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July 13, 2012

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Mike Monasmith
Senior Project Manager
Systems Assessment & Facility Siting Division
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, CA 95814

Subject: Supplemental Data Response, Set 5
Hidden Hills Solar Electric Generating System (11-AFC-2)

Dear Mr. Monasmith:

On behalf of Hidden Hills Solar I, LLC; and Hidden Hills Solar II, LLC, please find attached a copy of Supplemental Data Response, Set 5 which addresses some of the questions raised at the Preliminary Staff Assessment workshop held on June 27, 2012 in Bishop, California.

Please call me if you have any questions.

Sincerely,
CH2M HILL

John L. Carrier, J.D.
Program Manager

Encl.

c: POS List
Project file

Supplemental Data Response Set 5

Hidden Hills

Solar Electric Generating System

(11-AFC-2)

Application for Certification

Hidden Hills Solar I, LLC; and Hidden Hills Solar II, LLC

July 2012

With Technical Assistance from

CH2MHILL®

IS061411043744SAC

Hidden Hills Solar Electric Generating System (HHSEGS)

(11-AFC-2)

Supplemental Data Response, Set 5
(Responses to Air Quality Workshop Questions)

Submitted to the

California Energy Commission

Submitted by

Hidden Hills Solar I, LLC; and
Hidden Hills Solar II, LLC

July 13, 2012

With Assistance from

CH2MHILL
2485 Natomas Park Drive
Suite 600
Sacramento, CA 95833

Contents

Attachments

Introduction

Attached are supplemental responses (Set 5) by Hidden Hills Solar I, LLC, and Hidden Hills Solar II, LLC (collectively, "Applicant") for the Hidden Hills Solar Electric Generating System project ("HHSEGS" or "project") (11-AFC-2). These materials are in response to questions raised at the Preliminary Staff Assessment (PSA) workshop held on June 27, 2012 in Bishop, California.

The responses are grouped by individual discipline or topic area. Within each discipline area, the responses are numbered for tracking and reference convenience. New graphics or tables are numbered in reference to the Supplemental Data Request number. For example, if a table were used in response to Supplemental Data Request AQ-7, it would be numbered Table AQ7-1. An attachment used in response to Supplemental Data Request AQ-9 would be Attachment AQ9-1, and so on. The attachments are found at the end of these Supplemental Data Responses.

Air Quality (AQ-7 through AQ-11)

BACKGROUND

This document provides responses to informal questions that were raised during the PSA Workshop that was held on June 27, 2012 in Bishop, California.

DATA REQUESTS

AQ-7. How many truck deliveries will there be for materials supplying the concrete batch plant?

Response: The cement, sand, and stone will be transported to the site during Months 4 through 15 of the construction schedule shown in Attachment 5.1F-1 to Appendix 5.1-F of the AFC (Detailed Construction Emissions Calculations). Most of the deliveries will take place during Months 4 through 9. The following table shows cement, sand and stone loads, and reinforcing steel loads by month. For comparison, the table also shows total monthly deliveries (for all construction materials and equipment) for that same period upon which the AFC construction emissions calculations were based.

TABLE AQ7-1
Concrete Batch Plant Truck Deliveries

	Concrete Batch Plant Raw Material Deliveries: Truckloads per Month			Reinforcing Steel, Truckloads per Month	Subtotal, Batch Plant and Steel Truckloads per Month	Total Truck Deliveries Per Month, All Materials
Month[1]	**Cement**	**Sand**	**Stone**			
4	11	147	199	25	382	480
5	11	147	199	25	382	665
6	11	147	199	25	382	652
7	11	147	199	25	382	717
8	11	147	199	22	379	683
9	11	145	199	22	377	656
10	11	10	10	22	53	357
11	11	10	10	22	53	366
12	11	10	10	19	50	394
13	11	10	10	19	50	387
14	11	10	10	19	50	383
15	11	10	10	19	50	411
Total	**132**	**940**	**1,254**	**264**	**2,590**	**6,151**

[1] Months listed correspond to those used for the air quality analysis in AFC Attachment 5.1F-1, Detailed Construction Emissions Calculations, not those used in Socioeconomics Table 5.10-16.

AQ-8. What kinds of dust control measures will be used to prevent fugitive dust during construction?

Response: There will be a variety of dust control measures used to prevent fugitive dust during construction, including watering for dust suppression; the application of approved non-toxic soil stabilizers, soil weighting agents and/or crushed rock; and limiting vehicle speeds on unpaved roads. Wind erosion control techniques (such as windbreaks, water, chemical dust suppressants and/or vegetation) will be used on disturbed areas as well as active construction areas to control windblown dust. Measures that are implemented to minimize soil erosion will also be effective in controlling sources of fugitive dust. These measures are described in the Preliminary Draft Construction Drainage, Erosion and Sedimentation Control Plan/ Stormwater Pollution Prevention Plan (Appendix 5.15A of the AFC).[1] Erosion control, also referred to as soil stabilization, is a source control measure designed to prevent soil particles from detaching and becoming transported in stormwater runoff. Erosion control BMPs [Best Management Practices] protect the soil surface by covering or binding soil particles. The project will incorporate erosion control measures required by regulatory agency permits, contract documents, and other measures selected by the project owner or the construction contractor.

"Project activities will incorporate the following practices:

- Existing vegetation will be preserved when feasible. Vegetation will be cut to a height that will not interfere with construction and operation of the heliostat fields, instead of clearing or grading the entire field.
- Clearing and grading activities will be restricted to areas where foundations, drainage facilities, and all-weather roads must be placed.
- Temporary erosion control measures will be implemented on active and non-active disturbed areas prior to and at regular intervals throughout the defined rainy season, and year-round prior to storm events.
- Erosion in concentrated flow paths will be controlled by lining channels with a non-erodible material such as compacted riprap, geosynthetic matting, or engineered vegetation.
- Diversion berms (for example, earth dikes) or drainage swales will be used, as needed, to redirect stormwater run-on or onsite stormwater flow around critical facilities or away from disturbed soil areas and stockpiles.
- Non-active areas will be stabilized with effective soil cover (such as aggregate, paving, or vegetation) as soon as feasible after construction or disturbance is complete and no later than 14 days after construction or disturbance in that portion of the site has temporarily or permanently ceased.
- The use of plastic materials will be limited when more sustainable, environmentally friendly alternatives exist. Where plastic materials are deemed necessary, the plastic materials will be resistant to solar degradation.

[1] Available at http://www.energy.ca.gov/sitingcases/hiddenhills/documents/applicant/afc/Volume-2-Appendixes/HHSEGS_Appendix_5-15A_Prelim_Construction_SWPPP-DESCP.pdf

- Areas compacted during construction activities will be restored, as appropriate, to approximate preconstruction compaction levels to minimize the opportunity for any increase in surface runoff.
- Implementation and maintenance of BMPs will be according to measures outlined in the applicable CASQA *2009 Construction Handbook* BMP fact sheets.
- A combination from the following list of erosion control measures will be implemented during project construction:

EC-1	Scheduling
EC-2	Preservation of Existing Vegetation
EC-3	Hydraulic Mulch
EC-5	Soil Binders
EC-6	Straw Mulch
EC-7	Geotextiles and Mats
EC-9	Earth Dikes and Drainage Swales
EC-10	Velocity Dissipation Devices
EC-11	Slope Drains
EC-12	Streambank Stabilization
EC-14	Compost Blankets
EC-15	Soil Preparation/Roughening
EC-16	Non-vegetative Stabilization”

Construction activity-related dust will be monitored by the onsite Air Quality Control Mitigation Manager (AQCMM) or AQCMM Delegate. Observations of visible dust plumes that have the potential to be transported off the project site may indicate that existing mitigation measures are not resulting in effective mitigation, and that additional steps must be taken. If adequate dust control cannot be achieved, then construction may be halted by the AQCMM.

AQ-9. If dust control plans for HHSEGS are not available, please provide available plans that have been prepared for the Ivanpah SEGS.

Response: A copy of the Air Quality Construction Mitigation Plan for Ivanpah SEGS, which has been approved by both the CEC Compliance Project Manager (CPM) and the Bureau of Land Management, is being provided as Attachment AQ9-1. A similar dust control plan will be prepared for HHSEGS.

AQ-10 Will there be anything besides water used for mirror washing? How many mirror washing machines will there be, and how many miles per day will they travel?

Response: The mirrors will be cleaned using a combination of water, air, and brushing. No chemical additives, such as ammonia, will be used in the water.

There will be one small mirror washing machine (MWM) and 7 large MWMs per solar field, for a total of 16 MWMs at the facility. Each large MWM is expected to travel about 7.4 miles per day, while each small MWM is expected to travel about 11 miles per day.

AQ-11 What kinds of soil stabilizing materials will be used onsite? Will the soil stabilizers be safe for people and wildlife?

Response: Soil stabilizing materials used onsite must be non-toxic and must be approved by CPM prior to application. Dust control efficiency will be required to equal or exceed the efficiency of ARB-approved soil stabilizers. As an example, a brochure for Soil-Sement, a polymer emulsion-type soil stabilization product evaluated and approved by ARB, EPA and others, is being provided as Attachment AQ11-1. A copy of an EPA evaluation of dust suppressants addressing toxicity is also provided as Attachment AQ11-2.

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Attachment AQ9-1
Air Quality Construction Mitigation Plan for Ivanpah SEGS

		Document No. 25542-000-4CP-T07G-00005

Air Quality Construction Mitigation Plan (AQCMP)

for

Ivanpah Solar Electric Generating Facility (ISEGF)

Rev.	Date	Reason for Revision	By	Checked	Approvals		
					PM	SM	ES MGR
000	7/14/10	Issued for Construction	PCC	TEC	PDS	TEC	PCC
001	~~1/27/10~~ 1/27/11	Revised per CPM Comments	PCC	TEC TEC	MB for PDS	TEC TEC	

Confidential

TABLE OF CONTENTS

1.0 PURPOSE

To minimize and control the dust generated on site due to construction activities to prevent all fugitive dust plumes from leaving the project and minimize diesel engine emissions from construction related equipment.

2.0 SCOPE

The following sections describe typical dust emission sources (including diesel engines), identify the selected best available control measures to be utilized to minimize onsite and offsite impacts, and summarize the documentation of fugitive dust measures employed onsite.

3.0 REFERENCES

The California Energy Commission (CEC) Final Decision No. CEC-800-2010-004 CMF (September 2010), Conditions of Certification, AQ-SC2 through AQ-SC5.

AQ-SC6 is an operational constraint related to mirror washing and will not be addressed herein.

4.0 DEFINITIONS

The following definitions are consistent with descriptions used in the CEC's Final Decision (September 2010).

Disturbed Surface Area: a portion of the earth's surface which has been physically moved, uncovered, destabilized, or modified from its undisturbed natural soil condition.

Dust Suppressant: water, hygroscopic materials, or non-toxic chemical stabilizers used as a treatment material to reduce fugitive dust emissions.

Inactive Disturbed Surface Area: any disturbed surface area where activities have not or will not occur for 10 days.

5.0 RESPONSIBILITIES

Bechtel's Site Manager, with the assistance of the Construction Environmental Coordinator, will be responsible for ensuring that all requirements of this plan are fully implemented in cooperation with Owner's independent Air Quality Construction Mitigation Manager (AQCMM).

The AQCMM will have overall responsibility for directing and documenting Bechtel's compliance with AQ-SC3 through AQ-SC5. Specifically this will include:

- Monitoring construction activities for visible dust plumes that have the potential to be transported offsite and within 400 feet of offsite structures not owned by the Owner or 200 feet from centerline of a linear facility (e.g., pipeline).

- Within 15 minutes of determination of non-compliant dust conditions (associated with construction activity), direct the more intensive application of existing mitigation measures.

- Within 30 minutes of determination of continuing non-compliant dust conditions (associated with construction activity), direct the more intensive application of additional mitigation measures.

- Within 60 minutes of determination of continuing non-compliant dust conditions (associated with construction activities), direct a temporary shutdown of the activity causing the emissions. Activity will not resume until effective mitigation has been implemented or site conditions have changed, such that non-compliant dust conditions will not resume upon restart of the activity.

- Respond to direction from the CPM or BLM Authorized Officer regarding Owner appeals to AQCMM directives.

- Submit related compliance and mitigation measures to the CPM via the Monthly Compliance Report.

6.0 REQUIREMENTS

6.1 Background

Construction activities have the potential to generate significant quantities of fugitive dust emissions, if not adequately controlled. Fugitive dust is generally defined as natural and/or man-associated dusts that become airborne due to the forces of wind or human activity. Construction-related fugitive dust emissions are generally in the coarse particle size range (significant fall velocity) and are emitted from near ground level sources. Thus, these particulate emissions are likely to redeposit on the site.

Diesel engine emissions generate finer particulate matter (soot), SO_2, NOx, VOC, and CO emissions.

6.2 Sources

Construction-phase fugitive dust emissions are generated during site clearing, grubbing and grading, excavation, transport/loading of bulk materials, and general construction operations. In addition, construction material storage piles may result in fugitive dust through wind erosion. The summary below lists the specific active operations that have the potential to generate fugitive dust during the course of construction:

- Clearing and grubbing of site access routes and areas.
- Performance of earthwork, such as removal of topsoil as necessary for constructing foundations for plant facilities; constructing access roadways; grading to subgrades; excavating for placement of footings, foundations, piping and conduit; and backfilling around these below-grade facilities.
- Construction of temporary (construction phase) storm water runoff storage basin(s) and drainage ditches.
- Development of the operational site drainage system (inclusive of drainage swales, new and relocated ditches, and discharge structures).
- Installation of temporary (construction) and permanent underground electrical and utility piping systems.
- Construction of temporary laydown and construction parking areas.
- Transportation, loading, and uncovered storage of bulk material.
- Vehicular traffic on unpaved onsite roads and on nearby public roads containing tracked-out material.
- Construction diesel engine emissions.

6.3 Dust Control Measures

In accordance with the Conditions of Certification AQ-SC2 through AQ-SC4 a number of fugitive dust control measures will be employed to minimize dust generation and avoid off-site impacts. A number of diesel engine related operating mitigation measures will be used in response to Condition of Certification AQ-SC5.

The table below summarizes the potential sources of fugitive dust and the accompanying mitigation measures required.

SOURCE OF DUST	MITIGATION MEASURES
Unpaved roads	The main access roads through the facility to the power block areas will either be paved or stabilized using soil binders (and crushed rock top layer) or equivalent methods. However, prior to initiating construction in the main power block area roads will be initially watered and stabilized to allow traffic flow as final surfacing of the access road continues. Delivery areas for operations materials (chemicals, replacement parts, etc.) will be paved prior to taking initial deliveries. All unpaved construction roads and unpaved operational site roads, as they are being constructed, shall be stabilized with a non-toxic soil stabilizer or soil weighting agent that can be determined to be both, as efficient, or more efficient for fugitive dust control as ARB approved soil stabilizers, and shall not increase any other environmental impacts including loss of vegetation. All other disturbed areas in the project and linear construction sites shall be watered as frequently as necessary during grading and stabilized (after active construction activities) with a non-toxic soil stabilizer or soil weighting agent (or approved alternative stabilizing method) to comply with the dust mitigation objectives of Condition of Certification AQ-SC4. The frequency of watering can be reduced or eliminated during periods of precipitation. -OR- All unpaved roads and disturbed areas in the project and linear construction sites shall be watered as frequently as necessary to comply with the dust mitigation objectives of Condition of Certification AQ-SC4. The frequency of watering can be reduced or eliminated during periods of precipitation.
Unpaved roads and disturbed areas	With the exception of stabilized roads (paved, compacted rock or rock milling with addition of wetting agent per AQ-SC3, i.e., water or wetting agent compound) most of the onsite areas will follow a 10 miles per hour (mph) speed limit. Visible speed limit signs shall be posted along Colosseum Road, at the construction site entrances, and in onsite areas as necessary
Site Access Points	All construction equipment vehicle tires shall be inspected and washed as necessary to be cleaned free of dirt prior to entering paved roadways.
	Gravel ramps of at least 20 feet in length must be provided at the tire washing-cleaning station.
	All unpaved exits from the construction site shall be graveled or treated to prevent track-out to public roadways.
	All construction vehicles shall enter the main construction site through the treated entrance roadways, unless an alternative route has been submitted to and approved by the CPM and BLM Authorized Officer.

SOURCE OF DUST	MITIGATION MEASURES
	At least the first 500 feet of any paved public roadway exiting the construction site or exiting other unpaved roads en route from the construction site or construction staging areas shall be swept as needed on days when construction activity occurs or on any other day when dirt or runoff resulting from the construction site activities is visible on the public paved roadways.
Storm Water Control	Construction areas adjacent to any paved roadway (below the grade of the surrounding construction area or otherwise directly impacted by sediment from site drainage) shall be provided with sandbags or other measures as specified in the Storm Water Pollution Prevention Plan (SWPPP) to prevent run-off to roadways.
Paved Roads	All paved roads within the construction site shall be swept at least daily, or as needed (or less during periods of precipitation) on days when construction activity occurs, to prevent the accumulation of dirt and debris.
Storage Piles	All soil storage piles and disturbed areas that remain inactive for longer than 10 days shall be covered, or shall be treated with appropriate dust suppressant compounds.
Large Haul Trucks	All vehicles that are used to transport solid bulk material on public roadways and that have potential to cause visible emissions shall be provided with a cover, or the materials shall be sufficiently wetted and loaded onto the trucks in a manner to provide at least one foot of freeboard.
Wind Erosion	Wind erosion control techniques (such as windbreaks, water, chemical dust suppressants, and/or vegetation) shall be used on all construction areas that may be disturbed. Any windbreaks installed to comply with this condition shall remain in place until the soil is stabilized or permanently covered with vegetation.

The construction activity related dust plumes will be monitored on an ongoing basis by the AQCMM or an AQCMM Delegate. Observations of visible dust plumes that have the potential to be transported:

- Off the project site, or
- Within 400 feet of any regularly occupied structure not owned by the Owner, or
- 200 feet beyond the centerline of the construction of linear facilities (including site perimeter fence construction) indicate that existing mitigation measures are not resulting in effective mitigation.

will be considered a clear indication that existing mitigation measures are not resulting in effective mitigation. If visible plumes meeting any of the criteria above or if the AQCMM or Delegate so advises the following escalating steps will be undertaken to mitigate plume visibility.

1. A more intensive application of the appropriate mitigation methods within 15 minutes of identification of visible plume meeting criteria above.

2. Application of additional methods of dust suppression if Step 1, specified above, fails to result in adequate mitigation within 30 minutes of the original determination.

3. Temporary shutdown of the activity causing the emissions if Step 2, specified above, fails to result in effective mitigation within 60 minutes of the original determination.

The associated activity will not restart until the AQCMM or Delegate is satisfied that appropriate additional mitigation or other site conditions have changed so that visual dust plumes will not result.

The owner/operator may appeal to the CPM or BLM Authorized Officer any directive from the AQCMM or Delegate to shut down an activity, if the shutdown shall go into effect within one hour of the original determination, unless overruled by the District before that time.

6.4 Diesel Engine Mitigation Measures

The table below summarizes the potential sources of diesel related engine air emissions and the accompanying mitigation measures required.

DIESEL ENGINE MITIGATION MEASURES
All diesel-fueled engines used in the construction of the facility shall have clearly visible tags issued by the on-site AQCMM showing that the engine meets the conditions set forth herein.
All construction diesel engines with a rating of 50 hp or higher shall meet, at a minimum, the Tier 3 California Emission Standards for Off-Road Compression-Ignition Engines, as specified in CCR Title 13, section 2423(b)(1), unless a good faith effort (i.e., contacting two different suppliers and providing letters of documentation from those suppliers confirming that they do not have any Tier III engine power versions of the specified equipment available) that is certified by the on-site AQCMM demonstrates that such engine is not available for a particular item of equipment.

DIESEL ENGINE MITIGATION MEASURES
In the event that a Tier 3 engine is not available for any off-road equipment larger than 100 hp, that equipment shall be equipped with a Tier 2 engine, or an engine that is equipped with retrofit controls to reduce exhaust emissions of nitrogen oxides (NOx) and diesel particulate matter (DPM) to no more than Tier 2 levels unless certified by engine manufacturers or the on-site AQCMM that the use of such devices is not practical for specific engine types. For purposes of this condition, the use of such devices is “not practical” for the following, as well as other, reasons. • There is no available retrofit control device that has been verified by either the CARB or USEPA control the engine in question to Tier 2 equivalent emission levels and the highest level of available control using retrofit or Tier 1 engines is being used for the engine in question; or • The construction equipment is intended to be on site for 5 days or less. • The CPM may grant relief from this requirement if the AQCMM can demonstrate a good faith effort to comply with this requirement and that compliance is not practical.
The use of a retrofit control device may be terminated immediately, provided that the CPM is informed within 10 working days of the termination and that a replacement for the equipment item in question meeting the controls required occurs within 10 days of termination of the use, if the equipment would be needed to continue working at this site for more than 15 days after the use of the retrofit control device is terminated, if one of the following conditions exists : • The use of the retrofit control device is excessively reducing the normal availability of the construction equipment due to increased down time for maintenance, and/or reduced power output due to an excessive increase in back pressure. • The retrofit control device is causing or is reasonably expected to cause engine damage. • The retrofit control device is causing or is reasonably expected to cause a substantial risk to workers or the public. • Any other seriously detrimental cause which has the approval of the CPM prior to implementation of the termination.
All heavy earth-moving equipment and heavy duty construction-related trucks with engines meeting the requirements of (b) above shall be properly maintained and the engines tuned to the engine manufacturer’s specifications.
All diesel heavy construction equipment shall not idle for more than five minutes. Vehicles that need to idle as part of their normal operation (such as concrete trucks) are exempted from this requirement.
Construction equipment will employ electric motors when feasible

6.5 Documentation

Consistent with Commission Final Decision Conditions of Certification AQ-SC2 through AQ-SC5,

- A summary of all actions taken to maintain compliance with this dust and diesel engine related constraints (date/time of inspection and date/time of control measure implemented).
- Copies of any dust related complaints filed with the District in relation to project construction; and

- A list of all heavy equipment used on site during that month, including the owner of that equipment and a letter from each owner indicating that equipment has been properly maintained; and
- Documentation for each non-Tier 3 engine demonstrating that the good faith efforts to obtain Tier 3 engines have been met (see Attachment B).
- Any other documentation deemed necessary by the CPM and AQCMM to verify compliance with dust related constraints.

Attachment A Fugitive Dust Log

Month:			Year:		Material Stock Pile Treatments		Roadways – Water Wagon/ Street Sweeper in use			
Date	Time	Daily Low Ambient Temp. °F	24 hr rainfall (inches)	Max 1 hr Wind Speed (mph)	Water Treatments Active Storage (Y/N)	Water Treatments Inactive Storage (Y/N)	Paved Roads (WW/SS)[1]	Unpaved Roads (WW/SS)[1]	Observer	Comments,
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										

Attachment A Fugitive Dust Log

Month:			Year:		Material Stock Pile Treatments		Roadways – Water Wagon/ Street Sweeper in use			
Date	Time	Daily Low Ambient Temp. °F	24 hr rainfall (inches)	Max 1 hr Wind Speed (mph)	Water Treatments Active Storage (Y/N)	Water Treatments Inactive Storage (Y/N)	Paved Roads (WW/SS)[1]	Unpaved Roads (WW/SS)[1]	Observer	Comments,
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										

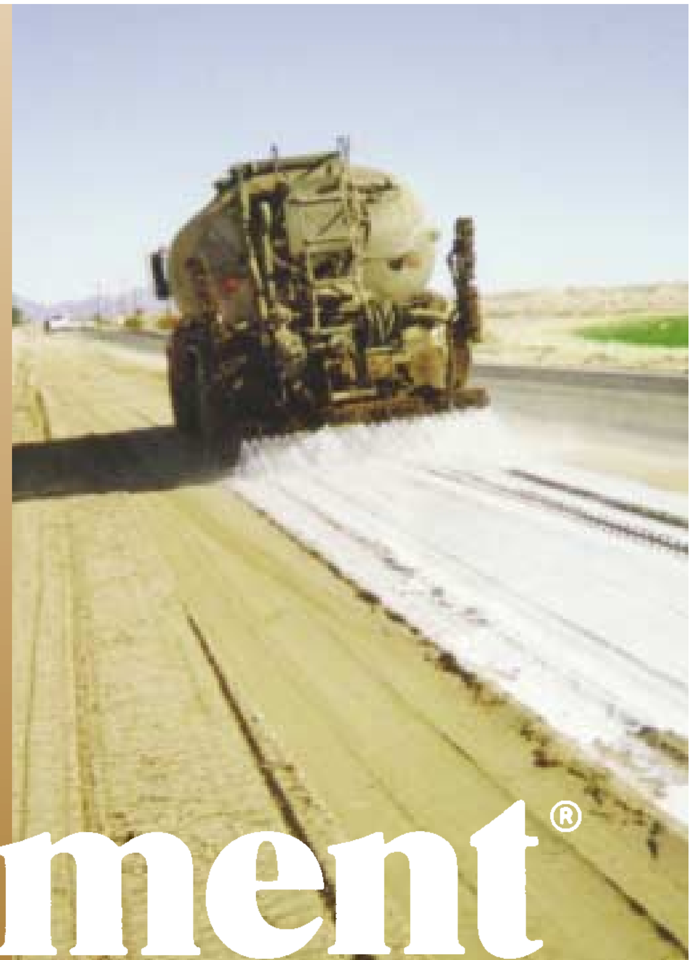
1. WW = water wagon, SS = street sweeper

SOURCE OF WEATHER DATA: RAIN ________________ WIND ___________________ TEMPERATURE _______________ SUPERVISOR REVIEW _
____________ Return Completed Sheet to CEL

Attachment B Heavy Equipment Log

No.	Heavy Equipment (bhp) (only applicable to diesel engines ≥ 50 bhp)	Contractor	Capacity (bhp)	Emission Tier (II, III, retrofit)	Rationale for Greater Than Tier III Emissions	Rationale for Inability to Retrofit Control Device	Removed from Site

Attachment AQ11-1
Soil~Sement Brochure



Soil~Sement®

DUST CONTROL, EROSION CONTROL, STABILIZATION

MIDWEST INDUSTRIAL SUPPLY, INC.

Industry Leadership Since 1975

Since 1975, Midwest Industrial Supply, Inc. has built a reputation of leadership through products and services that continually redefine dust, erosion control and stabilization technology.

Our customers expect products that deliver real benefits, with performance far superior to other types of products being used today.

Our advantages include a full on-site laboratory with the latest state-of-the-art equipment. We also have a group of dedicated, experienced professionals who are always ready to assist you with all of your dust, erosion control and stabilization needs.

MIDWEST INDUSTRIAL SUPPLY, INC.

What is Soil-Sement®

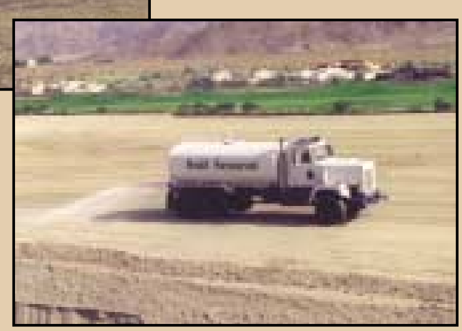
Dust and Erosion Control Agent

Soil-Sement® is an environmentally safe, powerful polymer emulsion that produces highly effective dust control, erosion control and soil stabilization. Soil-Sement® provides excellent bonding, cohesion, versatility, cost-effectiveness, environmental compliance and superior overall performance.

Soil-Sement®'s effectiveness results from the length and strength of its unique polymer molecule formulation and those polymer molecule's ability to bond with the surface materials. Its' chemical structure is made of molecules attached in relatively straight linked chains and then cross-linked between other chains or grids that may be 1,000,000 molecules long. It is a true giant compared to the much smaller molecular structure of oil, calcium, petroleum resin and asphalt emulsion products, which range from 100 to 10,000 molecules. As a result, Soil-Sement® can be as strong as steel or as resilient as rubber.

Soil-Sement® is the cumulation of 24 years of focused research and development, and unparalleled concentration on PM10, PM2.5, erosion control and stabilization solutions. It yields proprietary one-of-a-kind polymer chemistry manufactured to rigid quality standards utilized in combination with field experience in all industrial, commercial and municipal environments. The result is a performance and value combination that is unequaled by other chemical and polymer products. As a result Soil-Sement® has been the standard of comparison for all chemical types, including polymer products, since it's introduction in 1978. Especially today Soil-Sement® exemplifies the fact that **all polymers are not made equal**.

A Soil-Sement® treated surface will provide you with optimum performance 365 days a year!



Independent Tests & Certifications Confirm Soil-Sement®'s Superior Performance & Reliability!

Pre-certified by the California Air Resources Board

California Environmental Technology Certification

Canada Verified Vérifié

ERDC Engineer Research and Development Center

CalCert Innovation Assured

Arizona Department of Emergency & Military Affairs (ADEMA)

desert research institute

MRI Midwest Research Institute

SDSU San Diego State University

The world's leading advocates of new environmental technologies, and internationally recognized scientific and engineering evaluators of environmental performance have certified that Soil-Sement® is effective for controlling dust and the damaging effects of erosion and sediment pollution, while protecting the environmental ecosystem.

"Soil-Sement® is used as a dust suppressant, as a soil-stabilization agent, and to control erosion and silt runoff. It is applied to unpaved roads, building pads, parking lots, parks, fields, off-highway motor vehicle parks, and other similar high dust areas. Soil-Sement® has a wide variety of applications other than road surfaces. It has been used to stabilize asbestos-containing soils and can also be used on slopes as a tackifier in hydroseeding applications. Soil-Sement® can be used to reduce windblown dust from ore and coal storage piles, stockpiles, mine tailing sites, power plant ash ponds, construction sites, military applications (vehicle staging areas, helicopter landing zones, trails for rubber tire and tracked vehicles, rapid deployment runways) and to control dust mites in orchards and vineyards." ***(The California Air Resource Board Evaluation of the Air Quality Performance Claims for Soil-Sement®, Dust Suppression - April 2002)***

Soil-Sement® Dust and Erosion Control Agent

CalCert and California Air Resources Board Certification

CALCERT
INNOVATION ASSURED

The California Environmental Technology Certification Program (CalCert), an internationally recognized independent, scientific and engineering evaluator of environmental performance, and the California Air Resource Board (CARB), one of the world's leading advocates of new environmental technologies, have certified Soil-Sement® performance. These certifications offer users and clients performance assurances when dependability is important and the cost of failure unacceptable.

Pre-certified by the California Air Resources Board

"When topically applied as a dust suppressant in accordance with manufacturer's instructions, including a total target concentration of 0.28 gallons of concentrate per square yard of treated surface applied in multiple passes in a single day, Soil-Sement® reduced PM_{10} emissions by approximately 84 percent after 339 days and 6,780 vehicles (predominantly light-duty) passes on an unpaved roadway consisting of a silty, sandy loam.

Soil-Sement® does not contain detectable levels of polynuclear organic matter which includes polynuclear aromatic hydrocarbons as defined by the Federal Clean Act section 112 (b); nor does Soil-Sement® contain detectable levels of fluorinated or brominated compounds that could be expected to contribute to ozone depletion or global warming."


California Environmental Technology Certification

Midwest Industrial Supply, Inc.'s
Soil-Sement®

CERTIFIED TECHNOLOGY

"Evaluation of the Air Quality Performance Claims for the Midwest Industrial Supply, Inc. Soil-Sement Dust Suppressant," California Air Resources Board, Executive Order G-096-029-035, April 2002.

For complete Soil-Sement® certification information from CalCert, visit calepa.ca.gov/CalCert/CertifiedTech/Midwest.htm, or from the California ARB, visit www.arb.ca.gov/eqpr/mainlist.htm, or www.soilsement.com.

Midwest Industrial Supply, Inc. Receives Canadian Verification Certificate.

The Honorable Christine S. Stewart, Canadian Minister of the Environment, awarded a verification certificate to Midwest Industrial Supply, Inc. under the Environmental Technology Verification (ETV) Program.

The ETV Program promotes the marketability of companies engaged in the environmental industry by providing assessment and validation of suppliers' technology performance. At the same time, it provides buyers with the assurance that the technology in question does indeed perform as claimed.

Environmental Technology Verification Program

.... enhancing the credibility of environmental technologies

CANADA VERIFIED VÉRIFIÉ

Soil-Sement®

Midwest Industrial Supply Inc.'s Soil-Sement®, when applied in accordance with the manufacturer's instructions, will:

1. on unpaved roadways in California's San Joaquin Valley
   a. achieve at least 95% suppressant efficiency on fugitive dust (PM_{10}) for three months after application and at least 80% after 11 months, and
   b. increase the R-value in the range of 30-40% when measured by ASTM Test Protocols D1883 and D2844, and calculated in accordance with the AASHTO Guide for Design of Pavement Structures, 1986; and
2. in acute toxicity tests, yield LC_{50}'s for rainbow trout (96-hr) and Daphnia magna (48-hr) of at least 7,000 ppm and 21,000ppm, respectively.

License Number: ETV 99005
Issued to: Midwest Industrial Supply Inc.

Verified* Performance March 25, 1999

John McMullen
President & CEO

Canada

* Refer to Technology Fact Sheet for additional information on the verification of this performance claim.

The Honorable Christine S. Stewart, Canadian Minister of the Environment presenting Canada Environmental Technology Verification certificate to Robert Vitale, President of Midwest Industrial Supply, Inc.

"Canada Environmental Technology Verification,"
March 25, 1999.

Stabilization with Soil-Sement®

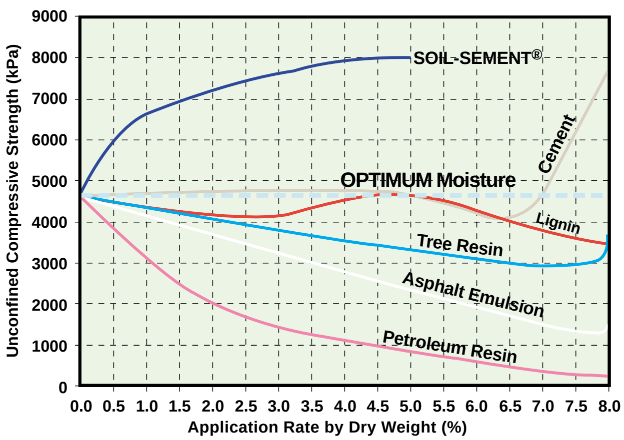
US ARMY ENGINEER RESEARCH AND DEVELOPMENT CENTER

Determines Potential Engineering Benefits of Soil-Sement®

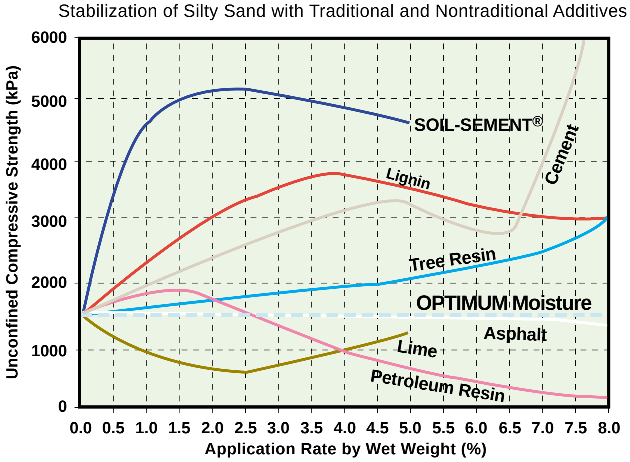
In a comprehensive study just released by the U.S. Army Research and Development Center of 12 non-traditional stabilizers and three traditional types, **SOIL-SEMENT®** (one of the non-traditional types) showed its potential to increase the UC strength of silty sand (SM) material under both “wet” **and** dry conditions.

The results verified that **SOIL-SEMENT®** polymer emulsion SIGNIFICANTLY improved the UC strength of the SM material **(58 percent in dry test conditions and 208 percent in wet conditions)**. Except for cement and polymers, other traditional and non-traditional stabilizers provided no significant potential.

DRY
UNCONFINED COMPRESSIVE STRENGTH TEST DATA
U.S. Army Corps of Engineers, CEERD-GM-A
Stabilization of Silty Sand with Traditional and Nontraditional Additives



WET
UNCONFINED COMPRESSIVE STRENGTH TEST DATA
U.S. Army Corps of Engineers, CEERD-GM-A
Stabilization of Silty Sand with Traditional and Nontraditional Additives



SOIL-SEMENT® SIGNIFICANTLY improved the UC strength of the SM material...

58%

in dry test conditions, and

208%

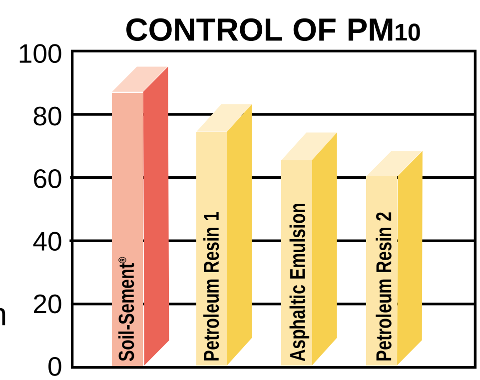
in wet conditions!

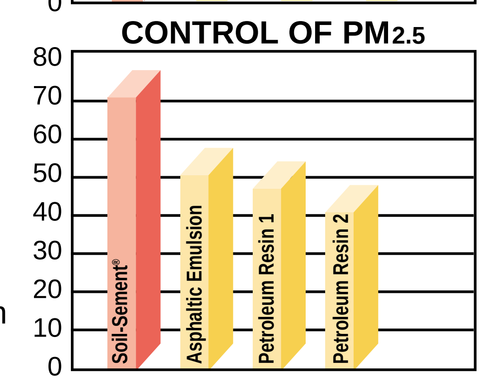
Graphs by Midwest Industrial Supply, Inc. using data from the U.S. Army Engineer Research and Development Center’s study of Nontraditional Stabilization of Silty-Sand.

“Nontraditional Stabilization of Silty-Sand,” Engineering Research and Development Center, August 1, 2001.

US EPA PM_{10} and $PM_{2.5}$ Control Efficiency Testing

In the most comprehensive study in the iron and steel industry performed for the United States Environmental Protection Agency, Soil-Sement® was compared to petroleum resins and asphaltic emulsions in controlled PM_{10} and $PM_{2.5}$ testing involving unpaved roadways in the iron and steel industry. While all of the products performed at a high level of effectiveness immediately following each application, the true test came when the results were once again compared 30 days later. Soil-Sement® maintained an effectiveness rating within 10% of the initial application, while the effectiveness of asphaltic emulsions and petroleum resins dropped significantly.

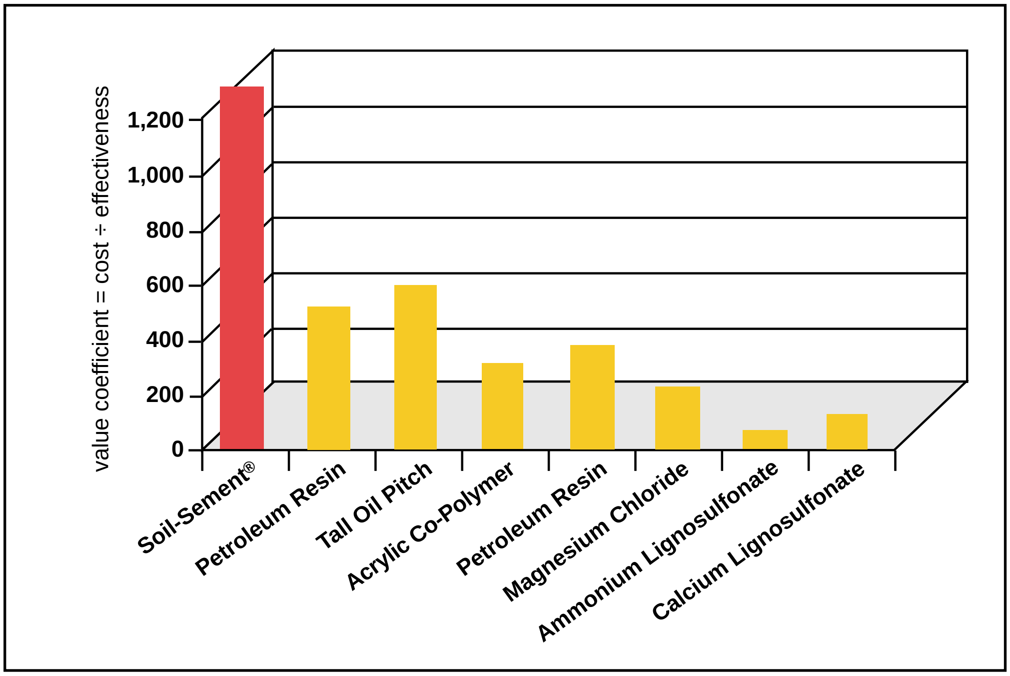




"Evaluation of the Effectiveness of Chemical Dust Suppressants on Unpaved Roads," Midwest Research Institute, MRI Document No: PB88-139936, November 1987.

SOIL-SEMENT® VALUE COMPARISON

vs. other suppressant types based on performance

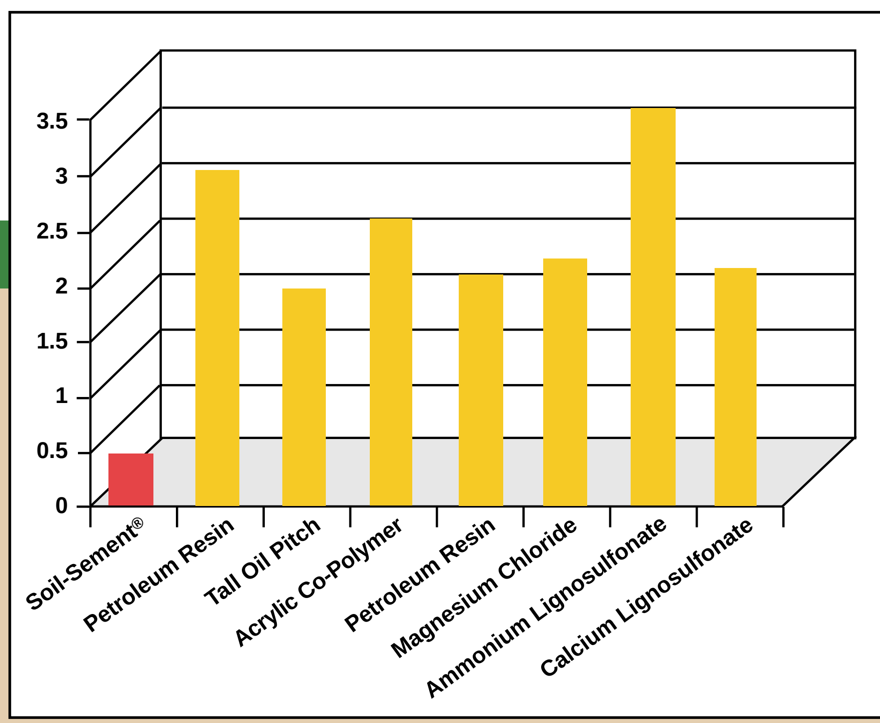


VALUE:

Value coefficient arrived at by dividing weight of dust collected into product cost.

(This value representation works especially well given the wide range of product costs typically available to a client because the value number is a true numeric expression determined by dividing effectiveness into cost.)

= GREATEST VALUE



PRODUCT PERFORMANCE:

Weight of the dust collected at the site over a 27-week period

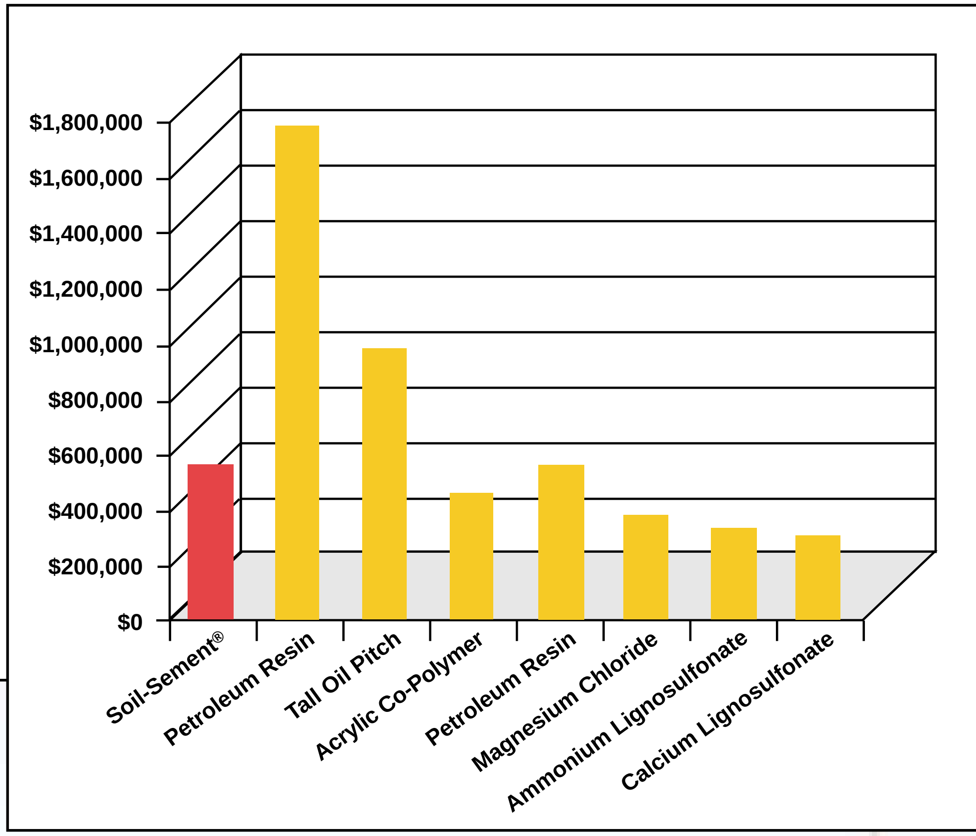
= LEAST DUST

SOIL-SEMENT® VALUE COMPARISON

vs. other suppressant types based on performance

PROJECTED ANNUAL PRODUCT COST:

Based on Manufacturers Recommendation



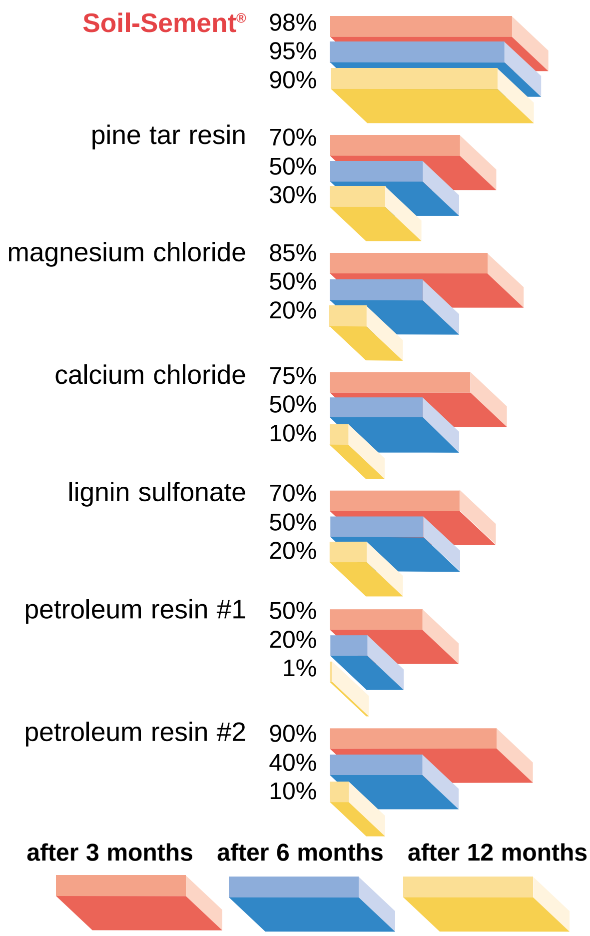
Whether four times more expensive or one-fourth less expensive, no other chemical dust suppressant in this test was close to the product performance of Soil-Sement®...

...and Soil-Sement® provided from

200% to 1,200%

greater value than other products in the test!

A county located in the high Mojave Desert region in California initiated a PM10 Dust Control Project to evaluate the effectiveness of various dust suppressants for unpaved roadways. The evaluation was conducted under the direction of the County Air Quality Management District's Board and coordinated through the County Waste Management Engineering Department. The products tested included a pine tar resin, magnesium chloride, calcium chloride, lignin sulfonate, petroleum resins and Soil-Sement®. Test sites were examined at 3 months, 6 months, and 12 months following application. The study found Soil-Sement® to be the product which best endured the test periods, and in fact continued to perform at a high level of effectiveness as both a dust and erosion control agent.



- Of the products tested, **only Soil-Sement®** was successful in preventing roadbed deterioration (potholes, washboarding, rutting, and areas breaking up).
- Of the products tested, **only the road segment using Soil-Sement®** did not require regrading after 6 months and prior to the maintenance application.
- **Only Soil-Sement®** prevented washing and excessive deterioration of the road surface following bad weather.
- **Only Soil-Sement** retained any practical ability for controlling dust after the 12-month period.

Soil-Sement®
Dust and Erosion Control Agent

efficiency exceeds 80% over one year!

Experiments conducted by the
Desert Research Institute —
July 1995 to August of 1996
determining the efficiencies of dust suppressant materials on unpaved public roads and unpaved shoulders along paved roads.

"PROJECT DUST (Dusty Unpaved Surfaces Treatment)," Kern County Air Pollution Control District, October 13, 1994.

Experiments were conducted from July 1995 to August 1996 in order to determine the efficiencies of different dust suppressant materials on unpaved public roads and unpaved shoulders along paved roads.

In an initial survey, more than 60 specific suppressant products were identified. These fell into categories of:

1) salts
2) asphalt or petroleum emulsions
3) emulsions of other materials
4) polymers
5) surfactants
6) bitumens
7) adhesives
8) solid materials, fibers and mulches
9) hydroseed vegetation
10) miscellaneous products

Conclusions were drawn with respect to:

1) efficiency and durability of each suppressant
2) fugitive dust emission rates
3) zones of influence of fugitive dust emissions

For the unpaved roads, PM10 was measured upwind and downwind of each test section. For the unpaved shoulder study, in addition to upwind and downwind measurements, fast-response observations from light scattering and turbulence sensors were used. The efficiencies of Soil-Sement® **exceeded 80%** on average, during the final measurement period, 12 months after application. Of all the other commercial products tested, the maximum efficiencies after a 12-month period amounted to no more than 49%.

"Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads," Desert Research Institute, DRI Document No.: 685-5200.1F1, December 31, 1996.

PM_{10} Suppression Efficiencies for each Test During Three Intensive Monitoring Periods

DATE	VEHICLE SPEED (km/hr)	SUPPRESSION EFFICIENCY (%) BS[a]	PEP[b]	Soil-Sement®	NHCO[c]
7-22-95	40	56	100	100	N/A
7-24-95	40	20	100	83	
7-26-95	40	37	99	93	
(Average)		38	100	92	
(Std. Dev.)		18	1	8	
7-23-95	55	50	100	94	
7-25-95	55	47	99	100	
7-27-95[d]	55	-13	94	97	
(Average)		28	98	97	
(Std. Dev.)		36	3	3	
10-17-95	40	3	73	97	N/A
10-20-95	40	-8	67	91	
10-22-95	40	-46	61	94	
(Average)		-17	67	94	
(Std. Dev.)		26	6	3	
10-18-95	55	-10	73	100	
10-21-95	55	37	84	100	
(Average)		13	79	100	
(Std. Dev.)		34	8	0	
6-13-96	40	18	65	90	83
6-14-96	40	-32	55	87	98
6-15-96	40	-20	42	86	89
(Average)		-11	54	88	90
(Std. Dev.)		26	11	2	7
6-19-96	55	-81	43	89	91
6-17-96	55	-75	37	77	97
6-18-96	55	-35	51	84	96
(Average)		-64	44	83	95
(Std. Dev.)		25	7	6	3

[a]Biocatalyst stabilizer (EMC^2, Soil Stabilization Products).
[b]Petroleum emulsion with polymer (CoherexPM, WITCO).
[c]Non-hazardous crude oil mixture (WSPA).
[d]Negative values denote emissions greater than the untreated section.

Dust Control Measures Project

By URS Corporation (formerly Dames & Moore)
for the
Arizona Department of Emergency & Military Affairs (ADEMA),
Arizona Army National Guard, Florence Military Reservation

• 6 Month • 12 Month • Post Implementation

6 MONTH CONCLUSIONS

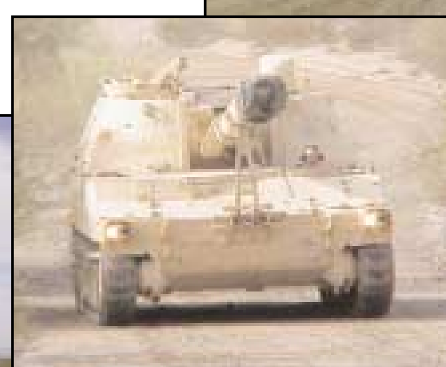
- The opacity of the dust plumes generated by the convoys on the Soil-Sement® treated areas were lower than 20% as required at the property line.

12 MONTH CONCLUSIONS

- The opacity of the dust plumes generated by the convoys on the Soil-Sement® treated areas were lower than 20% as required at the property line.

POST-IMPLEMENTATION EVALUATION

- The opacity of the dust plumes generated by the convoys on the Soil-Sement® treated areas were lower than 20% as required at the property line.
- The Soil-Sement® palliative appeared to exhibit a tolerance to the type of vehicular traffic of the MSR (Main Supply Route) (generally heavy vehicles with both rubber tires and tracks). At the time of the evaluation (after 1 year), the Soil-Sement® appeared to show some signs of wear but maintained its general integrity at the surface after receiving some heavy, abrasive traffic, particularly from tracked vehicles. The spalling observed appears to be predominantly from the aggregate being crushed or "popped" out of the surface, with only minor flaking of the Soil-Sement®-treated crossing.



"Implement Fugitive Dust Control Measures," URS (formerly Dames and Moore), URS Job No.: 29679006, May 16, 2001.

Soil-Sement® and NPDES monitoring.

Beginning in 1975, Midwest Industrial Supply, Inc. has been solving environmental problems, not creating them. When used per the manufacturer's guidelines, Soil-Sement® will help you to meet your NPDES permitting requirements.

CONTRIBUTIONS TO PHASE I COMPLIANCE BY SOIL-SEMENT®:

- Soil-Sement® will not affect pH levels. As applied, Soil-Sement® is neutral pH.
- Soil-Sement® does not contain oil or grease.
- Soil-Sement® does not contain volatile organic compounds or semi-volatile organic compounds above the regulatory levels.
- Soil-Sement®, when applied correctly and cured, will not increase BOD or COD.
- Soil-Sement® will not increase TSS (Total Suspended Solids) if applied properly. In fact, once dried and cured, Soil-Sement® will decrease the TSS.

CONTRIBUTIONS TO PHASE II COMPLIANCE BY SOIL-SEMENT®:

Technical data is available showing:

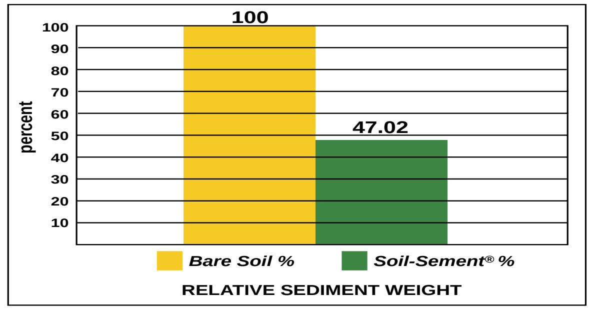
- The effectiveness of Soil-Sement® in binding naturally occurring pollutants such as metals and arsenic to the soil, making them unable to enter into stormwater runoff.
- That Soil-Sement® will prevent dust from becoming airborne and settling as sediment in stormwater runoff.

DEPARTMENTS OF TRANSPORTATION NOW RECOMMEND:

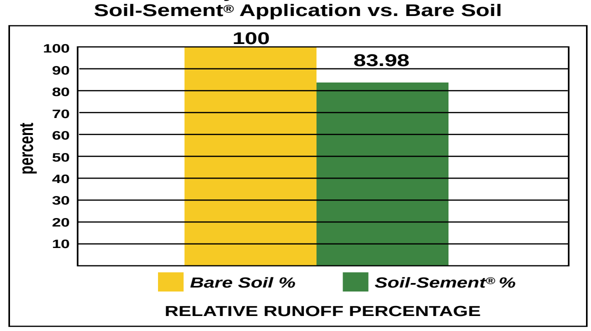
- That methods of erosion and sediment control should be considered "pay items" in the bids and specifications.
- That new road construction is usually funded approximately 80% by the federal government, and on-going maintenance is 100% funded by each state, therefore it is more economical to plan the erosion and sediment control into the initial budget.
- Part 91, Soil Erosion and Sedimentation Control, of the Natural Resources and Environmental Protection Act requires that soil and sedimentation control be considered throughout the development and delivery phases of a project, including planning, design, construction and maintenance.

Runoff Characteristics & Sediment Retention Under Simulated Rainfall Conditions

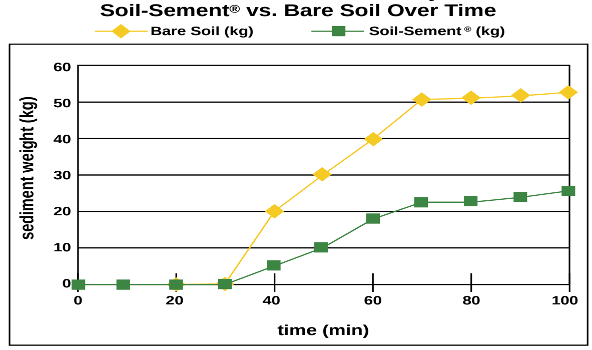
Relative Sediment Weights Comparison for a 10-year Storm Event on a Soil-Sement® Application vs. Bare Soil



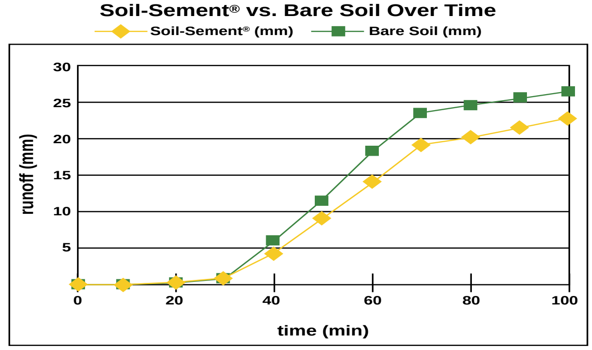
Relative Runoff Percentage Comparison for a 10-year Storm Event on a Soil-Sement® Application vs. Bare Soil



Cumulative Sediment Delivery for Soil-Sement® vs. Bare Soil Over Time



Cumulative Runoff for Soil-Sement® vs. Bare Soil Over Time



"Runoff Characteristics and Sediment Retention Under Simulated Rainfall Conditions," San Diego State University, SDASU/SERL PROJECT REFERENCE NO.: 2001-01-MIS, March 15, 2001.

Soil-Sement® and YOU:

Proven Health & Environmental Results

1. Acute toxicity tests yield LC50's for rainbow trout (96-hr.), and Daphnia Magna (48-hr.) of at least 7,000 ppm and 21,000 ppm, respectively.
2. Soil-Sement® does not contain chemicals known to cause cancer or reproductive toxicity as designed in California Health and Safety Code Proposition 65.
3. Soil-Sement® does not contain any polycyclic organic matter (POM) which includes polynuclear aromatic hydrocarbons (PAH), as defined by the Federal Clean Air Act; nor does Soil-Sement® contain fluorinated or brominated compounds that could be expected to contribute to Ozone Depletion or Global Warming.
4. The 96-hour LC50 of Soil-Sement® undiluted concentrate for fathead minnows, pimephales promelas is greater than 750 mg/L using the aquatic bioassay protocol found in Title 22, Section 66261.24(a)(6) in the California Code of Regulations (CCR).
5. Soil-Sement® does not contain concentrations of the metals listed U.S. EPA CFR Title 40, Chapter 1, Subchapter 1, Part 261.24 and in Title 22, Section 66261.24(a)(2)(A) of the California Code of Regulations (CCR) greater than their corresponding STLC and TTLC values.
6. Soil-Sement® upon curing is insoluble in water and reduces soil erosion and sediment delivery in extreme rain events approximately 53%. Soil-Sement® will not contribute, greater than regulatory levels, TCLP organics or heavy metals to stormwater runoff.

ALL THE TIME
CERTIFIED
EVERY TIME

Outstanding Features and Benefits of Soil-Sement®:

Eliminates PM_{10} and $PM_{2.5}$ particulate matter.

Does not contain any polycyclic organic matter (POM) which includes polynuclear aromatic hydrocarbons (PAH).

Is environmentally safe, non-toxic, non-corrosive, non-flammable and does not pollute ground water.

Has a cumulative effect and creates a stabilized surface which will resist shifting, breaking up or sink failures.

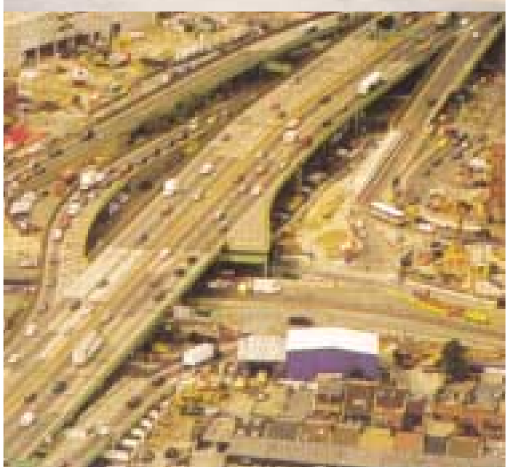
Offers maximum weatherability to wind, rain, ultraviolet light and other weather conditions.

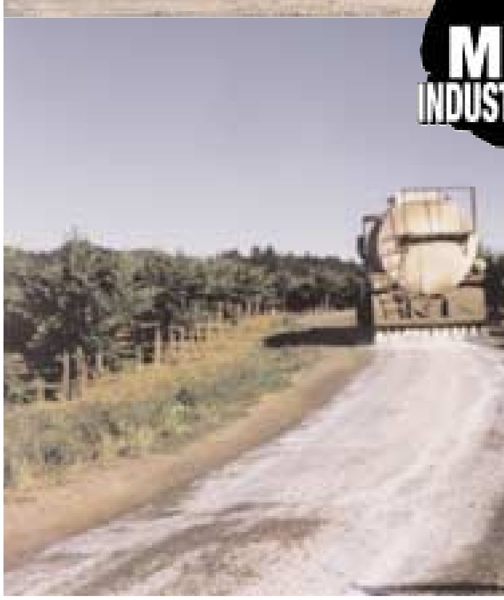
Increases load-bearing strength of all types of soils and surfaces.

Prevents water from seeping into and destabilizing the surface.

Dries clear, providing an aesthetically pleasing appearance.

Meets air, water, groundwater and stormwater compliance.





Soil-Sement® is used worldwide by:

- **Airports**
- **Air Quality Compliance Agencies**
- **Construction/Development Companies**
- **Erosion Control Industry**
- **Hydroseeders**
- **Industrial Plants**
- **Intermodal Yards**
- **Iron & Steel Industry**
- **Military**
- **Mining**
- **Municipal Districts**
- **Parks, Golf Courses & Recreational Areas**
- **Quarries**
- **State & County Departments of Transportation**
- **Utility Companies**
- **Water Quality Compliance Agencies**
- **Wineries**

COMPLETE REPORTS AND TECHNICAL DATA
AVAILABLE UPON REQUEST

MIDWEST INDUSTRIAL SUPPLY, INC.

For more information or to receive a complete list of other Midwest products, contact:

MIDWEST INDUSTRIAL SUPPLY, INC.

P.O. BOX 8431 • CANTON, OH 44711 • USA
330-456-3121 • FAX: 330-456-3247

TOLL-FREE: 1-800-321-0699

E-MAIL: custserv@midwestind.com • www.midwestind.com • www.soilsement.com

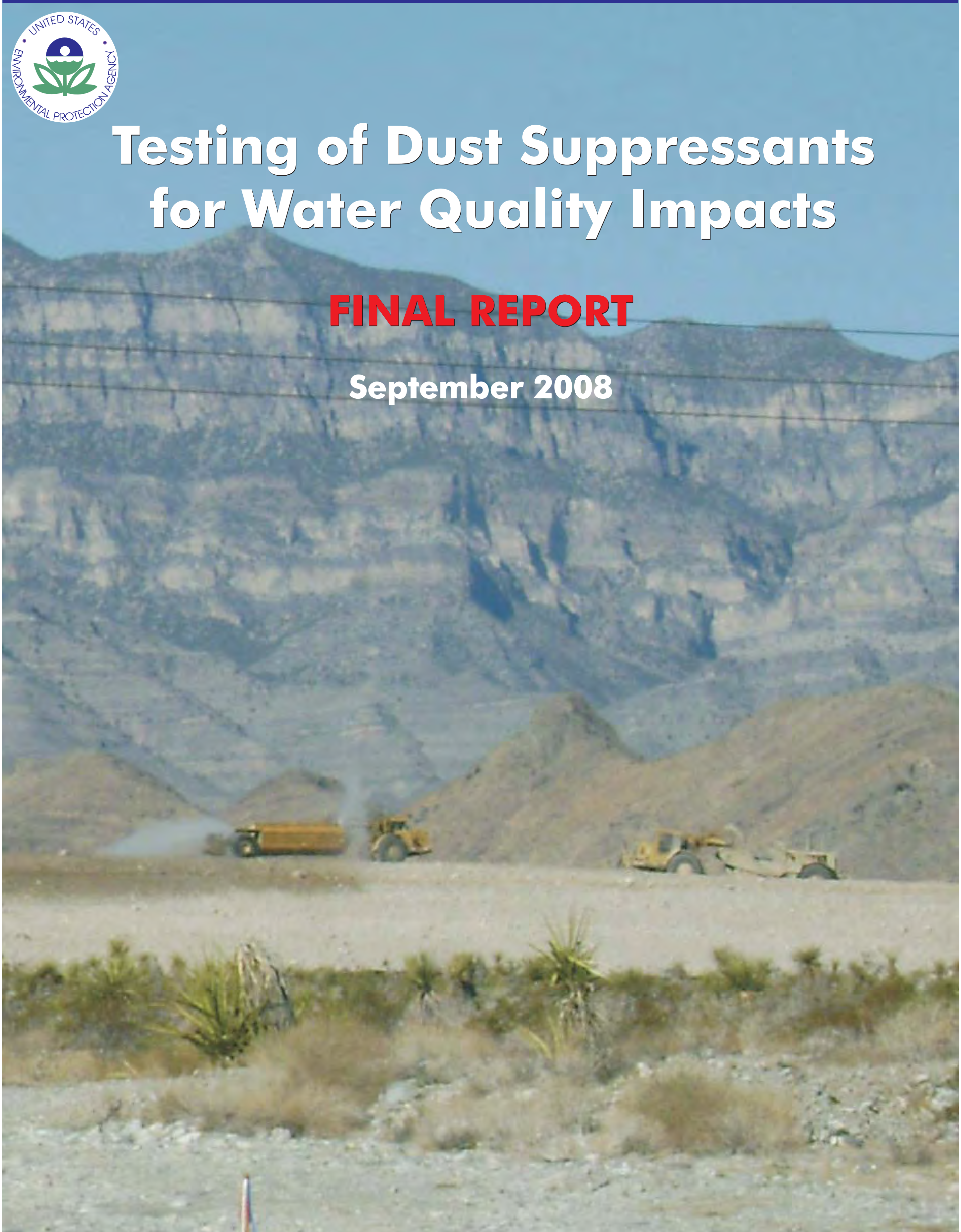
VISA, Mastercard and American Express accepted

Attachment AQ11-2
Testing of Dust Suppressants for Water Quality Impacts

Testing of Dust Suppressants for Water Quality Impacts

FINAL REPORT

September 2008



Testing of Dust Suppressants for Water Quality Impacts

Final Report

September 2008

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National Risk Management Research Laboratory
Office of Research and Development
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Cincinnati, OH 45268

Notice

The information in this document has been funded by the United States Environmental Protection Agency, Office of Research & Development. Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA for use.

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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

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[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.

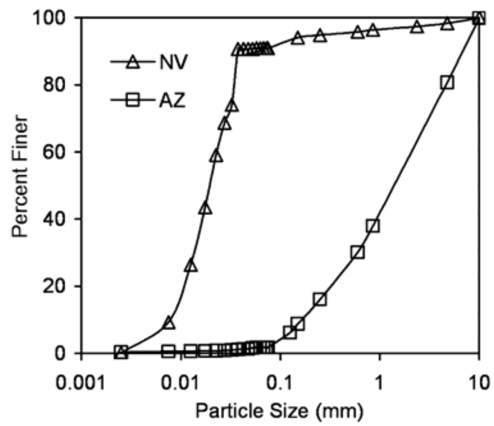

Figure 2-3. Particle Size Distributions for Bulk Soils

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	Manufac-turer	Suppress-ant Type	Product-To-Water Ratio	Applica-tion 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)	Envirospeci alists 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.

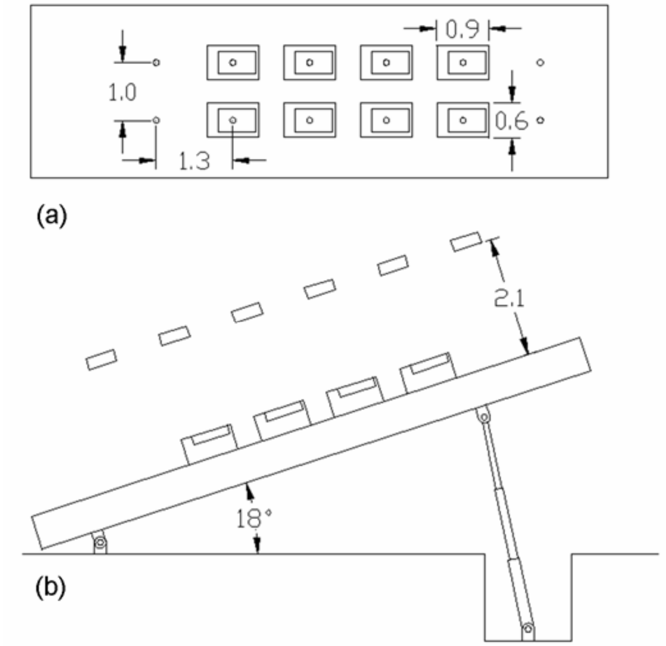

Figure 2-4. SERL's Tilting Bed with Overhead Rainfall Simulators and Soil Test Plots: ***(a) view shows spacing of rainfall simulator spray nozzles (circles), and dimensions of soil boxes in meters (rectangles); and (b) view shows vertical placement of rainfall simulators and soil test plots.***

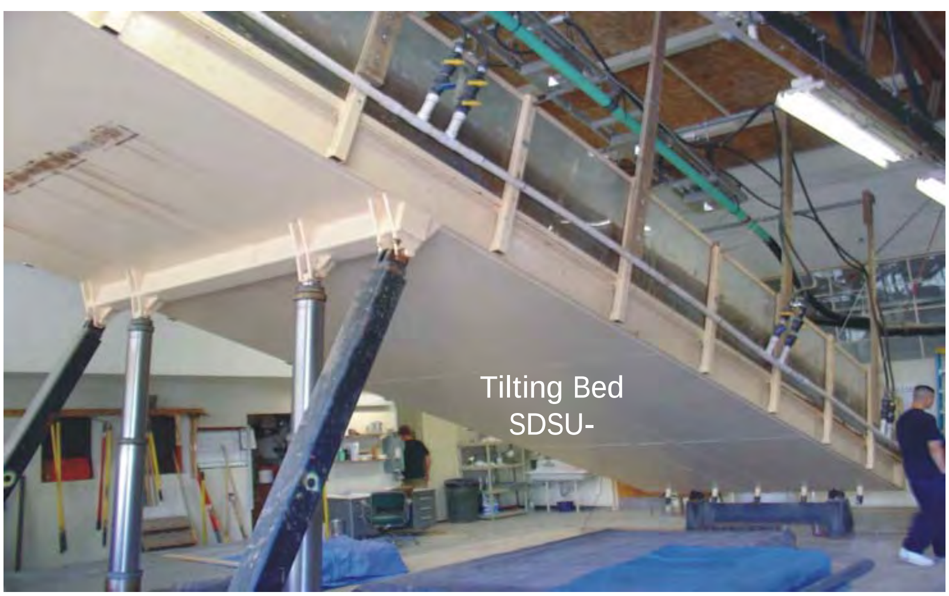

Figure 2-5. Tilting Test Bed (underside view)

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

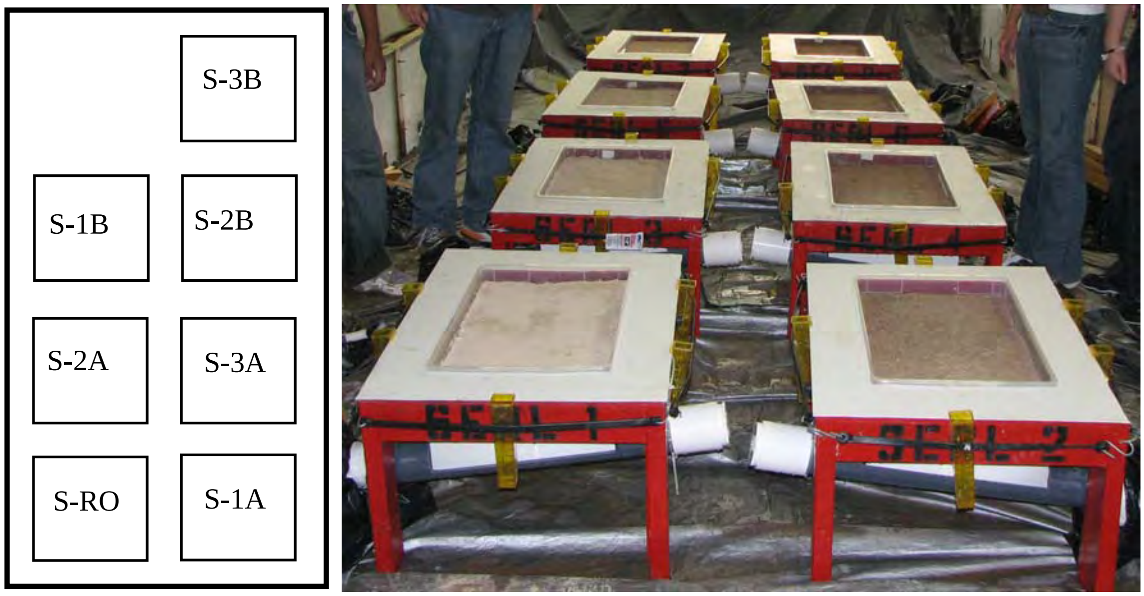

Figure 2-11. Plan view of tilting soil bed with approximate location of soil test boxes; drawing not to scale, where *S* is soil type; 1, 2, 3 are products; *A* and *B* are product application scenarios.

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.

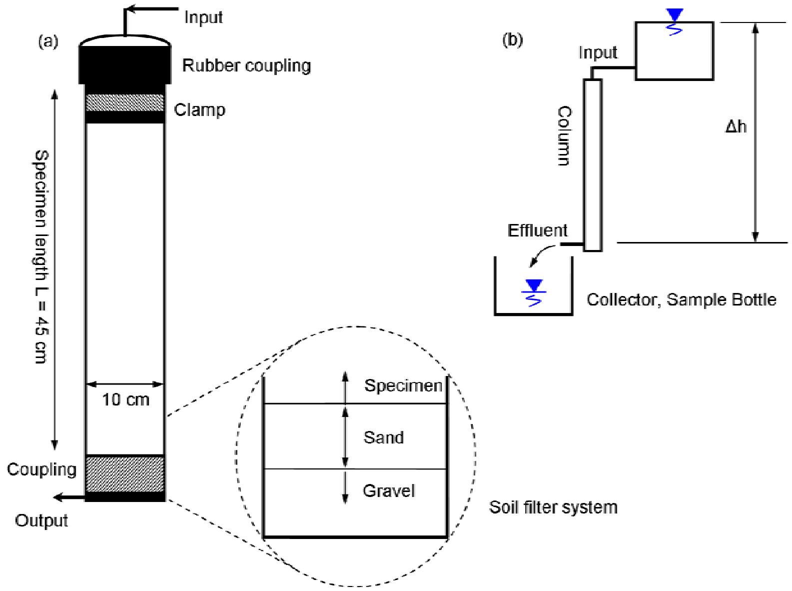

Figure 2-12. Vertical Leaching Experiment: (a) column design and (b) experimental setup

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:

TDS (mg/l) = 0.7 x 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

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[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 ≤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 ≥ 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 ≥50% control sample…	…could indicate lower oxygen levels.
TSS	If TSS is ≥25% control sample…	…potential for adverse impact
Nitrate, Nitrite, Phosphate	1. If higher than control sample… 2. If value is ≥ 25% control sample… 3. If nitrate < 10 mg/L; nitrite < 1 mg/L; phosphate ≤ 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

[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 not 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]

[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 ≤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 ≥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.

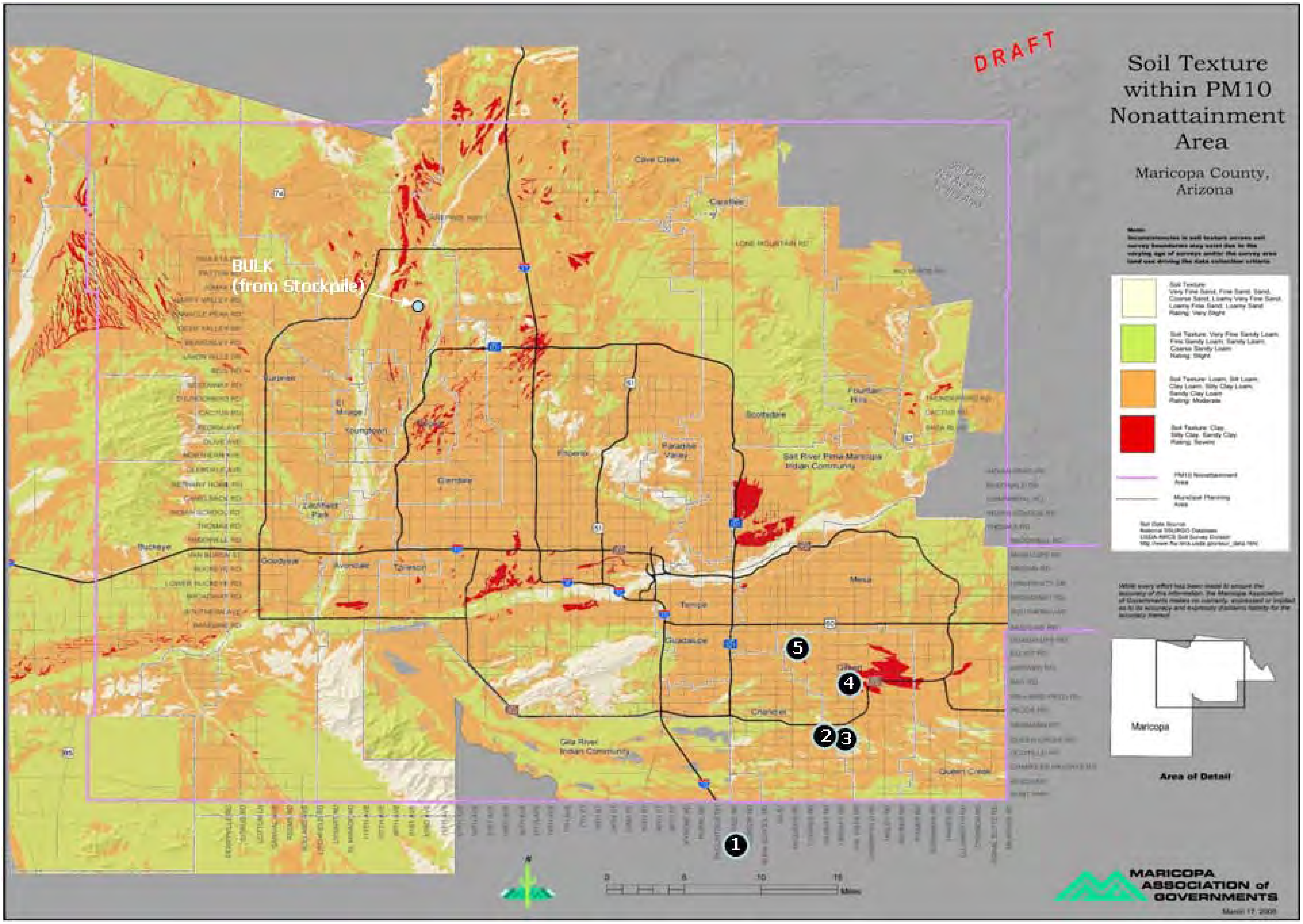
EK met all water quality parameters in the vertical leaching experiment. In the pilot experiment, EK met the water quality parameters for pH and TDS but not for Conductivity, in which average results were higher relative to control tests. Conductivity results may be influenced by the propensity of Arizona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

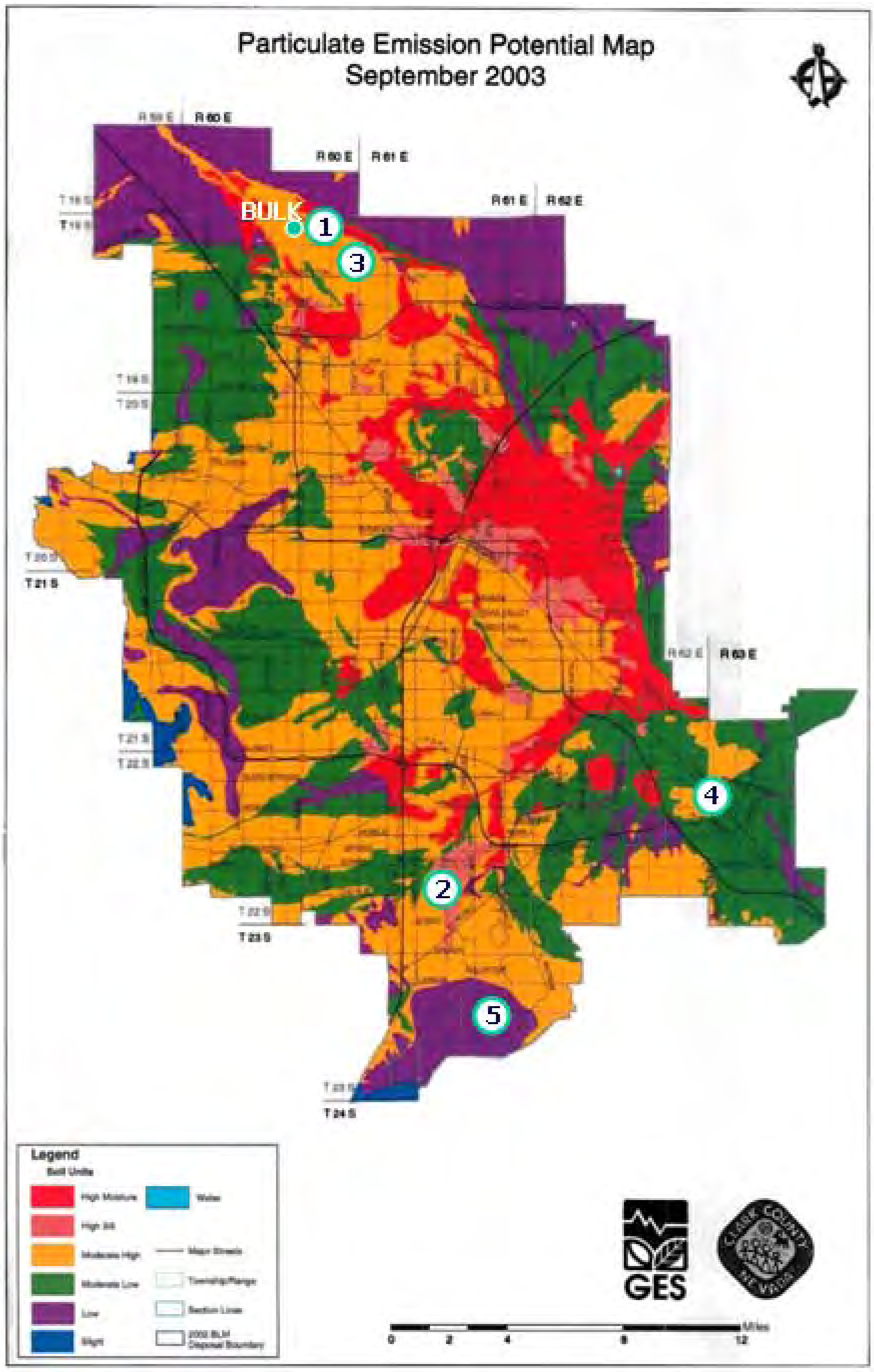
APPENDIX A

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)

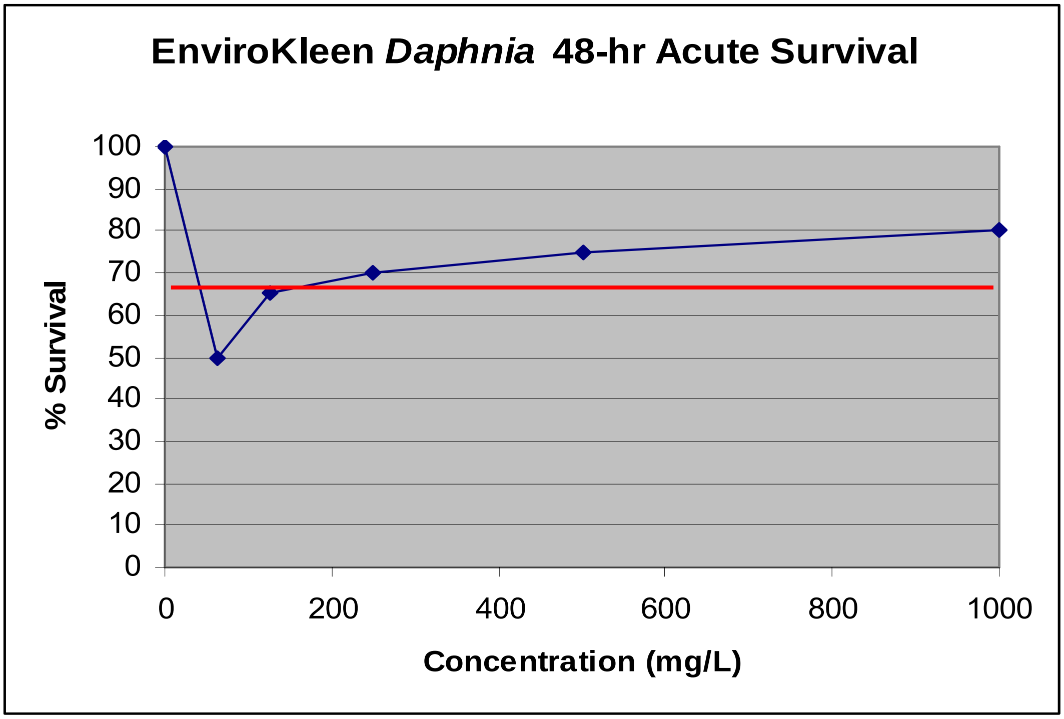
Sample ID#	Date of Analysis	ORGANISM	SOP #	% Survival 24 hour	% Survival 48 hour	*Significant Response in Test 24 hour vs control	48 hour vs control	24 hour vs RO	48 hour vs RO	24 hour vs RC	48 hour vs RC
T-NV-T-3[1]	1/18/2007	Fathead minnow Acute	SOP1030	100	100						
T-NV-T-3[1]	1/18/2007	Daphnia magna 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

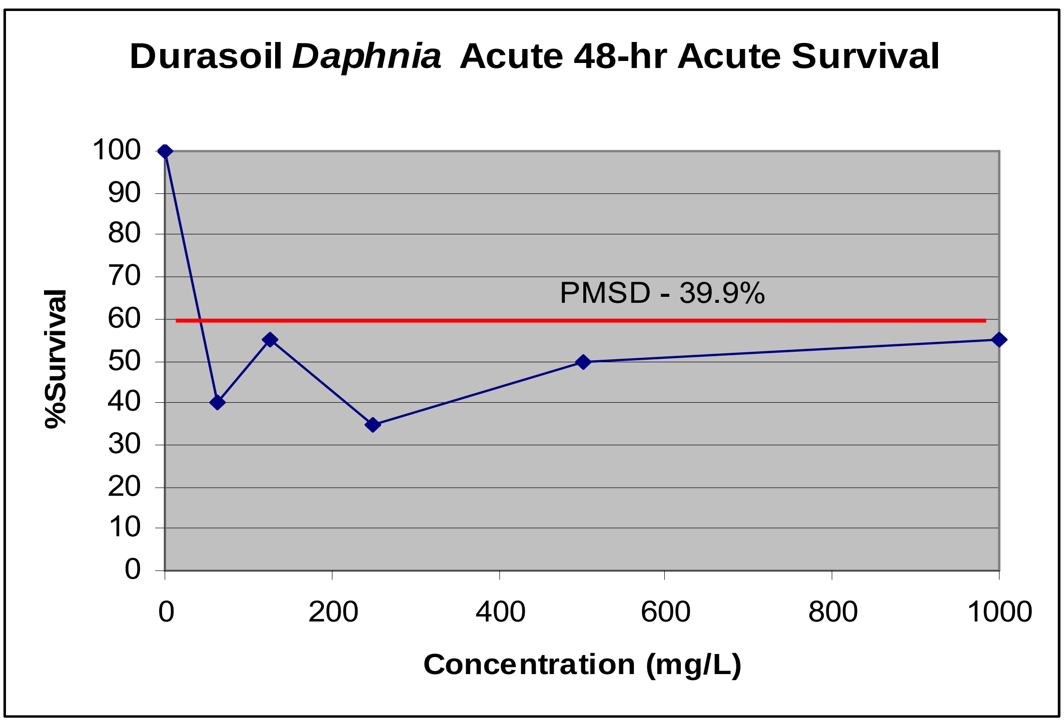
*If marked, test response is statistically significantly less than relevant control, either control water, RO water, or untreated runoff control (RC).
Algal test comparisons are based on the 96 hour cell density readings.

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

APPENDIX I

Figures I-1 & I-2





BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
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APPLICATION FOR CERTIFICATION FOR THE *HIDDEN HILLS SOLAR ELECTRIC GENERATING SYSTEM*

DOCKET NO. 11-AFC-02

PROOF OF SERVICE
(Revised 6/18/2012)

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Declaration of Service

I, Mary Finn, declare that on July 13, 2012, I served and filed copies of the attached Supplemental Data Response, Set 5, dated July 13, 2012. This document is accompanied by the most recent Proof of Service list, located on the web page for this project at: www.energy.ca.gov/sitingcases/hiddenhills/index.html.

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit or Chief Counsel, as appropriate, in the following manner:

(*Check all that Apply*)

For service to all other parties:

__x__ Served electronically to all e-mail addresses on the Proof of Service list;

____ Served by delivering on this date, either personally, or for mailing with the U.S. Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses NOT marked "e-mail preferred."

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docket@energy.ca.gov

OR, if filing a Petition for Reconsideration of Decision or Order pursuant to Title 20, § 1720:

____ Served by delivering on this date one electronic copy by e-mail, and an original paper copy to the Chief Counsel at the following address, either personally, or for mailing with the U.S. Postal Service with first class postage thereon fully prepaid:

California Energy Commission
Michael J. Levy, Chief Counsel
1516 Ninth Street MS-14
Sacramento, CA 95814
mchael.levy@energy.ca.gov

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.

Mary Finn, CH2M Hill