7.2			0.01	
C-AZ-24	AZ	ERM(B)	0	IV-C-AZ-24	7.86	1382	ND	1,016	6.5	74.08	4.38	ND	0.43	7.85	1383			6.4		4.47	ND	0.44
C-AZ-25	AZ	ERM(B)	1	V-C-AZ-25	7.67	1318	1	1,064	8.4	22.86	1.14	0.12	0.63						24.41			
C-AZ-26	AZ	ERM(B)	1	V-C-AZ-26	7.81	1750	ND	1,350	8.2	28.14	2.12	0.08	1.19						30.17			
C-AZ-27	AZ	ERM(B)	2	C-AZ-27	7.78	2310	ND	1,938	9.7	24.76	6.60	0.18	2.16	7.75	2280			9.6		6.65		2.18
C-AZ-28	AZ	ERM(B)	2	C-AZ-28	7.86	1967	ND	1,782	8.0	35.12	5.69	0.13	1.68	7.85	1930			7.1				
C-AZ-29	AZ	DS(A)	0	III-C-AZ-29	7.85	1797	1	1,446	7.3	31.96	3.98	0.01	0.66	7.86	1796			7.4				
C-AZ-30	AZ	DS(A)	0	IV-C-AZ-30	8.07	1413	ND	1,130	9.1	28.56	2.96	0.04	0.64	8.09	1411	ND	1152	8.9				
C-AZ-31	AZ	DS(A)	1	V-C-AZ-31	8.06	1366	ND	1,113	8.3	23.95	1.80	0.10	0.56						23.97		0.10	
C-AZ-32	AZ	DS(A)	1	V-C-AZ-32	7.80	1718	ND	1,386	8.1	27.58	1.81	0.08	0.80									
C-AZ-33	AZ	DS(A)	2	C-AZ-33	7.91	2480	ND	1,862	8.9	42.28	5.82	0.30	1.22	7.90	2500			9.0				
C-AZ-34	AZ	DS(A)	2	C-AZ-34	7.68	1934	51	1,762	8.8	37.21	5.07	0.12	1.28	7.76	1920			8.9				
C-AZ-35	AZ	DS(B)	0	III-C-AZ-35	7.95	1408	ND	1,100	7.8	87.77	2.97	0.02	0.60	7.96	1409	ND	1084	7.9				
C-AZ-36	AZ	DS(B)	0	IV-C-AZ-36	8.04	1478	1	1,156	8.2	29.06	4.04	0.01	0.90	8.06	1480			8.3		4.21		0.94
C-AZ-37	AZ	DS(B)	1	C-AZ-37	7.95	1520	ND	1,285	8.3	33.52	4.21	0.04	1.05						32.11			
C-AZ-38	AZ	DS(B)	1	C-AZ-38	8.06	1599	ND	1,248	8.0	36.47	3.86	0.05	1.23									
C-AZ-39	AZ	DS(B)	2	C-AZ-39	8.05	3220	3	2,720	8.8	54.24	5.97	0.08	1.31	8.02	3270			8.7				
C-AZ-40	AZ	DS(B)	2	C-AZ-40	7.87	2300	ND	516	9.1	37.12	5.30	0.29	1.08	7.89	2320			9.2				
C-NV-1	NV	RO	0	I-C-NV-1	7.83	3850	3	4,864	7.6	3.04	2.37	0.03	2.26						3.24			

Results From Individual Tests in the Vertical Leaching Experiment (continued)

													Replicates								
Column No.	Soil Type	Product	Aged (Month)	Sample ID	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l	pH	Conductivity μmhos/cm	TSS mg/l	TDS mg/l	DO mg/l	TOC mg/l	Nitrate mg/l	Nitrite mg-N/l	P mg/l
C-NV-2	NV	RO	0	II-C-NV-2	7.92	4260	4	5,294	7.4	4.94	2.81	0.34	1.01						5.17			
C-NV-3	NV	RO	1	VI-C-NV-3	7.80	5320	13	6,310	7.9	3.73	3.52	0.23	0.59				5,958		3.74	3.69	0.24	0.61
C-NV-4	NV	RO	2	C-NV-4	7.95	5010	92	5,314	7.7	5.93	5.53	0.04	5.39	7.92	5010			7.8				
C-NV-5	NV	JD(A)	0	I-C-NV-5	7.96	3890	2	4,818	7.2	3.62	1.25	0.03	0.75									
C-NV-6	NV	JD(A)	0	II-C-NV-6	7.87	4040	3	4,820	7.8	4.14	2.01	0.16	0.90			3	4,916		4.30		0.15	
C-NV-7	NV	JD(A)	1	VI-C-NV-7	7.82	4240	4	4,758	7.9	3.62	3.21	0.08	0.66									
C-NV-8	NV	JD(A)	1	VI-C-NV-8	8.09	5150	14	6,322	7.5	4.11	3.84	0.64	0.90							3.80		0.91
C-NV-9	NV	JD(A)	2	C-NV-9	8.05	5470	124	6,068	8.6	5.28	0.80	0.48	1.79	8.04	5540			8.6			0.49	
C-NV-10	NV	JD(A)	2	C-NV-10	7.87	4570	32	8,126	8.9	4.30	4.88	0.09	1.72	7.89	4600			9.0				
C-NV-11	NV	JD(B)	0	II-C-NV-11	7.63	3820	2	4,154	7.3	8.05	2.93	0.01	1.02	7.64	3830			7.4				
C-NV-12	NV	JD(B)	0	II-C-NV-12	7.63	3740	1	4,070	6.9	3.32	2.30	0.05	0.48	7.64	3720	ND	4,029	7.0				
C-NV-13	NV	JD(B)	1	VI-C-NV-13	7.47	3480	7	4,274	8.4	2.51	2.53	0.17	0.40						2.64			
C-NV-14	NV	JD(B)	1	VI-C-NV-14	7.54	3580	2	4,244	6.1	2.79	3.96	0.24	0.44			2	4,371		2.64			
C-NV-15	NV	JD(B)	2	C-NV-15	7.63	3940	67	3,984	7.8	2.69	2.62	0.08	1.85	7.63	3840			7.9		2.59		1.84
C-NV-16	NV	JD(B)	2	C-NV-16	7.62	3810	14	3,714	6.9	2.90	2.79	0.10	1.16	7.63	3860			7.0				
C-NV-17	NV	HR(A)	0	I-C-NV-17	7.61	3990	2	4,384	7.3	4.41	2.85	0.02	4.91	7.60	4000			7.4				
C-NV-18	NV	HR(A)	0	I-C-NV-18	7.61	3880	3	4,410	6.8	5.48	2.61	0.06	0.48	7.62	3870			6.9				
C-NV-19	NV	HR(A)	1	VI-C-NV-19	7.50	3390	1	4,190	7.6	2.54	1.60	0.19	0.49			ND	4,819					
C-NV-20	NV	HR(A)	1	VII-C-NV-20	7.45	3670	6	4,390	6.9	2.48	2.87	0.21	0.76								0.20	
C-NV-21	NV	HR(A)	2	C-NV-21	7.67	4290	32	4,564	7.0	2.98	3.94	0.16	1.74	7.67	4200			7.0		3.99		1.75
C-NV-22	NV	HR(A)	2	C-NV-22	7.68	3710	7	3,920	7.6	3.48	2.87	0.04	1.06	7.67	3650			7.7				
C-NV-23	NV	HR(B)	0	I-C-NV-23	7.63	3750	10	29,681	3.7	4.83	2.82	0.02	0.52	7.61	3740			7.1		2.77	0.02	0.54
C-NV-24	NV	HR(B)	0	II-C-NV-24	7.61	3620	2	3,992	7.1	4.20	2.31	0.01	0.49	7.63	3630			7.2				
C-NV-25	NV	HR(B)	1	VII-C-NV-25	7.40	3680	3	4,376	8.9	3.07	3.25	0.21	0.39			4	4,267					
C-NV-26	NV	HR(B)	1	VII-C-NV-26	7.50	3460	2	4,314	6.4	2.60	2.74	0.15	0.45						2.74			
C-NV-27	NV	HR(B)	2	C-NV-27	7.69	3990	31	4,806	7.1	3.49	3.13	0.14	4.20	7.70	4000			7.2				
C-NV-28	NV	HR(B)	2	C-NV-28	7.64	3550	6	3,798	7.1	4.25	4.05	0.22	1.12	7.66	3600			7.0		4.10	0.22	1.11
C-NV-29	NV	EK(A)	0	I-C-NV-29	7.52	3810	2	4,294	7.2	3.98	3.09	0.02	0.58	7.53	3800			7.3				
C-NV-30	NV	EK(A)	0	II-C-NV-30	7.73	4010	1	3,812	7.4	3.89	2.38	0.08	0.77			ND	3,869					
C-NV-31	NV	EK(A)	1	VII-C-NV-31	7.41	3800	3	4,654	8.6	3.44	2.92	0.18	0.54							2.96	0.19	0.57
C-NV-32	NV	EK(A)	1	VII-C-NV-32	7.55	3730	3	4,336	6.5	3.19	2.46	0.14	0.54						3.17			
C-NV-33	NV	EK(A)	2	C-NV-33	7.67	4450	9	4,644	7.9	3.73	4.88	0.24	1.70	7.69	4460			7.9				
C-NV-34	NV	EK(A)	2	C-NV-34	7.71	4620	48	5,204	7.6	4.60	5.74	0.04	1.20	7.69	4810			7.7				
C-NV-35	NV	EK(B)	0	I-C-NV-35	7.67	3500	3	4,220	7.1	4.13	2.88	0.04	0.55	7.68	3490			7.2				
C-NV-36	NV	EK(B)	0	II-C-NV-36	7.71	3660	2	1,076	7.2	4.39	3.01	0.02	0.94	7.69	3580			7.4				
C-NV-37	NV	EK(B)	1	C-NV-37	7.83	4050	5	2,250	7.8	7.00	5.83	0.14	2.40	7.84	3980			7.9		5.86		2.39
C-NV-38	NV	EK(B)	1	C-NV-38	7.63	3750	20	2,476	8.1	4.39	2.82	0.37	4.57	7.61	3800			8.0			0.36	
C-NV-39	NV	EK(B)	2	C-NV-39	7.72	2900	28	2,916	8.9	2.91	2.19	0.1	1.79	7.74	3100			8.9				
C-NV-40	NV	EK(B)	2	C-NV-40	7.84	5100	26	5,830	8.0	6.03	6.81	0.06	1.84	7.86	5160			7.9				

APPENDIX F

Table F.1. Results From Individual Tests in the Pilot Experiment

Sample No.	Soil Type	Product	pH	Conductivity µmhos/cm	TDS mg/l	pH	Conductivity µmhos/cm	TDS mg/l
P-1	NV-1	RO	8.76	185.9	146	8.74	188.6	144
P-2	NV-1	RO	8.73	184.2	109			
P-3	NV-2	RO	8.38	197.4	452			
P-4	NV-2	RO	8.49	161.5	950			
P-5	NV-3	RO	8.64	176.3	486			
P-6	NV-3	RO	8.74	160.1	230			
P-7	NV-4	RO	8.69	170.7	148			
P-8	NV-4	RO	8.79	167.9	132			
P-9	NV-5	RO	8.58	160.1	180			
P-10	NV-5	RO	8.47	164.8	344	8.51	166.9	350
P-11	AZ-1	RO	8.70	174.9	266			
P-12	AZ-1	RO	8.67	169.2	274			
P-13	AZ-2	RO	8.30	163.4	578			
P-14	AZ-2	RO	8.21	199.4	448			
P-15	AZ-3	RO	8.92	165.2	2212			
P-16	AZ-3	RO	8.80	166.8	3266			
P-17	AZ-4	RO	8.33	322	272			
P-18	AZ-4	RO	8.41	303	198			
P-19	AZ-5	RO	8.46	176.7	350			
P-20	AZ-5	RO	8.40	173.9	398	8.38	173.1	
P-21	NV-1	CL	8.87	172.5	182	8.90	171.5	186
P-22	NV-1	CL	8.90	174.0	136			
P-23	NV-2	CL	8.65	133.6	270			
P-24	NV-2	CL	8.73	130.1	254			
P-25	NV-3	CL	8.84	142.0	555			
P-26	NV-3	CL	8.88	141.2	245			
P-27	NV-4	CL	8.89	111.0	110			
P-28	NV-4	CL	8.92	106.2	120			
P-29	NV-5	CL	8.75	101.1	144	8.73	103.5	
P-30	NV-5	CL	8.82	100.0	134			
P-31	AZ-1	CL	8.71	152.8	373			
P-32	AZ-1	CL	8.61	169.4	402			
P-33	AZ-2	CL	8.30	169.4	412	8.32	168.8	415
P-34	AZ-2	CL	8.34	173.5	568			
P-35	AZ-3	CL	8.74	145.4	1190			
P-36	AZ-3	CL	8.75	167.7	1760			
P-37	AZ-4	CL	8.23	255	154			
P-38	AZ-4	CL	8.31	322	216			
P-39	AZ-5	CL	8.48	133.5	320			
P-40	AZ-5	CL	8.47	156.2	274			
P-41	NV-1	ERM	8.76	177.6	7910			

Sample No.	Soil Type	Product	pH	Conductivity μmhos/cm	TDS mg/l	pH	Conductivity μmhos/cm	TDS mg/l
P-42	NV-1	ERM	9.05	182.6	690			
P-43	NV-2	ERM	8.85	129.6	3358	8.86	128.2	3375
P-44	NV-2	ERM	8.78	137.8	9238			
P-45	NV-3	ERM	8.82	157.0	8384			
P-46	NV-3	ERM	8.93	152.9	1850			
P-47	NV-4	ERM	8.98	128.3	8320			
P-48	NV-4	ERM	8.84	121.3	9512			
P-49	NV-5	ERM	8.90	123.9	12816	8.88	123.8	12989
P-50	NV-5	ERM	8.76	137.9	20570			
P-51	AZ-1	ERM	8.47	137.7	10628			
P-52	AZ-1	ERM	8.86	197.6	4030			
P-53	AZ-2	ERM	7.76	241	4978			
P-54	AZ-2	ERM	7.89	197.7	5094			
P-55	AZ-3	ERM	8.82	191.5	6676			
P-56	AZ-3	ERM	8.66	176.7	5738			
P-57	AZ-4	ERM	8.45	274	1812			
P-58	AZ-4	ERM	8.41	319	4652	8.40	321	
P-59	AZ-5	ERM	8.08	180.9	2392			
P-60	AZ-5	ERM	8.05	180.1	1824			
P-61	NV-1	JD	8.74	199.1	180			
P-62	NV-1	JD	8.72	234	154			
P-63	NV-2	JD	8.41	175.8	310			
P-64	NV-2	JD	8.41	172.8	352			
P-65	NV-3	JD	8.69	163.6	236	8.70	165.1	229
P-66	NV-3	JD	8.89	172.7	274			
P-67	NV-4	JD	8.88	138.5	218			
P-68	NV-4	JD	8.87	142.9	198			
P-69	NV-5	JD	8.46	157.4	232			
P-70	NV-5	JD	8.56	130.8	266			
P-71	AZ-1	JD	8.70	148.2	247	8.69	146.9	
P-72	AZ-1	JD	8.49	283	582			
P-73	AZ-2	JD	7.98	288	418			
P-74	AZ-2	JD	8.08	286	420			
P-75	AZ-3	JD	8.69	260	2270			
P-76	AZ-3	JD	8.74	197.6	1564			
P-77	AZ-4	JD	8.35	286	290			
P-78	AZ-4	JD	8.33	365	280			
P-79	AZ-5	JD	8.32	193.4	30			
P-80	AZ-5	JD	8.46	160.1	292	8.44	161.9	301
P-81	NV-1	HR	8.87	182.8	212			
P-82	NV-1	HR	8.86	178.1	140			
P-83	NV-2	HR	8.75	136.9	314			
P-84	NV-2	HR	8.89	109.8	220			
P-85	NV-3	HR	8.82	149.2	174			
P-86	NV-3	HR	8.84	147.2	215			
P-87	NV-4	HR	8.96	127.4	178			

Sample No.	Soil Type	Product	pH	Conductivity μmhos/cm	TDS mg/l	pH	Conductivity μmhos/cm	TDS mg/l
P-88	NV-4	HR	8.95	137.3	188			
P-89	NV-5	HR	8.86	116.7	180			
P-90	NV-5	HR	8.87	108.7	182	8.89	107.7	177
P-91	AZ-1	HR	8.25	317	294			
P-92	AZ-1	HR	8.25	350	384			
P-93	AZ-2	HR	7.90	344	376			
P-94	AZ-2	HR	7.48	330	440			
P-95	AZ-3	HR	8.41	290	1120			
P-96	AZ-3	HR	8.45	272	522			
P-97	AZ-4	HR	8.08	392	328	8.08	388	322
P-98	AZ-4	HR	8.13	350	342			
P-99	AZ-5	HR	7.86	280	363			
P-100	AZ-5	HR	7.92	310	332			
P-101	NV-1	EK	8.74	226	130			
P-102	NV-1	EK	8.65	199.2	145			
P-103	NV-2	EK	8.36	183.1	190			
P-104	NV-2	EK	8.38	191.1	286			
P-105	NV-3	EK	8.74	163.9	364	8.76	162.1	
P-106	NV-3	EK	8.75	157.1	430			
P-107	NV-4	EK	8.80	154.7	188			
P-108	NV-4	EK	8.78	157.9	178			
P-109	NV-5	EK	8.54	156.8	192			
P-110	NV-5	EK	8.41	162.1	230			
P-111	AZ-1	EK	8.48	269	350	8.47	274	344
P-112	AZ-1	EK	8.49	322	440			
P-113	AZ-2	EK	7.96	288	384			
P-114	AZ-2	EK	8.01	298	406			
P-115	AZ-3	EK	8.75	235	1268			
P-116	AZ-3	EK	8.68	275	2072			
P-117	AZ-4	EK	8.35	364	288			
P-118	AZ-4	EK	8.33	379	298	8.33	372	289
P-119	AZ-5	EK	8.28	239	264			
P-120	AZ-5	EK	8.29	262	294			
P-121	NV-1	DS	8.76	228	178			
P-122	NV-1	DS	8.75	226	1106			
P-123	NV-2	DS	8.62	149.9	5610			
P-124	NV-2	DS	8.76	113.1	1864			
P-125	NV-3	DS	8.56	193.6	776			
P-126	NV-3	DS	8.61	179.6	6542			
P-127	NV-4	DS	8.98	131.5	3532	8.98	131.4	3583
P-128	NV-4	DS	8.96	141.9	1192			
P-129	NV-5	DS	8.72	133.5	248			
P-130	NV-5	DS	8.63	139.5	7640			
P-131	AZ-1	DS	8.53	322	4282			
P-132	AZ-1	DS	8.55	330	684			
P-133	AZ-2	DS	8.28	285	588			

Sample No.	Soil Type	Product	pH	Conductivity μmhos/cm	TDS mg/l	pH	Conductivity μmhos/cm	TDS mg/l
P-134	AZ-2	DS	8.19	331	684			
P-135	AZ-3	DS	8.83	276	1480	8.82	277	1464
P-136	AZ-3	DS	8.86	271	1236			
P-137	AZ-4	DS	8.43	435	1330			
P-138	AZ-4	DS	8.56	290	1493			
P-139	AZ-5	DS	8.46	274	628			
P-140	AZ-5	DS	8.49	233	334	8.50	231	

APPENDIX G

Table G-1. Toxicity Sample IDs - Nevada Soil Runoff

		EPA Toxic Sample Information		
Product	Sample ID	Sample ID	Rain Rate	Month
NA-Runoff Control	T-NV-1	T-NV-T-1	1	0
NA-Runoff Control	T-NV-2		2	0
NA-Runoff Control	T-NV-3		3	0
NA-Runoff Control	T-NV-4	T-NV-T-2	1	1
NA-Runoff Control	T-NV-5		2	1
NA-Runoff Control	T-NV-6		3	1
NA-Runoff Control	T-NV-7	T-NV-T-3	1	2
NA-Runoff Control	T-NV-8		2	2
NA-Runoff Control	T-NV-9		3	2
Jet-Dry	T-NV-10	T-NV-T-4*	1	0
Jet-Dry	T-NV-11		2	0
Jet-Dry	T-NV-12		3	0
Jet-Dry	T-NV-13	T-NV-T-5	1	0
Jet-Dry	T-NV-14		2	0
Jet-Dry	T-NV-15		3	0
Jet-Dry	T-NV-16	T-NV-T-6	1	1
Jet-Dry	T-NV-17		2	1
Jet-Dry	T-NV-18		3	1
Jet-Dry	T-NV-19	T-NV-T-7	1	1
Jet-Dry	T-NV-20		2	1
Jet-Dry	T-NV-21		3	1
Jet-Dry	T-NV-22	T-NV-T-8	1	2
Jet-Dry	T-NV-23		2	2
Jet-Dry	T-NV-24		3	2
Jet-Dry	T-NV-25	T-NV-T-9	1	2
Jet-Dry	T-NV-26		2	2
Jet-Dry	T-NV-27		3	2
Haul Road Dust Control	T-NV-28	T-NV-T-10	1	0
Haul Road Dust Control	T-NV-29		2	0
Haul Road Dust Control	T-NV-30		3	0
Haul Road Dust Control	T-NV-31	T-NV-T-11	1	0
Haul Road Dust Control	T-NV-32		2	0
Haul Road Dust Control	T-NV-33		3	0
Haul Road Dust Control	T-NV-34	T-NV-T-12	1	1
Haul Road Dust Control	T-NV-35		2	1
Haul Road Dust Control	T-NV-36		3	1
Haul Road Dust Control	T-NV-37	T-NV-T-13	1	1
Haul Road Dust Control	T-NV-38		2	1
Haul Road Dust Control	T-NV-39		3	1
Haul Road Dust Control	T-NV-40	T-NV-T-14	1	2
Haul Road Dust Control	T-NV-41		2	2
Haul Road Dust Control	T-NV-42		3	2
Haul Road Dust Control	T-NV-43	T-NV-T-15	1	2
Haul Road Dust Control	T-NV-44		2	2
Haul Road Dust Control	T-NV-45		3	2
EnviroKleen (App A)	T-NV-46	T-NV-T-16	1	0
EnviroKleen (App A)	T-NV-47		2	0
EnviroKleen (App A)	T-NV-48		3	0
EnviroKleen (App A)	T-NV-49	T-NV-T-17	1	0
EnviroKleen (App A)	T-NV-50		2	0
EnviroKleen (App A)	T-NV-51		3	0
EnviroKleen (App A)	T-NV-52	T-NV-T-18	1	1
EnviroKleen (App A)	T-NV-53		2	1
EnviroKleen (App A)	T-NV-54		3	1
EnviroKleen (App B)	T-NV-55	T-NV-T-19	1	1
EnviroKleen (App B)	T-NV-56		2	1
EnviroKleen (App B)	T-NV-57		3	1
EnviroKleen (App B)	T-NV-58	T-NV-T-20	1	2
EnviroKleen (App B)	T-NV-59		2	2
EnviroKleen (App B)	T-NV-60		3	2
EnviroKleen (App B)	T-NV-61	T-NV-T-21	1	2
EnviroKleen (App B)	T-NV-62		2	2
EnviroKleen (App B)	T-NV-63		3	2

* This sample number corresponds to the RC sample for 12/12/2006 tests.

Table G-2. Toxicity Sample IDs -Arizona Soil Runoff

		EPA Toxic Sample Information		
Product	Sample ID	Sample ID	Rain Rate	Month
NA-Runoff Control	T-AZ-1	T-AZ-T-1	1	0
NA-Runoff Control	T-AZ-2		2	0
NA-Runoff Control	T-AZ-3		3	0
NA-Runoff Control	T-AZ-4	T-AZ-T-2	1	1
NA-Runoff Control	T-AZ-5		2	1
NA-Runoff Control	T-AZ-6		3	1
NA-Runoff Control	T-AZ-7	T-AZ-T-3	1	2
NA-Runoff Control	T-AZ-8		2	2
NA-Runoff Control	T-AZ-9		3	2
Chem Loc 101	T-AZ-10	T-AZ-T-4	1	0
Chem Loc 101	T-AZ-11		2	0
Chem Loc 101	T-AZ-12		3	0
Chem Loc 101	T-AZ-13	T-AZ-T-5	1	0
Chem Loc 101	T-AZ-14		2	0
Chem Loc 101	T-AZ-15		3	0
Chem Loc 101	T-AZ-16	T-AZ-T-6	1	1
Chem Loc 101	T-AZ-17		2	1
Chem Loc 101	T-AZ-18		3	1
Chem Loc 101	T-AZ-19	T-AZ-T-7	1	1
Chem Loc 101	T-AZ-20		2	1
Chem Loc 101	T-AZ-21		3	1
Chem Loc 101	T-AZ-22	T-AZ-T-8	1	2
Chem Loc 101	T-AZ-23		2	2
Chem Loc 101	T-AZ-24		3	2
Chem Loc 101	T-AZ-25	T-AZ-T-9	1	2
Chem Loc 101	T-AZ-26		2	2
Chem Loc 101	T-AZ-27		3	2
Enviro RoadMoisture 2.5	T-AZ-28	T-AZ-T-10	1	0
Enviro RoadMoisture 2.5	T-AZ-29		2	0
Enviro RoadMoisture 2.5	T-AZ-30		3	0
Enviro RoadMoisture 2.5	T-AZ-31	T-AZ-T-11	1	0
Enviro RoadMoisture 2.5	T-AZ-32		2	0
Enviro RoadMoisture 2.5	T-AZ-33		3	0
Enviro RoadMoisture 2.5	T-AZ-34	T-AZ-T-12	1	1
Enviro RoadMoisture 2.5	T-AZ-35		2	1
Enviro RoadMoisture 2.5	T-AZ-36		3	1
Enviro RoadMoisture 2.5	T-AZ-37	T-AZ-T-13	1	1
Enviro RoadMoisture 2.5	T-AZ-38		2	1
Enviro RoadMoisture 2.5	T-AZ-39		3	1
Enviro RoadMoisture 2.5	T-AZ-40	T-AZ-T-14	1	2
Enviro RoadMoisture 2.5	T-AZ-41		2	2
Enviro RoadMoisture 2.5	T-AZ-42		3	2
Enviro RoadMoisture 2.5	T-AZ-43	T-AZ-T-15	1	2
Enviro RoadMoisture 2.5	T-AZ-44		2	2
Enviro RoadMoisture 2.5	T-AZ-45		3	2
Durasoil (App A)	T-AZ-46	T-AZ-T-16	1	0
Durasoil (App A)	T-AZ-47		2	0
Durasoil (App A)	T-AZ-48		3	0
Durasoil (App A)	T-AZ-49	T-AZ-T-17	1	0
Durasoil (App A)	T-AZ-50		2	0
Durasoil (App A)	T-AZ-51		3	0
Durasoil (App A)	T-AZ-52	T-AZ-T-18	1	1
Durasoil (App A)	T-AZ-53		2	1
Durasoil (App A)	T-AZ-54		3	1
Durasoil (App B)	T-AZ-55	T-AZ-T-19	1	1
Durasoil (App B)	T-AZ-56		2	1
Durasoil (App B)	T-AZ-57		3	1
Durasoil (App B)	T-AZ-58	T-AZ-T-20	1	2
Durasoil (App B)	T-AZ-59		2	2
Durasoil (App B)	T-AZ-60		3	2
Durasoil (App B)	T-AZ-61	T-AZ-T-21	1	2
Durasoil (App B)	T-AZ-62		2	2
Durasoil (App B)	T-AZ-63		3	2

APPENDIX H

Table H-1. Algae Test Results Summary

Sample ID#	Date of Analysis	Mean Cell Density X 10^6 cells/mL	% response as compared to control	% response as compared to RO	% response as compared to RC	*Statistical Comparison < control	< RO	< Runoff Control
Control Water	12/12/2006	2.93	NA	NA	NA	NA	NA	NA
RO-Water Blank 1	12/12/2006	2.44	83	NA	NA		NA	NA
T-NV-T-4[1]	12/12/2006	1.78	61	73	NA	X	X	NA
T-NV-T-6	12/12/2006	1.82	62	75	102	X	X	
T-NV-T-7	12/12/2006	1.89	64	78	106	X	X	
T-NV-T-12	12/12/2006	1.66	57	68	93	X	X	
T-NV-T-13	12/12/2006	1.61	55	66	90	X	X	
T-NV-T-18	12/12/2006	1.73	59	71	97	X	X	
T-NV-T-19	12/12/2006	1.93	66	79	108	X	X	
Control Water	1/18/2007	3.34	NA	NA	NA	NA	NA	NA
RO-Blank	1/18/2007	3.15	94	NA	NA		NA	NA
T-NV-T-3[1]	1/18/2007	1.58	47	50	NA	X	X	NA
T-NV-T-8	1/18/2007	1.69	51	54	107	X	X	
T-NV-T-9	1/18/2007	1.25	37	40	79	X	X	
T-NV-T-14	1/18/2007	1.69	51	54	107	X	X	
T-NV-T-15	1/18/2007	2.54	76	81	161	X	X	
T-NV-T-20	1/18/2007	2.91	87	92	184			
T-NV-T-21	1/18/2007	2.54	76	81	161	X	X	
Control Water	1/19/2007	0.78	NA	NA	NA	NA	NA	NA
RO-Water Blank 2	1/19/2007	3.74	NA	NA	NA		NA	NA
T-AZ-T-3[1]	1/19/2007	3.85	NA	103	NA			NA
T-AZ-T-8	1/19/2007	3.87	NA	104	100			
T-AZ-T-9	1/19/2007	3.48	NA	93	90			
T-AZ-T-14	1/19/2007	3.98	NA	106	103			
T-AZ-T-15	1/19/2007	4.52	NA	121	117			
T-AZ-T-20	1/19/2007	4.03	NA	108	105			
T-AZ-T-21	1/19/2007	4.55	NA	122	118			

*If marked, test response is statistically significantly less than relevant control, either control water, RO water or untreated runoff control(RC).

[1] Samples are untreated runoff control samples. The results were compared to the other treated samples in column 3 of the statistical comparison.

Table H-2. Fish and Invertebrate Test Results Summary (November '06)

SAMPLE NAME	Date of Analysis	ORGANISM	SOP #	% Survival 24 hour	% Survival 48 hour	*Significant Response in Test 24 hour vs control	48 hour vs control	24 hour vs RO	48 hour vs RO	24 hour vs RC	48 hour vs RC
T-NV-T-1[1]	11/14/2006	Fathead minnow Acute	SOP1030	100	100					NA	NA
T-NV-T-1[1]	11/14/2006	Daphnia magna Acute	SOP1032	90	45		X			NA	NA
T-NV-T-4	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-4	11/14/2006	Daphnia magna Acute	SOP1032	95	30		X				
T-NV-T-5	11/14/2006	Fathead minnow Acute	SOP1030	100	92						
T-NV-T-5	11/14/2006	Daphnia magna Acute	SOP1032	95	20		X				X
T-NV-T-10	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-10	11/14/2006	Daphnia magna Acute	SOP1032	100	55		X				
T-NV-T-11	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-11	11/14/2006	Daphnia magna Acute	SOP1032	100	10		X				X
T-NV-T-16	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-16	11/14/2006	Daphnia magna Acute	SOP1032	80	5		X		X		X
T-NV-T-17	11/14/2006	Fathead minnow Acute	SOP1030	100	98						
T-NV-T-17	11/14/2006	Daphnia magna Acute	SOP1032	55	10	X	X	X		X	X
RO-Water Blank 1	11/14/2006	Fathead minnow Acute	SOP1030	100	98			NA	NA	NA	NA
RO-Water Blank 1	11/14/2006	Daphnia magna Acute	SOP1032	100	40		X	NA	NA	NA	NA
Control Water	11/14/2006	Fathead minnow Acute	SOP1030	100	100	NA	NA	NA	NA	NA	NA
Control Water	11/14/2006	Daphnia magna Acute	SOP1032	100	95	NA	NA	NA	NA	NA	NA
RO-Water Blank 2	11/14/2006	Fathead minnow Acute	SOP1030	95	95			NA	NA	NA	NA
RO-Water Blank 2	11/14/2006	Daphnia magna Acute	SOP1032	100	20		X	NA	NA	NA	NA
T-AZ-T-1[1]	11/14/2006	Fathead minnow Acute	SOP1030	100	100					NA	NA
T-AZ-T-1[1]	11/14/2006	Daphnia magna Acute	SOP1032	95	55		X			NA	NA
T-AZ-T-4	11/14/2006	Fathead minnow Acute	SOP1030	100	98						
T-AZ-T-4	11/14/2006	Daphnia magna Acute	SOP1032	95	65		X				
T-AZ-T-5	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-5	11/14/2006	Daphnia magna Acute	SOP1032	90	10		X				X
T-AZ-T-10	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-10	11/14/2006	Daphnia magna Acute	SOP1032	95	10		X				X
T-AZ-T-11	11/14/2006	Fathead minnow Acute	SOP1030	100	98						
T-AZ-T-11	11/14/2006	Daphnia magna Acute	SOP1032	100	45		X				
T-AZ-T-16	11/14/2006	Fathead minnow Acute	SOP1030	98	92						
T-AZ-T-16	11/14/2006	Daphnia magna Acute	SOP1032	65	0	X	X	X		X	X
T-AZ-T-17	11/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-17	11/14/2006	Daphnia magna Acute	SOP1032	35	0	X	X	X		X	X

*If marked, test response is statistically significantly less than relevant control, either control water or RO water.

[1]These samples are from untreated runoff control plots.

Table H-3. Fish and Invertebrate Test Results Summary (December '06)

SAMPLE NAME	Date of Analysis	ORGANISM	SOP #	% Survival 24 hour	% Survival 48 hour	*Significant Response in Test: 24 hour vs control	48 hour vs control	24 hour vs RO	48 hour vs RO	24 hour vs RC	48 hour vs RC
T-NV-T-4[1]	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-4[1]	12/12/2006	Daphnia magna Acute	SOP1032	100	85						
T-NV-T-6	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-6	12/12/2006	Daphnia magna Acute	SOP1032	100	90						
T-NV-T-7	12/12/2006	Fathead minnow Acute	SOP1030	100	98						
T-NV-T-7	12/12/2006	Daphnia magna Acute	SOP1032	100	85						
T-NV-T-12	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-12	12/12/2006	Daphnia magna Acute	SOP1032	100	70				X		
T-NV-T-13	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-13	12/12/2006	Daphnia magna Acute	SOP1032	100	95						
T-NV-T-18	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-18	12/12/2006	Daphnia magna Acute	SOP1032	5	0	X	X	X	X	X	X
T-NV-T-19	12/12/2006	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-19	12/12/2006	Daphnia magna Acute	SOP1032	0	0	X	X	X	X	X	X
RO-Water Blank 1	12/12/2006	Fathead minnow Acute	SOP1030	100	95			NA	NA	NA	NA
RO-Water Blank 1	12/12/2006	Daphnia magna Acute	SOP1032	100	95			NA	NA	NA	NA
Control Water	12/12/2006	Fathead minnow Acute	SOP1030	100	100	NA	NA	NA	NA	NA	NA
Control Water	12/12/2006	Daphnia magna Acute	SOP1032	100	90	NA	NA	NA	NA	NA	NA
T-AZ-T-2[1]	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-2[1]	12/14/2006	Daphnia magna Acute	SOP1032	100	80						
T-AZ-T-6	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-6	12/14/2006	Daphnia magna Acute	SOP1032	95	80						
T-AZ-T-7	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-7	12/14/2006	Daphnia magna Acute	SOP1032	100	80						
T-AZ-T-12	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-12	12/14/2006	Daphnia magna Acute	SOP1032	100	70						
T-AZ-T-13	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-13	12/14/2006	Daphnia magna Acute	SOP1032	100	70						
T-AZ-T-18	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-18	12/14/2006	Daphnia magna Acute	SOP1032	0	0	X	X	X		X	X
T-AZ-T-19	12/14/2006	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-19	12/14/2006	Daphnia magna Acute	SOP1032	15	0	X	X	X		X	X
RO-Water Blank 2	12/14/2006	Fathead minnow Acute	SOP1030	100	100			NA		NA	NA
RO-Water Blank 2	12/14/2006	Daphnia magna Acute	SOP1032	95	10		X	NA		NA	NA
Control Water	12/14/2006	Fathead minnow Acute	SOP1030	100	100	NA	NA	NA	NA	NA	NA
Control Water	12/14/2006	Daphnia magna Acute	SOP1032	80	80	NA	NA	NA	NA	NA	NA

*If marked, test response is statistically significantly less than relevant control, either control water, RO water, or untreated runoff control (RC).
Algal test comparisons are based on the 96 hour cell density readings.

[1]These samples are from untreated runoff control plots.

Table H-4. Fish and Invertebrate Test Results Summary (January '07)

Sample ID#	Date of Analysis	ORGANISM	SOP #	% Survival 24 hour	% Survival 48 hour	*Significant Response in Test 24 hour vs control	48 hour vs control	24 hour vs RO	48 hour vs RO	24 hour vs RC	48 hour vs RC
T-NV-T-3[1]	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-3[1]	1/18/2007	Daphnia magna Acute	SOP1032	80	40		X				
T-NV-T-8	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-8	1/18/2007	Daphnia magna Acute	SOP1032	95	45		X				
T-NV-T-9	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-9	1/18/2007	Daphnia magna Acute	SOP1032	90	60		X				
T-NV-T-14	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-14	1/18/2007	Daphnia magna Acute	SOP1032	90	60		X				
T-NV-T-15	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-15	1/18/2007	Daphnia magna Acute	SOP1032	100	76		X				
T-NV-T-20	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-20	1/18/2007	Daphnia magna Acute	SOP1032	73	6.7	X	X		X		X
T-NV-T-21	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-21	1/18/2007	Daphnia magna Acute	SOP1032	95	15		X				X
RO- Blank	1/18/2007	Fathead minnow Acute	SOP1030	100	100			NA	NA	NA	NA
RO-Blank	1/18/2007	Daphnia magna Acute	SOP1032	60	45	X	X	NA	NA	NA	NA
Control Water	1/18/2007	Fathead minnow Acute	SOP1030	100	100	NA	NA	NA	NA	NA	NA
Control Water	1/18/2007	Daphnia magna Acute	SOP1032	100	100	NA	NA	NA	NA	NA	NA
T-AZ-T-3[1]	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-3[1]	1/19/2007	Daphnia magna Acute	SOP1032	100	95						
T-AZ-T-8	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-8	1/19/2007	Daphnia magna Acute	SOP1032	100	95						
T-AZ-T-9	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-9	1/19/2007	Daphnia magna Acute	SOP1032	100	90						
T-AZ-T-14	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-14	1/19/2007	Daphnia magna Acute	SOP1032	100	80						
T-AZ-T-15	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-15	1/19/2007	Daphnia magna Acute	SOP1032	60	0	X	X	X	X	X	X
T-AZ-T-20	1/19/2007	Fathead minnow Acute	SOP1030	100	100						
T-AZ-T-20	1/19/2007	Daphnia magna Acute	SOP1032	60	0	X	X	X	X	X	X
T-AZ-T-21	1/19/2007	Fathead minnow Acute	SOP1030	98	98						
T-AZ-T-21	1/19/2007	Daphnia magna Acute	SOP1032	80	10	X	X				X
RO-Water Blank 2	1/19/2007	Fathead minnow Acute	SOP1030	100	100			NA	NA	NA	NA
RO-Water Blank 2	1/19/2007	Daphnia magna Acute	SOP1032	100	25		X	NA	NA	NA	NA
Control Water	1/19/2007	Fathead minnow Acute	SOP1030	100	100	NA	NA	NA	NA	NA	NA
Control Water	1/19/2007	Daphnia magna Acute	SOP1032	100	85	NA	NA	NA	NA	NA	NA

*If marked, test response is statistically significantly less than relevant control, either control water, RO water, or untreated runoff control (RC).
Algal test comparisons are based on the 96 hour cell density readings.

[1]These samples are from untreated runoff control plots.

APPENDIX I

Figures I-1 & I-2