A MANAGEMENT PLAN FOR THE SPRINGTOWN ALKALI SINK WETLANDS AND THE ENDANGERED PLANT <u>CORDYLANTHUS PALMATUS</u>

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December 27, 1988

Mr. Robert Brown, Planning Director
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Dear Mr. Brown:

Management Plan for the Springtown Alkali Sink Wetlands and the Endangered Plant Cordylanthus palmatus (palmate-bracted bird's-beak)

We are pleased to present the results of the recently completed proposed management plan for the Springtown wetlands in the City of Livermore. This project was undertaken as a consequence of the substantial concerns of the U.S. Fish and Wildlife Service and California Department of Fish and Game that, without specific regulatory and management guidance to the City from our agencies, urban development would threaten the highly significant biological values and resources of the Springtown wetlands, an area that supports the largest viable population of the state and federally endangered palmate-bracted bird's-beak (Cordylanthus palmatus). Expansion of urban development in and around Livermore has already eliminated substantial areas of valuable wetland and other formerly productive fish and wildlife habitat. Projected future growth of the City of Livermore threatens to cause additional significant losses of these dwindling natural resources. Without adequate native habitat, healthy populations of fish, wildlife and endangered species will not survive in the wild, depriving future generations of their natural biological heritage.

Chapter 10 of the attached report identifies land use designations and wetland management actions necessary to ensure the protection and long-term maintenance of the wetland area and its diversity of fish, wildlife and plants. The land use designations constitute zones of allowable use intensity, with guidelines for each zone on the general types and levels of land use that are compatible with maintaining the long-term viability of the Springtown wetlands. This is intended to assist the City of Livermore in making land use decisions for the area. We believe that, if implemented, they would ensure the protection of this highly significant ecosystem.

The report emphasizes that the continued viability of the Springtown wetlands and its animals and plants directly and critically depends upon maintaining the structural and functional integrity of the watershed. Therefore, the planning area identified in the report for the maintenance of the Springtown wetlands includes approximately 13 square miles of watershed lands. The potential presence of the state- and federally listed endangered San Joaquin kit fox in this area should be an important additional consideration in implementing these recommedations.

We recognize that implementing this plan would create an ecological preserve that would prohibit or severely restrict private development. To obtain the necessary degree of habitat protection, therefore, will require that government at all levels proceed to bring the private land under public protection through one or more mechanisms available to them. Alternatives include:

(1) A city-administered density transfer from Zones A and B to less sensitive private lands planned for development, with dedication of the preserved lands to the City;

(2) Use of funds from development fees within a designated fee boundary area or assessment district;

(3) Use of funds conveyed to cities and counties for preservation of natural resources through Proposition 70;

(4) Use of funds administered by the State Wildlife Conservation Board generated by Proposition 70 or derived from the California Environmental License Plate Fund;

(5) Acquisition by the U.S. Fish and Wildlife Service; or

(6) A combination of the above.

Ultimately, management and administration of a preserve could be undertaken by local, regional, state or federal agencies through interagency agreements.

We offer this report in the spirit of cooperation and as a first step toward resolving the land use conflicts surrounding the protection of the Springtown wetlands. We further suggest a meeting of our staffs to discuss the contents of the report and to answer any questions you or your staff may have. We look forward to working with the City and private landowners on this important matter.

If you or your staff have any questions, please contact Carl Wilcox at (707-944-5525) or Ted Wooster (707-944-5524) of the Department, or Monty Knudsen (916-978-4866) of the Service.

Sincerely,

for Pete Bontadelli
Director
Department of Fish and Game

David L. Harlow
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Attachment

cc: Col. Galen H. Yanagihara, District Engineer, U.S. Army Corps of Engineers
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EXECUTIVE SUMMARY

The Springtown Alkali Sink on the northeast side of the Livermore Valley in Alameda County is a complex mosaic of vernal pools, mounds, and alkali "scalds," supporting a significant remnant of alkali sink scrub vegetation. This vegetation type, which formerly covered extensive areas of the Sacramento and San Joaquin valleys, has been largely destroyed by agricultural and urban development. At Springtown, the alkali sink scrub community includes the largest of the four remaining populations of the palmate-bracted bird's-beak (*Cordylanthus palmatus*). This hemiparasitic annual plant is on both the State and Federal lists of Endangered Species. Seasonally, the wetlands support migrating shorebirds and waterfowl. A variety of hawks, eagles, and falcons use the area year-round. Recently, parts of the Springtown Alkali Sink have been destroyed directly by subdivisions, disturbed by off-road vehicles, discing, scraping, or hydrologically altered by developments off-site. The long-term survival of *Cordylanthus palmatus* depends on the careful management of the existing habitat and restoration of the remaining areas of alkali sink at Springtown.

The Springtown Alkali Sink formed on the gently sloping alluvial valley floor, where a fault has occluded groundwater movement and altered the course of Altamont Creek. Erosion of the marine shale and sandstone that comprise the Altamont uplands northeast of the Sink has contributed both fine-grained sediment and dissolved salt, especially sodium chloride, to the sink. Mean annual potential evaporation is about 57 inches, far greater than the mean annual precipitation of only 14 inches. Runoff from the Altamont uplands reaches the Sink either as surface flow during intense storms or as relatively shallow groundwater flow. The water table in the lower portions of the Sink is within 2-4 ft. of the soil surface even in dry years, allowing upward movement of water and salts by capillary action.

Two saline-sodic soils occur in the Alkali Sink. These are the Solano Fine Sandy Loam and the Pescadero Clay. Both are characterized by a moderately acid surface horizon (pH of 5 to 6) and a sodium-rich clayey subsoil with poor structure. The structure of the subsoil reduces the internal drainage of the soil, contributing to ponding of water on the soil surface during the winter, and further enhancing the accumulation of soluble salts.

The soils of the Alkali Sink are characterized by a distinctive microtopography of mounds and swales. The origin of this microtopography is unclear, but it is responsible for much of the vegetative and hydrologic diversity of the site.

The local variation in soil chemistry and hydrology in the Alkali Sink associated with the mound topography has led to the development of a complex mosaic of alkali sink scrub vegetation and annual grassland. The alkali sink scrub may be subdivided into two subtypes: iodine bush scrub and alkali grassland. The iodine bush subtype occurs along the braided channels of the alkali sink. The alkali grassland subtype also occurs in the channels, although it is not restricted to them.

In some swales, the accumulation of salt and high levels of sodium in the soil has led to the development of "alkali scalds." Conditions in the scalds are so harsh that only a few isolated individuals of salt-tolerant plants occur in them. Where drainage and soil chemical conditions are somewhat better, alkali scalds grade into alkali grassland and, in best-drained areas, annual grassland. Where water accumulates in pools but salt concentrations are somewhat lower, a rich vernal pool biota may be found.

Cordylanthus palmatus occurs primarily along the braided drainage channels on the sides of the swales in the iodine bush subtype, often at the boundary between the iodine bush subtype and the annual grassland. It also occurs to a lesser extent in alkali scalds, where soil conditions are more extreme. It never occurs on mound tops in the annual grassland.

The distribution of Cordylanthus on the sides of swales may result from: 1) seed dispersal by flowing water; 2) dilution of soil salt concentrations by surface water; and 3) segregation of plants along gradients of soil chemistry and available soil moisture. Measurement of stem water potentials in Cordylanthus at the Springtown site showed that in July, the predawn water potential of Cordylanthus was comparable to that of plants in a well-tended garden. Stem water potential measurements of plants associated with Cordylanthus suggested that salt grass may be the host plant, but the results were somewhat inconclusive.

Land-use impacts have destroyed or severely altered much of the Springtown Alkali Sink. Cattle have grazed there for many years, reducing the vigor of iodine bush and probably favoring introduced annual grasses over perennials. In the early 1970s, subdivisions were built in and around the Alkali Sink. Some areas not directly destroyed were hydrologically altered. Ephemeral drainages were diverted to storm drains and routed directly to Altamont Creek, thus reducing overland flow to the Sink. To provide flood protection for newly constructed homes, Altamont Creek was deepened and straightened in some reaches, further reducing the flooding on the valley floor. Where ephemeral streams were diverted around a subdivision, gully erosion was initiated, threatening to further lower the shallow groundwater level.

Subdivisions in the Sink have brought with them another problem: off-road vehicles. Motorcycles and all-terrain vehicles have caused considerable damage where the mound-swale topography is best developed. In some areas, vegetation has been completely eliminated and the soils compacted to the extent that substantial efforts will be necessary to restore the habitat.

Some parts of the Alkali Sink (including areas supporting Cordylanthus) were disced in 1983, resulting in the issuance of two cease-and-desist orders by the U.S. Army Corps of Engineers. Cordylanthus still occurs on some of the disced area, but not to its previous extent.

The northern portion of the Springtown Alkali Sink is owned by the City of Livermore, which intends to develop the area for public use. Development of privately owned parcels has been held in abeyance pending resolution of issues regarding protection of the wetlands and the endangered plant. The City and the U.S. Army Corps of Engineers would be the lead and permitting agencies for proposed land-use changes on these lands. California Environmental Quality Act and National Environmental Protection Act documents would be required. The presence of wetlands and endangered species on-site would trigger a number of applicable State and Federal laws, regulations, and policies administered by several agencies.

Under the Fish and Wildlife Coordination Act and the Federal Endangered Species Act, the U.S. Fish and Wildlife Service and the California Department of Fish and Game would advise the Corps during their consideration of permit applications. The recommendations developed in this study represent the measures necessary to comply with the applicable laws, regulations, and agency policies to ensure the continued survival of these resources.

We have subdivided the Alkali Sink and its watershed into land use intensity zones. Zone A is the Alkali Sink, wetlands, and potential habitat for Cordylanthus palmatus. No further development should occur in this zone, and an active protection and management program should be implemented. Zone B is a buffer zone around Zone A; no subdivisions or new roads should intrude on this zone, but open space uses (such as a ballpark or picnic area) should cause no problem if properly designed to assure compatibility with maintenance of the adjoining wetlands. Zone C is the watershed of the Alkali Sink. Any development in Zone C should be carefully designed to prevent indirect impacts to the wetlands.

Maintaining the alkali sink for its hydrologic and ecological values, however, will require more than simply acquiring and fencing the site. It will require long-term management actions including: 1) exclusion of future development from the Alkali Sink and wetlands; 2) careful design of future developments within the surrounding watershed to prevent hydrologic impacts to the alkali sink and wetland habitat; 3) public education and enforcement to prevent further ORV intrusion; 4) hydrologic restoration to repair gully erosion and enhance overland flow; 5) removal or reduction of grazing; 6) experimental controlled burning; 7) long-term monitoring of vegetation and hydrology; and 8) establishment of new populations of Cordylanthus palmatus on suitable habitat at other sites, with appropriate protection, monitoring, and management.

The presence of Cordylanthus palmatus and its unique alkali sink habitat at Springtown offers substantial opportunities for educational and interpretive programs, scientific research, and some kinds of outdoor recreation. With proper planning and maintenance, the alkali sink ecosystem can become a valuable asset to the Livermore community, while preserving important wildlife habitat and the finest remaining example of one of California's rarest and most endangered plants.

MANAGEMENT PLAN FOR THE SPRINGTOWN ALKALI SINK

AND THE ENDANGERED PLANT CORDYLANTHUS PALMATUS

1.0 Introduction

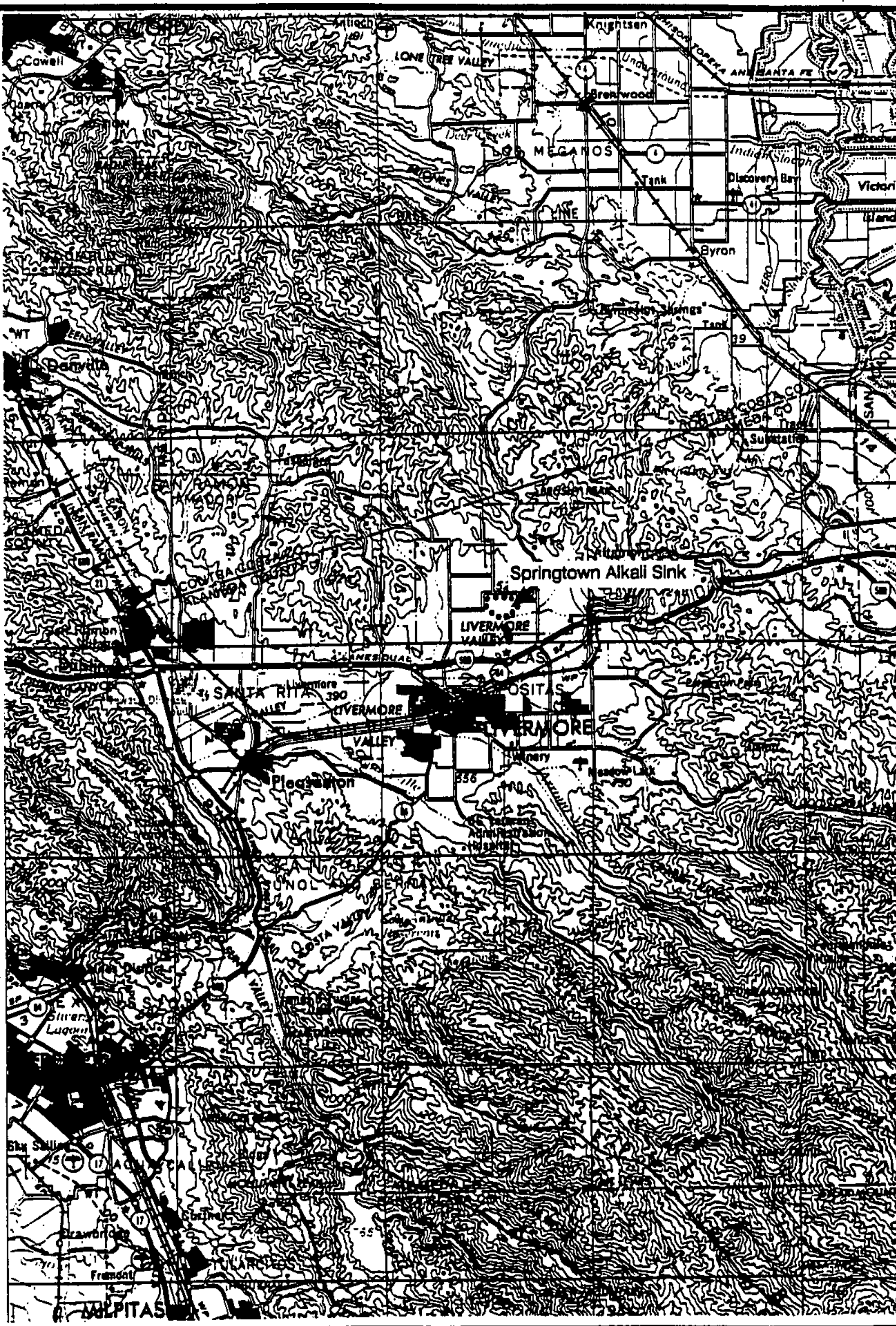
The Springtown Alkali Sink is a unique seasonal wetland of considerable ecological significance. It is located in Eastern Alameda County, about 3.5 miles northeast of downtown Livermore (see Fig. 1.0). Parts of the alkali sink were developed in recent decades for residential subdivisions and a golf course, or disturbed by off-road vehicles or earth-moving equipment. Much of the remaining alkali sink areas are proposed for future development. In 1982, an endangered plant - Cordylanthus palmatus (palmate-bracted bird's beak) - was discovered on the site. The presence of this State - and Federally-listed endangered plant and the designation of parts of the area as wetlands have placed constraints on future development of the area.

The bird's-beak genus, Cordylanthus, is indigenous to western North America, and is represented by approximately thirty-two species. It is related to Indian paintbrush (Castilleja) and to owl's clover (Orthocarpus). Cordylanthus palmatus (Ferris) MacBride, also known as palmate-bracted bird's-beak or Ferris' bird's-beak, belongs to a morphologically and ecologically distinct group of species in the subgenus Hemistegia. All species within the subgenus occur in saline and alkaline habitats.

Cordylanthus palmatus is a low, highly branched herbaceous annual, 10-30 cm. high. The leaves are gray-green, hairy, and lie close to the stem. The plant has glands that enable it to secrete salt, and mature plants are often encrusted with salt crystals. All members of the genus Cordylanthus are hemiparasitic, that is, able to parasitize the roots of other plants. For a more detailed description of the plant, see Appendix I. Cordylanthus palmatus was added to the Federal list of endangered species in 1983 and the state list of endangered plants in 1984.

The historic range of Cordylanthus palmatus included at least ten scattered locations in the San Joaquin and Sacramento Valleys, in Fresno, Madera, San Joaquin, Yolo, and Colusa Counties. It now occurs in only four populations within the historic range: in Colusa, Yolo, Alameda, and Fresno Counties. The Alameda County site, at Springtown, is by far the most important of these due to its large size and relatively high habitat quality.

This study was undertaken in order to: 1) determine the extent of the existing population of Cordylanthus on the site; 2) determine the environmental factors that are critical to the



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Location Map of the Springtown Alkali Sink

FIGURE 1.0

long-term viability of the alkali sink ecosystem and the endangered plant population; 3) identify habitat that must be preserved to ensure the survivial of the remaining Cordylanthus population; and 4) develop management recommendations for the alkali sink ecosystem. The specific steps involved in this study are: 1) mapping the distribution of Cordylanthus on the site, at a scale of 1:2400; 2) analyzing the statewide significance of the Springtown Alkali Sink; 3) characterizing the soils, hydrology, and land-use history of the site; 4) characterizing the physiological ecology of Cordylanthus palmatus and relating its ecological requirements to the environment of the site; and 5) developing a management plan that specifies allowable use intensity zones and a monitoring program for the site.

Although concern for one endangered plant provided the impetus for this study, the Springtown Alkali Sink is more than a habitat for Cordylanthus. Rather, it is a complex mosaic that includes streams, vernal pools, alkali "scalds," and annual grasslands with a unique assemblage of plants and animals. The proper approach to protecting Cordylanthus on the site is to maintain a viable alkali sink wetland ecosystem.

1.1 The Importance of Wetlands

1.11 The Significance of Wetland Preservation

The preservation of wetlands and the biological diversity they support has become a national conservation priority, a cause recognized by leaders from all parts of the political spectrum. This high priority was necessary because: 1) wetland ecosystems are of great value to human and non-human species; and 2) wetland ecosystems are highly endangered by many types of human activity, including urban development, pollution, and water diversion. An inability to perceive the former has led directly to the latter, producing an urgent need for decisive action. The Emergency Wetlands Resources Act, signed into law by President Reagan in November 1987, and the reauthorization of the Clean Water Act by Congress in 1988, recognized the urgency of the problem. Other Federal and State laws and regulations address the protection of our nation's wetlands, but where there is absence of awareness and support by local governments and planning agencies, the successful application of those laws has not always accomplished the goal of long-term preservation of intact, healthy ecosystems. That success comes first from the recognition of the endangered status and great value of wetlands, and second, from the willingness of local governments to plan for and implement measures within the scope of their jurisdiction and authority.

1.12 The Endangered Status of Wetlands

The U.S. Fish and Wildlife Service (1970, 1979) estimates that wild America was once covered by vast tracts of wetlands, from Maine to Florida, throughout the Mississippi Valley and the prairie states, across the Great Basin and along the Pacific

Coast. It is estimated that 127 million acres existed prior to 1800, with 108 million acres persisting until the 1950's. Drainage and development began to accelerate at that time, with rates of wetland loss somewhere between 200,000 to 300,000 acres per year. At present, approximately 84 million acres remain, or about 66% of the original natural wetlands (U.S.F.W.S., 1970, 1979). Another estimate by the Environmental Protection Agency, based on different criteria for defining wetlands, suggests that only 47% of the nation's wetlands have survived.

The situation in California, however, is even more serious. Prior to 1900, there existed 4 to 5 million acres of wetlands in the state. Those wetlands comprised many different ecosystem types - coastal salt marshes, freshwater marshes, seasonal wetlands, and riparian forests, among others. Water development by the U.S. Bureau of Reclamation, including the diversion of Sierran flows and drainage of lowland basins, reduced the wetlands to 1.2 million acres by 1922. Wetlands have been replaced by the conversion to agricultural uses, especially in the San Joaquin Valley. Recent estimates indicate that only 450,000 acres remain, about 10% of the original pristine wetlands (U.S.F.W.S. 1979, Dennis 1984). But those that remain can hardly be considered pristine. About 62% of the state's coastal wetlands have been subjected to "severe damage," according to the California Coastal Zone Conservation Commission (Zentner 1982). Wetlands in California are not only scarce - they are also in poor condition.

Much of the loss of California wetlands has occurred along the coast, especially in and around the major bays and estuaries (e.g., Humboldt Bay, San Francisco Bay, San Diego Bay - see MacDonald 1977). Interior seasonal wetland communities, such as Valley Sink Scrub community at the Springtown Alkali Sink, have also been drastically reduced. The National Natural Landmark Evaluation, conducted by California Department of Fish and Game's Natural Diversity Data Base, estimated that Valley Sink Scrub has been reduced by more than 80% since Spanish settlement (Bittman 1985). Accelerated agricultural development over the last 20 years has left only scattered remnants throughout its original, historical range. Like other types of wetland plant communities, Valley Sink Scrub is considered among the most endangered communities in California by the Department of Fish and Game (Holland 1986).

1.13 <u>Values of Wetlands</u>

The biological, economic, and cultural value of the nation's remaining wetlands is widely recognized. Detailed discussions of these values are provided by Jahn (1979), Brown (1979), and Zentner (1982).

Wetlands are among the most productive ecosystems on earth. The plant life of these areas is often capable of high rates and prolonged periods of photosynthesis, depending on the genetic and environmental constraints within a particular wetland. In some situations, production is achieved despite stressful environmental conditions. At the Springtown Alkali Sink, for example, the dominant plant species are able to photosynthesize, grow, and reproduce in the presence of high soil salinity. Salt tolerance is a poorly understood attribute of many wetland plants that allows the colonization of great tracts of land that would otherwise be biologically sterile. There are hundreds, perhaps thousands, of plant species in North American wetlands, some rare and endangered, others abundant and widespread, but all dependent upon the specific conditions of these transitional ecosystems.

Plant productivity is translated into animal productivity by grazing, seed predation, and the consumption of detritus. The availability of energy compounds and mineral nutrients attract a great abundance and diversity of animal species, both rare and common, as part of an intricate food web. Humans are part of that food web, as we harvest large quantities of shellfish, fish, and waterfowl that feed on other components of the wetland ecosystem.

Wetlands are sanctuaries to many commercially-important species of wildlife. Coastal wetlands provide habitat for some harvested fish and shellfish. Both coastal and interior wetlands, regardless of their seasonal nature, provide migrating waterfowl with "rest stops" and "fast food" along the Pacific Flyway. Nearly 100,000 acres of modified Alkali Sink wetlands in the Central Valley are managed by the state or federal governments for waterfowl preservation and sport hunting. Scientific studies of salt-tolerant wetland plants are providing insights into our own technological problems associated with the salinization of agricultural lands. Salts accumulation in soils resulting from poor irrigation practices have damaged valuable farmland and crops in many interior areas of California and the nation as a whole. The genetic capabilities of salt-tolerant plants are being studied and developed for implantation into less tolerant, commercially important crop plants.

The unique conditions found in wetlands are important elements in the maintenance and purity of water supplies. Groundwater recharge, water purification, and flood protection can be of great economic value, especially in an enclosed basin like the modern Livermore Valley.

Wetlands have educational, recreational, and aesthetic values that are closely linked to the quality of their biological resources. If wetland ecosystems are allowed to function in a natural fashion, plant and animal species diversity will be high and so will levels of human interest and concern. The Springtown Alkali Sink, if properly managed, could provide many of these benefits and cultural dividends to local schools, hikers, historians, naturalists, and lovers of open space.

1.2 Legal and Political Framework

The Springtown Alkali Sink wetland ecosystem was first officially recognized in a Draft Environmental Impact Report prepared for the City of Livermore in 1982. The DEIR was prompted by objections received from the California Department of Fish and Game to a Negative Declaration that was circulated by the City for a proposal to cancel a Williamson Act agreement for an 85-acre parcel known as the Garaventa property. During the preparation of the document, *Cordylanthus palmatus*, a federal candidate species at that time, was reported to occur on the site, on City land to the north and the adjoining Shean property (Barnett Range). Shortly thereafter, the plant was listed by the U.S. Department of the Interior and the California Fish and Game Commission as an Endangered species. In 1983, the San Francisco District of the U.S. Army Corps of Engineers asserted jurisdiction over the wetlands in the Springtown area.

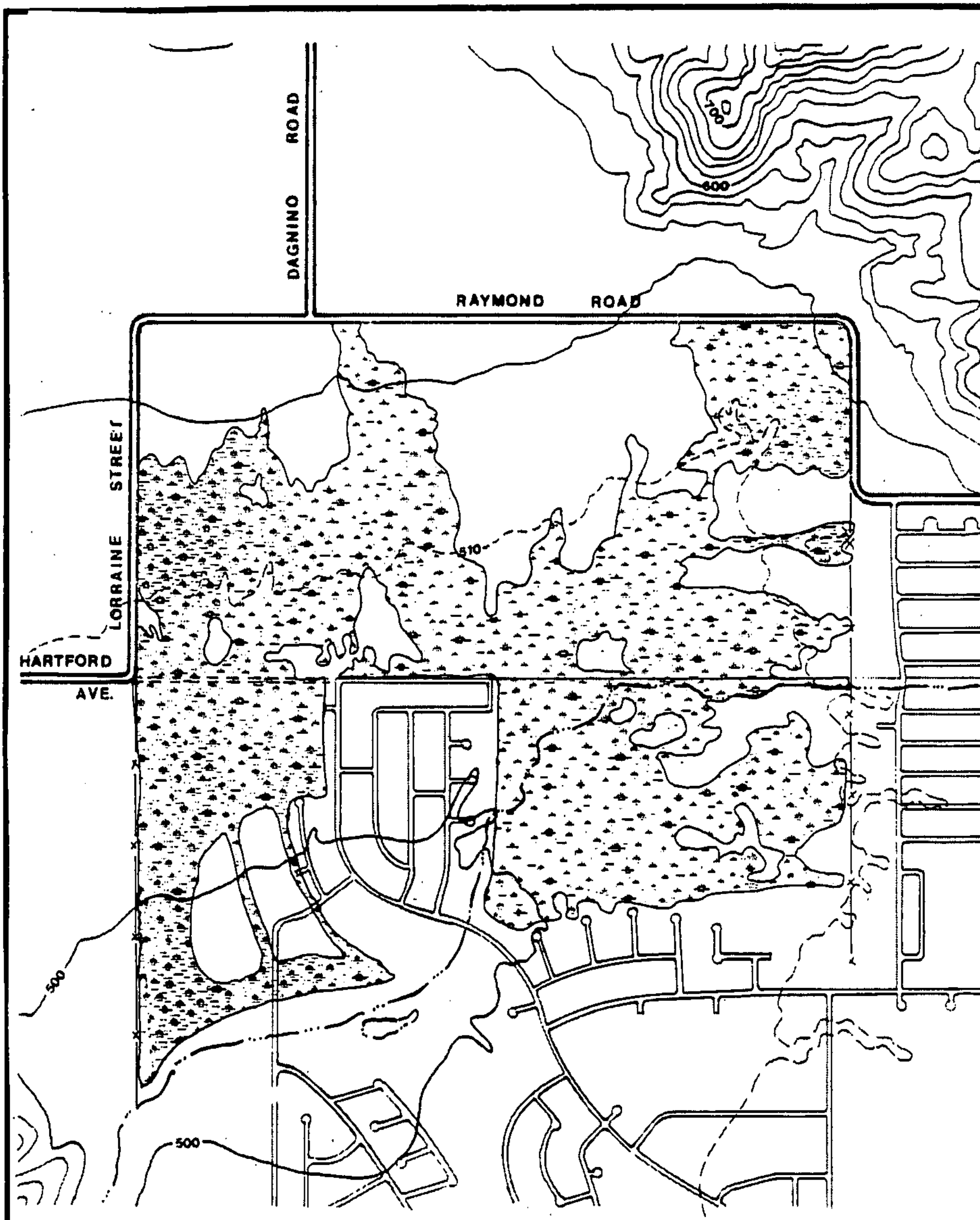
During this time, intense development pressure in the Springtown area, paralleling that throughout the Livermore Valley, placed the future of the wetlands in doubt. In 1983, the Corps issued a permit to fill 4 acres of wetlands, including *Cordylanthus palmatus* habitat, south of Arroyo Las Positas, for a residential development. A condition of that permit was a requirement to construct a pond at the northeast corner of the housing development in an attempt to compensate for wetlands values that were eliminated elsewhere on the property. That effort failed, and thus far there is no precedent for recreating alkali sink wetlands. Since 1983, no further development in those wetlands has occurred. Portions of the wetlands on the private and public properties have been disturbed intermittently, however, by grazing, discing, bulldozing, scraping and burning of vegetation, and by off-road vehicle activity. The Corps issued two Cease-and-Desist Orders in 1983 when such unauthorized activities were detected.

In the last few years, the City and the Corps have received proposals from the Kaufman and Broad Company and the Anden Group to construct housing in the wetlands. The City and the Corps have delayed consideration of these proposals pending the completion of this document. The U.S. Fish and Wildlife Service and the California Department of Fish and Game, recognizing the problems associated with piecemeal planning in this area and the continuing threat to these natural resources, have developed comprehensive recommendations for the Springtown area, which are presented in Section 10. These coordinated recommendations reflect these agencies' policies and responsibilities and various applicable laws and regulations.

Any proposed land-use changes which would affect the wetlands in the Springtown area would be subject to a number of laws and regulations administered by various agencies. The primary permitting agencies for a proposed project would be the City of Livermore and the U.S. Army Corps of Engineers. However, because wetlands and endangered species are involved, several other federal, state, and local agencies would also serve as commenting, review, or advisory agencies. The agencies involved and a summary of their regulatory or statutory authorities and policies may be found in Appendix VII.

1.3 The U.S. Army Corps of Engineers Wetlands Jurisdiction at Springtown

Under Section 404 of the Clean Water Act, the U.S. Army Corps of Engineers regulates the fill or disposal of material in wetlands. A wetland, under the Corps's definition, meets test criteria for vegetation, soils, and hydrology (U.S. Army Corps of Engineers, 1988). On three occasions, Corps personnel have made wetland determinations at the Springtown Alkali Sink. Fig. 1.1 shows the approximate boundaries of the areas designated as wetlands. Within these areas are complex inclusions of non-wetlands that cannot be accurately represented at the map scale. More detailed maps from the Corps's jurisdictional determinations of 1987 and 1988 will be furnished by the Corps's district office in San Francisco on request.



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Wetland Areas on Portions of the Springtown Alkali Sink as Determined by the U.S. Army Corps of Engineers

FIGURE 1.1

2.0 State-wide Status of Cordylanthus palmatus

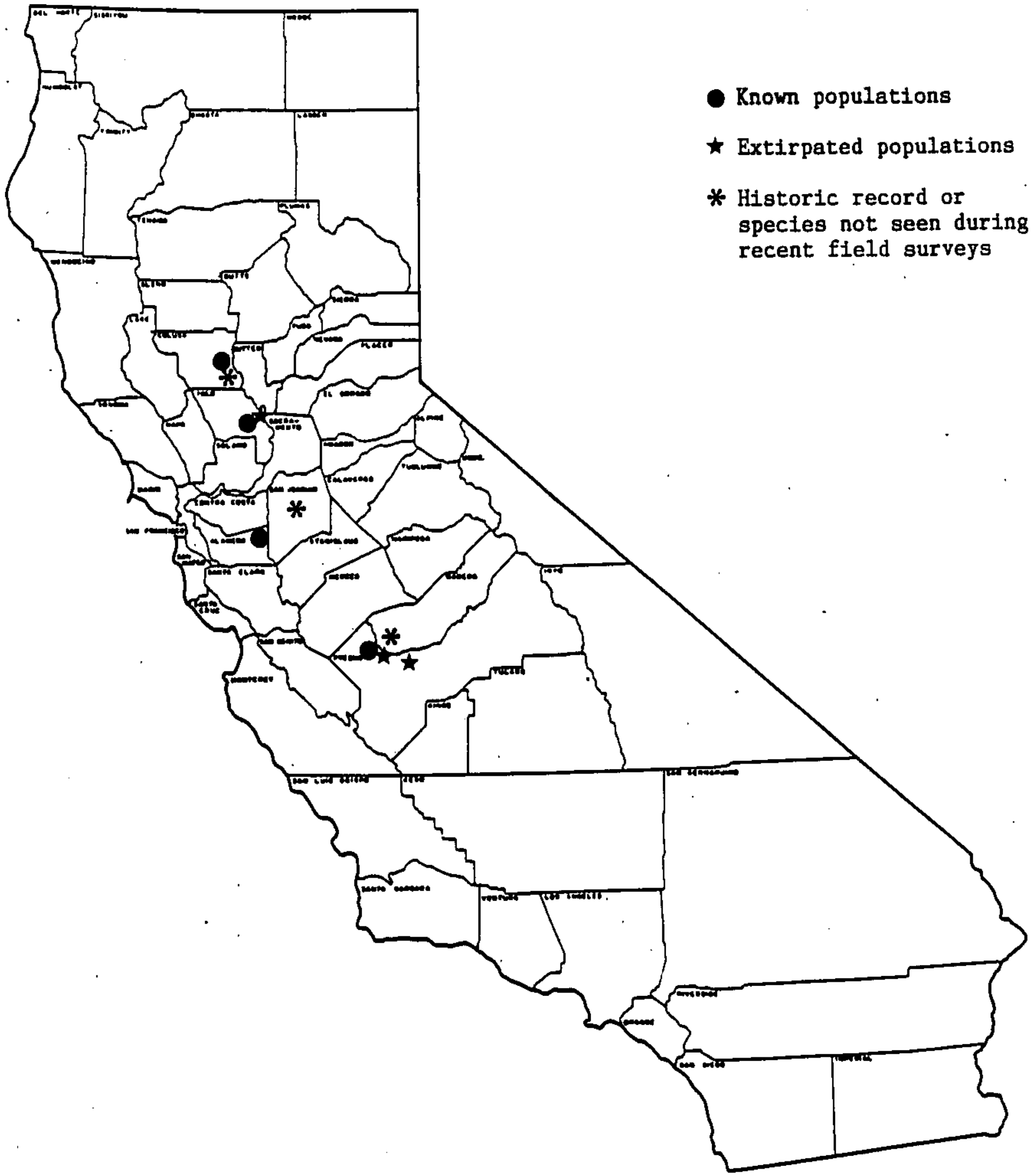
Cordylanthus palmatus has been extirpated from much of its former range as a result of habitat loss due to agricultural conversion, changes in historic hydrologic regime, intensive livestock grazing, and urban expansion and industrial development.

Agricultural development in the Central Valley, including livestock grazing, began with European settlement, and proceeded apace of groundwater utilization. Prior to the advent of agriculture, the Central Valley experienced seasonal spring and winter flooding to varying degrees. The water table was very close to the surface due to subsurface clay layers, and was within the rooting zone of most plants, thus providing plants with water through the summer. Reclamation projects, stream diversions, and flood control practices facilitated the expansion of agriculture into "marginal" saline-alkaline lands, resulting in the direct loss of native vegetation. Groundwater pumping has lowered the water table beyond the effective rooting depth of many plants, and flood control has stopped or minimized overland flows in most areas (Bittman, 1983; Warner & Hendrix, 1985; USFWS, 1986; CDF&G, no date). Overland flows appear to be important in the maintenance of Cordylanthus palmatus habitat. Overland freshwater flows dilute salts in the saline-alkaline soils, and may enable seeds to germinate and seedlings to become established. Overland flows may also transport Cordylanthus seed, and partially influence the seasonal distribution of individual plants.

Competition from non-native weeds, introduced through grazing practics and agricultural development, also has negatively affected Cordylanthus palmatus. Cordylanthus palmatus does not appear to compete well with annual grasses on circumneutral soils that are low in soluble salts. It grows in open areas, e.g., in alkali scalds, with little vegetative cover, and is not associated with areas of dense weedy species.

The increase in human populations near metropolitan centers has resulted in rapid urban expansion onto lands once under agriculture, as well as previously undeveloped sites. Industrial expansion has also paralleled urbanization. Although historic saline-alkaline habitats can sometimes recover partially following cessation of agriculture, urbanization creates irreversible changes in land use and hydrology.

Four disjunct populations of Cordylanthus palmatus in the Central Valley of California are extant: Colusa National Wildlife Refuge, Colusa County; southeast of the City of Woodland, adjacent to Willow Slough, Yolo County; Mendota Wildlife Management Area, Fresno County and the Springtown site near Livermore in Alameda County (see Figure 2.0). The total area encompassed by populations of Cordylanthus palmatus at these sites is approximately 400 acres.



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State-wide Distribution of *Cordylanthus palmatus*

FIGURE 2.0

2.1 Colusa County

The Colusa County site is in the Colusa National Wildlife Refuge and is bordered by irrigation ditches and an earthen levee containing a freshwater marsh that is managed for waterfowl. At this site, Cordylanthus palmatus occurs on strongly alkaline Willows clay in a shallow saline-alkaline depression that is seasonally inundated. The majority of plants are found among a relatively sparse cover of seepweed (Suaeda moquinii) and alkali heath (Frankenia grandifolia ssp. campestris). A slightly deeper depression consisting of hard, cracked clay soil is found in the center of the Colusa population. Soils in this central area are highly expansive and support only alkali weed (Cressa truxillensis var. vallicola). Few Cordylanthus plants occur on this clay depression, and those that do are growing along its margin (Stone 1987). In addition to seepweed, alkali heath, and alkali weed, associate species at this site include silver saltbush (Atriplex argentea ssp. expansa), salt grass (Distichlis spicata), bassia (Bassia hyssopifolia), spurry (Spergularia bocconei), Bigelow's plantain (Plantago bigelovii), and Mediterranean barley (Hordeum geniculatum).

The site has been fenced by the refuge manager to restrict vehicle access and reduce the potential of trampling; however, it could be flooded easily if a levee breaks. Due to the site configuration, expansion of this population is not possible (Monty Knudsen, U.S.F.W.S., personal communication). In a 1987 census, approximately 500 individual plants were counted; these occurred as individuals and as small groups (Stone 1987).

2.2 Yolo County

The population southeast of the City of Woodland occurs on city land adjacent to the City's wastewater treatment facility ponds. Surrounding acreage has been converted primarily to agriculture or light industrial uses. Cordylanthus palmatus occurs primarily on the banks and sides of raised irrigation ditches and on small berms in relatively open areas subject to overland flows. The berms are remnants of "checks" installed for rice cultivation. Cordylanthus palmatus is associated primarily with seepweed, alkali heath, spikeweed (Hemizonia pungens), pickleweed (Salicornia subterminalis), and salt grass at the Woodland site. "Check" berm sites occupied by Cordylanthus also support a diverse early spring flora characterized by Bigelow's plantain, popcorn flower (Plagiobothrys stipitatus), goldfields (Lasthenia fremontii), milkvetch (Astragalus tener), spurry (Spergularia macrotheca var. leucantha), and pepperweed (Lepidium oxycarpum; L. latipes). Downingia (Downingia bella) occurs in areas remaining inundated for a longer time than the berms. Native grasses include Nuttall's alkali grass (Puccinellia nutalliana), California alkali grass (Puccinellia simplex), and hair grass (Deschampsia danthonioides). The two species of alkali grass are not common on the site, possibly due to competition from non-native grasses. Mediterranean barley is the dominant non-native grass at the Woodland site. Few individuals of Cordylanthus occur in the dense stands of non-native grasses found at the site.

The Yolo County population extended previously to the north, under what are now sewage ponds, as well as south of the city-owned land. The portion of the population south of city property was disced by the landowner in 1988; it is not known if Cordylanthus will recolonize the area. The Woodland site is managed under a Register of Natural Areas Agreement between The Nature Conservancy and the City of Woodland. However, the area is currently being studied as a possible site for a police/public shooting range. Construction of such a facility at this site would require high berms, resulting in the importation of non-native soils. The facility could also disrupt the existing hydrologic regime. During a 1986 survey, approximately 800 individuals were counted; in 1987, the population totaled about 400 plants; and, in 1988, about 1400 plants were counted. In previous years, the population has comprised about 200 plants (Crampton, 1974; Showers, 1983, 1984, 1985, 1986, 1987, 1988; York and Showers, 1982).

2.3 Fresno County

The third extant site, discovered in 1986, is adjacent to the Alkali Sink Ecological Reserve at the Mendota Wildlife Management Area, operated by the California Department of Fish and Game (Taylor, 1986).

The existing Mendota population consisted of about 800 plants in 1987 (Showers and Knudsen, 1987), but only 40 individuals in 1988 (Stebbins, 1988). The decrease may be due to two consecutive dry years. The plants were found above a small drainage ditch along the edge of a road through the ecological reserve. *Cordylanthus palmatus* is associated at this site with alkali sink species: iodine bush (*Allenrolfea occidentalis*), pickleweed, alkali heath, kochia (*Kochia californica*), species of saltbush (*Atriplex cordulata*; *Atriplex vallicola*; *Atriplex lentiformis*; *Atriplex phyllostegia*), and *Aster intricatus*. Alkali sacaton (*Sporobolus airiodes*), which occurs within the reserve boundaries, does not occur along the roadside. The population also extends into the Alkali Sink Ecological Reserve where plants are scattered among "shrub islands" following an ephemeral drainage feature. The drainage feature is visible mainly as a dark organic film with rills. Within the ecological reserve, Cordylanthus is associated with seepweed and kochia. This population is vulnerable to road grading and herbicide use. The road also impedes the natural drainage in the area.

A small colony was established at the Mendota Wildlife Management Area in the 1970s from ten transplanted seedlings. These seedlings were grown from seed collected from a population located approximately seven miles from Mendota, which subsequently disappeared. During a 1987 survey, no individuals were observed at the transplant population site, which currently supports a dense growth of creeping wild-rye (Elymus triticoides), indicating a change in hydrologic regime and/or soil salinity.

2.4 Alameda County

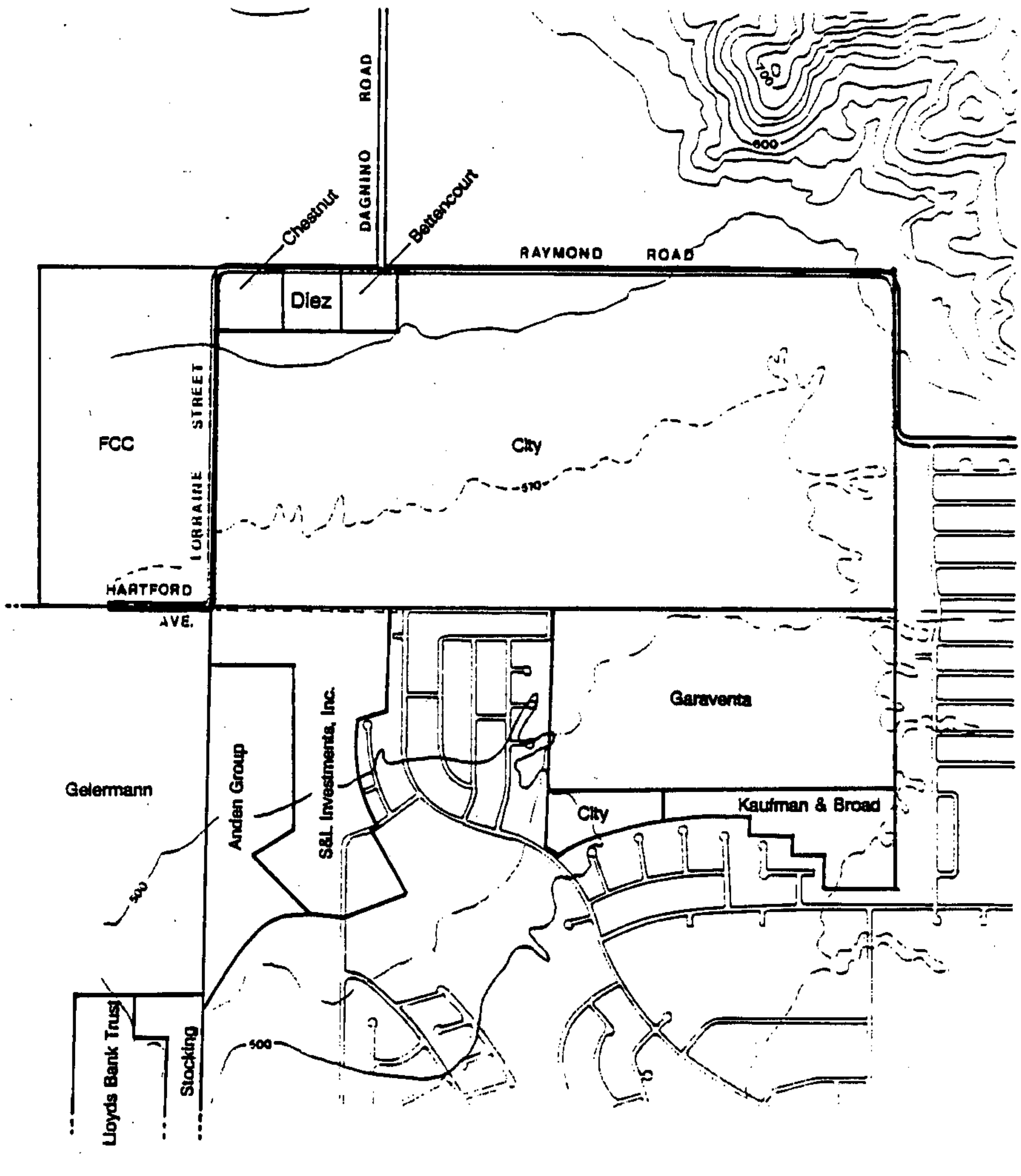
The Springtown site constitutes the largest population of Cordylanthus, with 10,000-11,000 individuals. Previous surveys by Zander (1982), Cochrane (1983), Reynolds, Kelly, and Knudsen (1983), Jokerst (1986), and Dains (1986) noted plant distribution but did not record the number of individuals at the site. The plants occur in a relatively natural basin receiving overland flow, and in association with a remnant of native valley sink scrub vegetation. The site comprises an iodine bush - alkali grassland subtype of the valley sink scrub vegetation type, with annual introduced grassland. Annual and alkali grassland, with alkali scalds, predominate in the northwestern and southwestern portions of the site. An extensive network of braided channels is found in the eastern portion of the site.

Of the four extant sites, Springtown site offers the best possibility for maintaining a population of Cordylanthus palmatus over the long term. Details on the environment and ecology of Cordylanthus palmatus at the Springtown site are discussed in Chapters 3 through 9.

3.0 Land Ownership and Land-Use History

Figure 3.0 shows the major property ownerships on the Springtown Alkali sink. It is likely that different landowners have different objectives for their property. To some extent, the different landowner objectives are reflected in different land-use histories and intensity.

Virtually the entire site was grazed extensively for many years. Grazing was recently terminated on the Garaventa parcel and on the Anden/Shean parcel. The City of Livermore property is still grazed. Sometime before 1957, a landfill was created along the northern edge of the city property along Raymond Road (Fig. 3.1) and operated until 1962. The Anden/Shean property was disced in 1983 and parts of the Garaventa property were bulldozed in the mid-1970's and in 1983. A fire-break is scraped annually around the Garaventa property, and sometimes across it. Offroad vehicle damage to the western half of the Garaventa property probably began in the mid-1970's, and continues today. Fig. 3.1 shows the major areas of disturbance and subdivisions in the study area, and Table 3.1 shows the timing of disturbance and subdivisions (dates supplied by Susan Frost, City of Livermore, and Monty Knudsen, U.S. Fish and Wildlife Service). Figures 3.2, 3.3, 3.4. and 3.5 show the alkali sink in 1957, 1976, 1980, and 1986, respectively.



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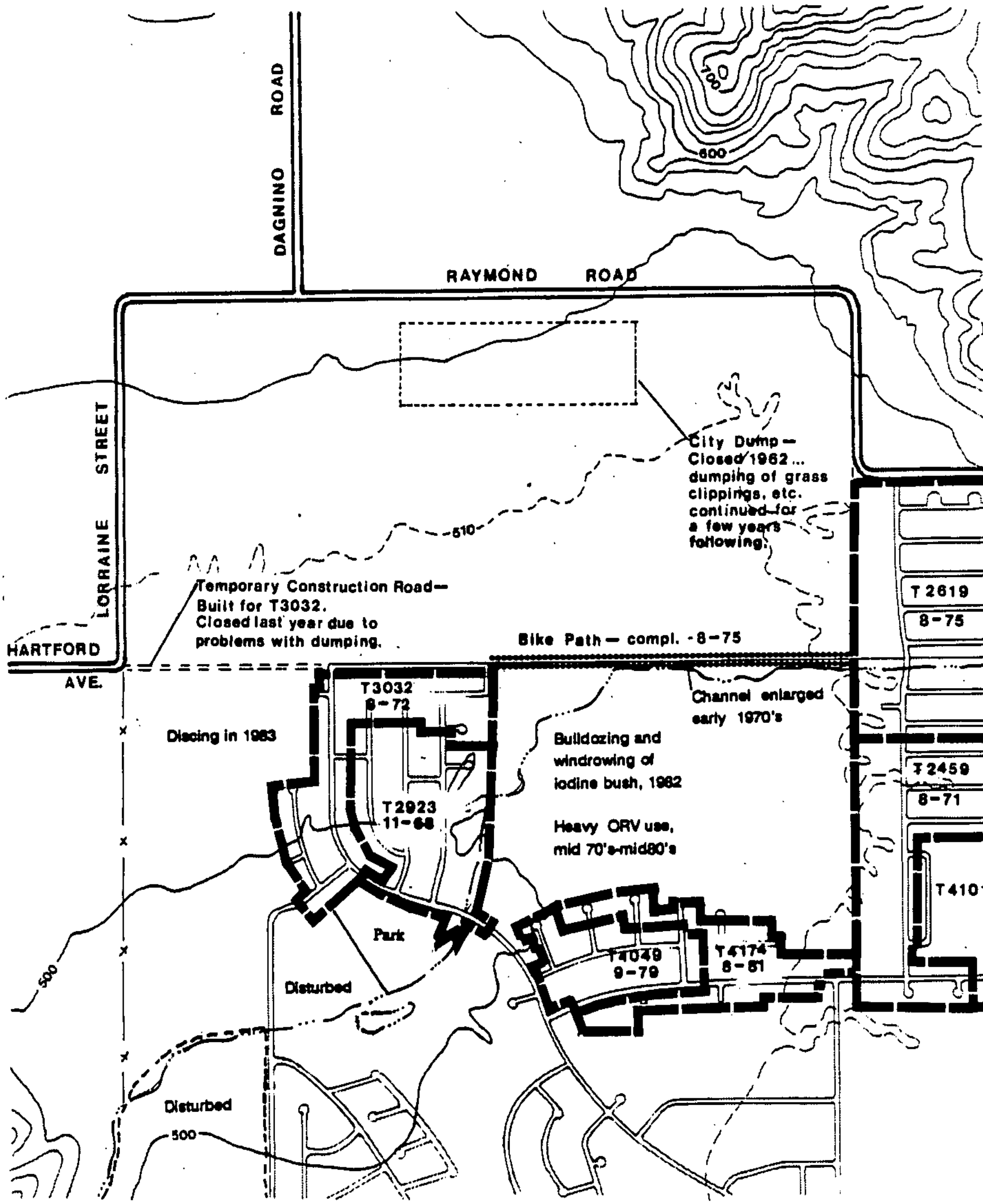
Major Property Ownerships on the Springtown Alkali Sink

FIGURE
3.0



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Major Areas of Disturbance and Subdivisions On and Near the Springtown Alkali Sink

FIGURE 3.1

Table 3.1:
Dates of Major Modifications
at the Springtown Alkali Sink

Parcel	Action	Date*
T2619	Subdivision	8/75
T2459	Subdivision	8/71
T4174	Subdivision	8/81
T4049	Subdivision	9/79
T3032	Subdivision	8/72
T2923	Subdivision	11/68
Anden/Shean	Discing and filling**	1983
Bike Path	Construction	1975
Altamont Creek	Relocation	1968
Altamont Creek	Widening	1985
City Dump	Closure	1982
Hartford Avenue Extension	Construction	Approx. 1972
Garaventa	Bulldozing and Wind-rowing of Iodine Bush**	1982-83
Garaventa and Kaufman-Broad	Scraping of Fire Breaks	1980
Garaventa and Kaufman-Broad	ORV Disturb-ance	Mid-1970's to 1980's

* Subdivision dates represent final map approval; construction is somewhat later.

** The Corps of Engineers issued cease-and-desist orders for these activities.

Fig. 3.2 May 22, 1957. Large "+" at upper right is the N.W. corner of Sec. 34, T2SR2E MDM. Small "+"'s are 1/4 corners. Scale is 1: 12,000.

Fig. 3.3 May 26, 1976. Note channelization and straightening of Altamont Creek, and interception and diversion of ephemeral channels.

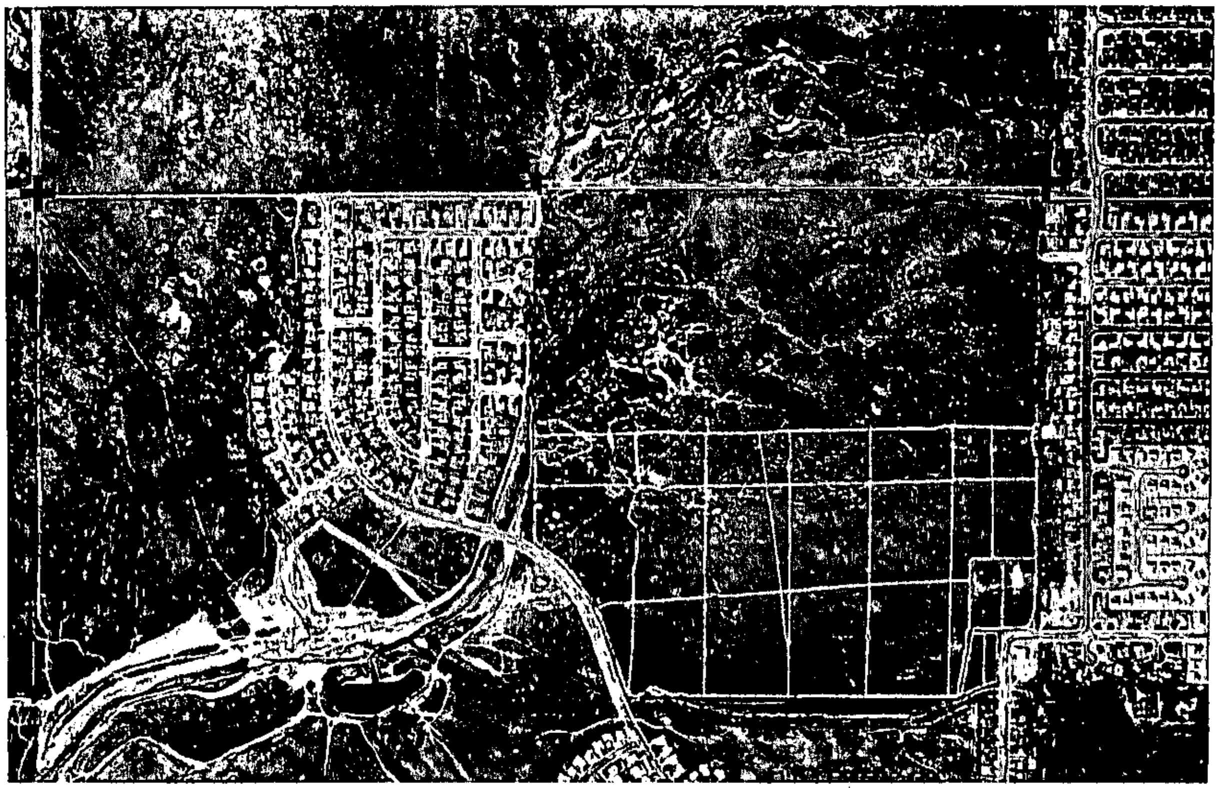


Fig. 3.4 April 30, 1980. Note damage from ORV tracks and fire breaks.

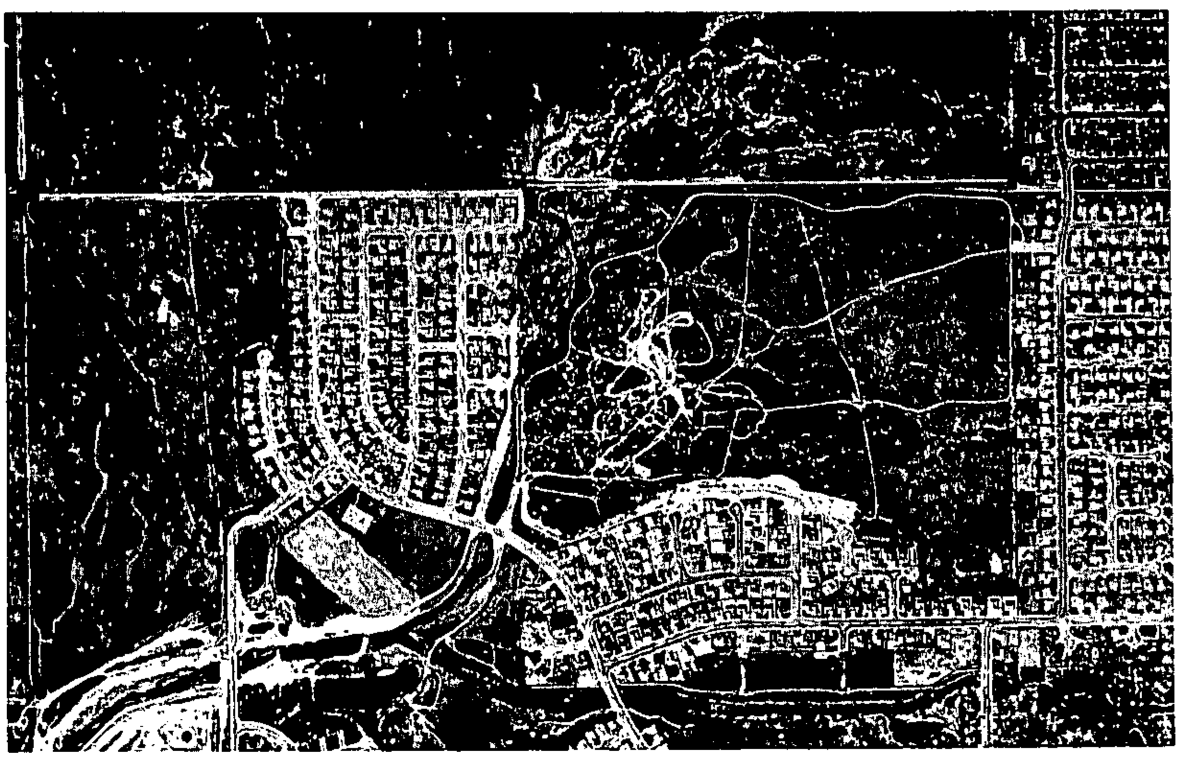


Fig. 3.5 April 23, 1986. Note new subdivisions and increased damage from ORV tracks, fire breaks and maintenance road along the channel bank.

4.0 Geomorphology and Soils

The Springtown Alkali Sink is located in the northern part of the Livermore Valley on a gently sloping lowland flanked on two sides by uplands. To the northeast lie the Altamont uplands, comprising marine shale and sandstone. Groundwater and springs originating in these sedimentary rocks are high in soluble salts, especially sodium chloride. These uplands are probably the source of the salt that has accumulated in the alkali sink. To the southeast lies a range of low hills underlain by the Livermore Gravels (Herd, 1977). The hills on the northeast side of the valley are flanked by alluvial fans formed where streams emerge from their canyons in the hills onto the flat valley floor. The alluvial fans have built outward from the mouths of the canyons, so that they coalesce along the front of the hills.

The valley floor in and around the alkali sink is composed primarily of two units of unconsolidated sediments. These materials were mapped by Herd (1977) as "older alluvium" (Pleistocene) and "recent floodplain alluvium" (Holocene). They seem to correspond to the "basin sediments" and "quaternary alluvium," respectively, mapped by the California Department of Water Resources (1974). The basin sediments are fine-grained silts and clays which occur in flat-lying areas. They appear to be derived from materials transported by streams from the hills to the north and northeast and deposited on the valley floor. They are poorly drained and impermeable. The alluvium is coarser-grained than the basin sediments and occurs in gently sloping terrain and adjacent to stream channels. The alluvium consists of clay, silt, sand, and gravel units. In some areas, it is well-drained and permeable; in other areas, it has weathered to form a poorly drained saline sodic soil.

The Livermore Valley is traversed by six major faults which trend northwest-southeast and divide the valley into a number of fault-bounded slices. A fault segment passes to the southeast of the sink, trending northwest to southeast. This segment was mapped by the Department of Water Resources (1974) as part of the recently-active left-lateral Tesla fault. Herd (1977) indicates it as a strike-slip fault, with the north-east side down-thrown. The fault trace itself is buried by alluvium, and its presence is inferred from the geomorphic evidence. Whatever its relationship to the other fault systems in the Livermore Valley, this fault appears to have affected the hydrology of the Springtown Alkali Sink in two ways.

First, movement on the fault has juxtaposed recent alluvium and basin sediments against the Livermore Gravels, and created an impediment to the movement of groundwater. Shallow groundwater tends to pond on the upslope (northeast) side of the fault. Such ponding of groundwater may cause a locally elevated water table which produces surface discharge of groundwater as springs where the water table intersects the ground surface.

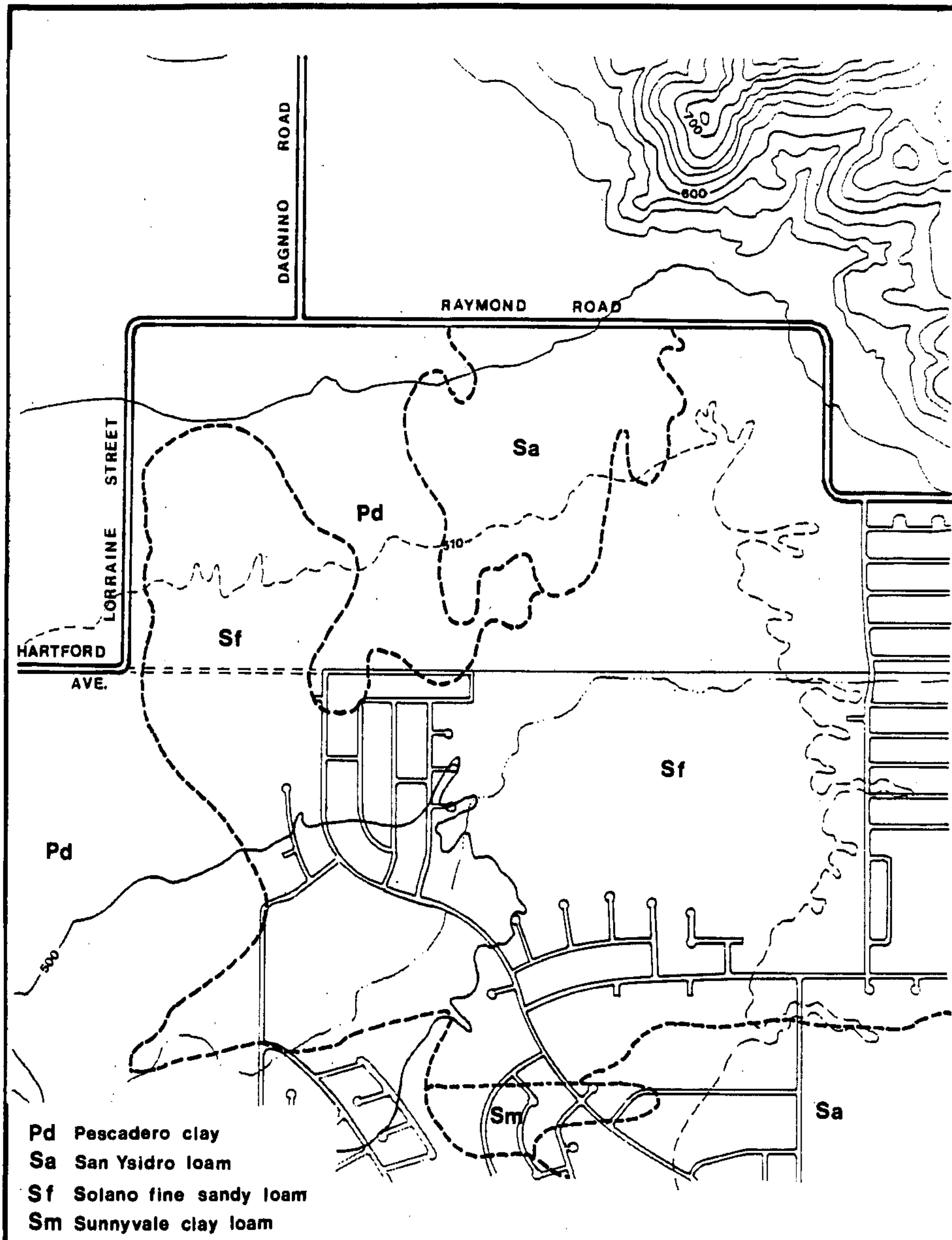
Secondly, the fault appears to act as a control of the level of the natural channel of Altamont Creek just southwest of the sink. The topographic map of the areas shows a broad basin (in which the sink is located) draining into a narrow outlet through the hills. The northeast front of the hills follows the trace of the fault. A possible effect of the fault on the course of Altamont Creek is apparent on a topographic map; the stream course is off-set toward the southeast where it cuts through the hills just south of Highway 580. Disruption of the drainage has apparently caused ponding of surface and groundwater and deposition of alluvium on the north side of the fault.

The Soil Conservation Service has mapped three soil series on the valley floor: the Solano fine sandy loam, the Pescadero clay, and the San Ysidro loam. The Solano and Pescadero are both saline sodic soils (or Natrixeralfs) characterized by a clay subhorizon (Bt) with a columnar prismatic structure and a high percentage of exchangeable sodium. These soils correspond somewhat with texture and sources of sediment deposited on the valley floor. The Pescadero clay formed on fine-grained "basin sediments" (clay and silt) derived from the Tertiary Marine Sediments to the north and east. The Solano fine sandy loam is derived from Quaternary alluvium on stream terraces deposited by Altamont Creek or on upper foot-slopes at the base of the hills. Both soils typically exhibit a "hog wallow" or hummocky microtopography, with alkali scalds, ephemeral channels, and vernal pools in depressions, and annual grasses on hummocks. The San Ysidro loam, derived from coarser-textured alluvium, lacks a sodium-rich B horizon and is somewhat better drained. The alkali sink ecosystem (including Cordylanthus) is confined to the Pescadero and Solano soils. Fig. 4.0 (modified slightly from the SCS soil survey report) shows the distribution of soils on the site.

The mounds and swales on the Pescadero and Solano soils are an important feature of the alkali sink ecosystem. They create a highly variable mosaic of vernal pools, alkali scalds, and well-drained upland microsites. Similar mounds, sometimes called "Mima Mounds" occur on specific poorly-drained sites worldwide. Their origin has puzzled geographers, geomorphologists, and soil scientists for many years; about 30 hypotheses for mound formation have been proposed (Zedler 1987). At least three hypotheses for the Springtown mounds seem plausible:

1. Burrowing animals. Ground squirrels prefer the better-drained mounds to swales as nesting and foraging sites. Cox (1984) showed experimentally that burrowing animals move soil preferentially toward mound centers at rates sufficient to account for mound formation.

2. Shrink-swell clays. The Pescadero soils are rich in montmorillonite, which has a strong tendency to swell on wetting and shrink on drying. It has been suggested that the forces generated by swelling can have a net



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Soils of the Springtown Alkali Sink

FIGURE
4.0

upward component sufficient to lift mounds (Knight 1980).

3. Differential weathering and solution loss. Accumulation of water in swales or small depressions could accelerate weathering and solution loss of material relative to higher or better-drained areas. Once initiated, the swales would concentrate and hold increasing amounts of water, thus accentuating the differential weathering rates (Zedler 1987).

Whatever the correct explanation for their origin, the Springtown mounds are an intriguing landscape feature of considerable educational and scientific interest.

5.0 Climate

Precipitation and evapotranspiration at the site influence both the soil moisture availability to plants and the frequency and elevation of flooding. Table 5.0 shows the mean monthly precipitation at Livermore and Altamont Creek and pan evaporation at Livermore. Mean annual precipitation at Livermore is about 14.5 inches and mean annual pan evaporation is about 72.8 inches. Precipitation exceeds evaporation only in December, January, and February, on average. Relatively intense storms, however, produce surface runoff to the alkali sink into March and April in some years.

Table 5.0:

Mean Precipitation and Evaporation Near Springtown

	Livermore (1872-1980)	Altamont Creek (Elev. 750 ft.; 1913-73)	Pan Evaporation (1962-79)
October	0.69	0.62	5.51
November	1.59	1.48	2.56
December	2.69	2.57	1.57
January	2.96	2.80	1.61
February	2.41	2.40	2.32
March	2.14	1.78	4.21
April	1.11	0.82	5.98
May	0.47	0.39	8.62
June	0.11	0.08	10.04
July	0.02	0.0	11.77
August	0.03	0.0	10.55
September	0.25	0.26	8.03
Annual	14.47	13.20	72.80

6.0 Hydrology

The hydrologic system of the Springtown Alkali Sink can be subdivided into 3 zones. In Zone I, the Altamont and Tassajara uplands, rainfall generates surface runoff or shallow subsurface flow that moves rapidly to well-defined intermittent and ephemeral stream channels. These channels deliver runoff rapidly to Zone II, the recharge zone at the base of the hills. Here, much of the surface runoff infiltrates into loam and sandy loam soils, and the stream channels become less well-defined. During intense or prolonged storms, however, surface runoff from Zone I can reach the alkali sink (Zone III) directly.

There are two aquifers or saturated zones beneath the site. The shallow alluvium and basin sediments contain poor quality water at a depth of 5 to 10 ft. There is not a close connection between this shallow groundwater and deeper groundwater body at a depth of over 100 ft. (DWR, 1974). An auger hole near the southwest corner of the City property (near Hartford Ave.) encountered groundwater 4.7 ft. below the surface (in June 1988) at an elevation of about 499 ft. The profile consisted of stratified clay and sand, with a cemented layer (probably caliche) at 60 inches. A well at the northeast corner of T3032 had a water elevation in March, 1988 of 501' and in September 1987 of 499.8, or 2-3 ft. below the soil surface.

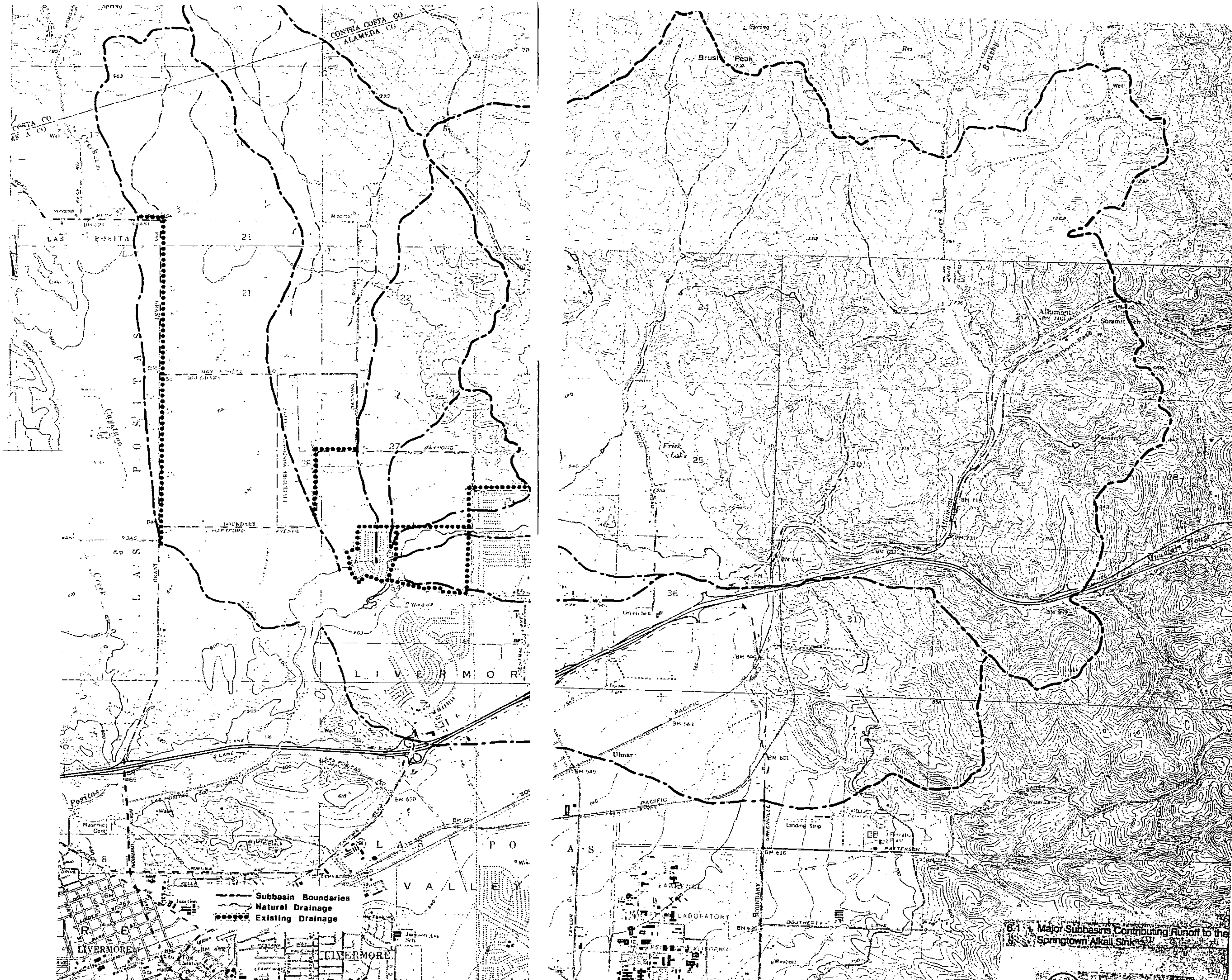
The relative importance of surface vs. subsurface flow to the sink is not known. Permeability through the shallow sandy layers (2-4 ft. depth) in the alluvium is no doubt quite high. Even if subsurface flow from Zone II to Zone III does not saturate the soil to the surface, it probably raises the water table enough that capillary action can allow moisture and dissolved salts to migrate upward to the soil surface under unsaturated conditions. This sets the stage for rapid saturation and surface flooding during an intense storm.

The Garaventa parcel is traversed by Altamont Creek, which drains a basin of 13 mi^2 to the east of the sink. Southwest of Springtown, this stream is known as Arroyo de las Positas.

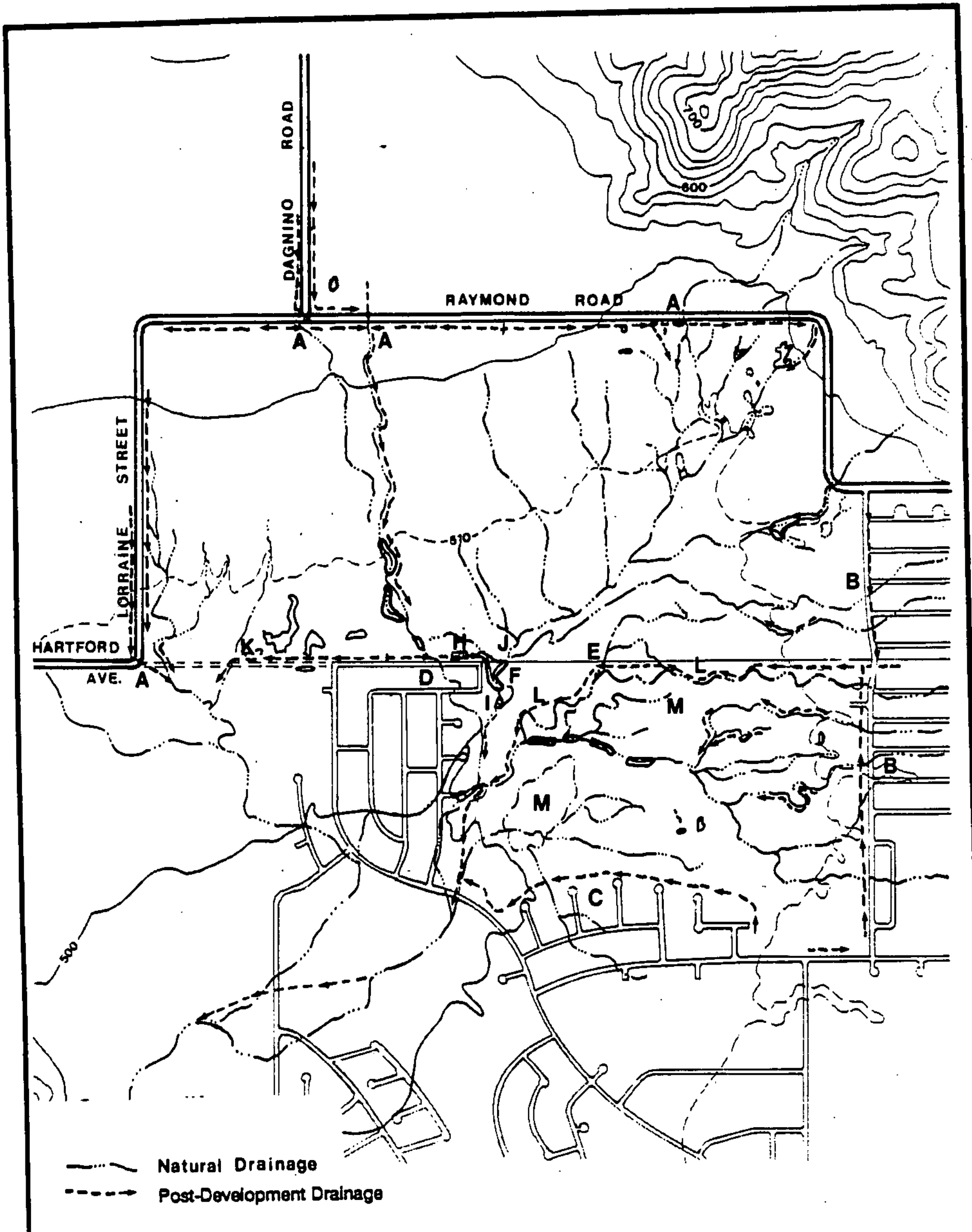
Fig. 6.1 shows the major subbasins that contribute runoff to the sink. Fig. 6.2 shows the existing and natural or "original" major drainage network on the site. It is apparent that roads and subdivisions have considerably altered both the amount of surface water delivered to the site and its route across the site. The most significant alterations (referenced to Fig. 6.2) are as follows:

1. Raymond Road and Lorraine Street interrupted poorly-defined channels, and concentrated flow at four culverts (A).

2. The subdivisions to the east (at B) and south (at C) of the Garaventa parcel have beheaded the channels that flowed across the property, re-routing storm runoff



6.1 Major Subbasins Contributing Runoff to the Springtown Alkali Sink



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Post-Development and Natural Drainage Network of the Springtown Alkali Sink

FIGURE 6.2

directly to Altamont Creek. The area contributing surface runoff and shallow groundwater to the Garaventa parcel has been reduced by roughly half. This loss of surface and subsurface water has probably caused changes in the alkali sink community, reducing the extent of Cordylanthus palmatus habitat and wildlife use.

3. The central subdivision and paved bicycle path have interrupted several drainage channels (D and E) and concentrated surface flow at culverts near the northeast corner of the subdivision (F). This has resulted in accelerated gully erosion (at H and I) and prolonged ponding of water in the spring (at J).

4. The unimproved (and recently barricaded) Hartford Avenue extension has blocked channels draining the eastern portion of the city property (at K); this blockage has expanded the vernal pools on the City property.

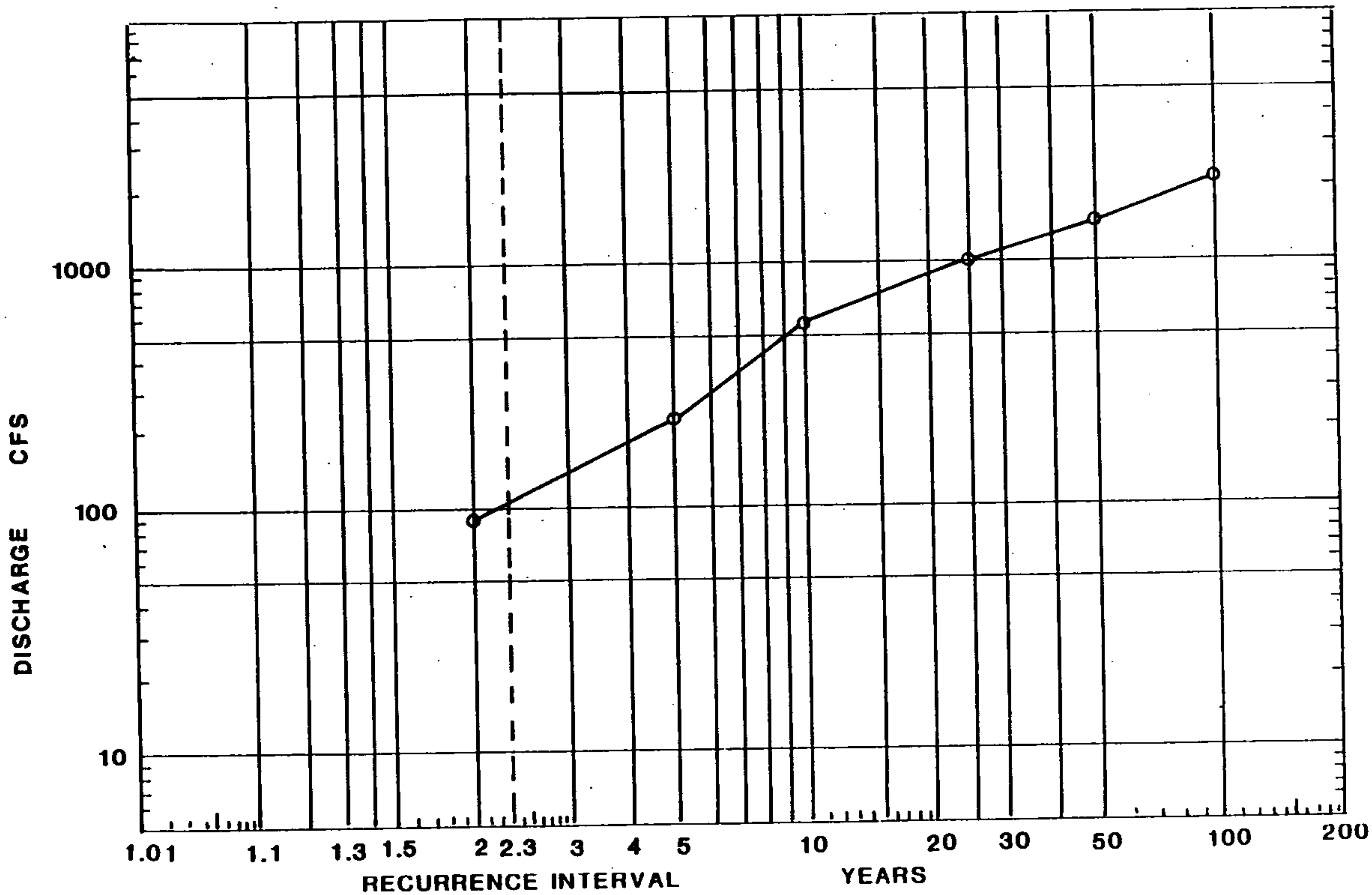
5. Altamont Creek has been realigned and widened to increase its flood conveyance capacity (L), and thus probably reduced the frequency of overbank flows and the extent of adjoining wetlands.

6. Bulldozing, windrowing of shrubs, and ORV activity have disrupted surface drainage patterns on the Garaventa parcel (M), causing direct damage to the wetlands.

In short, the pattern (timing, distribution, and magnitude) of flow across the site has been significantly altered. Minor redirection of flow (as by Lorraine Street and Raymond Road) has merely redistributed water within the alkali sink. The storm drainage systems for the subdivisions, however, have significantly reduced the input of water (and possibly of dissolved salt) to portions of the sink, and undoubtedly affected the quality and extent of wetlands on the site.

The hydrologic characteristics of the site are due in large part to the physical and chemical characteristics of the Natrixeralfs (Pescadero and Solano soils). The high sodium concentration in the clay-rich B horizon of these soils causes "deflocculation," impeded drainage, and a "perched" water table. Where water is ponded on the surface or can move to the surface by capillary action, soluble salts accumulate. The life cycle of Cordylanthus is tied to the annual cycle of surface flooding and dilution of soluble salts.

It is likely that Altamont Creek formerly overflowed its banks onto the Garaventa parcel more frequently than it does at present. Figure 6.3 shows the estimated flood frequency relationship for Altamont Creek. The realignment and deepening of Altamont Creek has increased its flood conveyance capacity. A natural alluvial channel could be expected to flow at bankfull



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Estimated Flood Frequency for Altamont Creek

FIGURE 6.3

capacity once every 1 or 2 years. The present channel can contain a flood that could be expected about once every 7 years; a ten-year flood would spill onto the floodplain in some spots.

Altamont Creek is also used to convey irrigation water during the summer from the South Bay Aqueduct to the Springtown Golf Course. Water is released to the creek three times weekly.

7.0 Vegetation of the Springtown Alkali Sink

7.1 Methods

The Springtown wetlands site was surveyed on foot, and mapped onto 1986 aerial photographs. Black-and-white aerial photographs, dated April 20, 1986, at a scale of 1" = 1000 feet (1:12,000) were enlarged to 1" = 200 feet (1:2400) and used for mapping purposes.

Selection of areas to be surveyed was based primarily upon knowledge of habitat requirements for *Cordylanthus palmatus*. The survey concentrated, therefore, on drainage features and alkali scalds. Physiographic features such as fencelines, dirt roads, and subdivision streets, visible in the aerial photographs, were used as points of reference during the survey. The starting points for areas surveyed corresponded to a definite physiographic feature. Surveying then proceeded by wandering through likely habitat. Attention was focused on alkali scalds, channel banks, and sides of mounds. As soon as individuals of *Cordylanthus* were observed, the entire drainage feature and periphery were searched. As much as possible, individual plants were counted during the survey. When plants were found in interconnecting drainage features, surveyed areas were flagged in the field so that duplicate surveys of adjacent areas would not occur. Species associated with *Cordylanthus palmatus* were recorded, as were species occurring in the major vegetation types at the site.

The northern portion of the Livermore site was surveyed during September, 1987. The two southern parcels were surveyed during April and May, 1988. A late spring/early summer survey may not give an accurate representation of reproducing individuals due to seedling/plant mortality during this part of the growing season.

A generalized vegetation-type map for the Livermore site was based on the enlarged aerial photograph (1 inch = 200 feet, or 200 scale) used for mapping the population of *Cordylanthus palmatus*. Areas of alkali grassland and of iodine bush scrub were mapped as valley sink scrub or alkali sink scrub. Unless clearly distinguishable, non-native annual grassland was not mapped. Boundaries between annual introduced grassland and perennial grassland were often not distinct on the aerial photographs. The lack of distinct vegetation features is due to two factors: annual grasses were green at the time of the photographic flight due to the high water table at the Livermore site and do not contrast with perennial grasses; and, grazing in the northern portion of the site apparently cropped both annual and perennial grasses to the same extent.

Table 7.0:
History of Recorded Cordylanthus Field Observations,
Springtown Alkali Sink

DATE	SPECIES	OBSERVED BY
1982	*Cordylanthus palmatus*	Michael Zander Harding & Lawson Assoc. (Formerly with ESA)
1983 Dates various	*Cordylanthus palmatus*	Paul Kelly CA Dept. of Fish & Game; Viki Reynolds, U.S. Army Corps of Engineers; Monty Knudsen, USFWS
Jul. 6, 1983	*Cordylanthus palmatus* *Cordylanthus mollis* ssp. *hispidus*	Susan Cochrane and Sandy Harrison, CA Dept. of Fish and Game
Jun. 5, 1986	*Cordylanthus palmatus* *Cordylanthus mollis* ssp. *hispidus*	James Jokerst Jones & Stokes
Aug. 6, 1986	*Cordylanthus palmatus* *Cordylanthus mollis* ssp. *hispidus*	Virginia Dains
1987/1988 Dates various	*Cordylanthus palmatus*	Mary Ann T. Showers David W. Showers CA Dept. of Fish & Game Monty Knudsen U.S. Fish & Wildlife Service Robert Coats Philip Williams & Assoc.

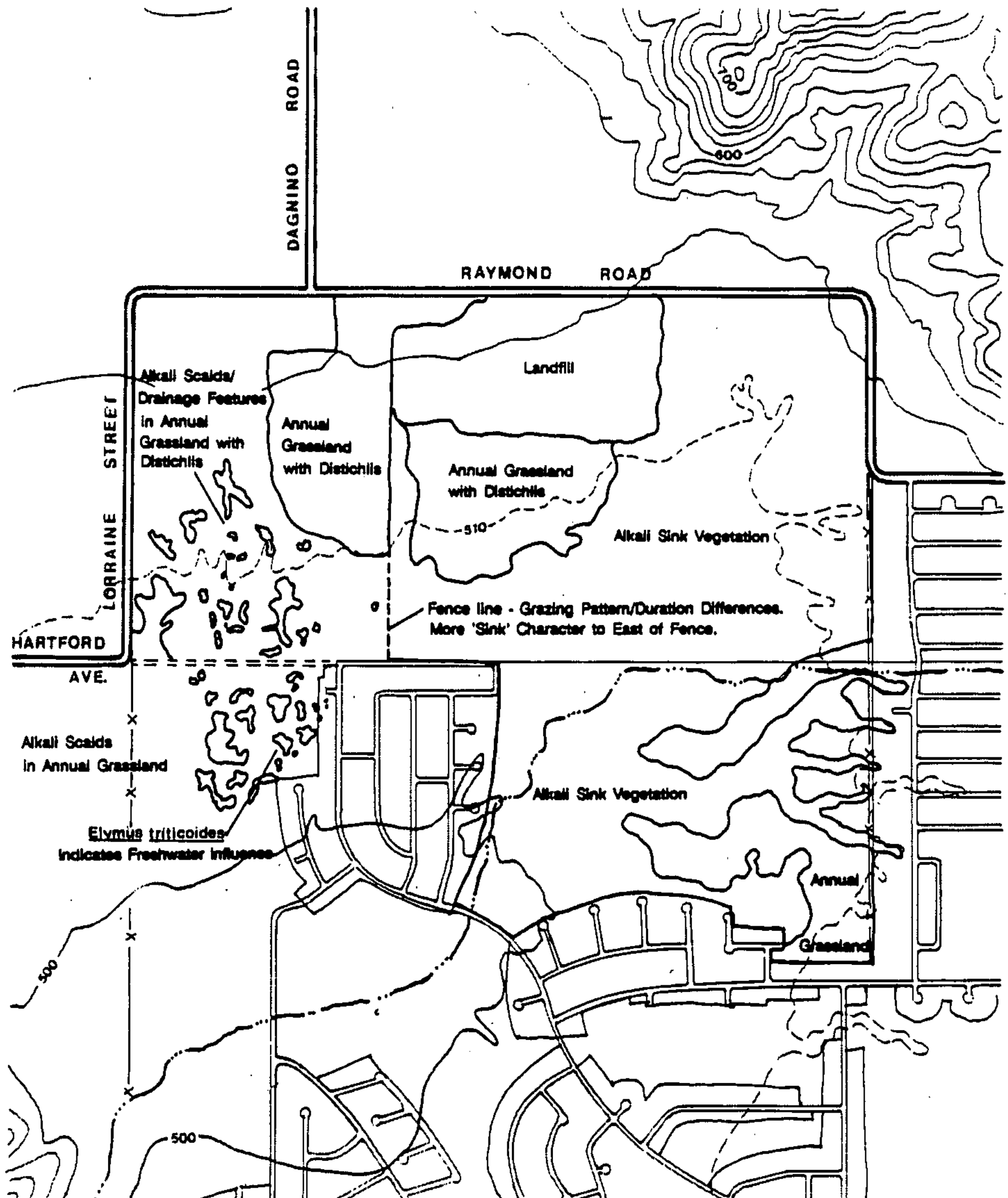
7.2 Results

Figure 7.0 shows the generalized vegetation type map of the Springtown Alkali Sink, and Figure 7.1 shows the distribution of Cordylanthus palmatus, as determined in this survey and two previous surveys. (These figures were copied from the 200 scale maps, which are available on request.) Table 7.0 shows the history of recorded Cordylanthus field observations at the Springtown Alkali Sink.

Cordylanthus palmatus occurs along seasonal drainage features within the iodine bush subtype. These drainage features include natural braided channels and depressions where water collects. Density of individuals along the channels is not uniform. Within the iodine bush subtype, Cordylanthus plants occur primarily along the edges of channels where there is a microtopographic rise above the channel bottom. Above this point, non-native grassland becomes dominant. Associated species in the iodine bush subtype are seepweed, pickleweed, and alkali heath. The drainage features support a diverse flora that changes seasonally. The early spring flora is represented by coyote thistle (Eryngium aristulatum), downingia (Downingia pulchella; Downingia cuspidata), goldfields (Lasthenia chrysostoma), spurry (Spergularia macrotheca var. longistyla), peppergrass (Lepidium lasiocarpum), and mousetail (Myosurus sp.). Summer flowering annual plants include alkali weed, spikeweed, tarplant (Holocarpha obconica), and saltbush (Atriplex cordulata). Hispid bird's-beak (Cordylanthus mollis var. hispidus) also has been reported as an associate of Cordylanthus palmatus, but was not found in this study (see Appendix I).

Cordylanthus palmatus is also associated with alkali scalds or barrens. These are primarily bare depressions surrounded by denser grassland, and are remnants of the once-more-extensive alkali sink ecosystem. A few isolated individuals of iodine bush, seepweed, and alkali heath occur on the scalds. Not all alkali scalds at the Livermore site contain Cordylanthus; overall distribution may vary from one year to another, based upon seasonal flooding, soil salinity levels, and seed set. Distribution within the scalds is also variable: some scalds support Cordylanthus only on the margins ("bathtub ring" distribution), while others support Cordylanthus throughout the entire scald area.

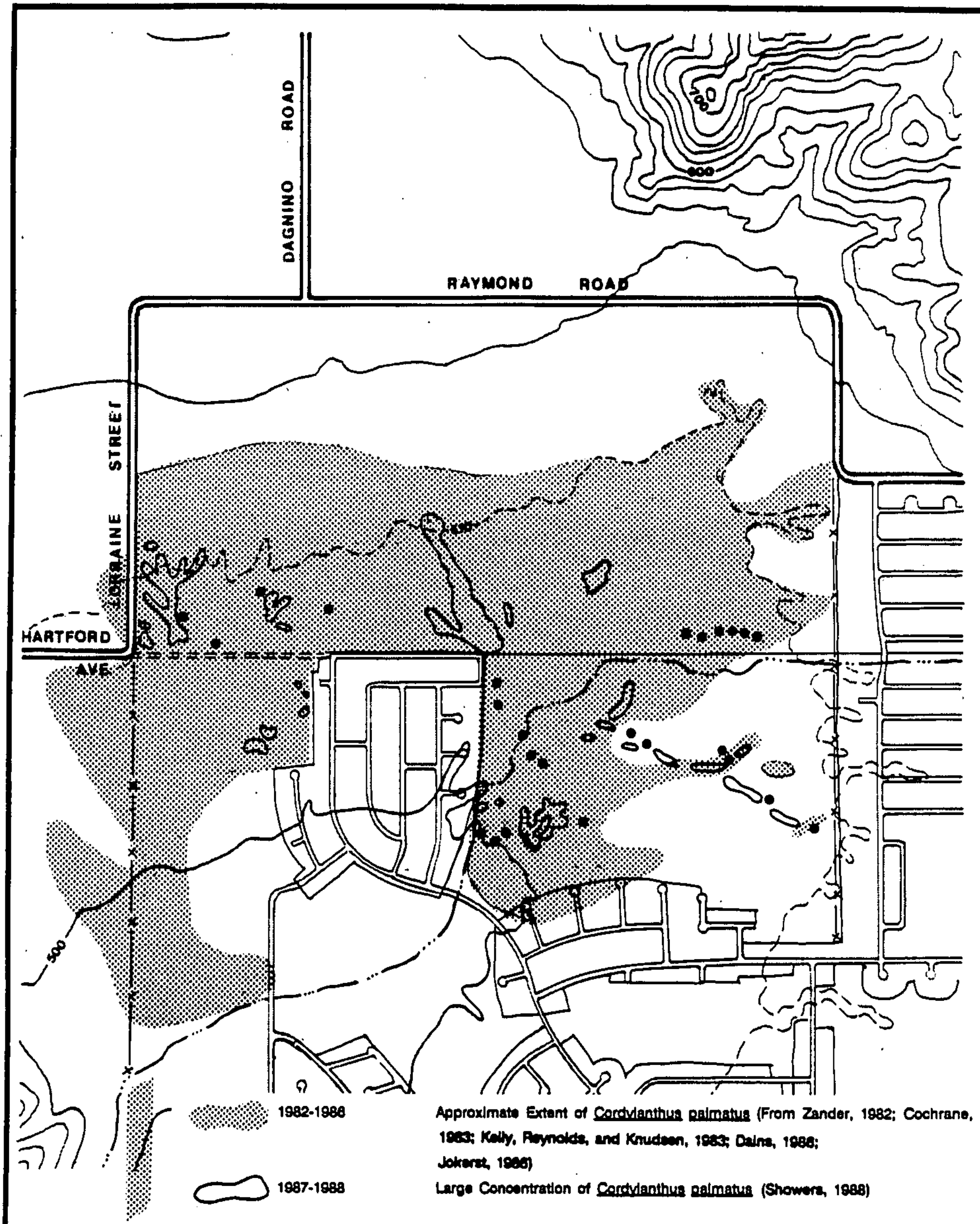
Dominant spring-flowering annuals on the scalds are goldfields (Lasthenia glaberrima; Lasthenia chrysostoma), plantain (Plantago hookeriana var. californica), spurry (Spergularia macrotheca var. longistyla), and peppergrass (Lepidium lasiocarpum). The scalds intergrade with annual grassland and perennial grassland. The annual grassland is dominated by soft chess (Bromus mollis), Mediterranean barley, and wild oats (Avena barbata). Blue dicks (Dichelostemma pulchella), lupine (Lupinus nanus), and fiddleneck (Amsinckia intermedia) are associated with the annual grassland. The area



Philip Williams & Associates
Consultants in Hydrology

Generalized Vegetation Map of the Springtown Alkali Sink Based on 1986 Aerial Photography (1:12000)

FIGURE 7.0



(shaded)	1982-1986	Approximate Extent of Cordylanthus palmatus (From Zander, 1982; Cochrane, 1983; Kelly, Reynolds, and Knudsen, 1983; Dains, 1986; Jokerst, 1986)
(outline)	1987-1988	Large Concentration of Cordylanthus palmatus (Showers, 1988)
●	1987-1988	Isolated Individuals, Groups of Few Plants (Showers, 1988)

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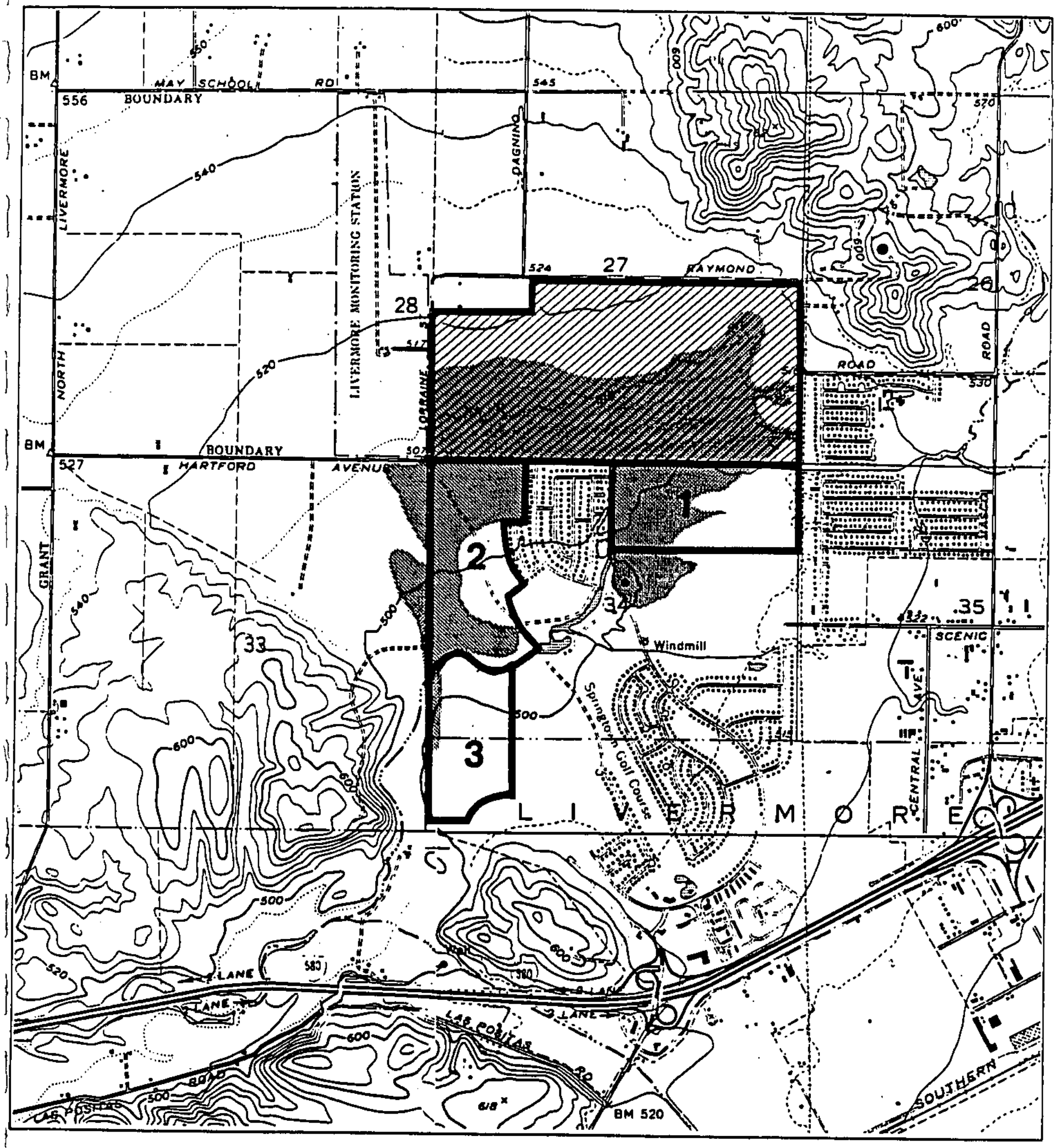
Distribution of *Cordylanthus palmatus* at the Springtown Alkali Sink

FIGURE 7.1

south and east of the scalds in the southwestern portion of the site supports a dense stand of creeping wild-rye.

The alkali grassland subtype, dominated by saltgrass, interdigitates with areas dominated by iodine bush and areas dominated by annual grasses. Saltgrass is common in many drainage channels, and, in some, provides 100 percent cover. Cordylanthus palmatus also occurs in the alkali grassland, principally in the drainage channels.

A previous study by ESA/Madrone also mapped the extent of Cordylanthus palmatus habitat in the Springtown Alkali Sink. Figures 7.2, 7.3, and 7.4 are the "Habitat Maps" from the ESA/Madrone report (Zander, 1982). The "Barnett Range" site in Figure 7.3 is referred to in this report as the Anden/Shean site. Portions of the areas mapped as annual grassland by ESA/Madrone have been designated as wetlands by the Corps of Engineers.



PROPOSED PROJECTS

1 Garaventa

2 Barnett Range

3 Anden

CITY PROPERTY

Approximate extent of Cordylanthus palmatus

FIGURE 7.2

Proposed Projects/ Species Range

ESA/MADRONE

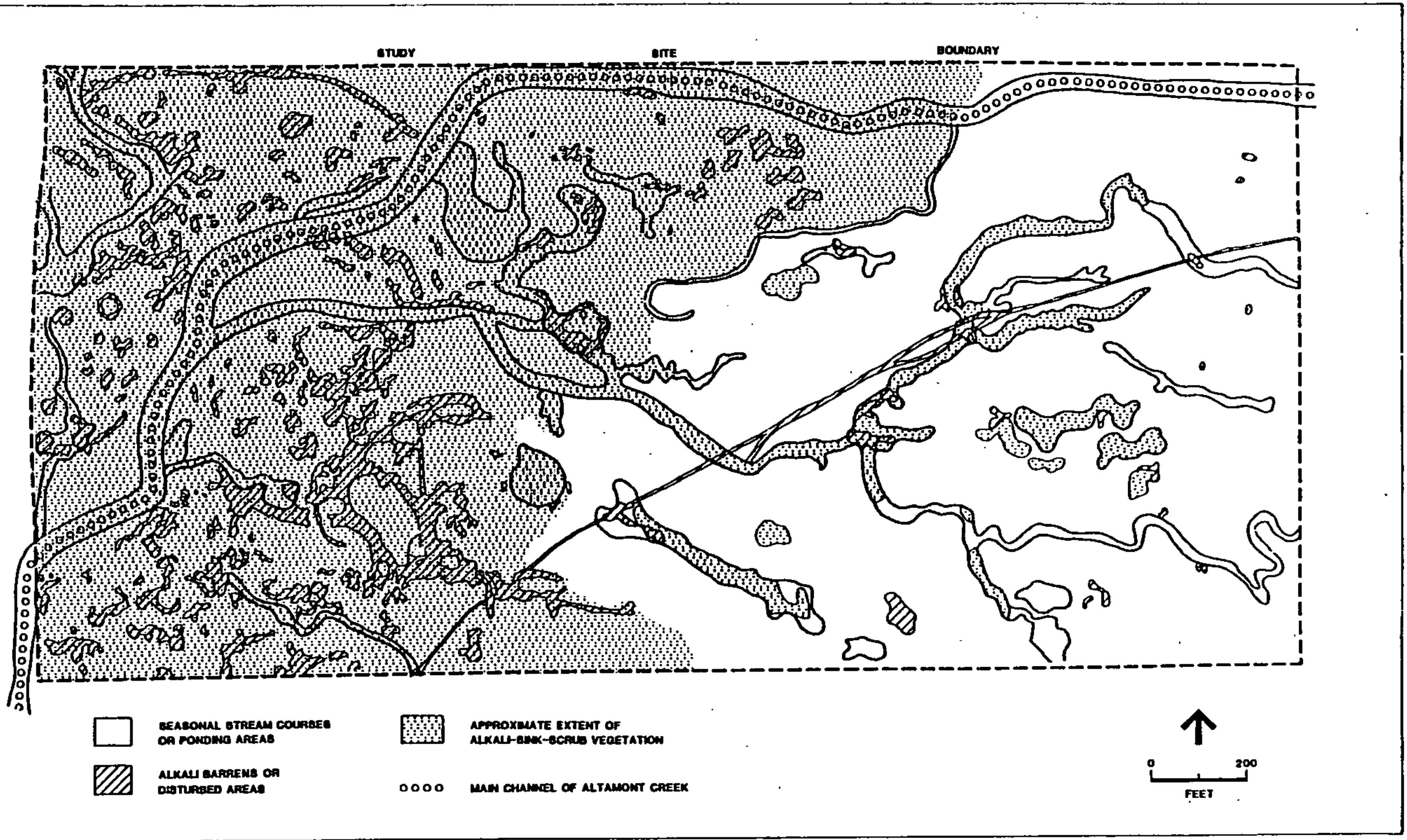


FIGURE 7.3

Habitat Map - Garaventa Site (1)

ESA/MADRONE

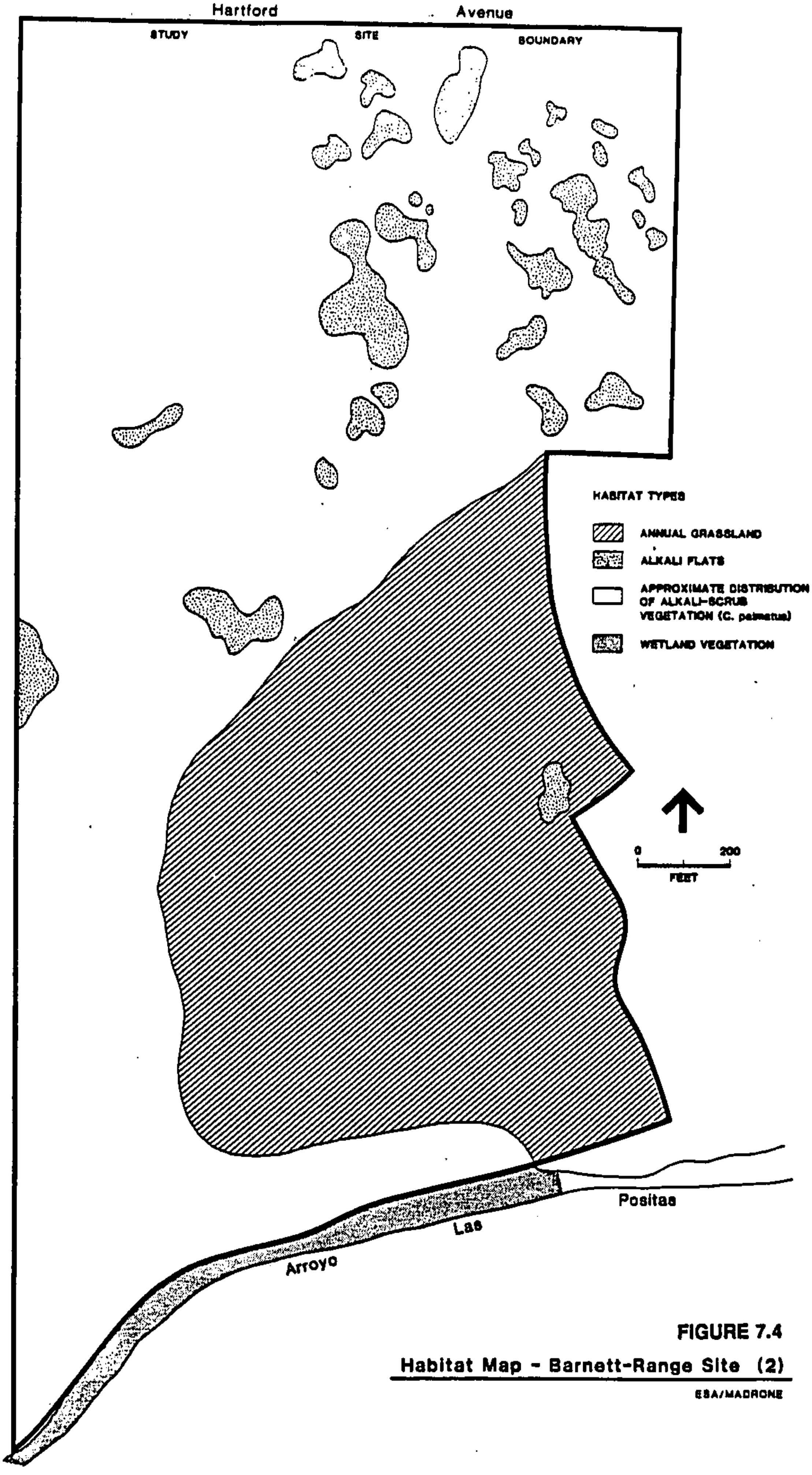


FIGURE 7.4

Habitat Map - Barnett-Range Site (2)

ESA/MADRONE

8.0 Water and Salinity Relations of Cordylanthus palmatus

Salt-affected habitats, such as coastal beaches, dunes, salt marshes and salt deserts, have a vegetation cover that is dominated by perennial plants (Barbour and Johnson 1977, MacDonald 1977, Barbour and Vasek 1977). Annual plants, such as Cordylanthus palmatus, are uncommon and tend to contribute a very small fraction of biomass and cover to the community. Annuals usually lack the physiological mechanisms that allow longer-lived species to persist under prolonged conditions of low soil moisture or high soil salinity (Bradford and Hsaio 1982, Pavlik 1984, Haines and Dunn 1985). As a result, the growth and reproduction of annuals is usually confined to periods of greater moisture availability and/or reduced salinity, with several important exceptions. One of these exceptions is Cordylanthus palmatus: its periods of maximum growth and reproduction extend through the summer and fall of each year, when soil moisture would be most limiting and salinity at its highest. There are two alternative explanations for this situation:

1) Cordylanthus palmatus is more drought- and/or salt-tolerant than the typical annual plant because it possesses physiological mechanisms that allow tolerance of low water potentials.

2) Cordylanthus palmatus is sensitive to drought and/or salt stress like other annuals, but does not experience low water potentials because its habitat is not as xeric as one would predict based on climate or soil salinity.

Although a complete study of the water and salinity relations of Cordylanthus palmatus is well beyond the scope of this report, it is possible to distingush between these two possible explanations. If the diurnal pattern of xylem water potential Cordylanthus palmatus during the summer is similar to that of dominant Springtown perennials (e.g., Allenrolfea occidentalis, Frankenia grandifolia), then explanation 1 would be supported. Since Cordylanthus palmatus is a hemiparasite, it may draw water and nutrients from the roots of most perennials through its haustoria. Although hemiparasitism is probably an important aspect of its water relations, Cordylanthus palmatus would still reflect the water status of its perennial hosts, which tend to experience low water potentials. With respect to management, this would mean that Cordylanthus palmatus is probably insensitive to hydrologic factors and would be tolerant of modifications to the habitat that affect soil moisture (e.g., runoff, infiltration, sheet flow). Otherwise, if the water potential of Cordylanthus palmatus was significantly higher than the dominant perennials, explanation 2 would be supported. In this case, the argument could be made that local hydrology, including topographic, climatic, and edaphic factors, were largely responsible for the existence and persistence of Cordylanthus palmatus at the Springtown site. It suggests that

Cordylanthus palmatus would be intolerant of modifications to the habitat that affect hydrology. Positive (i.e., less negative) deviations of Cordylanthus palmatus water potential from those of other species in its immediate vicinity would also eliminate those plants as hosts.

In July 1987, stem water potentials of Cordylanthus palmatus, Frankenia grandiflora, and Allenrolfea occidentalis were measured using a pressure bomb (Soil Moisture Equipment, Santa Barbara, California). Replicate samples were used from different individuals at the "FCC Corner" site at three times during the day -- predawn, mid-morning, and mid-day. An attempt was also made to measure leaf conductance to water vapor using a steady state porometer, but accumulations of salt and dew on the outside surfaces of Cordylanthus palmatus made the technique unfeasible. Pressure bomb readings were also obtained in February 1988, except that the annual Cressa truxillensis was substituted for the acaulescent Cordylanthus palmatus seedlings (which were not large enough to fit into the chamber). The diminutive Cressa has a root system that is similar in form and extent to the Cordylanthus palmatus seedlings and, therefore, probably experiences the same water potentials as Cordylanthus palmatus at this time. The July and February measurements should represent seasonal extremes in water potential of these species, with the former being most important in testing the alternative explanations for the activity of Cordylanthus palmatus at Springtown Alkali Sink.

The diurnal course of July and February water potentials of Cordylanthus palmatus, Cressa truxillensis , Frankenia grandifolia, and Allenrolfea occidentalis are shown in Figures 8.0 - 8.2. In all species, water potential was highest at predawn and declined steadily through the day, as is typical for plants from most terrestrial habitats. The lack of any significant difference between the July and February patterns of the annuals (Figure 8.0), however, was unexpected and extremely unusual according to the published data for wetland plants. Even in July, more than two months after the last significant rainfall, predawn water potential of Cordylanthus palmatus was higher than -1.0 MPa (similar in magnitude to plants in a tended garden). The two perennial species at this site had significantly more negative water potentials than did Cordylanthus palmatus during the predawn and morning periods of July (Table 8.0) and both exhibited typical seasonal fluctuations in the magnitude of water potential (Figures 8.1 and 8.2). Although Cordylanthus palmatus and Frankenia grandifolia exhibited the same midday water potential in July, it is still very unlikely that the two share a parasite-host relationship. This is because the water potential gradient at other times of the day, (e.g., predawn and morning) would indicate that water was flowing in the wrong direction (i.e., from Cordylanthus palmatus to Frankenia grandifolia), a condition that would rapidly lead to the dehydration and death of Cordylanthus palmatus. The same is true for Allenrolfea occidentalis - its water potential is too low to allow parasitism by Cordylanthus

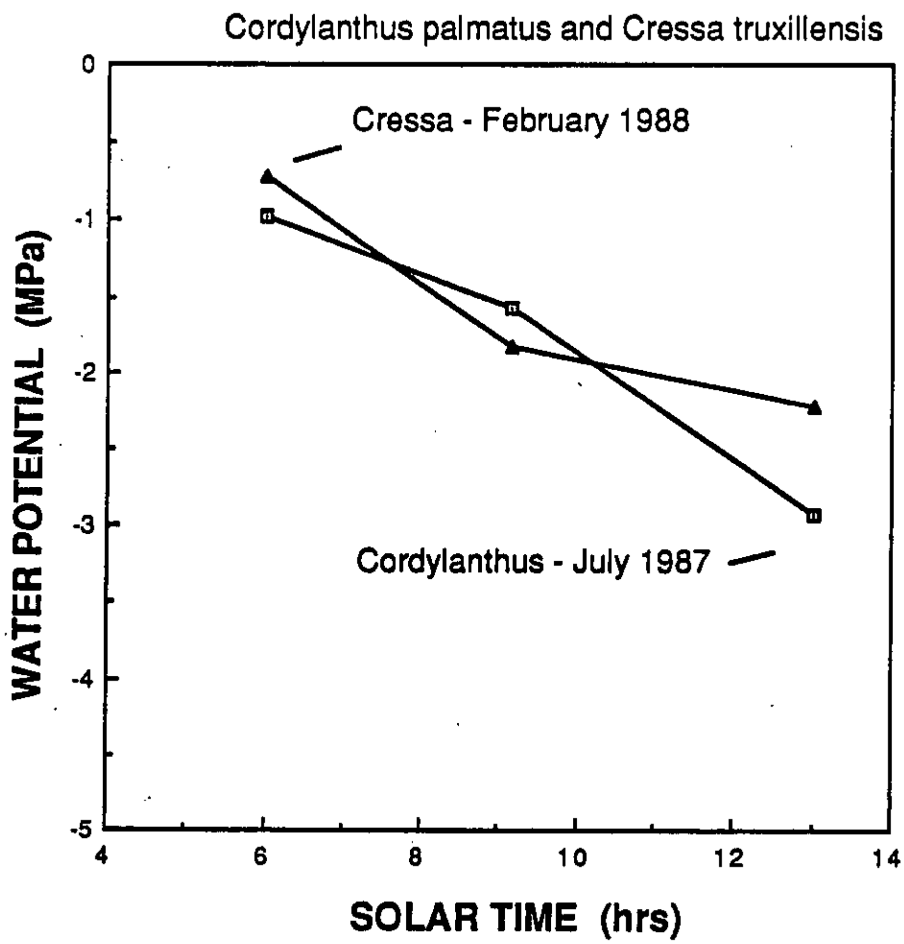


Figure 8.0 Daily pattern of xylem water potential for two annual species at Springtown Alkali Sink, 1987-88. The endangered Cordylanthus palmatus experienced the same water potentials in July as Cressatruxillensis did in winter.

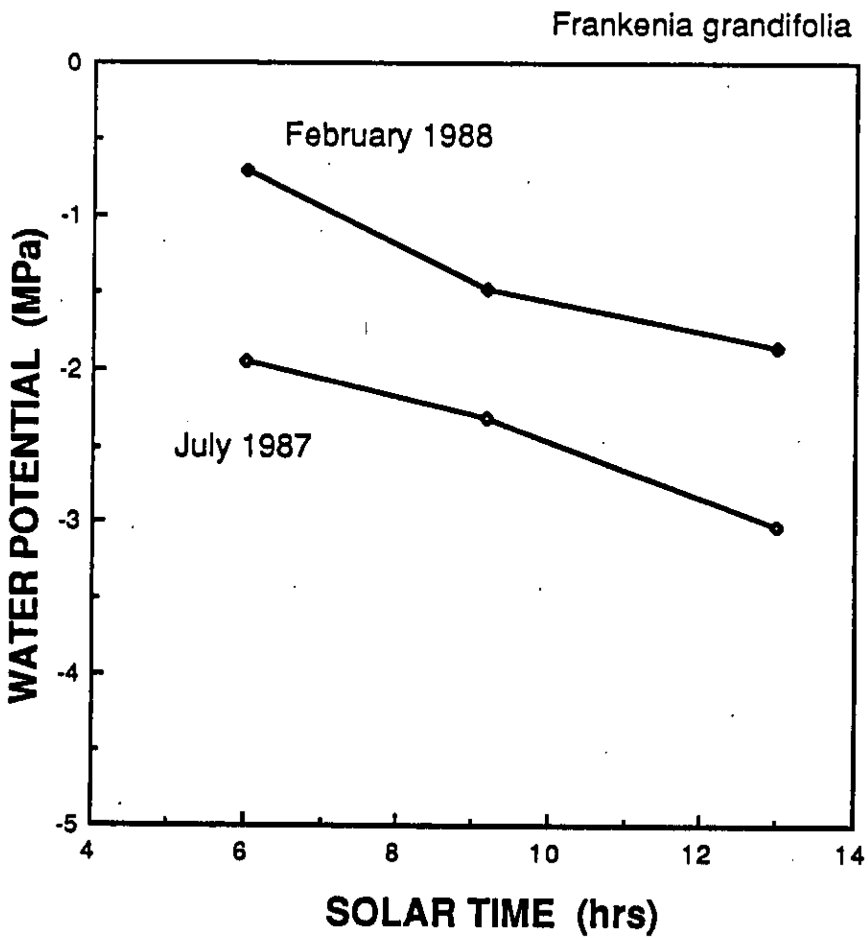


Figure 8.1 Daily and seasonal pattern of xylem water potential of the perennial Frankenia randifolia at Springtown Alkali Sink, 1987-88.

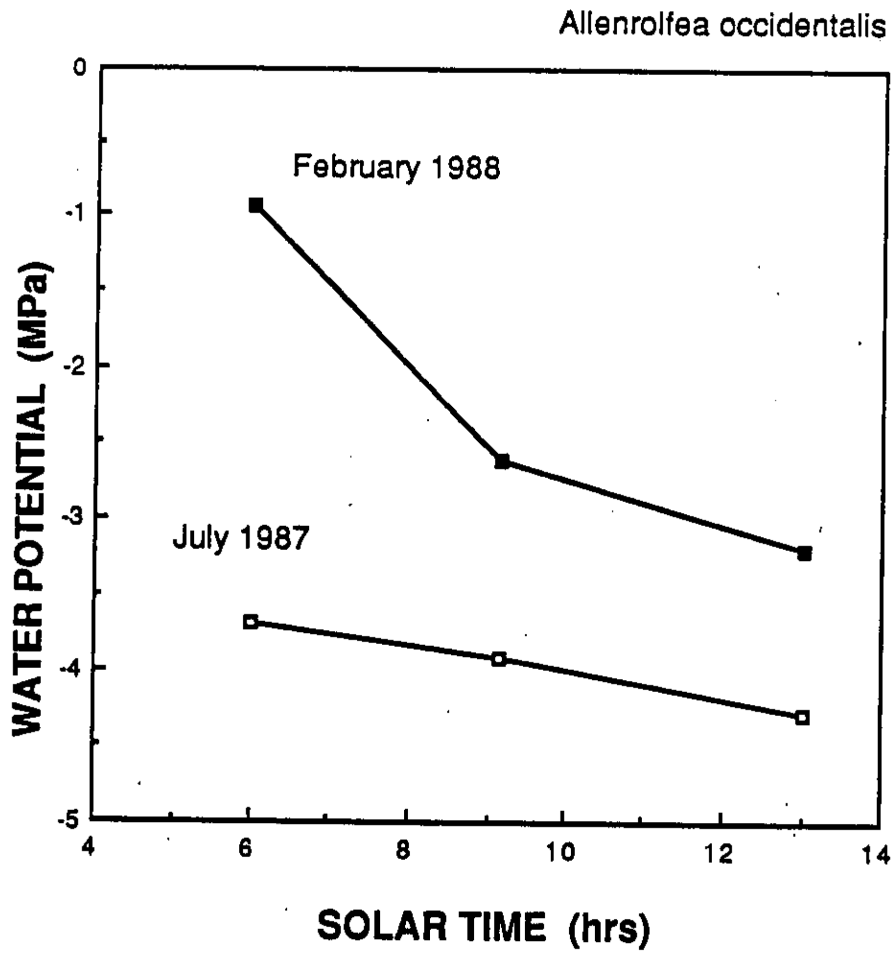


Figure 8.2 Daily and seasonal pattern of xylem water potential of the perennial _Allenrolfea occidentalis_ at Springtown Alkali Sink, 1987-88.

TABLE 8.0

Comparison of xylem water potentials (MPa) of plants from Springtown Wetlands, July 1987. Each value is a mean + SD of pressure bomb measurements made *in situ* . Values within a row followed by the same letter are not significantly different (ANOVA, $P<0.05$).

solar time	*Cordylanthus*	*Frankenia*	*Allenrolfea*
predawn	-0.98± 0.22a	-1.95± 0.63b	-3.70± 0.16c
9:15 am	-1.59± 0.17a	-2.33± 0.06b	-3.94± 0.14c
1:00 pm	-2.93± 0.62a	-3.02± 0.08a	-4.18± 0.17b

palmatus. A more likely candidate for the host plant is Distichlis spicata, but its stems were too small to be used in the pressure bomb.

These measurements of water potential integrate both the effects of soil dehydration and soil salinity. The presence of high concentrations of sodium chloride presents an additional source of stress for Cordylanthus palmatus and other plants at this site. Each of the species studied has its own mechanisms to deal with salt in order to reduce its effect on water potential and mineral nutrition. Cressa truxillensis, like most salt-intolerant annuals, avoids high salinities by germinating, growing, and reproducing when winter rains dilute the salt and hydrate the soil. Cordylanthus palmatus, Frankenia grandiflora and Allenrolfea occidentalis grow and reproduce during the dry summer, when salinity increases. Each of these species must deal with the salts that accumulate in their tissues. Allenrolfea occidentalis sequesters the salt in its own succulent stem tissues, using water to dilute its osmotic effects. In contrast, Cordylanthus palmatus and Frankenia grandiflora have glands that excrete salt to the exterior of the plant. These salts, when washed or shed to the soil surface, would achieve high concentrations and potentially accentuate the effect of soil dehydration on plant water potential if they were reintroduced into the root zone.

Given the high values of July water potential of Cordylanthus palmatus, it is clear that these excreted salts are spatially separated from the root zone after deposition on the soil surface. This is supported by the results of a single experiment conducted during July, when Cordylanthus palmatus plants were given 500 ml of distilled water at their base just prior to the predawn pressure bomb measurements. During the course of the day, the plants given water were at a much lower water potential (i.e., they were more stressed) than unwatered plants (Table 8.1). Evidently, the water leached the surficial salts into the root zone, thus lowering plant water potential. The implication is that Cordylanthus palmatus may depend on low salinity in the groundwater during its period of maximum reproductive activity. It is also possible that the salt-laden droplets of dew that form on plants overnight could contribute to the elevation of plant water potentials if the water potential of those droplets were significantly higher than the water potential of the plants. In this way, atmospheric moisture could contribute to rehydration of the plants without leaching soil surface salts into the root zone.

The available data suggest that Cordylanthus palmatus does not experience low water potentials because its habitat is not as xeric as one would predict based on climate or soil salinity. Runoff and subsurface storage of water are, therefore, important to maintaining the relatively high water potentials of Cordylanthus palmatus plants at the Springtown Alkali Sink. It is probable that like other annuals, Cordylanthus palmatus is sensitive to drought and/or salt stress and intolerant of

TABLE 8.1

Effect of surficial watering on the water potential (MPa) of *Cordylanthus palmatus* at the Springtown site, July 1987. Each value (except the 1:00 pm watered) is a mean-+ SD of pressure bomb measurements made *in situ* . Values in a column followed by the same letter are not significantly different (ANOVA $P < 0.05$).

treatment	predawn	9:15 am	1:00 pm
unwatered control	-0.98± 0.22a	-1.59 ± 0.17c	-2.93± 0.62
watered	-1.98± 0.27b	-2.59 ± 0.30d	< -3.5

hydrologic modifications to the habitat. The data do not, however: 1) confirm the source of available water; 2) indicate the importance of atmospheric deposition in the form of condensation to plant hydration; 3) identify the host plant (if any); or 4) rule out the possibility that Cordylanthus palmatus possesses tolerance mechanisms that are not expressed under the conditions found at Springtown. Nevertheless, no data exist that indicate insensitivity to drought and/or salt stress.

9.0 *Microdistribution of Cordylanthus palmatus*

In mapping the distribution of *Cordylanthus palmatus* at the Springtown site, it was noted that the plant is generally most successful on the sides of drainage swales or channels rather than on the tops of mounds or floors of vernal pools. Three hypotheses may explain the microdistribution of the plant. First, flowing water may be essential for dispersing seeds. Floating seeds would be caught in grass along the margins of ephemeral channels rather than deposited on the channel bottoms. Second, surface water (or high soil moisture levels) may be necessary to dilute soil solute concentrations enough to permit germination and seeding establishment. Third, *Cordylanthus palmatus* and competing vegetation may segregate along gradients of soil chemistry and available soil moisture. Microsites between the mound tops and swale bottoms may simply have the range of physical and chemical soils properties at which *Cordylanthus palmatus* competes most successfully.

9.1 Methods

In order to describe the microdistribution of *Cordylanthus palmatus* in relation to soil chemistry and hydrology, two 24-meter transects were surveyed near the southwest corner of the Livermore City property. Transect No. 1 crossed a swale adjacent to an ephemeral channel; transect No. 2 crossed a channel that held ponded water during the spring of 1988. Along each transect, elevation was measured at 1 meter intervals and percent cover of annual grasses and alkali sink vegetation (including *Cordylanthus palmatus*) was noted. Soil samples were collected at 2-meter intervals from depths of 0-2 inches and 2-4 inches, and returned to the laboratory for chemical analysis. This included pH, electrical conductivity (E.C.) and Sodium Adsorption Ratio (SAR) of the saturation extract.[1]

9.2 Results

Figures 9.20 and 9.21 show the elevation along the two transects. Figure 9.22 shows the distribution of vegetation along the two transects, and Figures 9.23 and 9.24 show the distribution of pH, E.C. and SAR along the transects. Since there was little difference between the values for 0-2 inches and 2-4 inches, the data for the two depths were averaged. The

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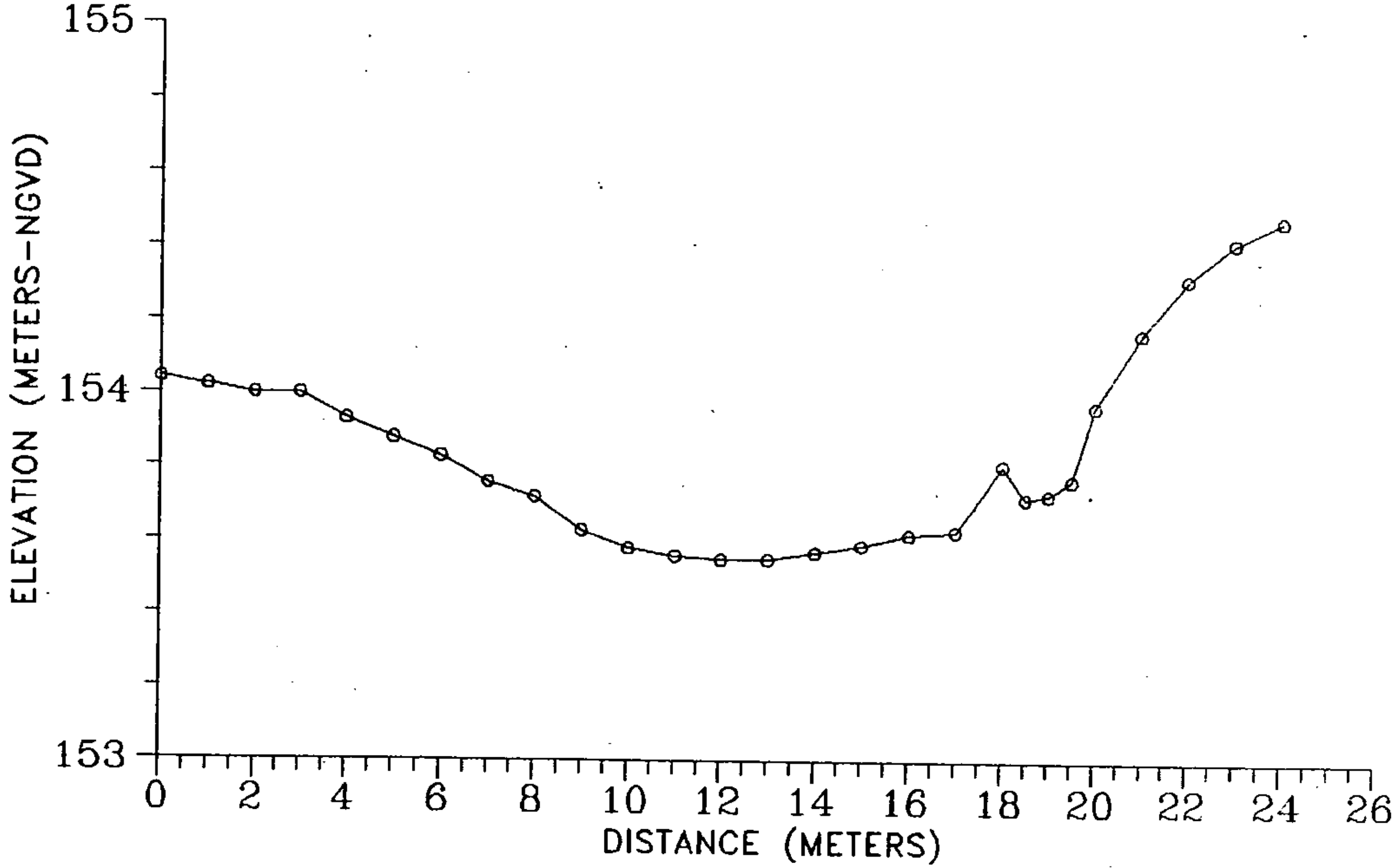
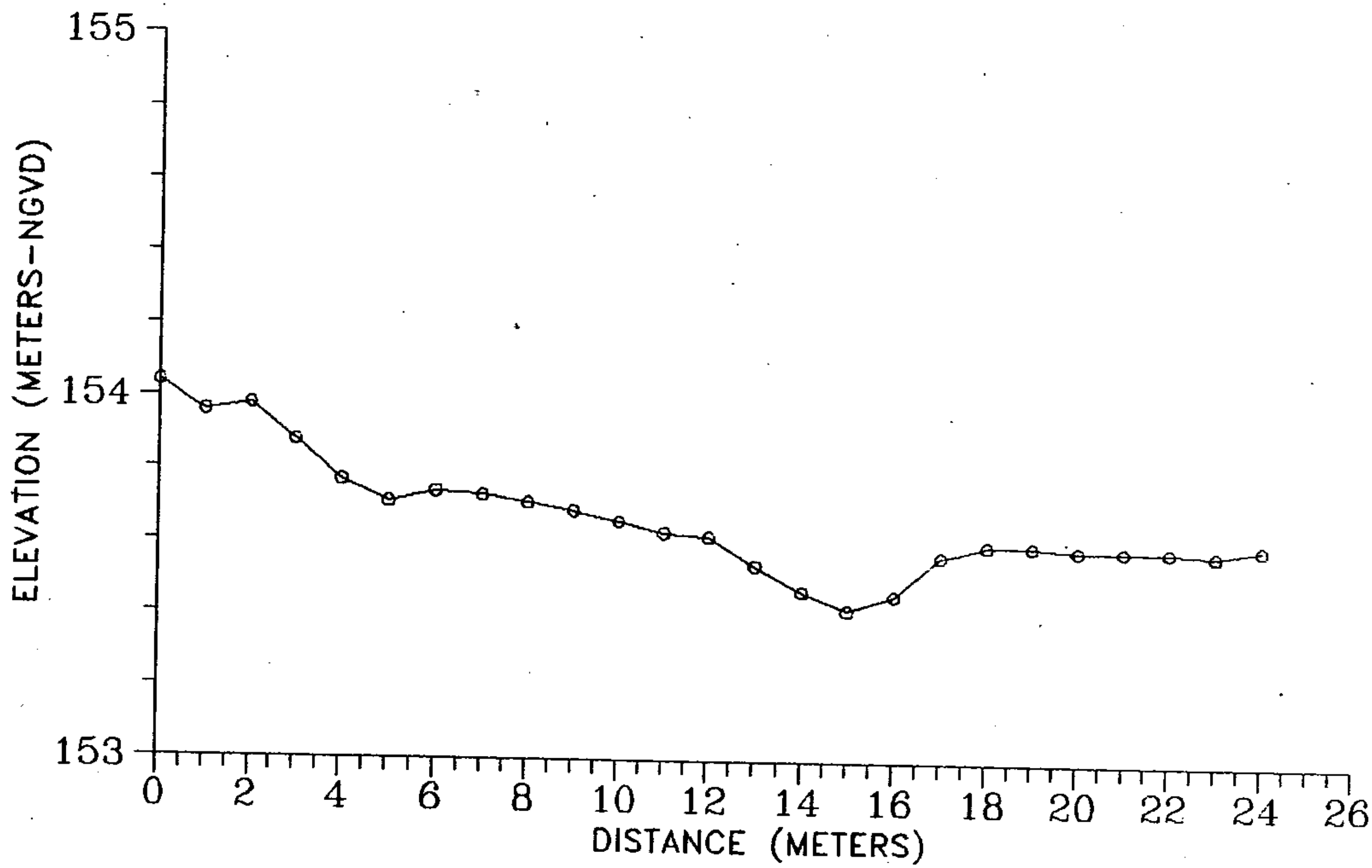
1/ $$\left(SAR = \frac{Na^{+}}{\sqrt{\dfrac{Ca^{++}+Mg^{++}}{2}}}\right.$$

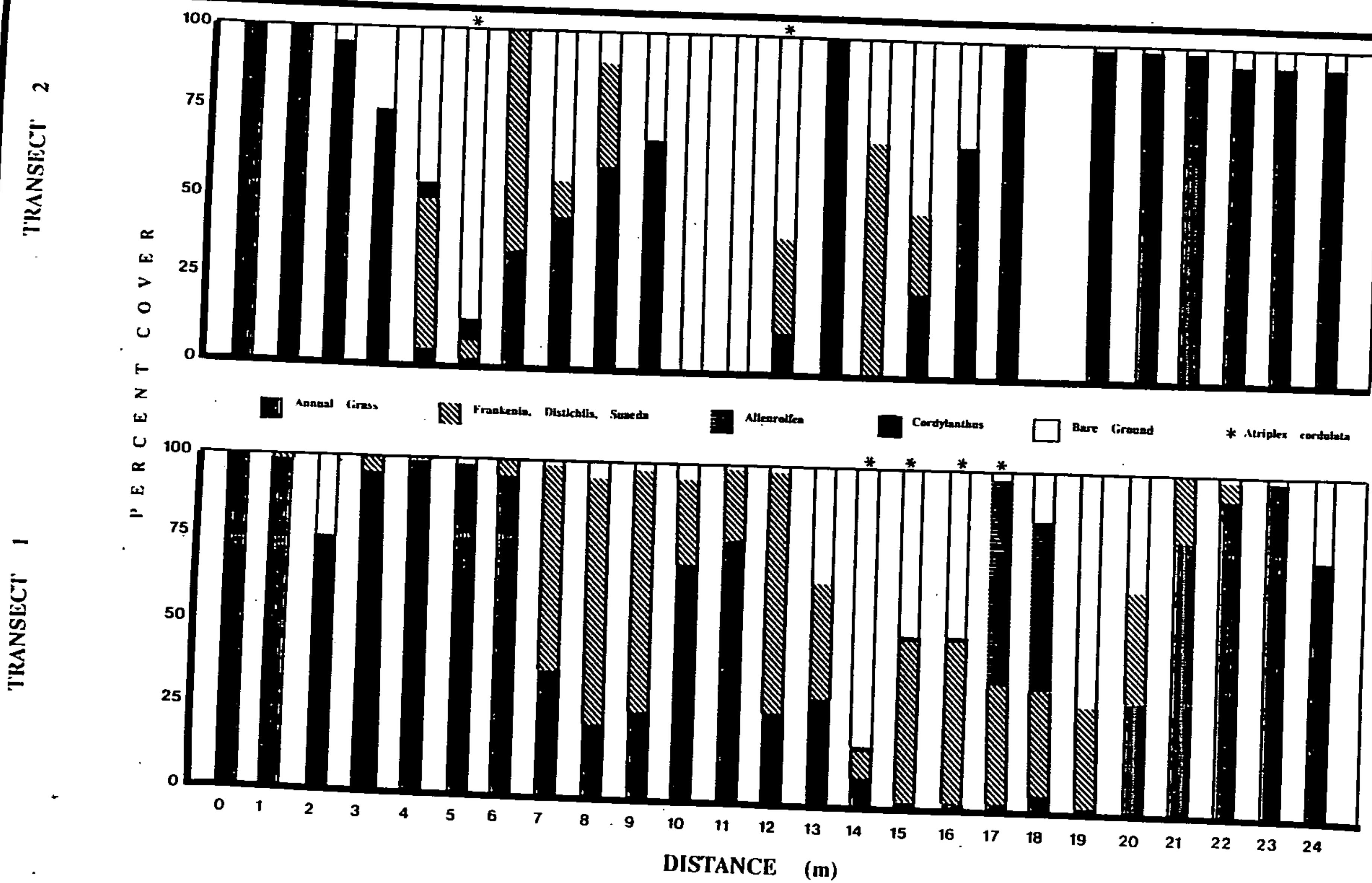
expressed as milliequivalents per liter; it is an expression of the degree to which the cation exchange complex is dominated by sodium.



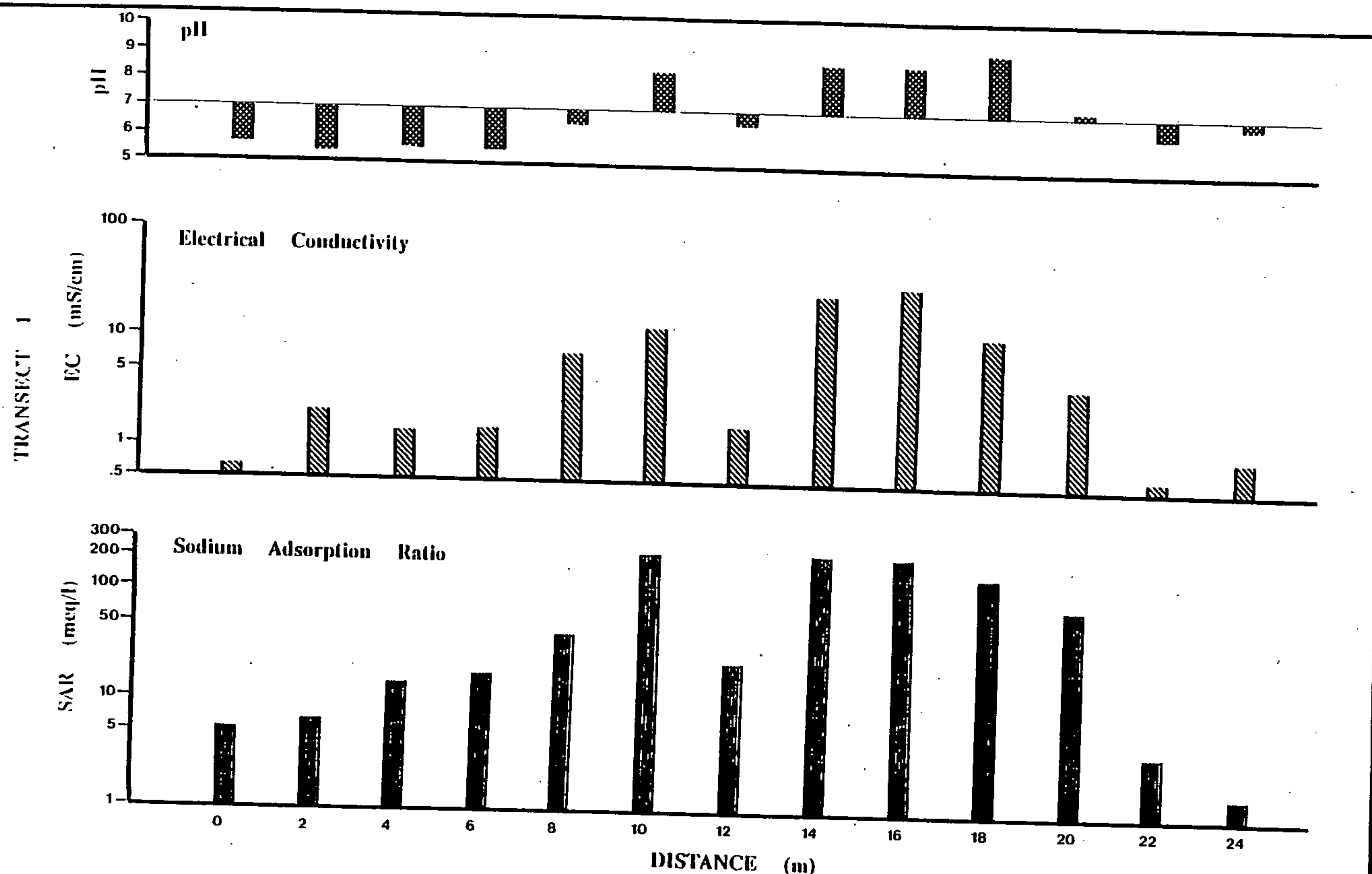
9.20 Surface Elevation Along Transect 1



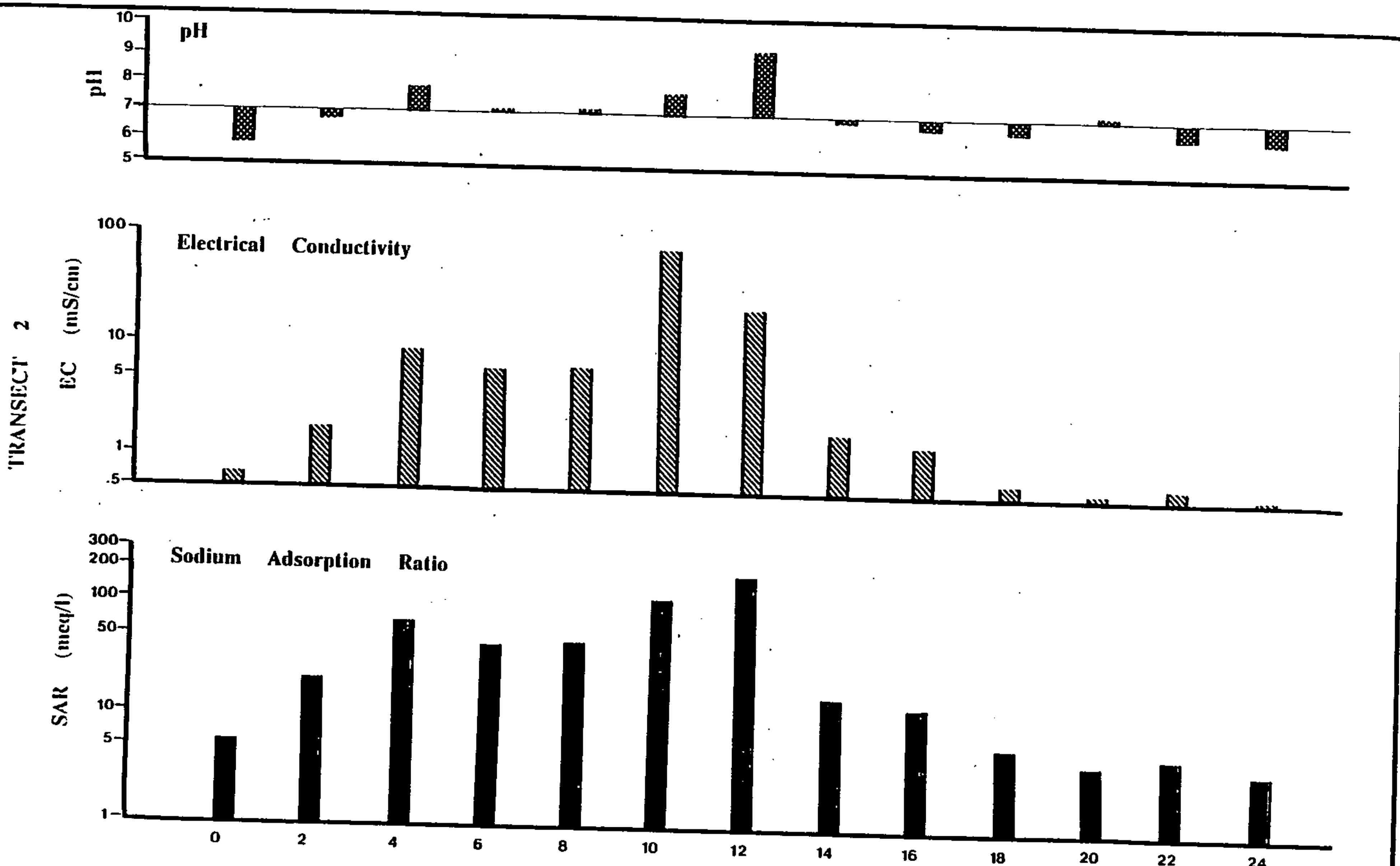
9.21 Surface Elevation Along Transect 2



Vegetation Distribution along Transects 1 and 2

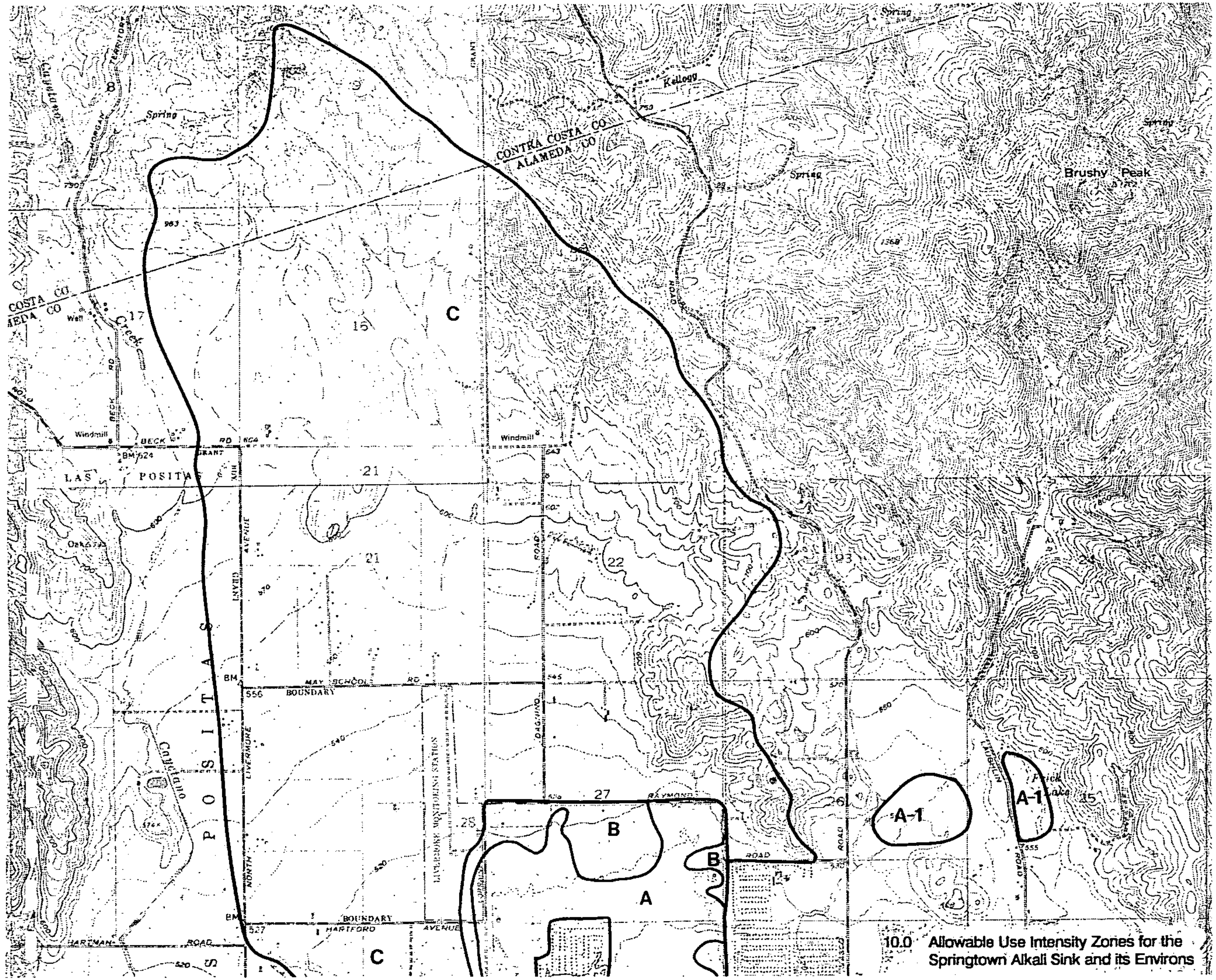


9.23 Soil Chemical Properties Along Transect 1



9.24 Soil Chemical Properties Along Transect 2 original data are shown in Appendix VI. From mound tops to swales, there is a sharp gradient in both soil chemistry and vegetation. Mound tops have slightly acid soils, low salinity and low SAR values; they are dominated by annual grasses. Moving toward the swales, the pH, E.C. and SAR increase dramatically, and vegetation is increasingly dominated by alkali and salt-tolerant plants, and plant cover decreases.

Along the first transect, Cordylanthus occurred at the most extreme saline-sodic conditions, with a pH of 8.5-9.2, electrical conductivity (E.C.) of 24-42 mS/cm, and SAR of 188-284 meq/l. Along the second transect, where it was more abundant, it occurred under less extreme conditions, with pH of 7.2-8.6, E.C. of 8.1-9.4, and SAR of 59-89 meq/l. It appears that Cordylanthus palmatus is unable to compete with annual grasses in moderately acid non-sodic soils; it can tolerate extreme conditions of salinity and alkalinity, but thrives best under moderately saline-alkali conditions.



10.0 Allowable Use Intensity Zones for the Springtown Alkali Sink and its Environs

10.0. Management Plan for *Cordylanthus palmatus*

The objective of management is to maintain a viable alkali sink wetland ecosystem that includes habitat for *Cordylanthus palmatus* and the many other plant and animal species that inhabit the site. This will require active management; simply fencing the site will neither provide adequate protection nor allow the public a valuable educational opportunity.

The U.S. Fish and Wildlife Service and California Department of Fish and Game developed these recommendations following a careful consideration of the technical information provided in this document, a review of the scientific literature, and consultation with agency biologists and biologists in the academic community.

Management of the site can best be approached by subdividing it into zones of allowable use intensity. These zones take account of plant distribution, soils, and hydrology (see Figure 10.0). The zone boundaries are for general planning purposes only; for design purposes, boundary locations may need to be field-verified.

Zone A. This zone comprises: 1) existing and potential habitat for *Cordylanthus*, defined by valley sink scrub vegetation and saline-sodic soils; and 2) areas defined by the U.S. Army Corps of Engineers as wetlands. Areas that fit these criteria in 1982 but have been subsequently disced are still included, since they are probably restorable as *Cordylanthus* habitat. Our management recommendations for this zone include:

A. Land Use

1. No additional roads, subdivisions, or other forms of development.

2. Removing the cattle and monitoring the subsequent vegetation changes.

3. Initiating a controlled burning experiment. Controlled burning would favor the dominance of saltgrass (*Distichlis*) and possibly other perennial species over annual exotic grasses. It would also reduce the fuel load and the likelihood of wildfire.

4. Repairing ORV damage on the Garaventa parcel, and improving fencing to prevent future intrusion.

5. Confining bicycle activity and foot traffic to one or two trails across the site. These should be designated and fenced with the active participation of the main user groups.

6. Developing an interpretive trail with boardwalk and signs in part of the zone, calling attention to the unique ecological features of the site. Dogs should be permitted only on leashes.

B. Hydrology

1. Restoring damage from gully erosion at the south margin of the city parcel and at the west side of the Garaventa parcel. The gully erosion at the south edge of the city property could be treated by excavating a shallow, more sinuous channel with a lower slope, and filling the existing channel. Erosion at the head of the gully at the western edge of the Garaventa property will have to be treated with check-dams and gully plugs. Control of gully erosion in the alkali sink is extremely important for maintaining site hydrology. Gully formation would in the long run lower the shallow water table, dewatering the wetland and altering both soil chemistry and soil water availability.

2. Restoring the hydrologic characteristics of the Garaventa-Kaufman and Broad parcels. This might be done by: a) diverting stormwater from the subdivision east of the area to the ephemeral channels on the site; it might be possible to divert storm runoff at the end of Berkshire Pl. to the relict channels 100 ft. and 600 ft. to the south (at "B" on Fig. 6.2); b) diverting water from Altamont Creek during runoff periods onto the floodplain. This could be done with a weir and side channels cut into the stream channel; c) pumping water from Altamont Creek during the summer. The price of water released to Altamont Creek from the South Bay Aqueduct is $30/ac-ft. All of these measures would require additional hydrologic and hydraulic analysis.

3. Assess hydrologic trends and apply results to species management planning (see Chapter 11).

C. Species Management

1. Initiate a long-term monitoring program designed to document population trends for Cordylanthus palmatus, determine the effects of site management on the species, and assess enhancement efforts (see Chapter 11 and Appendix IV).

2. Identify potential Cordylanthus habitat offsite and establish new populations. Establish a management and monitoring program for the new sites.

Zone A-I. These areas, around Frick Lake, and between Frick Lake and Vasco Road, are discontiguous areas of alkali sink. They appear to have the physical characteristics of good Cordylanthus habitat, but no Cordylanthus has been found on them. They may, however, be potential mitigation sites for establishment of new populations of Cordylanthus. It is likely that the U.S. Army Corps of Engineers would assert jurisdiction over these areas as wetlands. If they are to be used as mitigation sites, additional hydrologic and ecological evaluation will be necessary.

In areas where Zone A abuts directly on existing subdivisions, land use and human impacts will have to be carefully planned. At present, the alkali sink areas are at the back of the subdivisions, and some local residents have no reason to view the alkali sink as anything other than a wasteland. The former dumping of debris and ORV damage attest to the attitude of at least part of the public. These border areas may need to be made the focal point for public access and education, with trails, interpretive signs, landscaping, and picnic areas. They will have to be patrolled and maintained by park personnel. In the long run, the alkali sink ecosystem and habitat for Cordylanthus can only be maintained with active community support and interest.

Zone B. This zone provides a buffer around Zone A that is needed to ensure protection from disturbance. The zone includes areas of saline-sodic soils that support annual and perennial grassland, but not wetlands or alkali sink scrub vegetation. Where roads abut Zone A, the road itself may be considered Zone B. The minimum zone width should be 200 yards, but in some areas the zone is defined to include the strip between Zone A and the nearest road or street.

Management objectives for this zone include:

1. No new subdivisions, roads, or other developments.

2. Open-space uses, such as picnic areas and playing fields, are acceptable, provided they create no off-site hydrologic impacts.

3. Free-roaming dogs and BMX bicycles are acceptable, but not mechanized ORVs.

Zone C. This zone comprises the watershed lands of the alkali sink. These areas are extremely important in providing groundwater recharge and surface runoff to the sink. Recommendations for this zone include:

1. Only low-density residential development or open-space uses should be permitted. A minimum lot size of 1/2 acre, and maximum allowable impervious surface of 10 percent would result in relatively little hydrologic impact (Rantz, 1971).

2. Any development should include site-specific mitigating measures to prevent off-site hydrologic impacts. Possible mitigation might include, for example, detention/recharge basins to reduce runoff peaks from impervious surfaces and allow infiltration to the shallow groundwater. Storm drains should have well-maintained trash racks to prevent deposition of debris and refuse in the alkali sink. Storm runoff should be routed to the sink, and not directly to Altamont Creek. This will require careful placement of culverts and drainways. All mitigation masures should be spelled out in detail in the permit conditions for any development in Zone C.

11.0 Monitoring Program for *Cordylanthus palmatus*

Objectives:

A monitoring program for the State- and Federally-listed Endangered Species, *Cordylanthus palmatus*, is required for proper management of the Springtown Alkali Sink wetlands. The specific objectives of this program include; 1) documentation of population trends; 2) determination of the effects of site management (fire, grazing, hydrological alteration) on the population; 3) assessment of efforts to increase the size of the existing population by identifying demographic factors that limit population growth; and 4) assessment of gully erosion, surface flooding, and shallow water table elevations.

Approach:

The preservation of rare and endangered plants depends on the establishment and maintenance of habitat reserves - intact ecosystems whose basic biotic communities have not been damaged or impaired by development or disturbance. Although these reserves and other forms of land-use restriction are absolutely essential, they do not, in and of themselves, ensure the recovery and persistence of endangered populations. It has become increasingly apparent that these populations must be actively managed, beyond passive protection, in order to slow and eventually reverse their decline. Endangered species management requires quantitative, autecological data that can readily be generated from a field monitoring program.

Monitoring is a quantitative assessment of the status of a population over time using data derived from individual plants. Excluded are conservation efforts related to rare plant inventory (a geographically-based assessment of entire taxa) and survey (an ecologically-based assessment of entire taxa). A monitoring census is accomplished by marking or mapping individual plants in a population and repeatedly measuring characteristics of their performance *in situ*. Monitoring is, therefore, capable of identifying the timing and causes of poor performance (e.g., mortality prior to reproduction, inhibited stomatal conductance due to drainage pattern alteration) and providing specific management recommendations for amelioration. Further discussion of monitoring may be found in Pavlik (1987) and Pavlik and Barbour (1988).

Rare plant monitoring has been discussed in general terms by Davy and Jefferies (1981), Williams (1981) and Huenneke *et al.* (1986). It is clear that a large number of demographic, physiological, and genetic characteristics of populations could be chosen for assessing performance over long or short periods of time, depending on the biology of the taxon in question. Most managers with training in plant ecology recognize that life history traits, demographic attributes, physiological performance, and genetic heterogeneity are important to plant conservation efforts, but they also need to know how these aspects of rare plant biology can be incorporated into monitoring programs and used to generate management decisions.

The relevant demographic attributes most readily incorporated into a monitoring program for Cordylanthus palmatus include survivorship, seed production and seed germination. These attributes are central to plant demographic studies in general and are especially applicable to rare plant monitoring (Butterwick 1987, Pavlik 1987, Taylor and Palmer 1987, Palmer *et al*. 1987, Berg 1987). Although many other life history features could have seen selected, the need for management-oriented information was given highest priority. In addition, certain characteristics of Cordylanthus palmatus (e.g., its annual, hemiparasitic, microspermous nature and apparent lack of native disease and predation vectors) suggested that some life history features (e.g., population age structure, seed bank dynamics) are of less importance for monitoring. Physiological monitoring (Pavlik 1987), involving measurements of plant water status and whole plant growth, would only be required if hydrological features near the site were altered by development or management.

Procedure:

The general design of demographic and physiological monitoring is outlined below with respect to each of the stated objectives of the program. The detailed methods for the monitoring program are described in Appendix IV.

I. Documentation of Population Trends

The successful management of Cordylanthus palmatus at the Springtown Alkali Sink will depend on the analysis of short-term (within a single year) and long-term (multi-year) trends in the population. Short-term trends, coupled with detailed observations *in situ*, can reveal the causes of plant mortality that restrict population growth. Long-term trends identify relationships between the population and variations in the environment (e.g., precipitation). This can allow managers to distinguish between natural and anthropogenic forces that act on the population and assess the effects of current management policy.

Two sites should be selected for monitoring. The recommended sites "FCC Corner" and "Livermore Central" are shown on Figure 11.0. These sites were selected because: 1) they are at the lower end of relatively undisturbed drainage systems; 2) they support substantial populations; and 3) they appear to be relatively inconspicuous and safe from accidental disruption or vandalism. The selected sites should be protected from livestock grazing and other forms of disturbance, but not by small enclosures. If controlled burning experiments are carried out, the long-term monitoring sites should be used as control plots.

Detailed mapping of individual plants should be carried out twice in the first year of monitoring, once after germination and

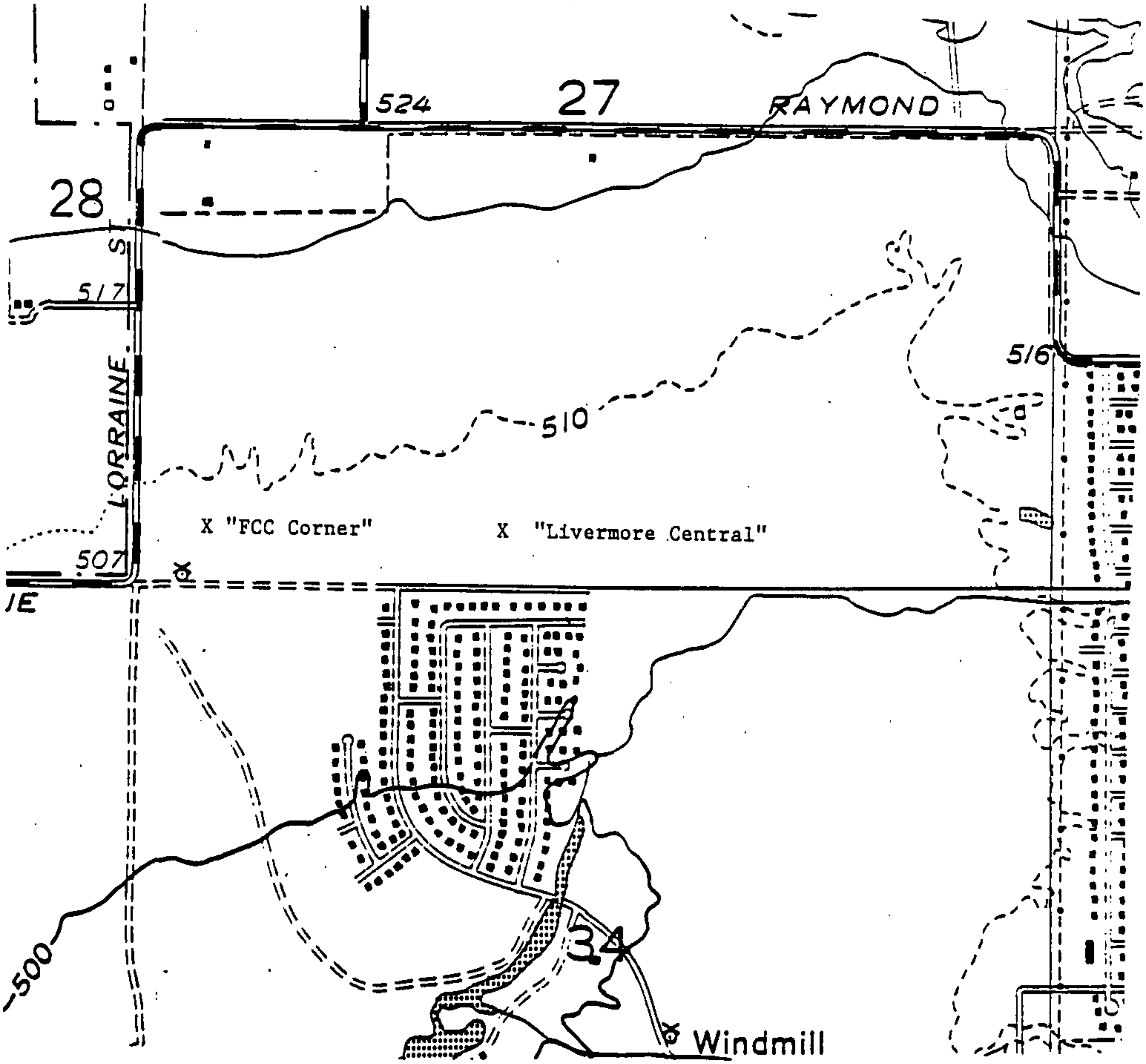


Figure 11.0 Location of the "FCC Corner" and "Livermore Central" subpopulations of Cordylanthus palmatus at Springtown Alkali Sink.

early growth (late January or early February), and again in early summer. Additional ecological information (such as microtopography, soil texture and chemistry, other vegetation, etc.) could be overlayed onto these maps. After the first year, it may not be necessary to remap the sites for another two or three years.

In addition to population mapping at both sites, it is also important to follow the survival of individual plants within subplots on each site. Annual demographic monitoring should provide useful information on the short- and long-term population trends of Cordylanthus palmatus, and the timing and causes of plant mortality. Such information is essential for designing mitigation for increases in mortality or decreases in fecundity.

II. Monitoring the Effects of Site Management

When the management of the Springtown Alkali Sink requires significant modifications to the habitat of Cordylanthus palmatus, it will be necessary to determine the effects of those modifications on the population. For example, if fire is going to be used to suppress the growth of non-native plants and promote the growth of natives, it will be necessary to determine how fire will effect Cordylanthus palmatus using a properly controlled, replicated, small-scale experiment. Such an experiment would be performed by designating control (non-burned) and experimental (burned) sites containing subpopulations of Cordylanthus palmatus. These sites would be surveyed for Cordylanthus palmatus in order to document its distribution and density prior to treatment. The cover and vigor of other native and non-native plants at this time should be documented using standard vegetation sampling techniques. After treatment, a monitoring program similar to that described in Appendix IV would be put in place to see if the relevant population parameters (seedling density, survivorship at reproduction, fecundity, seed rain, seed quality) indicate a favorable effect of the treatment on Cordylanthus palmatus.

If management or development, either on or off the site, involves hydrological modification, it may be necessary to physiologically monitor plants in the vicinity. Physiological monitoring has the advantage of detecting plant stress and identifying its cause before the onset of senescence or death (Pavlik 1987). In this case, the water relations and growth of control plants (in an adjacent, unmodified drainage) would be compared to the water relations of plants growing in the modified drainage.

III. Enhancement of Existing Population

Although the Springtown population of Cordylanthus palmatus was estimated to consist of 10,000 to 11,000 individuals in 1988, it will be necessary to promote population growth in disturbed areas of suitable habitat in order to optimize the chances for long-term survival of the plant. Observations made during demographic monitoring of undisturbed subpopulations should identify factors that limit growth. For example, data collected in 1988 suggest that density-dependent factors, such as intraspecific competition among seedlings, result in high mortality (Figure 11.1). If so, artificial "seed dispersal" would serve to establish new subpopulations and reduce mortality within the parental subpopulation. Demographic monitoring of these new subpopulations would provide additional management information for both the natural and artificial populations at Springtown (Pavlik et al. 1988). The procedure for monitoring the new subpopulation would be the same as described above for monitoring at the control sites.

IV. Assessment of Hydrologic Trends

Maintaining a viable population of Cordylanthus in the long run requires maintaining favorable hydrologic conditions on the site. Monitoring of hydrologic variables should include: 1) periodic measurement or photo-documentation of erosion hot-spots. This would enable corrective action to be taken if erosion control measures proved to be ineffective. 2) Measurement of flood levels and extent of surface flooding. This should be done at surveyed cross-sections following major floods or rainfall periods. Such observations could help evaluate the effectiveness of measures taken to restore surface runoff to portions of the site. 3) Monitoring of shallow groundwater levels. This could be done by installing piezometer tubes on transects at known elevations across the site, and periodically measuring the depth to water. The results would help determine the extent to which offsite developments have altered the shallow groundwater regime and duration of soil saturation.

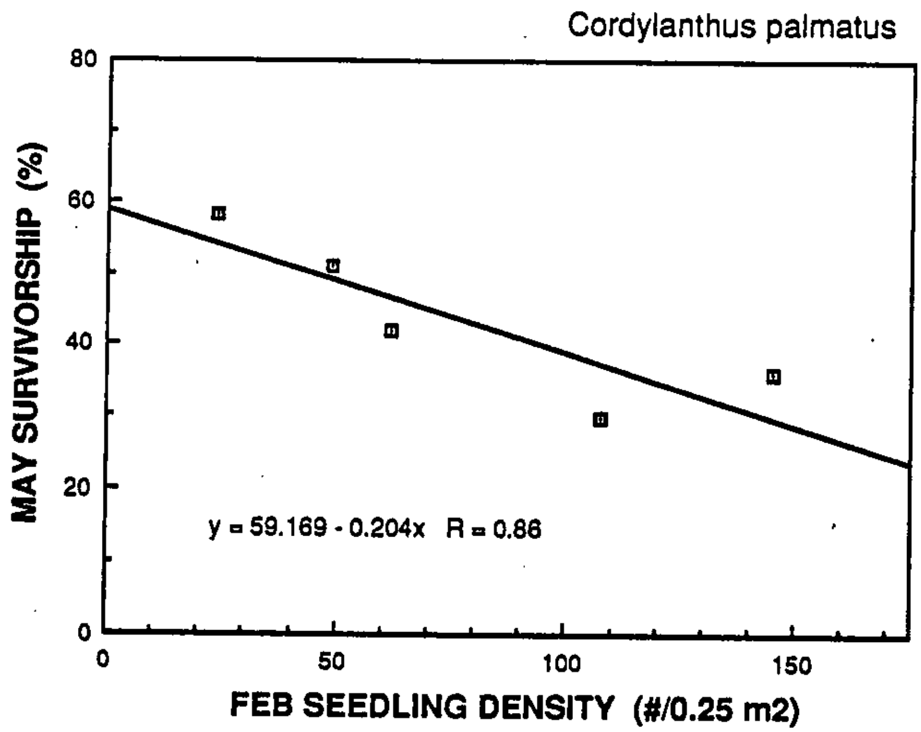


Figure 11.1 An example of data from demographic monitoring of <u>Cordylanthus palmatus</u> at Springtown, 1988. Quadrats with lower seedling density experienced higher survivorship of adult (flowering) plants.

12.0 Summary and Conclusions

Alkali sinks have long been viewed as wastelands, suitable at best for agricultural "reclamation" or suburban development and at worst for wastewater and refuse disposal. In recent years, however, they have come to be recognized for other values: they provide important habitat for a unique assemblage of plants and wildlife, and have considerable scientific and educational value.

The Springtown Alkali Sink is a Federally regulated wetland and habitat for the State- and Federally-designated endangered *Cordylanthus palmatus*. The life cycle of the plant is intimately connected to the annual cycle of seasonal flooding, dilution of surface salinity, and subsequent dessication. In order to maintain a viable population of the plant and to enhance the existing and potential values of the site, it will be necessary to:

1. Prohibit future development in areas currently or potentially occupied by *Cordylanthus*, and in buffer zone areas.

2. Maintain a hydrologic regime on the site that permits annual flooding and maintains the saline-alkali nature of the soils. This will require some protection of watershed lands that drain into the sink.

3. Eliminate intrusion by offroad vehicles.

4. Repair existing damage from gully erosion at some spots, and restore seasonal ponding and high water table.

5. Remove cattle and initiate burning experiments on the site.

6. Develop and implement a long-term plan for monitoring and maintenance.

Protection and enhancement of the alkali sink ecosystem do not preclude all development on lands that drain into the sink. They do require, however, that any development include site-specific mitigation measures that will prevent off-site hydrologic impacts.

With careful management, the degraded and damaged areas of the alkali sink wetland will gradually recover their former diversity and productivity. Wildlife use will increase, and spring wildflower displays will be enhanced.

The alkali sink habitat at Springtown that supports *Cordylanthus palmatus* is a unique environment that offers great opportunities for educational and interpretive programs, scientific research, and some kinds of outdoor recreation. With proper planning and maintenance, the alkali sink ecosystem can become a valuable asset to the community.

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APPENDIX I

MORPHOLOGY OF CORDYLANTHUS PALMATUS AND C. MOLLIS SSP. HISPIDUS

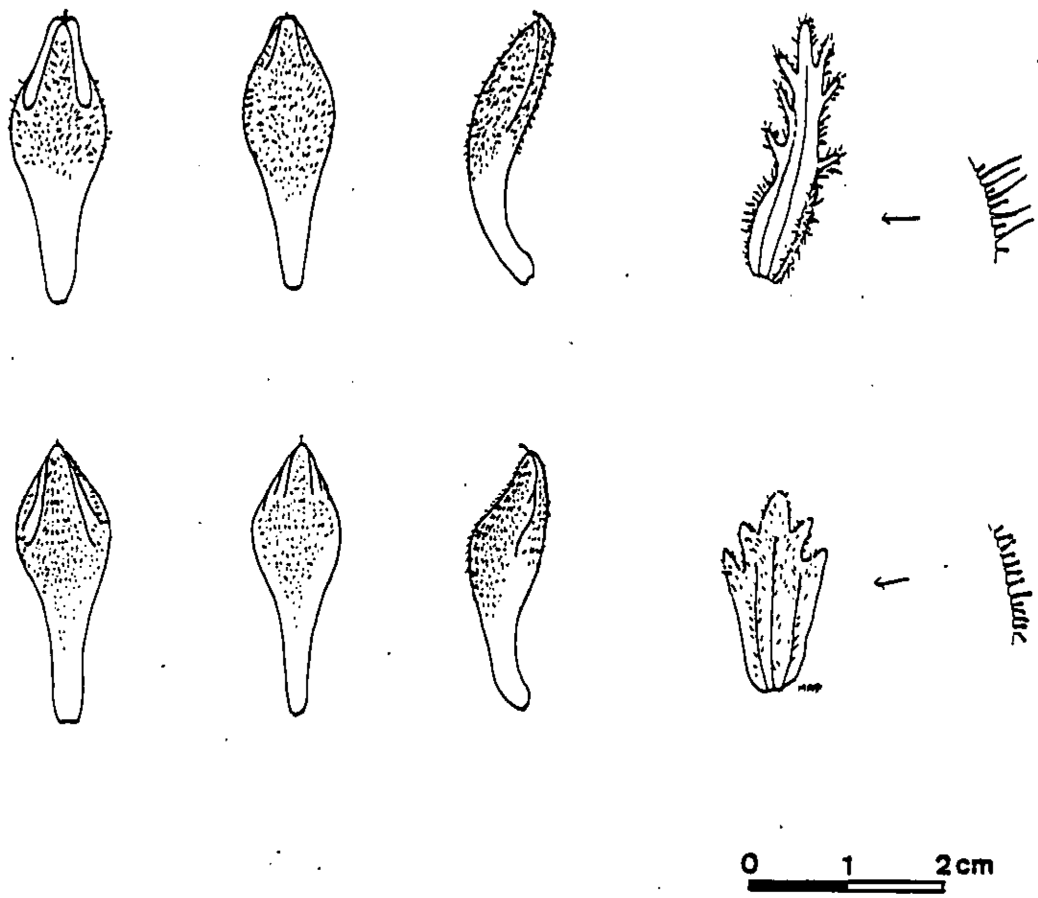
Cordylanthus palmatus has been placed in the subgenus Hemistegia, which is characterized by oblong to oval leaves, an elongated flower spike, and the association of one bract with each flower. (Chuang and Heckard, 1971). Cordylanthus palmatus was described in 1918 as Adenostegia palmata (Ferris 1918). This species is a low, highly branched herbaceous annual, 10-30 cm high. It is hirsute throughout with short hairs. Leaves are pale green, 8-18 mm long, and are usually irregularly-toothed, although the lower leaves can be entire. The flower spike is 5-15 cm long, dense and erect. The flower bracts are 12-18 mm long, pale lavender, and deeply divided with 2-3 pairs of lobes, the middle division exceeding the others (hence "palmate"). The corolla, consisting of a tube and pouch-like apex, is 12-16 mm long, finely hairy, lavender at the apex and with fine purple striations on the lower lip. The calyx bract is 11-15 mm long, entire or bidentate. Pollen-bearing stamens, 2. The seed capsule is 6-7 mm long, with 14-18 minute brownish seeds. Seeds are 2.5-3 mm long. The seed coat is irregularly crested, with distinct arching crests on the dorsal sides of the seeds.

Cordylanthus palmatus possesses glands that enable the plants to excrete salts. Although young plants are obviously green, mature plants appear pale green to whitish, having become encrusted with salt crystals. Members of the genus Cordylanthus are hemiparasitic on roots of other plants (Chuang and Heckard 1973). Hemiparasitism refers to the ability of photosynthetic plants to obtain additional nutrients from host plants through specialized root structures called haustoria. It is believed that hemiparasitism enables species of Cordylanthus to thrive at a time when other annual plants have ceased to grow (Piehl 1966).

Cordylanthus mollis ssp. hispidus (hispid bird's-beak), also a rare plant, occurs with Cordylanthus palmatus at the Livermore site. Taxonomically, hispid bird's-beak is closely related to C. palmatus. Both species are in the subgenus Hemistegia. The primary distinguishing features of the two species are the type of hairs on the plants, the length of the hairs, and the characteristics of the seed coats. Morphological features of these two species are given in the following table.

Morphological features	*Cordylanthus palmatus*	*Cordylanthus mollis ssp. hispidus*
Stature, habit	10-30 cm tall, with several stems ascending from base or above.	10-30 cm tall; branched from near base and upwards.
Type of hairs	Short, dense (to hairless); hairs gland-tipped; the longest hairs less than 1 mm.	Long, bristly, with some short and gland-tipped; the longest hairs longer than 1 mm.
Lower leaves	Entire	Entire
Upper leaves	1-2 pairs of lobes	1-2 pairs of lobes
Flower bract	Oval-shaped with 2-3 pairs of lobes	Lance-shaped with 2-3 pairs of lobes
Flowers	Pale lavender with downward-curving (retrorse) hairs on back	White to yellowish with spreading hairs on back and flower pouch
Flower relationship to flower bract	Equaling or longer than bract	Equaling or shorter than bract
Seeds	Deeply reticulate with prominent, undulating crests on ridges	Reticulate without dorsal crests on ridges

Hispid bird's-beak occurs with salt grass, and occasionally with pickleweed, on saline flats from the Sacramento-San Joaquin delta southward. There is some evidence that hispid bird's-beak and *Cordylanthus palmatus* may occur on different types of soils, with hispid bird's-beak on saline soils and *Cordylanthus palmatus* on saline-alkaline soils (Chuang and Heckard 1973). Jokerst (1986) reported hispid bird's-beak at the Livermore site as occurring along the upper edge of the iodine bush (scrub) near and in the ecotone with the adjacent annual grassland. At the



A1.0 Flower Detail of *Cordylanthus palmatus* (below) and
and *C. mollis* ssp. *hispidus* (above)

Livermore site, obvious changes in vegetation type correlate with changes in soil type.

Hispid bird's-beak was first reported at the Livermore site during July, 1983 (Cochrane 1983). Subsequent records are by Jokerst in June, 1986 and by Dains in August, 1986. No individuals of hispid bird's-beak were observed during the course of the current survey for Cordylanthus palmatus.

APPENDIX II

PARTIAL LIST OF SPECIES

SPRINGTOWN ALKALI SINK

AMARYLLIDACEAE

Brodiaea coronaria	Harvest brodiaea
Dichelostemma pulchella	Blue dicks

APIACEAE

Eryngium aristulatum	Coyote thistle

ASTERACEAE

Achyraechaena mollis	Blow wives
Blennosperma nanum	Blennosperma
Cotula coronopifolia	Brass buttons
H. pungens	Spikeweed
Holocarpha obconica	Tarplant
Iva axillaris	Poverty weed
Lactuca sericea	Wire lettuce
Lasthenia chrysantha ssp. gracilis	Goldfields
L. chrysostoma	Goldfields
L. ferrisiae	Goldfields
L. glaberrima	Goldfields
Matricaria matricarioides	Pineapple weed
Psilocarphus brevissimus	Wooly marbles
Senecio vulgare	Common groundsel

BORAGINACEAE

Amsinckia intermedia	Fiddleneck
Plagiobothrys leptocladus	Popcorn flower

CAMPANULACEAE

Downingia cuspidata	Downingia
D. pulchella	Downingia

CARYOPHYLLACEAE

Spergularia macrotheca var. longistyla	Spurry

CHENOPODIACEAE

Allenrolfea occidentalis	Iodine bush
Atriplex cordulata	Saltbush
A. fruticulosa	Saltbush
A. rosea	Saltbush
Salicornia subterminalis	Pickleweed
Suaeda moquinii	Seepweed

CONVOLVULACEAE

Cressa truxillensis var. vallicola	Alkali weed

CUSCUTACEAE

Cuscuta californica	Dodder

CYPERACEAE

Carex sp.	Sedge

EUPHORBIACEAE

Eremocarpus setigerus	Turkey mullein

FABACEAE

Lotus subpinnatus	Lotus
Lupinus nanus	Lupine
Melilotus indicus	Sweet clover
Trifolium depauperatum	Clover
T. microdon	Clover

FRANKENIACEAE

Frankenia grandifolia var. campestris	Alkali heath

GERANIACEAE

Erodium cicutarium	Filaree

LAMIACEAE

Trichostemma lanceolatum	Vinegar weed

LYTHRACEAE

Lythrum sp.	Lythrum

PLANTAGINIACEAE

Plantago hookeri var. californica	Plaintain

POACEAE

Alopecurus howellii	Alopecurus
Avena fatua	Wild oat
Bromus diandrus	Ripgut
B. mollis	Soft chess
Deschampsia danthoniodes	Hair grass
Distichlis spicata ssp. stricta	Salt grass
Elymus triticoides	Creeping wild-rye
Hordeum geniculatum	Mediterranean barley
Lolium multiflorum	Ryegrass
Monerma cylindrica	Monerma
Pleuropogon californicus	Pleuropogon
Poa annua	Annual bluegrass
Polypogon monspeliensis	Rabbit's-foot grass
Puccinellia nuttalliana	Nuttall's alkali grass
Puccinellia simplex	California alkali grass
Sporobolus sp.	Sacaton
Vulpia dertonensis	Annual fescue

POLEMONIACEAE

Linanthus liniflorus	Linanthus
Linanthus sp.	Linanthus

RANUNCULACEAE

Myosurus minimus ssp. apus var. sessiliflorus	Mousetail

SCROPHULARIACEAE

Cordylanthus mollis ssp. hispidus	Hispid bird's beak
C. palmatus	Palmate-bracted bird's beak
Orthocarpus sp.	Owl's clover

TYPHACEAE

Typha domingensis	Cattail

APPENDIX III:

SALINE-SODIC SOILS AND ALKALI SINK SCRUB VEGETATION IN CALIFORNIA

Cordylanthus palmatus is restricted to relatively undisturbed, seasonally-flooded, saline-alkali soils in lowland plains and basins of the Central Valley of California. These lowland plains and basins are remnants of once-extensive wetlands that occurred historically in the Central Valley. Cordylanthus palmatus is associated primarily with valley sink scrub vegetation.

Prior to European settlement, the surface hydrology of the Central Valley consisted of numerous seasonal and permanent streams draining into the central trough of the valley. The onset of winter rains and spring snowmelt produced two annual pulses of water into the lowlands. The pulses resulted in lowlands being seasonally flooded and created large expanses of floodplain interspersed with sloughs, ponds, and seasonal lakes. The duration of these seasonal floods varied, based on the periodicity and magnitude of storms and depth of snowpack. Before extensive artificial levee construction and water diversion during the 1800s, these "swamp and overflow lands" and the wetlands they supported covered more than three million acres. It is estimated that 1.5 million acres were aquatic wetlands, including tule marsh, while 1.6 million acres were riparian forests (Warner and Hendrix 1985).

In the Sacramento Valley, streams from the surrounding foothills and mountains proliferated into a system of distributary channels that drained into the natural flood basins or "sinks". During peak flows, the flood basins were filled by sediment-laden waters. Natural levees prevented some inflowing water from reaching the Sacramento River, creating "sinks". The sinks supported tule marsh and alkaline wetlands surrounded by riparian woodlands and forests.

Numerous rivers from the Sierra Nevada flowed into the San Joaquin Valley, which can be divided into two distinct hydrologic basins: the Tulare Basin and the San Joaquin Basin. The San Joaquin River drains the San Joaquin Basin. The Tulare Basin has no perennial surface outlet, but, when it becomes filled, drains into the San Joaquin Basin. The Tulare Basin formed at the southern end of the San Joaquin Valley by the coalescing alluvial fans of the Kings River and Los Gatos Creek. Runoff water was captured in this basin, creating large, shallow, seasonal lakes: Tulare, Buena Vista, Kern, and Goose Lakes. As the lakes exceeded storage capacity, they overtopped the alluvial fans and flowed into the San Joaquin River via Fresno Slough. The lakes were interconnected by sloughs, and their basins supported extensive wetlands. Except in the northern San Joaquin Valley, streams and rivers did not usually produce the natural levees characteristic of Sacramento Valley watercourses, because lower peak flows limited the ability of San Joaquin Valley streams to transport sediment. For example, the southern San Joaquin River did not develop an extensive levee system although some levee formation occurred when it reached the valley floor. Without natural levees to contain its flows, the San Joaquin River flowed overland and large freshwater marshes formed. Levees did develop at its confluence with the Merced River, a sediment-bearing stream (Warner and Hendrix 1985).

Valley sink scrub is the natural vegetation type of valley bottoms and playas in the San Joaquin Valley and Carrizo Plain at elevations below 300 feet (Bittman 1985). Historically, this vegetation type surrounded Kern, Buena Vista, Tulare, and Goose Lakes in the San Joaquin Valley, as well as valley basins north along the trough of the San Joaquin Valley through Merced County to the "gooselands" of Solano and Glenn Counties (Holland 1986). In the San Joaquin Valley, valley sink scrub once covered more than 260,000 acres from Buena Vista Lake to Merced County; today, less than twenty percent remains (Bittman 1986). A depauperate, that is, less complex, form of the vegetation type occurs in Yolo and Colusa Counties. This more northern extension of valley sink scrub has also been referred to as alkali meadow or alkali grassland by Holland (1986).

Valley sink scrub is best developed in highly alkaline soils where there is a gradual slope extending up and away from a lake or basin lacking external drainage. It is the first dryland association found upslope from marshes and lakes, and localized distribution is dependent on soil salinity and alkalinity, duration of seasonal inundation, microtopographic relief, and depth to the water table (Bittman 1985).

Valley sink scrub is a complex mosaic having an open to relatively dense shrub cover. Cover can vary from site to site, as well as seasonally. An understory of annual wildflowers and grasses may be present between the shrubs. When the natural topography consists of low hillocks alternating with alkali flats and bare ground, a variety of annual wildflowers adapted to differences in soil texture, salinity/alkalinity, and soil moisture produce spectacular floral displays with adequate rainfall. These wildflowers include species of popcornflower, goldfields, pepperweed, downingia, milkvetch, and owl's clover. Bare soil, often encrusted with salts and organic films, is also common between shrubs.

Two major sub-types of vegetation comprise valley sink scrub. One, dominated by iodine bush, occurs in low, heavily saline/alkaline areas that are wet in winter; the other, dominated by seepweed, occurs in less alkaline soils at slightly higher elevations and intergrades with areas of iodine bush (Bittman 1985). Cordylanthus palmatus is associated with iodine bush-dominated valley sink scrub at Livermore and at the Mendota Wildlife Management Area. A third sub-type, the alkali "grassland" has also developed in poorly-drained alkaline soils subject to overland winter flooding. It is thought that alkali grassland occurs on slightly higher ground within sinks where the duration of inundation is shorter (Bittman 1985). This subtype is characterized by scattered shrubs of seepweed, pickleweed, and alkali heath, and suffrutescent annuals such as spikeweed and low seepweed (Suaeda depressa var. erecta), interspersed with stands of annual and perennial grasses. Native grass species include salt grass, Nuttall alkali grass, California alkali grass, hair grass, and alkali sacaton. Non-native grasses such as foxtail (Hordeum ssp.), red brome (Bromus rubens), and rye grass (Lolium multiflorum) are also common. The alkali grassland subtype occurs in Colusa and Yolo Counties at the two northern populations of Cordylanthus palmatus.

Valley sink scrub evolved on basin soils. The parent material is sedimentary rock of recent geologic origin, consisting primarily of clay and silt settled out of flood waters. Originally poorly-drained, basin soils are mottled with a gleyed or olive subsoil. In northern California, many large flood basins occur west of the Sacramento River. Several smaller basins occur in shallow depressions in alluvial plains or where drainage has been blocked, as in the Springtown Alkali Sink. The Colusa Basin to the north and the Yolo Basin, which extends from east of Woodland south to the Solano County line, are two somewhat larger basins. These two basins are separated by a ridge formed by Cache Creek. Historically, when the Sacramento River and its tributaries overflowed, they filled the low-lying basins; as flood waters subsided, they drained slowly back into the main tributaries. Artificial levees now prevent flooding and the natural basins have largely been diked to form channels, called bypasses, to carry flood waters. Prior to "reclamation", portions of the basins were wetlands supporting tule marsh. Other areas, where salt concentrations were higher, supported alkali grasslands and halophytic shrub communities.

Soils in the Colusa and Yolo Basins derived from soft sedimentary shales and sandstones containing large quantities of soluble salts. The Colusa Basin, subject to annual winter flooding by slow moving waters from the north, has a high water table. The high rate of evaporation during the summer causes some salts to accumulate in the upper soil horizons and to remain there as long as imperfect subsoil drainage exists.

Five soil series are associated with the basin in Colusa County: Grimes, Marvin, Mormon, Sacramento, and Willows. All are dark-colored, fine-textured, poorly-drained, and have lime in the profile. Willows and Marvin soils encompass the largest acreage. Willows soils occupy the lowest and most poorly drained central basin. They are characterized by a dense clay subsoil and moderate to strong concentrations of alkali salts. Surface and subsurface drainage is poor. Annual floodwaters are removed by evaporation, or, in agricultural situations, by pumping. Marvin soils are transitional between the lowest basin and older, imperfectly drained portions of the floodplain of the Sacramento River. A perched water table is associated with Marvin soils.

Alkalinity is variable in Mormon, Grimes, and Sacramento soils and is associated with basin position and evaporation from the water table (Harradine 1948).

In Yolo County, Capay, Marvin, Pescadero, and Willows soils occur in basins and on basin rims. Of these soils, Pescadero and Willows soils have a high sodium content, possibly related to a combination of ground water, organic matter content in the upper soil profile, and anerobic conditions. Exchangeable sodium percentage in saline Pescadero soils is greater than 20 percent (Soil Conservation Service 1972). Cordylanthus palmatus occurs on Willows soils in Colusa and Yolo Counties, as well as on Pescadero soils in Yolo County.

As in the Sacramento Valley, the central San Joaquin Valley is characterized by large flood basins. Under natural conditions, the trough of the San Joaquin Valley was flooded seasonally and supported extensive wetlands. The floodplain was (and is) traversed by the meandering channel of the Fresno Slough, an intermittent tributary of the Kings River that joins the San Joaquin River near Mendota. Many other drainageways also traversed the floodplain. Present-day stream control, flood protection, reclamation, and deep pumping have lowered the water table and permanently altered historic overland flows.

Two soil associations occur in basin areas in Alameda County. The Clear Lake-Sunnyvale Association occurs in basins and on low terraces east of Dublin and southwest of Sunol and Pleasanton. The Clear Lake, Sunnyvale, and Pescadero soils in this association formed under poor drainage. Clear Lake and Sunnyvale soils are mildly alkaline while Pescadero soils are highly alkaline in character. The Pescadero series, consisting of imperfectly drained saline-alkali soils north of Livermore, occurs on nearly level basin rims and along the lower edge of terraces. It has "hogwallowed" microrelief. The Rincon-San Ysidro Association is characterized by nearly level to gently sloping fans and floodplains, with small areas of hummocky relief. Although Rincon and San Ysidro soils are the principal soils in this association, Solano soils make up a small percentage. These soils formed in alluvium weathered from sedimentary rock and have a loamy texure. Of the soils in the Rincon-San Ysidro Association, soils in the Solano series are shallow, poorly-drained, and saline-alkaline; they have a "hogwallow" microrelief. Both Pescadero and Solano soils support Cordylanthus palmatus in the Livermore area.

Soils of the basin rim in Fresno and Madera Counties occupy a broad, irregular area bordering the lower part of the alluvial fans of the Kings and San Joaquin Rivers. Run-off is slow, and, in places, the water becomes impounded in small depressions or playas. Rim soils are usually situated in elevation above those inundated on the basin floor, although the water table can rise to near the surface. The rise in the water table has facilitated the accumulation of solutes through capillary action and evaporation. As a result, many basin and rim soils have a pronounced saline-alkali character.

In the Mendota area, located in the northwestern part of Fresno County, the parent material consists almost exclusively of fine-textured calcareous alluvium derived from weakly-consolidated calcareous sandstones and shales. Soils are fine-textured and characterized by moderate to strong concentrations of alkali and a high concentration of gypsum. Surface run-off is slow, however, and salts have accumulated due to the salinity of flood waters. Eight soil series, containing strongly alkaline soils, are associated from the basin in the Mendota area: Lethent, Levis, Merced, Oxalis, Roddi, Traver, Waukena, and Willows. With the exception of the Willow series, the basin soils do not have a high water table (Harradine 1940).

Cordylanthus palmatus occurs on Waukena soils at the Mendota Wildlife Management Area. The Waukena soils formed in broad, flat, saline-alkaline basin areas where the water table is high and surface run-off is slow. Mound microrelief occurs in some areas, as does hardpan.

APPENDIX IV:

MONITORING METHODS IN DETAIL

A. Site selection and preparation

1. Two undisturbed sites harboring subpopulations of Cordylanthus palmatus should be selected using the maps compiled for this report. Recommended are the "FCC corner" and "Livermore Central" sites (Figure 1) because;

    a. both lie at the lower end of an intact, existing drainage system and probably support naturally-occurring, self-sustaining and, therefore, ecologically representative subpopulations.

    b. each supported at least 300 reproductive individuals in 1987, thus allowing for statistical analysis of patterns in the data.

    c. their topographically featureless nature and distance from existing trails and recreation sites will minimize the probability of vandalism or accidental disruption of the study.

2. These sites need to be protected from all non-native grazing and other forms of disturbance for the following reasons:

    a, Grazing represents a direct source of mortality that is incompatable with the goals of endangered plant management.

    b. Grazing could indirectly impact Cordylanthus palmatus by reducing the vigor of its potential hosts (e.g. Frankenia grandiflora, Distichlis spicata).

    c. Grazing would disturb monitoring by destroying plants, markers, soil surface characteristics and other essential features of the program.

3. Fencing the sites is not a recommended method of excluding grazing and disturbance because the exclosures would:

    a. introduce another form of disturbance to the subpopulations and their habitat.

    b. attract the attention of vandals.

c. inhibit natural sources of mortality (e.g., rodents) from interacting with the subpopulation.

d. be an aesthetic detraction.

4. No experimental manipulations (e.g. controlled burning, resource supplement) would take place on these sites - their purpose is to serve as undisturbed controls.

B. Initial survey of the subpopulation sites

1. Detailed mapping of the selected Cordylanthus palmatus subpopulations is required to;

   a. document the present distribution of individuals in relation to subtle topographic and ecological features of the sites.

   b. detect the effects of seed dispersal on the future distribution of individuals at the site.

   c. indicate exactly where managers and other visitors to the site can walk with minimum damage to the plants or their habitat.

2. This mapping should be done twice in the first year of the monitoring program -- once after germination and early growth of the seedlings (e.g. late January or early February) and again during the peak reproductive period (July or August). Differences in seedling and adult distribution will indicate routes of seed dispersal and the distribution of germination microsites in relation to the extent of potential habitat at the site during a particular year. Routes of dispersal and sites for germination would need to be protected from disturbance, so that maps would be used to define routes of access to the subpopulation.

3. A recommended method of mapping is to cover the site with a grid of 20 cm X 20 cm (or 30 cm X 30 cm) pixels that would extend beyond the actual distribution of the subpopulations during the initial survey (Figure 2). The grid would be established using permanent markers (e.g. 20 cm long nails) along two edges of the grid with removable string strung between. Perpendicular to these strings would be two movable pieces of lightweight PVC tubing that defined the other two edges of each row of pixels (i.e. that were joined by additional tubing 20 or 30 cm apart to form a frame). Managers would move this frame from one end of the grid to the other, recording the presence of Cordylanthus palmatus individuals in each pixel. This presentation of results could be simplified if density indices were

used instead of the actual counts to represent density in each pixel. A density index system would resemble the cover-abundance indices used in vegetation description (e.g. 3 = >100 individuals/pixel, 2 = 11-100/pixel, 1 = 1-10/pixel, 0 = no plants in the pixel). Each pixel could then be portrayed on a computer-generated map, with degrees of gray-scale shading representing different density indices.

a. During this mapping process it is important to minimize human impact on the subpopulation. Pixels that could not be observed from the grid edge could be reached by a simple board scaffold, resting on support "feet" that were carefully placed when the scaffold was moved across the site.

b. Additional ecological information (microtopography, surface characteristics, distributions of other species, etc.) could be overlayed onto these maps to reveal more information of the ecology of the species.

c. After the first year's mapping (once for seedlings, once for adults), it may not be necessary to generate new maps for another two or three years if care is taken to minimize disturbance at the site. Remapping would be warrented by an unusual year of rainfall and subsequent runoff.

C. Demographic monitoring of undisturbed subpopulations of <u>Cordylanthus palmatus</u>

1. The purpose of demographic monitoring at the "FCC corner" and "Livermore central" sites is to:

   a. detect short and long-term trends in the population of <u>Cordylanthus palmatus</u> at Springtown Alkali Sink by detailed studies of representative, relatively undisturbed subpopulations.

   b. identify the timing and causes of plant mortality and fluctuations in fecundity (seed output per plant).

   c. suggest proper management actions to mitigate for natural or anthropogenic increases in mortality or decreases in fecundity.

2. At each of the two sites, the following procedure is recommended for obtaining and analyzing survivorship/mortality data:

a. Using the pixel maps, the edge of the subpopulation will be delineated and 12 quadrats (circular wire hoops, 0.25 m2 in area) distributed in relation to the edge (Figure A4.1). Several designs are possible, but the important features include:

   1. four quadrats just beyond the existing population edge to detect dispersal and subpopulation expansion (plant density = 0).

   2. eight quadrats within the subpopulation, each containing between 20 and 200 individuals (February tally).

   3. a permanently-marked center to each quadrat, consisting of a 10 inch long, 1/4 inch diameter aluminum rod, with 2" exposed above ground. The center of each removable wire sample hoop would fit precisely over the rod to ensure accurate placement.

   4. a lightweight, removable boardwalk to allow access to the quadrats without impacting the habitat or subpopulation (Figure A4.1).

b. All quadrats will be sampled at least 4 times per year, for a minimum of four years. It is important to use a seasonal schedule that includes critical phenological stages. For this reason, the calendar dates for sampling will vary slightly from year to year, depending on the amount and timing of precipitation, the magnitude of winter temperatures, and the onset of summer drought. A suggested schedule, based on observations made in 1987 and 1988, is:

   1. January or February (post-germination, seedlings with 2-6 leaves each).

   2. mid-May (plants established, branched, 5-7 cm tall, and beginning to flower).

   3. early August (peak of flowering and seed set).

   4. late September (end of reproduction, onset of senescence).

c. The following data would be collected for all quadrats at each site on every sample date:

   1. total live (= green, moist) plants per quadrat ($0.25\ m^2$)

2. phenological state (number of live leaves, presence of flowers, seed)

3. average plant height (based on a subsample of 10 plants in each quad)

4. observations related to pollination, predation, disease, disturbance and other significant demographic factors

5. observations related to habitat factors (soil moisture, soil salinity, vigor of dominant plant species (e.g. Allenrolfea, Frankenia, Distichlis).

d. The analysis of the survivorship data should follow standard conventions and examples in relation to rare plant management can be found in Butterwick (1987), Pavlik (1987), Taylor and Palmer (1987), Palmer et al. (1987), and Berg (1987). The expression of survivorship data for purposes of demographic monitoring should include the following:

1. survivorship curves

2. calculations of population half-lives

3. survivorship at the onset of reproduction (e.g. May)

4. long-term trends in population size (combination of data from different years)

5. correlations of survivorship parameters with environmental factors from year to year (e.g. precipitation)

3. In order to provide estimates of plant fecundity and population seed rain, a correlation between plant height and total seed output per plant (September measurements) needs to be developed using Springtown plants. This relationship, combined with in situ height and density measurements would allow estimates of seed output per individual (fecundity) and per unit of habitat area (seed rain) for every monitoring year (see Pavlik 1987). This would provide an additional measure for predicting population trends and determining factors that limit population growth.

4. Each year, a sample of at least 150 seeds should be germinated to indicate seed quality. The specific germinations requirements of Cordylanthus palmatus are not known at present, but seeds have been germinated in the laboratory and seedlings raised on sunflowers in

the greenhouse (L. Heckard, Department of Botany, University of California, Berkeley). Low germination would indicate poor seed quality and provide another demographic parameter used in monitoring and management.

A. Site selection and preparation

1. Physiological monitoring would be conducted at a control site (e.g. "Livermore Central" and an experimental site (effected by hydrological modification). Ideally, the two sites should resemble each other in terms of Cordylanthus palmatus density, microtopographic characteristics, and composition of the vegetation.

2. These sites need to be protected from all non-native grazing and other forms of disturbance.

3. No other manipulations (e.g. controlled buring) would impact these sites.

4. A permanent plot, containing 50 - 100 plants, would be marked at each site and used as a source of individuals for water potential and growth measurements.

B. Comparative water relations and growth

1. At control and impacted sites, the predawn and midday water potentials should be measured using standard pressure bomb techniques. Although seedlings are too small for accurate determinations, seasonal monitoring is possible using caulescent plants during the April to September period (a total of four sample days/yr). Within the permanent plot, individuals would be randomly chosen for pressure bomb and growth measurements.

2. Replicate measurements should allow statistical comparisons of water potential between the two sites. Significant decreases in plant water potential at the impacted site relative to the control would indicate negative effects from hydrological modification. It would also justify mitigation for existing impacts.

3. Plants that were harvested for pressure bomb measurements would be used for documenting shoot growth at the control and impacted sites. Significant decreases in shoot dry weight at the impacted site relative to the control site would indicate negative effects from hydrological modification. It would also justify mitigation for existing impacts.

Estimate of Person-hours:. Tables 4.1 and 4.2 provide an overview and summary of the estimated number of person-hours and field days to be spent on the Cordylanthus palmatus monitoring program over a four year period. The estimates are presented according to the objectives of the program, some of which might not be implemented. For example, if controlled burning or hydrologic alteration of the site do not occur, these portions of the monitoring program would not be implemented. Included in these estimates of person-hours are Ph.D or supervisory hours that would be required by certain tasks (e.g. selection of study sites, placement of quadrats, data analyses, report preparation). Otherwise, tasks could be executed by well-trained field biologists with more limited research experience. This distinction between Ph.D hours and technician hours should be useful in developing budgets for implementing the monitoring program.

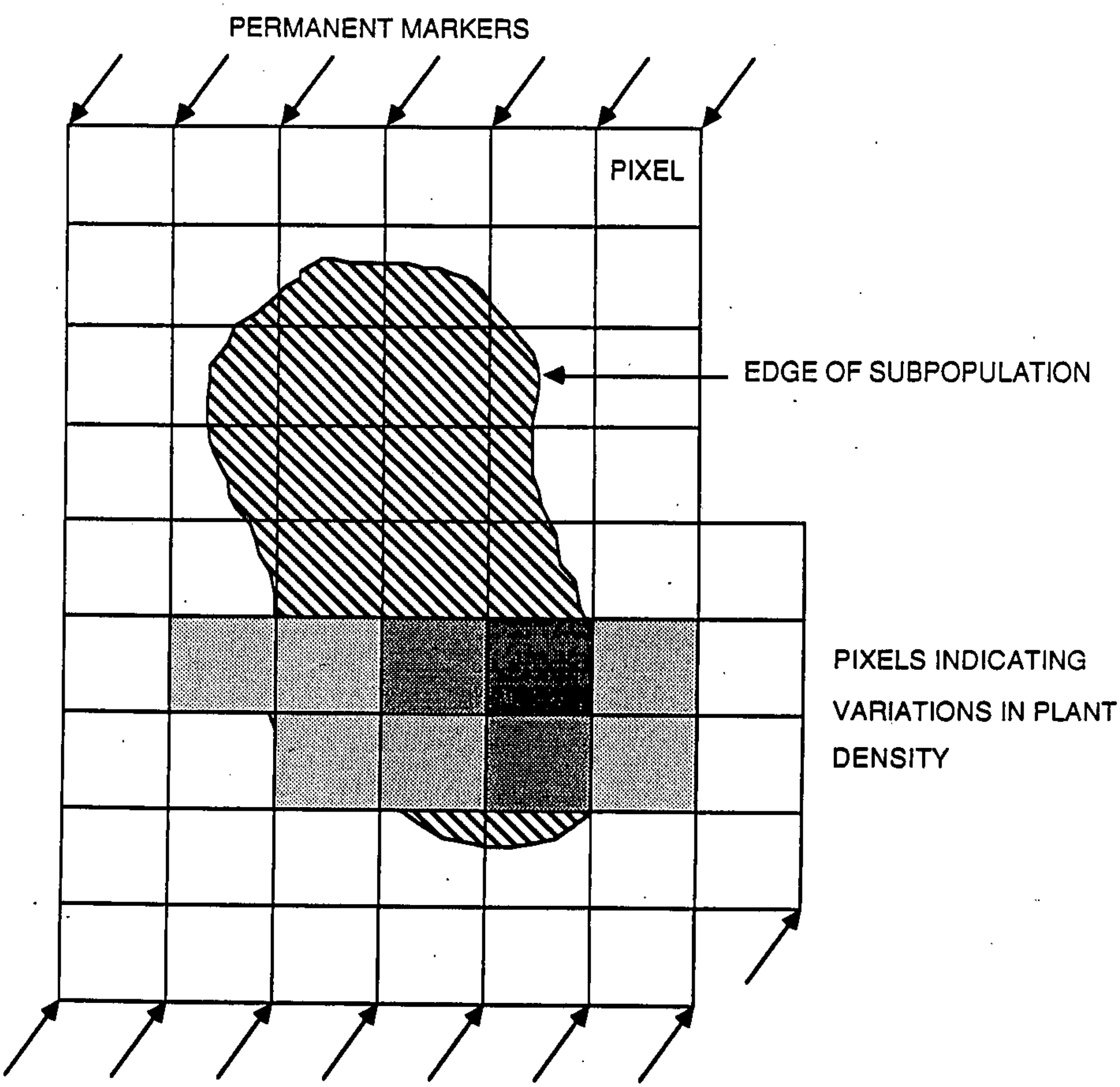


Figure A4.0 Design for mapping a subpopulation of *Cordylanthus palmatus*. Pixels would be 20 X 20 cm or 30 X 30 cm and used to indicate the distribution and relative density of individuals.

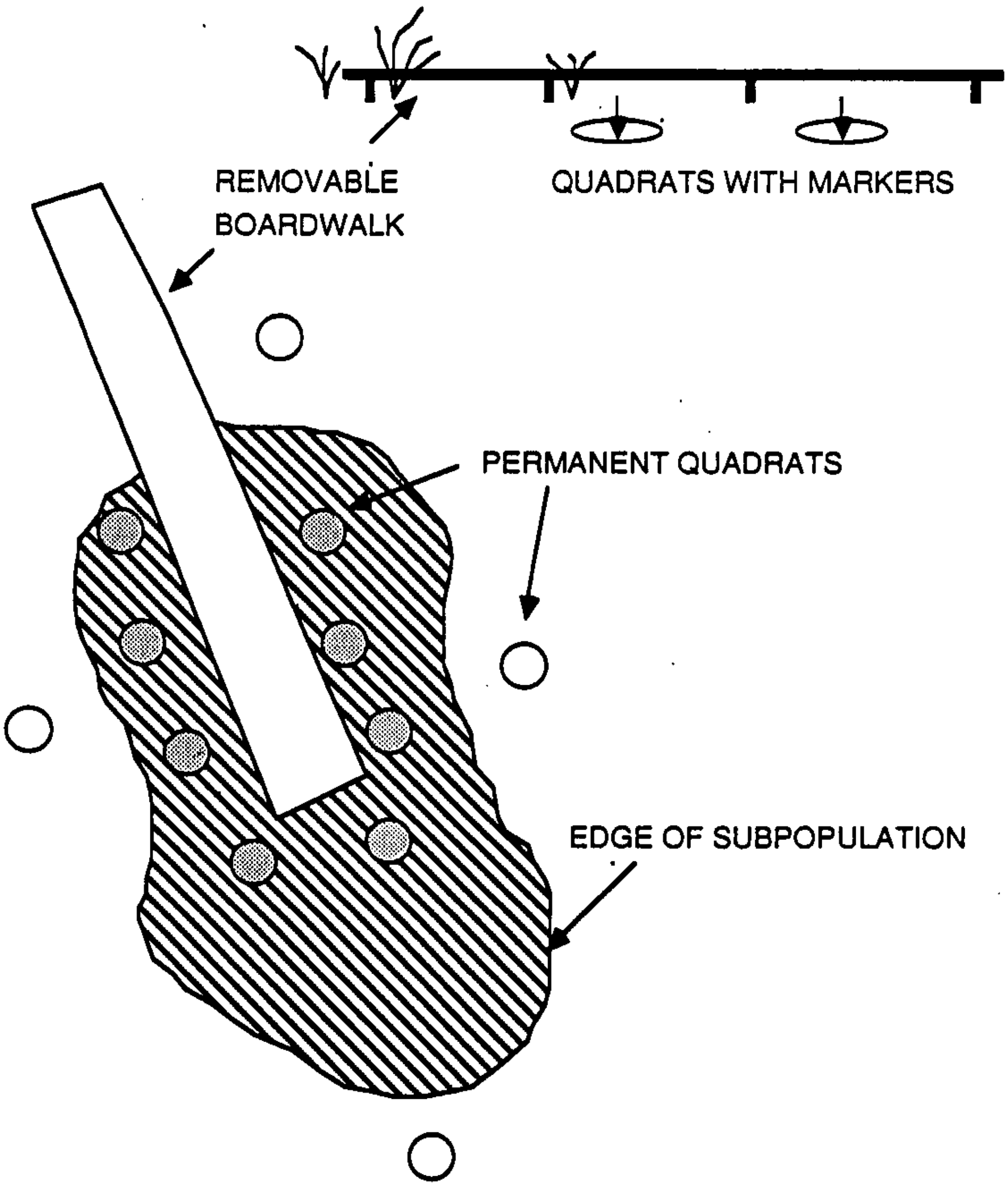


Figure A4.1 Design for demographic monitoring of Cordylanthus palmatus. Individual plants within the quadrats would be marked with small wooden markers.

Table A4.0 Estimated number of person-hours for tasks specified in the monitoring program for *Cordylanthus palmatus* at Springtown Alkali Sink. Tasks are listed under the program objectives (bold type).

	year 1												year 2												year 3												year 4											
objective / task	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
I. Long-term Population Trends																																																
A. Site																																																
selection	3																																															
preparation	3																																															
B. Survey																																																
boardwalks	16																																					8										
mapping		64					64																															64					64					
field data		5					5																																5				5					
data analysis				24					24																															24					24			
C. Demographic Monitoring																																																
establ. quads		6																																														
boardwalks		3												3												3												3										
quad sampling		8		8		8			8					8		8		8			8					8			8			8		8				8		8			8			8		
field data		4		4		4			4					4		4		4			4					4			4			4		4				4		4			4			4		
data analysis		4		4		4			8					4		4		4			8					4			4			4		8				4		4			4			8		
seed production									12																										12													
seed rain										2																										2												
seed germination										4																										4												
report preparation											32												32													32											32	

Table A4.0 (continued)

Year 1

objective / task	J	F	M	A	M	J	J	A	S	O	N	D
II. Impact Assessment												
A. Site												
selection	3											
preparation	3											
B. Demographic Monitoring (effects of controlled burn)												
establ. quads	6											
boardwalks	3											
quad sampling	8			8		8			8			
field data	4			4		4			4			
data analysis	4			4		4			8			
seed production										12		
seed rain										2		
seed germination										4		
report preparation											32	
C. Physiological Monitoring (effects of hydrologic alteration)												
site selection				3								
water relations				10		10			10		10	
data analysis				4		4			4		8	
report preparation											24	

Year 2

objective / task	J	F	M	A	M	J	J	A	S	O	N	D
boardwalks		3										
quad sampling		8		8			8		8			
field data		4		4			4		4			
data analysis		4		4			4		8			
report preparation											32	
water relations				10			10		10		10	
data analysis				4			4		4		8	
report preparation												24

Year 3

objective / task	J	F	M	A	M	J	J	A	S	O	N	D
boardwalks		3										
quad sampling		8		8			8			8		
field data		4		4			4			4		
data analysis		4		4			4			8		
seed production											12	
seed rain											2	
seed germination											4	
report preparation												32
water relations				10		10	10			10		
data analysis				4		4		4		8		
report preparation												24

Year 4

objective / task	J	F	M	A	M	J	J	A	S	O	N	D
boardwalks		3										
quad sampling		8		8			8			8		
field data		4		4			4			4		
data analysis		4		4			4			8		
report preparation												32
water relations				10		10	10			10		
data analysis				4		4		4		8		
report preparation												24

Table A4.0 (continued)

objective / task	year 1												year 2												year 3												year 4											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
III. Establishment of New Subpopulations																																																
A. Site																																																
selection	3																																															
preparation	6																																															
B. Planting																																																
boardwalks	3													1												1												1										
establ. quads	6																																															
sowing	10 (done in November of preceeding year)																																															
C. Demographic Monitoring																																																
quad sampling	8			8		8			8					8		8			8		8					8		8			8			8				8		8			8			8		
field data	4			4		4			4					4		4			4		4					4		4			4			4				4		4			4			4		
data analysis	4			4		4			8					4		4			4		8					4		4			4			8				4		4			4			8		
seed production										12																									12													
seed rain										2																									2													
report preparation											32													32												32												32

Table A4.1 Summary of person-hours (total hours includes Ph.D or supervisory hours) and the number of field days to be spent on a four-year monitoring program for *Cordylanthus palmatus.*

objective	year 1	year 2	year 3	year 4	sum of hours	sum of field days
I. Long-term Population Trends						
total hrs	335	105	129	291	860	
Ph.D hrs	172	35	59	128	394	
field days	14	5	6	14		39
II. Impact Assessment						
total hrs	87	84	84	84	339	
Ph.D hrs	49	32	49	32	162	
field days	4	4	4	4		16
III. Establishment of New Sub-populations						
total hrs	142	101	115	101	459	
Ph.D hrs	70	40	46	46	202	
field days	4	4	4	4		16

APPENDIX V

Wildlife of the Alkali Sink Ecosystem

It is difficult for the current human inhabitants of the Amador-Livermore Valley to imagine, but this fertile valley was once inhabited by herds of tule elk and pronghorn antelope, grizzly bears, and bald eagles. Oak-lined creeks flowed through grasslands filling a lake and willow-cottonwood forest of some 2,000 acres near the intersection of Highways 580 and 680. These resources disappeared decades ago. With the arrival of European man, his cattle and agriculture, the landscape changed dramatically, and only those hardy wildlife species that could adapt to modern agricultural practices survived. The jackrabbit, ground squirrel, meadowlark, and red-tailed hawk are common native animals familiar to many Livermore residents today. Even these survivors, however, are now disappearing as tens of thousands of acres of agricultural lands along the Highway 580 and 680 corridor are replaced by industrial, housing, and business developments.

Perhaps because its alkaline soils made it unsuitable for agriculture, a remnant of a historical valley habitat has persisted to the present - the alkali sink wetlands of the Springtown area in Livermore. Although best known for its endangered flora, an equally unique assemblage of wildlife inhabits this area. Even today, an alert observer can spot seven or more species of hawks, falcons, and eagles at one time on the edge of the Springtown development. With extensive grasslands to the north and east interspaced with rocky, brush-covered peaks, the wetlands at Springtown, although only a few hundred acres in size, are visited by an amazing array of wildlife and support some species year-round. The Mediterranean climate results in wetlands that are seasonally flooded and seasonally as dry as the desert. This climatic pattern has influenced the evolution of migratory waterbirds, many of which breed at northern latitudes and winter in mild winter areas of California where lush marshlands with abundant food once flourished. As 80-90 percent of California's wetlands were destroyed, waterfowl populations plummeted. The trend in Livermore was similar. Hunters have reported that the Springtown area was once teeming with ducks. Now much reduced in size, many fewer waterfowl return, but flocks of mallards and cinnamon teal still migrate to Springtown. When ponds from winter rains persist into the spring, mallards will nest on the site. The well-documented decline in California's waterfowl populations in recent years has resulted in the lowest hunter bag limits on record. This fact underscores the importance of preserving and enhancing all remaining wetland habitat. Other waterbirds observed on the site include long-billed dowitchers, greater yellow-legs, black-necked stilts, great egrets, snowy egrets, great blue herons, Forester's terns, least sandpipers, and snipe.

Another conspicuous group of birds utilizing the site are the raptors. These predatory birds include the falcons, hawks, and eagles. Well-known historic nest sites for prairie falcons and golden eagles occur just north of Springtown. These species can be seen during the spring and summer along with red-tailed hawks, American kestrels, and northern harriers (marsh hawks) foraging on the wetlands. During the winter, species from the north winter in the area, including rough-legged hawks and ferruginous hawks. Burrowing owls, a species which has disappeared from much of its former range, probably nest on the site.

Mammals commonly observed on the site include jackrabbits, ground squirrels, and meadow voles. The abundance of rodents and rabbits is undoubtedly the reason one can see golden eagles swooping low over the fields within a few yards of residences in Springtown. The San Joaquin kit fox, a state and federally-listed Endangered species, is known to occur nearby. On-site field surveys are needed to clarify the importance of the Springtown site for this species. In the meantime, the area should be considered potential kit fox habitat.

Comprehensive wildlife surveys have not been undertaken at the Springtown alkali sink wetlands; however, the visits of wildlife biologists thus far have confirmed the presence of diverse and valuable wildlife resources. These resources will be of particular importance to the public, students, scientists, naturalists, and nature photographers if the lands are managed as a natural reserve in the future. Opportunities to view such wildlife in proximity to urban areas are scarce. An environmental education center at this site would be the only one of its kind in the area and would provide a unique opportunity for residents of Livermore.

PRELIMINARY WILDLIFE CHECKLIST FOR THE SPRINGTOWN ALKALI SINK WETLANDS

Birds

great blue heron
great egret
snowy egret
mallard*
cinnamon teal*
turkey vulture
norther harrier (marsh hawk)
red-tailed hawk
rough-legged hawk
ferruginous hawk
golden eagle
American kestrel
merlin
prairie falcon
black-necked stilt
American crocet
killdeer
greater yellowlegs
common snipe
long-billed dowitcher
Forster's tern
mourning dove
burrowing owl*
short-eared owl
common flicker
western kingbird
horned lark
barn swallow
common crow
water pipit
loggerhead shrike
western meadowlark
red-winged blackbird
Brewer's blackbird
house finch
Savannah sparrow
Lincoln's sparrow

* breeding species

Mammals

California ground squirrel
Botta's pocket gopher
California meadow vole
muskrat

black-tailed jackrabbit
Audubon's cottontail

Reptiles

western fence lizard
gopher snake

Amphibians

Pacific tree frog

APPENDIX VI

PROPERTIES OF SOLANO FINE SANDY LOAM FROM THE SPRINGTOWN ALKALI SINK

Transect 1

number	depth (in)	pH	E.C. (mS/cm)	---properties of saturation extract--- cations (meq/l) Na	Ca	Mg	K	SAR
1	0 - 2	5.7	0.80	5.43	0.84	0.67	0.41	6.25
	2 - 4	5.8	0.60	3.95	0.62	0.50	0.20	5.28
2	0 - 2	5.3	2.00	10.43	2.15	2.33	2.43	6.97
	2 - 4	5.4	2.50	11.33	2.66	2.95	3.33	6.76
4	0 - 2	5.0	1.40	11.51	0.37	0.46	0.15	12.63
	2 - 4	5.9	1.60	12.82	0.31	0.57	0.13	19.33
6	0 - 2	5.1	1.70	12.61	0.48	0.41	0.22	18.90
	2 - 4	5.8	1.50	10.64	0.35	0.27	0.13	19.06
8	0 - 2	6.1	7.25	56.16	2.40	2.59	1.06	35.55
	2 - 4	7.3	8.00	54.48	1.12	1.05	1.20	52.30
10	0 - 2	7.8	15.00	115.89	0.72	1.01	0.73	124.61
	2 - 4	9.0	10.95	88.02	0.62	0.92	0.57	100.31
12	0 - 2	6.4	1.70	11.59	0.24	0.27	0.22	22.95
	2 - 4	6.9	1.80	11.59	0.26	0.24	0.16	25.92
14	0 - 2	8.6	23.65	226.25	1.65	1.26	1.04	187.59
	2 - 4	9.1	34.80	282.90	1.10	0.89	0.53	283.61
16	0 - 2	8.5	41.60	337.21	3.52	2.03	1.50	202.42
	2 - 4	9.2	25.90	191.80	0.97	0.54	0.44	219.82
18	0 - 2	9.0	11.40	77.48	1.13	0.38	0.29	63.05
	2 - 4	9.5	12.20	81.46	1.17	0.39	0.27	92.24
20	0 - 2	6.5	3.10	22.68	0.56	0.52	0.29	30.78
	2 - 4	7.9	5.40	40.57	0.75	0.51	0.18	51.11
22	0 - 2	6.0	0.68	3.17	1.09	1.03	0.23	3.08
	2 - 4	6.4	0.55	2.91	0.46	0.40	0.08	4.44
24	0 - 2	6.6	1.28	3.29	3.39	2.70	0.66	1.89
	2 - 4	6.7	0.70	2.09	1.70	1.66	0.43	1.61

PROPERTIES OF SOLANO FINE SANDY LOAM FROM THE

SPRINGTOWN ALKALI SINK

Transect 2

number	depth (in)	pH	E.C. (mS/cm)	---properties of saturation extract--- cations (meq/l) Na	Ca	Mg	K	SAR
2	0 - 2	6.2	1.52	12.31	0.41	0.37	0.27	19.71
	2 - 4	7.2	2.00	14.29	0.40	0.36	0.09	23.18
4	0 - 2	7.2	9.40	60.02	1.05	1.04	0.53	58.71
	2 - 4	8.6	8.10	59.29	0.75	0.73	0.32	68.92
6	0 - 2	6.8	7.30	59.91	1.82	1.85	0.46	44.23
	2 - 4	7.8	6.00	48.95	1.38	1.33	0.17	42.05
8	0 - 2	6.7	5.75	54.36	1.53	1.67	0.58	42.91
	2 - 4	7.9	7.60	68.40	1.40	1.66	0.09	55.30
10	0 - 2	7.5	85.20	664.05	19.08	50.00	1.19	112.79
	2 - 4	8.2	59.60	404.54	7.72	18.23	0.45	112.31
12	0 - 2	9.1	22.10	169.78	1.60	0.54	0.43	164.12
	2 - 4	9.8	23.90	182.23	0.98	0.40	0.19	219.38
14	0 - 2	6.6	2.02	15.78	0.32	0.91	0.26	16.97
	2 - 4	7.2	1.60	13.15	0.69	0.54	0.14	16.78
16	0 - 2	6.5	1.74	12.48	0.68	0.85	0.32	14.27
	2 - 4	7.0	1.12	9.23	0.43	0.35	0.12	14.78
18	0 - 2	6.6	0.81	6.34	1.07	0.85	0.06	6.47
	2 - 4	6.7	0.44	3.74	0.62	0.33	0.04	5.43
20	0 - 2	7.0	0.58	3.95	1.12	0.77	0.10	4.06
	2 - 4	7.5	0.50	3.67	0.90	0.57	0.08	4.28
22	0 - 2	6.4	0.68	3.42	1.43	1.22	0.12	4.80
	2 - 4	7.2	0.54	4.40	1.04	0.81	0.08	4.57
24	0 - 2	6.5	0.57	3.24	0.91	0.88	0.14	3.42
	2 - 4	6.9	0.40	2.38	0.54	0.38	0.09	3.51

note: SAR = Na / sqrt(Ca + Mg)

APPENDIX VII

THE POLICIES AND STATUTORY AUTHORITIES OF AGENCIES INVOLVED WITH THE SPRINGTOWN ALKALI SINK WETLANDS

City of Livermore

The lands in question are almost entirely within the City limits of the City of Livermore. The City has statutory authority and jurisdiction over any land-use change. The City's general plan and policies will guide any proposed use change. The City would be the lead agency for any proposed project and would prepare an Environmental Impact Report to meet the requirements of the California Environmental Quality Act. For the purposes of this document, the focus is on state and federal agency responsibilities. Consequently, the City's general plan and policies are not presented.

U.S. Department of the Army, Corps of Engineers

A Department of the Army permit is required under Section 404 of the Clean Water Act. Section 404 gives the Corps the authority to regulate the filling of "waters of the United States," including wetlands. The Corps' definition of "wetlands" is "...those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." 33 CRF 323.2(c) (1982).

Regarding the term "normal circumstances" in the above wetland definition, the Corps of Engineers' national office issued Regulatory Guidance Letter 86-9 to clarify this term. Their letter states, in part:

> "Our intent under Section 404 is to regulate discharges of dredged or fill material into the aquatic system as it exists and not as it may have existed over a record period of time. The wetland definition is designed to achieve this intent. It pertains to an existing wetland and requires that the area be inundated or saturated by water at a frequency and duration sufficient to support aquatic vegetation. We do not intend, by this clarification, to assert jurisdiction over those areas that once were wetlands and part of an aquatic system, but which, in the past, have been transformed into dry land for various purposes. Neither do we intend the definition of "wetlands"

to be interpreted as extending to abnormal situations including non-aquatic areas that have aquatic vegetation. Thus, we have listed swamps, bogs, and marshes at the end of the definition at 32.3.2(c) to further clarify our intent to include only truly aquatic areas."

The use of the phrase "under normal circumstances" is meant to respond to those situations in which an individual would attempt to eliminate the permit review requirements of Section 404 by destroying aquatic vegetation, and to those areas that are not aquatic but experience an abnormal presence of aquatic vegetation. Several instances of destruction of aquatic vegetation to eliminate Section 404 jurisdiction have actually occurred. Because those areas would still support aquatic vegetation "under normal circumstances, they remain a part of the overall aquatic system intended to be protected by the Section 404 program; therefore, 404 jurisdiction still exists.

All proposed discharges of dredged or fill material into "waters of the United States" require Corps of Engineers authorization under Section 404 of the Clean Water Act (CWA) (33 USC 1344). "Waters of the United States" include, but are not limited to, coastal and inland waters, lakes, rivers, and streams that are navigable waters of the United States, including adjacent wetlands; tributaries to "navigable waters of the United States," including adjacent wetlands; interstate waters and their tributaries, including adjacent wetlands; and all other waters of the United States.

Among the "waters of the United States" regulated by the Corps of Engineers and the Environmental Protection Agency under the Clean Water Act are waters "the use, degradation, or destruction of which could affect interstate or foreign commerce" (33 CRF 328.3(a)(3)). On September 12, 1985, the EPA General Counsel issued a legal memorandum regarding jurisdiction over such waters. The memorandum concluded that if water is used or would reasonably be expected to be used by interstate migratory birds or by endangered species, then it is sufficiently connected to interstate commerce to meet the definition of regulated "waters of the United States." The Corps of Engineers has endorsed this legal opinion. The seasonal ponds utilized by migratory waterbirds in the Springtown wetlands are "waters of the United States" subject to Corps of Engineers jurisdiction under Section 404 of the Clean Water Act.

Because the issuance of a Department of the Army permit is a "major Federal action" under the National Environmental Policy Act, and because a project affecting the Springtown wetlands project would have a significant impact on the human environment, the Corps would be required to prepare an EIS as part of the review of an application for a permit.

Pursuant to Corps of Engineers regulations (33 CFR 320.4(a)(2)(b) and (c)), the applicant would be required to provide a project site alternatives analysis demonstrating that there are no other reasonable locations for the project.

Policies' Context and Compliance

The decision whether to issue a permit by the Department of the Army is based on a public interest review, which is an evaluation of the probable impacts, including cumulative impacts, of the proposed activity and its intended use on the public interest. The decision whether to authorize a proposal, and if so the conditions under which it will be alllowed to occur, are determined by balancing the benefits of the proposal against its detriments, reflecting the national concern for both protection and utilization of important resources. All relevant factors are considered, including conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral production, considerations of property ownership and, in general, the needs and welfare of the people. The Corps of Engineers considers the views of other government agencies and the public in its public review process. No permit can be issued which does not comply with all applicable Federal laws, regulations, and policies.

An application for a permit under Section 404 of the Clean Water Act must be denied if the proposed activity would not comply with the "Guidelines for Specification of Disposal Sites for Dredged or Fill Material" (40 CRF 30) promulgated by the Environmental Protection Agency pursuant to Section 404(b)(1) of the Clean Water Act. The most important portions of the guidelines relative to the Springtown wetlands are summarized below:

a. Definitions: The following are some of the definitions set forth in the guidelines which are essential to their understanding:

> The terms "aquatic environment" and "aquatic ecosystem" mean waters of the United States, including wetlands, that serve as habitat for interrelated and interacting communities and populations of plants and animals. "Special aquatic sights" means...geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall

environmental health or vitality of the entire ecosystem or region." Wetlands (as defined by the Corps of Engineers' regulations) are identified as special aquatic sites by the guidelines.

b) Guidelines to discharge (fill) on an aquatic site, include:

"Except as provided under Section 404(b)(2), [consideration of the economics of anchorage and navigation], no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences (40 CFR 230.10(a)).

An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. If it is otherwise a practicable alternative, an area not presently owned by the applicant which could reasonably be obtained, utilized, expanded, or managed in order to fulfill the basic purpose of the proposed activity may be considered (40 CFR 230.10(a)(2)).

Where the activity associated with a discharge which is proposed for a special aquatic site does not require access or proximity to or siting within the special aquatic site in question to fulfill its basic purpose (i.e., is not "water dependent"), practicable alternatives that do not involve special aquatic sites are presumed to be available, unless clearly demonstrated otherwise. In addition, where a discharge is proposed for a special aquatic site, all practicable alternatives to the proposed discharge which do not involve a discharge into a special aquatic site are presumed to have less adverse impact on the aquatic ecosystem, unless clearly demonstrated otherwise (40 CFR 230.10(a)(3)).

c. Possible actions to minimize adverse effects include:

"Minimization of adverse effects on populations of plants and animals can be achieved by:

Selecting sites or managing discharges to prevent or avoid creating habitat conducive to the development of undesirable predators or species which have a competitive edge ecologically over indigenous plants or animals;

Avoiding sites having unique habitat or other value, including habitat of threatened or endangered species;

Using planning and construction practices to institute habitat development and restoration to produce a new or modified environmental state of higher ecological value by displacement of some or all of the existing environmental characteristics. Habitat development and restoration techniques can be used to minimize adverse impacts and to compensate for destroyed habitat.

San Francisco Bay Regional Water Quality Control Board (RWQCB)

The California Regional Water Quality Control Board for the San Francisco Bay operates in conjunction with nine other regional water quality control boards under the direction of the State Resources Agency. The RWQCB attempts to protect and enhance the quality of both surface and underground waters in the Region by reviewing activities that affect water quality in the Bay and its tributaries.

Water quality standards would be established by the RWQCB for any proposed project as part of the National Pollutant DIscharge Elimination System (NPDES) permit procedure.

Section 401(a)(1) of the Federal Clean Water Act prohibits Federal agencies, including the Corps of Engineers, from granting permits to conduct any activity which may result in any discharge to navigable waters until the applicant has obtained RWQCB certification that the discharge will comply with the applicable provisions of Sections 301, 302, 303, 306, and 307 of the Act, or a waiver of certification.

The RWQCB's major planning document, the Water Quality Control Plan for the San Francisco Bay Basin, recognizes the habitat value of wetlands and cites them as a "beneficial use." In 1988, the RWQCB adopted a wetlands policy which guides the Board in reviewing projects affecting wetlands. Under that policy, the Board will not approve projects that will result in a net loss of wetlands.

Alameda County

A portion of the wetlands to the west and northwest of Springtown are unincorporated lands within Alameda County. The following environmental resource and open space policies contained in the County's Open Space Element are pertinent to the proposed project:

* Acquire for public management those environmental resource areas which are of critical countywide, regional, statewide or national significance, including important wildlife habitat areas, watersheds and groundwater basins, and areas providing or having potential to serve outdoor recreation needs.

* Uses or development which will seriously impact or jeopardize resource values should be located away from areas of significant environmental resources.

In 1987, the Alameda County Board of Supervisors adopted a wetlands policy which directs the County to only approve projects which do not result in a net loss of wetland acreage or values.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service is the Federal Government's principal conservation agency for fish and wildlife resources. Goals of the Service include fostering the wise use of land and water resources protecting and enhancing the nation's endowment of fish and wildlife, preserving the quality of the environment and providing for the conservation, enhancement, and protection of this nation's fish and wildlife resources for the continuing benefit of the people.

The U.S. Fish and Wildlife Service has three basic objectives: 1) to assist in the development and application of an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility; 2) to guide the conservation, development, and management of the Nation's fish and wildlife resources; and 3) to administer a national program to provide the public opportunities to understand, appreciate, and wisely use fish and wildlife resources. These objectives support the Service mission of conserving, enhancing, and protecting fish and wildlife and their habitats for the continuing benefit of people.

In fulfillment of these objectives, the U.S. Fish and Wildlife Service performs a variety of functions, including but not limited to:

- Acquisition, protection, and management of unique ecosystems necessary to sustain fish and wildlife such as migratory birds, resident species, and endangered species.

- Conducting fundamental research on fish, wildlife, and their habitats to provide scientific information leading to better management, healthier, more vigorous animals, and protection of fish and wildlife from dislocation or destruction of their habitats, overuse, and industrial, agricultural, and domestic pollutants.

- Providing financial and professional technical assistance to States through Federal aid programs for the enhancement and restoration of fish and wildlife resources.

- Conducting programs of research, enforcement, management, and professional technical assistance to other agencies for the protection of endangered species.

- Promulgation and enforcement of regulations for the protection of migratory birds, marine mammals, fish and other nonendangered wildlife from illegal taking, transportation, or sale within the United States or from foreign countries.

- Conducting programs of research, enforcement, management, and professional technical assistance to other agencies for the protection of endangered species.

- Promulgation and enforcement of regulations for the protection of migratory birds, marine mammals, fish and other nonendangered wildlife from illegal taking, transportation, or sale within the United States or from foreign countries.

- Conducting programs of planning, evaluation, and professional technical assistance to other agencies for the proper use and protection of fish and wildlife habitat, that directly benefit the living natural resources and add quality to human life.

- Conducting programs of interpretation, education, and recreation to foster a stewardship ethic in the American public through high quality fish and wildlife oriented experiences.

- Communication of information essential for public awareness and understanding of the importance of fish and wildlife resources and interpreting fish and wildlife changes reflecting environmental degradation that ultimately will affect the welfare of human beings.

The Service's authority for receiving and commenting on projects affecting wetlands, endangered species, and other fish and wildlife resources are prescribed in: the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e; 48 Stat. 401, as amended), the National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347; 83 Stat. 852), the Endangered Species Act of 1973 (16 U.S.C. 1531-1534, 87 STat. 884), the Estuary Protection Act (16 U.S.C. 1224; 82 Stat. 627), the Department of Transportation Act

(49 U.S.C. 1653(f); 82 Stat. 825), the Federal Aid Highway Act (23 U.S.C. 138; 82 Stat. 823), the Airport and Airway Development Act of 1970 (49 U.S.C. 1712(c) and (f), 1716(c)(4); 84 Stat. 222, 227), the Watershed Protection and Flood Prevention Act (16 U.S.C. 1008, 72 Stat. 567), and the Endangered Species Act of 1973 (16 U.S.C. 1536; 87 Stat. 892). The Service also has advisory and consulting roles under the Coastal Zone Management Act of 1972 (16 U.S.C. 1451) and the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1401), as well as basic and other authorities.

These laws, statutes, and regulations, in conjunction with the Service's published mitigation policy (46FR7644-7663) guide the Service in formulating its comments and position on proposed actions affecting fish and wildlife resources.

Wetland Protection Policy

It is the Service's policy in this region to view wetland degradation or losses as unacceptable changes to an important national resource (generally considered to be Resource Categories 1, 2, or occasionally 3 of the Service's Mitigation Policy). As such, it is the goal of this Region to ensure that no net loss (acreage or value, whichever is greater) of wetland habitats occur. Development proposals adversely impacting wetlands generally will be discouraged unconditionally at the Field Office level. To ensure Regional consistency, any recommendations (negotiations) which would result in a net loss of wetland habitat acres or values must have Assistant Regional Director-Habitat Resources concurrence.

All of the following criteria must be met for concurrence:

1. The site is not in the Service's Resource Category 1.

2. The area is not used by nor provides habitat for any threatened, endangered, or unique species.

3. The proposed work is water-dependent (refer to Regional Policy EN-S, Water Dependency Considerations).

4. There are no feasible means to mitigate at or near the project site nor to restore or manage the site as a wetland.

5. The area to be destroyed exhibits no unusual fish or wildlife values and is isolated from other wetlands relative to these values, to other functional values, and to any hydrologic connection.

This policy applies, but is not limited, to Service involvement in federal projects, permits and licenses, RCA, NEPA, area-wide planning, technical assistance, and all other HR activities.

California Department of Fish and Game

The Department of Fish and Game is the state agency entrusted with the protection of California's fish and wildlife resources. The Department comments on and makes recommendations on CEQA documents, NEPA documents, Corps public notices, and other planning and permitting documents. The Department is responsible for administering the California Endangered Species Act of 1984, the language of which expresses the intent of the California Legislature (Chapter 1.5, Article 1, Fish and Game Code):

> The Legislature hereby finds and declares all of the following:
>
> (a) Certain species of fish, wildlife, and plants have been rendered extinct as a consequence of man's activities, untempered by adequate concern and conservation.
>
> (b) Other species of fish, wildlife, and plants are in danger of, or threatened with, extinction because their habitats are threatened with destruction, adverse modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors.
>
> (c) These species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this State, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern.
>
> The Legislature further finds and declares that it is the policy of the State to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat and that it is the intent of the Legislature, consistent with conserving the species, to acquire lands for habitat for these species.
>
> The Legislature further finds and declares that it is the policy of this State that all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance of the purposes of this chapter.

The Department is also guided in formulating its position by the policies of the Fish and Game Commission, including the following Wetlands Resources Policy statements, adopted in 1987:

The Fish and Game Commission finds that:

I. California's remaining wetlands provide significant and essential habitat for a wide variety of important resident and migratory fish and wildlife species.

II. The quantity and quality of the wetlands habitat remaining in California have been significantly reduced; thus, maintenance and restoration are essential to meet the needs of the public for fish and wildlife resources and related beneficial uses. In addition, the protection, preservation, restoration, enhancement, and expansion of wetlands as migratory bird breeding and wintering habitat are justly recognized as being critical to the long-term survival of such species. Wetland habitat is also recognized as providing habitat for over half of the listed endangered and threatened species in California.

III. Projects which impact wetlands are damaging to fish and wildlife resources if they result in a net loss of wetland acreage or wetland habitat value.

IV. Through the passage of Senate Concurrent Resolution 28 (January 1, 1983), the Legislature, in recognition of the importance of wetlands, indicated its "intent to preserve, protect, restore, and enhance California's wetlands and the multiple resources which depend upon them for the benefit of the people of the State." The Legislature further declared its desire that wetland habitat acreage be increased by 50 percent by the year 2000.

Therefore, it is the policy of the Fish and Game Commission to seek to provide for the protection, preservation, restoration, enhancement, and expansion of wetland habitat in California.

Furthermore, it is the policy of the Fish and Game Commission to strongly discourage development in or conversion of wetlands. It opposes, consistent with its legal authority, any development or conversion which would result in a reduction of wetland acreage or wetland habitat values. To that end, the Commission opposes wetland development proposals unless, at a minimum, project mitigation assures there will be "no net loss" of either wetland habitat values or acreage.

Other Relevant Federal Laws and Regulations

U.S. Endangered Species Act

This Act was passed by Congress in 1973 to provide protection for animal and plant species that are currently in danger of extinction (endangered) and those that may become so in the future (threatened). Section 7 of the Act requires federal agencies to ensure that their actions do not have adverse impacts on the continued existence of Threatened or Endangered Species or on designated areas (critical habitats) that are essential in conserving those species. The U.S. Fish and Wildlife Service maintains a current list of species which have been designated as Threatened or Endangered. Under the Act, the Corps must consult with the U.S. Fish and Wildlife Service if a permit application for a project which would affect a listed species is received. A Biological Assessment is provided to the Service along with an Environmental Impact Statement (NEPA document) as part of the consultation process. The Service must render a biological opinion making either a jeopardy or no-jeopardy finding which will guide the Corps' issuance or denial of a permit application.

Executive Order 11988, Floodplain Management (May 24, 1977)

In order to reduce the risk to human safety, health, welfare, and property associated with floods and in order to preserve the natural and beneficial values served by floodplains, Federal agencies are directed by this Order to evaluate the potential effects of actions, including the granting of permits, which they may take in the floodplains.

Fish and Wildlife Coordination Act

This Act requires the Corps to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the California Department of Fish and Game prior to issuance of a Department of the Army permit. Formal consultation with these agencies would occur through their review of the Corps Public Notice and an EIR. The Corps of Engineers' regulatory program requires the District Engineers to give full consideration to the views of these agencies in deciding on the issuance, denial, or conditioning of permits.