Large Area Land Managers Guide

to Controlling Windblown Sand and Dust

Information in this Guide applies to high elevation desert regions of Southern California. It is based on approximately 20 years of research conducted by the Dustbusters Research Group in the Antelope Valley of Northern Los Angeles County.

ANTELOPE VALLEY DUSTBUSTERS

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Front Cover: Windblown sand causes vehicle damage, reduces visibility, and creates a severe safety hazard. This residence experienced blown sand deposits in an unstable landscape.

Back Cover: California poppies, which are native vegetation, stabilize the soil.

Summary

Large area land managers in the high elevation Mojave Desert and other Southwestern U.S. locations encounter extended droughts, high winds, *soil** erosion, and other circumstances that result in blowing dust. Any process that results in minimal soil cover also invites dust problems. Wind speeds in this area can exceed 50 mph. When the wind blows, dust will follow.

Many public and private agencies are available to help land managers handle their dust problems. The techniques in this Guide may serve as a starting point. However, a comprehensive program often requires consultation with experts.

For assistance, large area land managers in the Antelope Valley can contact one or more of the resources listed in the Resources Guide. Land managers in other areas may also benefit by using web-based resources listed in the Resources Guide or by contacting similar agencies in their own areas.

Figure 1: The undisturbed desert is stable and is not a source of blowing dust.

* The definitions of italicized words are listed in the Glossary of Terms.

Introduction

Statement of Problem

When it's windy in the desert, *sand* and *dust* can be a problem to property owners, whether the land accompanies a single residence or surrounds a large commercial operation like an airport. Blowing sand may cause health and safety problems to the community. It can also reduce property values because of damage to buildings and vegetation and the build-up of sand deposits on the land. (See Figures 2 and 3.)

Figure 2: During high wind events, the disturbed parts of the desert experience blowing sand and dust.

Figure 3: Blading the unpaved road shoulder with this grader disturbs the soil.

This Large Area Land Managers Guide describes procedures for controlling windblown sand and dust on larger land areas that have sparse vegetation and few building structures to block the wind flow. These areas include:

Large commercial, public, and private land developments

- Open lands adjacent to commercial operations such as airports or utilities
- Public lands used for recreation
- Private lands held for future development
- Residential development projects
- Recreational businesses with soil arenas or parking lots.

This Guide helps you to understand the cause of the problems and how to solve them. It explains:

- Sources of sand and dust that should be controlled
- Different methods and practices used to control blowing sand and soil
- Where and how to install *control* measures
- Resources for getting advice and assistance.

This Guide will clearly describe for you:

- A two-part process for controlling sand and dust
- Guidelines for carrying out both parts of the process.

Controlling Dust is Everyone's Responsibility

Windblown sand and dust are a community responsibility, and every large area land manager must control the problem within his/her property.

The Antelope Valley Air Quality Management District (AVAQMD) regulations state:

> "A person shall not cause or allow the emissions of Fugitive Dust from any applicable source, such that the presence of such dust remains visible in the atmosphere beyond the Property Line of the emission source, or . . ."

As a land manager in the Antelope Valley, you are responsible for stabilizing loose sand and soil on your property and keeping it within your property line. This will lessen the problem for those who own land downwind of your property. You can also protect your property by stopping the flow of intruding sand from upwind locations.

If you must disturb your soil, it is important that you develop a plan **before** you begin. Your plan should allow for immediate re-stabilization of the soil. Soil disturbance may include (but is not limited to) such activities as planting, weed clearing, raking, or plowing. Do not disturb soils or clear vegetation until you are ready to plant, re-seed, or implement other soil stabilization measures. Plan to conduct this re-vegetation and stabilization during the seasons when high winds are at a minimum. The strongest winds tend to occur in the spring.

To stabilize sand and loose soil on your property, you can:

- Cover it with wind resistant material
- Cover it with small vegetation such as grasses
- Build wind barriers or wind breaks.

To stop the flow of sand onto your property from upwind properties, you can:

- Build wind barriers, such as berms, solid fences, or walls of concrete blocks or other structural materials
- Build wind breaks, such as porous fences or rows of large vegetation (trees and shrubs).

Sources of Sand and Dust

Most desert soils are naturally crusted and protected from the wind by scattered native vegetation. Even areas of loose sand are protected if the coverage of vegetation is sufficient. However, ground disturbances from activities such as vehicle traffic, construction, farming, and fires can damage or destroy the vegetation and crusts.

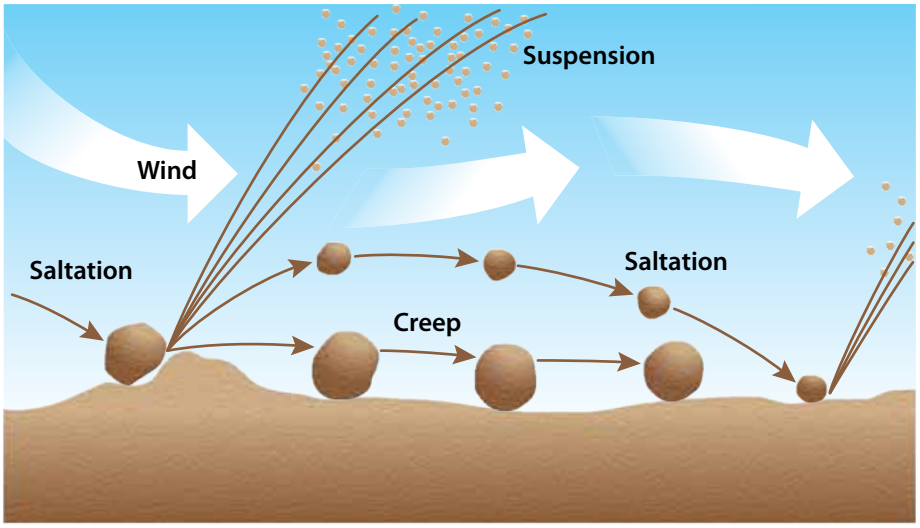

Figure 4: Wind erosion begins with particle creep (rolling) of large particles. Soon, saltation (bouncing) of sand particles begins. These energetic particles erode even stable soil, causing suspension of dust particles into the air.

As a result, high winds can pick up loose sand particles from the desert soil surface and bounce them along the ground up to a height of about 3 feet. This bouncing or *saltation* of sand particles abrades the soil surface and causes fine dust to be lofted into the air in a process known as wind erosion. (See Figure 4.) If allowed to be transported *downwind*, these cascading sand particles will destroy surface crusts, create new areas of blowing dust, and form sand dunes that cover and kill existing native vegetation.

Only the restoration of mature native vegetation can return eroded desert soil to its naturally stable condition. This process of revegetation can take many years and may be difficult to achieve. New vegetation in the form of seedlings must be protected from *sandblasting* in order to survive. So the first step in the dust control process is to stop the sand flow.

For large land managers, there are two sources of sand and dust:

- *Bare ground* areas with loose sand and soil on your property
- Loose sand areas *upwind* of your property.

Purpose and Description of Guides

Information in this Guide will assist large area land managers with control of blowing sand and dust. It is based on approximately 20 years of research conducted in the Antelope Valley by the Dustbusters. It describes procedures for controlling sand and dust on larger land areas that have sparse vegetation and few building structures to block wind flow. Two other Guides have been prepared, one for homeowners and another for growers. *The Homeowners Guide, Large Area Land Managers Guide,* and *Agricultural Guide* may be accessed at the Antelope Valley AQMD website at *http://www.avaqmd.ca.gov/*. Then click on "Windblown Dust Guidance".

Process for Controlling Sand and Dust

The problem of sand and dust control can be divided into two steps:

- Step 1: Stop the flow of intruding sand onto the owner's property from nearby upwind properties.
- Step 2: Stabilize the loose soil on the owner's property.

The fine dust that is lofted above a height of 3 feet from the ground cannot be captured effectively, so this Guide emphasizes controlling the sand flow that generates coarse dust. Controlling the sand flow prevents most of the generation of fine dust.

Figure 5: Sand deposits on the windward side of this house make it uninhabitable.

A number of dust control measures address the problem of sand and dust control and have been evaluated by Dustbusters in the Antelope Valley. Table 1 lists these measures and their associated United States Department of Agriculture / Natural Resources Conservation Service (USDA/NRCS) Conservation Practice and Reference Code.

Table 1: Dust control practices to consider in the Antelope Valley and their associated USDA/NRCS Conservation Practice and Reference Code.

Situation	Suggested Practices	Conservation Practice	USDA/NRCS Reference Code*
Stop flow of sand from upwind	Wind breaks and wind barriers	Windbreak / Shelterbelt Establishment	380
		Herbaceous Wind Barriers	603
	Vegetation	Herbaceous Wind Barriers	603
		Tree/Shrub Establishment	612
	Temporary	Cover Crop	340
	Berms		Trial studies being conducted
	Stacked straw bales		Trial studies being conducted
Stabilize loose soil	Native/locally adapted vegetation	Conservation Cover	327
	Native/locally adapted vegetation	Critical Area Planting	342
	Mulch – wood chips or gravel	Mulching	484
	Emergency tillage	Cross Wind Ridges	589A
	Herbaceous cover	Cross Wind Trap Strips	589C
	Roughened surface or furrows across the wind	Surface Roughening or Emergency Tillage	609
Surface binders	Chemical coatings	Dust Control on Unpaved Roads and Surfaces	729
	Gravel		
	Paving		
	Watering		

NOTE: This list identifies the most common (but not all) Conservation Practices for land mangers. For information about additional options or for assistance, land managers can contact the Lancaster Service Center of U. S. Department of Agriculture Natural Resources Conservation Service (USDA/NRCS) office at 661-945-2604. Additional resources are listed in the Resources Guide.

The following information provides a two-step approach to selecting and implementing cost-effective measures for controlling dust.

* For more detailed information about these Conservation Practices, go to the USDA/NRCS website *http://www.ca.nrcs.usda.gov/*. Under Quick Access in left margin, select Electronic Field Office Technical Guide (eFOTG). Then click on California Map to select county. Page opens to display list of eFOTG sections in left margin. Select Section IV; then select Table of Contents. As an option, select Conservation Practices under the individual folders that appear under the Table of Contents heading.

Step 1:
Stop Flow of Sand from Upwind

Wind Barriers and Wind Breaks

The first step in controlling sand and dust problems is to prevent blowing sand from entering your property. You can control blowing sand from areas outside your property by placing *wind barriers* or *wind breaks* along the upwind property boundaries that face the direction of high winds. You can block wind flow with:

Wind barriers – these provide total wind blockage

- *Berms* made from wood chips or soil
- Walls of concrete blocks or other structural materials
- Stacks of hay bales
- Solid fences

Wind breaks – these provide partial wind blockage

- *Porous fences* (lattice design)
- Rows of large vegetation – trees and shrubs.

Blowing sand seldom reaches a height greater than 3 feet above the ground. Thus, to effectively stop windblown sand, it is important that the wind barriers or wind breaks be at least 3 feet high. A taller wind barrier or wind break has greater capacity for trapping blowing sand. For example, if the height is 6 feet rather than 3 feet, the capacity is increased by at least 4 times.

Berms made from wood chips or soil

Berms can be constructed of wood chips or soil. (See Figures 6 and 7.) A 3-foot high berm will stop sand from entering your property and will shelter vegetation and shrubs planted *downwind* of it. When the berm fills in (saturates) with sand on its upwind side, the sand will flow over the top of the berm and deposit on the downwind side. This will make the berm ineffective.

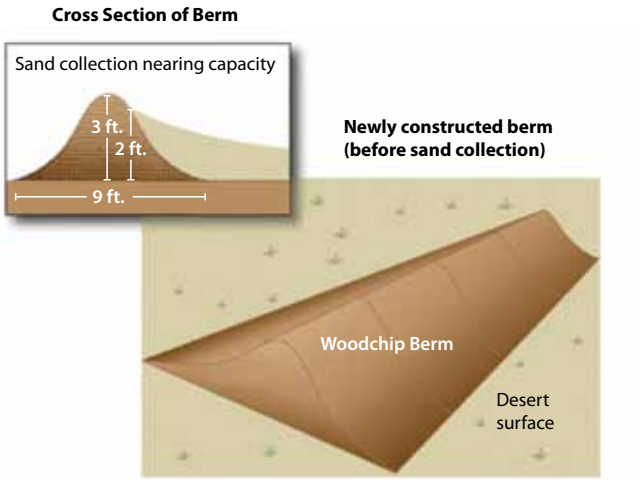

Figure 6: These diagrams show the structure and cross section of a berm.

So it is important to maintain the berm before this saturation condition is reached. Do this either (a) by removing the sand deposit or (b) by using it to build a taller berm in the same place.

To remove the sand deposit, a variety of equipment can be used, depending on the amount of sand. A truck loading operation may be required to transport the sand to a location where it is protected from the wind by a shelter or covering.

Figure 7: Berms are semi-permanent features on the landscape that provide effective reduction of blowing sand. (Prevailing wind blows from right to left.)

The second option is much more feasible for a wood chip berm than a soil berm. Push or roll the wood chips in the upwind direction so that they cover the previously captured sand deposit. Alternatively, use a specially equipped tractor to lift the chips, allow the sand to drop to the ground, and restack the chips on top of the sand deposit. Keep in mind that space must be available on the upwind side of the berm for new sand accumulation after the berm is moved or restacked in place.

Fences or walls that are solid wind barriers

Wood fences or concrete block walls are examples of solid wind barriers that do not have openings for wind flow. These barriers collect blowing sand on the upwind side until the collected sand reaches top of barrier. Because these barrier surfaces are vertical, they collect much more sand than sloped berms of the same height. So solid barriers require more work to remove the accumulated sand.

Fences that are partial wind barriers

Porous polyethylene wind fencing (lattice design) is an example of a partial wind barrier. (See Figure 8.) It is available from many hardware stores. Lattice fence material slows the wind but does not block it. Sand is deposited on the ground mostly on the downwind side. A standard fence height of 4 feet will cause blowing sand to deposit in an area up to 40 feet

Figure 8: This 50% wind porosity fencing causes sand to deposit on both sides, but more on the downwind side of the fence. (Prevailing wind blows from left to right.)

downwind of the fence. The area of sand accumulation is large, so the buildup of sand depth is slower. As a result, cleanups are less frequent than with solid wind barriers of the same height.

Figure 9: The row of shrubs is protected from sandblasting by a wind fence.

Large vegetation – trees and shrubs

Rows of large vegetation, such as trees and shrubs with a minimum height of 4 feet at maturity, collect blowing sand in a way similar to porous wind fences. They also provide an attractive wind barrier, even after the upwind sand encroachment problem stops. If vegetation already exists in an area that needs to be cleared, do not remove the vegetation until you have installed other control measures.

To grow properly, vegetation needs a fine, moist subsurface of soil and protection from sandblasting. Plant the vegetation along the downwind edge of a berm or other wind barrier. (See Figure 9.) This protects the vegetation during its early stages of growth. If possible, use tubular or cone-shaped vented coverings constructed of wire mesh or other materials which are designed to protect seedlings from sandblasting and animals.

Plant trees or shrubs in a single row or in a pattern of multiple rows that provides a wind blockage of about 50 percent. In other words, about half of the wind flow will be blocked between the ground and the height of the vegetation. As with other wind barriers, large vegetation protects land areas to a downwind distance of 10 times the vegetation height. For example, a row of 10-foot tall trees will protect downwind areas from eroding out to a distance of 100 feet.

Temporary wind barriers

Temporary barriers also effectively reduce the wind speed and limit wind erosion of soil in areas downwind. On a land development site, these can include rows or piles of excavated soil, construction materials, or debris. When land is cleared for development, the dead brush and trees can be piled in a row about 6 feet high, oriented perpendicular to the wind to form a berm. Do not burn or remove debris from berms until absolutely necessary.

Examples of other wind barriers include:

- Intermittently spaced straw bales used for drainage control, stacked to a height of at least 4 feet.
- Rows of earthmoving and other equipment that is idled when high winds occur. Park tractors, large trucks, scrapers, and bulldozers in a crosswind line just upwind of any severely disturbed and unprotected soil.

Making a Selection

First, determine how you intend to use the property. Then modify the selection process to suit your purpose in using the land.

The following tables will help you make choices for controlling blowing sand, based on three important considerations:

- Cost
- Appearance
- Effectiveness.

Dustbusters researchers have rated the suitability of each option for stopping sand flow. Table 2 rates three popular wind barriers and wind breaks for capturing blowing sand. **In Table 2, wood chips score the highest, with cost being a deciding factor. Wood chips have the clear advantage of being biodegradable and suitable as a future soil amendment.**

You may wish to rate each sub-factor differently, which may lead to a different score. In addition, you may gather information that leads to variations of these options. For example, you may decide to evaluate a soil berm rather than a wood chip berm. Your local experts can offer valuable information and recommendations to assist your decision-making process.

For guidance, job sheets, and other information, contact the Lancaster Service Center of United States Department of Agriculture / Natural Resources Conservation Service (USDA/NRCS) office at 661-945-2604. For more detailed information about vegetation, go to USDA/NRCS website at *http://www.ca.nrcs.usda.gov/*.

Once you have completed your preliminary ratings, proceed to the implementation steps outlined in the next section.

Table 2: Rating of Wind Breaks and Barriers

Control Characteristic		Rating: 1 (least favorable) to 5 (most favorable)		
Factor	**Subfactor**	**Wood Chip Berm**	**Tall Vegetation**	**Porous Wind Fence**
Cost	Materials	5	1	2
	Installation	4	2	2
	Maintenance	4	2	1
Appearance	0-2 years	2	4	3
	More than 2 years	2	5	2
Effectiveness	0-1 year	5	3	4
	1-3 years	5	4	4
	More than 3 years	4	5	4
Overall Score		**31/40 = 78%**	**26/40 = 65%**	**22/40 = 55%**

Step 2:
Stabilize Loose Soil on Your Property

Stabilization Options

The second step in controlling sand and dust problems is to stabilize any areas of sand or loose soil on your property. Cover areas of loose soil or accumulated sand with a thin layer (2-3 inches) of wind-resistant material such as wood chips or gravel. This is a quick, easy way to temporarily stabilize the ground surface. This layer can provide protection for up to 5 years, unless it is covered with additional sand or soil.

You can also use small vegetation such as grasses to stabilize the soil. However, you must protect the vegetation from blowing sand while it gets established. One way to protect the vegetation is by growing it in the protection zone of a wind barrier or wind break. This zone extends downwind from the base of the barrier/break to a distance of 10 barrier/break heights. For example, a 4-foot high wind fence will protect an area up to 40 feet downwind of the fence.

Limit activities that disturb soil

Undisturbed soil has a natural stability and resistance to wind erosion. The best approach to preventing windblown sand and dust is to limit the areas where soil is disturbed. For example, whenever possible, plan the schedule and locations of construction or other activities so that soil disturbance is minimized. The purpose of this planning is to limit disturbance of desert soils to the time immediately before construction activities begin and to the seasons when high winds are at a minimum. Highest winds tend to occur in the spring.

Other important steps you can take to limit land disturbance:

1. Develop the land in stages.
2. Do not clear an area of vegetation until development work is ready to begin.
3. Confine traffic on desert surfaces to actual work locations.
4. Construct site roads only when necessary to support development.

Surface Coverings

Protect disturbed loose sand and soil from further blowing by stabilizing the surface. Surface covering choices include:

Wood chip layers

A thin layer (2-3 inches) of wood chips will stabilize erodible areas that are not exposed to traffic. (See Figure 10.) Also, it will provide mulch for new vegetation. Wood chip layers have been tested by the Dustbusters for durability and have proven to provide erosion protection for up to 5 years.

Figure 10: A fertilizer spreader can be used to cover unstable soil with a uniform 2-3 inch layer of wood chips.

For spreading of wood chips over large areas (5 acres or more), consider renting a fertilizer spreader with a walking flow and flayer. Wood chips/mulch can be spread at varying rates to create a layer up to 3 inches in thickness by adjusting the spreading settings or making multiple passes to obtain the desired depth. For additional stability, use a sheepsfoot roller to mix the wood chip mulch with the soil and provide water to bind the materials together.

Small vegetation

A ground cover of small vegetation with high density is very effective in protecting the ground surface. (See Figure 11.) Fast-growing vegetation (such as barley or mustard) needs irrigation only during the growth phase. Once plants reach maturity, they can be allowed to die and will continue to protect the surface for up to a year. For more information on cover crops, see the Dustbusters Agricultural Guide.

Figure 11: A planted cover crop will stabilize barren soil.

Long Term Native Plant Cover

Consider using native species for permanent soil stabilization. Native species provide the greatest sustainability and return the system as closely as possible to its natural state, which typically resists erosion.

For disturbed land that will be barren for longer than 3 years, choose native grasses and shrubs. Dustbusters experiments evaluated saltbush *(Atriplex* spp.), California buckwheat *(Eriogonum fasciculatum),* rabbitbrush *(Chrysothamnus nauseosus)* and Indian ricegrass *(Achnatherum hymenoides).* These species establish adequate long term ground cover in the Antelope Valley. In some cases, seed costs for native plants are high, and seed availability is low. Obtain specific seeding rates and methods from the Lancaster Service Center of USDA/NRCS.

Broadcasting methods followed by sufficient rainfall allow successful establishment of saltbush, California buckwheat, and Indian ricegrass in a very favorable year. If available, supplemental irrigation maximizes germination and increases plant establishment in most years. Once established, however, do not irrigate shrubs except during severe drought. Seed will lie dormant if moisture is not sufficient for germination, although this does not help with short term dust control.

Successful methods of planting saltbush *(Atriplex canescens)* include broadcasting seed over undisturbed soil, drilling seed with a rangeland drill, and ripping and furrowing soil prior to drilling with a conventional drill. However, soil preparation by ripping and furrowing does not increase ground cover more than drilling seed without prior soil preparation.

Long term irrigation and fertilization of arid lands leads to the accumulation of salts in the soil. Large area land managers who want to re-vegetate with native shrubs in areas with potential salinity problems should choose species with high salt tolerance. Studies in the Antelope Valley have shown that saltbushes *(Atriplex* spp.) are ideal for this purpose. The three species studied were fourwinged saltbush *(Atriplex canescens),* quailbush *(Atriplex lentiformis),* and allscale *(Atriplex polycarpa).* All three species had high survival and growth rates on high-salinity lands and are therefore suitable choices for re-vegetation purposes.

Among these three species, fourwinged saltbush is likely to be the best choice across the widest range of situations. It has one of the highest salt tolerances of all saltbush species. Fourwinged saltbush can grow up to a foot per year, and at maturity, a single plant can cover up to 200 cubic feet. It has a highly-branched structure which is ideal for trapping windblown dust and sand. Fourwinged saltbush can live more than 100 years and produces large numbers of seeds, speeding the natural recovery process in barren areas. Also important in areas prone to windblown sand, fourwinged saltbush seed has shown the ability to germinate and emerge through 2 inches of cover.

California buckwheat established rapidly and sustained its coverage, declining briefly following drought. However, it performed well only at elevations above the valley floor.

Indian ricegrass established rapidly in the first years in many locations but then dropped out of most populations. It was most successful in deep sand and provided only minor cover in other areas. Indian ricegrass did not have the longevity exhibited by shrubs, especially under drought conditions.

Rabbitbrush became well-established in control plots, even without prior soil preparation and seed application, when nearby upwind populations provided a seed source. Drilling and broadcasting were less expensive than ripping and furrowing, though the seed of rabbitbrush is difficult to handle.

In all cases, removing tumbleweeds by burning in place or tilling is beneficial to establishment of native species. Perhaps for this reason, disking the seedbed prior to seeding improved native plant establishment.

Exposed Desert

Wind erosion may be reduced on rangeland, open desert, or other suitable locations through establishment of adapted annual or perennial vegetation such as grasses, forbs, legumes, and perennial shrubs and trees. This practice may be applied where desirable vegetation is below the acceptable level for dust suppression and natural reseeding to occur.

For more information about native species, contact the Antelope Valley Resource Conservation District or the Lancaster Service Center of USDA/NRCS listed in the Resources Guide.

Surface Binders

Watering / chemical coatings

Water binds soil particles together to temporarily stop wind erosion in areas disturbed by heavy activity, such as construction sites with vehicle traffic and soil excavation. Water promotes soil crusts that inhibit wind erosion, unless the soil is too sandy to consolidate. The crusted soil maintains its effectiveness until the area is further disturbed.

Figure 12: A water truck applies a chemical binder to the road.

Chemical coatings added to the water can further inhibit wind erosion. (See Figure 12.) However, chemical binders are not recommended for construction sites, with the exception of bitumens (naturally occurring organic materials such as asphalt or tar). Oil-based compounds form a hard surface when applied to the surface of soil and sand. Use these in areas of repeated mechanical disturbance, such as primary unpaved travel routes at construction sites.

Graveling and paving

Graveling and paving protect the soil surface and prevent wind erosion of sand and soil particles. (See Figure 13.) Because they are expensive, use these controls only for high traffic areas that are frequently disturbed.

Figure 13: A road grader with front dozer blade is used to spread gravel over soil. Gravel is an expensive but effective dust suppressant for areas heavily used by motor vehicles.

Other Methods

Furrowing of soil

A rough soil structure at the ground surface greatly reduces the movement of sand and soil particles. Furrowing forms ridges of soil clods. These clods decrease wind shear in the trenches, allowing sand to be captured in the trenches. However, this tillage practice is not effective for sandy soils because sand particles lack the cohesiveness needed to form stable furrows. Be sure to make the furrows perpendicular to the prevailing wind direction. For more information on emergency tillage and building furrows, see the Dustbusters Agricultural Guide.

Making a Selection

First, determine how you intend to use the property. Then modify the selection process to suit your purpose in using the land.

The following tables will help you make choices for stabilizing loose soil or sand, based on three important considerations:

- Cost
- Appearance
- Effectiveness.

Dustbusters researchers have evaluated the suitability of specific soil stabilization options. Table 3 rates three popular stabilizers that can protect loose soil and sand on land managers' property. Each sub-factor receives equal weighting in the rating process. **In Table 3, wood chip coverings score the highest, with cost being a deciding factor. Wood chips also have the clear advantage of being biodegradable and suitable as a future soil amendment.** The ratings in Tables 2 and 3 apply to slow growing permanent vegetation rather than fast growing cover crops.

You may wish to rate each sub-factor differently, which will lead to a different score. In addition, you may gather information about variations of these options. For example, you may decide to evaluate a different type of covering. Often, your local experts can offer valuable information and recommendations to assist your decision-making process.

For guidance, job sheets, and other information, contact the Lancaster Service Center of USDA/NRCS office at 661-945-2604. For more detailed information about vegetation, go to USDA/NRCS website at *http://www.ca.nrcs.usda.gov/*.

Once you have completed your preliminary ratings, proceed to the implementation steps outlined in the next section.

Table 3: Rating of Stabilizers for Loose Soil

Control Characteristic		Rating: 1 (least favorable) to 5 (most favorable)		
Factor	**Subfactor**	**Wood Chip Layer**	**Vegetation**	**Gravel**
Cost	Materials	5	2	3
	Installation	5	2	4
	Maintenance	5	3	5
Appearance	0-2 years	4	4	4
	More than 2 years	3	5	3
Effectiveness	0-1 year	5	4	5
	1-3 years	4	5	3
	More than 3 years	3	5	1
Overall Score		**34/40 = 85%**	**30/40 = 75%**	**28/40 = 70%**

Steps for Control Implementation

As previously discussed, large area land managers may use several control approaches, based on cost, ease of implementation, required lifetime of control, control effectiveness, and other considerations. Timeliness and required maintenance are usually the most important factors for business owners and developers.

Recommendations for a Multi-Step Control Strategy

Based on 20 years of evaluating wind erosion in large disturbed areas in the Western Mojave Desert, Dustbusters researchers recommend the following multi-step strategy for controlling dust:

1. Protect existing vegetation and structures that serve as wind barriers as long as possible before the necessary clearing or demolition.
2. Construct wood chip and earthen berms at critical points along property boundaries. These will stop encroaching sand and provide protected areas for possible development of new vegetative wind breaks.
3. Plant and irrigate permanent tree and shrub wind breaks in the protected downwind area of berms as part of the overall site landscaping plan.
4. Place a thin wood chip layer on loose blow sand areas within the property.
5. Stabilize large areas of disturbed soil with temporary vegetation or furrows, especially where land development activities will not begin immediately on previously cleared land. Temporary vegetation such as mustard, barley, or cereal grains will require irrigation for quick and effective germination during cool weather conditions.
6. Construct wood chip and earthen berms at critical points within the property to stop the blowing sand and to provide protected areas for possible development of new vegetative wind breaks.
7. Reduce the length of unobstructed terrain over which the wind flows, including straight stretches of unpaved roads that run parallel to the direction of prevailing high winds.
8. Develop a plan and work schedule that minimize the time during which each parcel of a new development remains in a disturbed condition.

Steps in Selecting and Implementing Control Solutions

Before selecting the preferred control measures, conduct a *temporal* and *spatial* examination of activities on the property. In your decision process, use the following four steps to help select and implement a final solution for sand and dust control.

Step 1: Answer the following questions. Your answers will help you select specific controls and estimate implementation costs.

- What are the boundaries and area of your property?
- Are there upwind sources of blow sand that impact the property during high wind events?
- What areas within the property are bare, with loose soil that can be eroded by strong winds? Are there blow sand areas within the property?
- From what directions do the highest winds come? What are the windiest months of the year?
- What land areas are protected by vegetation and building structures on the property? Can these wind barriers be temporarily or permanently retained?
- What activities will likely disturb the land surface? Where? When? How often?
- Can land clearing and other disturbance activities be done in stages scheduled to avoid the windy season, in order to minimize wind erosion?
- Is enough water available to irrigate new vegetation wind breaks established for sand capture or surface stabilization?
- How long will you need to protect areas of loose sand and soil before they are permanently stabilized?
- Can materials and equipment be used as temporary wind barriers during high winds when dust-producing activities are restricted?
- Can parcels be developed first that have the greatest potential for erosion or the greatest potential for preventing further erosion?
- Can temporary on-site roads be constructed to avoid long straight sections that run parallel to the prevailing high wind direction?

Step 2: Draw a map

- Using answers to the questions under Step 1, draw an overhead map that shows the boundaries of your property, unpaved roads, building locations, and large vegetation.
- Draw an arrow that shows the prevailing direction of high winds.
- Identify upwind sources of loose sand that might blow onto the property.
- Identify the best locations for perimeter wind barriers or wind breaks to stop the flow of sand onto the property.

- Identify current areas of loose soil and blow sand within the property that need to be protected.
- Identify the future areas that will be disturbed, creating loose soil that needs to be protected.
- Prioritize the locations where surface disturbance will be greatest and where erosion control measures should be implemented first.
- For complex development of large areas such as residential communities, draw a series of maps that represent varying temporal activities on different areas of the development property. These maps will help you:
  - Determine wind break and surface cover locations
  - Identify critical surface areas to be protected
  - Estimate the associated costs of control.

Step 3: Identify locations for installing perimeter wind barriers or wind breaks

- Plan a layout of wind barriers or wind breaks along the upwind property line that will stop blowing sand from entering the property.
- Draw lines representing the planned wind barriers or wind breaks on the map created in Step 2.
- Shade in the ground surface areas that will be protected by the wind barriers or wind breaks.
- Develop a general plan for periodically maintaining the wind barriers or wind breaks as the captured sand accumulates.
- Consider establishing immediate and follow-on wind breaks if sand from an upwind source will continue to blow onto property.

Step 4: Identify additional areas on the property where loose sand or soil needs to be stabilized or otherwise protected from high winds.

- Identify current areas of loose soil or sand that need to be protected from high winds but will not be protected by perimeter wind barriers or wind breaks.
- Circle or shade the areas on the map created in Step 2.
- Determine whether to use wind breaks or surface stabilization to protect these additional areas within your property.
- Develop a general plan for monitoring the stabilized areas of loose soil or sand to make sure that the protective layer does not become covered with sand during high winds.

To identify the most effective placement of additional wind breaks and surface coverings, determine the schedule of disturbance activities and the orientation of these activities relative to the prevailing high wind directions. For example, if an area is oriented mostly north and south and the prevailing wind direction is from the west, then place wind breaks on the western boundaries of each eroding area.

Case Study: Community of Rancho Seco

The 160-acre desert community of Rancho Seco lies about 45 miles north of the Antelope Valley, a few miles east of U.S. Highway 395. During the past 20 years, the community and the 3,500-acre Honda Proving Center of California (HPCC) facility to the east have been periodically inundated by sandstorms. Large sand accumulation areas have developed as the result of obstacles to wind flow such as houses and other structures that trap migrating sand during high wind events. (See Figure 14.)

Figure 14: Rancho Seco residence has sand accumulation on the upwind side of the house.

The primary source of this blowing sand is several thousand acres of abandoned land to the west. This land was farmed prior to the 1980s and has not been sufficiently revegetated with native desert species. Much of this sand originates from the upper stretches of the Jawbone Wash that meanders from the west through the abandoned farmland. During heavy rains and summer thunderstorms, this wash can fill with water and sediment, but most of the time it is dry with loose sand on the surface.

The control strategy for limiting sand movement and dust emissions in Rancho Seco entails two major steps. The first is to capture the flow of saltating sand transported during high winds from upwind sources to the west. The second is to stabilize the sand accumulation areas within the boundaries of the 160-acre community.

To stop the intruding transport of blow sand, a 2,600-foot north-south berm of wood chips was installed immediately to the west of Rancho Seco at the end of 2007 and

beginning of 2008. This berm is 6 feet high and 12 feet wide at the base. Saltating sand accumulates on the windward side of the berm. (See Figure 15.) Periodically, the berm can be rejuvenated using a front loader to roll the berm several feet to the west, thereby covering the windward sand deposits. This also increases the effective height of the reconfigured berm.

Figure 15: View (looking north) of 6 foot high frontline berm that borders the western edge of Rancho Seco, showing accumulation of captured sand on the upwind face of the berm.

The front line berm has proven very effective in capturing sand flow from the west, so that additional sand accumulation within Rancho Seco has been minor. Much of the prior sand deposits in Rancho Seco have been eroded by high winds and carried off to the Honda property to the east. Those areas of primary accumulation remaining one year after constructing the front line berm are shown in the following Rancho Seco Dust Mitigation Project diagram. (See Figure 16.)

In the interest of good neighbor responsibility to property owners downwind, such as Honda, additional berms should be considered for controlling the migration of sand flow from these remaining accumulation areas. An alternative strategy for stabilizing these areas is to cover them with a layer of wood chips (2-inch minimum thickness).

A future option for dealing with existing sand accumulations is to re-contour the sand deposits into landscaping mounds that would blend with the topography. These mounds could be vegetated with desert shrubs to provide an attractive land feature. A few large landscaping mounds would be preferable to many smaller mounds for long term efficiency of control. A wood chip covering of the mounds would provide surface stability while acting as mulch for sustaining new vegetation. Water availability is another factor in assuring that the vegetation program is successful.

Rancho Seco Dust Mitigation Project

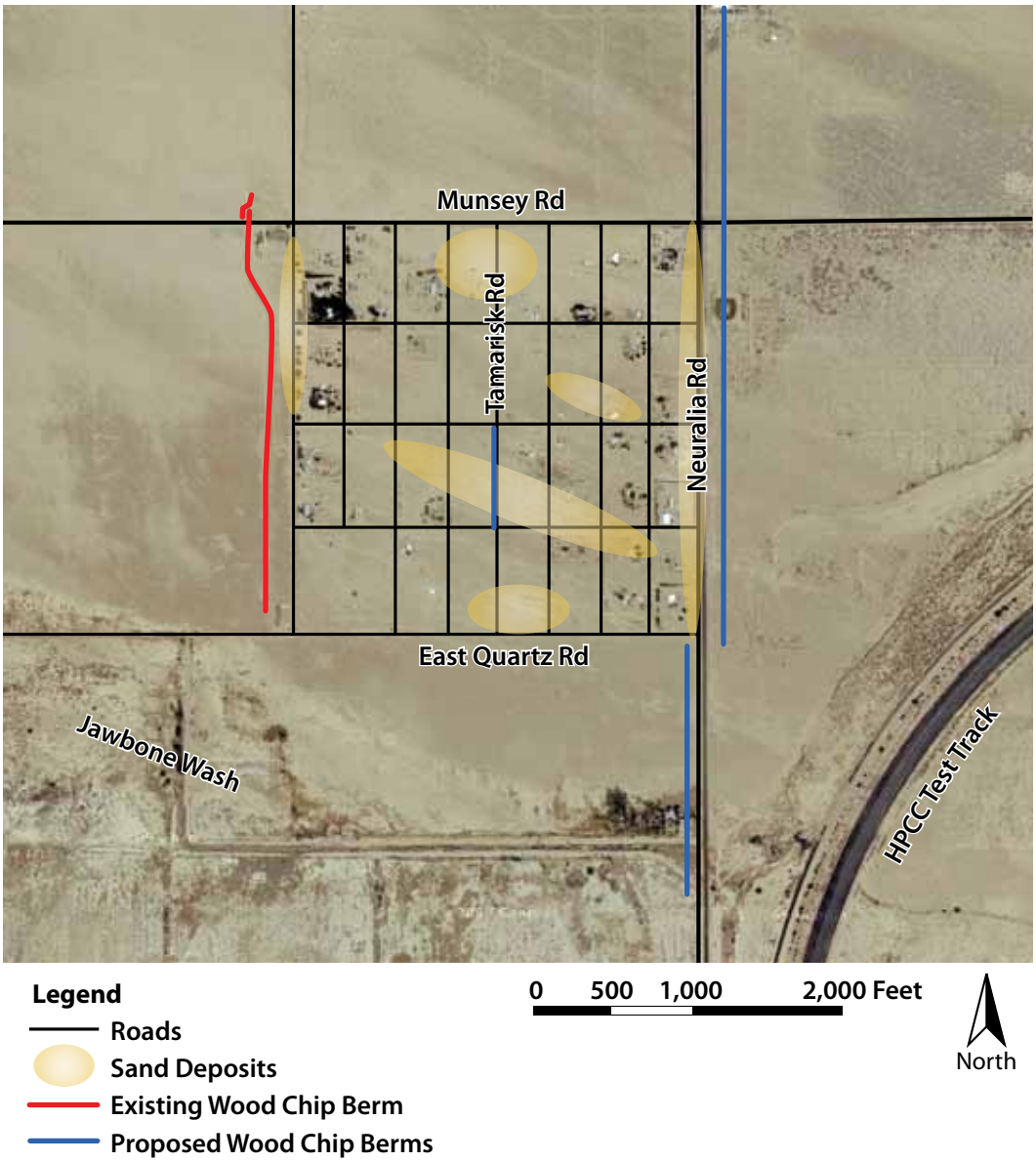

Figure 16: Diagram of Rancho Seco showing front line wood chip berm to the west, the remaining sand deposits within Rancho Seco, three proposed additional berms and the northwest edge of the 7-mile HPCC test track east of Neuralia Rd.

How to Build a Wood Chip Berm

These instructions describe how to build a wood chip berm that will stop sand from blowing onto your property. For purposes of illustration, the height of the berm is 6 feet – the minimum height required for effectiveness.

Step 1: Calculate the volume of wood chips required.

- To calculate the volume (cubic yards) of wood chips needed for a 6-foot high berm, multiply length of the berm (feet) by 8 cubic yards of wood chips per foot.

Step 2: Procure the wood chips

- Find a supplier. Local tree trimmers, utility companies, and city governments can be a source for **free** wood chips. Often, the wood chips are delivered free of charge but may arrive at random times.
- Arrange for delivery. Ask the supplier for the schedule. Tell the supplier where and what volume of wood chips to dump on your property. Don't expect the delivery truck to place the wood chips evenly in a row along upwind edge of your property, unless you have arranged for this separately.

Step 3: Install the wood chip berm

- Use a tractor or other equipment to load the wood chips and to transport the wood chips to the upwind edge of property along the line(s) indicated on the property map.
- Construct the berm at least 6 feet high and be sure that it is oriented perpendicular to the wind. (See Figure 6.) Use a tractor with implements to construct the berm.
- Place the berm at least 10 feet inside the property line. Start at least 10 feet from boundary. This will allow you to access the upwind side of the berm for maintenance without crossing onto your neighbor's property.

Step 4: Maintain the wood chip berm

- Maintain the berm when the accumulated sand on the upwind side reaches half the height of the berm. To do this, use a tractor with an implement to lift the wood chips. Allow the sand to fall through to the ground and place the chips on top of the sand accumulation along the upwind edge of the berm. Alternatively, push or roll the berm onto the sand accumulation.

How to Build a Wind Break of Vegetation

These instructions describe how to build a wind break of trees or shrubs to stop sand from blowing onto your property.

Step 1: Select and purchase the vegetation

- Select vegetation that will grow to at least 5 feet high and will flourish in your local soil and climate conditions. A local nursery sponsored by the Antelope Valley Resource Conservation District (AVRCD) sells this wind break vegetation at cost. Nursery staff can advise you about trees or shrubs suitable for this purpose.
- Determine the spacing of trees or shrubs and the total number of plants needed.
- Purchase the trees and shrubs at or after the time that the wood chip berm or other wind barrier is built. The berm or barrier will help block blowing sand and prevent it from damaging the new vegetation.

Step 2: Plant the rows of trees or shrubs

- Use a tractor with implements to prepare the soil or prepare it manually.
- Follow USDA/NRCS instructions for planting the vegetation wind breaks, including recommendations for spacing, root depth, irrigation, and protection from animals. (See Resources Guide for local USDA/NRCS contact information.)
- Plant the vegetation in the fall to assure the best survival rate.
- If you use seedlings, use cone-shaped or tube-shaped vented coverings to protect them from sandblasting or animals from their early stages of growth.
- Install irrigation lines or make other provisions for regular watering, as needed.

Step 3: Inspect and maintain the vegetation

- Periodically inspect the new trees or shrubs for plant vitality and for any structural damage by sand or animals.
- Add water and nutrients to the soil around the vegetation, as needed.

How to Stabilize Soil with Wood Chips

These instructions describe how to use wood chips to stabilize areas of loose sand or soil on your property.

Step 1: Calculate the volume of wood chips required.

- To calculate the volume (cubic yards) of wood chips needed to cover exposed soil areas for protection, multiply length by width of the area(s) in feet by 0.33 feet (equivalent of 4 inches). Then divide by 9 to convert the volume of chips from cubic feet to cubic yards.

Step 2: Procure the wood chips

- Find a supplier. Local tree trimmers, utility companies, and city governments can be a source for free wood chips. Often, the wood chips are delivered free of charge but may arrive at random times.
- Arrange for delivery. Ask the supplier for the schedule. Tell the supplier where and what volume of wood chips to dump. Don't expect the delivery truck to place wood chips in numerous piles on your property, unless you have arranged for this separately.

Step 3: Install the wood chip covering

- Use a tractor or other equipment to transfer the wood chips from the central pile to multiple piles within the bare soil areas to be protected.
- Use a tractor or other implement to spread the wood chips evenly over each of the bare soil areas to a thickness of 4 inches. This layer will keep surface soil from blowing during high winds for up to 5 years. It will also serve as mulch for new plants.

Step 4: Maintain the wood chip covering

- Maintain the wood chip layer if accumulated sand begins to cover it. Use a pitch fork or shovel to lift and restack the wood chips, allowing the sand to fall through to the ground.

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- City of Palmdale
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- Sanitation District of Los Angeles County
- Southern California Edison Company
- South Coast Air Quality Management District
- United States Department of Agriculture Natural Resources Conservation Service

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Disclaimer

The dust mitigation measures, research results, and conclusions and recommendations expressed in this Guide are solely those of its authors and contributors and are not necessarily endorsed by the many agencies, organizations, and companies who have supported and contributed to Dustbusters Research.

The user of this Guide must determine the appropriateness of a specific measure and must avoid creating fire, drainage, flood, or other safety issues when implementing dust mitigation measures. The user is advised to check with local agencies regarding safety and regulatory issues.

Resources Guide

The following is a list of organizations that can help you select and implement the most cost-effective dust mitigation measures to address your problem:

Antelope Valley Air Quality Management District (AVAQMD) at **661-723-8070**; at website *http://www.avaqmd.ca.gov/*; or email *bbanks@avaqmd.ca.gov.*

Antelope Valley Resource Conservation District (AVRCD) at **661-945-2604**; at website *http://www.avrcd.org/*; or email *avrcd@carcd.org*.

Antelope Valley Resource Conservation District Nursery (AVRCD) at **661-942-7306**; at website *http://avrcd.org/nursery.htm*; or email *avrcd@carcd.org*.

Kern County Agricultural Commissioner at **661-868-6300**; at website *http://www.kernag.com/*; or email *agcomm@co.kern.ca.us*.

Lancaster Service Center of U. S. Department of Agriculture Natural Resources Conservation Service (USDA/NRCS) office at **661-945-2604**; website at *http://www.ca.nrcs.usda.gov/*.

Los Angeles County Agricultural Commissioner at **661-974-8801**; or at website *http://acwm.co.la.ca.us/*; or email *dbrackin@acwm.lacounty.gov*.

U. S. Department of Agriculture Natural Resources Conservation Service (USDA/NRCS); website at *http://www.ca.nrcs.usda.gov/*.

University of California – Los Angeles County Cooperative Extension – Antelope Valley/Lancaster Office at **661-974-8824**; or at website *http://celosangeles.ucdavis.edu/*; or *asbiscaro@ucdavis.edu*.

Other Sources of Information:

The Antelope Valley Air Quality Management District website provides additional information that may help with your selection and implementation of cost-effective dust mitigation measures. Go to the website at *http://www.avaqmd.ca.gov/*; then select "Windblown Dust Guidance," where you will find:

Case Studies

Provides descriptions of several successful windblown dust mitigation field case studies that have been conducted in the western Mojave Desert since 1992. During these case studies, several different dust mitigation strategies were developed, tested, and implemented.

Publications

Provides a list of peer reviewed open literature and conference papers. Also provides access to the complete papers.

Extended Abstracts of Publications

All peer reviewed publications have an abstract of approximately 300 words.

Reports

Provides a list of reports developed by the Dustbusters Research Group since 1992, organized by topic. Also provides access to the complete reports.

WRAP

You will also find information at the archived Western Regional Air Partnership (WRAP) at website *http://www.wrapair.org/forums/dejf/fdh/index.html*. WRAP provides access to the fugitive dust handbook developed by the Western Regional Air Partnership. This comprehensive handbook discusses the fugitive dust problem, mitigation solutions, and costs associated with the various control measures.

Glossary of Terms

Bare ground	Land covered by loose or crusted soil which is not vegetated or otherwise protected from the wind.
Berm	An elongated pile of wood chips, uprooted brush, earth or other material which acts as a wind barrier and captures saltating sand.
Control	Steps taken to reduce the movement of sand and dust during high winds.
Downwind	The direction toward which the wind blows.
Dust	Small soil particles that loft from bare ground when the wind blows. Talcum powder and milled flour are examples of dust-sized particles. Heavy winds can loft airborne dust as high as hundreds of feet above the ground.
Porous fence	A durable, lattice-design fence often used to create barriers for construction sites, sporting events, or gardens. Typically, the fence material is made of non-biodegradable plastic.
Saltation	The bouncing of sand-size particles, typically to as high as 3 feet above ground during high-wind events.
Sand	Intermediate soil particles, comparable in size to beach sand or table salt. Wind transports fine sand (via saltation) in a layer that is confined to about 3 feet above the ground.
Sandblasting	Abrasion of the ground surface or wind barriers, caused by saltating sand particles during high winds.
Soil	A heterogeneous combination of sand, dust and other particles, which may be loose or crusted; the natural body comprised of mineral and organic solids, liquids and gases that occur on the land surface.
Spatial	Relating to space.
Temporal	Relating to time.
Upwind	The direction from which the wind blows.
Wind barrier	A solid obstacle to wind flow, such as a berm, wall or solid fence.
Wind break	A porous obstacle which slows high wind enough for the sand carried in the air to be deposited on the ground, such as a row of trees or a porous fence.

Dustbusters Research Group

In 1991, the Dustbusters Research Group formed a partnership to develop best management practices for mitigating wind erosion, reducing blowing dust, and improving air quality in the Antelope Valley. Since then, this Group has developed and implemented a land treatment program to minimize wind erosion through vegetative, physical, and chemical stabilization procedures.

This Group consists of private entities and federal, county, and city government representatives. For a complete listing of participants, go to the Antelope Valley Air Quality Management District's website at *http://www.avaqmd.ca.gov*.