APPENDIX C

Kleinfelder Report: Letter to Larry Aksland Regarding Twin Creeks Subdivision in Stockton, California
File No. 20-1739-02
March 9, 1989

Larry Aksland
8282 E. Veritas
Manteca, CA  95336

Subject: ADDENDUM TO OUR LETTER DATED FEBRUARY 14, 1989
TWIN CREEKS ESTATE SUBDIVISION
STOCKTON, CALIFORNIA

Gentlemen:

Following our conference discussion with David LeBeouf and representatives of Michael Baker Engineers, we understand that additional information has been requested regarding Item 5 of our February 14, 1989 letter. We understand that this is the last item of concern before a LOMR can be issued. In summary, Michael Baker Engineers continues to be concerned regarding the presence of trees on the water side of the Mosher Creek Levee as well as the placement of new trees required by the Corps of Engineers and Department of Fish and Game. Computer analyses have been requested showing the effect on levee stability should some of the existing trees fall over. Even though such an event would technically require a three dimensional analysis we have continued to use the two dimensional TSTAB program since it would provide conservative solutions.

In our evaluation of the root zone depth to include in our levee profile, we have used the actual measurements of a downed 24 inch diameter oak tree that exists at the site as shown on photograph R2-6. This photograph is one of many taken along the water side slope adjacent to Mosher Slough. Reference is also made to the cross section presented opposite to each photograph showing surveying measurements of the slope and tree location. We point out that every tree has been numbered and marked in the field. The measured root zone in photograph R2-6 was approximately 2 feet in depth and had a plan dimension of approximately 3 by 5 feet. We understand that survey measurements taken in the hole left by the toppled tree indicate a ground elevation
above the theoretical levee profile.

Presented on Plates I through III are the profiles analyzed. Considering the fact that existing trees are located near the top of slope, at the base of slope, and in clusters we have accordingly removed portions of the water side slope at these locations. The observed two foot root zone depth is consistent with normal growth patterns where tree roots seldom extend into saturated soil. For the benefit of representatives of FEMA and Michael Baker Engineers, we point out that Larry Aksland has owned and operated as much as 280 acres of almond trees and has never observed extensive root development below the groundwater table. In order to evaluate the effect of a deeper root zone, such as may occur for a tree near the top of slope we have also performed our analysis with a root depth of 3 feet. The results of the computed Factors of Safety for these six analyses are presented in Table I. As can be shown there is little impact to the previously computed Factors of Safety. As additional justification for leaving the existing trees in place, we have included a letter dated March 3, 1989 by the Corps of Engineers. This letter describes the requirement to revegetate the levee along Mosher Slough. Since the Corps of Engineers have not only insisted on leaving the existing trees in place but have required additional trees to be planted, it is implied that levee stability would not be adversely affected.

We have included along with this letter to FEMA and Michael Baker Engineers a revised revegetation plan showing the locations of 14 new trees, all located at approximate elevation 5 feet. This elevation is approximately 2 feet above the normal tide level. It was originally intended to locate new trees on the water side as far away from the hinge point of levee as possible, however, the Corps of Engineers and Department of Fish and Game have insisted that several of the bare spots along the creek be covered. Reference is made specifically to that area between Trees No. 26 and 27. As noted the lots are relatively high at this location varying from elevation 5.5 to 9.8 feet. At these locations as well as all other locations where new trees are planned, the elevation of the new trees will be substantially below the adjacent pad elevation. We also note that the fallen 24 inch Oak tree shown on photograph R2-6 is
required to remain in place to provide fish habitat by the State Department of Fish and Game.

A photo album with corresponding cross sections describes the relationship between location and landscaping has been provided with this report. A master plan showing cross sections of the levee with survey locations and elevations of existing trees along this portion of the project has also been attached to this report. For the benefit of FEMA and representatives of Michael Baker Engineers any further questions on the revegetation requirements can be directed to the following individuals who all have met with Larry Askland at the site;

Lou Cadwell of the Corps of Engineers   -  916/551-2253
Tom Skordal of the Corps of Engineers   -  916/551-2262
Kay Goodie of Department of Interior, Fish and Wildlife Service - 916/978-4613

Peggy Coal or James Messersmith of State of California Fish and Game Department   - 916/355-0922
We trust that the information presented sufficiently addresses the last concern expressed by FEMA and representatives of Michael Baker Engineers. We understand that Mr. LeBeouf will be in Washington some time during the week of March 13 through 18 to review this report with FEMA and Michael Baker Engineers. In the mean time if you have any questions regarding the information attached, please contact us.

Respectfully submitted,

KLEINFELDER, INC.

Ron Heinzen, G. E.
Regional Manager

RTH:sfa
MD#73
Summary of Factors of Safety
Waterside – Falling Trees
Table I

<table>
<thead>
<tr>
<th>2 Feet Roots:</th>
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<th>Factors of Safety</th>
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<tr>
<td><strong>Case #</strong></td>
<td><strong>Description</strong></td>
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</tr>
<tr>
<td>1</td>
<td>Top Tree</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>Bottom Tree</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>Top and Bottom Trees</td>
<td>2.4</td>
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<table>
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<th>3 Feet Roots:</th>
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<th>Factors of Safety</th>
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</thead>
<tbody>
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<td><strong>Description</strong></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Top Tree</td>
<td>2.4</td>
</tr>
<tr>
<td>5</td>
<td>Bottom Tree</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>Top and Bottom Tree</td>
<td>2.4</td>
</tr>
</tbody>
</table>
March 3, 1989

Regulatory Section (9665)

Mr. Larry W. Aksland
8282 East Veritas Avenue
Manteca, California 95336

Dear Mr. Aksland:

This letter is to verify a conversation between you and Lou Cadwell of my staff. As Mrs. Cadwell pointed out to you the revegetation of the levee along Mosher Slough is a condition of your Department of the Army Permit Number 9665.

The planting of additional vegetation along the Mosher Slough levee is a mitigation measure for the loss of riparian vegetation caused by allowing you to place fill across the mouth of a tidal irrigation canal.

I am enclosing for your information and assistance in planning your revegetation a list of desirable plant species and undesirable plant species and a drawing which is a guide to spacing of plants on levees. This information was copied from a "Guide for Vegetation on Project Levees" adopted by the State Reclamation Board on December 1, 1967. It has been revised several times, most recently on December 18, 1981. In choosing your plant species, please select native plant species from the list of desirable plants.

If you have any questions, please contact Mrs. Cadwell at the above letterhead address, or telephone (916) 551-2263.

Sincerely,

[Signature]

Tom Skordal
Chief, Regulatory Unit 1

Enclosure
# TABLE 1
Desirable and Undesirable Plant Species for Levees

## Desirable Trees

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
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<tr>
<td>Ash, Arizona <em>Fraxinus velutina</em></td>
<td></td>
</tr>
<tr>
<td>Ash, flowering <em>Fraxinus ornus</em></td>
<td></td>
</tr>
<tr>
<td>Ash, Modesto <em>Fraxinus velutina</em> 'Modesto'</td>
<td><em>Native</em></td>
</tr>
<tr>
<td>Ash, Oregon <em>Native</em> <em>Fraxinus latifolia</em></td>
<td></td>
</tr>
<tr>
<td>California bay <em>Native</em> <em>Umbellularia californica</em></td>
<td></td>
</tr>
<tr>
<td>California pepper tree <em>Schinus molle</em></td>
<td></td>
</tr>
<tr>
<td>Chinese pistache <em>Pistacia chinensis</em></td>
<td></td>
</tr>
<tr>
<td>Coast beefwood <em>Casuarina stricta</em></td>
<td></td>
</tr>
<tr>
<td>Common catalpa <em>Catalpa bignonidides</em></td>
<td></td>
</tr>
<tr>
<td>Crape myrtle <em>Lagerstroemia indica</em></td>
<td></td>
</tr>
<tr>
<td>Eucalyptus, flooded box <em>Eucalyptus microtheca</em></td>
<td></td>
</tr>
<tr>
<td>Eucalyptus, red ironbark <em>Eucalyptus sideroxylon</em></td>
<td></td>
</tr>
<tr>
<td>Evergreen pear <em>Pyrus kawakamii</em></td>
<td></td>
</tr>
<tr>
<td>Fremont cottonwood (male tree) <em>Native</em> <em>Populus fremontii</em></td>
<td></td>
</tr>
<tr>
<td>Goldenrain tree <em>Koelreuteria paniculata</em></td>
<td></td>
</tr>
<tr>
<td>Hackberry, Chinese <em>Celtis sinenis</em></td>
<td></td>
</tr>
<tr>
<td>Hackberry, common <em>Celtis occidentalis</em></td>
<td></td>
</tr>
<tr>
<td>Hackberry, European <em>Celtis australis</em></td>
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</tr>
<tr>
<td>Maidenhair tree (male tree only) <em>Ginkgo biloba</em></td>
<td></td>
</tr>
<tr>
<td>Montezuma cypress <em>Taxodium mucronatum</em></td>
<td></td>
</tr>
<tr>
<td>Oak, coast live <em>Native</em> <em>Quercus agrifolia</em></td>
<td></td>
</tr>
<tr>
<td>Oak, valley <em>Native</em> <em>Quercus lobata</em></td>
<td></td>
</tr>
<tr>
<td>Pagoda tree <em>Sophora japonica</em></td>
<td></td>
</tr>
<tr>
<td>Redtwig dogwood <em>Native</em> <em>Cornus stolonifera</em></td>
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</tr>
</tbody>
</table>
Desirable Trees (continued)

Sawleaf zelkova
    Zelkova serrata

Silk tree
    Albizia julibrissin

Tallow tree
    Sapium sebiferum

Thornless honey locust
    Gleditsia triacanthos
        var. inermis

Tupelo
    Nyssa sylvatica

Wattle, golden
    Acacia longifolia

Wattle, water
    Acacia retinoids

Willow, black
    Salix goodingii
        var. goodingii and
        var. variabilis

Desirable Shrubs

Bladder pod
    Isomeris arborea

Bottlebrush
    Callistemon citrinus

Bush germander
    Teucrium fruticans

Buttonwillow
    Cephalanthus occidentalis

Cleveland sage
    Salvia clevelandii

Coyote bush
    Baccharis pilularis
        var. consanguinea

Dwarf oleander
    Nerium oleander 'Petite Pink or Petite Salmon'

False willow
    Baccharis glutinosa

Fremont silktassel
    Garrya fremontii

Greasewood
    Sarcobatus vermiculatus

Heavenly bamboo
    Nandina domestica

Hop bush
    Dodonaea viscosa

Japanese boxwood
    Buxus microphylla
        var. Japonica

Mugho pine
    Pinus mugho mugho

Mugwort
    Artemisia douglasiana

Myrtle
    Myrtus communis

Noel grevillea
    Grevillea noellii
Desirable Shrubs (continued)

Photina
   Photina fraseri

Redbud, Western \textit{Native}
   Cercis occidentalis

Redbud, Eastern
   Cercis canadensis

Rockrose, sageleaf
   Cistus salvifolius

Rockrose, white
   Cistus hybridus

Saltbush, four-wing \textit{Native}
   Atriplex canescens

Saltbush, quaibush \textit{Native}
   Atriplex lentiformis

Spice bush \textit{Native}
   Calycanthus occidentalis

Strawberry tree (dwarf)
   Arbutus unedo var. compacta

Toyon \textit{Native}
   Heteromeles arbutifolia

Willow, arroyo \textit{Native}
   Salix lasiolepis

Willow, sandbar \textit{Native}
   Salix hindsiana

Desirable Ground Covers

Australian saltbush
   Atriplex semibaccata

Basket-of-gold
   Aurinia saxatilis

Bermuda Grass \textit{Naturalized}
   \textit{Cynodon dactylon 'tifgreen'}
   \textit{Cynodon dactylon 'coastal'}
   \textit{Cynodon dactylon 'Turcote'}

Blue-eyed grass \textit{Native}
   Sisyrinchium bellum

Cape weed
   Arctotheca calendula

Creeping wild rye \textit{Native}
   Elymhus triticoides

Dwarf coyote brush (male plant)
   Baccharis pilularis
   \textit{Twin Peaks No. 2' \textit{Native}}

Dwarf rosemary
   Rosmarinus officinalis 'Prostratus'

Garden lippia
   Phyla nodiflora
   \textit{(Lippia nodiflora)}

Green carpet
   Herniaria glabra

Horsetail \textit{Native}
   Equisetum hyemale

Indian mock strawberry
   Duchesnea indica

Lavender cotton
   Santolina
   \textit{Chamaecyparissus}
Desirable Ground Covers (continued)

Mexican evening primrose
Oenothera berlandieri

Palestine orchardgrass
Dactyliis glomerata
'Palestine'

Perlako creastgrass
Phalaris tuberosa
var. hirtiglumis

Prostrate germander
Teucrium chamaedrys
'Prostratum'

Reed canary grass
Phalaris arundinacea

Salt grass
Distichlis spicata

Stonecrop
Sedum - spp

Trailing African daisy
Osteospermum fruticosum

Wheatgrass, fairway crested
Agropyron cristatum

Wheatgrass, intermediate
Agropyron intermedium

Wheatgrass, pubescent
Agropyron trichophorum

Wheatgrass, sodor
Agropyron riparium

Wheatgrass, tall
Agropyron elongatum

Yellow-eyed grass
Sisyrinchium californicum

Undesirable Trees

Acacia, Bailey
Acacia baileyana

Acacia, kangaroo thorn
Acacia armata

Almond, edible
Prunus dulcis

Apple, crabapple, edible
Malus - spp
Undesirable Trees (continued)

Apricot, edible
Prunus armeniaca

Blue gum
Eucalyptus globulus

Cedar²/
Cedrus - spp

Cherry, edible
Prunus avium

Chinese jujube
Zizyphus jujube

Chinese wingnut
Pterocarya stenoptera

Citrus, edible
Citrus - spp

Coast redwood
Sequoia sempervirens

Colorado spruce
Picea pungens

Cypress²/
Cupressus - spp

Date palm
Phoenix - spp

Elm
Ulmus - spp

English walnut
Juglans regia

Fan palm
Washingtonia - spp

Fig, edible
Ficus carica

Fir²/
Abies - spp

Giant sequoia
Sequoiadendron giganteum

Hawthorn
Crataegus -

Incense cedar²/
Calocedrus decurrens

Locust
Robinia - spp

Loquat
Eriobotrya - spp

Magnolia
Magnolia - spp

Mayten tree
Maytenus boaria

Olive
Olea europaea

Osage orange
Maclura pomifera

Peach and nectarine
Prunus persica

² Conifers, whose normal mature height is 50 feet or less, may be considered desirable under maintenance conditions that (1) protect the tree from drought and (2) will assure proper pruning of the lower branches.
Undesirable Trees (continued)

Pecan
Carya illinoinsis

Persimmon
Diospyros - spp

Pine
Pinus - spp

Plum and prune, edible
Prunus domestica, salicina

Pomegranate, edible
Punica granatum

Quince, edible
Cydonia oblonga

Russian olive
Elaeagnus augustifolia

Silver maple
Acer saccharinum

Tree of heaven
Ailanthus altissima

Yew
Taxus - spp

Undesirable Shrubs

Bamboo
Bambusa - spp

Barberry
Berberis - spp

Berry
Rubus - spp

Broom
cytisus - spp

Cactus
Cactaceae (Many general)

Camellia
Camellia japonica

Cane
Arundinaria - spp

Cape plumbago
Plumbago auriculata

Century plant
Agave americana

Firethorn
Pyracantha - spp

Flowering quince
Chaenomeles

Fuchsia - Flowering gooseberry
Ribes speciosum

Holly
Ilex - spp

Hydrangea
Hydrangea - spp

1/ Conifers, whose normal mature height is 50 feet or less, may be considered desirable under maintenance conditions that (1) protect the tree from drought and (2) will assure proper pruning of the lower branches.
Undesirable Shrubs (continued)

Jasmine
Jasminum - spp

Kumquat
Fortunella margarita

New Zealand flax
Phormium tenax

Oleander /
Nerium oleander

Oregon grape
Mahonia aquifolium

Fompas grass
Cortaderia selloana

Pfitzer Juniper
Juniperus chinensis

'Pfitzrana'

Rose
Rosa - spp

Siberian peashrub
Caragana arborescens

Spanish broom
Genista hispanica

Undesirable Ground Covers

Honeysuckle
Lonicera - spp

Periwinkle
Vinca - spp

Ivy
Hedera - spp

Except dwarf varieties 'Petite Pink' and 'Petite Salmon', which are desirable.
FIGURE 1
GUIDE FOR PLANT SPECIES ON LEVEES

REQUIRED LEVEE DIMENSIONS FOR TREES
(Section View)

MINIMUM SPACING REQUIREMENTS FOR TREES AND SHRUBS
(Plan View)

22-21
ROOT PATTERN INVESTIGATION
NATIVE RIPARIAN VEGETATION ON MOSHER SLOUGH LEVEE
TWIN CREEK ESTATES SUBDIVISION
STOCKTON, CALIFORNIA

Supplement To Response Letter
Dated February 14, 1989

PREPARED FOR: LARRY AKSLAND, INC.
8282 EAST VERITAS
MANTECA, CALIFORNIA 95336

BY: ROBERT C. DIXON
AGRO ENVIRONMENTAL SERVICES
STOCKTON, CA 95207

DATE: APRIL 14, 1989
Reference: Twin Creek Estates Subdivision Stockton, California

FEMA Case No. 89-09-02R

Date Of This Report: April 14, 1989

BACKGROUND

The Federal Emergency Management Agency (FEMA) has requested additional data to support a conditional Letter of Map Revisions (LOMR) for the project referenced above. In part, FEMA has expressed concern that the presence of native riparian vegetation along the water-side of the Mosher Slough levee could impair stability of this levee. Additionally, FEMA has questioned revegetation of certain sections of this levee with desirable plant species. Pursuant to the issuance of Army Permit Number 9665, the Corps of Engineers has required that desirable plant species be replanted as a mitigation measure for the loss of riparian vegetation at another location in this project. Furthermore, the Corps has provided a list of desirable plant species -- "A Guide for Vegetation on Project Levees" -- adopted by the State Reclamation Board (California) on December 1, 1967. This list has been revised and updated several times, most recently on December 18, 1981.

Based on an inspection of the levee vegetation on June 3, 1987, a biologist of the United States Department of Interior, Fish and Wildlife Service, concluded that the waters of Mosher Slough and the native riparian vegetation that line its banks are a crucial habitat to a variety of important migratory birds and fish of concern to the Service. Many unique native species are found in the Sacramento - San Joaquin River Delta in which Mosher Slough is located. For these reasons, the Service desires that this native riparian vegetation be protected.

SCOPE AND PURPOSE OF THIS REPORT

Agro Environmental Services, Stockton, California, was retained by Mr. Larry Aksland, Larry Aksland, Inc. to: 1) determine the root system patterns of this riparian vegetation established along the northern levee of Mosher Slough, and 2) report as to the potential for seepage or other detrimental conditions which could result from the roots of existing trees or trees to be planted as part of the revegetation requirement.
DISCUSSION

Root Development - In native ecosystems, woody vegetation germinating from seed produces a taproot that will grow vertically downward 3 to 7 feet or until oxygen levels or other physical conditions become limiting. However, the vertical taproot is usually choked out by lateral roots and is generally absent in most mature trees. Lateral roots radiate out from the base of the trunk. They rapidly decrease in diameter within 3 to 10 feet from the trunk to form an extensive network of long, rope-like roots one to two inches in diameter. Few large lateral roots are found beyond 10 feet from the trunk. In undisturbed clay soil, these roots are 8-12 inches below the surface. Multiple rebranching of the lateral roots produces a mat or fan of fine, short, non-woody absorbing roots, commonly called "feeder roots", that grow up into the surface soil as conditions are favorable. This root network is short-lived and constantly being replaced (Figure 2-1).

Fig 2-1. Schematic representation of a typical root system of a mature tree
Root Depth and Distribution - A common misconception about roots is that they grow vertically downward in response to gravity. This is only true for a very short period of time in the growth of very young trees. Roots do not grow to or toward anything, rather they grow where soil conditions allow. Roots grow where there is sufficient oxygen, moisture, nutrients, and where the physical structure of the soil does not restrict root elongation and growth. Most roots grow radially outward from the trunk and largely horizontal to the soil surface. Ninety (90) percent or more of the roots of a tree are found within the first three feet of soil. Up to 70% of the roots are found in the top foot of soil (Figure 3-1).

Vertical growing roots are commonly found close to and under the tree. Small roots lateral to large roots grow at many angles to the vertical, and some grow up into the surface soil.

<table>
<thead>
<tr>
<th>Depth (in)</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>12</td>
<td>70%</td>
</tr>
<tr>
<td>24</td>
<td>15%</td>
</tr>
<tr>
<td>36</td>
<td>5%</td>
</tr>
</tbody>
</table>

48" - with favorable soil conditions, the balance of the root system (10%) may be below 3 feet.

Fig 3-1. Typical root system distribution with depth.

Under conditions where the soil is not disturbed by cultivation and a mulch of leaves, weeds, and other plant debris covers the surface of the soil, surface rooting is a common phenomenon. Generally, an extensive network of small diameter and fine roots (feeder roots) are confined to the first 8-12 inches of soil where water and oxygen can readily penetrate.
Fig 4-1. Large roots tend to grow at about the same soil depth regardless of the slope of the soil surface.
Oxygen Starvation - Oxygen availability is a key component of root growth and function. Poor oxygen availability is associated with compacted, waterlogged, heavy clay, paved over and filled (raised) soils. The mixing of soil or the addition of off-site soil, greatly reduces oxygen availability.

Undisturbed soils contain approximately 50 percent pore space in the surface layer (upper 8 to 12 inches) allowing air, water and roots to penetrate. As soil depth increases, the number of soil pores and available oxygen decreases while resistance to root penetration increases. Soil compaction effectively eliminates pore space.

Most land plants will not survive long with the root system submerged in water or surrounded by a soil that is water-soaked. Notable exceptions are rice, various swamp and marsh plants, and the bald cypress (Taxodium distichum).

Air in the pore spaces of the soil is displaced when the spaces become filled with water either from flooding, seepage, or a static, fluctuating or perched water table. Roots will not grow into a water-saturated or oxygen depleted environment. Once the oxygen supply is depleted and anaerobic conditions prevail, roots disfunction and can be killed within 1 to 3 or 4 days of anaerobiosis.

Decreased levels of soil oxygen can result in soils of high clay content, from compaction, and from raising the soil grade or mixing of soils. The latter condition is common with levees and construction sites.

PROCEDURE

A previous study by Aksland provided detailed drawings of the levee cross section at every item of native riparian vegetation along the Mosher Slough levee. Each respective cross section showed the surveyed elevations of the vegetation, the levee, and the normal water level in the slough. From this data, four of the largest and most representative trees of the woody riparian vegetation were selected.

The slope of the levee and the presence of vegetation prevented the use of a backhoe to dig a series of slit-trenches to assess rooting patterns. Furthermore, trenching would have caused greater damage to the integrity of the levee and to any roots which might have been encountered.
Therefore, a portable, 6-inch diameter power auger was used to drill a series of vertical inspection holes into the levee to visually determine the presence of roots, their size and their depth relative to the surface of the soil or the face of the levee. Borings were made ranging in depth from 6 to 8 feet. Depending on the configuration of the leaf canopy of the tree selected for evaluation, borings were made at distances ranging from 5 to 18 feet from the respective tree trunk to the land-side of the levee. See APPENDIX A-1 through A-4.

FINDINGS

Groundwater was not encountered in any of the borings. When roots were encountered, small diameter to fine feeder roots (1/8 inch or less in diameter) were found in the upper 2 feet of soil. At one site (Bore-2, Item #2, a 30" diameter willow), feeder roots were visible to a depth of 4.5 feet. When encountered, larger diameter lateral roots were found at a depth of 2 to 2.5 feet. None were found below this depth. See Logs APPENDIX B-1 through B-4.

CONCLUSIONS

Established Native Vegetation - The depth of roots observed in the representative bore holes is consistent with root patterns of trees described in the literature and actually seen under "field" conditions. It is also concluded that the root patterns seen in the bore holes are representative of the root patterns of all native vegetation along the levee.

The constant waterlogged conditions on the water-side of the levee and the concurrent oxygen deficient soil at the water-bank interface precludes any root growth or development into the water or below the waterline as established by the normal water level in the slough. In other words, roots will not grow or function in water-logged soil.

Horizontal root growth into the interior part of the levee is likewise restricted due to the compacted, high density of the levee soil. Geophysical assessments made by Kleinfelder indicate that the soil of the original levee is compacted to greater than 85 percent. The improved levee has an average compaction of 93 percent. In soils compacted to this density, there is insufficient pore space to provide adequate moisture and aeration (oxygen) to sustain root activity. Therefore, it is concluded that the root pattern of the native vegetation, particularly of the large trees, occupies the upper 2.5 feet of soil with a network of fine roots predominantly in the top 24 inches of soil. The roots lie in a plain that is parallel to the slope of the surface soil.
(Figure 4-1). From the root pattern of a large wind-fallen oak on the levee and a large tree that was removed from the levee for construction purposes, the roots of this native vegetation has not penetrated deeper than 3 feet into the soil.

It is further concluded that because the roots are in the surface soil of the levee, loss of any vegetation and the subsequent decay of any roots would not impair the integrity of the levee even if water rose to the designed flood level. Evidence at the site indicates that any uprooting of trees along the levee will only disturb the upper to 2 to 3 feet of soil on the levee slope and in most cases this would be above a 3:1 slope configuration of the levee.

Another key element is a ledge that is evidence of the original levee. By the obvious age of the trees and shrubs which line the bank of Mosher Slough, this native vegetation has established its roots in this soil matrix and not in soil that has been added to build-up the levee to its present height of 11.5 feet. Observation of the bank shows numerous large roots which are visible just above the water line. These roots run parallel with the levee and the water course. They do not grow into the water-logged soil on the water-side of the levee and they do not grow horizontally into the levee to any great distance because of a lack of oxygen. According to Kleinfeld, borings into this original levee reveal that it consists primarily of cohesive silt and clay materials in a medium-stiff to stiff condition. Therefore, the root pattern of vegetation along the levee is shallow, parallel to the levee and slough, and confined to that soil where the conditions of moisture and aeration favor root activity. Such conditions do not prevail in the interior of the levee or in the water-logged soil of the slough.

Revegetation - It is my opinion that planting of desirable plant species, as required by the Corps of Engineers and as desired by the Fish and Wildlife Service, will not impair the integrity of the levee or necessarily set the conditions for seepage (Department of Army letter, March 3, 1989, Guide For Plant Species On Levees). This opinion is given based on the information on rooting patterns presented in the discussion section of this report and on visual evidence obtained at the site. Trees and shrubs planted near the normal waterline of the slough where favorable conditions of moisture and aeration occur will become established on their own without much supplement care. This would be a preferred planting area.
However, it is my opinion that plantings higher on the slopes of the levee may require periodic watering until they become fully established. In drought years, supplemental irrigation may have to be provided even for these trees and shrubs if they are to maintain minimum levels of health and vigor.

*** *** *** *** ***

I trust that this report adequately addresses the concerns expressed in various correspondence from FEMA. If you have any further questions, please contact me.

Respectfully submitted,

[Signature]

Robert C. Dixon, CP Ag
Certified Professional Agronomist
ARCPACS #354

RCD/md
REFERENCES

1. Tree Roots - Major Considerations For The Developer, January 1989, B. W. Hagen, Staff Forester, California Department of Forestry and Fire Protection.

2. Tree Notes - Roots Function, Distribution and Depth, B. W. Hagen, Staff Forester, California Department of Forestry and Fire Protection.


4. Tree Tolerance to Inundation, Progress Report, July 1, 1973, R. W. Harris et. al., Department of Environmental Horticulture, University of California, Davis.

5. Arboriculture, R. W. Harris, pages 42-47.

6. Private technical reference library, Agro Environmental Services.
TWIN CREEKS ESTATES
MOSHER CREEK
Levee cross sections

DATE 03/20/89
SCALE:
HORIZ $1'' = 10'$
VERT $1'' = 10$

ITEM: #2, 30" Tree
PHOTO: 27
R2-31 Full view

$\n = $ Bore Location

APPENDIX A-1
Agro Environmental Services
TWIN CREEKS ESTATES
MOSHER CREEK
Levee cross sections

DATE 03/20/89
SCALE:
HORIZ 1" = 10'
VERT 1" = 10'

ITEM: #9, 42" Oak
PHOTO: 36
R2-1 is SE view of brush between #9 and #10
R2-2 is SW view of brush between #10 and #9

\(\n\begin{align*} 
\text{TOP LEVEE} & \quad 12.0' \quad 11.5' \\
\text{LOT GRADE} & \quad \text{EL 4.1} \quad 2 \\
\text{1} & \quad \text{1} \\
\text{EL 9.7} & \quad \text{EL 7.9} \\
\text{EL 0.0} & \quad \text{EL 4.7} \\
\text{EL 1.4} & \quad \text{EL 5.9} \\
\end{align*} 
\)

\(\n\n\bigtriangledown = \text{Bore Location}
\)

APPENDIX A-2
Agro Environmental Services
TWIN CREEKS ESTATES
MOSHER CREEK
Levee cross sections

DATE 03/20/89

SCALE:
HORIZ 1" = 10'
VERT 1" = 10'

LEVINGE TOP
EL 11.5

LOT GRADE
EL 4.7

\( \n = \) Bore Location

ITEM: #16 21" OAK
PHOTO: R2-10

APPELLIX A-3
Agro Environmental Services

Depth of bore is 8.0 feet
TWIN CREEKS ESTATES
MOSHER CREEK
Levee cross sections

DATE 03/20/89

SCALE:
HORIZ 1" = 10'
VERT 1" = 10'

ITEM: #22 48" Willow
PHOTO: P2-15

\( \nabla \) = Bore Location

TOP OF LEVEE
EL 11.5

LOT GRADE
EL 5.7

3
1

EL 9.1

3

EL 4.7
EL 3.5
EL 1.3

APPENDIX A-4
Agro Environmental Services
LOG DESIGNATION  Item #2, 30" dia Willow Tree

Date: 4-05-89
Logged by: RCD
Elevation:
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description Soil Profile</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 0 to 3&quot;</td>
<td>Surface roots 1&quot; dia or less.</td>
<td>Bore-1, 5 feet to the levee side of tree trunk.</td>
</tr>
<tr>
<td>2.5'</td>
<td>Large diameter root - auger could not pass.</td>
<td></td>
</tr>
<tr>
<td>- 0 to 4.5'</td>
<td>Fine surface and feeder roots length of auger hole.</td>
<td>Bore-2, moved slightly to side of Bore-1.</td>
</tr>
<tr>
<td>4.5' to 6.0'</td>
<td>No roots visible. Moist clay at 6 feet, auger would not clear, drilling stopped.</td>
<td></td>
</tr>
</tbody>
</table>

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.
LOG DESIGNATION  Item #9, 42" dia Oak Tree

Date: 4-05-89  Job: Aksland - Mosher Slough
Logged by: RCD  Reference: Item #9, 42" dia
Elevation: oak tree
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 0 to 6'</td>
<td>No roots visible. Soil uniformly moist.</td>
<td>Bore-1, 18 feet to levee side of tree trunk. Approximate dripline of the leaf canopy.</td>
</tr>
<tr>
<td>- 0 to 12 inches of soil</td>
<td>A few small surface roots in upper moisture.</td>
<td>Bore-2, 12 feet west of tree trunk and 8 feet from water edge.</td>
</tr>
</tbody>
</table>

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

APPENDIX B-2
Agro Environmental Services
LOG DESIGNATION  Item #16, 21" dia Oak Tree

Date: 4-05-89  Job: Aksland - Mosher Slough
Logged by: RCD  Reference: Item #16, 21" dia
Elevation:  oak tree
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description Soil Profile</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 8'</td>
<td>No roots visible.</td>
<td>Bore-1, 14 feet to levee side of tree trunk. Approximate dripline of the leaf canopy.</td>
</tr>
</tbody>
</table>

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

APPENDIX B-3
Agro Environmental Services
LOG DESIGNATION  

Item #22, 48" dia Willow Tree

Date: 4-05-89  
Job: Aksland - Mosher Slough
Logged by: RCD  
Reference: Item #22, 48" dia
Elevation:  
willow tree
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description Soil Profile</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 0 to 24&quot;</td>
<td>Small roots 1/8 inch or less in diameter.</td>
<td>Bore-1, 5.5 feet to levee side of tree trunk.</td>
</tr>
<tr>
<td>- 24&quot;</td>
<td>Large root, auger could not pass.</td>
<td></td>
</tr>
<tr>
<td>- 0 to 24&quot;</td>
<td>Small diameter roots to 24 inches, large root encountered at 24 inches, auger could not pass.</td>
<td>Bore-2, 5.5 feet to levee side of trunk, approx. 2 feet west of Bore-1.</td>
</tr>
<tr>
<td>- 0 to 84&quot;</td>
<td>No visible roots.</td>
<td>Bore-3, 13.5 feet to levee side of trunk, approx 2 feet west of Bore-2.</td>
</tr>
</tbody>
</table>

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

APPENDIX B-4  
Agro Environmental Services
VITA
ROBERT C. DIXON
Consulting Agronomist

Experience

Mr. Dixon has 30 years of agronomic experience with responsibilities in sales, marketing, management, and technical functions. As the principal in Agro Environmental Services, he provides agronomic and agriculturally related environmental services to industry, agribusiness, and large-scale mechanized and small-holder irrigated farming systems.

These services include technical, management, and hands-on agronomic and pest management responsibilities for over 1500 acres of diversified crops including alfalfa. Mr. Dixon has provided soil and crop agronomic expertise for projects involving the recycling of industrial waste water to land/crop systems and the conversion of liquid rocket fuel into fertilizer. He is currently Project Manager and Consultant involving the treatment of agricultural wash water for cropland disposal. This project also involves a multidisciplinary team effort to assess the impact on soil and groundwater resulting from previous, long-term wash water discharges. Mr. Dixon is functioning in a similar capacity for an industrial site assessment of soil and groundwater which could impact adjacent prime agricultural land.

Mr. Dixon is the author of the "Crop Nutrient News" column which appears monthly in the Agribusiness Fieldman. He has also authored trade journal articles and numerous technical papers on fertilizer-use, plant nutrition, and salinity and sodic soil management. He is a frequent speaker at industry technical conferences and university workshops.

Education

Mr. Dixon is a graduate of the University of California at Davis. He holds a B.S. degree in Plant Science (Agronomy) with emphasis in soil chemistry and plant nutrition. Mr. Dixon is a Certified Professional Agronomist, a Pest Control Advisor licensed by the State of California, and holds a certificate in Hazardous Materials Management from the University of California Extension. He is recognized as a Certified Professional Agronomist by the American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS). He is a Certified Member of the American Society of Agricultural Consultants, and a member of the American Society of Agronomy, Soil Science Society of America, the California Agricultural Production Consultants Association (CAPCA), and the California Fertilizer Association.

APPENDIX C-1
Agro Environmental Services
Evidence of Experience

Mr. Dixon has been or is currently responsible for the following projects:

**Crop Production**
- Deseret Farms of California (1250 acres - walnuts)
- Ohm Ranch (200 acres - sugar beets)
- Thompson Ranch (1200 acres - walnut, sugarbeets, wheat, corn, and alfalfa)

**Agricultural Land Evaluation**
- Neumiller & Beardslee, Attorneys & Counselors
- Nichols & Berman, Environmental Planners
- RLC Associates, Civil Engineers
- Jake Weststeyn

**Agronomic Assistance and Training**
- Agro Tech
- Arcadian Corp.
- California Agricultural Resources Inc.
- California Ammonia Co.
- City of Piedmont, California
- Earth Resource Data Corp. (Verde Technologies)
- Kerley Ag Products Inc.
- SoilServ Inc.
- Willoughby Farms Inc.

**Crop Loss and Damage (Forensic Agronomy)**
- Angelakis Vineyards
- CGG Land Seismic
- Franchetti & Franchetti, Attorneys at Law
- Mazzera, Snyder & DeMartini, Attorneys at Law
- R. C. Farms
- Scoular Grain Inc.
- South San Joaquin Irrigation District
- Stammer, McKnight, Barnum & Bailey, Attorneys at Law

**Environmental Agronomy**
- All Pure Chemical Co.
- Diablo Ag Chemical Co.
- Snow Commodities Inc.
- Triple E Produce Corp.
- Vandenberg Air Force Base/Dowell Schlumberger
- Western Farm Service Inc.

APPENDIX C-2
Agro Environmental Services
Product Development and Marketing Studies

Alpine Plant Foods, Inc.
Arcadian Corp.
Domtar Gypsum America Inc.
Foster Farms
J.R. Simplot Co.

Writing and Publishing

California Ammonia Co.
Kerley Ag Products Inc.
Western Agricultural Publishing Co.

References

1. Mr. Carl Spiva, Agronomist/Consultant
   1101 Stratford Lane
   Modesto, CA 95350  (209) 529-4460

2. John H. Sammons, Ph.D.
   Principal Scientist, Western Division Manager
   The Traverse Group, Inc.
   2011 Feliz Road
   Novato, CA 94945-1702  (415) 892-0022

3. Dr. Roland E. Meyer
   Extension Soil Specialist
   University of California
   129 Hoagland Hall
   Davis, CA 95616  (916) 752-2531

4. Terry L. Prichard
   Area Soils and Water Specialist
   University of California, Cooperative Extension
   420 South Wilson Way
   Stockton, CA 95205  (209) 944-3711

APPENDIX C-3
Agro Environmental Services
TO: Mr. Tim Washburn, Director of Planning, Sacramento Area Flood Control Agency  
1007 7th Street, 7th Floor, Sacramento, CA 95814  
FROM: Alison M. Berry, PhD  

Dear Mr. Washburn:  

In response to your request of 1/29/2010, I have reviewed the documents that were  
emailed to me on Jan 29, 2010, regarding assessment of trees and tree roots along the  
Mosher Creek Levee, Stockton, California, with particular attention to the methods,  
results and interpretations presented in the report by Robert C. Dixon.  

I received copies of 3 documents, which I will briefly describe:  
Document 1: An addendum dated March 9, 1989, and stamped by Ronald Heinzen,  
Regional Manager of Kleinfelder, Inc., containing results of 2D modeling of levee profile  
impacts of root systems either 2’ or 3’ deep. The root depth dimensions were based on  
field observations of the root system of a downed oak tree that fell over along the water  
side slope adjacent to Mosher Slough, and on personal observations of a local almond-  
tree farmer. The tree was 24” in diameter, with a root plate that was 2’ deep, and 3’ – 5’  
in horizontal extent. Photos of the tree were not included in this copy of the document.  
One conclusion was that the shallow root plate indicates a high water table. This  
evaluation appears to be reasonable and accurate. Factors of Safety were calculated using  
the 2D profile data, and did not differ greatly among the cases considered.  

Document 2: A cover letter dated March 3, 1989, and accompanying tables, from Tom  
Skordal, Chief, Regulatory Unit 1 of the Department of the Army, Sacramento District  
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planting on levees, including trees, shrubs and ground cover. Included also are levee sections  
indicating locations on the levee slopes where trees and shrubs should be planted. The list of desirable trees includes many species observed on or adjacent to  
levees I have visited in the Sacramento and Delta region. Many, but not all of the tree  
species indicated as desirable on this list are native California riparian species.  

Supplement titled: Root Pattern Investigation: Native Riparian Vegetation on Mosher
Slough Levee, Twin Creeks Estate Subdivision, Stockton, CA. Author: Robert C. Dixon, Consultant to Agriculture, Agro Environmental Services, Stockton, CA 95207. Mr. Dixon carried out a field study of root system depth and extent of 4 trees located on or adjacent to the Mosher Slough Levee, with respect to potential for seepage or other detrimental effects of the tree root systems on the levee.

Assessment:
Mr. Dixon first presents a discussion of tree root system architecture, root depth and distribution (pp. 2-3). The discussion is generally accurate, except that estimates of rooting depth are somewhat too shallow to apply to all soil conditions, and estimates of percent of roots in the top 12” of the soil horizon (70%; Fig. 3-1) are only accurate for trees with root systems within 12-24” of the water table. In deeply-drained, sandy soils adjacent to levees in Sacramento, I have measured somewhat deeper rooting patterns, i.e. major structural roots of one oak tree were found at 4-5’ depth (Mayhew Levee), and a taproot on another oak tree extended beyond 6’ of depth (Pocket Levee).

The pattern of root growth observed by Mr. Dixon to follow below the grade of the levee slope, depicted in Fig. 4, has also been observed by us at the Pocket Levee.

Mr. Dixon’s description of oxygen availability in soils and the consequences for tree roots (p. 5) is generally correct.

The method used by Mr. Dixon to assess the depth and extent of tree root systems without causing major damage to the levee structure seems reasonable, although with some limitations, as described below. A 6-inch diameter power auger was used to drill vertical inspection holes at distances from the trunks of 4 trees – 2 willows and 2 oaks (shown in Appendices A1-A4). The trees were selected as representative of the Mosher Levee vegetation based on survey data previously acquired.

Information on soil particle distribution and other soil characteristics at the site was not provided in the report I received. Photos were taken of the trees measured, but these were not part of the report I received.

The results, summarized in the text, p. 6, and presented in Appendices B1-B4, showed:
1. that roots were present in bore holes near the tree trunks, but that no major roots were identified in bore holes at or beyond a horizontal distance of 12’ from the center of the trees sampled.
2. in terms of root depth in bore holes made closer to the tree trunks (distances of 5’ and 5.5’ from the trunk), in two cases (B-1-1, B-4), large roots were encountered at 2’-2.5’ depth, at which time augering was stopped. It was not possible to auger through the roots, and therefore it was not possible to determine the depth of the root systems beyond 2’-2.5’. In one bore-hole at 5’ from a willow trunk (B-1-2), no roots were encountered to a depth of 6’.

Mr. Dixon’s conclusion is that planting desirable tree species would not impair the integrity of the levee or set conditions for seepage. He suggested that trees should be planted close to the water line, rather than on the levee slope, because the Mosher Creek Levee is highly compacted. This is a reasonable conclusion, since tree roots will not penetrate highly-compacted soil.
General Summary Comments:
Mr. Dixon’s report and its conclusions are consistent with his field findings. However, a more extensive drilling survey (more trees, more bore-holes per tree, and some intermediate sampling distances between 5’ and 12”) is needed to provide a more robust data set, so long as extensive drilling would not compromise the levee integrity. The auger method also has the limitation of being able to penetrate the soil profile only to the depth where a large woody root is encountered; this prevents measurement of full rooting depth.

References

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Mattheck web page: