A GUIDE TO STEEP LAND AVOCADO DEVELOPMENT

VENTURA COUNTY

January 2000

Prepared by:
U.S.D.A. Soil Conservation Service
624-B West Foster Rd., Suite 1
Santa Maria, CA 93455

Edited For Ventura County By:
U.S.D.A. Soil Conservation Service
3380 Somis Road, P.O. Box 260
Somis, CA 93066 - (805) 482-4206
Ben A. Faber, U.C. Cooperative Extension
669 County Square Dr., Suite 100
Ventura, CA 93003-5401 (805) 645-1451

In Cooperation With:
Santa Barbara County Resource Conservation District
Ventura County Resource Conservation District
University of California Cooperative Extension, Ventura County
CONTENTS

Introduction .......................................................... Page 3
About the Ventura County Resource Conservation District .......... Page 4
Hillside Erosion Control Ordinance for Ag Land Use (3539) ........ Page 6
Site Selection
  Climate .................................................................. Page 8
  Water ..................................................................... Page 8
  Soils ...................................................................... Page 8
Site Development
  Site Maps ............................................................... Page 10
  Land Clearing ......................................................... Page 10
  Hillside Erosion Control Plan .................................... Page 11
Erosion Control Practices
  Roads ....................................................................... Page 14
Drainage Ditches
  Drain Pipes ............................................................. Page 16
Vegetative Erosion Control
  Benefits ................................................................. Page 17
  Limitations ............................................................ Page 17
  Cover Crop Alternatives ......................................... Page 17
  Irrigation ............................................................... Page 19
  Soils ...................................................................... Page 19
  Climate ................................................................. Page 20
  Topography ........................................................... Page 20
  Water Supply ......................................................... Page 20
  Site Management .................................................. Page 21
  Rodent Control ...................................................... Page 21
  Surface Drainage system ......................................... Page 21
  Structural Devices ................................................. Page 21
  Ground Covers ...................................................... Page 22
  Irrigation Systems .................................................. Page 22
Selected References ..................................................... Page 23
A Guide to
Steep Land Avocado Orchard Development
Ventura County

Orchard development of steep brush-covered foothill areas in Ventura County has increased dramatically in recent years and undoubtedly may continue to do so with a continuing favorable market. Unfortunately, such developments can create two threats to downstream properties if they are not treated properly. One threat is from recurring erosion and sediment deposition. The other, which is usually much more dramatic and virtually impossible to correct, is from landslides. To develop the hills with relative safety, certain accommodations must be made to the environment. These hazards must be accepted as part of the nature of the hills and then proper steps must be taken to provide protection.

Productive, safe, and esthetically acceptable hillside orchards can be achieved by careful planning. This booklet is intended for use as a guide. Since each area is unique, developers should contact professional consultants for site specific planning. Planning specialists are available through the USDA-Soil Conservation Service and the University of California Cooperative Extension. Private engineering firms also offer similar services.

Board of Directors

Ventura County Resource Conservation District
Ventura County Resource Conservation District

Responsibilities

The Ventura County Resource Conservation District (VCRC'D or RCD) is responsible for the direction of programs related to the conservation and wise use of soil, water and related resources in Ventura County. The District covers 1,126,900 acres, including private and public lands.

Programs

Farm and Ranch Conservation Planning: The RCD assists individual landowners in making planning decisions to install conservation practices as part of total resource management systems. Special emphasis is placed on the control of excessive erosion.

Hillside Erosion Control Program: The District assists in the preparation and review of hillside Erosion Control Plans on new agricultural developments in critical areas (sloping lands). This service is provided to the County of Ventura as specified in the Ventura County Hillside Erosion Control Ordinance.

Watershed Protection and Flood Prevention Projects (PL-566): The RCD serves as a local sponsor for Soil Conservation Service federally funded watershed protection and flood prevention projects in Ventura County. They provide local input in setting priorities and determining their feasibility in addition to assisting with inter-agency coordination.

Water Resources Conservation and Development: The County of Ventura has developed and adopted a Water Conservation Plan. The RCD has a lead role in the implementation of the measures recommended for agricultural water conservation including: on-farm evaluations, field tours and educational services.

District Long Range Plan: The RCD produces a comprehensive Long Range Plan which assesses resource conditions and soil and water conservation needs throughout the county. The multi-year plan then sets forth goals and the programs necessary to achieve adequate resource protection and improvement. Portions of this Long Range Plan are used each year as the Districts’ Annual Work Plan.

Organization

The Ventura County Resource Conservation District is a local unit of government and is administered under the provisions of Division 9 of the Public Resources Code, State of California. The VCRC'D is one of 128 Districts in California and belongs to the National Association of Conservation Districts (NACD) which represents over 3,000 Districts in the country. Formation of the District was accomplished in steps involving a merger and consolidation of the Ojai and South Ventura County RCDs and annexation of all remaining unincorporated land in Ventura County. The three Divisions of the District coincide with these three geographical areas (Ojai, Santa Clara Valley and South Ventura County). The RCD is governed by a Board of nine directors nominated by division and elected for four-year terms. Directors must be landowners residing within the District. Regular District meetings are held on the second Thursday of each month.

Working Together

technical assistance is provided to the District by the USDA Soil Conservation Service (SCS) through a Memorandum of Understanding. In addition, the District works with other government agencies and units of government to provide coordinated resource planning throughout the county. Individual landowners are eligible for assistance by signing a Cooperative Agreement with the District.
Why Become a District Cooperator?

Receive help in planning to conserve and improve the resources on your farm or ranch.

Receive engineering assistance in survey and design of conservation practices.

Receive help in coordination of solving problems on a group basis.

Be represented by a respected "agricultural/conservation voice" in the county.

County Resource Facts

Ventura County is the 17th most important agricultural producing county of the 3,175 counties in the United States (based on 1978 Bureau of Census figures).

There are over 28,000 acres of gullies and badlands in the Southern half of Ventura County producing an estimated 880,000 tons of sediment per year.

Our cropland can withstand the loss of 2 to 5 tons of topsoil a year without losing its capacity to sustain crop yields.

About one-fourth of our cropland is eroding at rates that, if continued, will reduce yields.

Approximately 13.5% of our irrigated acres (922 square miles) are affected by seawater intrusion.

Groundwater basins supply approximately 70% of the water used in the county, and are being overdrafted at a rate of about 80,000 acre feet per year.

VENTURA COUNTY RCD
3380 Somis Rd.
P.O. Box 147
Somis, CA 93066
(805) 386-4489
Meetings: 2nd Thursday, 11:30 a.m. – contact office for meeting location.
Why a New Law?

Moving earth, clearing vegetation or other land preparation work on hillsides can cause erosion, deposition or water quality problems. The County Grading ordinance does not regulate grading and clearing in isolated and self-contained areas. Many hillside areas that are not subject to the County Grading Ordinance are being developed for agricultural purposes in a manner that can cause serious hazardous runoff and erosion problems. The new Hillside Erosion Control Ordinance is a County law that governs new agricultural developments and changes in agricultural use in certain described critical areas.

What is the Existing County Grading Ordinance?

The County Grading Ordinance (separate from the Hillside Erosion Control Ordinance) requires that property owners excavating or filling in excess of 50 cubic yards obtain a grading permit unless the work is located in an isolated, self-contained area. An isolated, self-contained area is defined as being more than 100 feet from the nearest property line and an area where the Public Works Agency has determined the proposed work will cause no apparent danger to adjacent private or public properties. If a grading permit is issued for work, the Hillside Erosion Control Ordinance does not apply to the same work. For additional information on the County Grading Ordinance, contact Senior Engineer, County Public Works Agency, Development Services Division, 800 S. Victoria Ave., Ventura, CA 93009 (805) 654-2059.

Does the New Law Apply to Me?

The Hillside Erosion Control Ordinance applies only in designated critical erosion areas. These areas are basically the hilly and mountainous terrain in the southern portion of this county. They are defined on the Official Erosion Maps, Southern Ventura County, which may be viewed at the County Public Works Agency, Development Services Division, 800 S. Victoria Ave., Ventura, CA 93009, (805) 654-2002 or the Ventura County Resource Conservation District, 3380 Somis Rd., Somis, CA 93066 (8050 386-4489 during regular business hours.

Within a critical erosion area, the law requires you to obtain and apply a hillside erosion control plan approved by the Resource Conservation District. If you clear vegetation or perform land preparation for new agricultural use or make a change in agricultural use, a hillside erosion control plan may be required. Exceptions are, if any of the following conditions apply:

1. During 12 consecutive months, the area affected does not exceed 10% of the size of the land parcel or 25 contiguous acres, whichever is less; or
2. The work is authorized by a valid grading, building, well, or conditional use permit; or
3. The Ventura County Resource Conservation District determines that for your specific proposal an erosion control plan is not required.

What are the Penalties for Violation of the New Law?

There is a maximum fine of $1,000 for violation or imprisonment for not more than 6 months, or both.

If work occurs in violation of the ordinance and the violator does not abate the problem, it may be abated by the County of Ventura and the cost charged to the violator or the property owner.

How Do I Get An Approved Hillside Erosion Control Plan?

Preparation of a Hillside Erosion Control Plan has several alternatives. The landowner may prepare the
plan or use the services of qualified professional agricultural planning assistance. The Resource Conservation District, with supporting technical assistance of the USDA Soil Conservation Service, will also advise and assist in the planning work at no cost to the agricultural developer or land-user.

The Hillside Erosion Control Plan is subject to the review and approval of the Resource Conservation District in accordance with procedures of the Ordinance.

For further information, direct inquiries to the following:

Ventura County Resource Conservation District
3380 Somis Road, P.O. Box 147
Somis, CA 93066
(805) 386-4489

Ventura County Public Works Agency
County Government Center
800 S. Victoria Ave.
Ventura, CA 93009
(805) 654-2059
SITE SELECTION

Three environmental conditions must be met to develop a successful avocado orchard; a favorable climate, a dependable supply of high quality water, and a suitable soil.

Climate

Avocados must be grown in relatively frost-free areas. Although certain commercial varieties can tolerate temperatures as low as 24°F, the more popular types are susceptible to damage at 30°F. In general, a favorable thermal belt exists between the elevations of 100 and 800 feet along the south facing slopes from Point Conception to the Ventura County line. However, wind-borne salts may cause problems if orchards are located in the immediate proximity of the ocean. Localized air movement is an important consideration at each site since poorly drained low areas may be several degrees colder than the surrounding uplands.

Water

Assuming typical planting densities (20 ft. x 20 ft.) the average mature avocado orchard will require a total of about 3.0 acre feet of water per acre per year. Based on average rainfall of 1.5 acre-feet per acre, about 1.6 acre-feet per acre must be supplied by irrigation. This demand will meet the requirements of the plants on most soil types and also provide for leaching needs, assuming average irrigation system efficiencies.

The average irrigation water demand quoted may vary as much as 20% depending on a variety of factors, the most significant of which is the conveyance system efficiency. Generally drip and low flow sprinklers are the most efficient systems. The system selected must be designed to meet the peak demand of a mature avocado tree. During peak periods, this requirement may be as much as 50 gallons per tree per day. Peak consumption periods in this area normally occur from June through September.

Water quality is important since avocado trees are sensitive to a variety of salts. The salt content of water is usually expressed as total dissolved solids (TDS) in concentrations of milligrams/liter (mg/l) or as electrical conductivity with units of decisiemens/meter (dSm - formally millimhos per centimeter).

The salt content of soil is usually expressed in percent salt or as electrical conductivity of the soil water extract at 25°C. Avocados have a low salt tolerance. Any water with an electrical conductivity above 1.0 dS/m may be harmful. Yields can be expected to decrease by 10% at 1.8 dS/m, 25% at 2.5 dS/m, 50% at 3.7 dS/m. Problems from salt concentrations are most likely to occur in soils with poor sub-surface drainage because most of the water extraction occurs within the root zone.

In addition to the total amount of salt, sodium and chloride concentrations can be particularly damaging. Sodium causes clay particles to disperse and lose their permeability. The sodium content of irrigation water or soil extract is usually expressed as the sodium absorption ratio (SAR) which is a measurement of the relative activity of sodium ions in exchange reactions. Tree problems can start to occur with an SAR of 3.0 and increase rapidly as sodium concentrations exceed this level. Chlorides can cause leaf damage. Problems can occur when chloride concentrations reach 140 mg/l.

Soil salinity problems are most difficult to manage in soils with poor sub-surface drainage because these soils do not allow water to drain out of the root zone fast enough to accomplish the leaching required to keep the concentration of salts in the root zone low enough for avocados.

Soil sampling done by laboratory personnel or as advised by the laboratory can determine whether leaching is required or if adequate leaching has been accomplished.

Soils

Avocado trees can be grown on practically any soil if it provides a rooting depth of at least 2 feet (preferably 3 ft.) and has good internal drainage. Poorly drained soils can cause physiological and pathological problems. Saturated soils inhibit proper air exchanges in the root systems and retard growth or, in the most severe cases, the trees are killed. A more serious problem associated with poor drainage is the Root Rot disease that could develop if the soil contains the fungus (Phytophthora cinnamomii). A common vector for infection on otherwise disease-free soils is water transport through the drainage pattern. A close inspection of the drainage area should be conducted above the selected site to ensure that the area is disease free. At present there is no known cure for this disease. All of the soils in Ventura
County have been mapped by the Soil Conservation Service. These surveys provide definitions of soil characteristics and a rating system concerning the relative potential hazard of root rot occurring on specific soils.

None of the soils in Ventura County have an inherent problem with harmful salts; however, salt buildup can be expected from irrigation water and chemical soil amendments. Generally, the added salts can be mitigated for by proper leaching if the soil has good internal drainage.

Steep slope developments obviously create opportunities for erosion. Erosion control techniques are discussed in other parts of this text. A more severe problem, and one that is almost impossible to correct, is the landslide. The natural factors known to promote landslides include steep, relatively thick soils with high clay contents and excessive moisture. The opportunity for slips is greatly enhanced if the soils overlay impervious parent material that is positioned parallel to the soil surface. Man-made disturbances on geologically unstable slopes increase the opportunities for slope failure by an infinite magnitude. Some of the most common causes for slope failures include year-round wetted soil from irrigation, removal of natural ground covers, and reduction of slope stability by making the slope angle steeper with road or terrace cuts.

Existing and potential slide prone areas should be excluded from developments. Evidence of slides may be readily apparent or it may be in a more subtle form.

The most recognizable evidence on otherwise uniform slopes is characterized by steep escarpments above bowl-like depressions with irregular soil deposition on the lower end. Other features that may indicate unstable slopes include curved tree trunks, oddly angled fences or poles, large transverse soil cracks, springs on steep slopes, and unusual patterns in drainage courses.

The Ventura County Resource Conservation District (VCRCD) has landslide maps on file in their office. If you have an orchard or are planning to develop hillside land, check with the RCD.

VENTURA COUNTY HAS A HILLSIDE EROSION CONTROL ORDINANCE. BEFORE BEGINNING TO DEVELOP ANY NEW ORCHARD, OR EXPANDING AN EXISTING ORCHARD, CHECK WITH THE VCRCD OR THE COUNTY PUBLIC WORKS AGENCY.
SITE DEVELOPMENT

Site Maps

The most critical element in the development of a steep land avocado orchard is the preparation of a sound plan. Corrective actions to repair erosion damage are usually much more expensive than preventive measures, and a landowner could be liable for downstream problems if they are products of his construction activities.

A detailed map illustrating the basic resources and concerns must be prepared in order to assess the site limitations. From this map grading schemes, planting plans, and erosion concerns can be logically addressed. The initial site map should include the following:

- Property boundaries
- Map extension to include affected off-site lands, particularly drainage systems.
- Topographic contouring. Ideally, minimum contours should be at 2-foot intervals for slopes less than 15%, and at 5-foot intervals for slopes in excess of 15%. Adjacent areas can be contoured at 20-foot intervals.
- Soils descriptions including texture types; depth, permeability, soil pH, depth to and type of parent material.
- Identification of geologically unstable areas and the location and apparent cause of current erosion.
- Location of usable water resources.
- Zones of trapped surface or sub-surface water including springs and seeps.
- General map of natural vegetation and identification of key species in plant community.
- Riparian corridors.
- Hydrologic province that includes a runoff area map, vegetative cover types, and soil types in off-site runoff area.

Site plans can be prepared on a variety of backgrounds. Aerial photographs are one of the most useful and commonly used maps. Commercial firms specializing in this work offer site-specific services at a reasonable cost. General photography from a 1978 flight is available at a nominal cost through the Agricultural Stabilization and Conservation Service (ASCS) in Buellton. Stereo viewing pairs (3 dimensional) are also available. This type of photography must be used with viewing equipment. Other maps available for general planning are USGS 7-1/2 minute quadrangles. One of the most useful features of such maps are illustrations of contour lines. These contours are usually marked at 20, 40, or 50-foot intervals.

Site maps should be prepared to scale at a sufficient size to accommodate all planning information. Generally orchards of 40 acres or less will require a scale of at least 100 feet per inch. Areas with steep irregular land forms may require larger scales.

After the limitation and hazards of the site are noted, the specific development plan can be addressed. On steep lands, topography will dictate the tree-planting scheme. In most cases, access roads, erosion control practices, and irrigation laterals must be compatible with the natural contours. As a result, the most effective plantings are placed on contours and parallel to roads. The development plan should also illustrate the location of irrigation lines, runoff control mechanisms, erosion control structures, and other relevant soil conservation practices.

Land Clearing

The method employed in clearing land is one of the most critical phases in the development process. A superficial analysis of costs may indicate that the use of straight-bladed bulldozers is the most economical clearing method. However, bulldozers usually increase the vulnerability of the soil to erosion and significantly increase the erosion control costs. Topsoil is also permanently damaged because of surface disturbance and the mixing of excessive amounts of soil with piled brush. A more desirable mechanical clearing method resulting in less soil disturbance is to use a brush mower, rake, or disc. Generally, brush discs or mowers are used on light brush and rakes on heavy
material. Hand removal is the most desirable technique as a primary method of brush clearing. Initial costs may not appear to favor hand clearing. However, a close analysis of costs required to mitigate the effects of mechanical clearing may prove otherwise.

Consideration prior to and during the brush clearing operation should include:

- Clear identification and avoidance of geologically unstable areas.
- Identification of primary surface drainage systems and environmentally sensitive riparian corridors. Undisturbed buffer zones should be left on each side of drainage courses to inhibit erosion.

**Hillside Erosion Control Plan Needed**

- Riparian areas are critical to wildlife needs. All streambed alterations come under the purview of the California Department of Fish and Game and a work permit may be required. Alterations to certain watercourses may also require an approval permit from the Army Corps of Engineers (ACE). In general, the ACE sphere of influence is restricted to perennial streams and tidal waters.
- Some areas that may be developed for avocados are within the sphere of influence of the California Coastal commission or they may be within incorporated areas. Special regulations apply in these zones.
- Identify spoil areas and disposal methods for cleared material beforehand. Ideally brush should be processed through a shredder and disposed of as mulch over the cleared area. This mulch will provide protection from soil erosion and improve soil fertility by returning bound nutrients, increasing water-holding capacities, and improving soil tilth.
- Excavated material should not encroach on water-courses or be deposited in areas subject to flooding.
- Clearing should be done far enough in advance of the rainy season to allow ample time to install erosion control measures.

**EROSION CONTROL PRACTICES**

**Roads**

After land clearing, road construction is the most critical element affecting the long-term viability of an orchard. When road patterns are in place and trees are planted, the layout of an orchard is virtually impossible to modify without a significant expense. Orchard roads serve a variety of purposes and they are constructed in a variety of ways to satisfy these needs. The construction technique employed will be dictated by the most severe slope condition on the orchard site.

On slopes of 15% or less, roads are usually installed to facilitate picking or cultural operations. If the soils indicate a relatively low erosion hazard and adequate orchard ground cover is used, these roads are usually cut-sloped at a minimum gradient of 2.5%, to allow surface water to sheet flow across. Generally cut-sloped roads are 10-12 feet in width and they are at a level grade. If conditions dictate a need to provide a rise in elevation, this rise should be at a uniform grade not exceeding 1.5%.

On slopes in excess of 15%, orchard roads must serve two functions; access and as a surface water diversion and conveyance system.

The need for steep land roads to serve a dual function is dictated by the increased erosion hazard. Following are general construction requirements for diversion roads:

- Width is dictated by equipment types, usually a 10-12 foot width is adequate with critical bends widened as necessary to accommodate vehicle turning radii.
- Gradients should be uniform and not exceed 1% on clay or clay loam soils and at ½% on all other soils. (Water velocities at grades less than 1% may not transport debris normally produced by avocado orchards).
- Road spacing on steep slopes should provide for uniform contour of tree rows. The distance between roads will be dictated by the degree of the slope. To accommodate cultural operations and minimize erosion
concerns, this spacing should allow for not more than 6 tree rows on slopes of 20% or less, 4 tree rows from 20% to 35%, and not more than 2 tree rows on slopes in excess of 35%.

- All diversions must be outletted to water control facilities. These outlets may be existing water-courses or man-made conveyance systems. If outlet velocities exceed 4.0 ft/sec., an energy dissipation device will be required. In general, most earthen outlet points with greater than 2% gradient will require an energy dissipator to ensure erosion control.

- The maximum flow in one direction on a diversion road should not exceed 5 cfs on 1.5% slopes, and 4 cfs on 1.0% slopes. Hydrologic output is a product of multiple factors including drainage area, soil and cover types, storm intensity, and slope. Since there are multiple factors affecting runoff, each orchard will have a unique set of characteristics dictating diversion limitations.

- The cross-sectional characteristics of diversion roads may be either trapezoidal, or elongated “V” shapes. Elongated “V” shapes are generally easier to construct and they require less cross-sectional area than trapezoidal sections; however, maintenance of “V” diversions is usually more difficult.

- “V” shaped roads should be constructed with 6:1 cross-slopes. To ensure stability, cut slope ratios should be 1-1/2:1 on clay or clay loam soils; 1:1 on loam or sandy loam soils; and 2:1 in parent material. Clay soils may be prone to slips or landslides. Compacted fill should be at minimum ratios of 1-1/2:1 on clay or clay loam soils and 1:1 on all other soils. (On slopes greater than 30% the recommended stable cut or fill slopes cannot be achieved without significant encroachment on planting areas).

- If excessively steep slopes are developed, special erosion control techniques must be employed to reduce cut or fill requirements).

- Ridge (berm) width should be at least 2 feet. The compacted height should be at least 1-1/2 feet above the lowest channel point.

Trapezoidal diversions require the same cut and fill slopes as “V” diversions. Cross slopes should be flat, if possible. Berm widths should be a minimum of at least 3 feet and have an effective height after compaction of at least one foot.
All fills must be free of organic material. (<1% organic matter)

A protection ground cover should be installed on all disturbed areas including water conveyance areas.

In addition to diversion on or contour access roads, various connecting roads may be necessary because of the site topography or property limits. Connecting roads usually must be constructed on relatively steep gradients. To mitigate the erosion potential, these roads should be built to exclude overland flows as much as possible. Strategies that can be employed to reduce surface flows include ridge-top locations, crowned or out-sloped roads, and the use of water bars. Some road sections may require additional mechanical controls such as paving with gutters. Water bars are earthen berms that serve as water deflecting devices on unsurfaced roads to prevent gullying. The ditch (or dip) depth should be approximately one foot. Slopes leading into and out of the berm will be determined by the road clearance and axle spacing of the vehicles that will traverse the road. Generally, a slope of at least 3:1 will be required to provide adequate 4x4 vehicle road clearance. The angle of incidence to the flow pattern should be between 30 degrees and 45 degrees. Rules for spacing are:

- A maximum of 80 ft. on any slope
- Immediately below all lateral drainage systems.
- Immediately below all road junctions
- Immediately below springs or seeps.

All water outlets should be into well-vegetated areas and devices such as field rock or concrete rubble should be used to reduce the water energy.
Outlet into well vegetated area or provide proper erosion protection (TYP.)

Dirt Road

Divert Above & Below Road Junctions

Divert above & below sharp curves & tributary drains

Drainage

Normal Spacing

Slope

Spring

On long slopes it may be advisable to tilt the water bar 45 degrees upstream and use an underground outlet to relieve drainage.

TYPICAL WATER BAR ARRANGEMENT

(No Scale)
DRAINAGE DITCHES

The use of drainage ditches is limited in steep orchard developments; however, with relatively flat slopes, they are an economical method of water control.

Ditches should be incised rather than leveed whenever possible, and trapezoidal in shape. The tables following will provide guidance for ditch construction in various soil types. The ditch dimensions are designed to control runoff at non-erosive velocities. If the drainage area is larger than listed in the table, professional help should be solicited. The cross-sectional area cannot be compromised by altering dimensions (increasing depth to narrow top widths) since this will increase water velocities.

<table>
<thead>
<tr>
<th>TABLE 11.1</th>
<th>Earthen Ditches in Highly Erodible Soils (Sandy, Sandy Loam Soils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres Drainage</td>
<td>Bottom Width (Ft)</td>
</tr>
<tr>
<td>1-2</td>
<td>4.0</td>
</tr>
<tr>
<td>3-6</td>
<td>6.0</td>
</tr>
<tr>
<td>7-10</td>
<td>8.0</td>
</tr>
<tr>
<td>11-20</td>
<td>12.0</td>
</tr>
<tr>
<td>21-30</td>
<td>14.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 11.2</th>
<th>Earthen Ditches in Highly Erodible Soils (Sandy Clay Loam, Clay Loam Soils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres Drainage</td>
<td>Bottom Width (Ft)</td>
</tr>
<tr>
<td>1-2</td>
<td>3.0</td>
</tr>
<tr>
<td>3-6</td>
<td>4.0</td>
</tr>
<tr>
<td>7-10</td>
<td>6.0</td>
</tr>
<tr>
<td>11-20</td>
<td>8.0</td>
</tr>
<tr>
<td>21-30</td>
<td>10.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 12.1</th>
<th>Earthen Ditches in Soils With Low Erosive Pot (Clay, Parent Material, i.e., Rock Shale, Sandstone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acre Drainage</td>
<td>Bottom Width (ft)</td>
</tr>
<tr>
<td>1-2</td>
<td>3.0</td>
</tr>
<tr>
<td>3-6</td>
<td>4.0</td>
</tr>
<tr>
<td>7-10</td>
<td>5.0</td>
</tr>
<tr>
<td>11-20</td>
<td>6.0</td>
</tr>
<tr>
<td>21-30</td>
<td>8.0</td>
</tr>
</tbody>
</table>
DRAIN PIPES

Pipelines are commonly used as conveyance systems to safely dispose of surface runoff. Many factors affect the design of pipeline and because of the inherently high cost of materials and construction, a qualified technician should be used to develop drainage plans. The following concerns should be evaluated:

- Pipes should be sized so depth of flow does not exceed \( \frac{3}{4} \) of the pipe diameter.
- Piped mainlines and entrance risers should never be less than 10 inches in diameter regardless of computed sizes. (Minimum sizes are to preclude blockage from floating debris).
- Inlets should have anti-vortex baffles unless they are at least 30% larger than dictated by the design capacity.
- Horizontal (pipe drop) inlets should be equipped with mechanical barriers for safety.
- If berms are required to build head at inlets, the toe of the berm should be at least one foot from the edge of the entrance orifice. The top of such berms should be at least equal to the berm height, but never less than 2.0 feet.
- Horizontal distances between vents should not exceed 160 feet for plastic pipe or 200 feet for other ipe material.
- Pipelines up to 12 inches in diameter require at least 18 inches of cover to adequately distribute weight from vehicles. Pipe diameters greater than 12 inches require at least 24 inches of cover.
- Cutoff collars are required on drainage pipelines to prevent parallel erosion and to provide anchoring if there is a break in grade. Cutoffs are also required at a maximum of 200 foot intervals on long sloping runs. Collars can be incorporated into other pipeline components such as inlets, vents, or at thrust block.
- Thrust blocks are required to absorb shock when there are abrupt changes in the pipeline route. An abrupt change is considered to be:
  a. an angle of 45 degrees or greater when the maximum working head is under 10 feet,
  b. an angle of 30 degrees or greater when the maximum working head is between 10 and 20 feet, and
  c. an angle of 15 degrees or greater when the maximum working head is greater than 20 feet.
- Drainage pipeline systems should be designed to accommodate at least a once in 10-year frequency storm.
- Water courses should not be used for pipeline routes unless the pipes are designed to accommodate the expected flow of the drainage system in addition to the external load. (Usually such pipelines are designed to handle significantly high storm frequencies than normally planned for in most drainage schemes because of their relatively high potential for failure).
Compaction material must have proper moisture. Backfilling should be done in not more than 4 inch layers before compaction. A compaction density of 95% is required.

All pipes should meet specification standards as established by the American Society for Testing and Materials (ASTM).

All outlets must be protected from erosion. Energy dissipators such as rock riprap or concrete may be required. Outlets subject to submergence need special design considerations.

VEGETATIVE EROSION CONTROL

One of the most effective and economical means of reducing erosion on sloping land is through the use of cover crops. Cover crops provide many benefits. There are also some limitations that must be addressed. However, most of the concerns can be mitigated with proper management.

BENEFITS

- Extremely effective erosion control.
- Increased stability of drainage system.
- Improved water penetration.
- Improved soil structure.
- Reduced water velocities and quantities.
- Dust control.
- May provide an environment that promotes the propagation of beneficial insects.
- Increased humidity and reduction of reflected heat.

LIMITATIONS

- Competition with trees for water and nutrients. Mitigate by using annual plants and/or using herbicides in strips in tree rows only.
- Undesirable plants may be harder to control. Mitigate by mowing and using selective herbicides.
- Increases fire hazard. Mitigate by mowing to reduce volume of residue. Disc annuals particularly around the orchard perimeter, before fire season if topography is suitable for equipment access.
- May improve habitat for rodents or some undesirable insects. Mitigate with insecticides and rodenticides.
- Temperatures may be reduced up to 2 degrees F during critical periods with high ground cover. Mitigate by mowing and applying herbicides in tree rows.

Cover crops can be established in a variety of ways, and with a variety of plant species. The method of establishment and the cover species selected will affect the degree of management required and the effectiveness for erosion control. Alternatives for establishing ground covers include:

1. cultivation of existing native annual plants,
2. seeding with improved varieties of native annual plants,
3. seeding with cereal grains,
4. seeding or sprigging perennial plants.

The discussion following is a relative analysis of the cover crop alternatives:

1. cultivation of existing plants

ADVANTAGES:

- No establishment cost.
- Preserves remnant of natural plant community.
- Existing species are probably best suited to that environment.
- Variety of plants is more likely to host a variety of beneficial insects.
Less need to disturb ground will provide higher degree of erosion control.
Self reseeding

**DISADVANTAGES**

- The site must have an inherent seed source. Generally, at least 30% of the existing plant cover has to contain desirable species and this cover type must be uniformly distributed.
- Existing plant communities will contain a variety of plants and a wide range of growth characteristics. So, management will be more difficult.
- Some native plants may serve as hosts for undesirable insects.
- A variety of native plants will be more attractive to a greater variety of vertebrate pests.
- Potentially competitive for water with trees.

(2) Seeding with improved varieties

**ADVANTAGES:**

- Desired growth characteristics can be selected.
- Monoculture is more easily managed.
- Self-seeding.
- Assurance of cover crop establishment.
- Higher degree of erosion protection.
- Does not require irrigation.

**DISADVANTAGES:**

- No additional significant disadvantages.

(3) Seeding with cereal grains

**ADVANTAGES:**

- Early germination and strong competitor.
- Relatively easy to control.
- High degree of erosion protection.
- Does not require irrigation.

**DISADVANTAGES:**

- Poor at self-seeding. Must be re-established each year.
- May produce an intolerable amount of straw.

(4) Seeding or sprigging perennial plants

**ADVANTAGES:**

- Provides highest degree of erosion control.

**DISADVANTAGES:**

- Requires irrigation.
- Difficult to establish.
- Installation costs higher.
- Difficult to eradicate when established.

In most newly developed orchards, the preferred method of establishing vegetative erosion controls is usually to plant self-reseeding grass. Although there are many annual grasses that are suitable, experience has proved that Blando Brome (Bromus mollis) is the most reliable plant on most soil conditions. It has dense fibrous roots, good surface growth characteristics. Moreover, it has outstanding re-seeding ability, and the ability to produce seed under intense
mowing programs provided a re-growth period of 3-4 weeks is allowed, prior to seed maturation. In this area the seed usually starts maturing by April 15. On droughty, infertile soils, Zarro annual fescue (Vulpis myuros) is better suited than Blando Brome. Both plants are winter annuals. They complete their growth cycles and die before the irrigation season.

The featured plants are relatively easy to establish is a reasonable seedbed is prepared. Since most newly cleared orchard sites are in a roughened soil condition, usually additional tillage is not required. Seed should be broadcast at a minimum rate of 6 lbs./acre and covered lightly with a harrow, heavy chain drag, or similar implement. Seed cover should not exceed one-half inch. Plant vigor will be enhanced if a nitrogen fertilizer is applied during the seeding operation. Areas with high potential such as road fills, and drainage courses should be mulched during the establishment year. Brush chips can be used for this purpose; however grain straw applied at a rate of at least 2 tons/acre provides a superior cover. The straw should be anchored by punching into the soil with a straight disc, shovel or similar device. A 90 lb. Bale uniformly distributed over 100 square feet is roughly equivalent to 2 tons/acre.

IRRIGATION

There are many factors affecting the selection of an irrigation system including soils, climate, crop requirements, topography, water supply, management, and cost. Since this guide only addresses mono-cultural agricultural systems on steep land, it is assumed that drip or low flow sprinklers are the only practical alternatives available to the grower. The design of the system selected must be based on specific site characteristics if it is to function successfully with average management input.

SOILS

Soil characteristics that affect design primarily include water intake capabilities, and moisture retention. These characteristics and other factors such as structure, texture, and depth are also of critical importance for effective water management. Water management is addressed under the Maintenance Section of this guide.

Water intake capability may vary within an orchard, if the soils are not relatively uniform. USDA soil surveys contain information that can be used as a general guide for irrigation system planning. These surveys are usually mapped at 5 acres minimum and the transition areas between mapped units may be variable so on-site soil investigations should be completed if there is an apparent and significant difference suspected in the intake characteristics. The following table represents average intake abilities based on textural classes most common in the area. Changes in soil properties because of development processes such as ripping or salinity changes because of improper leaching are not considered.

<table>
<thead>
<tr>
<th>TABLE 18.1</th>
<th>PERMEABILITY AS RELATED TO SOIL TEXTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEXTURE</td>
<td>1/RANGE</td>
</tr>
<tr>
<td>Clay</td>
<td>0.06 - 0.3</td>
</tr>
<tr>
<td>Silty clay loam</td>
<td>0.1 - 0.5</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.3 - 1.0</td>
</tr>
<tr>
<td>Loam</td>
<td>0.5 - 1.5</td>
</tr>
<tr>
<td>Very fine sandy loam</td>
<td>0.5 - 2.0</td>
</tr>
<tr>
<td>Fine sandy loam</td>
<td>1.0 - 3.0</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>1.0 - 3.0</td>
</tr>
<tr>
<td>Coarse sandy loam</td>
<td>1.5 - 3.0</td>
</tr>
<tr>
<td>Loamy fine sand</td>
<td>2.0 - 4.0</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>2.0 - 4.0</td>
</tr>
</tbody>
</table>

1/ Expressed as inches of water/inch of soil

The moisture retention ability of soil is usually expressed as the available water holding capacity (AWC). Available water is the difference between the maximum amount of water a well-drained soil can hold against gravity and the permanent wilting point. AWC is most closely associated with soil texture. Table 19.1 following provides a guide for the most common textural classes. Salt concentrations will reduce the amount of water available to the plants. None of the soils in Ventura County have an inherent problem with salinity. Any salt factor affecting irrigation will be a product of water quality or introduced chemical amendments.
TABLE 19.1
AVAILABLE WATER CAPACITY RELATED TO SOIL TEXTURE

<table>
<thead>
<tr>
<th>TEXTURE</th>
<th>AWC</th>
<th>AWC (IN/3FT) 1/</th>
<th>MAD 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>0.12 - 0.15</td>
<td>4.2 - 5.4</td>
<td>1.68 - 2.16</td>
</tr>
<tr>
<td>Silty clay loam</td>
<td>0.17 - 0.21</td>
<td>6.0 - 7.5</td>
<td>2.4 - 3.0</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.17 - 0.21</td>
<td>6.0 - 7.5</td>
<td>2.4 - 3.0</td>
</tr>
<tr>
<td>Loam</td>
<td>0.14 - 0.18</td>
<td>5.1 - 6.6</td>
<td>2.04 - 2.64</td>
</tr>
<tr>
<td>Very fine sandy loam</td>
<td>0.14 - 0.17</td>
<td>5.1 - 6.0</td>
<td>2.04 - 2.4</td>
</tr>
<tr>
<td>Fine sandy loam</td>
<td>0.13 - 0.15</td>
<td>4.8 - 5.4</td>
<td>1.92 - 2.16</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>0.10 - 0.13</td>
<td>3.6 - 4.8</td>
<td>1.44 - 1.92</td>
</tr>
<tr>
<td>Coarse sandy loam</td>
<td>0.09 - 0.12</td>
<td>3.3 - 4.2</td>
<td>1.32 - 1.68</td>
</tr>
<tr>
<td>Loam fine sand</td>
<td>0.0 - 0.11</td>
<td>3.0 - 3.9</td>
<td>1.2 - 1.56</td>
</tr>
</tbody>
</table>

1/ Three feet average effective rooting depth for avocados
2/ Management allowed deficiency before plant uptake is affected

CLIMATE

The climate in the foothills of Ventura County is characterized by year-round mild temperatures moving through gradual transitions, rather than clearly defined seasons. Fog is a common occurrence because of the marine influence; however, the fog usually dissipates before noon. Freezing temperatures are not uncommon, but they are not a factor of concern relative to irrigation system design unless frost protection is a desired management objective. Abnormally high temperatures, particularly when associated with wind and low humidity are, however, significant and must be planned for. During such periods, the evapotranspiration rate may be as high as 0.20 in/day. The depletion allowance (MAD) of available soil water (AWC) is about 40% for avocados.

TOPOGRAPHY

Steep irregular topography is a limiting factor for drip or low flow sprinkler systems only to the extent that the designs must account for gravity pressures and/or deficit. Emitter discharge rates must be within soil intake capabilities (Table 18.1) to prevent irrigation-induced erosion and to conserve water.

WATER SUPPLY

The water demand during periods of peak consumptive use is about 43-gallons/day/mature tree. Assuming an 85% efficient system and 116 trees/acre, the gross water requirements will be about 50 gallons per tree or 5,800 gallons/acre/day. Expressed as inches of water, this demand will be 0.213"/day/acre. By factoring into the MAD (Table 19.1) a maximum allowable period between irrigations can be determined. If, for example, the soil texture is loamy fine sand, the maximum time of depletion without recharge would be about 6 days. Thus it would require 34,800 gallons of 1.287 acre/inch of water to reach the field water holding capacity. A ten acre irrigation set would, for example, require a system input of 348,000 gallons (12.78 acre/inch).

There are many design strategies to achieve the necessary system input relative to volume requirements if the water resource is limited. Alternatives include the employment of storage or regulating reservoirs, reduced set areas, and increased irrigation frequencies.

A useful formula for checking an irrigation system design is:

\[ F/n = 1.604 \text{ QNTE} \]

\[ (af) \]

Where: \( F/n \) = Net application depth in inches/day
\( Q \) = Discharge rate in gal/hr/emitter
\( N \) = Number of emitters
\( E \) = Field application efficiency, expressed as a decimal (should not exceed 0.90)
\( A \) = Ft (2) of field area served by \( N \) (tree rooting area)
\( F \) = Percent of total area to be settled, expressed as decimal.
1.604 = Units conversion constant (12 in/ft/7.48 gal/ft3)
NOTE: Other water requirements such as leaching must be added to the system output.

The minimum design capacity must be adequate to deliver the average daily water requirements in not more than 18 hours during the peak consumptive period.

SITE MANAGEMENT

A plan that includes frequent and thorough inspections is necessary so routine maintenance can be scheduled. Repairs completed under emergency conditions are frequently sub-standard because the work usually must be performed during adverse weather conditions with inadequate time to provide proper material and equipment.

The site development maps should provide the basis for inspections. Most plans will itemize all the features which affect the orchard drainage and erosion control systems – features which could be overlooked if inspections are performed at random.

RODENT CONTROL

Burrowing rodents are the single most important cause of failure of water control facilities. Rodents are particularly attracted to fill slopes and structural devices such as culvert headwalls – areas that are especially vulnerable to erosion. Plant damage is also a potential problem because of rodent feeding habits. Significant irrigation water can be lost in their extensive tunnel systems.

The animals should be controlled as soon as soil mounds are noted since all rodents are prolific breeders. Either trapping or the application of rodenticides can provide effective control. Pesticides are poisonous and must be used with caution. Consult with the Agricultural Commissioner for proper materials and methods. Many pesticides require a permit before possession or use. Always read the labels carefully and follow the directions exactly.

SURFACE DRAINAGE SYSTEM

Flow capacity depends on the slope, watercourse roughness, and cross-sectional area. Maintaining the designed characteristics of a drainage system is a major concern. The need for removal of debris obstruction is usually apparent; however, hydraulic impairment can also occur in a more subtle fashion from sediment accumulation and excess vegetation.

Sediment usually occurs in channels on the inside of curves and at changes in grade. The tolerable volume of accumulation depends on the designed intent of the system. Generally, sediment should be removed when the cross-sectional capacity is reduced by 10%. Maintenance excavations should not exceed the design limits of the system unless an apparent design deficiency is to be corrected.

Rank vegetation will significantly impair channel flow characteristics by reducing water velocities. However, ground covers are extremely important for erosion control. When possible, grasses and other low-growing plants should be controlled by mowing. Plants with upright growth characteristics should be removed by grubbing or treated with an herbicide and cut back.

Hydraulic capacity will also be reduced from abnormal settlement. In most cases excessive settlement occurs because of improper compaction at the time of construction, vehicle damage, or undermining by rodents. If rodent damage is the apparent cause, the berm should be excavated and recompacted to ensure that all voids are filled. Otherwise the berm can be rehabilitated to specifications with a series of compacted laminations.

STRUCTURAL DEVICES

Erosion is a hazard at or near culvert entrances and outlets, surface drain inlets, diversion outlets and similar devices because flow characteristics at these areas are significantly different than in the principal conveyance. Entrance facilities at drain lines and culverts, in particular, should be closely inspected for piping or cracking in the fill material around the conduit. If there are damaged parts around the inlet, they should be repaired or replaced immediately.

Removal of accumulated trash is a common maintenance requirement. All drainage systems should be inspected for trash accumulations after the first storm producing runoff and at least after each subsequent major storm.
GROUND COVERS

Maintenance of annual self-re-seeding grasses is relatively simple. The only significant concern is that the plants have about a one-month opportunity for seed production at the late stages of their life cycle. In this area, most annual grasses reach maturity around mid-May so the plants should not be mowed or cultivated from mid-March until the plants dry and the seed shatters. Cereal grains or perennial grasses can be mowed at any time, since seed reproduction is not a concern. Any of the grass ground covers will respond to nitrogen/phosphorous fertilizers if a more vigorous cover is desired.

IRRIGATION SYSTEMS

Maintaining an irrigation system is one of the most complex and time-consuming operations in orchard care. Along with assuring that all mechanical, electrical, and hydraulic systems function properly, a critical concern is water distribution at each plant. As the plants mature, water requirement will change. This will affect the needed discharge rate and the area to be wetted, thus the number of emitters or sprinklers required to achieve the water replacement objectives. On page 20, a formula was presented for use in checking the design of irrigation systems. This same formula could be transposed and used as a guide in determining an ever-maturing plant's needs. Keep in mind that this formula initially was presented as a check to ensure system adequacy under mature conditions. The variables, N, A, f, and sometimes Q change throughout various growth stages.

There are many ways to check soil moisture ranging from a simple feel of the soil to various instruments that measure electrical conductivity as a product of soil moisture content. Water losses from the soil are usually expressed as evapotranspiration rates (ET) which is the sum of water loss to the atmosphere from direct evaporation and transpiration from plant leaves. Many factors affect ET including soils, climate, plant community and cultural practices. After orchards are well established, the weather largely controls the ET. Obviously knowledge of the daily ET could be an important management tool in determining irrigation schedules and volume requirements. ET modeling based on historic rates in various climatic zones is available through the USDA for irrigation system planning and for approximations of scheduling requirements during various periods of the year. The University of California is currently engaged in a research and extension program (CIMIS Project) to determine site specific ETs on a daily basis 1/. If feasible, this project will be expanded and ultimately the data would become available to the public as a same day service.

1/ CIMIS Project – California Irrigation Management Information System
SELECTED REFERENCES


References 1-13 are available for review only at: USDA, Soil Conservation Service, 3380 Somis Road, Somis, CA 93066 (805) 482-4206. Personal copies may be obtained from the respective publishers.

References 14-22 are available at: U.C. Cooperative Extension, 669 County Square Dr., Suite 100, Ventura, CA 93003-5401. (8050) 645-1451.

END