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The Ojai Meadows Preserve:
Enhancement, Revegetation and Creation of Native Habitats

A Group Project submitted in partial satisfaction of the requirements for the degree of
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by

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Abstract

The Ojai Valley Land Conservancy (OVLC) is a volunteer-supported, community group working to preserve open space in Ojai, California. OVLC recently purchased 23 hectares of degraded open space, located in the southwest corner of Lower Ojai Valley, known as the Ojai Meadows Preserve. The Ojai Meadows Preserve is dominated by non-native vegetation, fauna species commonly associated with degraded urban areas, and a few interspersed native plants. Although the preserve is highly degraded, it has considerable potential for having high conservation, educational and recreational value. Located adjacent to a high school and an elementary school, the Preserve has the potential for becoming a hands-on, environmental education center. The Bren Ojai Restoration Group (BORG) developed a restoration plan that provides overall recommendations to the OVLC on how to improve the ecological integrity of the Preserve, and provide educational and recreational opportunities.

The restoration plan creates a framework for transforming the site into predominately native habitats characteristic of the Ojai Valley, including Valley oak savanna, vernal pool, freshwater marsh, and riparian habitats. Based on the constraints of the site, different restoration approaches are suggested for the various habitat restoration and management plans. For the oak savanna and vernal pool habitats, an adaptive management approach is recommended, which uses experiments to determine optimal restoration strategies. To address the limited water supply in the area, the freshwater marsh restoration and management plan identifies two alternatives: a permanent and a seasonal freshwater marsh. Finally, we suggest using an engineering approach that draws on "best management practices" to restore the riparian habitat.

1.0 PROJECT BACKGROUND AND GOALS

1.1 Description

The Ojai Valley Land Conservancy (OVLC), with support from the community, intends to restore 23 hectares (58 acres) of degraded, urban open space in Ojai Valley, California known as the Ojai Meadows Preserve (Preserve). The OVLC is committed to restoring this property to a beautiful, well designed preserve based on the enhancement and revegetation of native habitats, including oak savanna, permanent freshwater marsh, vernal pools, and a scrub riparian area. The Bren Ojai Restoration Group (BORG) developed a conceptual restoration plan for the Preserve that incorporates the vision of the OVLC and Ojai community. The plan is intended to convert the Ojai Meadows Preserve into the most self-sustaining system possible given significant ecological and social constraints. The restoration plan is structured to enhance the value of the Preserve by providing open space, increased habitat for native species, and a "living" classroom that promotes environmental education and an appreciation for native biodiversity.

1.2 General Aspects of Restoration

Restoration has been defined as "return of an ecosystem to a close approximation of its condition prior to disturbance (National Research Council (NRC), 1992). For most restoration projects, this usually refers to the ecological conditions of pre-European settlement. However, in the context ecosystems contained within urban and semi-urban landscapes, restoration generally means the functional rehabilitation of an ecosystem so that it provides multiple environmental benefits, rather than the restoration to pre-European settlement conditions (Morris and Moses, 1999). Although the Ojai Valley is perceived as a rural area with considerable open space, the immediate surroundings of the Ojai Meadows Preserve have undergone significant urbanization, which precludes returning the site to pre-settlement conditions. For these reasons and the purposes of this report, we will use this latter definition of restoration.

Ecological rehabilitation efforts strive to reverse the losses of biodiversity and the degradation of ecosystems that have occurred as a result of anthropogenic effects on landscapes (Geist and Galatowitsch, 1999). However, in spite of increasing ecological knowledge, restoration efforts have resulted in limited success (Geist and Galatowitsch, 1999; NRC, 1992). There are many reasons for this including, unrealistic goals and expectations (Ehrenfeld, 2000), inadequate understanding of complex ecological processes (Kondolf and Micheli, 1995), limited funding, insufficient time and labor, and lack of post-project monitoring and evaluation (Kondolf and Micheli, 1995).

Restoration projects that avoid these common shortcomings greatly increase their probability of success. Since success of a restoration project is determined by the degree to which it achieves the specified goals, establishing realistic goals provides for high success rates. The primary concern should be developing project goals and objectives relative to the scope of the project (Ehrenfeld, 2000) and ecological constraints of the site. The most well intentioned restoration efforts often fail because of inadequate knowledge of site-specific, ecological constraints. As mentioned above, restoration of the Preserve is highly constrained by unchangeable modifications of the surrounding watershed and greater landscape. For this reason, considerable time was invested into developing a conceptual model of site ecology, which helps to identify constraints to proposed management actions. Perhaps the single, most important determinant of project success is funding. Adequate funds must be appropriated for both implementation and post-project monitoring to avoid the common pitfalls realized by many other restoration projects (Kondolf and Micheli, 1995). Long-term monitoring and management costs must be carefully estimated and incorporated into the total cost of the project. Furthermore, all restoration success and especially failures should be well documented so that the science of ecological restoration can be improved.

1.3 Primary Stakeholders

The OVLC is a volunteer-supported community group of private citizens working to preserve open space in the Ojai Valley. The OVLC began in 1987 and is a non-profit, tax-exempt organization. The OVLC works with local governments to preserve and manage land in public interest, provide educational opportunities, and pursue land restoration and enhancement projects. The OVLC currently manages three preserve areas: Ilvento Preserve, Ojai Meadows Preserve, and a City Park.

1.4 Site Description

The Ojai Meadows Preserve is composed of two previously owned properties: the Besant Meadow and Palmer Property. The OVLC acquired the Palmer property in December 1999 under the agreement that there would be no development on the property. The Palmer Property is west of Nordhoff High School and south of Maricopa Highway. Adjacent to and west of the Palmer property lies the Besant Meadows property, which comprises 10 hectares between Meiners Oaks Elementary School and the Ranch House Restaurant. This property was acquired in 2000. The Happy Valley Drain, which provides flood control for Meiners Oaks and West Ojai hills, bisects the Preserve.

1.5 Project Importance

Although the Preserve is highly degraded, it is of high conservation and recreational value. The habitats proposed for restoration have been severely reduced within the Ojai Valley from past agricultural and development activities. These habitats are also of high conservation concern throughout California. Vernal pools are unique and rare habitats that support a diversity of rare species. Freshwater marsh and riparian habitats have been adversely impacted by human activities such as dam construction, channelization of rivers, fill for development, and pumping of groundwater. Valley oak and native grassland habitats have been severely reduced by development

pressures, and 90% of the current distribution in California is found on lands with no formal protection (Davis et al., 1998).
Located adjacent to a high school and an elementary school, the Preserve (Figure 1.1) has the potential for becoming a hands-on, environmental education center. Once restored, this property also offers the communities of Ojai and Meiners Oaks an inviting setting for passive recreation in the form of nature walks or bike rides on designated trails.

1.6 Project Scope

BORG developed the restoration plan for the Preserve through a multidisciplinary team approach. This report provides overall recommendations to the OVLC on how to enhance the ecological integrity of the Preserve. The restoration plan provides a framework for enhancing valley oak savanna, vernal pool, freshwater marsh, and riparian habitats that are characteristic of the Ojai Valley. The project includes the establishment of goals and objectives, the collection of baseline data, and the development of a restoration plan that provides strategies to restore, maintain, and monitor each of the habitat types. The project also addresses policy considerations, costs, long-term maintenance, and educational opportunities involved in the management of the Preserve. Due to time constraints, the project does not include detailed designs for implementing the restoration strategies.

1.7 Project Approach

Traditionally, restoration projects involved simple implementation and monitoring plans, which help managers assess the success of the restoration and respond to unexpected management impacts. However, uncertainty in the restoration process has led to the need for and the adoption of an adaptive management approach that provides structured process in the development and implementation of restoration plans. Adaptive management emphasizes the need to address the uncertainty and complex ecological issues inherent in ecological restoration (Holling, 1978), and allows for flexibility concerning previously agreed upon management actions. It requires the acknowledgement of uncertainty and potential failure while retaining the ability to change management decisions as new information becomes available (Federal Interagency Stream Restoration Working Group, 1998).

Progress at the restoration site should be assessed periodically so that decisions can be made regarding mid-course adjustments or alternative actions. Through this iterative process, specific problems can be identified and corrected, preventing the inflexible adherence to unrealistic restoration goals. Adaptive management should not be perceived as "trial and error" with the flexibility to modify management decisions. Although such an approach is often referred to as adaptive management, it lacks the experimental component that is fundamental to the adaptive management process. Adaptive management is often referred to as an "experimental approach" since it emphasizes regarding the project as an experiment that serves to test the veracity of a stated hypothesis. It calls for simultaneously conducting several different experiments (in this case, restoration strategies) within a particular ecosystem to determine the best method of restoration. Such experiments will highlight the most successful restoration strategy and provide direction for management actions.

Unfortunately, due to spatial scale limitations, the experimental approach inherent in adaptive management is applicable only to the oak savanna and vernal pool habitat restoration and management plans. The physical size of the Preserve prevents the freshwater marsh and riparian habitats from being restored and managed adaptively. Therefore, enhancement efforts concerning the freshwater marsh and riparian habitats are relegated to prescribed restoration strategies and techniques that, based on review of relevant literature and projects, are considered optimal given the goals and constraints of the project. Although aspects of the adaptive management approach, such as development of a conceptual model, will be incorporated into the restoration of these habitats, the signature experimental element will be lacking. Furthermore, the feasibility of establishing a permanent freshwater marsh is in doubt, thus seasonal and permanent alternatives were developed for the freshwater marsh habitat restoration and management plan.

The BORG adaptive management scheme consists of a continuous feedback loop (Figure1.2) that emphasizes consistent monitoring and subsequent modification of restoration plans. The first step is to articulate specific goals and objectives, which will guide all future decisions and actions. Second, baseline site data consistent with project goals and objectives are collected. Based on data analysis, ecosystem threats are identified and site-specific conceptual models are developed. Conceptual models highlight historical and current ecosystem processes operating on the site, threats to these processes, and management actions to ameliorate the identified threats.

The next step involves creating a detailed management plan that serves to carry out the management actions and achieve the desired goals. The management plan consists of experimental restoration strategies and techniques that are based on and consistent with the conceptual model, scientific literature, and reference conditions. Also included are proposed success criteria that illustrate the trajectory of the restoration work and reveal whether the restoration techniques employed are working towards achieving target conditions.

The final three elements of the adaptive management model are implementation, monitoring, and revision, which are all part of the “doing” phase rather than the “design” phase. Although BORG will not be involved in this second phase, the components therein must be discussed and developed. Therefore, guidelines are provided to implement the management plan, monitor results of restoration techniques, and revise as necessary. Targets for revision may include the specific techniques/strategies, the broader management actions, and/or the underlying goals and objectives. This is where the flexibility inherent in adaptive management is exemplified. For example, the monitoring results may reveal that particular goals are difficult to achieve, and should therefore be abandoned or transformed to fit the constraints of the ecological system. The adaptive management approach allows one to make such changes and continue with the restoration effort. At this point, the user would go through the steps of the model again, making necessary changes in each component. This iterative process is continued until the desired goals and objectives are achieved and management always on-going.

1.8 Goals and Objectives

Members of the OVLC met with BORG to discuss their overall goals and restoration visions for the site. Constraints of the site such as size, proximity to residential neighborhoods and community expectations were also considered when developing the goals.

Goal 1: Restore and maintain habitat for native plants and animals of Ojai Valley.

Objective 1: Remove and manage invasive exotic species.

Objective 2: Enhance native habitats: oak savanna, fresh water marsh, vernal pool and riparian.

Objective 3: Reintroduce native species.

Goal 2: Reintroduce processes that will enhance the ecological functions of the Preserve while providing ecosystem services to the Ojai community.

Objective 1: Restore riparian corridor.

Objective 2: Create a wetland to improve and maintain flood control and water quality.

Goal 3: Create and maintain a nature preserve for the community of Ojai Valley that fosters appreciation of local ecosystems and biological diversity through outdoor education and passive recreation.

Objective 1: Enhance public awareness of local ecological processes.

Objective 2: Develop walking and bicycle trails to facilitate passive recreation and nature observation.

Goal 4: Provide facilities and opportunities for environmental education.

Objective 1: Develop a modern, onsite education center.

Objective 2: Create a native plant demonstration garden onsite.

Objective 3: Involve students and the local community in the restoration process and long-term monitoring.

1.9 Conceptual Model

Individual conceptual models were constructed for each existing and proposed habitat type: oak savanna, vernal pool, freshwater marsh, and riparian area (Figures 1.3, 1.4, 1.5, 1.6). Target conditions for the restoration of these habitat types were determined based on the underlying goals of the project. Once the target conditions were established, stressors affecting these target conditions were identified for each habitat. Stressors include current disturbance such as the absence of native dispersers and altered water regime that have negative effects on the target conditions. Management actions were proposed to reduce the effects of the stressors on the target conditions. Experiments (where applicable) will be conducted to determine which management actions are the most successful for each habitat.

The conceptual models for each habitat type were combined and used for comprehensive site planning. The combined model (Figure 1.7) is a useful tool for integrating the different habitat types found on the site. Overriding stressors of the site include presence of non-native species, absence of a native species pool, and hydrological alterations.

2.0 ENVIRONMENTAL SETTING

Ojai Valley is situated within the foothills of the Sierra Madre Mountains, 24 km from the coast of Ventura County, California. The valley runs in an east-west direction and is approximately 19 km long and 5 km wide. The Ventura River and its tributaries, including San Antonio Creek, drain the valley. The city is in the center of the valley at an elevation of approximately 226 m (Gerard and Perkins, 1927).

The Ojai Meadows Preserve lies in the southwest corner of the Lower Ojai Valley near Meiners Oaks (Figure 1.1). The site is characterized by species commonly associated with degraded urban areas. Natural processes, including the hydrology, have been significantly altered by human related impacts. Baseline data for the site and the Ojai Valley were collected prior to development of the restoration plan. The results of our environmental characterization are discussed below.

2.1 Land Use History

Although land use history is an important component in the development of a restoration plan, such information on the Preserve is limited. However, using available literature and personal accounts, some assumptions can be made regarding the natural setting of the site.

The Oak Grove People, Hunting People, and Chumash are the earliest humans known to inhabit the Ojai Valley. Their impacts to the natural landscape are not fully known but considered to be minimal (Fry, 1999). With the arrival of European settlers in 1855, the valley slowly began to change until 1887 when urban development expanded (Fry, 1999). In the early part of the 20th century, the landscape consisted of agricultural patches scattered throughout the area with alternating patches of land consisting of native oak groves (Fry, 1999). The city gradually developed and, by the 1980s, the population of Ojai Valley reached 25,000, resulting in degradation of the Valley's natural habitats (Fry, 1999). In 1876, Meiners Oaks, land that was considered to maintain one of the largest stands of oaks on flat ground in California, was transformed into farmland (Fry, 1999). Since the Preserve is adjacent to Meiners Oaks, there is reason to believe it was subjected to the same transformation. Few remnant oaks and marshes remain on the site today.

Historical aerial photographs reveal some of the onsite changes that have taken place over time (Table 2.1; Figures 2.1-2.4). These photographs show that progressive development destroyed several drainage channels that drained into the historic wetland on the site. Maricopa Highway was constructed adjacent to and north of the site in October 1933, which bisects what was most likely a wetland. In the mid-1950s, Frank Noyes, the Happy Valley School (currently the Meiners Oaks Elementary School) gardener, and local students planted a large eucalyptus grove, which prevents native plant colonization in this area and reduces water availablity to the wetland (Fry, 1999). In 1959, Matilija Junior High School was constructed adjacent to the Preserve, eventually becoming Nordhoff High School in 1966 (Fry, 1999). This development has significantly altered the drainages and greater watershed.

Attempts have been made to turn the Preserve into a shopping center and housing development. The zoning change required by the City of Ojai for the development was denied due to adverse environmental and cultural impacts. Mr. Palmer, the resident owner of the property, developed several other proposals in an effort to sell and develop the property until the area was rezoned as Institutional/Recreational in the Maricopa Specific Plan, which prohibited development of 60% of the property.

Community members use the site for passive recreation, and students use it as a pathway and play area. The adjacent land use is both rural and urban (Figure 2.5) with the Los Padres National Forest to the North and Sulfur Mountains and Lake Casitas to the South

2.2 Hydrology

The hydrology of the Ojai area is primarily controlled by precipitation and evapotranspiration. The annual precipitation in Ojai ranges from 18.36 cm/yr. to 120.10 cm/yr., with a mean annual precipitation of 53.23 cm/yr. (Table 2.2). Most of the rainfall occurs during the winter months (December through March), comprising over 90% of the total annual rainfall. The data presented are based on 50 years of precipitation gauge data collected from 1949 to 1999 by the Western Regional Climate Center (WRCC).

Large seasonal and annual variations in precipitation are typical of a Mediterranean climate. A cumulative rainfall frequency curve shows that the probability of drought or flood conditions in the Ojai Valley is 40% (Figure 2.6). Drought conditions were considered to be rainfall years with total precipitation less than 27 cm/yr. (one standard deviation below the average value) and flood conditions were considered to be rainfall years with total precipitation greater than 70 cm/yr. (one standard deviation above the average value).

The two significant sources of surface water to the site have been drastically altered as the Ojai/Meiners Oaks area was developed. Drainage patterns observed in historical aerial photographs show that surface runoff to the site originated from the Nordhoff Ridge and the area that is currently Nordhoff High School. Upon construction of the high school, runoff from this area was localized to the western edge of the baseball field. After 1969, runoff originating from Nordhoff Ridge was diverted into the Happy Valley Drain.

Current surface water inflow to the Preserve includes local storm water discharge from surrounding developments. Four main points have been identified as surface water inflow areas for the Preserve: the drainage ditch, Happy Valley Drain, a drain

from Krontona Hills, and runoff from Nordhoff High School. The inflow points and associated drainage areas are shown in Figure 2.7.
Storm runoff volumes for the surrounding sources of inflow were calculated using the Soil Conservation Service (SCS) method. This method is based on a simplified infiltration model in which runoff is determined from a curve number, an empirical estimate of the hydrological performance of a drainage area (Dunne and Leopold, 1978). The curve number represents the effect of different soil types, antecedent moisture conditions, and vegetation types on the infiltration rate and capacity of an area (Viessman et al., 1977). Curve numbers were estimated for each drainage area (Table 2.3), and volumes of runoff were calculated for each inflow point.

Approximately 9700 m^3 of runoff flow onto the site annually (Table 2.4). Over 50 percent of the average annual storm flow input occurs in January and February. A majority of the average annual surface runoff (5,000 m^3) is channeled through the Happy Valley Drain. This channel can accommodate 1,910 m^3s^{-1}, the expected volume of water for the 100-yr flood event. The flood conveyance of Happy Valley Drain cannot be altered, as specified by the Ventura County Flood Control District (VCFCD). This constraint precludes over-bank flooding and therefore using much of the surface runoff as a water source for the freshwater wetland restoration.

Groundwater inflows to the site include local flow systems from West Hills (at the base of the Nordhoff Ridge) and Krotona Hill, and regional flow systems from Nordhoff Ridge (David Magney Environmental Consulting (DMEC), 2001). In January 2001, groundwater was observed at a depth of 56 cm on the eastern portion the site. It is uncertain whether the groundwater observed is evidence of a perched water table or a shallow aquifer. On February 6, 2001, the groundwater level of the aquifer was measured on the western portion of the site at well 10G1 (Figure 2.8). Groundwater was found at a depth of 14.3 m, measured from the top of the well casing to the water surface by Marvin Hanson. Hall Oquist drilled well 10G1 in 1991, which is located 20 m North of Beasant Road. It is 73 m deep and 15 cm in diameter (Panaro, pers. comm., 2001).

The well was test pumped at 100 gpm, and the depth to static water was 18.3 m for a dry year (Panaro, pers. comm., 2001). No water quality data is available for this well, but a nearby well (10J1) (Figure 2.8) to the south, drilled in 1939, has water quality data available and has similar geology to well 10G1. Given this, it can be assumed that the water quality data for 10G1 is fairly similar. Well 10J1 has good water quality, meeting regional drinking-water standards (Panaro, pers. comm., 2001). However, before water is used from 10G1 it should be pumped at 3 casing volumes before any water quality tests are done (Panaro, pers.comm., 2001).

The yearly and seasonal fluctuations of the regional aquifer were determined from California State Well data collected from 1972 to 1999. The State Well is located 0.5 km NE of the Preserve in the flow line of the groundwater flow (Figure 2.8). The average groundwater level fluctuation for the well is 1.8 meters/year (Figure 2.9). The seasonally high water table occurs in the spring from March to April. The seasonal low water table occurs in the late fall to early winter from October to January.

Evapotranspiration is defined as the combined outflow of water via soil and surface water evaporation and transpiration by plants. Solar radiation, wind speed, turbulence, relative humidity, available soil moisture and vegetation influence the rate of evapotranspiration (Dunne and Leopold, 1978). Seasonal and daily fluctuations in evapotranspiration are considerable and measurements are difficult to collect. Evapotranspiration rates are typically estimated using calibrations from pan evaporation rates collected from an area and theoretical equations, which relate evapotranspiration to available energy. Estimations of evapotranspiration made by pan-evaporation rates more accurately reflect local evapotranspiration fluctuations (Dunne and Leopold, 1978).

Estimations of evapotranspiration were derived using pan-evaporation rates collected at Casitas Dam Headquarters by the National Weather Service. Experimental derivations of coefficients for pan-evaporation rates for the Ojai area were not found. Therefore the pan evaporation rates were calibrated with an average vegetation coefficient. Calibration coefficients can range from 30% to 90% (Mitsch and Gosselink, 2000). An average consumptive use factor applied in many agricultural areas is 66% (Gray et al., 1970), and was used to calibrate the pan evaporation rates. The average monthly evapotranspiration demand ranges from approximately 7 cm/mo. in January to 17 cm/mo. in July (Table 2.5).

2.2 Geology

The geology of the site was determined from geological maps and a site investigation conducted on January 17, 2001 by Mark Rains along with members of BORG (Appendix A). Ojai Meadows Preserve is located on an old stream terrace and alluvial fan deposits. The old stream terrace deposits were laid down primarily from the Ventura River. Historically, the stream terrace extended from the toe of Nordhoff Ridge to the toe of Sulphur Mountain. The adjacent Krotona Hills were probably formed by uplift along a blind thrust fault, interrupting the once continuous terrace. A finger of alluvial fan deposits, generating from Nordhoff Ridge, overlies the old stream terrace deposits on the north end of the site (DMEC, 2001).

The subsurface geology was found from records of when the 10G1 well was drilled (Table 2.6). This geology is evidence of a perched water table with several impervious layers (Panaro, pers. comm., 2001). Well 10J1 shows an impervious clay layer at 4 to 8 m, which is slightly deeper than the clay layer found at well 10G1 (Panaro, pers. comm., 2001). Therefore, it may be assumed that the clay layer is fairly continuous across the nearby landscape.

2.2.1 Soils

The Soil Conservation Service (SCS) mapped the soils of the Preserve in 1970 as the Ojai-Sorrento association (Edwards et al., 1970). The Preserve consists of two main soil types: a very fine sandy loam (OhC2) in the Ojai series and a clay loam (SzC) in the Sorrento series. Soils in the Ojai series consist of well-drained, very fine sandy loams or stony fine sandy loams that have a sandy clay loam subsoil. They have slopes of 0 to 30 percent and elevations of 30 to 518 m (Edwards et al., 1970). The Sorrento series consists of well-drained loams and silty clay loams. They have slopes of 0 to 9 percent, and elevations range from 7 to 518 m (Edwards et al., 1970).

The OhC2 phase consists of very fine sandy loam with 2 to 9 percent slopes (Edwards et al., 1970). It is moderately eroded and has therefore lost as much as one-fourth of the original surface layer, and/or contains numerous gullies. The present surface layer is 23 to 38 centimeters thick. Surface runoff from the OhC2 series is slow to medium and the erosion hazard is slight to moderate. The available water holding capacity is 13 to 18 cm in the 152 cm of effective rooting depth (Edwards et al., 1970).

The SzC phase consists of clay loam with heavy variant and slopes of 2 to 9 percent (Edwards et al., 1970). The surface layer is dark grayish-brown, slightly acid (pH 6.5) clay loam about 36 cm thick; the next layer is dark grayish-brown, neutral (pH 7.0) heavy clay loam about 40 cm thick; and the third layer is brown, moderately alkaline (pH 8.0) heavy clay loam about 76 cm thick (Edwards et al., 1970). These three layers are typically moist and are very hard, sticky and plastic. Permeability is slow, surface runoff is medium, and the erosion hazard is slight. The available water holding capacity is 24 to 29 cm in the 152 cm of effective rooting depth (Edwards et al., 1970).

BORG conducted a soil survey of the Preserve to ground truth the findings of the Service. BORG found that the SCS survey map (Figure 2.10) was generally accurate. However, we determined that the Sorrento clay loam covered a larger portion of the site than mapped in the 1970 survey. The soils on the eastern portion of the Palmer Property Preserve were found to be sandy loam or loam, which are characteristic of Ojai series soil. The soil steadily increases in silt and/or clay content moving west across the Preserve. Soils of the Besant Meadows property and western portions of the Palmer property were found to be clay loam or silty clay loam, which are characteristic of Sorrento series soil. In general, the soils steadily increase in silt and/or clay content from east to west.

2.2.2 Topography

A coarse scale topographic survey was conducted on the Ojai Meadows Preserve to determine major features and site drainage patterns. BORG completed the topographic survey using transits, stadia rods and a GPS unit. The site was surveyed at 50-meter grid interval and the data were compiled and interpolated using Spatial Analyst on ArcView (Figure 2.11).

The surface of the Preserve is flat with many minor mounds and depressions up to 0.3 m in height. Two channels bisect the site, the Happy Valley Drain and a man-made drainage ditch. The Happy Valley drain is a red line drain, created for flood control. It is 1.5 m deep, 3.5 m wide at the base and 7.6 m wide along its upper edges. The man-made drainage ditch is a remnant of previous agricultural practices. Water drains from a sump, located alongside Maricopa Highway, into the man-made ditch southwest until it intersects with Happy Valley Drain. The site generally drains from east to the west.

The Preserve also consists of a three larger depressions in which runoff could potentially collect. The largest depression identified in the survey was approximately 250 m^2 in size and lies 200 m southwest of the sump along Maricopa highway. Runoff from adjacent areas to the east and southeast of the site, including Nordhoff High School, is expected to collect in the largest depression. Smaller depressions, approximately 75 m^2 in size, were identified in the southwest corner of the site, at the northwestern edge of the Happy Valley Drain, and at the sump along Maricopa highway.

Two small hills on the site are man-made features. One hill, 1 m in height, traverses the border of the Palmer and the Besant Meadows properties. The hill was created from the burial of a city sewage pipe (Figure 2.11). The other hill occurs along the southwestern edge of the property and appears to be the result of excavation.

2.3 Biological Resources

Baseline studies are important pre-restoration steps that allow managers to determine species composition and assess project success. We conducted a baseline inventory of the vegetation and wildlife found on the Preserve in the summer of 2000. Although this inventory provided important information on the available biological resources, a more in depth inventory should be conducted prior to implementation of the restoration plan. We may have missed some species due the season and timeframe in which the survey was conducted, and rare species may have been overlooked.

2.3.1 Vegetation

A vegetation list for the site was compiled from surveys conducted by BORG and Bowland and Assosciates (1996) (Table 2.7). BORG surveyed the site on three occasions during the summer of 2000, noting presence and status (native or non-native) of species. We created a GIS map (Figure 2.12) delineating current dominance of species on the Preserve based on our survey. The map is a rough sketch of the vegetation, which is helpful in determining locations for restored habitat types.

The majority of the site is composed of non-native annual grasses such as ripgut brome (*Bromus diandrus*), wild barley (*Lolium multiflorum*) and wild oat (*Avena barbata*). These species dominate the grassland area that is scattered with a couple acorn producing, mature valley oak (*Quercus lobata*) trees. A few juvenile valley oak trees occur near one of the mature oaks, and the large oak located in the middle of the site is dead possibly due to fluctuations in the water table depth (Ferren, pers. comm., 2001).

A windrow of blue gum eucalyptus (*Eucalyptus globules*) is located along a small drainage ditch entering from the Krotona Hills area. The windrow connects with the eucalyptus grove, which contains seven different species. The riparian vegetation along the drainage ditch entering from Maricopa Highway consists of native live oaks (*Quercus agrifolia*), sedges, rushes and cattails as well as non-native plants. This drain flows through the eucalyptus grove and connects with the Happy Valley Drain before leaving the site. The Happy Valley Drain is devoid of vegetation, which is due to herbicide treatments applied by Ventura County Flood Control.

West of the Happy Valley Drain, the grassland is dominated by *Phalaris paradoxa* and *Hordeum murinum*, species tolerant of standing water. Although these species are non-native, they are considered wetland indicator species (Reed, 1988). At the west end of the property, non-native grasses from the genus *Bromus*, *Avena* and *Lolium* dominate, with ornamentals scattered throughout. Other exotic species on the site include a patch of castor bean located near the eucalyptus windrow, exotic acacia and pepper trees scattered near the eucalyptus grove and several Monterey pines (*Pinus radiata*) south of the church near the entrance of the Happy Valley Drain

2.3.2 Wildlife

Survey Description

Preliminary wildlife surveys of the Preserve were conducted to determine dominant species composition. Further analysis of onsite wildlife is recommended to provide a better baseline on which to determine the degree of wildlife enhancement attributed to restoration actions. A survey was conducted in June 2000 by systematically walking the site. At approximately every 50 meters, the researcher paused (5 to 10 minutes) to observe and record wildlife within view or earshot. A limited aquatic invertebrate survey was also conducted in February 2001. The site is primarily composed of generalist species characteristic of the Ojai Valley. We observed 26 bird species, 2 mammals, 2 amphibians, 1 reptile species and numerous aquatic insects and invertebrates (Table 2.8).

Insect and Other Invertebrate Life

Terrestrial:
Monarch Butterflies *(Danaus plexippus)* were observed in and around the eucalyptus grove. An unidentified species of checkerspot butterfly was observed in the grassland of the Besant Meadows area.

Aquatic:
Numerous aquatic invertebrates were observed in the Happy Valley Drain and the drainage ditch. Recent rains had formed small areas of ponded water on the grassland area of the Palmer property, which contained the freshwater copepod, Cyclops. This provides strong evidence that this area is of vernal pool or ephemeral marsh habitat (Ferren, pers. comm., 2001). A tan colored Ostracod species was also found on an algae mat in the Happy Valley Drain.

Numerous dragonfly larvae and three adults species *(Anisoptera sp)*, crane fly (family Tipulidae), and left handed pond snails (family Physidae) were observed in the Happy Valley Drain. Since both aquatic insect larvae are considered to be moderately intolerant of pollution (Allen, 1995), inferences can be made concerning general water quality. Abundant periphyton was also observed in this same area. The drainage ditch, which is completely shaded by cattails and eucalyptus trees, was observed to contain an introduced crayfish species, (*Procambarus clarkii)*, and left handed pond snails.

Vertebrates

Mammals:
Gopher and western ground squirrel populations reside on the Preserve, as evidenced by their soil mounds that dominate the Besant Meadow area. There was no direct evidence of any other mammal species residing permanently on the site.

Birds:
The Preserve's habitat diversity provides for a varied bird life. Flocks of Brewer's blackbird *(Euphagus cyanocephalus)* and a few Eurasian starlings (*Sturnus vulgares)* were observed during the June survey. Domestic pigeons (rock dove, *Columba livia)* were seen flying over in flocks but were not observed using the site. House finches (*Carpodacus mexicanus)* were abundant. Characteristic grassland species such as western meadowlark *(Sturnella neglecta)*, Lesser goldfinch and western bluebird (*Sialia mexicana)* were also observed. Oak woodland species such as the acorn woodpecker *(Melanerpes formicivorus)* were abundant on and around the Valley Oak (*Quercus lobata)* and coast live oak (*Quercus agrifolia)* trees. Wetland species present included red-winged blackbirds (*Agelaius phoeniceus)* and common yellowthroat *(Geothlypis trichas),* which were observed nesting in the reed growth of the drainage ditch. Raptors were quite numerous. A resident pair of red-tailed hawks *(Buteo jamaicensis)*, with a fledgling, was seen flying over the site and perching on the large Valley oak trees. Red shoulder hawks *(Buteo lineatus*), turkey vultures *(Cathartes aura)*, American kestrels *(Falco sparvarious)* and a Cooper's hawk (*Accipiter cooperii*) were also seen.

Species only associated with introduced vegetation were also observed. Hooded orioles *(Icterus cucullatus)* were feeding and nesting almost exclusively in the eucalyptus grove; western kingbirds (*Tyrannus vociferans)* and American robin *(Turdus migratorius)* also utilized the tall eucalypti for nesting. Two spice finches (*Lonchura punctulata)* were observed coming to drink from the Happy Valley Drain.

Herpetofauna:
Amphibian life consisted of color morphs of both the Pacific tree frog and the western toad. During the June survey, the Happy Valley Drain contained very dense aggregations of metamorphosing tadpoles of both species. Frog and toadlets were also abundant along the bank. Several western fence lizards were seen within the sloughed bark and branch debris of the eucalyptus grove floor.

HABITAT ENHANCEMENT AND REVEGETATION PLAN

Understanding and reacting to dynamic ecological and social environments at a restoration site determines its level of success. The challenge of designing a restoration plan is in understanding the complexity of the restoration process and addressing its uncertainties. In order to make appropriate management decisions, the restoration plan draws upon existing work and relevant literature to develop sound and applicable management approaches that can be used to guide the restoration process.

The following sections describe restoration plans for Valley oak savanna, fresh water marsh, vernal pool and riparian habitats. The restoration plans developed include a description of reference conditions, goals and objectives, conceptual model, and instructions for implementing and monitoring the management actions.

3.0 Oak Savanna Restoration and Management Plan

Non-native annuals currently dominate the Preserve with a few Valley oaks growing in the 14-hectare area slated for oak savanna restoration. Oak restoration usually involves "planting trees or acorns; eradicating non-native vegetation and reintroducing native plant species; limiting or excluding livestock access; and conducting carefully prescribed burns" (Pavlik et al., 1991).

3.1 Description of Oak Savanna Habitat

Oak savanna habitat today is composed of scattered oaks (*Quercus lobata* on our site) and other tree species, with about 30% crown cover, throughout a now Mediterranean dominated grassland understory (Griffin, 1976). Historically, valley oak savannas consisted of various aged valley oak trees with an understory of native perennial bunchgrasses and a diversity native annual grasses and forbs (Pavlik et al., 1991, Harker et al., 1999). Valley oak savanna occurs at 100-1500 m elevations occurring on lowland or alluvial bottoms throughout the hills and valleys of California (Griffin, 1976). Trees and understory vegetation grow in deep, well-drained soil typical of valley floors and floodplains. Soils such as silty loam, clay loam and sandy clay loam are typical textural classes that support valley oak trees.

Valley oak (*Quercus lobata*) is a monoecious, deciduous tree that can live 400-500 years. The crowns are broad and very branched. *Quercus lobata* develop a taproot to capture ground water, which can grow as deep as 25 m. Valley oak trees provide habitat and resources for nesting birds and cavity-storing birds and mammals (Johnson and Tietje, 2000). Scrub jay and ground squirrels are important acorn dispersers that cache acorns into the ground that may be left to germinate. Remaining cached acorns, not consumed by the jays or ground squirrels, are eaten by insects or other animals, and the rest are left to germinate. Scrub jays can bury up to 7,000 acorns a year in the ground, few of which are retrieved and later eaten by the jay (Johnson and Tietje, 2000).

There is debate in the current literature about the vegetative composition of oak savanna understory (Hamilton, 1997). The three main hypotheses include dominance by perennial grasses, dominance by sclerophyllous shrubs (in areas with 25-76 cm annual rainfall) and dominance by annual plants (Hamilton, 1997). Most scientists however believe that native perennial bunchgrasses in the genera *Nasella pulchra* dominated the community (about 60% cover) with other native perennials, forbs, geophytes and shrubs filling in the matrices in between (Keeley, 1989, Stromberg, pers. comm., 2001, Wilken, pers. comm., 2001). Schoenherr (1992) noted that plants from the genera *Nasella* and *Poa* were the primary native component of the valley grassland community and form the under story in oak/foothill woodlands of the California Floristic Province.

Fire is a natural disturbance regime that commonly swept through native grassland and oak savanna habitats (Wilken, pers. comm., 2001). It is hypothesized that lightening strikes of tall, old trees led to the annual burning of valley oak woodlands. These fires burned hot and quick, reducing the above ground biomass and removing non-native annuals, allowing native perennials to grow within three years (Brown, 1985). Fires are important for regeneration of perennial grassland species and keeping the open structure of oak savanna (Wilken, pers. comm., 2001). In addition, fire can release nutrients into the topsoil, making them available to plants.

3.1.1 Recent History and Threats to Valley Oak Habitat

As early as the 1700's, European annual grasses in the genera *Avena* (wild oat), *Bromus* (brome grass) and *Hordeum* (barley) tolerant of California's Mediterranean climate spread across the state and occupied bare soil areas between the perennial native grasses (Schoenherr, 1992). Valley oak savannas are typically found on relatively flat, fertile soils that were converted to agriculture and pastures upon the arrival of Europeans (Brown, 1985). Intensive grazing and drought conditions existed during the time of non-native annual introduction; conditions native perennial grasses had not evolved in, which further increased the spread of these weeds (Keeley, 1989). Non-native annuals may be more prolific here than in the Mediterranean Basin because of the arid climate (Brown, 1985). Most of these exotic weed species were accidentally introduced to California in the hair, digestive tracts and food of domesticated animals brought over by the European settlers (Schoenherr, 1992).

The invasion of annual grasses into the native perennial grasslands is attributed to several mechanisms: (1) similar phenologies in response to comparable climates in California and the Mediterranean, (2) fairly poor seedling establishment of native perennial grasses in the presence of annual grass seedlings, (3) long-duration, intensive and continuous grazing by livestock, and (4) changes in fire regime associated with cessation of Native American burning practices (Stromberg and Griffin, 1996). Today, disturbance of grassland ecosystems by grazing, agriculture and high densities of fossorial mammals enhances the spread and persistence of exotic species.

3.1.2 Current range and Conservation status

Valley Oak, *Quercus lobata*, is endemic to California, and was historically widespread throughout riparian forests, valleys, and foothills, ranging from the Santa Monica Mountains to the northern end of the Sacramento Valley. Today, the Valley oak range has been reduced to a small remnant of its former population due to agricultural pressure and urban development. Drying of lowland habitats through damming of waterways and chopping down oaks for firewood and grazing land dramatically decreased the cover of oak species (Schoenherr, 1992). The decline of Valley oak has been particularly severe in alluvial plain environments, where development pressures have been extreme. Successful regeneration of oaks has been significantly altered by human activities, and during the past decade, Valley oak regeneration has been "almost nonexistent" (Adams et al., 1997). Unsuccessful recruitment is mainly due to seedling and sapling mortality and the presence of annuals that continue to grow until all available soil water is removed (Adams et al., 1997). The seedling stage is the most vulnerable life stage for oaks, when they are susceptible to changes in grass species (native perennials to exotic annuals), high populations of small rodents, livestock grazing, fire suppression and other changes in the savanna (Johnson and Tietje, 2000).

Perennial grasslands that form the understory of oak savannas originally covered 20-25% of California (Brown, 1985). Today, only about 0.1% of these native communities remain (Keeley, 1989). As with the Valley oaks, grasslands are found on relatively flat, often fertile soils suitable for agriculture. Only 10% of the current distribution of Valley oak and native grassland habitat are currently found on lands with formal protection (Davis et al., 1998).

3.2 Reference Conditions

As stated earlier, the composition of Valley oak understory is unknown. Other native perennial grass species characteristic of oak savanna habitat include *Hordeum branchyantherum*, *Elymus glaucus* (Stromberg, pers. comm., 2001), *Nasella cernua*, *Nasella lepida* and *Poa secunda* (Harker et al., 1999). In addition, forbs and annual grasses were also components of the valley grassland (Brown, 1985). Forbs including Indian paintbrush, owl's clover, brodiaeas, lupines, gilias and nemophilas, and yellow-flowered tarweed (Brown, 1985). See Table 3.1 for proposed revegetation list of oak understory species and associate species.

Many areas now delineated, as grasslands may have once been chaparral, and through grazing and frequent burning underwent a type conversion to annual grasslands. Many grassland restorations assume all annual grasslands were once native perennial grasslands. A good determination of native perennial grasslands is deep soils (1-2m thick) devoid of rocks. If rocks are present, the area probably was not native grassland.

3.3 Goals and Objectives

Goal 1: Increase the cover of native perennial grasses, annual vegetation and shrubs characteristic of Valley oak under story.

> **Objective 1:** Reduce the cover of non-native annual grasses through the use of different weed management techniques.
>
> **Objective 2:** Reintroduce native grassland and oak understory species.
>
> **Objective 3:** Reintroduce fire as a natural disturbance regime.

Goal 2: Increase the number of Valley oak trees, diversify their age distribution and enhance natural regeneration.

Objective 1: Plant acorns and/or saplings.

Objective 2: Reduce non-native annuals.

Objective 3: Reduce herbivory by fossorial mammals.

Objective 4: Increase the number of native acorn dispersers.

3.4 Conceptual Model

The conceptual model includes stressors acting on the oak savanna ecosystem, effects of the stressors and possible management actions to reduce effects of the stressors in order to reach target conditions (Figure 1.3). The target conditions for the oak savanna are 1) to increase the abundance of native plant species characteristic of California valley grasslands and oak understory and 2) to enhance valley oak seedling establishment. Additional stressors affecting the site such as tilling and mowing no longer occur or cannot be reduced.

Natural regeneration of oaks on the site as well as throughout California has not been occurring for many years. This problem may be due to various stressors, such as presence of non-native annual grasses, fire suppression and high densities of native fossorial mammals leading to a decline in age distribution and cover of *Quercus lobata* trees throughout California. Valley grasslands making up the understory of oak savannas have been displaced mainly as a result of grazing by domesticated animals, the introduction of exotic annual weeds and increased densities of fossorial mammals. We constructed a conceptual model to identify stressors before planning for oak savanna restoration on the Preserve.

Before creating the conceptual model, the following assumptions were made about the system:

1) The depth of the water table at the well located on the site is 14 m. Since oak taproot can grow to be 24 m long, we assume valley oak establishment can be successful if the main stressors are removed or reduced.
2) Non-native weeds can be reduced significantly to provide for the reestablishment of grassland species and Valley oak trees.
3) Densities of fossorial mammals are higher than historic onsite abundances due to the presence of annual exotic grasses and lack of native predators. This can lead to high herbivory of oaks and acorns and their soil disturbance may enhance non-native annual grass recruitment. Although ground squirrels consume acorns and oak seedlings, they also disperse acorns and may be helpful in regenerating oaks on site.

Past and current land use at the Preserve
Tilling was conducted across the site for fire control measures until 1996. Tilling causes soil disturbance and facilitates the invasion/expansion of non-native annual species that presently dominate the oak savanna onsite. Tilling kills seedlings, germinating acorns and reduces native grassland species.

In addition to tilling, the site is mowed once or twice a year for fire control and to provide access for emergency vehicles on the site. This action likely killed Valley oak seedlings. Although mowing is a necessary action, management actions such as flagging out existing seedlings, restricting mowing from the understory of existing oaks, and planting Valley oaks and other trees away from mowed areas may increase the natural regeneration on the site.

3.5 Development of Management Plan

Grassland restoration is in its infancy and many unknowns and uncertainties exist regarding the best way to plant and maintain native grassland species over time. Several experiments are currently underway throughout the state to answer some of these questions. Some of the key questions in grassland restoration include:

- Should non-native annuals be removed prior to planting?
- Can fire, tilling or other methods be used to reduce exotics before planting native grassland species?
- Once the perennials are established, what is the best method of non-native annual weed control? Methods such as fire and hand pulling may be useful tools to use.
- What is the best way to plant native perennial bunchgrasses? Broadcast seeding, direct seeding or planting plugs
- What proportions of perennial and annual grasses and forbs should be in the seed mix? Different proportion can be used depending on soil type and location.
- Should perennial grasses and annual/perennial forbs be planted at the same time or should the forbs be planted after the perennial grasses are established? Perennial grasses could be established and then drill or broadcast seeded with forbs or perennial grasses, and forbs seeds could be planted at the same time using various seeding or planting techniques.
- What is the best method for planting Valley oaks on the site? Direct seeding of acorns or planting seedlings?

Due to the uncertainty and lack of knowledge in native grassland restoration, onsite experiments will be instrumental in determining the best method before developing a plan to restore the entire site. Small-scale experimentation also provides educational opportunities for the students of Ojai. Students can assist in monitoring the experiments and see science at work. Native perennial grasses grown in the experimental plots can also provide some of the seeds source for planting over the entire site (Kline, 1997). Onsite monoculture plots of native perennials can be another source of seeds for the Preserve.

3.5.1 Experimental approach

The experimental approach for the oak savanna habitat onsite will mainly focus on the best method for reestablishment of native perennial bunchgrasses. A sample of an experiment was designed to answer two important questions in grassland restoration. This experiment is provided to guide Preserve managers with onsite grassland restoration.

Hypothesis 1: Establishment of native perennial grasses is greater when plugs are used rather than seeds

Planting plugs is one method of reestablishing native perennial grasses and is useful when revegetating slopes or areas that cannot be easily disked (Stromberg, pers. comm., 2001). Plugs are very successful, 90% survivorship with 2.5 cm plug, however they are relatively expensive and labor intensive (Stromberg, pers. comm., 2001). Another method for reestablishing native perennial grasses is planting seeds using broadcast or direct seeding methods. Both of these techniques have been successful (Stromberg, pers. comm., 2001 and Dremann, pers. comm., 2001) and are relatively inexpensive and can be applied relatively quickly to the entire site.

Hypothesis 2: Native perennial grasses need to be established before planting annual grasses and forbs.

Native annual forbs may outcompete perennial grasses at the seedling stage and may inhibit the growth of perennial grasses (Stromberg, pers. comm., 2001). However, there is no hard evidence regarding the amount of impact or the effect of simultaneously planting both native perennial grasses and annual forbs on the composition and structure of vegetation. This hypothesis will be tested using the revegetation methods in Hypothesis 1.

Experimental Design

A latin square design (Figure 3.1) is useful for conducting an experiment with four different treatments (Underwood, 1997). Latin square design spreads four replicates of four different treatments across a grid in which no treatment is repeated across a single row (Underwood, 1997). We recommend size of the latin square to be 9 by 9 m with each treatment square measuring 1 m^2 and a buffer of 1 m around all treatments and eight latin squares scattered across the site to capture environmental variability in the soil substrate (Figure 3.2).

The four treatments for the seeding experiment include:

A_1 = Planting plugs and annual forbs simultaneously

A_2 = Seeding with perennial grasses and annual forbs simultaneously

A_3 = Planting plugs and planting annual forbs one year later

A_4 = Seeding with perennial grasses and planting annual forbs one year later

Methods

The current trend in grassland restoration involves reducing non-native annual grasses before planting and seeding perennials into the ground (Stromberg, pers. comm., 2001). Although eradication would be ideal, it is virtually impossible to remove all of the weeds from a large area (Bossard et al., 2000). Because many weed seeds do not have dormancy, there is "relatively little seed carry-over from year to year"(Keeley, 1989). This means that a few years of weed control before planting can greatly reduce the abundance of exotics on the site. Once natives are established, they may also act as a weed management tool by out-competing non-natives and preventing their growth and reinvasion (Bossard et al., 2000).

Many techniques exist to control non-native annuals such as tilling, fire and soil solarization (Stromberg, pers. comm., 2001 and Bossard et al., 2000). Based on current research, the inability to burn the entire site at once and the amount of labor/cost of soil solarization, we are suggesting tilling and harrowing the site for 2 years to exhaust the non-native annual seed bank. Although tilling can disturb the soil and increase the potential for weed invasion on a site, it can also be used as a technique to reduce existing exotic vegetation. Mark Stromberg (pers. comm., 2001) developed a method of tilling that has been highly successful in removing exotic annual grasses at the UC Hastings Reserve. This method involves tilling and harrowing the soil many times over several growing seasons, which greatly reduces the non-native soil seed bank. Using tractors to till and harrow the entire site may be less time consuming than the other suggested methods.

Non-native annual grass reduction

The tilling/harrow method takes approximately 2 years for successful non-native species reduction to be seen (Stromberg, pers. comm., 2001). The entire oak restoration area at the Preserve should not be tilled until a planting method is determined which will be after results of the experiment are analyzed. If the entire site is tilled and left fallow, soil may be lost to erosion and weeds will reestablish. For the experiment, the tilling harrow method can be applied to the experimental plots within the oak savanna restoration area. A small tractor can be used to till and harrow the areas delineated as experimental plots. In addition to tilling the 81 m^2 experimental plots, 5 m around each block should be mowed. This will reduce the seed rain coming into the plots and prevent reestablishment of non-native annuals. A 50 m measuring tape, stakes and flags can be used to delineate the different blocks within the latin square before planting.

Year 1: In year one, till the field in the winter, after the rains and before the grasses set seed. Then, harrow the field every three to four weeks into May. Harrowing uproots the plants and by doing this every three to four weeks, the plants are unable to produce seed.

Year 2: In year two, repeat the actions from the previous year, till in winter and harrow every three to four weeks into May.

Year 3: By year three, the seed bank should be exhausted after two years of removing growth and not allowing seed production or reestablishment. In addition to removing non-native grasses, tilling and harrowing also decreases the amount of gophers by removing their primary food source. Depending on rainfall, planting can begin this year, probably in December.

Seed collection and plug propagation

Seeds should be collected from relict stands that are relatively close to the Preserve to ensure local genotypes are represented. When collecting seeds, only a small amount of seed should be collected from each plant and collections should be made from many plants to ensure greater genetic diversity. It is also important to leave a proportion of seeds on each plant to maintain or increase the plant's population (Kline, 1997). Plugs should be purchased from a grower that collects local seeds or grows plugs from local seed sources. Plugs can be container grown or planted bare root. Growing Solutions, a non-profit horticultural restoration organization in Santa Barbara, concentrates its restoration efforts on collecting seeds and cuttings from onsite or local sources. This group will be a good source of information regarding propagation of native plants for the Preserve.

Seeding and planting plugs

Once the weeds are reduced and the blocks marked, the different seed mixes can be planted. Because the different treatment plots are small (1 m^2), we recommend using broadcast seeding either by hand or hand held seeder. Seeds should be distributed at a density of 50-100 seeds per 45 cm^2 (Stromberg, pers. comm., 2001). Seed mixes should include a diverse mix of perennial grasses, annual grasses and forbs (See Table 3.1 for proposed list of understory species). The soil surface should be raked to bury the seeds below the soil surface after the seeds are spread, ensuring that seeds are not moved to one end of the plot.

Native perennials should be planted at a density of about 12-20 plants per 1 m^2 (Dremann, pers. comm., 2001). At the scale of the treatment plots, plugs can be planted by hand. When planting plugs, a small amount of organic fertilizer can be placed in the hole before planting the plug (Stromberg, pers. comm., 2001). Depending upon rainfall, supplemental watering may be necessary after planting.

Experimental monitoring

Monitoring experiments is crucial to test the proposed hypotheses and to determine which treatment is most successful at restoring native perennial grass composition. Presence and percent cover of perennial grasses and forbs are important aspects to measure. Presence is determined by monitoring treatments and noting which species are present or absent. Percent cover can be measured using the point intercept method. This method involves placing a pin frame along a transect and noting the number of times a pin hits vegetation (Elzinga et al., 1997). For the grassland experiment, the pin frame (1 m long with ten pins spaced every 10 cm) should be placed every ten centimeters within each treatment. The plant species and number of hits for each species should be recorded as well as recording the number of times a pin hits open ground.

Statistical analysis
After collecting data through monitoring, analysis of results will be instrumental in choosing management actions to prescribe over the site. Before analyzing data, it is useful to develop graphical representations of the results to detect trends (Elzinga et al., 1997).

The data collected from the point intercept method can be easily converted to a percentage (Elzinga et al., 1997):

$$\% \text{ cover} = \text{number of hits}/\text{total number of points}$$

For example, if *Nasella pulchra* in a treatment has 67 hits out of 100 total points, percent cover within that treatment would be 67%. This calculation can be conducted for all species noted within the experiment. Percent cover for individual treatments can be averaged across replicates to determine average percent cover for each species.

After determining percent cover within all experimental plots, results can be compared to proposed vegetative composition of the grassland. Cover of perennial grasses should range from 60-80% cover (Keeley, 1989; Stromberg, pers. comm., 2001; Wilken, pers. comm., 2001; Dremann, pers. comm., 2001) with *Nasella pulchra* as the dominant species (>50% cover). Forbs and annual grasses should cover at least 20% (Stromberg, pers. comm., 2001) and cover of non-native weeds should be no more than 20%.

An assumption of the latin square experiment is that no interaction between the treatments occurs. However, due to the close proximity of the treatments, there may be some interaction. Differences of the various treatments can be detected using an F-ratio of mean square A / mean square error (Underwood, 1997).

3.6 Large Scale Implementation
Areas zoned for oak savanna restoration were determined based on a preliminary topographic survey of the site, soil type and present vegetation composition. The areas set aside for grassland and oak savanna revegetation are upland areas that are currently composed of annual grasses typical of mesic conditions. Figure 3.3 shows the proposed future placement of the oak savanna habitat. Upon completion of a more detailed baseline inventory, survey of the topography and onsite experimentation, these areas may change slightly.

Perennials and oaks can be planted throughout the designated oak savanna habitat after significant reduction of non-native annual grasses. The method for planting perennial grasses will be based upon results from the onsite experiment explained above. Valley oaks should be planted a few years after successful establishment of understory vegetation.

3.6.1 Oak understory species

Native grasses and forbs

The method for reestablishing native grasses and forbs will be dependent upon the results of the onsite experiment. Large-scale implementation will be similar to the methods described in the experiment. If planting plugs is chosen for site wide implementation, a planting machine can be used to plant the plugs into the soil. If seeding is more successful, the method of implementation will be scaled up from the experiment. Seeds will either be planted using a direct seeding machine or a mechanical seed spreader. If broadcast seeding is used, seeds should be mixed with mm-square cubes of vermiculite, and once distributed, a chain and pipe or slow ring roller should be dragged over the site to compact the seeds into the ground (Stromberg, pers. comm., 2001).

Depending on experimental results, forbs will either be included in the seed mix, planted immediately after native perennial plugs or a year or two following perennial grass establishment. Forbs can be broadcast seeded by hand across the site or drill seeded among the perennial grasses (Stromberg, pers. comm., 2001).

Shrubs

After perennial and annual grass and forbs establishment, native shrubs can be planted. The density and cover of shrubs in native California oak savannas is under debate, therefore more research needs to be done prior to planting. However, the methods we suggest can be used. Shrubs should be grown in a greenhouse and then planted directly into the ground from 1-gallon pots. Planting involves digging a hole approximately the same depth and width of the pot, removing the plant from the pot, placing the plant in the ground and refilling the hole with excavated dirt. Once planted, above ground cages to protect the plants from herbivory by rabbits and rodents may have to be installed.

3.6.2 Planting Valley oak trees

There are two primary methods to plant oak trees, direct seeding of acorns and planting seedlings grown in a greenhouse. We recommend direct seeding acorns versus planting seedlings grown in a greenhouse. Direct seeding is advantageous for taproot growth, reduces maintenance by not having to add supplemental water and is more cost effective. If the taproot is exposed to air, it never regenerates and seedling survivorship will decrease (Motz, 1997). Another onsite experiment may include trying these two methods and monitoring for several years to determine which method is more successful. Acorns for the site should be collected from trees onsite or trees close to the site, in the Ojai Valley. It is important to collect from local trees to keep genetic integrity and because local stocks will be more adapted to the local conditions of the area.

Acorn collection
To ensure that the acorns are ripe, they should be collected during the fall, when they fall to the ground or release easily from the cap. After collection, acorns should be soaked in water for a few minutes. "Good" acorns are denser than water and sink to the bottom whereas "bad" acorns often have insect holes, are lighter and will float to the surface (Tyler, pers. comm., 2000). Once the "bad" acorns are discarded, remaining acorns should be laid out to dry, placed in a bag with vermiculite and stored in cold storage between 1-4 ^{o}C to reduce metabolic activity and prevent germination (Adams et al., 1997).

Direct seeding
The taproot of an oak grows to a depth of 0.3-0.6 m before the shoot reaches the surface (Tyler, pers. comm., 2000). Acorns can be planted directly into the ground, about 2.5-5 cm below the surface (Tyler, pers. comm., 2000). Planting can occur as early as November through early March, depending on the amount and timing of rainfall (McCreary, 1995). Holes for acorn planting can be dug using a shovel, hand trowel, auger or other tool. The holes should be several inches deeper than the planting depth and refilled with soil. This acts to loosen up the soil, making it easier for the acorn root to grow (McCreary, 1995). Two to four acorns can be planted per hole, laid horizontally on the soil surface. Once planted, the acorns are covered with excess soils and tapped down. If the acorns are already germinating and the tip of the root is visible, a small indentation should be made in the soil to prevent damage to the emergent root.

Small scale exclusion with underground and above ground cages
Regardless of the planting method (acorns or seedlings), it is important to protect the growing oak seedlings from gophers, ground squirrels, and insects such as grasshoppers (Adams et al., 1997). Stromberg and Griffin (1996) found that Valley oak seedlings are susceptible to herbivory by gophers until the base diameter is 5 cm or greater. Excluding gophers from plantings by installing cages or total exclusion from larger areas are two methods to accomplish this.

Small underground cages can be installed during the planting phase to prevent gophers and ground squirrels from consuming seedlings and acorns. Cages made of hardware cloth (1.25 x 1.25 cm mesh x 1 m high) should be approximately 15 cm in diameter and 1 m long. The tubes should be buried halfway underground, filled in with dirt and then planted with either acorns or seedlings. A lid made of aviary wire (mesh = 1.25 x 2.5 cm) can be fastened on the top to provide protection from other small mammals such as mice and voles (Tyler, pers. comm., 2000). Damage from grasshoppers can also be reduced by these cages and by keeping the planting site clear of weeds (Adams et al., 1997).

Non-native species removal around newly planted oaks
Adams et al. (1997) concluded that weed competition may be the biggest threat facing Valley oak acorns and planted seedlings. Mulch mats have not been an effective strategy for controlling weeds around planted oaks because they lead to increases in

rodent damage by providing cover (Adams et al., 1997). Manual techniques such as hand weeding, mowing and tilling may be successful techniques to apply prior to planting. Weeds should be removed in a 1-1.3 m diameter circle around the planting and maintained weed free for at least one growing season (Adams et al., 1997).

3.7 Monitoring

Preliminary baseline surveys should be conducted prior to revegetation activities to assist in determining the success of the project. BORG conducted a baseline inventory of the plant and animal species, however this was done in the summer. Many annual species are difficult to key out due to lack of flowers, and above ground plant biomass is mostly dry and dead. Plant surveys should be conducted in late winter to early spring depending upon precipitation patterns to get a better idea of the species that are present. In addition to conducting vegetation inventories, quantitative sampling should also be conducted to track changes (increase or decrease) and to determine densities (Kline, 1997).

3.7.1 Success criteria

The success criteria for the oak savanna help to guide and determine the type of monitoring that should be conducted onsite. Success criteria were determined based on goals, objectives and research of oak savanna habitats.

Establish a self-regenerating California grassland community at the Preserve that resists invasion of weeds

- Native grasses are healthy and producing seeds
- 60%-80% cover of native perennial grasses and annual forbs in 5 years
- No more than 30% cover of non-native annual species
- Increase in native insect and bird diversity

Enhance Valley oak establishment

- Increase crown cover of acorn producing Valley oaks, with a goal of 30% for the duration of the project
- Planted seedlings be a minimum of 2.5 cm in basal diameter and a minimum of 1 m in 5 years
- Increase bird use of Valley oak trees
- Reestablishment of Valley oak seedlings in the grassland without the aid of planting

Monitoring should be conducted on a regular basis throughout the length of the project. Results obtained from monitoring can be statistically analyzed to ascertain if the success criteria have been met. If restoration of the oak savanna is not leading toward the desired goals and success criteria are not being met, changes can be made to the various steps of the management plan.

3.7.2 Grassland species

In the oak savanna, presence/absence, frequency and percent cover are important vegetative components to monitor. These criteria can be monitored using a quadrat and pin frame along transect lines in the grassland. The quadrat method is subjective when determining percent cover and should only be utilized by trained botanists or someone that will be conducting the monitoring year after year. As long as percent cover values are applied consistently, results can be repeatable and helpful (Kline, 1997). A more objective method for determining percent cover is the pin frame method. This method is an appropriate monitoring technique when various individuals or students will be conducting the monitoring.

3.7.2 Valley oak trees

The cover and abundance of Valley oak trees is important to monitor to determine if success criteria of 30% cover of trees is reached. This may take a hundred years before the goal is achieved. Oak trees grow relatively slow and are monitored best using aerial photos of the site. Such photos provide a birds-eye view of the site, allowing the monitoring team to count individual trees and determine total cover of Valley oaks by measuring the area of crown cover. Onsite observations to ascertain whether the oaks are producing acorns and the overall viability of the trees are also important. An annual count of the number of new seedlings and assessment of survivorship can be used to indicate whether the trees are successfully regenerating.

3.7.4 Birds and insects

In addition, grassland bird and insect surveys will determine the success of the oak savanna area at providing habitat for native animals. Bird surveys include going out to the site at various times of the year and marking the presence of species seen and whether they are nesting, feeding or passing through. Insect nets and pits can be used to collect insects in the grassland. Collected insects can be taken back to a lab or classroom for identification. Monitoring insect and bird diversity provide good educational opportunities for Nordhoff High School students.

3.8 Maintenance

After planting grasses and oaks, maintenance of plantings will be required throughout the length of the project. Maintenance for the oak savanna includes controlling non-native annual species, reseeding or supplemental planting, supplemental watering and gopher cage repair.

Weeding by hand or controlled burns can control weeds. Hand weeding is costly, about $1200 per acre, and very labor intensive. Prescribed burns are much cheaper, around $80 per acre. Both of these methods can be used on the experimental plots after native grasses are established to determine the efficacy for reducing non-native annuals and maintaining structural integrity of the oak savanna. We have spoken with the Fire Chief from the Ojai Fire Department regarding the reintroduction of fire.

Although the entire site cannot be burned at once, large strips can be burned until the whole site is covered.

4.0 VERNAL POOL RESTORATION AND MANAGEMENT PLAN

We recommend that the OVLC create a vernal pool habitat at the preserve using an adaptive management approach. The following is a description of vernal pools, reasons for restoring them onsite, an experimental approach to vernal pool creation, procedures and guidelines for implementation, a monitoring and management program, and cost analysis.

4.1 Description of Vernal Pools

Vernal pools are rare habitats found throughout California and other Mediterranean climates (Keeley and Zedler, 1998). They are "Precipitation-filled seasonal wetlands inundated during periods when temperature is sufficient for plant growth, followed by a brief waterlogged-terrestrial stage and culminating in extreme desiccating soil conditions of extended duration" (Keeley and Zedler, 1998). Pools form during the winter rains in shallow depressions where the soil is overlying an impervious substrate that prevents downward percolation, resulting in a perched water table. They support a diversity of rare and endemic flora, aquatic invertebrates, and amphibians that are adapted to this habitat. Vernal pools are defined by the presence of indicator species, such as *Pilularia americana* (pillwort) (Ferren, pers. comm., 2001).

Natural California vernal pools contain 15-25 plant species, including cosmopolitan aquatic taxa found worldwide and vernal pool specialists from western North America (Keeley and Zedler, 1998). Vernal pool plants do not have much competition because upland species cannot survive during the inundation period and most freshwater marsh species cannot last the extended dry period (Keeley and Zedler, 1998). During the waterlogged-terrestrial stage, most species undergo a metamorphosis in which cylindrical foliage is replaced with laminate foliage (Keeley and Zedler, 1998). Conspicuous rings of flowers form during the spring when pools dry, providing exceptional recreational value (Faber, 1982).

Invertebrates adapted to vernal pool habitat generally include Branchiopoda, Anostraca, Conchostraca, Notostraca, and Ostracods. The invertebrates grow and reproduce during the aquatic phase and persist in the soil during the drought stage (Hubbard, 2000).

In addition, vernal pools serve as feeding grounds for many birds and bees. They provide feeding, nesting, and resting sites for many avian species such as ducks, geese, herons, and egrets (Hubbard, 2000). Although it is not completely understood, birds serve to disperse vernal pool seeds to maintain the genetic health of vernal pools. This function is critical in urban areas in which pool habitat is fragmented, because the probability of seed dispersal by wind or water is lower (Clark, 1993). Vernal pool flowers provide an ecosystem service by serving as a host for pollinators, such as native solitary bees (Thorp and Leong, 1996).

4.2 Justification for Vernal Pool Restoration

Due to the high amount of endemism and the restricted distribution of vernal pools, they are of high conservation priority. A report for the California Senate Committee on Natural Resources and Wildlife concluded that, " Vernal pools of all types, and the species that depend on them, are among the most threatened of all the State's natural diversity" (Bauder et al., 1997). Creating vernal pools at the Preserve will increase the conservation value of the site and contribute to vernal pool preservation.

The location of the Preserve falls within the extreme eastern portion of the Santa Barbara Region vernal pools (Figure 4.1) (Keeler-Wolf et al., 1998). Most of the pools in the region vary from fault sag-ponds to coastal marine terrace pools (Keeler-Wolf et al., 1998). Agriculture, military, university facilities, and general urban development in the Santa Barbara Region have destroyed at least 90 % of vernal pools (Ferren et al., 1998). Few vernal pools are known to exist in Ojai. These include Mirror Lake and Happy Valley School vernal pool (Figure 4.2). Mirror Lake has been severely altered by development, so many of its historic and rare vernal pool plant species have been lost (Ferren, pers. comm., 2001). This restoration project provides a unique opportunity to potentially support many vernal pool endemics that were lost from Mirror Lake.

There is no historic evidence available to support that a natural vernal pool once existed at the Preserve. However, vernal pools are characteristic of the region and most of the criteria that define a vernal pool are present in the wetland area west of the Happy Valley Drain. This area has clay soils (Figure 2.10) and an underlying impervious hard pan according to the geological data from well 10G1 (Table 2.6) and the onsite soil characterization completed in January 2001 (Appendix A). After a storm event on January 27th, 2001, we walked the area and observed ponding water with some macroinvertebrates. No remnant vernal pool plants were seen through casual observation, but the dominant vegetation type including *Hordeum marinum* and *Phalaris paradoxa* suggested a wetland habitat (Figure 2.12).

4.3 Reference Conditions

Mirror Lake and Happy Valley School vernal pools in Ojai and the Tierra Rejada vernal pool in Moorpark are recommended to serve as reference pools because they are the least degraded pools known nearest to the project site (Figure 4.2). These pools in their current condition do not represent the range of variability in a vernal pool system, so caution must be taken when using these pools as reference sites. More detailed studies of the natural variability in inundation, vegetation and aquatic invertebrate composition, and vertebrate use of these pools is necessary to determine success criteria and the composition of inocula.

The pools in the Santa Barbara Region are in a transition between northern and southern pools, so many species reach their northern and southern limits here (Keeler-

Wolf et al., 1998). It is unknown if the Preserve would support more northern, southern or some mixture of species. This makes it difficult to determine which, if any, of these reference pools are appropriate for the Preserve. The weather conditions are much drier and warmer in the Ojai area than along the coast where most of the pools in the region occur. Since annual vernal pool species are adapted to drier and warmer conditions and are more common in interior areas, while perennials are not adapted as well to these conditions and are more common along the coast, it is expected that pools in Ojai will have more annual species. Pools range from small 0.1 ha depressions to 4.86 ha in size, with some of the largest pools in the extreme edges of the region (Keeler-Wolf et al., 1998). The Tierra Rejada pool and Happy Valley School vernal pool have very similar vegetation composition (Table 4.1). These reference pools may be more closely related to the Southern California Regions, but further study is needed (Keeler-Wolf et al., 1998). The historical plants of Mirror Lake are similar to the vegetation of the Del Sol pools in Isla Vista (Table 4.1).

Although the historic vernal pool vegetation at Mirror Lake was perennial dominated, it can serve as a reference for vegetation composition, with flexibility knowing that some species may not be suited for the Preserve vernal pools (Table 3.1). Many of the species known to occur historically in Mirror Lake are uncommon to rare in Ventura County and some have nearest localities in vernal pools in Santa Barbara, San Luis Obispo or Fresno Counties, and few are found south (Ferren, pers. comm., 2001). The nearest localities of historic plants should be used as a seed source.

The Happy Valley School vernal pool is located in upper Ojai Valley on Happy Valley School grounds Northwest of the school office (Figure 4.2). It is about 1.21-1.62 ha and when full is about 1 m deep, and surrounded by annual non-native grasses. It is reported to be full most years and can remain wet up until early August. It may support the Spadefoot toad and fairy shrimp. Preliminary invertebrates sampled include clam shrimp, water boatmen, Ostracods, dragon fly nymphs, many Pacific tree frogs and toads. When drying, it is dominated by *Crypsis alopecuroides.* When full, the pool is 50% open water and 50% *Eleocharis macrostachya*, and is surrounded by *Lolium multiflorum*. *Eleocharis macrostachya* is a wetland generalist whose dominance may prevent many of the vernal pool indicator species from establishing (Gecy, 1993).

The Tierra Rejada vernal pool in Moorpark, Ventura County is a deep 1.21-hectare pool known to fill only in above average rainfall years (Figure 4.2) (Meyer, pers. comm., 2001). *Orcuttia californica, Pentachaeto lyonii,* and the Riverside fairy shrimp (*Branchineta lynchi*) are the rare species known to inhabit this pool (Meyer, pers. comm., 2001). Some macroinvertebrates found here include the seed shrimp (Ostracoda), copepods (Copepoda), water fleas (Cladocera), aquatic beetles (Dytiscdae and Hydrophylilidae), mayflies (Ephemeroptera), Odonates (dragonfly larva), Culicidae (mosquito larva), Chironomidae (midge larvae), Notonectidae (backswimmers) and Corixidae (waterboatment) (Meyer, pers. comm., 2001). This vernal pool may be the best source for inoculum, but due to the presence of rare species, it may be illegal or difficult to obtain a permit for collection of inoculum. However, collection of seeds would most likely be allowed.

4.4 Development of Management Plan

The purpose of the vernal pool creation is to provide an array of natural ecosystem functions including hydrology, native plant associations, native faunal associations, food chain support, and habitat for sensitive species characteristic of vernal pools of the Ojai Valley. Vernal pools contribute a unique and valuable habitat to the community of Ojai. They provide an additional link in a very limited vernal pool community, which will help to improve available habitat for species in the area that depend on vernal pools. This project can also serve as an example for other vernal pools in the area that are in need of restoration.

4.4.1 Goals and Objectives

Goal 1: Establish a vernal pool habitat that represents natural conditions.

Objective 1: Form pool basins similar in size to reference pools.

Objective 2: Establish native vernal pool species including plants and macroinvertebrates.

Goal 2: Provide opportunities for high native species diversity.

Objective 1: Manage invasive and weedy species.

Objective 2: Promote a high diversity of native plant species.

Goal 3: Promote the establishment of vernal pool native endemics and rare species characteristic of the Ojai Valley.

Objective 1: Promote rare plant species and aquatic invertebrates.

Objective 2: Research the possibility of introducing rare amphibian species that depend on vernal habitats.

Goal 4: Provide educational and recreational opportunities in connection with vernal pool habitats.

Objective 1: Develop vernal pool interpretive signs describing the functions of this habitat and the species involved.

Objective 2: Provide opportunities for citizens to be involved in the restoration of vernal pools.

Objective 3: Locate trails where viewing of the pools is easily accessed without threatening the habitat and its associated organisms.

4.4.2 Conceptual Model and Constraints

A self-sustaining vernal pool representing natural conditions may be possible if several human induced alterations (stressors) are removed and the appropriate basins and seed material are added. A conceptual model was developed to identify stressors, their impacts to the system, and the management actions needed to reduce or eliminate them (Figure 1.4). The constraints preventing a completely natural pool are required mosquito abatement, which can have harmful affects to some aquatic invertebrates other than mosquitoes, keeping pools within site boundaries to prevent flooding of surrounding properties, and a limited seed source derived from somewhat degraded reference pools.

4.4.3 Experimental Approach

An adaptive management approach is recommended to determine whether a self-sustaining vernal pool within the natural range of variability can be created at the Preserve. We highly recommend this approach due to the uncertainty in the success of this project. The Santa Barbara vernal pools at Del Sol may serve as a tool to guide vernal pool restoration at the Preserve, because they have been successfully restored through an ongoing 15-year-old vernal pool restoration project (Ferren, pers. comm., 2001). Ferren and Pritchette (1988) concluded from their study of vernal pools that excavation of depressions at sites with clay subsoil and adding seed bank material from existing vernal pools can result in short-term creation of new vernal pool habitat within the range of natural pools (Ferren et al., 1998). The created pools that were not inoculated showed a weaker establishment of natives during the first two years of monitoring (Ferren et al., 1998). This provides some confidence in restoring vernal pools at the Preserve, but since vernal pools do not currently exist onsite, the probability of success is less certain. The uncertainties for the Preserve vernal pool restoration lies in determining the most appropriate source of inoculum, whether they can maintain natural hydrologic cycles, and if they can support endemic species.

An experimental approach is necessary to determine which source of inoculum is most appropriate for the Preserve pools. We recommend a basic design of 6 pools, each 20 m in diameter with a maximum depth in the center of about 40-50 cm or until the clay layer is reached, and gradually sloping banks to provide a gradient of habitats for different species (Ferren, pers. comm., 2001). The pools should be kept separated. Inoculum and seed from one reference pool will be added to two pools, and similarly for the other two reference pools, resulting in three paired pools with three

different sources of inoculum. The location of the experimental plots is shown in Figure 3.2.
If collection of inoculum from the reference pools is not permitted or not practical due to a high percentage of weedy plants, then seed should be collected. In this case, aquatic invertebrates will be expected to establish on their own, since they have already been observed in puddles on the site. However, it is expected to take longer for the aquatic invertebrate community to fall within the natural variability of vernal pools than if they were inoculated.

The results obtained from thorough monitoring of the experimental pools and reference pools will help to determine the most appropriate reference pool to be used as a source for vernal pool species at the Preserve. Once the experiment is completed, we recommend that the 6 pools be combined into a larger vernal pool and inoculated with the appropriate source, to support a vernal pool on the site that is most characteristic of the natural vernal pools in the region.

4.4.4 Implementation

The following is a description of how the vernal pool restoration should proceed. Pre-construction monitoring must be done to determine, on a finer scale, where the pools should be located. This includes a detailed topographic map, thorough vegetation survey, soil samples to determine variation in soil type and depth of the clay layer, and hydrologic monitoring to determine where surface runoff and ponding occurs. If vernal pool plants are found, the area should be excavated but not inoculated, and should be considered extra pools in addition to the experimental pools. Experimental pools should be placed in a randomized fashion in the most suitable areas. Once pool locations are determined, location of trails and signs should follow the guidelines set forth in the recreation plan.

During spring and summer, on average to wet years only, collect inocula and seeds after reference pools have dried and seeds have matured. Collect inocula in 1 m^2 quadrats randomly placed across pools for every 10 m^2 of vernal pool (Hubbard, pers. comm., 2001). Place quadrats in several areas throughout the pool to capture diversity, but avoid areas with high non-native cover. Collect seeds by hand to reduce the percentage of weeds collected by other methods. Collect soil samples to capture aquatic invertebrate eggs and mycorrhizal fungi. Collect no more than 15% of the total surface area to ensure that reference pools are not significantly impacted (Stebbins et al., 1997). Store plant material in burlap bags and soil in paper bags at room temperature for up to one year (Stebbins et al., 1997).

Construct pools by late summer to early fall, before the first rains. We recommend following the successful implementation process used for the restoration of the Del Sol vernal pools (Hubbard, pers. comm., 2001). Determine how much material should be cut to attain design depth and width of basins. Mark edge of proposed basins with spray paint or flags. Repeat surveying work as necessary throughout the project to achieve flat-bottomed and non-tilted basins. De-thatch restoration area and path improvements before grading. Survey path enhancement areas to determine proposed profile for efficient drainage. Remove topsoil from basin and stockpile. Excavate pools in a bowl-like shape with a skip loader and backhoe slightly deeper than wanted so that it will be the desired depth when topsoil is replaced. While grading, leave a small area that has the original height of ground in the center of the pool with a measuring bar to use as a reference point. When finished remove soil, but keep reference bar (Ferren, pers. comm., 2001). Spread subsoil on path enhancement areas, compress, and water for dust control. Redistribute topsoil to the edges of paths and basins. After completion of pool construction, inocula should be spread by hand and hand raked evenly throughout the top 2 inches of soil for the entire pool and compacted with a water filled drum (Stebbins et al., 1997).

4.4.5 Monitoring

Pre-implementation monitoring is necessary to determine vernal pool locations and the natural variability of reference pools, and to ensure that surface runoff is insignificant. Surface runoff in vernal pool restoration should be measured for one year prior to construction because vernal pool species may be replaced by freshwater marsh species if vernal pool inundation cycles are altered. Vernal pool biota can cycle nutrients such as nitrogen and phosphorus, but they are not capable of filtering a large degree of pollutants from surface runoff like a freshwater marsh (Ferren, pers. comm., 2001). If this is determined a problem, surface runoff should be rerouted away from the pools.

Monitoring of all reference pools is needed prior to restoration and on a long-term basis to develop a list of plants for seed collection and to quantify the range of natural variability. Once the vernal pools have been created, they should be monitored for a minimum of 10 years to determine when revegetation, weeding, or other management actions are necessary and whether the success criteria are achieved. For reference and created pools, monitor soil chemistry and topography yearly. Additionally, several times throughout the inundation period, monitor vegetation species cover and diversity, abundance and diversity of aquatic invertebrates and vertebrates, water loss, water chemistry, and depth, width, and timing of inundation. Gathering data is difficult because annual variation in weather patterns will change the duration of different phases of pool inundation, thereby altering community composition (Keeley and Zedler, 1998). In order to provide more realistic data on cover of vernal and non-vernal pool species, only pools that are inundated for more than twelve consecutive days during the growing season should be monitored (Stebbins et al., 1997).

Monitoring of vegetation should be done using multiple transects or the randomized quadrat method with a permanent transect to correct some of the biases of the single transect method (Stebbins et al., 1997). Monitor aquatic invertebrates using a D-net, making several sweeps in different areas of the pool. Store in labeled bottles and identify to the family level. Vertebrate monitoring should be conducted several times throughout the wet phases of the vernal pool cycle by visual observation. Photo monitoring should be done to capture the different phases of the vernal pool inundation cycles.

Success criteria are critical to determine whether the goals and objectives have been achieved. The following success criteria are to be used as a general guideline with some flexibility, especially if weather conditions are not ideal. After 2 years, 50% cover of native vernal pool plants, 50% abundance of reference pool aquatic invertebrates, a similar number of vernal pool indicator species found in reference pools, and ponding within the range of reference pools will serve as success criteria (Clark, 1993). By the end of 5 years, 75% cover and 75% species diversity established, similar aquatic invertebrate populations found in reference pools, and avian species using pools (Clark, 1993). By the end of 10 years, 90% cover and 90% species diversity established, and pools overall fall within the natural variability of reference pools (Clark, 1993). The pools that fall within a range that statistically is not significantly different from the success criteria can be determined successful. The pool that is determined most successful should have the greatest diversity and cover of native vernal pool plants, abundance and diversity of aquatic invertebrates, and bird use.

To determine if success criteria are being achieved, monitoring data of the created vernal pools should be compared statistically with reference pools (Ferren et al., 1998). Data analysis should compare created verses reference pools for percent cover in vegetation as a function of depth, log transform plot of percent cover or abundance of species, and a gradient of rare to common species (Ferren, pers. comm., 2001). The data from the created pools should not be significantly different than the range of natural variability of the reference pools. The vegetation composition of vernal pools varies with size, and since the restored experimental pools are smaller than the reference pools, it is expected that the vegetation composition will differ. This should be accounted for when comparing created pools to reference pools.

Monitoring is essential to the adaptive management cycle allowing for continual assessment and revision of restoration actions. The monitoring data obtained from the experiment can be used to determine the best approach to vernal pool restoration and whether it is possible to restore vernal pools at the site at all. If the monitoring results indicate that it is unlikely the success criteria will be met, the monitoring data should be assessed to determine what alternative actions might lend to reaching the success criteria. If the success criteria are met, the hypothesis that a self-sustaining vernal pool within the natural range of variability can be created at the sight is true. The pools that meet the success criteria should be compared to conclude, the source of inocula that lends to the greatest abundance and diversity of species.

4.4.6 Management

Maintaining drainage patterns, controlling weeds, preventing invasion of non-native species, and maintaining paths to reduce human impacts will help to manage the vernal pools (Hubbard, per. comm., 2001). Once plants are established, seeds from these pools should be collected and planted.

Weeds do not survive in vernal pools during the inundation phase, but upon pool desiccation, weed encroachment occurs. *Rumex crispus* (Curly dock) and *Cripsus schoenoides* (Swamp grass) are some of the most invasive species that need to be removed on a regular basis (Hubbard, pers. comm., 2001). *Lolium multiflorum* and *Hordeum geniculatum* colonize vernal pools in drier years and the thatch from the dead annuals covers the substrate and prevents native annuals from germinating (Shadbourne, 1993). Weeding techniques must not destroy the vernal pool seed bank material. We suggest that upland areas be planted with annual native grassland species such as *Sisyrinchium bellum* and *Nassella pulchra* to provide a buffer from weedy non-native species. This will help to reduce the cover of non-native species in the pools.

4.4.7 Cost of Experimental Approach

The approximate cost of vernal pool restoration was determined by the cost to restore a 20-30 m size pool. A skiploader costs $500 per day, which results in a total of $1,000 for 2 days to complete one pool of this size (Hubbard, pers. comm., 2001). A supervisor biologist costs approximately $25 per hour (Hubbard, pers. comm., 2001). They collect and plants seeds and supervise the project, which takes approximately 8 hours for 5 days totaling approximately $1,000 (Hubbard, pers. comm., 2001). The total cost of restoration for one pool is approximately $2,000. To restore six pools of this size, the cost ranges from approximately $12,000 to $20,000. Maintenance, monitoring, and data analysis combined will cost approximately $3,000 to $30,000 a year depending on the level of sophistication (Ferren, per. comm., 2001).

The cost of a non-experimental restoration consisting of one large pool equaling the size of all six combined would likely cost slightly less due to less surveying, reduced complication of grading, and less sources of seeds and inocula. One large pool would have less monitoring initially because it would not have to include monitoring of two additional reference pools. However, cost is expected to be higher in the long run, because of the risk of failure. The experimental pools would cost more initially, due to more intensive monitoring, but would save money in the long run because there would be less maintenance required once the inoculum that provides the most diversity and cover of native species is determined.

We highly recommend the experimental approach to vernal pool restoration because it is less costly in the long run and is much more valuable. It prevents the large-scale risk so commonly associated with restoration projects that do not implement the adaptive management approach. If a “trial and error” approach was implemented and failed, the reasons for failure would not be known. The experimental approach provides more educational opportunities because students can compare the differences between pools and see why some succeed and others fail. Conservation value is greater because the experimental approach helps to determine the inoculum that provides the most diversity and cover of native plants within the constraints.

5.0 FRESHWATER MARSH RESTORATION AND MANAGEMENT PLAN

5.1 Introduction

According to the U.S. Fish and Wildlife Service (USFWS), wetlands are defined as "transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Tiner, 1996). The FWS classification system for wetlands has become the national and international standard for distinguishing wetlands. The presence of hydrophytic vegetation, hydric soils, and saturated or inundated substrates are the general criteria used to identify wetland areas. Each wetland type can then be described by a large number of dominance types to distinguish the wetland by dominant or characteristic vegetation and/or by a number of modifiers to characterize the hydrologic, chemical and soil characteristics of the wetland (Cowardin et al., 1979).

California has lost or converted about 90% of its historical wetlands (Ferren et al., 1996). Statewide, riparian wetlands have dropped by 95%, freshwater marshes by 90%, and coastal salt marshes by 80 % (Ferren et al., 1996). Many unique wetland areas in the Ojai Valley, such as Mirror Lake, have similarly been destroyed by development. By the 1980's, Mirror Lake was significantly drained and filled due to the construction of a housing development. Alterations led to the elimination of the majority of rare plant species, including *Sagittaria sanfordii*, a species of arrowhead that was only found at this locality in southern California (Ferren et al., 1996).

A majority of wetland restoration projects fail to meet their goals. Mitsch andGosselink (2000) report that over 60% of wetland mitigation projects in south Florida were considered incomplete or failures. Improper water levels and hydroperiods were cited as the most important reason for the failures. Reestablishment of open water wetland habitat, which supports a diversity of species characteristic of historic Mirror Lake is a primary goal of the OVLC (DMEC, 2001). However, the feasibility of establishing a permanent freshwater marsh with open water habitat is uncertain.

Historical accounts and photographs indicate that a freshwater marsh existed on the Preserve, but it is unclear from these records if the marsh was seasonal or permanent. However, past agriculture and development in the area have altered the surface and ground water inputs in the area, degrading the wetland habitat. Currently, the drainage ditch on the site supports freshwater marsh vegetation. The management plan presents two alternatives for freshwater wetland restoration on the Preserve. The feasibility of establishing hydrologic conditions needed to support a freshwater pond that will sustain permanent water onsite and the creation of a seasonal marsh are evaluated. Management techniques are also assessed.

5.2 Reference Conditions

Freshwater marshes or palustrine wetland systems can have a range of hydrologic conditions (seasonally flooded to permanently flooded) and dominant vegetation characteristics (forested to non-persistent emergent wetland plants). Due to recent development and surrounding land use, many of the natural processes, such as natural hydrologic flows, cannot be restored. The hydrologic reference criteria used in the development of the wetland restoration plan are based upon the regional hydrologic freshwater palustrine systems. The reference criteria for vegetation are based on characteristic species of freshwater marsh communities of the Ventura area.

Hydrologic conditions are the major determinant of the type of wetland that can be established and maintained (Mitsch and Gosselink, 2000). The frequency, depth and duration of water, or hydroperiod, on a site determine, to a large extent, the diversity and type of vegetation existing in the wetland (Marble, 1991). The hydroperiod of southern Californian freshwater marshes are characterized by deep basins that flood for a significant portion of the year (Ferren et al, 1996). Ferren et al. (1996) classified Mirror Lake as a palustrine, emergent-persistent, seasonally flooded vernal lake; southern California ponds were classified as palustrine, aquatic bed, permanently flooded ponds. A permanently flooded wetland is defined by a hydroperiod where surface water covers the land surface through out the year in all years (Cowardin et al., 1979). It is distinguished from a seasonal wetland, in which surface water is present through large parts of the growing season, except in dry years (Cowardin et al., 1979). Ventura County, like much of southern California, operates under a water deficit (Bertoldi and Swain, 1996). Winter months have a surplus of water, and summer months have a deficit. Without additional significant ground water or surface water inputs, freshwater marshes in southern California have a seasonally flooded hydroperiod.

Seasonal freshwater marsh communities are generally dominated by perennial monocots (Holland and Keil, 1990). Common perennial monocot species associated with freshwater marsh wetland communities are *Carex* spp., *Eleocharis* spp., *Juncus* spp., *Saggitaria* spp., *Scirpus* spp, *Sparganium* spp., and *Typha* spp. (Holland and Keil, 1990). Dominant freshwater marsh species found at Mirror Lake include *Eleocharis palutris, Juncus phaeocephalus, Juncus bufonius, Juncus mexicanus, Scirpus saximontanus,* and *Typha domingensis* (Ferren, per. comm., 2001).

Permanently flooded areas of wetlands are dominanted by *Azolla sp.* and *Lemna sp.* Characteristic floating vascular species of southern California ponds include *Azolla filiculoides, Lemna gibba, L.minro,, L.valdiviana, Spirodella polyrrhiza, S. punctana* (Ferren et al., 1996). Only 2 floating hydrophytes, *Azolla ficuloides* and *Naias guadalupenesis,* have been reported in the UCSB herbarium collection for Mirror Lake.

Mirror Lake, a seasonally flooded freshwater lake, historically supported a diverse assemblage of native wetland species. During the winter and spring when ample moisture was available in the soil, perennial monocots dominated this wetland habitat. In the summer, areas that retain soil moisture continue to support perennial species, and annuals begin to expand into and dominate drier surfaces. Typical annual species found at Mirror Lake can be found in Table 3.1.

Reference conditions are used to establish quantitative goals for restoration. Therefore, the design of the wetland should achieve the appropriate hydroperiod for the desired habitat, and the revegetation efforts should focus on establishing the characteristic species of freshwater marsh, either seasonal or permanent. Dominant species of each strata layer should cover at least 50% of wetland surface, which is a vegetation criteria used to delineate wetlands (NRC, 1995). Dominance refers to those species that account for the greatest coverage in the community. Dominance measures for vegetation varies in the wetland delineation manuals (NRC, 1995). In the 1987 Federal Delineation Manual, estimates of dominance are made visually, and the determination of dominant species is subjectively assessed.

5.3 Goals and Objectives

A primary goal of the OVLC is to create open water habitat on the Preserve. However, the feasibility of establishing and maintaining permanent water onsite is uncertain. Therefore, seasonal and permanent wetland alternatives were developed with the secondary goal of bringing back habitat that supports a wide diversity of native wetland plants and animals historically found at Mirror Lake, a seasonal vernal lake. This will increase the aesthetic and passive recreational values of the currently degraded site. The wetland restoration will also provide services for the community, including flood control, improved water quality, and recreational opportunities.

Goal 1: Establish a palustrine persistent emergent wetland.

> **Objective 1:** Establish hydrologic conditions necessary to maintain a freshwater emergent wetland.
>
> **Objective 2:** Introduce and promote the growth of native wetland vegetation characteristic of Ojai.
>
> **Objective 3**: Provide educational and recreational opportunities for the Ojai Community.

Goal 2: Maintain wetland habitat for native flora and fauna.

> **Objective 1:** Increase diversity and abundance of fauna.
>
> **Objective 2:** Increase plant diversity of wetland.

Goal 3: Provide increased flood control opportunities of the surrounding areas.

Objective 1: Divert surface water from adjacent areas to the wetland.

Goal 4: Provide improved water quality

Objective 1: Divert surface runoff through wetland.

Objective 2: Vegetate wetland with plant species that are good for filtering out urban runoff.

5.4 Conceptual Model

Successful creation of wetland habitat depends on the mitigation of the key stressors operating in the area: channelization, exotic species, and polluted runoff. Channelization of the Happy Valley Drain and diversion of surface runoff is preventing accumulation of onsite water, increasing the flood peaks down stream, and decreasing the amount of groundwater discharge. The invasion and establishment of exotic species onsite and in the Ojai Valley has reduced the available species pool and dramatically changed the seed bank. Watershed runoff is more polluted and will affect the ability of the created wetland to function properly. A diagram of the main stressors, their effects and the proposed management actions is shown in Table 1.5.

5.5 Feasibility of Permanent Water

The historic surface water inputs to the site have been significantly altered. Historical photographs from 1929 and 1945 (Figures 2.1 and 2.2) show the Preserve receiving substantial surface inflows from the east and north. The surface flow from the north has been channeled into Happy Valley Drain to improve flood conveyance for the surrounding developments. Flows from the east were altered with the development of Nordhoff High School, which diverted most of the surface runoff. Furthermore, a drainage ditch was installed to increase the flood conveyance from the adjacent Maricopa Highway.

The drainage ditch, installed by the Ojai Public Works Department, provides flood relief for the adjacent Maricopa Highway. Cattails, bulrushes, rushes, coast live oaks and planted poplars line the edges of the ditch. The sump alongside Maricopa Highway holds water year-round, except in drought years. The management plan focuses on expanding freshwater wetland habitat from the drainage ditch area to create freshwater marsh habitat.

Runoff, local subsurface flow and precipitation are primary sources of water input to the proposed wetland site. According to residents, flooding of the Preserve occurs frequently. Flooding from Happy Valley Drain is not anticipated to contribute significantly to surface water input to the proposed wetland area, except in extreme flood events (i.e. >100-year recurrence interval). Surface water inputs to the wetland area are restricted to a small area and are expected to contribute only a third of the total water input. Regional groundwater levels are located approximately 6 to 18 m below the surface elevation and do not contribute significantly to the wetland

hydrologic inflows. A shallow aquifer or perched water table, however, is assumed to be a source of water and contribute to the ponding observed on the Preserve.
A water budget and a water balance were used to evaluate hydrologic conditions of the site. The water budget serves as a useful summary to calculate hydrologic components. In a basic water budget, the total hydrologic inflows equal the outflows. Hydrologic inflows to the proposed wetland area include direct precipitation, surface runoff, and seasonal discharge of local subsurface groundwater flows. The drainage area contributing to surface flow to wetland area encompasses 74 ha and includes the immediately adjacent slopes from Maricopa Highway, Nordhoff High School and Krotona Hill (Figure 2.7). The hydrologic outputs include evapotranspiration, surface runoff, and outflow of local groundwater flow. Based on the subsurface geology (Table 2.6), the regional groundwater flow is significantly below the surface, and does not contribute to water input.

Infiltration rate was used to estimate the amount of water that would be lost to subsurface percolation. The infiltration rate was found for the sandy soils of the site using a single ring infiltrometer method developed by Hills (1970). The average infiltration rate was 312 cm^3/min. Approximately, 150 m^3 of water is lost annually from infiltration. The water budget calculations for the proposed wetland area (Figure 5.1) show a substantial water deficit for the wetland area. Furthermore, water balance calculations (Figure 5.2) indicate that surplus water is expected only in the winter months.

The proposed freshwater wetland restoration area (Figure 5.3) was identified as having the highest potential for successful restoration given the constraints of the site. The site selected lies in a major topographic depression of the Preserve and is approximately 2 ha in size. The proposed area receives runoff from the adjacent areas and groundwater discharge from the local groundwater flow. Ponding of surface water has been observed in the winter, and the area is dominated by grass species (*Lolium multiflorum*) characteristic of seasonally wet areas (Ferren, per. comm., 2001). Wetland development on the clay soils, which would allow for more ponding and greater water storage was not considered feasible because expansion of the wetland habitat onto the clay soils is constrained by the location of onsite sewer lines and the need to access existing manholes.

Climate variation strongly influences the effects of precipitation and evapotranspiration on the hydroperiod of a wetland, while the design of the pond determines the effects of surface water or groundwater inputs (SCS, 1992). Water budget calculations (Figure 5.1) indicate that there is a water deficit of approximately 10,000 m^3 for the proposed wetland area, primarily resulting from the high evapotranspiration rates. To establish and support a permanently flooded wetland, water needs to be supplied to offset the yearly water deficit plus an additional volume to maintain permanent water. An additional 20,000 m^3 is needed to maintain a large shallow wetland that is 2 ha in area and 1 m in depth throughout. However, only

13,000 m^3 of water is needed to support roughly 0.5 ha of a 2 ha wetland area with 1 m of permanent water. A smaller, deeper wetland would require less water. For example, a wetland 0.5 ha wide and 1.5 m deep would only require 8,500 m^3 of permanent water, but a wetland of this size will not provide as diverse of a habitat as a larger wetland. Since one of the most important goals of the restoration is to restore habitat for the flora and fauna in the region, this option was not considered feasible. The surplus water from winter rains and surface runoff can sustain a wetland that is seasonally flooded.

5.6 Choosing a Restoration Alternative and Implementing the Hydrology

The project goals, site characteristics and desired functional values determine the type of the wetland. The two alternatives explained below include a seasonal wetland and a permanent wetland alternative. The primary goal of the OVLC is to restore a permanent wetland. However, the current hydrology of the site precludes the establishment of such a habitat unless other measures are taken to provide additional water sources. The expense of restoration and maintenance of the permanent wetland is substantially greater than the seasonal alternative. Furthermore, the management actions required to maintain permanent water are expected to decrease the species and habitat diversity of the wetland relative to the seasonal alternative. Therefore, BORG recommends the seasonal wetland alternative for the site.

5.6.1 Seasonal Wetland Alternative

Surplus water from winter precipitation and the presence of ponding during the winter months indicates that a seasonally flooded wetland can readily be restored onsite. Many methods can be employed to create and maintain the necessary hydrologic conditions. Described below are three general techniques that can be used to establish the hydrologic conditions needed to restore and maintain a seasonal wetland habitat: blocking of surface water, creating water-holding depressions, and excavating down to the seasonally high water table. These techniques were selected based on the need to maximize water input to accommodate the large summer evapotranspiration rate and achieve the project goals of providing diverse habitat conditions, flood relief, and filtration of runoff.

Excess surface water is currently channeled through the site relatively quickly via the drainage ditch. Constricting the outlet will potentially provide 1200 m^3 of water. A berm can be used to constrain the water flowing through the drainage ditch. The berm should be large enough to control overflow from storm events and degradation of the berm from sediment and plant accumulation. The exterior berms must be constructed with cores of impermeable materials. In shallowly constructed wetlands, a 10:1 or 20:1 slope is typically used to create habitat diversity (Hammer, 1992). To provide conveyance for flooding events, the outlet from the drainage ditch should be elevated to a level that can accommodate the expected overflow from the wetland area. Excavated materials onsite can be used to elevate the bed of the drainage ditch. The specific design depends upon the size of the wetland designed.

Flood lines observed on the Preserve along Maricopa Highway indicate that runoff is not being effectively conveyed through the drainage ditch. Re-grading the inlet and clearing the upper portion of the ditch will direct more water to the wetland area. Furthermore, local subsurface flow saturates the potential wetland area in the winter months. Excavating a gently sloping basin will provide additional water through groundwater discharge and diverse habitat areas for revegetation. The precise depth to the seasonally low local water table and its fluctuations are not known. Wetlands created on highly permeable soils should have direct contact with the seasonal water table (Marble, 1991). Contact with the ground water will provide nutrient source and stabilize the water fluctuations. The excavation of the wetland basin should also provide gradually sloping sides to maximize habitat areas

Flow channels created from Nordhoff High School and Krotona Hill will provide additional water in the winter to be stored in the wetland. The correct abundance and types of wetland plant species should be available to accommodate the amount and type of pollutants entering the wetland. Cattails (*Typha sp*) and bulrushes (*Scirpus sp*) are commonly used for filtration. Characteristic species of the region include *Typha dominguesis* and *Scirpus californica.*

5.6.2 Permanent Wetland Alternative

The proposed wetland area lies on sandy substrate, and the soils have a moderately low hydraulic conductivity (Edwards et al., 1970). Ponding for a long duration on the highly permeable soils is unlikely (DMEC, 2001). To restore permanently flooded conditions to the proposed wetland basin, lining the excavated basin, suggested in the seasonal alternative is recommended to slow the infiltration of water into soil. However, surface runoff emptying into the impermeable basin will most likely alter the water chemistry, particularl pH levels. Ferren (pers. comm., 2001) noted that wetlands receiving urban runoff without circulation generally support only a few perennial species such as cattails and bulrushes. Furthermore, the water deficit (10,000 m^3) calculated for the proposed wetland area indicates that water will need to be pumped to maintain permanent water onsite.

Many different types of liners can be used to seal the basin including: compaction, clay, bentonite, flexible membrane, and chemical treatment. Compaction is the least expensive method and is recommended for fine sandy soils, such as those found on the site. However, liners created with the compaction or clay method are only relatively impervious. (Hammer, 1992). Given the low precipitation/evapotranspiration ratios of the summer months, the compaction and clay methods are not recommended. The flexible membrane and chemical treatment methods could potentially cause contaminant leaching into the groundwater and are also not recommended (Hammer, 1992).

The bentonite clay is a fine-textured colloidal clay that will absorb several times its own weight of water. When compacted and saturated, the liner is almost impervious. Approximately 0.2 to 0.6 kg/m^2 of bentonite is mixed with soil, depending on the clay content of the soil. Riprap should be installed to protect the inflow area from erosion. Bentonite will crack when dry, so it is important to maintain saturated conditions. Given the high evapotranspiration rates and little precipitation in the summer months, ground water will need to be pumped into the wetland to maintain saturated conditions. Aboveground and belowground pumps could be employed. Aboveground pumps are considerably cheaper. However, the pumps are only effective for groundwater at depths above 10 m (Sinclair Services, per. comm., 2001). The regional groundwater fluctuations range from 8 to 18 m, so a submersible pump is recommended.

A well on the site could potentially be used for water input. The well is located 150 m east of South Lomita Road and 50 m north of Happy Valley Drain (Figure 2.8). Water can be pumped from the well at approximately 0.15 to 0.20 m^3/min (Panaro, per. comm., 2001). The precise length of pumping is not known, however David Panaro (pers. comm., 2001) reports that this well should not be pumped for more than a few hours at a time. Thus, the well onsite will potentially provide 10 to 40 m^3/day.

Year-round pumping of the wetland will provide between 6500m^3 and 14,000m^3 of water. To establish permanently flooded conditions, approximately 10,000 m^3 is needed to account for the water deficit of the summer. At the maximum pumping rate, 4000 m^3 of water is potentially available to maintain permanent water in the wetland basin. The minimum pumping rate will not completely offset the water deficit, and the establishment of permanent water is unlikely. Furthermore, the water available from the maximum pumping rate from March to December will only provide approximately 10,800 m^3 of water to offset the water deficit of the summer months. Therefore, testing of the well is recommended to ensure that the maximum water will be available to sustain open water habitat.

Wetlands dependent on groundwater input generally have a higher mineral content (Mitsch and Gosselink, 2000). High concentration of minerals can significantly affect the growth and establishment of plants. Given the high evaporation rates, permanent water in the sealed basin could potentially reach toxic levels of certain minerals. Thus, plant assemblage of permanent wetland will most likely support few species, and we recommend that the marsh be sampled regularly for water quality.

5.7 Revegetation

Typical plant species of freshwater marshes do not occur randomly mixed (Mitsch and Gosselink, 2000). Hydrologic conditions, particularly the water fluctuations, influence the species composition of the wetland. The gradient of the created wetland basin coupled with the water fluctuations will affect the types of established species (Mitsch and Gosselink, 2000). Various species tolerate different water conditions and

establish in particular zones of the wetlands. Gently sloping basins generally support a larger diversity of plants and animals (Marble, 1991). In a properly constructed freshwater marsh, the lowest point of the wetland is inundated year-round; emergent vegetation persist in seasonally-flooded zones, and annuals will dominate periodically flooded conditions at the edges of the marsh (Bertoldi and Swain, 1996). Depending on the time period and depth of inundation, the lowest portion of the marsh will support floating hydrophytes or perennial emergent species.
Revegetation techniques of wetland areas include direct seeding, transplanting, and use of excavated soil. Mitsch and Gosselink (2000) recommend using different planting techniques for specific life histories. Transplanting has proved the most successful for emergent species, whereas annual species are most effectively introduced through seeding. Soil cores, which capture rhizomes, seeds, and shoots from established wetlands, promote the introduction of a diversity of species. Aquatic hydrophytes have traditionally been left out of revegetation plans (Mitsch and Gosselink, 2000). However, direct transplant from donor sites has been used with some success. Therefore, different revegetation methods are recommended for the various zones of the wetland. Regardless of the method used, Reinhartz and Warne (1993) report that early introduction of a diversity of plants enhances the long-term diversity.

5.7.1 Tranplanting

Transplanting plants can be done with species from a donor wetland or those grown in nurseries. Locally grown nursery stock is the most reliable and accepted way to acquire plants (National Resources Conservation Service (NRCS), 1998). Mitsch and Gosselink (2000) report that locally grown plants with stems having a base of 20-30 cm are the most successful when planted. Manual collection of species from donor sites is accomplished by uprooting whole plants with simple garden tools and bags to store the plants. Transplants of species from donor sites should be completed within 36 hours of collection (Mitsch and Gosselink, 2000). For both the permanent and seasonal alternatives, planting of perennial emergents is recommended for the seasonally flooded zones. Collection of aquatic hydrophytes and immediate transplanting is suggested for the permanent wetland alternative.

5.7.2 Seeding

Seeding success rates vary greatly in wetland communities (Mitsch and Gosselink, 2000). Many plants will not germinate in standing water, but will germinate in saturated soils. Propagation by seed requires an exposed, wet surface, and broadcasting should be done in the late spring to early summer when there is little to no standing water. Seeding provides an inexpensive method to increase the diversity of species (NRCS, 1998). Broadcast or hand seeding is suggested for the wetland/upland transitional zones, which dry in the summer. Local seed sources are also recommended. Mitsch and Gosselink (2000) report that local sources are more likely to survive and will not adversely affect local gene pool.

5.7.3 Soil Cores

Using cores or plugs from existing wetlands is a common wetland revegetation technique that has been used with success. Cores should be taken from wetland areas that closely match the hydrologic conditions of the site. However, using cores could also potentially establish exotic species not presently found onsite. Therefore, highly disturbed communities are not recommended as donor sites. Once transplanted, the soil should be kept moist until germination. Additionally, approval from appropriate agencies is required before any removal.

For seasonal wetland, soil cores are recommended in the lowest point of the wetland, which will remain saturated. Cores or plugs of 8 to 10 cm should be transplanted from donor sites (Mitsch and Gosselink, 2000). Newbury Park, a wetland restoration site in Ventura County, or the Villanova wetland (which is across the street from the Villanova School) could potentially serve as donor sites (Lindsey, pers. comm., 2001). Soil cores are also suggested for the saturated zones along the margins of the permanent water. However, no donor sites have been identified for this habitat.

5.8 Implementation

5.8.1 Planning and Additional Data Needs

The development of specific designs and specifications for the wetland restoration will require approximately 80 to 100 hours of planning and engineering work. A consulting firm that specializes in permitting should also be brought into the planning process. CEQA permitting, Army Corps of Engineers permit, California Fish and Game permit, LA Regional Water Quality Board permit are needed before any restoration can begin.

Further soil tests, groundwater monitoring, and a detailed topographic survey are needed to aid in the detailed planning and design of the wetland restoration. The soil tests will provide information on the amount of bentonite required for the liner, which depends on soil particle size and the amount of clay in the substrate. Groundwater data will initially be used to design the wetland excavation. For long-term management, the data will be used in monitoring and assessment of the restoration. Temporary wells should be installed to a depth of 1.2 to 1.8 m (DMEC, 2001) to determine the fluctuations of the local groundwater. Groundwater levels should be monitored quarterly for an entire water year.

A detailed topographic map of the Preserve should be conducted before any surface grading or excavation. A State-certified surveyor or an environmental consulting agency with a credited surveyor should be hired for the work. Non-certified surveys are not recognized by the State, and can only be used for planning purposes. Data of digital format, which can be incorporated into a GIS database, should be supplied. A 15 cm contour interval is recommended. However, the permit for excavation and regrading only requires a 60 cm contour interval.

5.8.2 Freshwater Marsh Creation

Creation of basin and flow channels, and inlet regrading can be accomplished through excavation. This depends upon the following site characteristics: geographic location, zoning, topography, and soil condition. The Preserve is accessible, and the soil condition and topography on the site will not present major complications in the excavation. However, a zoning permit must be obtained from the Ojai Planning and Zoning Department. The permit should include:

- The quantity of earth material moved in project
- A small scale map, showing the location of the lot, the names of all owners within 152 m, and streets and the names of the applicant and the lot owner
- Within 60 m of the proposed operation, existing contours and the proposed contours for the completed operation. The contours shall have a maximum interval of 60 cm
- The grades of all adjacent streets and lands
- Location and size of any existing and proposed building or structures on the lot
- Proposed travel access to the area of proposed operation
- Location of any water bodies on and adjacent to the lot

Using information from groundwater monitoring and topographical survey, the wetland basin should be excavated to the seasonally high water table. Excavation of the basin, creation of flow channels, and regrading of the inlet should occur during the summer months. The configuration of the wetland should adhere to the following guidelines:

- The wetland shape should be irregular to provide diverse habitat areas and more sedimentation.
- The lowest portion of the basin should be placed at the lowest topographic point
- The inlet and outlet should be disjoined so that water flowing in does not flow directly out.
- The basin should be able to accommodate 90% of the runoff producing storms

The drainage ditch past the outflow area should be elevated with excavated fill to a level that will still accommodate large precipitation events. Flow channels from Krotona Hill and Nordhoff High School should be dug to maximize water input to the wetland area. The estimated cost of the excavation and grading ranges from approximately $50,000 to $100,000.

Liners and groundwater pumps are expensive to install and difficult to maintain (NRCS, 1998). The bentonite should be mixed in a pug mill and applied to the top 15 cm of the soil. The soil should be compacted with a sheepsfoot roller, completing at least 4 to 6 passes (SCS, 1992). A mulch of sterile straw or hay may also be needed to cover the bentonite and to prevent the clay from drying. The cost of bentonite is roughly $8.00 to $10.00 per 20 kg bag. The projected cost of bentonite for the proposed restoration ranges from $15,000 to $40,000. Liner installation could potentially cost as much as $8,500 per hectare, meaning an additional cost of $17,000 for the permanent wetland creation. The cost of pump installation and equipment ranges from $1,500 to $2,000. Typical operating and maintenance expenses are approximately $5,000 to $9,000 per year. A submersible pump should be installed before major wetland excavation occurs. The well should be cleaned when the pump is installed to reduce the amount of maintenance (BC2 Corporation, pers. comm., 2001).

Seed collection and propagation should occur a full-year prior to restoration. Table 3.1 lists proposed species for the area. It is recommended that seeds and plants for the initial planting be purchased from local nurseries to ensure that a large volume and a diversity of plants and are supplied. School groups can assist with the seed collection and propagation of the supplemental planting efforts. The collection and propagation of widespread species such as cattails and California bulrush are better suited for school groups. Pam Lindsey (per. comm., 2001) recommended Matillija Nursery as a local nursery source. Growing Solutions of Santa Barbara, which offers both seed collection and propagation services, is another viable alternative.

Planting efforts should occur in the spring, when the seasonally wet zone begins to dry out. Before planting, the vegetation zones should be clearly marked as follows: continuously saturated, seasonally flooded, and transitional. Soil cores (8 to 10 cm) should be placed in the continuously saturated zones. Container grown or rooted cuttings of perennial species should occur in the seasonally flooded zone. Annual species should be broadcast in the transitional zone, which dries yearly, while the area is still moist.

For the initial plantings, Mitsch and Gosselink (2000) recommend high density planting 2,000 to 5,000 plants/ha to reduce the rapid colonization of *Typha* sp., which tends to form monocultures in restored wetlands. Permission for removal of soil cores from donor sites must also be obtained prior to removal of soil cores. If sensitive species are present at the donor site, the USFWS must be consulted to determine the impact. A consultant should supervise the initial planting efforts after excavation and the supplemental plantings of the following two-years.

5.8.3 Monitoring

Monitoring serves an integral component that provides information to evaluate the initial success of the restoration and to assess the long-term management of the Preserve. The restoration is considered successful when the goals and objectives of the plan are met. We recommend that monitoring of the freshwater marsh focus on hydrology, vegetation, and water quality as indicators of successful restoration.

5.8.3.1 Hydrology

The purpose of the hydrologic monitoring is to determine the depth and temporal extent of saturation and to characterize the variability of the hydrologic inputs and outputs of the site. The depth and duration of flooding will show how much water is circulating in the excavated basin, if the desired hydroperiod has been established, and where the different vegetation zones are located. Measurements of the hydrologic inputs and outputs will be used to evaluate the overall health and the long-term variations of the site.

In a seasonal wetland, water should inundate all portions of the surface for at least 15 consecutive days and the surface of the deepest portion of the wetland should remain saturated for most of the year (NRC, 1995). To maintain open water habitat, the deepest portion of the wetland should have standing water to a depth of at least 46 cm (NRC, 1995). Measurement of water elevation can be made using simple graduated measuring sticks placed around the wetland. Elevation measurements should be taken monthly. Weekly measurements, particularly in the summer, are recommended for the permanent wetland to determine when pumping is necessary.

Height data plotted monthly will help identify stagnant water areas in the seasonal marsh, which promotes conditions in which mosquitoes thrive. Gauges should be also be placed in different zones to distinguish the different planting areas, which can then guide supplemental planting efforts.

The magnitude and duration of wetland inundation is a factor of the hydrologic inputs and outputs. Therefore, groundwater, runoff, and precipitation monitoring is recommended to assess hydrologic functioning of the system. Precipitation can be measured with rain gauges. Surface runoff inputs, which can be measured with a staff gauge, are calculated by subtracting net precipitation from the increase in water level during and immediately after a rain event. Ground water wells are used to determine ground water height. The data collected should be analyzed in a water budget and compared to the initial water budget calculations.

5.8.3.2 Vegetation

The purpose of revegetation efforts is to promote the growth and establishment of a diverse native flora while discouraging the spread of exotic species. A goal of the restoration is also to enhance habitat for native species, and vegetation is the most prominent indicator of habitat conditions. Therefore, vegetation should be monitored to determine the success of the plant growth and the potential of the wetland to support diverse habitat conditions.

A goal of the restoration is to have >65% native cover by the end of 5 years and >75% cover of native vegetation by the end of 10 years. Achieving a diverse assemblage is also a prime objective. The Shannon-Weiner index is a useful tool for assessing community composition. Using this method, index values were calculated based on desired assemblage for area: 50% coverage of dominant species and between 5% and 10% cover for at least 4 additional species. Using this scenario as a base, an index value greater than 1.3 is desired 5 years into the restoration.

Quadrat monitoring and photo-monitoring of the vegetation composition and growth of the wetland is recommended. One m^2 quadrats should be monitored along transects every 5 m for percent cover and abundance. Yearly, spring monitoring is recommended. Monthly photo-monitoring will help to determine seasonal changes in dominant vegetation cover.

5.8.3.3 Water Quality

Monitoring of both groundwater and surface water quality are needed to ensure restoration has improved water quality and to enhance monitoring efforts. Dissolved oxygen, nutrient concentration, and pH are common criteria used to assess surface water quality. Mineral content is used as an indicator for groundwater. The presence of certain aquatic organisms is also used to characterize the water quality.

Low dissolved oxygen levels in the wetland could potentially constrain the establishment of plants, fish and invertebrates. Dissolved oxygen levels greater than 4 ppm are desired. Morning and nightly monitoring will help determine the peak and minimum levels, which are needed to determine if growth is constrained by oxygen levels. Nutrient concentrations reveal how much nutrient loading can be accommodated without substantial changes in water quality. Levels of ammonias, nitrates, and phosphates should meet the LA Regional Water Quality Control Board standards. Samples from permanent monitoring stations at the inlet, outlet, and from three places within the basin should be collected monthly to determine the seasonal variation. The pH should also be determined at the sampling stations. Acidic water reduces growth and establishment of many species. The optimal pH level is 7. However, the pH levels should fall between 6 and 8.

Presence of aquatic invertebrates is also used to characterize the water quality of the wetland. The EPA Standard Rapid Bioassessment Protocols provide a framework for characterization. Using the EPA protocols, an “unimpaired” wetland characterization is desired. Sampling for aquatic invertebrates generally occurs once during the spring. However, quarterly monitoring is recommended to capture changes in species composition.

The mineral content of groundwater also influences the development of plants, in that large concentrations of minerals decrease the ability of vegetation to become established. Monthly measurements of total dissolved solids (TDS), phosphorous, and magnesium will detect both large and small scale changes over time. The mineral content of the groundwater water should meet State Irrigation Standards.

6.0 Riparian Restoration and Management Plan

6.1 Site Description

The Happy Valley Drain is a seasonal stream, which has been channelized and is incised in the stream terrace, and does not flood the Preserve except at discharges characteristic of the 100-year recurrence interval (DMEC, 2001). The Ventura Flood Control District channelized (straightened, widened, and deepened) the channel in order to increase flood conveyance. The modified channel now has 65 times the capacity that it had before channelization. Except for the segment that is located on the Preserve, the channel is concrete lined with vertical walls. The channel that crosses the Preserve is composed of earthen material, slightly slope-sided (~0.8), approximately 290 m in length and has a drainage area of approximately 2.33 km^2 (DMEC, 2001). Mean dimensions for this trapezoidal channel are as follows: top width = 8.5 m, bottom width = 3.6 m, and height = 1.5 m. The channel enters the Preserve from the north (south of El Camino Avenue), curves in a southwest direction and exists the Preserve south of Besant Road. This segment dissects both Ojai series and Sorrento series soils. However, the channel bed has been filled with riverwash, and therefore consists of some stony material, silt, clay, and sand. The channel has received repeated applications of herbicides, and is therefore completely devoid of vegetation on both the channel bottom and banks. However, a eucalyptus grove is present on the adjacent floodplain of the southeastern portion of the drain.

6.2 Importance of Riparian Corridors and Implications for Enhancement

Riparian corridors play a unique and important role in the ecology of landscapes. Since riparian areas represent the interface between aquatic and terrestrial ecosystems, they provide unique habitat for a vast array of species. This relatively narrow habitat provides transportation required for vegetation recruitment and invertebrate survival. Riparian vegetation is extremely important for filtering both natural and anthropogenic chemicals and retaining soil material, thereby managing stream soil fluxes. Healthy riparian areas also provide aesthetic and recreational functions, which are becoming increasingly important as the demand for natural resources increases. However, worldwide, the ecological integrity of riparian ecosystems is on the decline. National estimates of riparian ecosystem alteration or loss by activities such as land drainage, channelization, or grazing exceed 70% (Swift, 1984; Willard et al., 1990; Hunt, 1992). Since these systems are a focus of increasing development, an understanding of the naturally stable character of the river is necessary if maintenance of its function and health is to be secure (Rosgen, 1996).

However, flood control projects have consistently changed the dimension, pattern and profile of streams, which often results in an increased frequency and magnitude of flood impacts (Brookes, 1987; Rosgen, 1996). This is due to the fact that stream modifications disrupt the dynamic equilibrium that characterizes all undisturbed lotic systems. The modified system will work to reestablish this equilibrium and will eventually dominate the anthropogenic influences, which often results in catastrophic flood events (Rosgen, 1996). Channel modifications also reduce the ability of the riparian ecosystem to provide its ecological function, whereby the system is simplified as physical features (habitat) are removed, chemical processes are inhibited, and overall biodiversity is reduced. Therefore, it is important to understand and restore the interrelated variables that govern the physical dimensions and related biological features of riparian corridors.

6.3 Baseline Data Collection

Collecting baseline data is an important step in designing an effective restoration plan, in that it helps to describe the present conditions of the stream corridor and it sets the "baseline" from which to base all restoration successes or failures (FISRWG, 1998). This becomes extremely important during post-project monitoring. Data collected include hydrology (peak flow record obtained from VCFCD), channel dimensions (depth, width, length, slope, and bank slope), watershed land use data, drainage area, soil type dissected by stream, aquatic and riparian fauna, floodplain/riparian vegetation, and historical conditions. See species lists for riparian wildlife (Table 2.8) and vegetation (Table 2.7). Very little information exists concerning the historical conditions of the Happy Valley Drain. Based on historical photos (Figure 2.1) and information from the VCFCD, we know that the drain was a sinuous, seasonal stream that spilled out onto a broad floodplain that now contains the Preserve, Nordhoff High School, and some urban development. Historical data on channel dimensions and discharge regime are unavailable.

6.4 Reference Conditions

Reference conditions are important components of restoration projects, in that they are used as ecological models upon which to base restoration designs. Defining reference conditions is often achieved by locating a similar site or collecting historical data that represents, as closely as possible, the desired outcome of restoration (FISRWG, 1998). For reasons discussed above, historical reference conditions are not applicable in this case. Additionally, since the Happy Valley Drain is a lowland stream running through an alluvial floodplain, finding an analogue channel in the Ojai Valley that has not been disturbed or modified has proven to be impossible. Therefore, reference conditions for channel morphology were inferred from empirical and semi-empirical equations based on discharge, drainage area and soil type; the specifics of these conditions are discussed below in section 6.8.1.

Reference conditions for riparian vegetation were based on historical accounts (Smith, 1998) and Holland's (1986) "Preliminary Descriptions of the Terrestrial Natural Communities of California." Using these data sources, we have identified several species to be planted and managed along channel banks. The species are characteristic of mulefat and southern willow scrub communities. Mulefat scrub is widely scattered along intermittent streams from about Tehama County south through the Coast Ranges and Sierra Nevada to San Diego and northwestern Baja California Norte, usually below 600 m in elevation (Holland, 1986). Southern willow scrub communities were formally extensive along the major rivers of coastal southern California, but have been greatly reduced by urban expansion, flood control, and channel "improvements" (Holland, 1986). Given these geographical parameters, the individual species identified for these two scrub communities are indeed characteristic of natural riparian vegetation communities of the Ojai Valley. See species list (Table 3.1) for a complete listing of riparian plant species. Species composition is difficult to determine since site-specific controlling factors often dictate species presence/absence and relative abundance. However, an approximation of such parameters is as follows: Herbaceous, 0-15%; *Salix sp.*, 20-40%; mulefat, 10-25%; cottonwood, 0-20%; sycamore, 0-20%; barren, ~10% (Harris, 1999; Science Applications International Corporation (SAIC), 1995).

6.5 Goals and Objectives

Developing realistic goals and objectives is an integral part of any restoration project, in that it clearly defines and identifies the areas of focus. Goals and objectives should reflect the assessment of existing and desired stream corridor conditions and the prevailing political, economic and social values (FISRWG, 1998). Listed below are the primary goals for restoration of the Happy Valley Drain and the objectives necessary to achieve such goals.

Goals:

Goal 1: Enhance stream function and increase biodiversity.

Goal 2: Enhance visual appeal of riparian corridor.

Goal 3: Attenuate nonpoint-source pollutants from upland sources.

Objectives:

Objective 1: Artificially restore channel morphology consistent with stream discharge, drainage area and soil type.

Objective 2: Revegetate stream banks with native flora.

Objective 3: Monitor stream response to modifications to ensure establishment of proper channel geomorphology.

Objective 4: Protect stream bank from erosion until vegetation is well established.

6.6 Conceptual Model

Once the goals and objectives for enhancing the Happy Valley Drain were established, we identified the stressors that are working to degrade this riparian area, the effects they have on riparian ecological processes, and methods or actions to alleviate the impact of the stressors. This information was organized into a conceptual model of site ecology and enhancement design. The major stressors are channelization and removal and abatement of streamside vegetation. Other stressors include direct human disturbance, runoff and pollution. See Figure 1.6 for conceptual model.

Channelization of the Happy Valley Drain has essentially simplified a complex ecological system. Channelization removes many of the physical features, such as riffles, pools, meander bends, gently sloped banks and point bars, which provide habitat to a variety of riparian animal and plant species. As a result, the particular plants, invertebrates and vertebrates that require these physical features for survival are lost. Through deepening of the channel, the ground water table of the adjacent floodplain is lowered (Brookes, 1987), thereby decreasing available soil moisture required by plant species. Additionally, the increase in stream slope, a direct result of channelization (Brookes, 1987), decreases the water storage function of the stream due to an increase in velocity that results in quicker downstream transport. Increased velocity also reduces the effectiveness of nutrient cycling and seed transport, and increases bank erosion and bed degradation, which further degrade the quality of stream habitat.

Removal and abatement of streamside vegetation also has severe, adverse effects on riparian ecosystems. Obviously, removal of vegetation will significantly impact and probably eradicate species that require the lost vegetation for habitat. More indirect impacts include stream bank instability and subsequent erosion, sedimentation and alteration of stream pattern (Brookes, 1987). Additionally, vegetation serves as food (carbon input) for detritivores, which in turn provide food for organisms of higher trophic levels. Woody debris supplied by streamside vegetation provides additional habitat via debris dams and subsequent pool formation. Vegetation is also critical for regulating in-stream light regimes, water temperature and potentially harmful pollution fluxes (Bunn et al., 1997; Fennessy and Cronk, 1997; Osborne and Kovacic, 1993).

6.7 Development of Management Plan

We recommend specific management actions that will eliminate the stressors and their impacts on the Happy Valley Drain riparian corridor. Although constraints exist that prevent complete elimination of all stressors and therefore full restoration of the ecosystem, certain management actions will at least enhance the ecological integrity of the Happy Valley Drain. We suggest artificially constructing meander patterns and appropriate channel cross-sectional geometry (to the extent possible), and revegetating stream banks. Although these actions will need to be implemented subject to the given constraints, they will partially or completely eliminate some stressors (i.e. channelization and devegetation) and significantly attenuate the impacts of others (i.e. pollution, runoff, and low native species recruitment).

6.7.1 Restoring Channel Morphology

Returning a stream channel to "pristine" conditions is often impossible due to lack of data, land use changes within the watershed, or other policy-oriented constraints. The Happy Valley Drain cannot be returned to such a condition for all of these reasons, but particularly because of constraints imposed by the VCFCD. The flood conveyance characteristics of the Happy Valley Drain must remain the same in order to provide flood control assurance, as specified by the local county district. Therefore, ecological function can only be enhanced to the extent that it does not reduce the channel's flood capacity (i.e. discharge for a 100-year recurrence interval). The depth (1.5 m) cannot be altered since that would require raising the bed of the entire channel, which is not possible. This essentially precludes the channel from properly interacting with the adjacent floodplain. Therefore, our restoration recommendations will not completely de-channelize the stream. However, channel width, bank slopes, vegetation cover, sinuosity and therefore slope can be modified to develop a stream corridor that is more "natural" than what currently exists. Such modifications will serve to achieve the goals and objectives (Section 6.6) of this restoration effort by enhancing channel visual appeal and habitat quality, and increasing overall biodiversity.

To re-establish aquatic and riparian ecosystems successfully, restoration efforts must recreate the physical conditions needed to maintain natural communities, including substrate, water depth and velocity, inundation frequency, and temperature (Gore, 1985; NRC, 1992). Channel and floodplain geomorphology constitute the framework within which these conditions can exist (Kondolf and Larson, 1995). There are three general approaches to the restoring stream geomorphology (Morris, 1995). The two simplest methods are based on mimicking channel geometry from either historical data or a nearby stream with similar slope, drainage area, soil type, and discharge regime. It is often impossible to achieve historical stream corridor conditions because the former geometry may be unworkable under a new discharge regime and altered watershed conditions (Morris and Moses, 1999). The reference stream approach usually poses similar problems; given the pervasive nature of land use disturbance, most nearby streams probably possess disturbed hydraulic geometry themselves (Morris, 1995). The third approach, and usually the most successful, infers channel cross-sectional dimensions and planform from design discharges (Morris, 1995; Williams, 1986).

We used this last approach of inferring the restoration design from design discharge. The design discharge was calculated to equal the bankfull discharge for the portion of the Happy Valley Drain that bisects the Preserve. The term bankfull discharge refers to the level of discharge that fills the channel to the top of its banks where water begins to overflow onto the floodplain (Rosgen, 1996). Using a flood frequency analysis, Dunne and Leopold (1978) have determined the recurrence interval of bankfull discharge to be 1.5 years. It is this regularly occurring event that governs the overall shape and size of the channel. Although great erosion may occur during larger flood events, it is the modest flow regime that transports the greatest quantity of sediment over time, because of the higher frequency of occurrence for such events (Wolman and Miller, 1960).

We derived of a bankfull discharge of 3.2 m^3s^{-1}, which was based on a 24-year historical peak flow summary conducted by Ventura County Flood Control. This information was generated at the Rice Road gauging station (#633), which is located downstream from the Preserve and corresponds to a drainage area of 4.14 km^2 (VCFCD, 2000). This area is 78% larger than the 2.33 km^2 drainage area for the stream reach located on the Preserve. However, gauge data do not exist for this particular reach, and therefore it was necessary to infer discharge levels from data at the Rice Road station. Since land use for both drainage areas is similar, we assumed a linear relationship for discharge, and therefore estimated the gauged discharge levels to be 78% larger than those of the Preserve's reach.

Bankfull discharge was then used, along with other stream parameters, to determine cross-sectional and meander geometry for the restored channel. Although many of the channel dimensions will not be modified due to flood conveyance constraints, it is necessary to calculate bankfull, cross-sectional geometry in order to determine meander geometry. We used the Manning equation to derive cross-sectional geometry at the bankfull stage. These results were used (using semi-empirical equations by Leopold and Wolman (1960)) to determine appropriate meander characteristics that are indicative of natural, undisturbed lotic systems. The Manning equation was developed in 1889, and is the primary equation used to determine hydraulic capacity for open channels (French, 1985). The equation is designed for steady state flows, which unfortunately is not characteristic of the Happy Valley Drain or most California streams. However, since historical records are sparse and reference reaches are not available or appropriate, it remains the only viable option for estimating the channel geometry of the Happy Valley Drain. Therefore, one must be wary of the simplistic nature of the Manning equation and acknowledge potential uncertainties when conducting the restoration.

Manning Equation (1-2) and derivations thereof (3-6) (French, 1985):

1) $Q = VA$

2) $V = 1/n\, R^{2/3}\, S^{1/2}$

3) $R = A/P$

4) $A = y/2\, (b + T)$

5) $P = b + y\, [(1 + z_1^2)^{1/2} + (1 + z_2^2)^{1/2}]$

6) $T = b + y (z_1 + z_2)$

Where Q = discharge ($m^3 s^{-1}$), V = average velocity ($m s^{-1}$), R = hydraulic radius of the flow cross section (m), A = Flow cross-sectional area (m^2), P = wetted perimeter (m), T = top width of the flowing water (m), S = slope of channel bottom, n = Manning roughness coefficient, y = average water depth (m), b = channel bottom width (m), z_1 and z_2 = side slopes of each channel bank.

Initial measurements for bankfull, channel geometry were estimated or measured on site so that the Manning equation could be employed to derive channel top width (basis for meander geometry) and discharge (to verify estimated dimensions). Mean stream bottom width was measured onsite at 3.6 m. However, we recommend a width of 2.3 m in order to better emulate a natural channel. Given the proposed bank slope changes, a 2.3 m bottom width will still provide the required flood conveyance. Based on current topography, the slope coefficient for the newly constructed channel was estimated to be 0.004. The Manning roughness coefficient (n) was determined to be 0.035, which is appropriate for a channel containing weedy grasses (n = 0.03), light brush (n = 0.05) and clay loam soils (n = 0.02) (French, 1985). Estimating an appropriate water depth was difficult because it can vary dramatically depending on other interrelated variables such as slope, roughness, bank slope, hydraulic radius, and cross-sectional area. Literature presented by Brookes and Shields (1996), Morris and Moses (1999), Rosgen (1996) and Williams (1986) provided information regarding bankfull channel depth for streams with similar discharge regimes, drainage areas, and soil types. Based on these data, a mean water depth was first estimated at 0.7 m and then later changed to 0.57 m (explained below). Desired stream bank slope was determined to be 3 for convex bends and 1 for concave bends (Riley, 1998; Morris and Moses, 1999).

Proper channel geometry is based on the bankfull discharge level (Dunne and Leopold, 1978; FISRWG, 1998; Morris and Moses, 1999; Rosgen, 1996), which in this case is 3.2 $m^3 s^{-1}$. Therefore, bankfull discharge, stream bottom width, depth, roughness, slope, and bank slope were entered into an Excel spreadsheet (equipped with the Manning equation) to derive bankfull values for top width, cross-sectional area, wetted perimeter, hydraulic radius, velocity and calculated discharge. The depth value was decreased until the calculated discharge equaled $3.2 m^3 s^{-1}$, or bankfull discharge. Deriving this discharge value indicates that our estimated dimensions are indeed consistent with the bankfull stage.

Since bankfull top width dictates the planform of a natural stream (Leopold and Wolman, 1960), we used the calculated value of 11.48 m to determine appropriate meander characteristics for the Happy Valley Drain. We used the equations for meander characteristics provided by Leopold and Wolman (1960), which are often used in channel restoration design (Rosgen, 1996).

Leopold and Wolman equations (1960):

(1) $\lambda = 10.95W^{1.01}$

(2) $A = 4.48W^{1.02}$

and

(3) $R_c = 2.59W^{1.01}$

Where λ = meander wavelength (m), W = bankfull channel width (m), A = amplitude (m), and Rc = radius of curvature (m).

The equations are based on empirical relationships developed for regions that are not exactly similar to the Ojai Valley. Reliance on these equations has resulted in failure of some stream restoration designs because of either excessive erosion or sedimentation (Rinaldi and Johnson, 1997). However, the prevailing recommendation in available literature suggests using the Leopold and Wolman equations with the understanding of inherent uncertainty (FISRWG, 1998; Riley, 1998; and Rosgen, 1996). We suggest verifying the slope coefficient once an engineering team has decided on the exact meander path. The estimated value of 0.004 was based on a cross reference of the current slope of approximately 0.009 and the calculated meander geometry. The current slope value was based on channel data from the VCFCD and the topographical survey that we conducted during the baseline data collection stage. A realized value that is significantly larger or smaller than 0.004 will affect the calculated cross-sectional dimensions, including top width, and therefore the overall suggested planform. However, once a spreadsheet is developed, parameter values can easily be changed, generating instantaneous calculations.

Due to the fact that the Happy Valley Drain will not be restored to a natural state of equilibrium, the accuracy of calculated and estimated dimensions is not critical. Bankfull top width was calculated only for reasons pertaining to revegetation, which will be discussed below, and to determine channel planform that is consistent with the discharge regime of the Happy Valley Drain. Since this stream will not flood its banks at the bankfull stage, as would a natural stream, slightly inaccurate dimensions will not affect its hydrological and ecological integrity. The sinuous channel is suggested for aesthetic and ecological reasons, which would not be compromised by marginal errors regarding overall planform. Table 6.1 shows the proposed channel cross-sectional and planform dimensions for the restored reach at bankfull discharge. See Figure 6.1 and 6.2 for schematic of meander and cross-sectional geometry, respectively.

6.7.2 Stream Bank Stabilization and Revegetation

A newly constructed channel is extremely susceptible to erosion and subsequent stream bank failure (Brookes, 1987). Therefore, it is imperative that as soon as the new course is completed, the exposed banks are protected with artificial revetments and vegetation. Stream bank revetments are often used to stabilize constructed outer (concave) bend banks, especially those with highly erodible soils (Morris and Moses, 1999). Due to the soil characteristics (sandy, clay, and silty clay loam) and potential high-flow velocity (1-3 $m\ s^{-1}$) of the Happy Valley Drain, revetments are recommended for the outer bend banks. Vegetation is also necessary to effectively stabilize the banks of the entire channel, regardless of their association with concave bends. In addition to bank stabilization, revegetation will provide for both aesthetic and habitat improvements for reasons discussed in section 6.7. Vegetation is both economical and a highly desirable stabilization method (Brookes, 1987), but it requires considerable time to become well established. Therefore, precautions must be taken to ensure bank protection and stability until vegetation is established. At least two growing seasons are required to establish a dense cover for most grasses and five years for appreciable growth for most woody species (Henderson, 1986).

Temporary erosion control treatment is often required until vegetation becomes established. This includes structural protection, geotextile fabrics, brush mats, brush layering techniques, and even wood chips and sawdust. Many riparian restoration projects often employ structural protection (revetments) of the bank toe with vegetation on the upper bank (Henderson, 1986; Riley, 1998; Morris and Moses, 1999). Discussed below are several stream bank stabilization options and recommended methods for planting, post-project monitoring, and measuring performance. These methods were compiled from successful riparian restoration projects and available literature (Morris, 1995; Morris and Moses, 1999; Riley, 1998; Brookes, 1987).

Stream bank Revetments

Traditional methods of providing structural integrity to stream banks involve installing concrete and riprap. The popularity of concrete liners is waning as citizens and policy makers are seeking more aesthetically pleasing and biologically compatible stabilization methods. Riprap consists of natural rock or quarry stone and is hand-placed against stream banks at localities subject to scouring (Brookes, 1987). This method is relatively simple and easy to install, and is therefore still widely practiced. However, increasingly, restoration practitioners are using softer bank treatments for both aesthetic and habitat value (Morris, 1995). Just as riprap was preferred over concrete, "soft" stream bank revetments are now preferred, in most cases, over riprap. Although we suggest using "soft" bank revetments, the benefits and shortcomings of riprap will be briefly discussed so that all options are presented.

Riprap

Installing riprap is less time consuming and less costly than other revetment methods. For example, one person operating a tracked excavator can cover about 60 m of stream bank in about 10 hours (Morris and Moses, 1999). Moreover, this method can be employed using low-skilled or volunteer labor if mechanical equipment is not available or too expensive. Maintenance is easy, in that replacement of rocks is straightforward and can usually be accomplished via hand placement by one person.

Riprap is relatively compatible with flora and fauna due to the fact that it provides a stable substrate for benthic invertebrates, and vegetation can become established between stones. However, riprap is criticized as blight on the landscape that is not consistent with the "natural" look of the stream. Additionally, the structural component of riprap is said to cause other types of erosion (Riley, 1998). Stream currents are deflected off the hard stone surface, creating eddying that erodes the stream banks both up and downstream of the riprap (Riley, 1998). Due to the prevailing criticism of riprap and the success of other types of revetments, we recommend the use of softer methods to stabilize the stream banks of the Happy Valley Drain.

"Soft" stream bank revetment methods

Structural revetments are necessary at concave bends of restored reaches due to the extreme scouring and erosion that occurs in these areas. Vegetation alone is fully capable of protecting against bank erosion, but structural revetments are needed until the vegetation becomes well established. We advocate using a combination of revetments at the bank toe with planting of native vegetation above. There are three major types of "soft" stream bank revetments (brush piles, trees and rootwads), as described by Riley (1998).

Brush piles:

The use of brush piles to protect stream banks by reducing erosion was reintroduced by George Palmiter in the 1980's. Installation involves driving wood posts into the ground (1 m apart) along the stream bank, placing piles of brush between the posts, and stringing wire in a criss-cross fashion between the posts to cable the brush against the stream bank. This method is the most low-tech and least costly, but provides only marginal protection against high flows, and is therefore recommended only for very small streams.

Trees:

Tree revetments essentially provide the same function as brush piles, but are generally more successful at reducing velocities, binding soil and protecting banks. They have been widely used by the Missouri Department of Conservation in Jefferson City and in other restoration projects (Morris and Moses, 1999). For these reasons we recommend using tree revetments to protect vulnerable banks of the Happy Valley Drain. This method involves cabling whole trees (branches intact) against the stream bank, strung in a line along outer banks or bank erosion zones. It is recommended that trees be cabled using Duckbills®, a product of Foresight Products, Inc., Commerce City, Colorado. Evergreen trees are recommended over broadleaf trees since they work better to increase roughness and collect sediment and debris. Live cuttings (willow or cottonwood) are then driven through the revetments and into the soil to further reduce velocities and promote the growth of riparian plant communities. The live cuttings will eventually take root and sprout, thereby eliminating the need for the artificial revetments. In addition sediment will collect along the cabled trees, which will promote voluntary plant growth. A regular inspection of the structures is necessary to ensure that loosened trees and cables are tightened. This is especially important after storm periods. Reference Riley (1998), pages 365-368, for specific installation instructions.

Rootwads:
Rootwads are tree trunks that are uprooted with their roots attached. They are often placed along channel banks in combination with vortex rocks to provide greater structural support. This method is effective at reducing erosion and is often used by Dave Rosgen in his restoration projects. However, tree revetments are recommended over rootwads since they are easier to obtain and install, equally as effective, and do not involve large, heavy vortex rocks.

6.7.2.1 Biotechnical Slope Stabilization
Biotechnical slope stabilization or soil bioengineering refers to the use of plant-based systems for stream bank or slope restoration (Riley, 1998). Slope stabilization strategies are necessary where a new slope has been constructed. In the context of the Happy Valley Drain, we have recommended reducing the slope of the stream banks to avoid soil losses to erosion, and allow for effective recruitment of plant species. Therefore, soil bioengineering systems are recommended to stabilize the banks, thereby reducing the probability of high flows destroying the newly constructed slopes and meanders. Soil bioengineering systems are composed of live and/or dead plant materials that are arranged in a way that provides an immediate structural component, which provides long-term slope protection (Riley, 1998).

There are conflicting data regarding the most effective stabilization methods and combinations thereof. However, after careful examination of literature and restoration projects, we suggest using the methods discussed below. There are three major categories of soil bioengineering (fascines, brush layering and brush matting) as described by Riley (1998). However, since fascines and brush matting are recommended for low flow areas or streams with drainage areas less than 1.3 km^2, we will only discuss the brush layering strategy.

Brush layering
This method works well in the bankfull zone or in areas subject to high flow. It involves layering cuttings of live brush on terraces cut perpendicular to the slope. The brush is covered with soil so only the growing tips protrude from the soil. This greatly increases stream bank roughness, which reduces velocity and erosion. Moreover, the plant material will eventually take root and produce a well-vegetated bank. This is more effective than conventional seeding since the brush provides instant protection and produces more groundcover in a shorter amount of time. However, brush layering is labor intensive, and is therefore recommended only where necessary (i.e. the bankfull zone). Reference Riley (1998), pages 378-381, for specific installation instructions.

Geotextile fabrics
Geotextile fabrics are often used in conjunction with biotechnical slope stabilization methods (Morris and Moses, 1999). These fabrics are woven netting of either natural

or synthetic fibers, which are fastened to exposed soils to help protect from erosion (Riley, 1998). Natural fibers, such as jute, cotton, sisal or coir, are recommended over synthetic fibers since the latter are not biodegradable. Coir fabrics have shown to be the most durable and successful in areas of high flow.

6.7.2.2 Revegetation

Vegetation is necessary to stabilize stream banks, improve habitat quality and increase biodiversity. We recommend establishing vegetation communities that emulate natural, undisturbed systems characteristic of the Ojai Valley. See Table 3.1 for plant species targeted for restoration.

Plants and plant material can be obtained from other sites (often free) or nurseries and companies specializing in restoration. However, when buying plants from commercial suppliers, one must ensure the plants are grown from local stocks. Local populations of plant communities evolve genetic characteristics that allow them to survive site-specific environmental conditions. Seeds, plants or cuttings should therefore be genetically adapted to the prevailing conditions of the site. We recommend collecting seeds and plant material from the Preserve itself or immediate surrounding area, and working with local plant distributors who have knowledge of local, ecological conditions. Growing Solutions, a small company located in Santa Barbara, CA, is highly recommended due to their local proximity, available resources and competitive prices.

The willow species, mulefat and Fremont cottonwood can be planted as cuttings, which facilitates growth and increases survival probability, whereas the remaining species are often planted as rooted plants (California sycamore) or seeds (herbaceous under story). Cuttings allow for rapid establishment and provide immediate structure and stability to banks even before rooting by reducing the velocity of flows.

Installing Cuttings

All information and techniques for installing cuttings were taken from literature contained in Riley (1998).

Collection and Preparation

Generally speaking, 4-5 truckloads (3/4 ton) of plant material are needed to properly revegetate 30-60 m of stream bank. Therefore, it is necessary to identify a source with large quantities of mulefat, cottonwoods and especially willows. A considerable portion of the required cuttings will probably have to be obtained from a commercial dealer. Cuttings should be 2.5-7.5 cm in diameter and 0.5-1 m long. Larger cuttings, often referred to as “poles,” can be as larges as 15 cm in diameter and 3 m long. Poles are more difficult to install, but provide more structural benefit, especially at the stream bank toe. They also have greater success of survival due to their ability to store more water and energy until developing root systems. Poles may also be effective in upper bank areas since their length allows them to get closer to ground water. Cuttings and poles must be placed in creek water or buckets of water upon arriving at the restoration site. Sharpen the butt end of the cuttings or poles so that it is pointed. This will identify the planting end and prevent upside down installation and make it easier to drive the cutting into the soil.

Installation
Make a hole with rebar or digging rod, place cutting in hole and lightly tap it in with a mallet. For extremely soft or wet soils, cuttings can be hammered into ground without preparing a hole. However, avoid splitting the cutting or stripping the bark since this will hinder rooting and sprouting. This underscores the importance of digging a hole of appropriate size. Bury approximately 4/5 of the cutting to ensure close proximity to groundwater. Arrange cuttings in a random pattern of 2-4 per m^2 (or at least 0.6 m apart). Poles are installed in similar fashion, but a 2x4 board should be placed on top of the pole while hammering. This will keep it from splitting, thereby increasing its survival probability. After hammering, saw off the damaged top few inches. To speed up the process, a power auger or an excavator with a steel ram can be used to dig holes and install poles.

Seeding
The plant species that comprise the herbaceous understory (*Carex barbarae, Urtica holosericea,* and *Pluchea sericea*) should be seeded by hand. Seeds should be applied liberally and broadcasted over the entire bank.

Upper bank plantings
The identified canopy plants (*Plantanus racemosa, Salix gooddingii, and Populus fremontii*) should be planted on the upper portion of the stream bank. These species will grow above the woody under story and provide shade for the stream, which in turn will limit in-stream plant growth. Regulation of sunlight is one major function of a riparian tree canopy that serves to limit excessive proliferation of in-stream macrophytes. These plants can choke stream channels, thereby reducing available oxygen and exacerbating flooding. This is one major reason why the VCFCD has historically applied herbicides to the Happy Valley Drain. However, a well-functioning canopy will obviate the need for such practices (Ferren, pers. comm., 2001). As mentioned before, the willow and cottonwood can and should be planted as cuttings or poles, whereas the sycamore must be rooted prior to planting (Riley, 1998). Since the groundwater depth is significantly greater along the upper bank, willow and cottonwood poles (as opposed to cuttings) are recommended. Poles will have greater success of survival than would cuttings since their length allows them to get closer to ground water.

6.8 Implementation
Implementing the restoration plan is perhaps the most difficult aspect of any restoration project. During this phase, unexpected weather conditions, permit requirements, funding problems and labor shortages can result in significant time delays. This poses problems for riparian restoration since construction opportunities are often dictated by seasonal flow rates. Channel construction should begin in mid-July or the beginning of August, which coincides with the period of lowest discharge (Morris and Moses, 1999). This should provide adequate time for channel

construction and bank stabilization/revegetation prior to winter flows. This will allow for easier implementation and eliminate the need for any type of bypass system.

A backhoe is necessary for channel construction since large quantities of soil will be moved and strategically placed during meander and stream bank construction. Channel planform should be mapped in accordance with the calculated measurements for wavelength, amplitude and radius of curvature listed in Table 6.1. Depending on the chosen channel path, it may be necessary to remove several eucalyptus trees. As mentioned before, at this time, the slope value for the new channel (0.04) should be verified so that, if necessary, the Manning equation can be re-calculated and appropriate changes made. Measurements for cross-sectional channel geometry are also listed in Table 6.1. Construct the trapezoidal channel according to these dimensions, keeping in mind that natural channels do not maintain consistent geometry. Stream channels vary in their dimensions over long distances. The values listed in Table 6.1 are only mean values and should be treated as such.

Once the channel has been constructed, stream bank revetments should be installed. This process (construction of channel and revetments) should be completed within 6-8 weeks depending on equipment and labor availability (Morris and Moses, 1999). Although several methods have been described, we recommend using tree revetments for reasons discussed above. Tree revetments should be installed along concave bends (outer bends) at the toe of the slope.

The next step involves further bank stabilization and revegetation. We recommend using the brush layering technique to stabilize the banks along concave bends immediately above the revetments within the bankfull zone (or a stream height of 0.57). Brush layering could be utilized to protect all slopes within the bankfull zone, but this would significantly increase labor and equipment costs and is probably not necessary. All other exposed banks should then be seeded with an herbaceous groundcover mix (See Table 3.1 for appropriate species), planted with live cuttings and covered with geotextile fabrics. The proper sequence of implementation is obvious: seeding, geotextile fabrics, cuttings. When fastening the geotextile fabrics, use biodegradable fasteners versus wire staples. The fasteners provide far more holding ability and pose fewer hazards to people (Morris and Moses, 1999). Mulefat cuttings should be planted on the lower portion of the stream banks (Ferren pers. comm., 2001) since they require more water and can withstand longer periods of inundation. All willow cuttings, excluding Gooding's willow (canopy species), can be planted anywhere on the bank. Attempt to have equal representation of the different willow species when planting. The cuttings should increase in length with increase in bank height to ensure survival. As mentioned earlier, poles should be used for the top portion of the stream bank (See upper bank planting). Refer to section 6.7.2.2 for installation instructions. Be aware that vegetation planted high on the stream bank may be susceptible to desiccation since the channel is approximately 1 m higher than it would be under pristine or natural conditions. Therefore, it might be beneficial to wait one full water year before installing expensive rooted plants or large, hard to find poles on the top or near the top of stream banks. This will allow adequate time to assess near-surface groundwater conditions following restoration.

6.9 Monitoring

Design and implementation are only parts of the complete restoration process. Despite the increasing commitment of resources to stream restoration, post-project evaluation has generally been neglected (Kondolf and Micheli, 1995). This stage is essential to the success of the restoration project and the science of riparian restoration itself. Systematic monitoring will highlight potential or realized project failures, signaling for a change in the management or restoration strategies being employed. Monitoring should extend over a period of years (minimum of a decade) in order to capture relevant changes and ensure successful implementation of management actions. See Table 8.5 for complete monitoring schedule.

We recommend placing greater emphasis on monitoring geomorphic (versus biological) characteristics of the restored reach. This is based on the understanding that interactions between the stream channel, floodplain, and stream flows provide the framework supporting aquatic and riparian structures and functions (Kondolf and Micheli, 1995). Recent studies in water quality monitoring have suggested that measurement of geomorphic channel characteristics may prove a cost-effective indicator of overall watershed condition (MacDonald et al., 1991; Kondolf and Micheli, 1995). We want to stress the ability to infer biological condition from geomorphic data, whereas a reverse flow of information is not as illustrative. In this section, we provide monitoring parameters and techniques for determining project success.

Pre-Project Monitoring

We recommend collecting additional riparian data prior to commencing restoration construction. Given our time constraints, we were not able to gather substantial data pertaining to water quality and aquatic fauna (particularly macroinvertebrates). Since one of the goals of restoring the Happy Valley Drain is to attenuate non-point source pollution, knowledge of baseline water quality is necessary so that comparisons can be made to post-project water quality samples over time. This will illustrate the level of water quality improvement attributed to restoration. Additionally, pre-project data on aquatic macroinvertebrate abundance and diversity should be collected in order to evaluate restoration success regarding species diversity.

Macroinvertebrate presence and abundance are important criteria for assessing overall stream health (Rosenberg and Resh, 1993). Benthic macroinvertebrates are indicators of community richness and diversity, and can be used to calculate biotic indices that serve as integrators of water quality (Rosenberg and Resh, 1993). Therefore, pre-project baseline data should be collected in order to determine the degree of post-project improvements in biodiversity. Additionally, appropriate methods for data collection and post-project monitoring should be assessed and established prior to restoration.

6.9.1 Cross-section surveys

Repeated cross-section surveys are a well-tested tool to detect changes in channel dimensions and overall planform (Kondolf and Micheli, 1995). For this reach, a network of monitoring points should consist of 10-15 cross sections located 2-5 channel widths (bankfull width or 11.48 m) apart (Kondolf and Micheli, 1995). Attempt to position cross sections at the apex and crossover points of each meander bend. Cross sections should be marked with fence posts, metal plates set in concrete, or marks chiseled into boulders.

To detect changes in channel form, stretch a tape across the channel and secure it at the apex of the convex bend and measure at 3-5 different points on the opposite side of the channel (Kondolf and Micheli, 1995). This will indicate any changes in meander wavelength and radius of curvature. Cross-section monitoring should also include an assessment of revetment structures, bank slope stability, and measurements of channel width and height. Cross-section surveys serve to ensure that channel dimensions and overall planform remain stable (Kondolf and Micheli, 1995). It is expected that the channel will migrate over time, but its general meander and cross-sectional geometry should remain relatively constant.

6.9.2 Riparian vegetation

Monitoring vegetated areas is extremely important given the level of proposed revegetation. The objective of vegetation monitoring is to document establishment and growth of planted species, and to evaluate the need for weed control, irrigation, protection from herbivory by domestic wildlife, replanting, and additional erosion control activities (SAIC, 1995).

Monitoring should be conducted via transects, which can simply be extensions of channel cross-sections, provided that vegetation is not disturbed during the survey (Kondolf and Micheli, 1995). Transects aligned in this fashion will best illustrate transitions in vegetation types due to difference in elevations and resultant depth to water table and inundation frequencies (Kondolf and Micheli, 1995). Important monitoring variables for determining the success of vegetative restoration include percent cover, species presence, relative abundance, size and vigor.

Persistent, weedy species that may interfere with revegetation goals should be the focus of weed control efforts (SAIC, 1995). A list of common invasive species is shown in Tables 9.1 and 9.2. Since we do not advocate the use of herbicides, manual weeding is the only option for eradicating invasive species. These species along with their roots should be removed immediately to prevent proliferation and competition to natives.

Revegetation success should be measured via performance criteria that draw upon reference conditions. The goal is to achieve, within a specified time period, species composition representative of undisturbed, natural conditions (See Reference Conditions, section 6.5). The restored area should attain 75% cover approximately after 3 years, and 90% cover after 5 years from planting date. Cover by weedy species should be at a minimum (no greater than 10% of the restored area). Trees should be able to withstand normal seasonal droughts and flooding.

6.9.3 Water quality

Since runoff is entering the Happy Valley Drain upstream and this project is of limited size, it may be difficult to measure specific improvements in water quality. Water quality benefits are most effectively realized when stream restoration is incorporated into an overall watershed management plan (Kondolf and Micheli, 1995). However, water quality measurements could provide educational opportunities regardless of the level of improvement. For efficiency, water quality sampling stations can be located at the cross-sections established for geomorphic monitoring.

6.9.4 Aquatic organisms

We recommend sampling macroinvertebrates as a means of measuring improvements in overall biodiversity. Sampling benthic macroinvertebrates can characterize community richness, diversity, and abundance and can be used to calculate biotic indices that serve as integrators of water quality (Rosenberg and Resh, 1993). Similar to water quality monitoring, sampling stations for aquatic organisms should also be located at identified cross-section locations (Kondolf and Micheli, 1995). Monitoring results should be compared to pre-project and post-project samples to detect increases in biodiversity.

6.9.5 Frequency

Cross-section surveys should be conducted at least once a year, particularly after large flood events (Kondolf and Micheli, 1995). During the first year, monitoring of post-project conditions is recommended after every high flow event. This will allow potential shortcomings in project performance to be recognized early. After the fifth year, monitoring frequency can be reduced to once a year unless a major flood event occurs.

Similar to cross-section surveys, vegetation monitoring is very intensive. The first three years, and especially the initial year, are the most critical since survival rates will become evident during this time. Low survival rates are a signal to change planting techniques and continue revegetation so that banks are not exposed for long periods of time. Monitoring during the first three years should include general, visual surveys focusing on establishment of planted species and identifying potential weed problems, as well as specific documentation of plant species presence/absence, abundance and vigor. The former type of monitoring should be conducted in the months of February/March and May/June of the first year, and only in May/June of the second and third year. The latter type of monitoring (specific documentation) should be conducted every year during the months of September/October. See Table 8.5 for complete monitoring schedule.

Water quality monitoring should be conducted at least once a season, and after major storm events. More frequent monitoring is recommended during the first two years after restoration. Monitoring of macroinvertebrates should be conducted at the same frequency as water quality. However, monitoring after major storm events is not equally as important.

7.0 EDUCATION AND RECREATION PLAN

The development of education and recreational opportunities are integral components of the restoration plan. Providing well-designed trails, volunteer programs, and interpretive features on the site will foster support from the community and minimize negative impacts of visitor use. The education and recreation plan includes opportunities for community awareness and involvement, construction of onsite educational features, development of school programs and activities, the creation of a trail system and debris removal measures.

7.1 Community Awareness and Involvement

The OVLC currently uses educational brochures, media and the Internet to inform the public about the Preserve. The OVLC should take additional actions to promote community awareness regarding development of the plan and provide opportunities for involvement. We recommend that the current efforts be expanded to include guided nature walks and partnerships with other local environmental organizations such as the Audubon Society.

Hands-on experience is an ideal way for citizens to “get in touch” with nature (Burke et al., 1988). The development of a volunteer restoration and monitoring program for the Preserve will provide additional “hands-on” opportunities for the community. The implementation, monitoring, and maintenance sections of this report can be used to develop a program for volunteer involvement.

7.2 Onsite Educational Features

Interpretive panels and placards should be placed along the trails to educate the community about the types of habitats being enhanced or created, what people can do to minimize their impact on these habitats and techniques used to establish these habitats. In addition, the design and location of trails should be structured to provide increased educational opportunities. For example, a raised bridge across the wetland allows access to areas that will then appreciate the complexity of the ecosystem (Burke et al., 1988).

A demonstration garden and a greenhouse constructed on the site can promote citizen appreciation for native flora of the area. This will serve as a place where students and citizens can assist with the propagation of native plants. Interpretative signs in the garden should include basic botanical identification and habitats in which the plants are being established on the Preserve. The demonstration garden and greenhouse can also serve as a field classroom where students can observe plant development. In addition, it is important to keep track of onsite plants and their original seed source.

The following are suggestions of additional onsite features that can provide environmental education opportunities:

- A viewfinder to view birds and habitat areas that are far away from trails

- Sample restoration plots
- Flora identification tags

7.3 Education Opportunities for Students
The Ojai Unified School District (OUSD) received a three-year, $150,000 grant from the State of California in 1999. The grant enabled the OUSD to implement a kindergarten through twelfth grade service learning program at the Preserve, which will serve as an outdoor classroom. There are currently 18 classes involved in the program with many more to be incorporated. The grant has also helped to establish an environmental science class at Nordhoff High School. The class focuses on field studies and hands-on service learning. This year, the students of the environmental science class assisted with the baseline data collection for the restoration plan of the Preserve as well as other field projects in the Ojai area.

The Ojai Meadows Preserve is a unique learning environment for students because it is directly adjacent to Nordhoff High School and Meiners Oaks Elementary School (Figure 1.1). Students will have the opportunity to observe and study complex ecological environments. The restoration plan also offers an excellent educational opportunity for student involvement in implementation, monitoring and assessment. Monitoring and revegetation are two primary areas in which student participation can be an essential part of the restoration. Examples of field and classroom activities are described in Appendix B

7.4 Recreation Plan
The recreation plan should encourage low-impact activities such as walking, running, biking, and nature observation. Providing well-designed trails and waste facilities are essential for the satisfaction of visitors as well as the success of the restoration.

7.4.1 Trails
Trails along the site boundaries have the least impact on the natural resources. They should be located in convenient access points to prevent development of unwanted trails. Well-designed trails will direct people away from sensitive habitat areas and encourage low-impact recreational use of the site. We have provided some guidelines for planning a trail system at the Preserve

Considerations for Planning
The type of terrain, microclimate features, public safety, and accessibility should be considered when determining trail substrate. Fine shale and gravel are appropriate trail substrates for moist areas. Wooden planks, raised wooden walkways, or tiles are necessary in low-lying areas prone to flooding. Wood chips and shredded bark make ideal substrates for dryer terrain (Ashbaugh and Kordish, 1971).

Educational objectives, restoration and recreational areas, and safety must also be considered when designing the trail layout (Ashbaugh and Kordish, 1971). Primary concerns of trail placement should consider the following:

- The trail will allow people and their pets to get closer to wildlife and natural resources on the site. This may potentially alter colonization, dispersion and animal behavior. A primary concern is that trails along restored habitats will be very disruptive due to the limited size of the restored area. Animals may not have an area to seek refuge from the perceived threat of humans. On the other hand, distancing trails from restored areas may tempt visitors to deviate from the trail and cause additional habitat disruption.

- Trails should be located away from plant species that may be affected by impacts of the trail. It has been shown that the root systems of some tree and plant species can be adversely affected by soil compaction on and around trail systems (Bhuju and Ohsawa, 1998).

- The trails need to serve as access ways for service vehicles that maintain infrastructure on the site and serve to control fire.

- Trails are vectors for exotic species invasion. Construction of trails with materials that prevent invasive species establishment may reduce long-term maintenance. For example, at the Del Sol vernal pool restoration site, the excavated hardpan clay, which reduces plant growth, was used to create elevated trails (Ferren, pers. comm., 2001).

There are many alternatives to meeting the challenges of the negative effects related to trails and trail building. In some places they may be raised off the ground to allow ground dwelling invertebrates, rodents, amphibians and reptiles to pass unimpeded (Hechinger, pers. comm., 2001). When on the ground, they can be lined with a substrate, which absorbs much of the compacting foot traffic and prevents soil erosion in the worn areas (Ashbaugh and Kordish, 1971). The subsoil from wetland and riparian excavation is an excellent trail material, because it is low in nutrients, which prevents plant growth and allows for the trail to be raised to reduce flooding (Hubbard, pers. comm., 2001). This reduces the cost of maintenance and the high costs of transporting subsoil offsite (Hubbard, pers. comm., 2001). Guardrails may be placed along the length of the trails to keep visitors from venturing out into sensitive areas (Ashbaugh and Kordish, 1971).

Site Specific Placement Concerns

Due to the dynamic nature of the landscape, trails should not be considered permanent features. Trails require continuous maintenance. Some general placement guidelines should be considered when planning a trail system for the Preserve. Using these guidelines, we have developed a potential trail system for the Preserve (Figure 3.3).

The central location of all trails should be at the eucalyptus memorial grove, crossing the riparian area at as few locations as possible. The riparian edge is a very species rich area in which species sensitive to disturbance are easily stressed. Many amphibian species complete their life cycle in the riparian area and are at high risk from human disturbance. Trails should not be placed near the Valley oak trees due to the possibility of it disrupting acorn dispersers and oak seedlings. Placement adjacent to the wetland should be along the sewer line to provide access to the manholes.

7.4.2 Waste Management

Waste on the site may have a negative impact on restoration areas. A key problem is pet waste, which can increase bacterial levels in adjacent streams and wetlands. Dog mitts and trashcans are currently located at the entrances to the Preserve. We recommend that additional trash and recycle bins be placed on the site in heavily used areas such as the eucalyptus grove.

8.0 INTEGRATION OF HABITAT RESTORATION PLANS

Although the habitat management plans provide needed guidelines for management techniques at the Preserve, it is important to understand how the individual habitat restoration plans interact. Due to the fact that constraints may preclude the simultaneous implementation of the developed habitat plans, we used a decision support tool to prioritize restoration efforts for the site. Furthermore, we integrated the plans in the context of implementation, monitoring and maintenance.

8.1 Ranking of Management Alternatives

Decision support tools provide a useful framework for ranking and prioritizing planning efforts. Values can be quantified and defined, which help to evaluate and compare various management actions. The process of applying decision support tools also leads to close examination and a greater understanding of the implications of different management choices (Guikema and Milke, 1999). The resulting decisions are based on clearly defined and accepted values.

To help the OVLC prioritize the restoration efforts at the Preserve, BORG developed a decision support tool, which ranks restoration options. The assessment metric provides a framework for evaluating management options based on the importance of selected criteria. Conservation, ecological services, recreation and costs were considered as key evaluation criteria. Importance values, defined for the selected criteria (Table 8.1), are quantified for each habitat restoration plan. The restoration priorities are then compared and evaluated through a simple weighting procedure.

Conservation values were defined by the regional protection status of the habitat. The status was determined from the California Southwestern Regional GAP analysis report (Davis et al., 1998). Recreational and educational opportunities used in the ranking evaluation include passive recreation, active recreation, and scientific study. Passive recreation is defined as unstructured activities, including nature observation and hiking, whereas active recreation includes structured, hands-on restoration activities that involve the community in the restoration such as planting native species. Scientific study includes educational opportunities for students and the community such as experimentation associated with adaptive management. Ecological services criteria are based on the combined services provided by all the habitat restoration efforts: biodiversity, flood attenuation, and improved water quality. Costs delineation was based on the anticipated initial, maintenance, and monitoring costs for restoring each habitat (Table 8.2). The cost estimations were derived through consultation with environmental professionals and government agencies and the use of the Property Analysis Record (PAR), a database developed by the Center for Natural Lands Management to calculate the costs of land management.

Two scenarios were developed to serve as examples of the analysis tool. The first scenario weighted conservation values highest and in the second scenario, ecological services values were given more importance. The top restoration priorities for the conservation scenario were the Valley oak and vernal pool restoration projects. Restoration of seasonal freshwater marsh and riparian habitats becomes more important when focusing on providing ecological services. Table 8.3 demonstrates the quantitative results of the metric analysis.

8.2 Site Implementation

The second tier in restoration planning is the development of a detailed implementation plan for the site. This should be based on the management priorities established using the metric analysis. Planning needs, implementation schedules, monitoring, and maintenance are important components of the integration. Guidelines for the development of a specific implementation plan are provided in the following sections.

8.2.1 Additional Planning Needs

Additional data and planning are needed to guide and refine proposed restoration actions. Planners are needed to develop specific designs and specifications for restoration, supervise site construction and initiate monitoring. Permits for site modifications can be acquired during this time.

8.2.2 Implementation schedule

We created an integrated, project time frame that incorporates the implementation schedules of the individual restoration plans in order to highlight common management needs of each plan. The time frame is a general guide that can be adjusted depending on the site priorities and delays such as unexpected weather, permit requirements, funding problems and labor shortages. An example of an integrated scheduling approach in which all habitats are equally weighted is shown in Table 8.4

8.3 Monitoring

The monitoring and evaluation stage is essential to the success of the restoration project and the science of restoration. Monitoring serves to ascertain the degree to which success criteria have been achieved. Vegetation, ecological services, and community involvement are indicators used to determine the success criteria of this plan. A suggested monitoring schedule for the site is shown in Table 8.5. Type, intensity, timing, and frequency of monitoring should be based on habitat type, success criteria and monitoring parameters. Data collection protocols should be simple and repeatable using accepted scientific and statistical procedures (Bauder et al., 1997).

8.3.1 Pre-project monitoring

Vegetation sampling, groundwater sampling, soil analyses, water quality sampling and a detailed topography map are major components needed to establish quantitative baseline measures prior to restoration. The sampling methods are described in the monitoring section. Measurements from the site and identified reference areas should be sampled for a full year prior to implementation. Baseline monitoring of reference sites is essential to ascertain the local variability.

8.3.3 Success criteria

We developed success criteria for the Preserve based on the overall goals of the project. The criteria are used to guide monitoring and evaluate data to assess whether project goals have been met and hypotheses tested.

Habitat:

- 60% cover of native plant species 5 years post implementation and >75% in 10 years
- Significant reduction (> 30% cover) of non-native species in 10 years
- Increase in bird diversity and use of the site

Ecological functions

- Reduce flooding of areas surrounding the Preserve.
- Increase in sensitive aquatic invertebrates, indicating improved water quality.
- Increase in native plant and animal diversity.

The community of Ojai Valley

- Increase in public awareness and appreciation of site ecology.
- Increase involvement of local students and Ojai community members in restoration, monitoring and other activities at the Preserve.

8.4 Maintenance

It is important to maintain the site following implementation. Maintenance involves long-term management of the site to safeguard restoration efforts and maintenance should be conducted throughout the duration of the project. Intensive maintenance of revegetation efforts will be required for a minimum of ten years following implementation (Mofatt and Nichol Engineers, 1997). After this time, maintenance will focus on general upkeep of the site.

Listed below are important considerations when developing a maintenance plan for restored sites:

- Supplemental watering and repairs to irrigation systems as needed (USFWS, 1999).
- Removal of non-native vegetation using appropriate methods (USFWS, 1999).
- Regular inspections to ensure that signage, trails and fencing are in good condition; repair and replace as needed (USFWS, 1999).
- Enforcement to reduce litter and vandalism.
- Continual removal of all excess debris
- Herbicides, fertilizers and road runoff should be controlled. Educate local homeowners about runoff from their yards, etc.

- Supplemental planting and should be done if the performance criteria will not be met in the designated time period
- Maintenance crews must be familiar with native plant seedlings in order to avoid destruction.

9.0 INVASIVE SPECIES MANAGEMENT PLAN

Invasive species management plays an integral role in the development, implementation and maintenance of restoration plans. Invasive species can have many different effects on vegetative communities including "alteration of ecosystem processes, displacement of native species, support of non-native animals, fungi, or microbes and alteration of gene pools through hybridization with native species" (Bossard et al., 2000). In order to meet restoration goals, invasive species management must be successful and maintained over time. Invasive species management includes prioritization of problematic species, control of infestations and long-term monitoring.

9.1 Identify and Prioritize Species that Interfere with Management Goals

Species onsite should be identified and mapped to determine location and size of infestation. BORG created a map indicating the dominant invasive species and locations of small infestations on the site (Figure 9.1). The map outlines the current occurrence of potentially problematic species such as *Arundo donax*.

After identifying species, it is important to prioritize them according to severity of impact on the site (Randall and Meyers-Rice, 1998). California Exotic Pest Plant Council (CalEPPC) has compiled various lists ranking invasive species that pose serious problems to wildlands. These lists provide a useful method for prioritizing species on small sites such as the Preserve. BORG recommends focusing weed control efforts on List A and B species. The highest priority should be given to List A species which are defined by CalEPPC as species that are "documented as aggressive invaders that displace natives and disrupt natural habitats," both widespread and regionally. Table 9.1 includes invasive species from List A, and Table 9.2 includes invasive species from List B. Species currently found on the Preserve are highlighted. Monitoring should include all species in List A and List B in order to limit future outbreaks.

9.2 Determine Control Techniques

Control of invasive species can be accomplished with physical, chemical and biological removal methods. The selection of the method depends on the size of the infestation, the biology of the species and site constraints. Chemical control uses herbicides that can kill or inhibit weed growth. Although this method may be successful for many invasive plants, we are discouraging the use of chemical agents due to the ecological damage and potential threat to human health. Biological control introduces natural animal predators, fungi or other microbes into the ecosystem that consume or parasitize invasive species (Bossard, 2000). Failures of this method far outweigh successes and only about one in six biological control experiments worldwide have been successful in eradicating non-native species (Hobbs and Humphries, 1994). We are not suggesting this method due to the size of the Preserve and the fact that the biocontrol agent becomes a harmful invader, leading to a new set of problems throughout the region. Physical control involves prescribed fire,

mulching, hand pulling and soil solarization. Many of these physical control methods are useful for controlling the non-native annual grasses onsite in addition to many of the small infestations of exotics. For the Ojai Meadows Preserve, physical control is the preferred method of weed management.
Methods for removing and managing List A species found on the Preserve are described below:

***Arundo donax* (Giant reed, giant cane)**
Arundo donax is native to the Mediterranean Basin and typically grows along riparian areas. Physical removal by hand pulling is effective for small infestations of plants that are less than 2 m tall. Since *Arundo donax* can resprout from underground rhizomes, all rhizome material must be removed to have successful eradication. At the Preserve, *Arundo donax* is growing along the drainage ditch entering the site from Maricopa Highway. The onsite population consists of a few scattered individuals that can be easily removed by hand pulling.

***Foeniculum vulgare* (Wild fennel)**
Fennel, native to southern Europe and the Mediterranean region, commonly colonizes disturbed grassland and riparian areas throughout California (Bossard et al., 2000). Individual plants can be dug out, making sure the entire root is removed because shoots can re-grow from roots (Bossard et al., 2000). Small patches of fennel are found near the Happy Valley Drain at the Preserve, and hand removal is recommended.

***Eucalyptus globules* (Tasmania blue gum)**
Native to Australia, *Eucalyptus globules* grows throughout California and is often planted as windbreaks in agricultural settings. This tree species takes up large amounts of water and produces toxic phenolic compounds that inhibit growth of understory species (Del Moral, 1968). A windrow approximately 200 m long of blue gum eucalyptus is growing on the site along the drain entering from Krotona Hills. Removal of the windrow and other blue gums scattered throughout the site is proposed by the OVLC (Magney, per. comm., 2000). The OVLC plans to remove these trees prior to revegetation activities.

A professional arborist or contractor generally handles the removal of such trees. The method is to first “top” the trees to reduce their height and then chop them down to a stump. The stumps can be either removed or left in place to provide bank stabilization and reduce soil disruption. Given the proximity of the eucalypti to the riparian and wetland restoration efforts, BORG recommends that herbicides not be used in the removal effort. Eucalypti are persistent trunk sprouters; therefore if the stumps are left in place, measures to prevent stump re-growth must be taken. This method involves the removal of the cambium from the stump down to the ground. Tools such as axes can be used to ‘cut’ this layer off the stump. Stump re-growth can be controlled with the application of surfactant free, registered for use near water, herbicide.

Removal of adult trees should be undertaken at the end of the last spring rains. The drought of the summer may create a more stressful environment for the felled eucalyptus. The stress will discourage re-sprouting from the stump of the tree. In addition, the barren ground underneath will not be exposed to pounding rainwater before a cover of some plant life can begin to establish.

The eucalyptus grove known as the Frank Noyes Memorial Grove will not be removed. This grove contains at least seven identified species of eucalyptus, which may provide shade and habitat for raptors (Havlik, 1970). However, to prevent the spread of eucalyptus, BORG recommends that seedlings be removed on a yearly basis. Pulling out seedlings and saplings measuring up to one inch in diameter can be a successful method for preventing the spread of blue gum and other eucalyptus species.

9.3 Monitoring

Monitoring should be conducted to determine success of the chosen control technique for each species. This step should be completed throughout the length of the project. Monitoring for trunk sprouting of *Eucalyptus globulus* is important to evaluate the effectiveness of the cambium removal method. To prevent the spread and reestablishment of *E. globules*, mapping and removal of new seedlings should be done on an annual basis. Complete eradication of *Arundo donax* and *Foeniculum vulgare* is recommended; therefore the area cleared of these two species should be monitored to ensure no re-growth has occurred. Monitoring can also detect new invasive species infestations, provide mapping information and allow managers to apply appropriate control techniques.

10.0 COMPLIANCE ISSUES

To implement the proposed changes to the existing site and ensure compliance with existing environmental regulations, it will be necessary to consult with appropriate federal, state, and local government agencies. Discussed below, are the specific agencies and corresponding permits (where applicable) associated with the proposed restoration actions. Obtaining permits and arranging for inspections by the appropriate agencies must be conducted in a specific, sequential manner. Therefore, the agencies listed below are arranged in order of priority. For example, California Fish and Game and Army Corps of Engineers must be contacted before approaching any county or city government agencies. Working with permitting agencies is often an iterative process. Therefore, the OVLC should be prepared to meet with agency officials perhaps on several occasions and undergo subsequent revisions of building and construction plans to ensure compliance with agency standards and regulations.

Land Use Permitting

The **California Fish and Game – Ventura County Branch** is in charge of issuing the permits for waterway modification and re-grading. The OVLC should apply for a 1603 permit before any alterations are made to the site or existing drains. Betty Coutney recommended that the OVLC invite the Department for a site consultation before the application is submitted. The Department has the broadest scope of regulatory influence, and should be consulted before other permitting agencies.
Contact: Betty Coutney: (661) 263-8306

Similar to the California Fish and Game, the **U.S. Army Corps of Engineers – Los Angeles Regional District** should be contacted early in the compliance process. They also oversee permits for waterway modification, particularly in designated wetland areas. Necessary permits depend on the specific construction plans regarding wetland restoration.
Contact number: (213) 452-3407

Additionally, a Section 401, Water Quality Certification is required by the **Los Angeles Regional Water Quality Control Board** prior to the modification of any existing water system contained on the site.
Contact number: (213) 576-6600

The **Ventura County Planning and Development Department** is responsible for issuing permits for zoning, grading and building (Zoning Permit, Grading Permit and Building Permit), which are required for this project. Grading and building permits are site and plan specific, and therefore require an onsite inspection conducted by department officials. The level of involvement by county inspectors associated with the inspection will partially determine permit costs. In addition to an inspection, the Department requires these following items before issuing grading and building permits: Soil report, geology report, grading plan and building blueprints.

Ventura County Planning and Development Department:
Grading: (805) 654-3774
Building and Safety: (805) 654-2771

The **VCFCD** must also be involved in any watercourse modifications on county land and waterways. To implement the proposed stream and wetland modifications, OVLC must obtain a Water Course Permit from this agency. A site visit and detailed descriptions of the proposed modifications will be required. The permit fee will only reflect the fee associated with the inspection. Application fees will be waived due to the non-profit status of the OVLC.
Contact Pam Lindsey: (805) 654-2036 or Fred Bourman: (805) 654-2906

Since the site crosses jurisdictional boundaries (city and county), zoning, grading, and building permits may also be required by the **City of Ojai, Planning and Development Department**. However, after reviewing the building and grading plans, the City may defer to regulations and inspection procedures of the County, or vice versa. This issue would need to be discussed among both agencies and the OVLC.
Contact Brian Meadows: (805) 640-2555

Fire

The **Ventura County Fire Department, Meiner's Oaks Station** has expressed concern over the fire hazard associated with the site. Since the site and surrounding areas are particularly prone to fire, abatement measures are required indefinitely. Therefore, the OVLC must maintain continuous consultation with this Department in order to ensure compliance of fire-related regulations.

The Meiner's Oaks Station is available for administering prescribed burns to the site for the purpose of re-establishing fire disturbance. Due to the fact that the Department would administer the burns and therefore assume all responsibility for doing so, county permits are not necessary. However, since the site is of low priority to the Department, Wayne Manard (Fire Chief of Meiner's Oaks Station) has recommended the OVLC develop the necessary burn plan in order to facilitate the timely execution of prescribed burns. Requirements for such a plan include: location of burn, acreage, distance to nearby receptor areas (i.e., homes and businesses), smoke analysis, project schedule, and cautionary mitigation measures. Generally, several revisions are required before receiving approval from the Department.
Contact Wayne Manard, Fire Chief: (805) 640-2777

Sewage

The **Ojai Sanitary District** has jurisdiction of the sewage pipelines running through the site. The manholes at the surface must be kept easily accessible.
Contact John Curia or Jan Steenberg: (805) 646-5548.

Mosquito Abatement

The **Environmental Health Department, Mosquito Abatement Program** should be consulted to evaluate and approve wetland modifications or creation. The

abatement program is concerned with the proposed dimensions and quantity and quality of the water contained within the wetland area. Emergent plant growth within the water bodies is a determining factor of the department's ability to control mosquitoes. The more emergent vegetation (e.g., cattails, rushes), the more difficult it is to apply mosquito-killing agents. The *Gambusia affinnis* on the site can be included as a part of the mosquito abatement program. Mosquito monitoring is done every other week from May to November.
Contact Randy Smith: (805) 654-2816

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TABLES

Table 2.1. Description of historical aerial photographs

Date	Scale	Description of site characteristics
May 9, 1929*	**1: 9,600**	Water flowing from the high school; two fairly large water bodies in an elliptical shape are present along the drain and the HVD, possible wetland.
Nov. 9, 1945*	**1: 1,000**	Two large water bodies are absent, but there is a narrow strip of water along the drainage areas. Small building onsite.
May 6, 1960		New grading on the high school property; tributaries near high school look altered and partially destroyed, but there is still some water evident on the high school property.
Jan. 30, 1969*		Eucalyptus grove established. Meiners Oaks housing becoming more developed. Drainages patterns evident from Nordhoff High School and Krotona Hill.
Oct. 29, 1970	**1:500**	HVD has water at channel entrance, the rest is dry; trails are distinctive; southeast corner has an elliptical shape with a white outline (maybe a horse arena); Vegetation is absent within a strip along both sides of Hwy 33, suggesting mowing to protect the highway from fires.
Aug. 24, 1978*		Small building on Beasant Meadow property is no longer there. Drainages from Nordhoff and Krotona Hills not evident.
Jan. 11, 1984	**1:500**	Trails are less defined; whole site is very green; brown patch south of the oaks and to the east of the drain; pond by Hwy 33 is extending slightly northwest; all drains show some water; patches of shrubs near oaks and south portion near edge of brown patch; west of HVD the ground is brown with a patch of green where the ornamental plants are currently.
June 20, 1989	**1:500**	Recently tilled or mowed, entire site absent of vegetation except trees & some shrub areas at the southern edge of the palmer property & a smaller patch of shrub to the south of the oak trees; some green is evident near the entrance of the HVD, indicating water is present for algae to grow; drainage channel looks darker, indicating presence of water.

(*photos included in document)

Table 2.2. Monthly and yearly precipitation data

**Data collected by Western Regional Climate Center from 1949 to 1999 in Ojai, CA*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Precipitation (cm)	12.21	12.35	8.786	3.809	1.106	0.163	0.06	0.12	0.82	1.199	5.339	7.286	53.23
Min (cm)	0	0	0	0	0	0	0	0	0	0	0	0	18.36
Max (cm)	65.43	60.35	36.83	22.89	10.34	2.032	1.98	3.099	14.1	8.433	35	25.48	120.1
Std. Dev.	13.79	13.83	8.873	4.739	2.153	0.374	0.28	0.487	2.14	1.908	6.418	7.068	27.11

Table 2.3. Curve numbers for areas draining onto the Preserve

Curve Number	Drainage Area*	Area (m2)
80	1A	331,200
79	4B	92,861
79	5B	330,535
74	2A	349,701
86.6	11C	166,797
85.47	10C	329,551
81.75	8A	188,386
83.82	3A	105,952
74	15A	239,613
74	13C	60,867
83.4	12C	182,791
71	site	242,812

Curve numbers (CN) were calculated using the SCS method
*Drainage areas correspond to Figure 2.7

Table 2.4. Surface-water runoff entering the Preserve

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Inflow to Happy Valley Drain	1409	1552	701	205	44	1	0	1	47	57	456	657	5130
Inflow to drainage ditch	493	559	272	91	20	1	0	1	19	24	174	245	1897
Inflow from Nordhoff High School	264	300	148	50	11	0	0	1	11	13	94	133	1025
Inflow from Krotona Hills	458	501	225	65	14	0	0	0	15	18	147	212	1656

Values calculated using the SCS method and reported in cubic meters

Table 2.5. Evapotranspiration rates

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
Pan Evaporation Estimation	6.73	6.71	10.06	10.69	13.54	14.71	17.22	17.78	16.76	10.97	9.26	6.53	140.96	(cm/mo)
	2.65	2.64	3.96	4.21	5.33	5.79	6.78	6.60	5.35	4.32	3.25	2.57	53.46	(in/mo)

Rates calculated from pan evaporation measurements at Lake Casitas Headquarters, CA

Table 2.6. Subsurface geology

Meters From Surface	Geology	Groundwater
0 to 3.05	adobe topsoil clack alluvium	perched
3.05 to 6.1	clay medium, rusted brown, silty	impervious layer
6.1 to 18.3	sand, medium brown with sandstone pebbles	groundwater
18.3 to 27.4	pebbly clay, medium brown, hard sandstone pebbles	impervious layer
27.4 to 73.2	pebbly grit, coarse sand, red sespe fragments	groundwater
73.2 to 89.9	hard sandstone, silty clay, blue/grey	impervious layer

* Well 10G1 is shown in Figure 2.8

Based on well records from Well 10G1* (Panaro, pers. comm., 2001)

Table 2.7. Observed plant species

Family	Latin Name	Common Name	Native?	Wetland Indicator Status
Alismataceae	*Alisma sp.* [B]	Water plantain	Unknown	
Apiaceae	*Conium maculatum* [B,O]	Poison hemlock	Non-native	
	Foeniculum vulgare [B,O]	Fennel	Non-native	FACU
Aristolochiaceae	*Asclepias fascicularis* [O]	Narrow-leaf milkweed	Native	FAC (dry grounds, valley foothills)[J]
Asteraceae	*Artemesia californica* [B]	California sagebrush	Native	
	Artemesia douglasiana [B]	Mugwort	Native	FACW
	Baccharis pilularis [B,O]	Coyote bush	Native	
	Baccharis salicifolia [B,O]	Mule fat	Native	FACW-
	Carduus pycnocephalus [O]	Italian thistle	Non-native	
	Centaurea solstitialis [B]	Yellow star thistle	Non-native	
	Conyza bonariensis [B]	Little horseweed	Non-native	
	Conyza canadensis [B]	Horseweed	Non-native	
	Hemizonia fasciculatum [O]	Tarweed	Native	
	Heterotheca grandiflora [B]	Telegraph weed	Native	
	Hypochaeris glabra [B]	Smooth cat's ear	Non-native	
	Sonchus asper [O]	Prickly sow thistle	Non-native	FAC
	Sonchus oleraceus [O]	Common sow thistle	Non-native	NI*
	Stephanomeria sp [O]	Chickory	Non-native	
Betulaceae	*Alnus sp* [O]	Alder	Unknown	
Brassicaceae	*Brassica nigra* [B]	Black mustard	Non-native	
	Brassica rapa [B,O]	Field mustard	Non-native	
	Raphanus sativus [B]	Wild raddish	Non-native	
Convolvulaceae	*Convolvulus arvenus* [B]	Bindweed	Non-native	
Cyperaceae	*Carex barbarae* [B]	Sedge	Native	FACW
	Cyperus eragrostis [O]	Nutsedge	Native	FACW (vernal pools, streambanks, ditches)[J]

Family	Latin Name	Common Name	Native?	Wetland Indicator Status
	Eleocharis macrostachya [O]	Common spikerush	Native	OBL
	Scirpus californica [O]	California bulrush	Native	marshes [J]
	Scirpus acutus var. occidentalis [B]	Tule	Native	OBL
Euphorbiaceae	*Eremocarpus setigerus* [B]	Turkey mullein	Native	
	Euphorbia crenulata [B]	Chinese caps	Non-native	
	Ricinus communis [B,O]	Castor bean	Non-native	FACU
Fabaceae	*Acacia baileyana* [O]	Cootamundra wattle	Non-native	
	Acacia sp [O]	Acacia	Non-native	
	Lupinus bicolor [O]	Miniature lupine	Native	
	Medicago polmorpha [B]	Burlclover	Non-native	
	Melilotus indica [B]	Yellow sweetclover	Non-native	FAC
	Melilotus medicago [O]	Bur clover	Non-native	
	Vicia sativa [B,O]	Common vetch	Non-native	FACU
	Vicia sp [B,O]	Vetch	Non-native	
Fagaceae	*Quercus agrifolia* [B,O]	Coast live oak	Native	
	Quercus lobata [B,O]	Valley oak	Native	FAC*
Gerniaceae	*Erodium botrys* [O]	Long-beaked filaree	Non-native	
	Erodium brachycarpum [O]	Stork's bill	Non-native	
	Erodium cicutarium [B,O]	Red-stem filaree	Non-native	
Juncaceae	*Juncus balticus* [O]	Baltic rush	Native	OBL
Lamiaceae	*Marrubium vulgare* [B]	Horehound	Non-native	FAC
Lythraceae	*Lythrum hyssopifolium* [B]	Hyssop loosestrife	Non-native	FACW
Malvaceae	*Malva parviflora* [B]	Cheeseweed	Non-native	
	Malvella leprosa [B]	Alkali mallow	Non-native	FAC
	Malvella macrosa [O]	Mallow	Non-native	
Myrtaceae	*Eucalyptus camaldulensis* [O]	Red gum	Non-native	
	Eucalyptus globulus [B,O]	Tasmanian blue gum	Non-native	
	Eucalyptus polyanthemos [O]	Red box	Non-native	
	Eucalyptus polyanthus [O]	Silver dollar	Non-native	

Family	Latin Name	Common Name	Native?	Wetland Indicator Status
	Eucalyptus rubida [O]	Candle bark	Non-native	
	Eucalyptus sideroxylon [O]	Red iron bark	Non-native	
	Eucalyptus urnigera [O]	Urn gum	Non-native	
Onagraceae	*Epilobium brachycarpum* [B]	Field willow-herb	Native	
	Gaura parviflora [B]	Lizard-tail, velvet weed	Non-native	
	Oenothera sp [O]	Evening primrose	Native	
Plantaginaceae	*Plantago lanceolata* [B,O]	Common plaintain	Non-native	FAC-
	Plantago major [B]	Broadleaf plantain	Non-native	FACW-
Poaceae	*Agrostis stolonifera* [O]	Creeping bentgrass	Non-native	FACW
	Arundo donax [O]	Giant Reed	Non-native	FACW
	Avena barbata [B,O]	Wild oats	Non-native	
	Avena fatua [B]	Wild oat	Non-native	
	Briza minor [O]	Little quakinggrass	Non-native	FACW-
	Bromus diandrus [B,O]	Ripgut brome	Non-native	
	Bromus hordeaceus [B,O]	Soft chess	Non-native	FACU-
	Bromus madritensis ssp. rubens [B]	Red brome	Non-native	
	Bromus tectorum [B]	Cheat grass	Non-native	
	Cynodon dactylon [B,O]	Bermuda grass	Non-native	FAC
	Cynosurus echinatus [O]	Hedgehog dogtail	Non-native	
	Hordeum marinum [B,O]	Mediterranean Barley	Non-native	?
	Hordeum murinum [O]	Barley	Non-native	prefers moist sites[J]
	Leptochloa fascicularis [O]	Bearded sprangletop	Native	marshes, wetlands, disturbed areas[J]
	Lolium multiflorum [B,O]	Wild barley	Non-native	
	Phalaris aquatica [B]	Harding grass	Non-native	FAC+
	Phalaris minor [O]	Littleseed canary grass	Non-native	
	Phalaris paradoxa [O]	Hood canary grass	Non-native	
	Piptatherum miliaceum [B]	Smilo	Non-native	
	Polypogon monspeliensis [B]	Rabbit's foot grass	Non-native	FACW+

Family	Latin Name	Common Name	Native?	Wetland Indicator Status
	Vulpia myuros [O]	Rat-tail fescue	Non-native	FACU*
	Vulpia sp [O]	Fescue	Non-native	
Polygonaceae	*Anagallis arvensis* [B]	Scarlet pimpernell	Non-native	FAC
	Rumex crispus [B,O]	Curly dock	Non-native	FACW-
Portulacaceae	*Calandrinia ciliata* [O]	Redmaids	Native	FACU*
Primulaceae	*Anagallis arvensis* [O]	Scarlet pimpernel	Non-native	FAC
Salicaceae	*Salix lasiolepis* [B]	Arroyo willow	Native	FACW
Scrophulariaceae	*Castilleja densiflora* [O]	owl's clover	Native	
	Veronica anagallis aquatica [O]	Water speedwell	Non-native	OBL
Tropaeolaceae	*Nasturtium officinale* [O]	Watercress	Non-native	
	Nasturtium sp [O]	Nasturtium	Non-native	
Typhaceae	*Typha domingensis* [B]	Southern cattail	Native	OBL
	Typha latifolia [O]	Broad-leaved cattail	Native	OBL

J In Jepson Manual
O Seen by BORG, survey conducted in summer, 2000
B Seen by Bowland and Associates, survey conducted on May 15, 1996

Wetland indicator status based on Reed (1988):

UPL	Obligate Upland	Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List.
OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67%-99%, but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%)
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67%-99%), but found on wetlands (estimated probability 1%-33%)

Table 2.8. Observed wildlife species

Scientific Name	Common Name	Location	Age Group	Notes
Accipiter cooperii	Cooper's hawk	Eucalyptus grove	A	
Agelaius phoeniceus	Red – winged blackbird	rushes and reeds	J, A	nesting
Aphelocorna coerulescens	Scrub jay	Besant meadow	J, A	nesting
Buteo jamaicensis	Red-tailed hawk	Eucalyptus grove	J, A (pair)	
Buteo lineatus	Red-shouldered hawk	Eucalyptus grove	A	
Callipepla californica	California quail	Eucalyptus grove	A (pair)	
Calypte anna	Anna's hummingbird	Eucalyptus grove	A	
Carduelis psaltria	Lesser goldfinch	Besant meadow	J, A	green backed color phase
Cathartes aura	Turkey vulture	Fly over site	A	
Carpodacus mexicanus	House Finch	Trees/shrubs throughout the site	J, A	
Euphagus cyanocephalus	Brewer's blackbird	Riparian and grassland areas	J, A	
Falco sparverius	American kestrel	Eucalyptus grove	A (pair)	
Geothlypis trichas	Common yellowthroat	rushes and reeds	A (pair)	nesting
Hirundo pyrrhonota	Cliff swallow	Fly over grassland	A	
Icterus cucullatus	Hooded Oriole	Eucalyptus grove	A (pair)	nesting
Lonchura punctulata	Spice Finch	North happy valley drain	A	exotic from South-East Asia
Melanerpes formicivorus	Acorn woodpecker	Valley oak trees	A	grainery in oak trees
Mimus polyglottos	Northern mockingbird	Shrubs Besant meadow	A	
Passerculus sanwichensis	Savannah sparrow	Besant meadow	A	
Sayornis nigricans	Black phoebe	Shrub in grassland	J	
Sialia mexicana	Western bluebird	Valley oak trees	J, A	
Sturnella neglecta	Western Meadowlark	Palmer property grassland	A	
Tachycineta bicolor	Tree swallow	Fly over grassland	A	
Turdus migratorius	American robin	Eucalyptus grove	A (pair)	nesting
Tyrannus vociferans	Western kingbird	Eucalyptus grove	J, A (pair)	fledgelings present

Scientific Name	Common Name	Location	Age Group	Notes
Tyto alba	Barn owl	Eucalyptus grove	?	secondary feather
Zenaida macroura	Mourning dove	Eucalyptus grove	A	
Reptiles/Amphibians				
Bufo boreas	Western toad	North Happy valley drain (HVD)	J, A	toadlets
Pseudacris regilla	Pacific treefrog	North HVD and drainage ditch	J	tadpoles, froglets
Sceloporus occidentalis	Western fence lizard	Woody debris along Euc. forest perimeter	A	
Mammals:				
Geomys sp.	Gopher	In upland grassland	A	diagnosis from burrow tailings
Otospermophilus beecheyi	California ground squirrel	In upland grassland	A	
Insects:				
Danaus plexippus	Monarch butterfly	Eucalyptus forest	A	
Anisoptera sp.	Dragonfly	Happy valley drain	J, A	
Crustaceans:				
Procambarus clarkii	Red swamp crayfish	Drainage ditch adjacent to Maricopa highway	A	Introduced
	Copepod	Flooded grassland on Basant Meadows	A	
	Ostracod	North Happy Valley Drain	A	
Fish:				
Gambusia affinis	Gambusia (mosquitofish)	North happy valley drain	J, A	Introduced

Surveys conducted in summer of 2000 and winter 2001
A=adult, J=juvenile

Table 3.1. Proposed plant list for the Preserve

Scientific Name	Common Name	R	WT	FM	VP	G	O	Comments	Suggested by	Source*
Achillea millefollium	Yarrow		x					wetter areas	Trish Munro	
Alisma triviale			x	x				margins	B & H, 1985	mirror lake
Alopecurus howellii	Pacific Foxtail				x			A, center	Wayne Ferren	mirror lake
Amaranthus blitoides			x					upland	B & H, 1985	mirror lake
Ambrosia psilostachya	Western ragweed					x		roadsides, dry fields	B & H, 1985	mirror lake
Ammannia robusta	Ammannia		x		x				Mary Meyer	HVS
Asclepias fascicularis	Narrrow-leaf milkweed					x		dry ground, valleys	B & H, 1985	onsite
Azolla filiculoides	mosquito fern			x					Wayne Ferren	mirror lake
Baccharis pilularis	Coyote brush					x		upland	B & H, 1985	onsite
Baccharis salicifolia	Mulefat	x	x					Wu	Harker et al, 1999	onsite
Barbarea orthoceras		x	x	x				banks, moist G	B & H, 1985	mirror lake
Boisduvalia glabella	Smooth spike-primrose				x			A, center of pools	Wayne Ferren	mirror lake
Calandrinia ciliata	Red maids		x					wetter areas	Trish Munro	onsite
Callitriche marginata	Wallow starwort				x			A, center	Wayne Ferren	mirror lake
Castilleja densiflora	Owl's clover					x			BORG	onsite
Castilleja exserta	Purple owl's clover					x			Trish Munro	
Clarkia bottae	Punchbowl godetia					x			Trish Munro	
Clarkia unguiculata	Clarkia					x			Trish Munro	
Clematis ligusticifolia	Virgin's Bower	x	x					Wu	Harker et al, 1999	
Colliinsia heterophylla	Chinese houses		x					wetter areas	Trish Munro	
Crassula aquatica	Stonecrop				x			A, center	Wayne Ferren	mirror lake
Cuscuta californica			x			x		upland	B & H, 1985	mirror lake
Dichlostemma capitatum	Blue dicks					x	x		Trish Munro	church site
Elatine brachysperma	Waterwort				x			A, center	Wayne Ferren	mirror lake
Elatine californica					x			A	Wayne Ferren	mirror lake

Scientific Name	Common Name	R	WT	FM	VP	G	O	Comments	Suggested by	Source*
Eleocharis acicularis	Needle spike-rush				x			P, deeper pools and margins of footpaths	Wayne Ferren	mirror lake
Eleocharis macrostachya	Common spike-rush			x	x			P	BORG	onsite, HVS
Eleocharis palustris	spike-rush			x	x				Wayne Ferren	mirror lake
Elymus glaucus	Blue wildrye					x	x	open areas, woodland	Harker et al, 1999	
Encelia californica	California encelia					x		coastal scrub	Trish Munro	
Epilobium canum	California fuchsia					x		dry slopes	Trish Munro	
Epilobium densiflorum		x	x		x			A	Mary Meyer	HVS
Epilobium pygmaeum					x			A	Mary Meyer	Tierra Rejada
Eremocarpus setigerus	Dove weed					x		dry, open, disturbed areas	B & H, 1985	mirror lake
Eschscholzia californica	California poppy					x		A, As	Harker et al, 1999	
Rhamnus californica	California coffee berry						x	Wu	Harker et al, 1999	
Gilia clivorum	Purple-spot gily-flower					x		As	Harker et al, 1999	
Gnaphalium palustre	Woolly everlasting		x		x			A, margins	Wayne Ferren, Mary Meyer	mirror lake, HVS
Hazardia squarrosa	Saw-toothedgoldenbush		x					wetter areas	Trish Munro	
Hemizonia fasciculata	Tarweed		x		x	x	x	A, pool margins	BORG	onsite
Heteromeles arbutifolia	Toyon						x	Wu	Harker et al, 1999	
Isoetes howellii	Howell's quillwort				x			P	Wayne Ferren	mirror lake
Juglans californica	California walnut						x	As	Harker et al, 1999	
Juncus balticus	Baltic rush		x	x					BORG	onsite
Juncus bufonius	Toad rush		x		x	x		A, moist,open, disturbed areas	Wayne Ferren, Mary Meyer	mirror lake, HVS, Tierra Rejada
Juncus mexicanus			x	x		x		P	B & H, 1985	mirror lake
Juncus patens	Green rush		x					wetter areas	Trish Munro	
Juncus phaeocephalus				x				P	Wayne Ferren	mirror lake

Scientific Name	Common Name	R	WT	FM	VP	G	O	Comments	Suggested by	Source*
Lasthenia californica	California goldfields					x		As	Harker et al, 1999	
Lemna gibba				x				floating vascular	Ferren et al, 1996	
Leptochloa uninervia	Mexican sprangle-top		x	x	x			ditches, drying ponds, disturbed wet areas	B & H, 1985	mirror lake
Leptochloa fascicularis	Bearded sprangletop		x	x					BORG	onsite
Leymus triticoides	Beardless lyme grass	x				x		As, moist meadows	Harker et al, 1999	
Lotus purshianus		x	x	x		x		roadsides, weedy	B & H, 1985	mirror lake
Lupinus bicolor	Miniature annual lupine					x		As	Harker et al, 1999, Trish M.	
Madia elegans	Tarweed		x			x		A	Cal Flora	
Marsilea vestita	Hairy water-clover		x		x			P, rare	Wayne Ferren, Mary Meyer	mirror lake, HVS
Melica californica	California melic grass					x	x	As	Harker et al, 1999	
Naias guadalupensis				x				submerged aquatic	Wayne Ferren	mirror lake
Nasella cernua	Tussock grass					x		Cs	Harker et al, 1999	
Nassella lepida	Tussock grass					x		As	Harker et al, 1999	
Nassella pulchra	Purple needle grass					x		Cs	Harker et al, 1999	
Orcuttia californica	California Orcutt grass				x			SE	Mary Meyer	Tierra Rejada
Pentachaeta lyonii	Lyon's pentachaeta				x			SE	Mary Meyer	Tierra Rejada
Pilularia americana	American pillwort				x			P, fern, rare	Wayne Ferren	mirror lake
Plagiobothrys nothofulvus	Rusty popcorn-flower					x		As	Harker et al, 1999	
Plagiobothrys undulatus	Popcorn flower				x			A, center	Wayne Ferren	mirror lake
Plagiobothrys stipitatus micranthus			x		x			A	Mary Meyer	HVS
Platanus racemosa	California sycamore	x						canopy	Holland, 1986	
Pluchea sericea	Arrow weed	x						Hb	Holland, 1986	
Poa secunda	Curly blue grass					x	x	As	Harker et al, 1999	
Polygonum amphibium	Water smartweed		x	x					B & H, 1985	mirror lake

Scientific Name	Common Name	R	WT	FM	VP	G	O	Comments	Suggested by	Source*
Populus fremontii	Fremont Cottonwood	x						Cs, canopy	Holland, 1986	
Prunus ilicifolia	Holly-leaf cherry						x	Wu, evg shrub/tree	Harker et al, 1999	
Quercus agrifolia	Coast live oak	x					x	As (O)	Harker et al, 1999	onsite
Quercus douglasii	Blue oak						x	Cs	Harker et al, 1999	
Quercus lobata	Valley oak	x	x				x	As, Cs	Harker et al, 1999	onsite
Rhamnus crocea	Spiny redberry						x	Wu, evg shrub	Harker et al, 1999	
Rosa californica	California rose	x	x					Wu	Harker et al, 1999	
Rumex salicifolius	Willow Dock	x	x	x				P, moist places	B & H, 1985	mirror lake
Salix exigua	Narrow-leaved willow	x	x	x				Wu	Holland, 1986	
Salix laevigata	Red willow	x	x	x				Wu	Holland, 1986	
Salix lasiolepis	Arroyo willow	x	x	x		x		Wu, meadows	Holland, 1986	
Salix lucida	Shining willow	x	x	x				Wu	Harker et al, 1999	
Salvia leucophylla	Purple sage		x			x		good buffer	Trish Munro	
Salvia mellifera	Black sage		x			x		good buffer	Trish Munro	
Scirpus californica	California bulrush			x				P	BORG	onsite
Scirpus saximontanus			x	x	x			A, Fern	Wayne Ferren	mirror lake
Sidalcea malvaflora	Checkerbloom					x		P	Trish Munro	
Sisyrinchium bellum	Blue-eyed-grass	x	x			x	x	As, wet areas	Harker et al, 1999, Trish M.	
Stachys ajugoides	Bee plant		x		x				Wayne Ferren	mirror lake
Toxicodendron diversilobum	Pacific poison-oak	x					x	Wu	Harker et al, 1999	
Trifolium albopurpureum	Rancheria clover					x		A, As	Harker et al, 1999	
Trifolium gracilentum	Pin-point clover		x			x		As	Harker et al, 1999	
Typha domingensis	Southern cattail			x				P, Cs	B & H, 1985	mirror lake
Typha latifolia	Broad-leaved cattail			x					BORG	onsite
Verbena bracteata	Bracted vervain		x		x			A	Wayne Ferren	mirror lake, Tierra Rejada

Scientific Name	Common Name	R	WT	FM	VP	G	O	Comments	Suggested by	Source*
Veronica peregrina xalapensis	Neckweed				x			A, deeper moist or desiccated pools	Wayne Ferren	mirror lake, Tierra Rejada
Vitis californica	California grape	x						Wu	Harker et al, 1999	
Vulpia microstachys	Small six-weeks grass					x		As	Harker et al, 1999	

Notes: (x) present, (A) Annual, (P) Perennial, (evg) evergreeen, (R) Riparian, (WT) Wetland Transition, (FM) Freshwater Marsh, (VP) Vernal Pool,
(G) Grassland, (O) Oak Savanna, (Hb) Herbaceous, (As) Associates, (Wu) Woody understory, (Cs) Characteristic species, (Ca) Canopy
associate, (SE) State Endangered, (HVS) Happy Valley School Vernal Pool, (B & H, 1985) Beauchamp and Hannon, 1985
* Source is a potentially location to collect seed, but further investigation is necessary Scientific Names as in Jepson Manual (Hickman, 1993)

Table 4.1. Reference plant species for vernal pools

Happy Valley School Vernal Pool 1995 (Meyer, pers. comm., 2001)		**Tierra Rejada Vernal Pool 1997, Average rainfall year (Meyer, pers. comm., 2001)**	**Mirror Lake Historical Vernal Pool Species Pre-1980s (Ferren, per. comm., 2001)**	
Scientific Name	**Total Cover**	**Scientific Name**	**Scientific Name**	
Ammania robusta	1%	*Ammania robusta*	*Alopecurus howellii*#	*Gnaphalium palustre*#
Conyza canadensis	1%	*Bergia texanus*	*Alisma triviale*	*Isoetes howellii*
*Crypsis alopecuroides**	35%	*Crypsis schoenoides**	*Ammania coccinea*	*Luduigia palustris pacitien*
Eleocharis macrostachya	48%	*Eleocharis macrostachya*	*Boisduvalia glabella*#	*Lythrum hyssopifolia*#
Epilobium deusiflorum	1%	*Epilobium pygmaeum*	*Callitriche marginata*#	*Marsilea vestita*
Gnaphalium palustre	1%	*Malvella leprosa**	*Crassula aquatica*#	*Phalaris lemmonii*#
Juncus bufonius	3%	*Marsilea vestita*	*Cyperus acuminatus*	*Pilularia americana*#
*Malvella leprosa**	1%	*Orcuttia californica*	*Cyperus aristatus*	*Plagiobothrys undulatus*#
Marsilea vestita	5%	*Rumex maritimus*	*Elatine brachysperma*#	*Sagitarria sanfordii*
Plagiobothrys (stipitatus micranthus)	1%	*Verbeana bracteata*	*Elatine californica*	*Veronica peregrina xalapensis*#
Typha species	1%	*Veronica peregrina xalapensis*	*Eleocharis acicularis*#	
Xanthium strumarium	3%	*Xanthium strumarium*	*Eleocharis palutris*#	

* exotic, invasive, or noxious weed

\# species occur in Del Sol vernal pools in Santa Barbara

Table 6.1. Calculated and estimated values for channel and meander geometry

Parameter	Symbol	Value
Discharge Derived From Flood Control Records	Q_1	3.2 $m^3 s^{-1}$
Bottom Width	b	2.3 m
Bankfull Water Depth	y	0.57 m
Manning Roughness	n	0.035
Stream Slope	S	0.004
Bank Slope #1	z_1	3
Bank Slope #2	z_2	1
Top Width	T	11.48 m
Cross-sectional Area	A	3.93 m^2
Wetted Perimeter	P	13.13 m
Hydraulic Radius	R	0.3 m
Velocity	V	0.81 m s^{-1}
Discharge Calculated Using Manning Equation	Q_2	3.2 $m^3 s^{-1}$
Meander Wavelength	λ	128.81 m
Amplitude	Am	54.00 m
Radius of Curvature	R_c	30.47 m

Table 8.1. Importance values for assessment metric

	High (3)	Medium (2)	Low (1)
Conservation Criteria	> 90% habitat not protected and/or >80% habitat destroyed	> 50% habitat not protected and/or >50% habitat destroyed	< 50% habitat not protected and/or <50% habitat destroyed
Recreation Criteria	provides opportunities for passive recreation, active recreation, and scientific study	provides opportunities for passive recreation, active recreation	provides opportunities for passive recreation or active recreation
Ecological Services Criteria	provides majority of services (biodiversity, flood control, water quality)	provides majority of services (biodiversity, flood control, water quality)	provides majority of services (biodiversity, flood control, water quality)
Cost Criteria	average cost of restoration is less than $50,000; average maintenance and monitoring is less than $15,000	average cost of restoration is between $50,000 and $200,000; average cost of maintenance and monitoring is between $15,000 and $50,000	average cost of restoration is greater than $200,000; average cost of maintenance and monitoring is greater than $50,000

Table 8.2. Projected initial, maintenance, and monitoring costs

	Riparian		Permanent Marsh		Seasonal Marsh		Vernal Pool		Oak Savanna	
	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper
Planning and Additional Data Needs	**$18,350**	**$30,350**	**$20,000**	**$32,050**	**$20,000**	**$32,050**	**$18,800**	**$32,050**	**$3,550**	**$8,550**
project planning[1]	1800	5600	1800	5600	1800	5600	1800	5600	1800	5600
groundwater	N/A	N/A	1500	1500	1500	1500	N/A	N/A	N/A	N/A
water quality	1000	1500	1000	1500	1000	1500	1000	1500	N/A	N/A
topography	2000	4000	2000	4000	2000	4000	2000	4000	N/A	N/A
biotic survey	N/A	N/A	N/A	N/A	N/A	N/A	400	1600	400	1600
plans and specifications[1]	10000	15000	10000	15000	10000	15000	10000	15000	N/A	N/A
construction scheduling[1]	1000	1500	1000	1500	1000	1500	1000	1500	N/A	N/A
permit, ACOE	100	100	100	100	100	100	100	100	100	100
permit, CDFG 1601	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
permit, grading	1200	1400	1200	1400	1200	1400	1200	1400	N/A	N/A
permit, zoning	50	50	50	50	50	50	50	50	50	50
mosquito abatement	N/A	N/A	150	200	150	200	50	100	N/A	N/A
Implementation	**$34,900**	**$75,400**	**$129,000**	**$245,200**	**$110,500**	**$198,200**	**$7,900**	**$12,700**	**$14,200**	**$48,500**
project management	1000	1500	1000	1500	1000	1500	1000	1500	1000	1500
excavation (equip/oper)	600	1200	1800	2400	1800	2400	600	1200	N/A	N/A
grading and fill	25000	50000	50000	75000	50000	75000	5000	7000	N/A	N/A
slope stabilization	600	1300	1300	1900	1300	1900	N/A	N/A	N/A	N/A
organic removal	600	1200	600	1200	600	1200	600	1200	N/A	N/A
dump fee	100	200	100	200	100	200	100	200	N/A	N/A
salvage topsoil	N/A	N/A	200	500	200	500	200	1000	N/A	N/A
salvage plant	N/A	N/A	200	500	200	500	N/A	N/A	N/A	N/A
liner	N/A	N/A	15000	40000	N/A	N/A	N/A	N/A	N/A	N/A
pump w/ installation	N/A	N/A	1500	2000	N/A	N/A	N/A	N/A	N/A	N/A

liner installation	N/A	N/A	2000	5000	N/A	N/A	N/A	N/A	N/A	N/A
seeds	N/A	N/A	12800	24000	12800	24000	400	600	1000	8000
plugs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5000	10000
container plants	N/A	N/A	36000	72000	36000	72000	N/A	N/A	N/A	N/A
gallon pots	5000	16000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
planting	2000	4000	4000	16000	4000	16000	N/A	N/A	1000	10000
broadcast seeding	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5000	15000
handseeding	N/A	N/A	2500	3000	2500	3000	N/A	N/A	500	1000
plant protection	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	200	1000
exotic removal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	500	2000
Monitoring and Maintenance (cost/yr)	**$10,100**	**$70,800**	**$24,000**	**$131,600**	**$7,900**	**$71,800**	**$3,500**	**$18,400**	**$10,000**	**$45,000**
project management[1]	1500	2000	2000	5000	2000	5000	1000	2000	2000	5000
data analysis[1]	1000	4000	1000	4000	1000	4000	1000	4000	1000	4000
groundwater[1]	N/A	N/A	300	3000	300	3000	N/A	N/A	N/A	N/A
other hydrology[1]	N/A	N/A	500	2000	500	1000	N/A	N/A	N/A	N/A
vegetation[1]	100	1500	100	1500	100	1500	200	5000	1000	2000
water quality[1]	100	1500	600	3000	200	700	200	5000	N/A	N/A
pump	N/A	N/A	5000	9000	N/A	N/A	N/A	N/A	N/A	N/A
liner[3]	N/A	N/A	500	45000	N/A	N/A	N/A	N/A	N/A	N/A
erosion control	5000	50000	500	5000	500	5000	N/A	N/A	N/A	N/A
seed collection	N/A	N/A	1000	5000	1000	5000	N/A	N/A	500	4000
exotic removal [4]	600	800	1200	1600	1200	1600	600	800	2500	20000
supplemental planting[5]	1700	10000	10000	44000	1000	44000	400	600	3000	10000
groundwater pumping	N/A	N/A	300	500	N/A	N/A	N/A	N/A	N/A	N/A
well	N/A	N/A	500	1000	N/A	N/A	N/A	N/A	N/A	N/A
mosquito abatement	100	1000	500	2000	100	1000	100	1000	N/A	N/A

Total Implementation Costs	**$53,250**	**$105,750**	**$149,000**	**$277,250**	**$130,500**	**$230,250**	**$26,700**	**$44,750**	**$17,750**	**$57,050**
Total Annual Costs	**$10,100**	**$70,800**	**$24,000**	**$131,600**	**$7,900**	**$71,800**	**$3,500**	**$18,400**	**$10,000**	**$45,000**

[1] Costs based on an hourly rate of $25 to $70

[3] Lower costs based on minimal spot treatment twice in lifetime of liner, Upper costs based on expense of draining pond and reapplication of liner
.

[2] Costs based on an hourly rate of $60 to $150

[4] Costs based on and hourly rate of $10 to $35

[5] Supplemental planting is assumed to be approximately 25% to 50% of original planting efforts, which includes plants and labor.

Cost estimations projected from consultation with the following agencies, companies, people and software: Army Corps of Engineers, BC2, Bitterroot Restoration, Cornflower Farms, Dave Hubbard, Growing Solutions, Ojai Planning Department, ReVeg Edge, Property Analysis Record (PAR), San Marcos Growers, SAIC, Sinclair, S&S Seeds, Tree of Life Nursery, URS, Ventura County Flood Control, Wayne Ferren

Table 8.3. Results of metric analysis

Conservation Priority						
	Weighting factor	Valley oak	vernal pool	permanent marsh	seasonal marsh	riparian
conservation	**0.5**	**3**	**3**	**1**	**2**	**2**
recreation	**0.125**	**3**	**3**	**1**	**2**	**1**
ecological services	**0.125**	**1**	**1**	**3**	**3**	**3**
initial costs	**0.125**	**3**	**3**	**1**	**2**	**2**
maintenance costs	**0.125**	**2**	**3**	**1**	**2**	**2**
priority total		***2.6***	***2.8***	***1.3***	***2.1***	***2.0***
Ecological Services Priority						
	Weighting factor	Valley oak	vernal pool	permanent marsh	seasonal marsh	riparian
conservation	**0.125**	**3**	**3**	**2**	**2**	**2**
recreation	**0.125**	**3**	**3**	**2**	**2**	**1**
ecological services	**0.5**	**1**	**1**	**3**	**3**	**3**
initial costs	**0.125**	**3**	**3**	**1**	**2**	**2**
maintenance costs	**0.125**	**2**	**3**	**1**	**2**	**2**
priority total		***1.9***	***2.0***	***2.3***	***2.5***	***2.4***

Table 8.4. Integrated implementation schedule
All habitats are weighted equally.

Time frame	Action
Immediately: spring, early summer 2001	-Review and assessment of BORG plan -Establish trails, some signs, and waste facilities -Debris clean up
Immediately: spring, early summer 2001 for at least one year.	Pre-monitoring: -Groundwater, topographic map, water quality, invertebrate and vertebrates, and vegetation -Development of a more detailed plan -Selective exotic species removal --non-native trees
Spring, early to late summer 2002	Begin experiments: -Collect inoculum and native seeds. -Grading and excavation of wetland, stream, vernal pools (mid-July or early August lasts ~6-8 weeks). -Mark vegetation zones - Stream bank stabilization and revegetation - Selective non-native species removal, especially non-native trees
Late fall 2002 to winter 2003	Revegetation of experimental plots: -Wetlands, stream, and vernal pools (before rains) - Oak savanna (vegetate in the spring after storms)
Winter 2002 to Winter 2004	-Post monitoring and maintenance, evaluation of experiments. -Assess information and develop large scale plan
Spring/summer 2004	Begin Large Scale Plan: -Collection of seeds -Excavate larger vernal pools (summer) -Large scale weed reduction using best method
Fall 2004 to winter 2005	-Large scale revegetation: -Grassland with perennial species (winter immediately following non-native reduction, 2-3 yrs)

Time frame	**Action**
	-Install expensive rooted plants on stream banks -Inoculate larger vernal pools -Plant native annuals forbs and oaks (after winter rain)
Ongoing	-Monitor vegetation for success, conduct weed management activities and assessment -Revise management plans accordingly

Table 8.5. Integrated monitoring schedule

Proposed Monitoring Schedule (SAIC, 1995)					
		Vernal Pool	**Fresh Water Marsh**	**Riparian**	**Oak Savanna**
Year	**2001**	April-Dec [1]	April-Dec [1]	May-Dec [1]	May-Dec [1]
Year	**2002**	Jan-Aug [1] Oct [2]	Jan-Mar [1] Oct [2]	Jan-Aug [1] Oct [2]	Jan-Aug [1] Oct [2]
Year1	**2003**	Mar/Apr [3, 5, 8, 9]	March/Apr [4, 5, 9] Jun/July [4, 5] monthly [8]	Feb/Mar [3, 5, 8, 9] May/Jun [4] Oct [6]	Feb/Mar [3, 5] May [4, 5] Oct [6]
Year 2	**2004**	Mar/Apr [4, 5, 7, 8, 9, 10]	March/Apr [4, 5, 9, 10] Jun/July [5, 6] monthly [8]	Feb/Mar [3, 5, 8, 9, 10] May/Jun [4] Oct [6]	May [4, 5, 10] Jul/Aug [3, 5] Oct [6]
Year3	**2005**	Mar/Apr [4, 5, 8, 9, 10]	March/Apr [4, 5, 9, 10] Jun/July [5, 6] monthly [8]	Feb/Mar [3, 5, 8, 9, 10] May/Jun [4,7] Sept [6]	May [4, 5, 10] Jul/Aug [3, 5] Oct [6]
Year4	**2006**	Mar/Apr [4, 5, 8, 9, 10]	March/Apr [4, 5, 9, 10] Jun/July [5, 6] monthly [8]	Feb/Mar [3, 5, 8, 9, 10] May/Jun [4] Sept [6]	May [4, 5, 10] Oct [5, 6]
Year5	**2007**	Mar/Apr [4, 5, 7, 8, 9, 10]	March/Apr [4, 5, 9, 10] Jun/July [5, 7] monthly [8]	Feb/Mar [3, 5, 8, 9, 10] May/Jun [4,7] Sept [6]	May [4, 5, 7, 10] Oct [5, 7]
Year 10	**2012**	Mar/Apr [4, 5, 7, 8, 9, 10]	March/Apr [4, 5, 9, 10] Jun/July [5, 7] monthly [8]	Feb/Mar [3, 5, 8, 9, 10] May/Jun [4,7] Sept [7]	May [4, 5, 7, 10] Oct [5, 7]

Dates are approximate time periods and are subject to change according to weather patterns and planning decisions. After Year 5 the monitoring should continue as in previous years, or as determined by evaluation of performance criteria.

1. Pre-construction monitoring
2. Post construction inspection to ensure everything has been implemented according to plan
3. Visual surveys of vegetation and structure
4. Vegetation surveys to document plant establishment, vigor, weeds
5. Photo-monitoring
6. Inspect plantings, possible supplemental planting
7. Surveys to ensure performance criteria are met
8. Hydrology monitoring
9. Aquatic invertebrate monitoring
10. Vertebrate surveys

Table 9.1. Invasive species (CalEPPC List A)

Latin name	Common name	Habitat of Concern
Ailanthus altissima	Tree of heaven	Riparian areas, grasslands, oak woodlands
Arundo donax	Giant reed, arundo	Riparian areas
Bromus madritensis ssp. *rubens*	Red brome	Widespread
Centaurea solstitialis	Yellow starthistle	Grasslands
Coraderia selloana	Pampas grass	Riparian, grassland
Cytisus scoparius	Scotch broom	Oak woodlands
Cytisus striatus	Striated broom	Grasslands
Eucalyptus globulus	Tasmanian blue gum	Riparian areas, Riparian area, grasslands
Foeniculum vulgare	Wild fennel	Grasslands
Genista monspessulana	French broom	Oak woodlands, grasslands
Lepidium latifolium	Perennial peppperweed, tall whhitetop	Riarian areas, wetlands, grasslands
Mentha pulegium	Pennyroyal	Vernal pools and wetlands
Pennisetum setaceum	Fountain grass	Grasslands
Rubus discolor	Himalayan blackberry	Riparian areas, oak woodlands
Senecio mikanioides	Cape ivy, German ivy	Riparian areas
Tamarix chinensis, T. gallica, T. parviflora & T. ramosissima	Tamarisk, salt cedar	Riparian areas, seeps

List A species are most invasive wildland pest plants. Species found on the Preserve are highlighted.

Table 9.2. Invasive species (CalEPPC List B)

Latin name	Common name	Habitat of Concern
Brassica nigra	Black mustard	Grasslands, disturbed areas
Cardaria chalepensis	Lens-podded white-top	Wetlands
Carduus pycnocephalus	Italian thistle	Grasslands, oak woodlands
Cetaurea melitensis	Tocalote, Malta starthistle	Widespread
Cirsium vulgare	Bull thistle	Riparian areas, marshes
Conium maculatum	Poison hemlock	Disturbed areas, riparian, oak understory
Ehrharta erecta	Veldt grass	Wetlands, riparian, grasslands
Festuca arundiacea	Tall fescue	Grassland
Hedera helix	English ivy	Riparian areas
Ilex aquifolium	English holly	Riparian areas
Iris pseudocorus	Yellow water iris, yellow flag	Riparian, wetland areas
Olea europaea	Olive	Riparian areas
Ricinus communis	Castor bean	Riparian habitats
Robinia pseudoacacia	Black locust	Riparian areas
Schinus molle	Peruvian pepper tree	Riparian areas
Schinus terebinthifolius	Brazilian pepper tree	Riparian areas
Senecio jacobaea	Tansy ragwort	Grasslands
Spartium junceum	Spanish broom	Grassland, wetlands, oak woodland
Vinca major	Periwinkle	Riparian, oak woodland

List B species are wildland plants of lesser invasiveness. Species found on the Preserve are highlighted.

FIGURES

Figure 1.1. Ojai Meadows Preserve and surrounding area

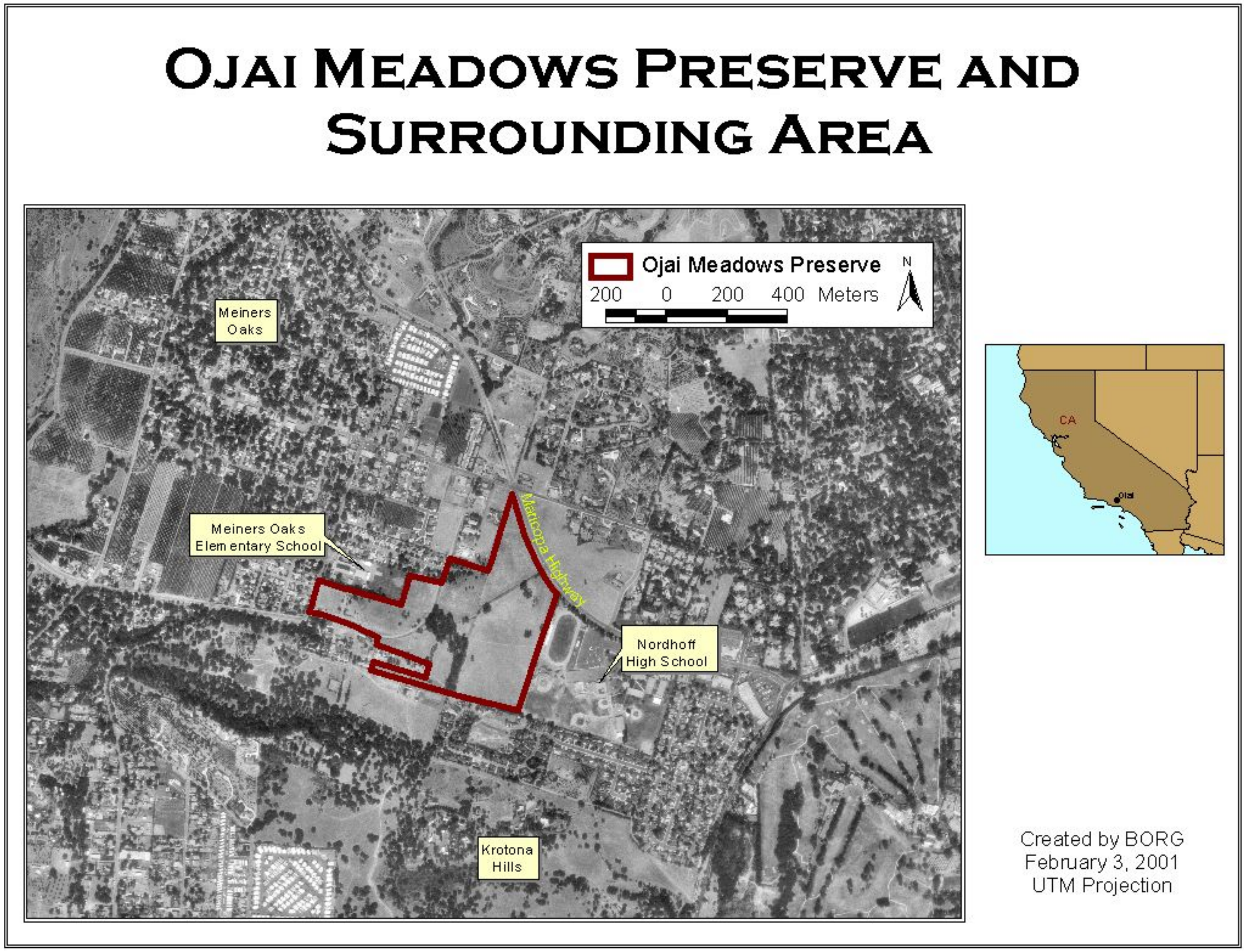


Figure 1.2.   Adaptive management model

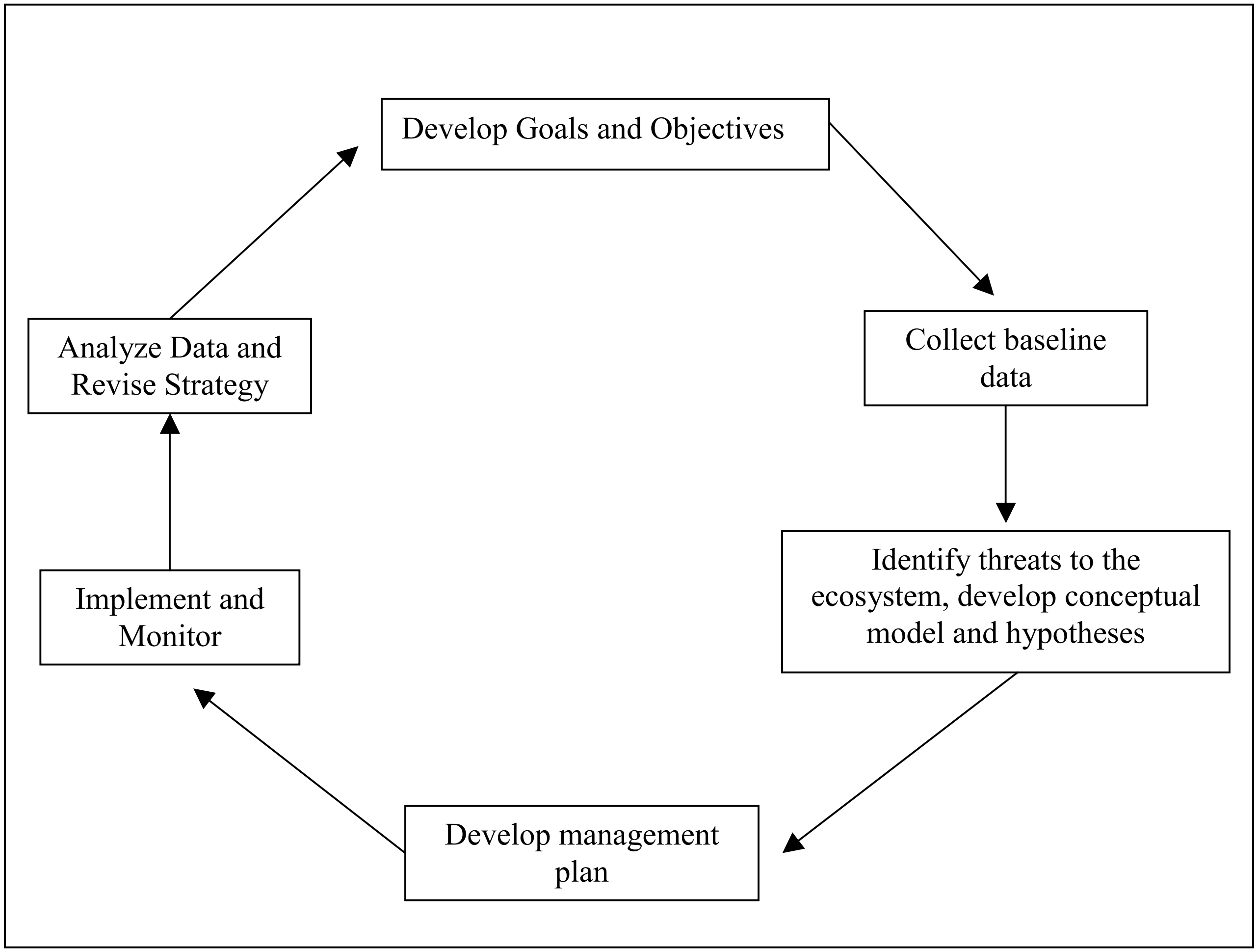


Figure 1.3. Oak savanna conceptual model

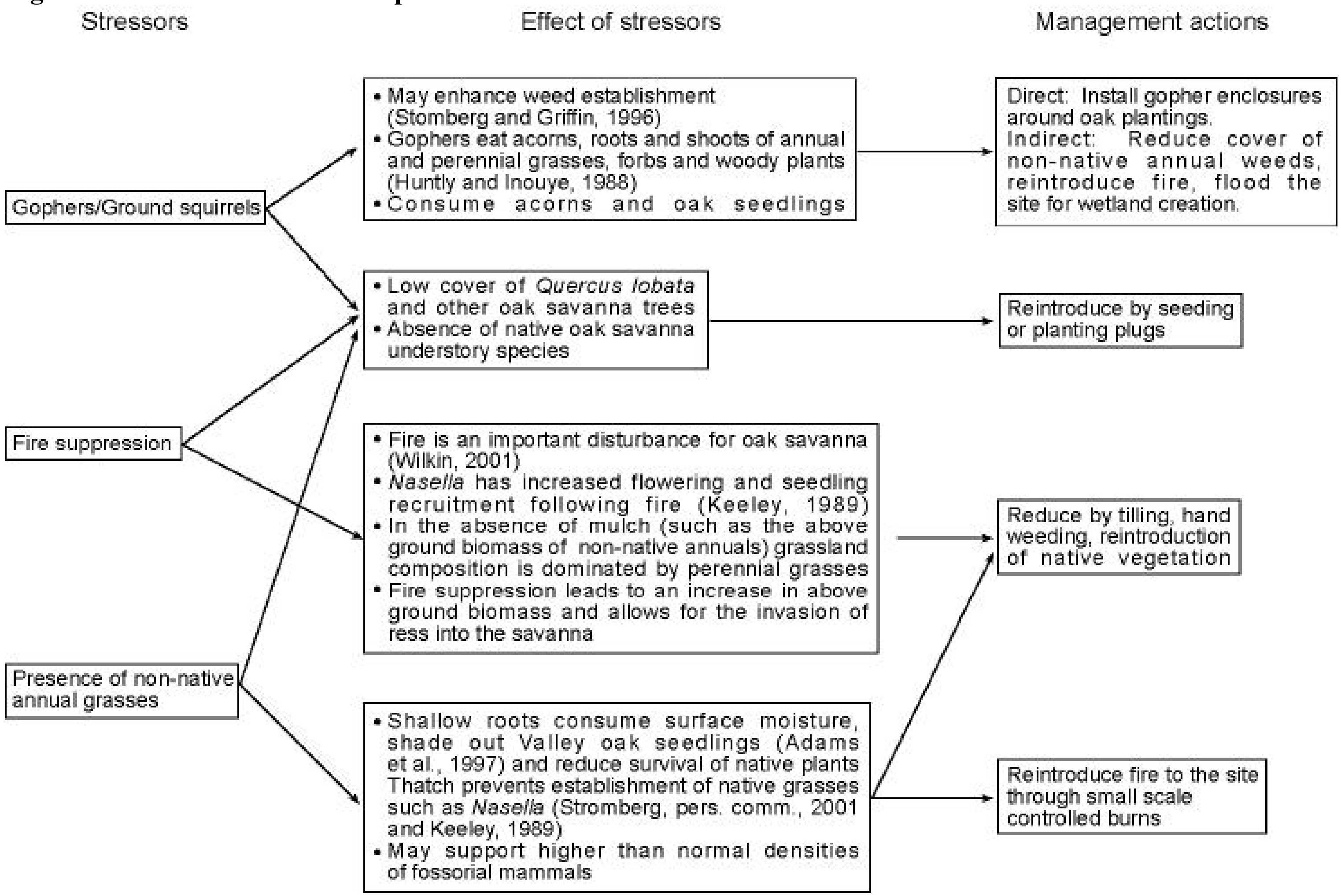


Figure 1.4. Vernal pool conceptual model

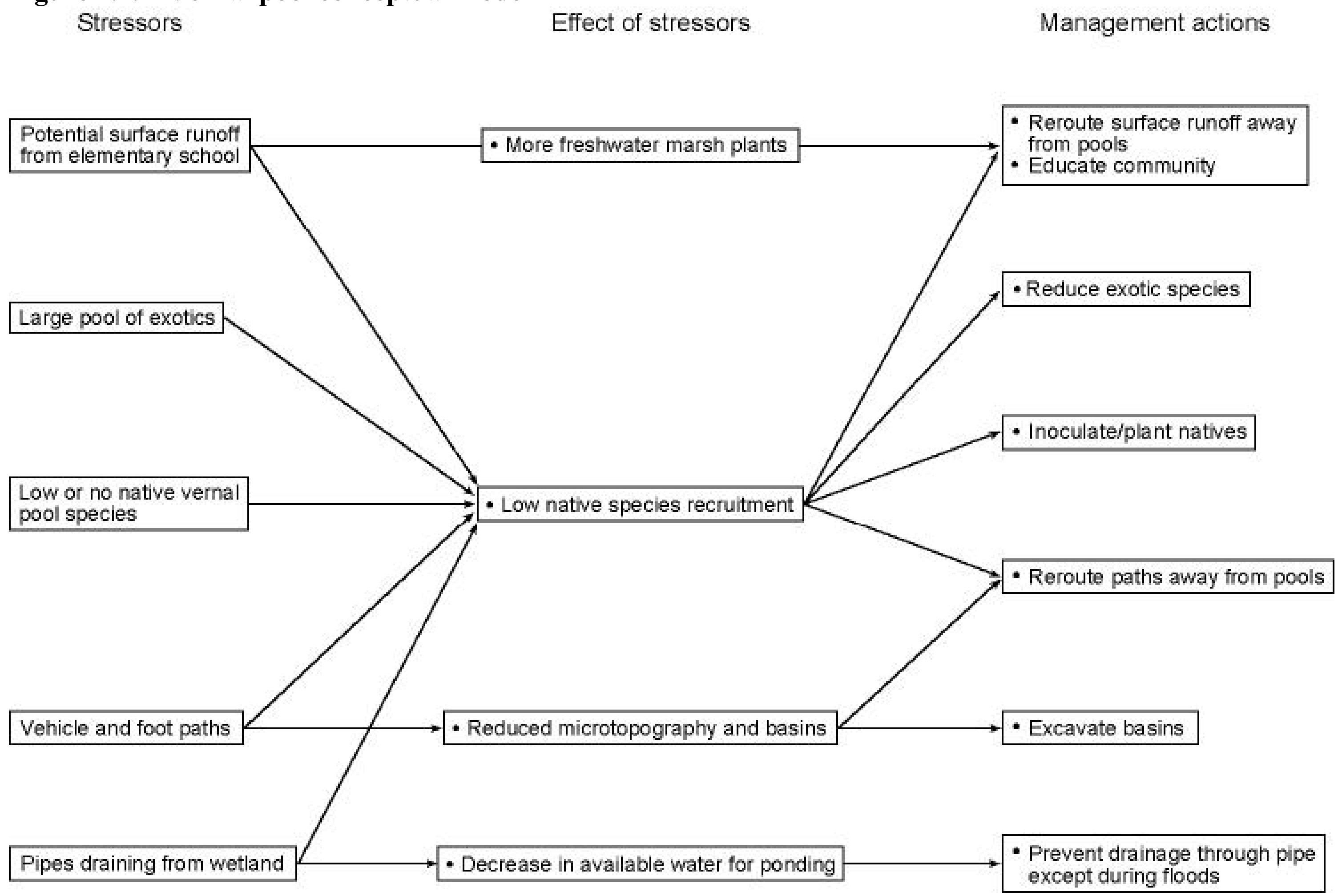


Figure 1.5. Freshwater marsh conceptual model

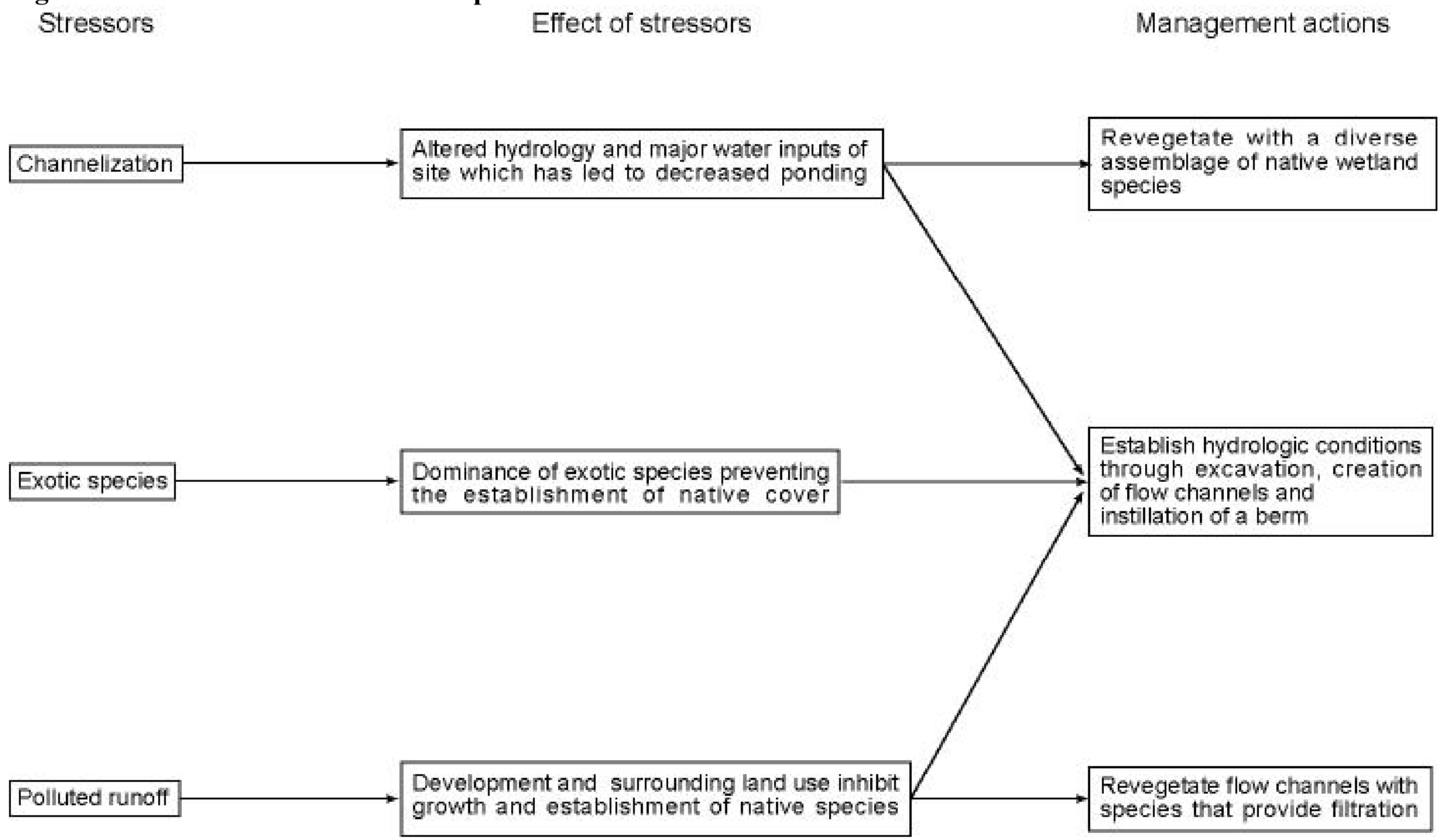


Figure 1.6. Riparian area conceptual model

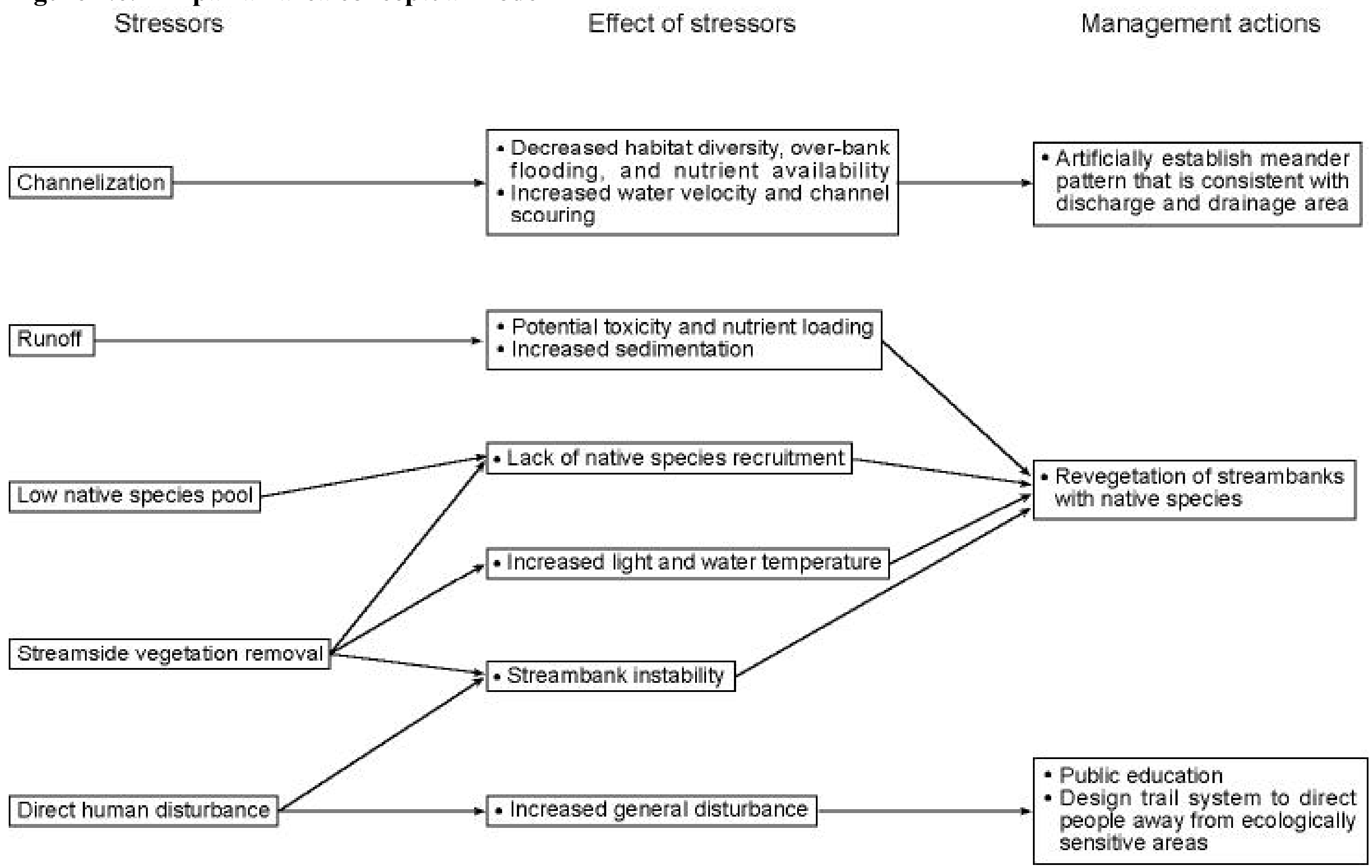


Figure 1.7. Combined conceptual model

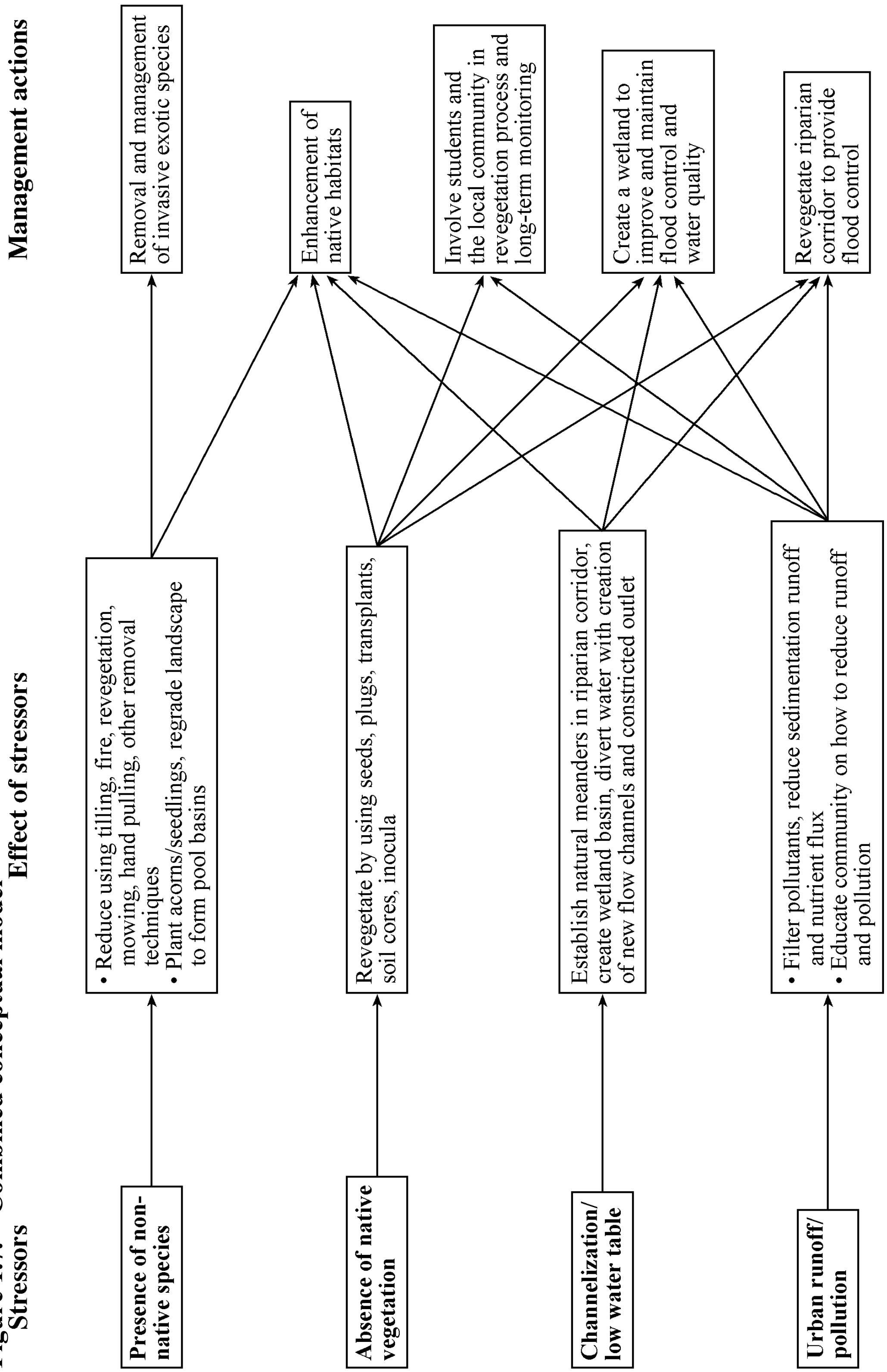


Figure 2.1. Historical photo, 1929

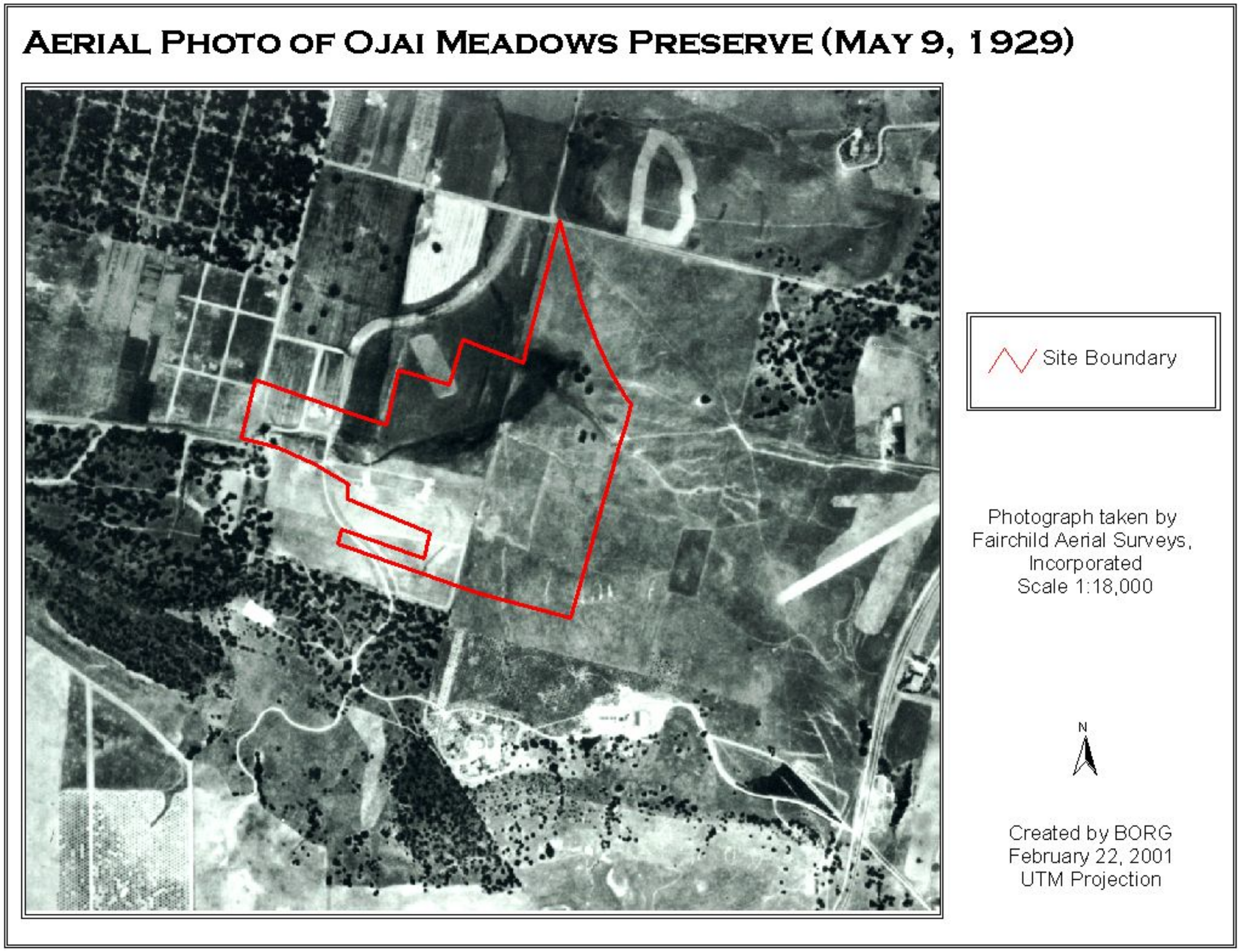


Figure 2.2. Historical photo, 1945

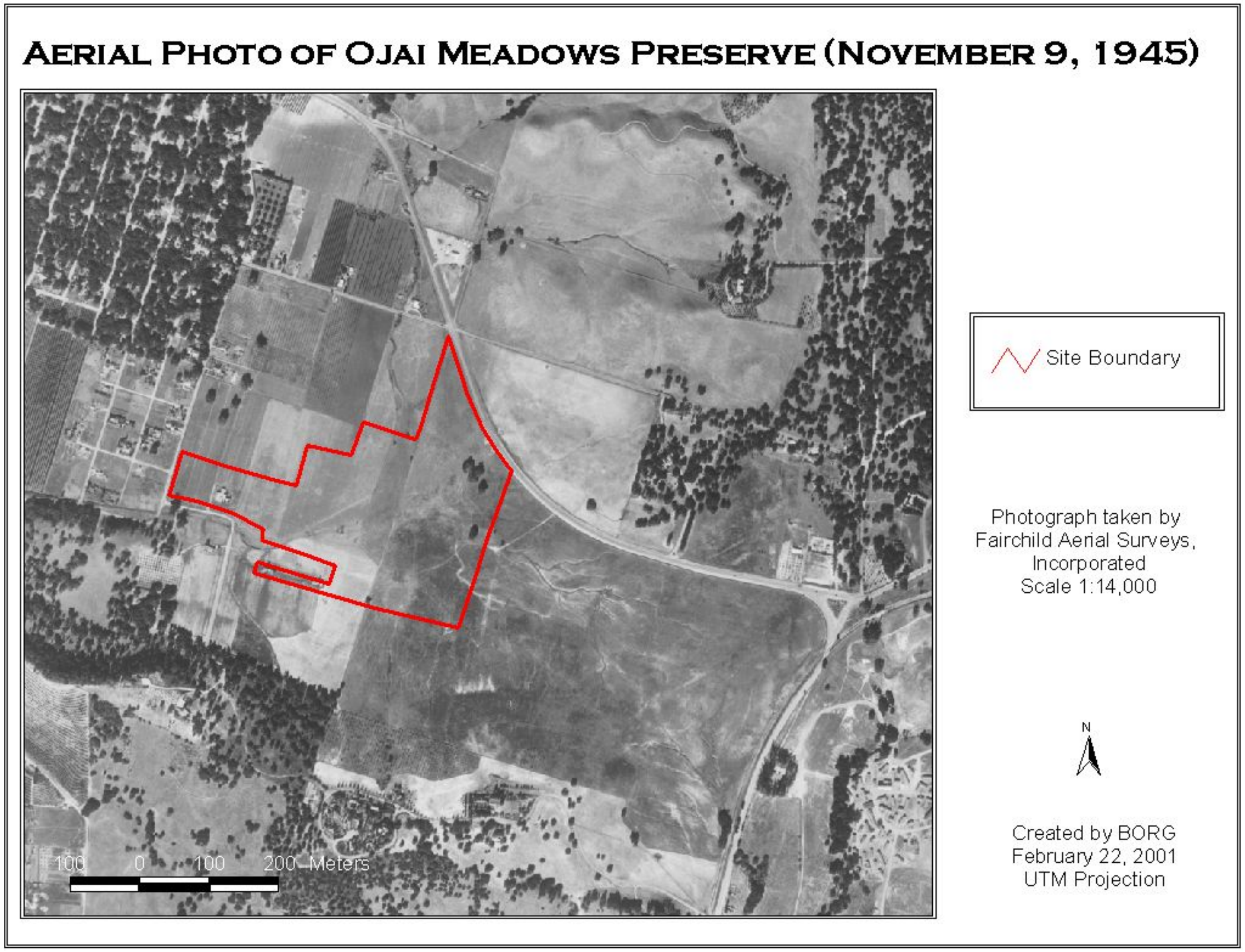


Figure 2.3. Historical photo, 1969

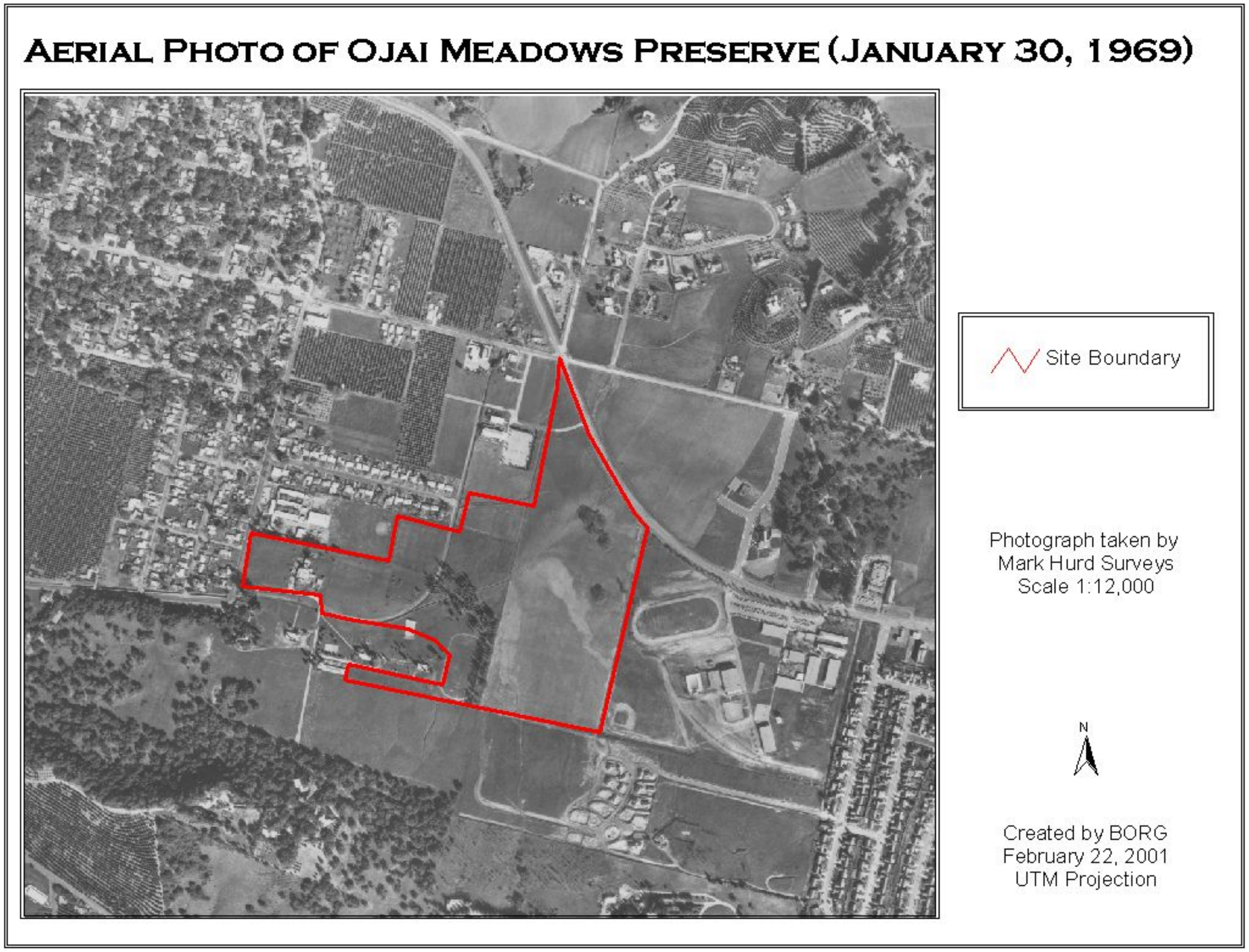


Figure 2.4. Historical photo, 1978

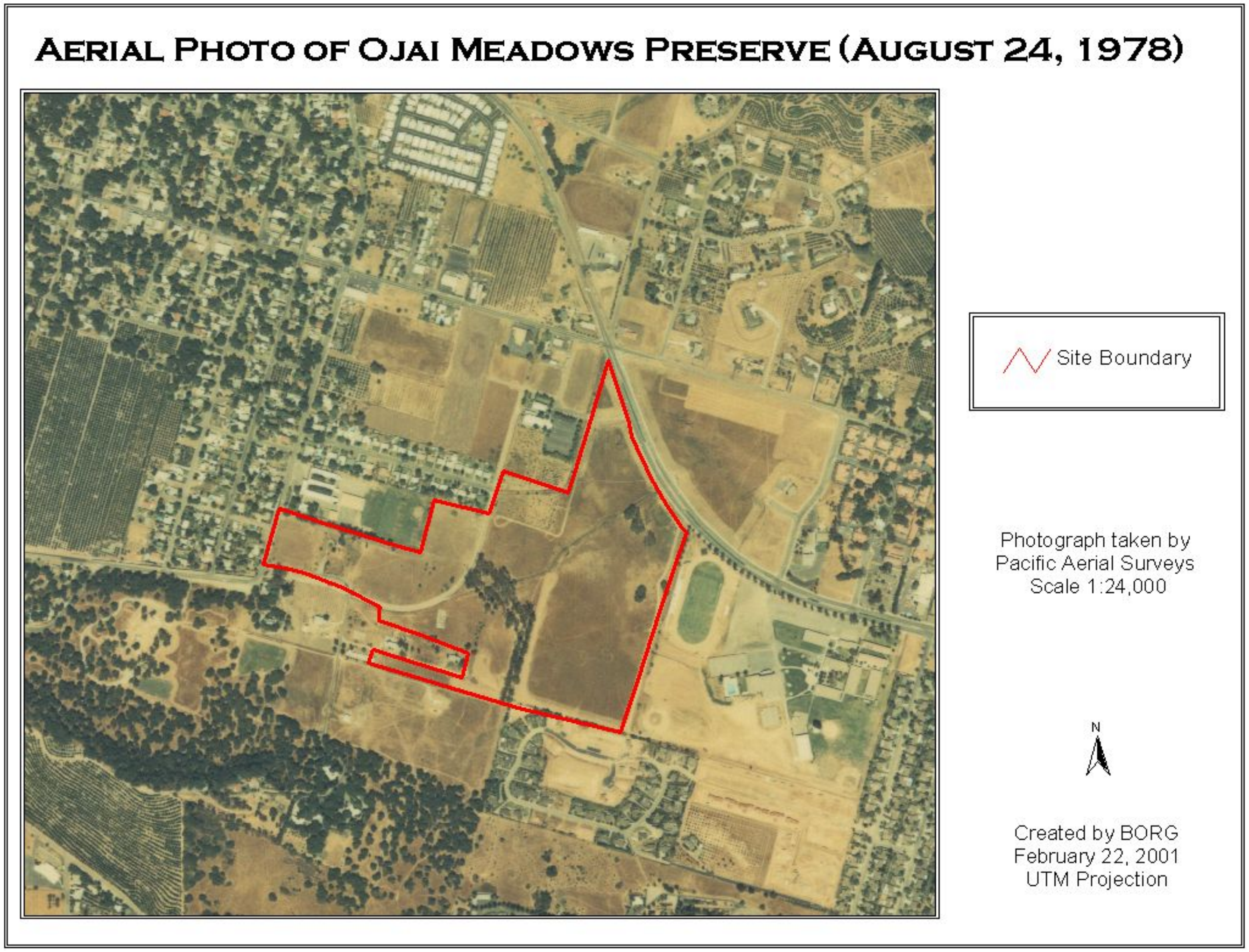


Figure 2.5. Land use map

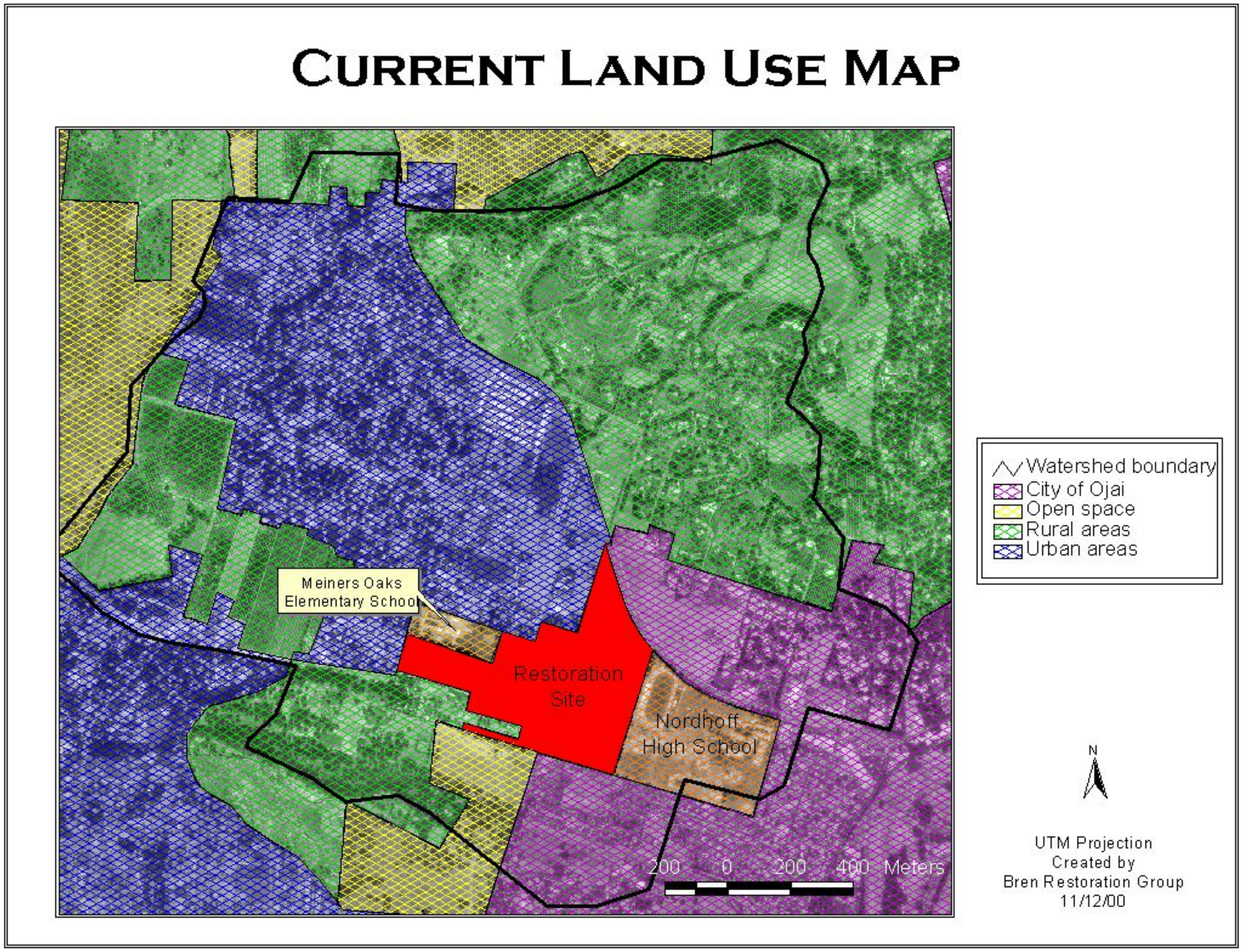


Figure 2.6. Cumulative rainfall frequency for Ojai, CA

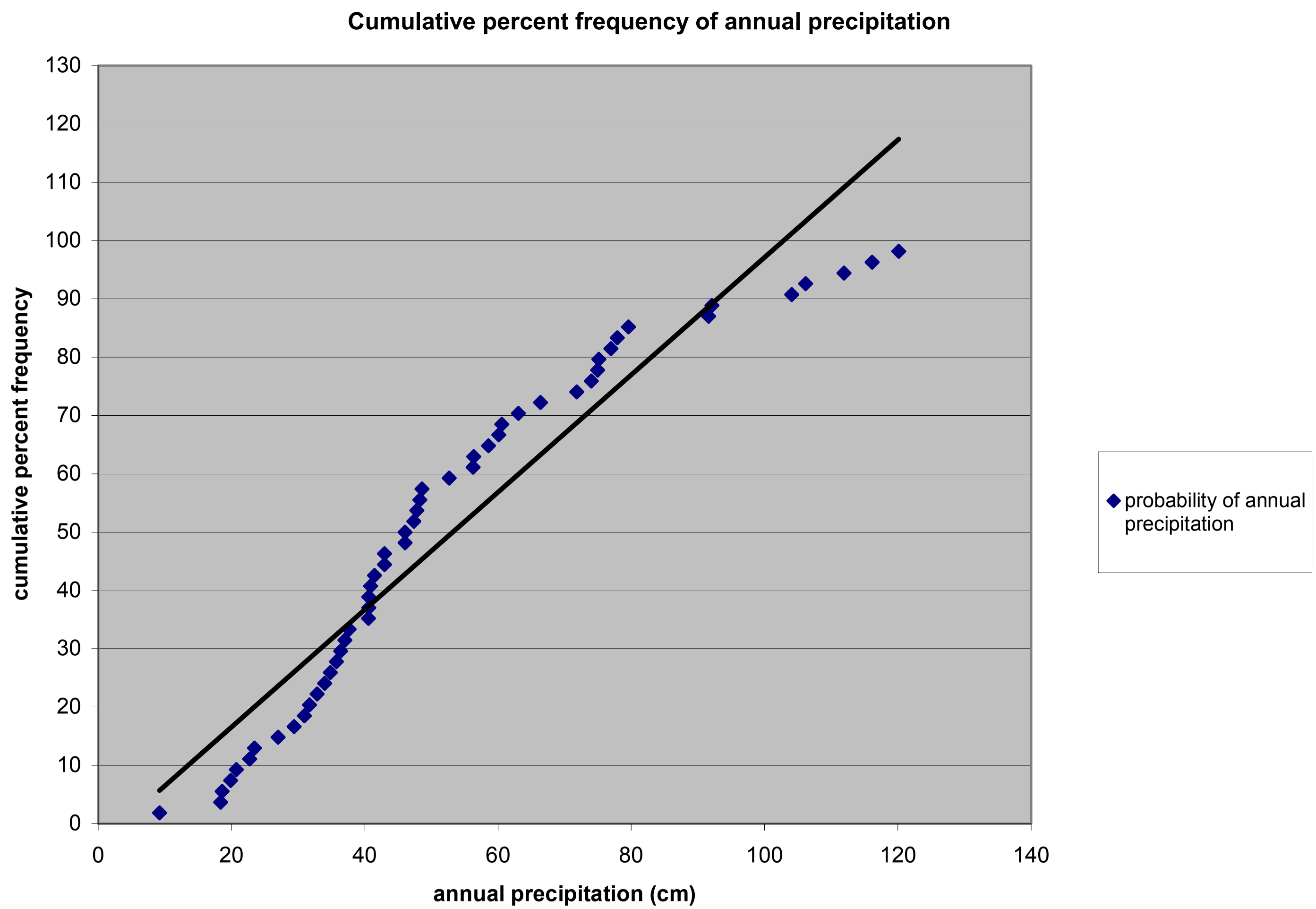


Figure 2.7.   Map of drainage and inflow points

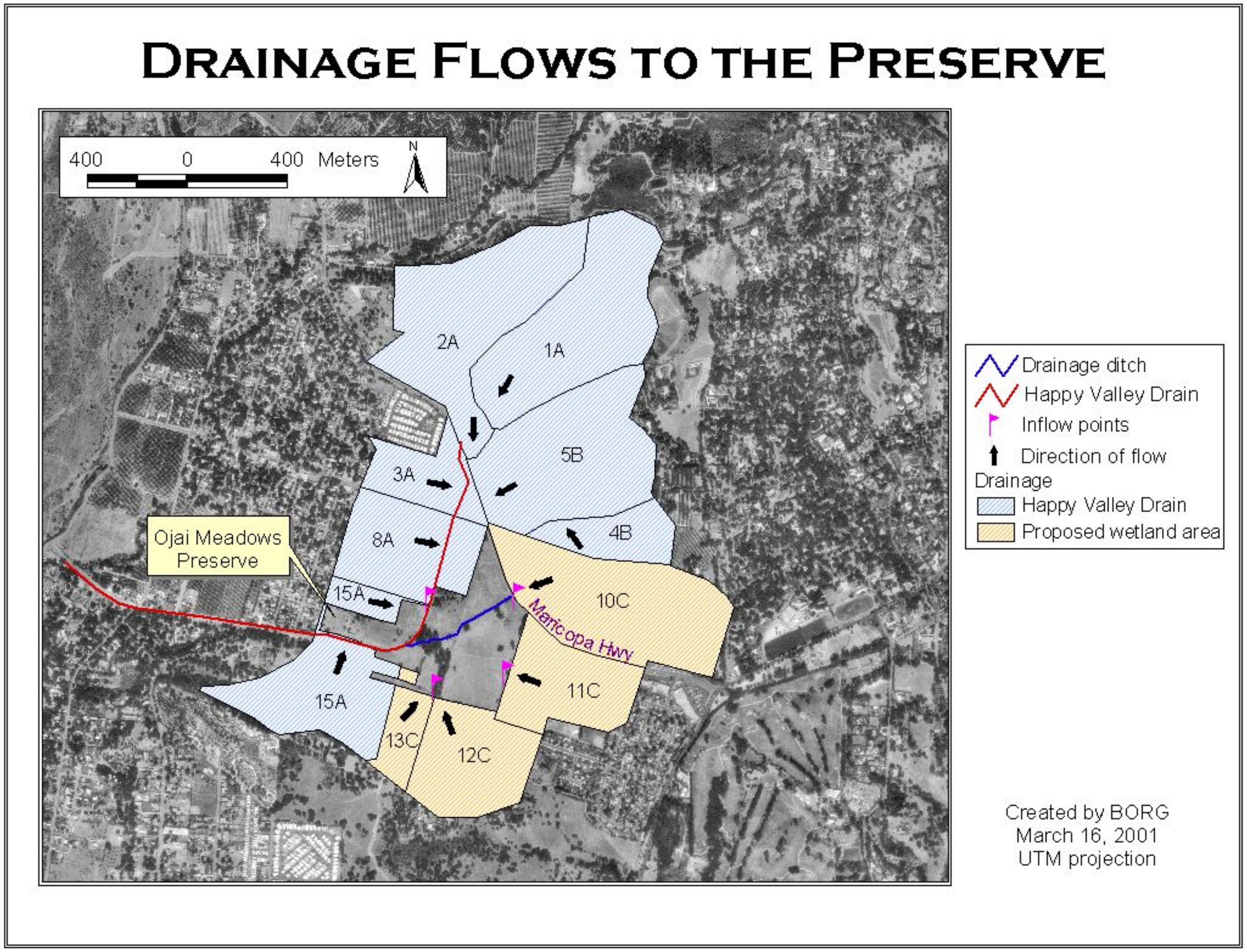


Figure 2.8. Map of wells

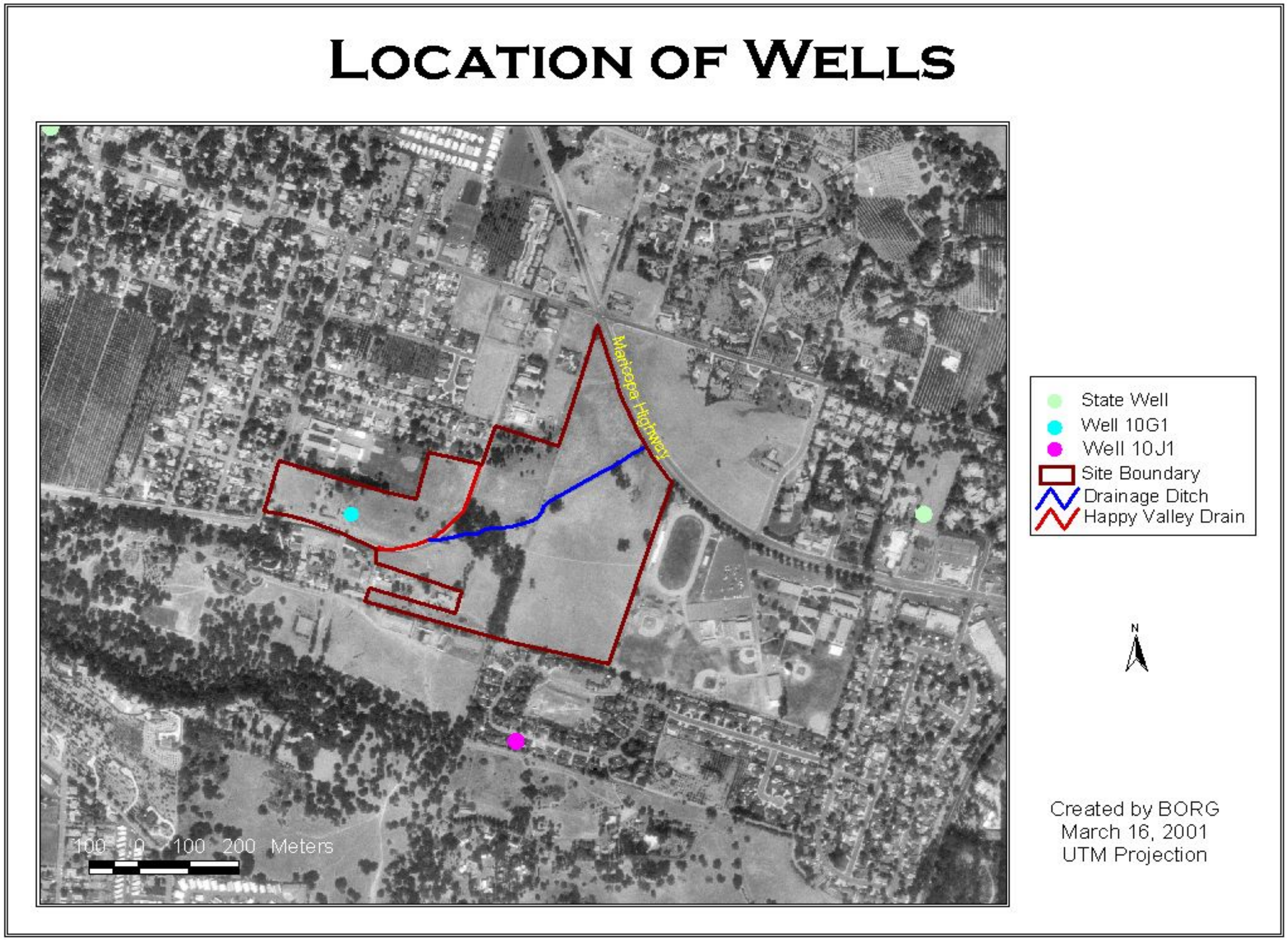


Figure 2.9. Seasonal groundwater fluctuation

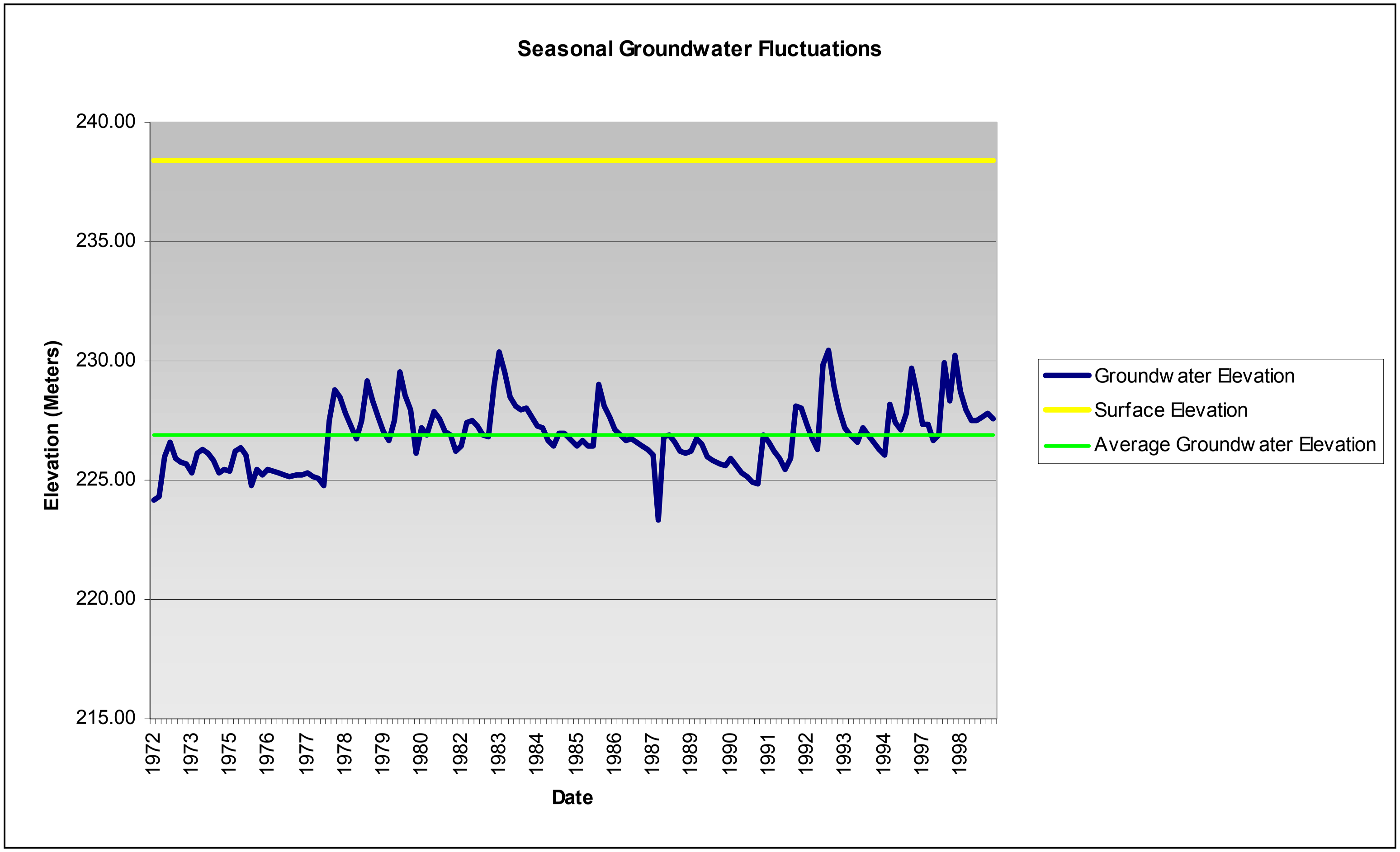


Figure 2.10. Soils map of the Preserve and surrounding area

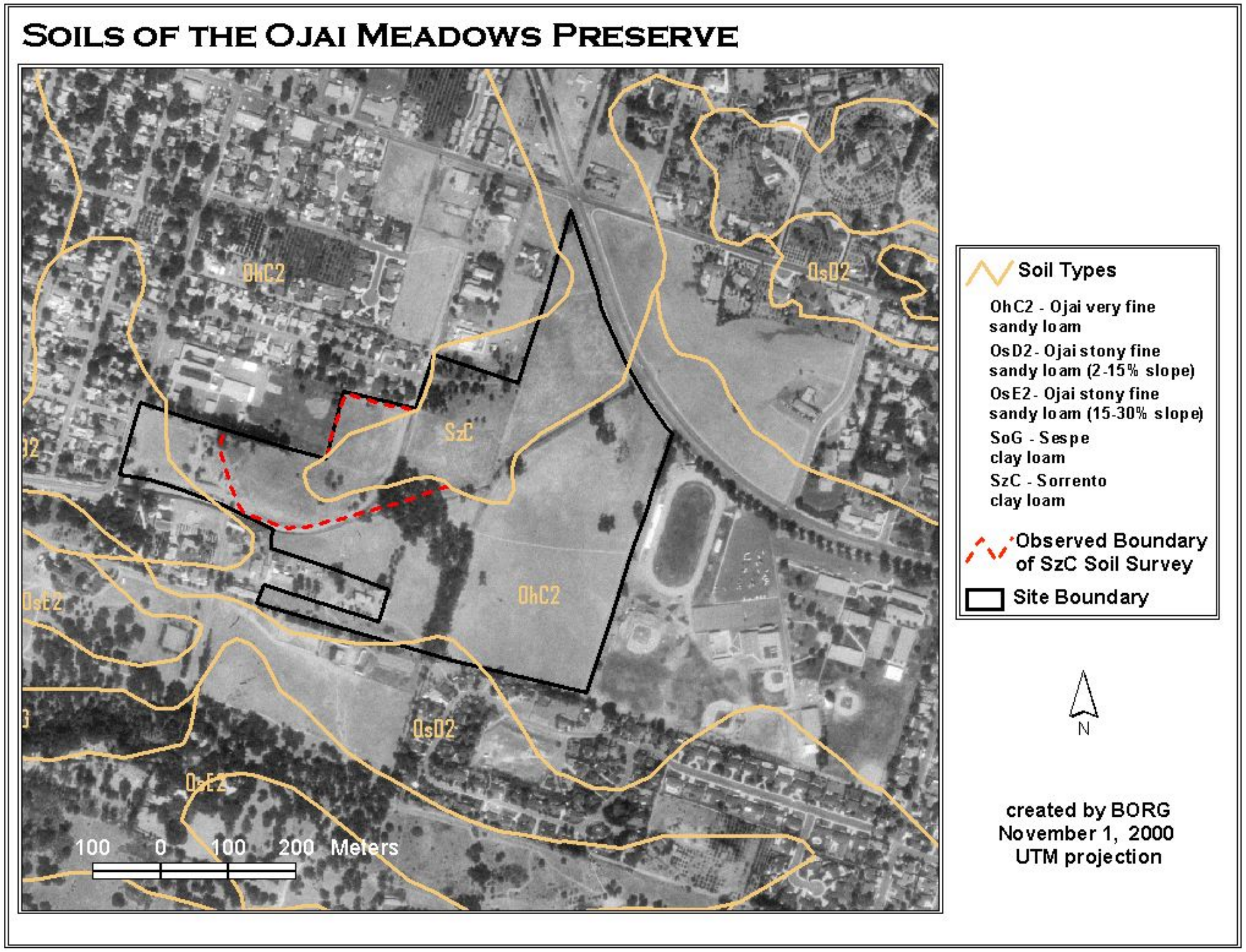


Figure 2.11. Results of topographic survey of the Preserve

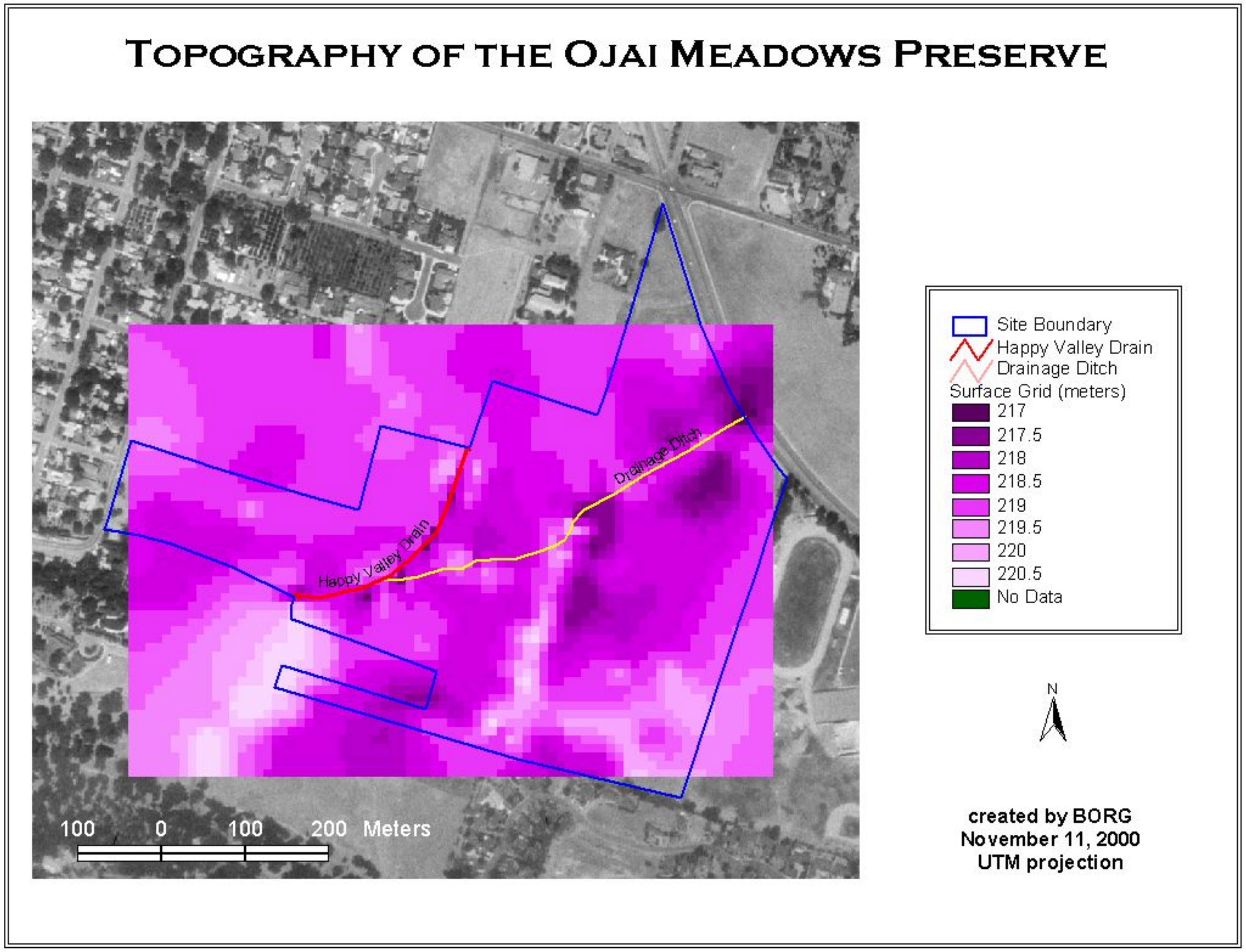


Figure 2.12. Existing vegetation on the Preserve

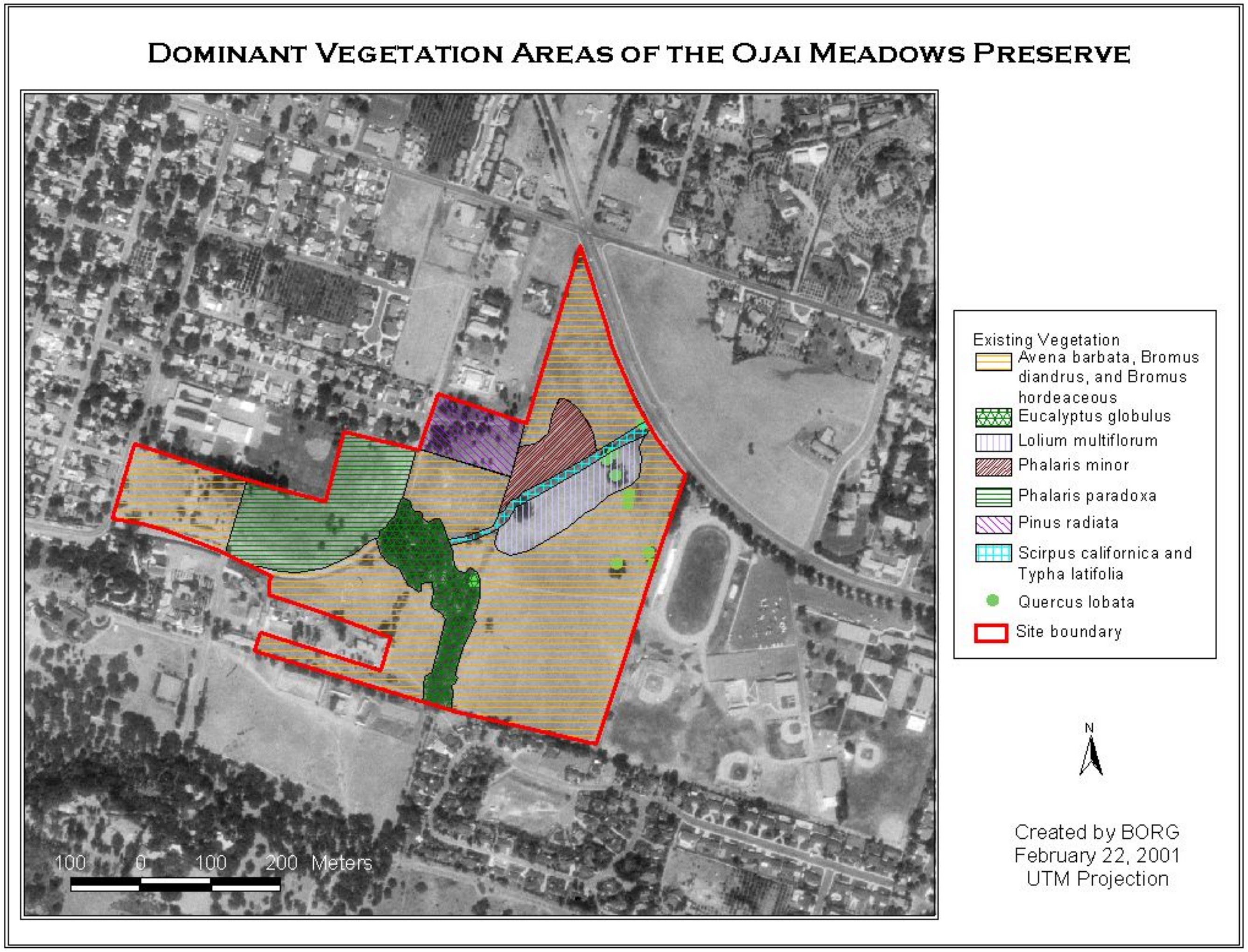


Figure 3.1. Latin square design for grassland experiment at the Preserve (Underwood, 1997).

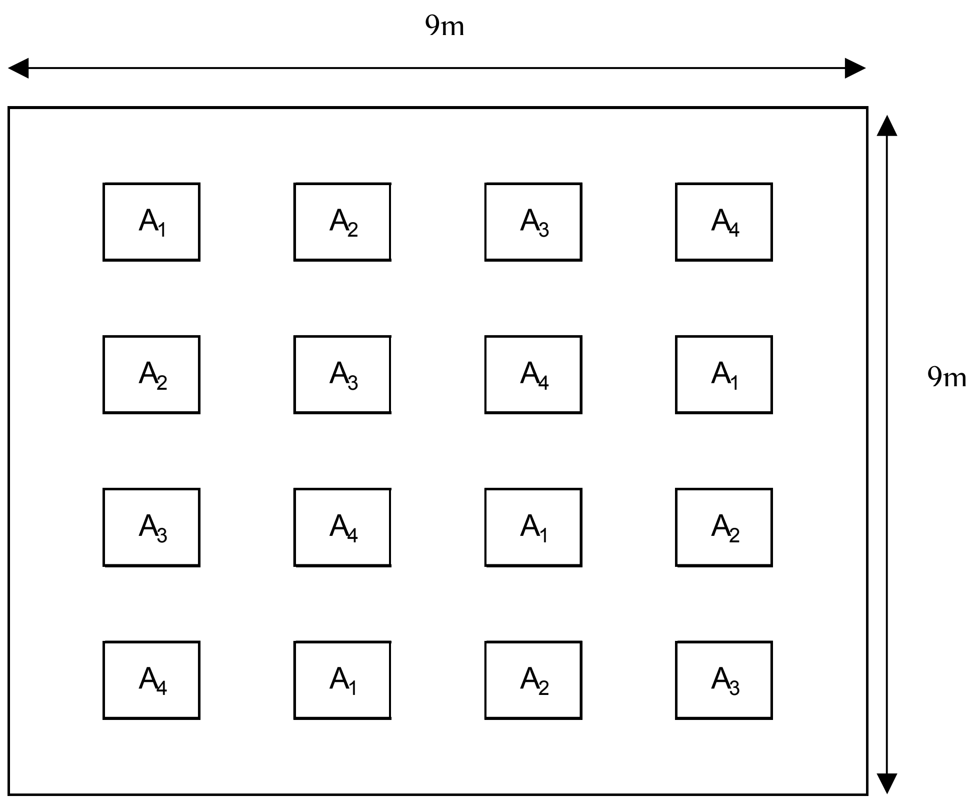


Figure 3.2. Map of experimental plots

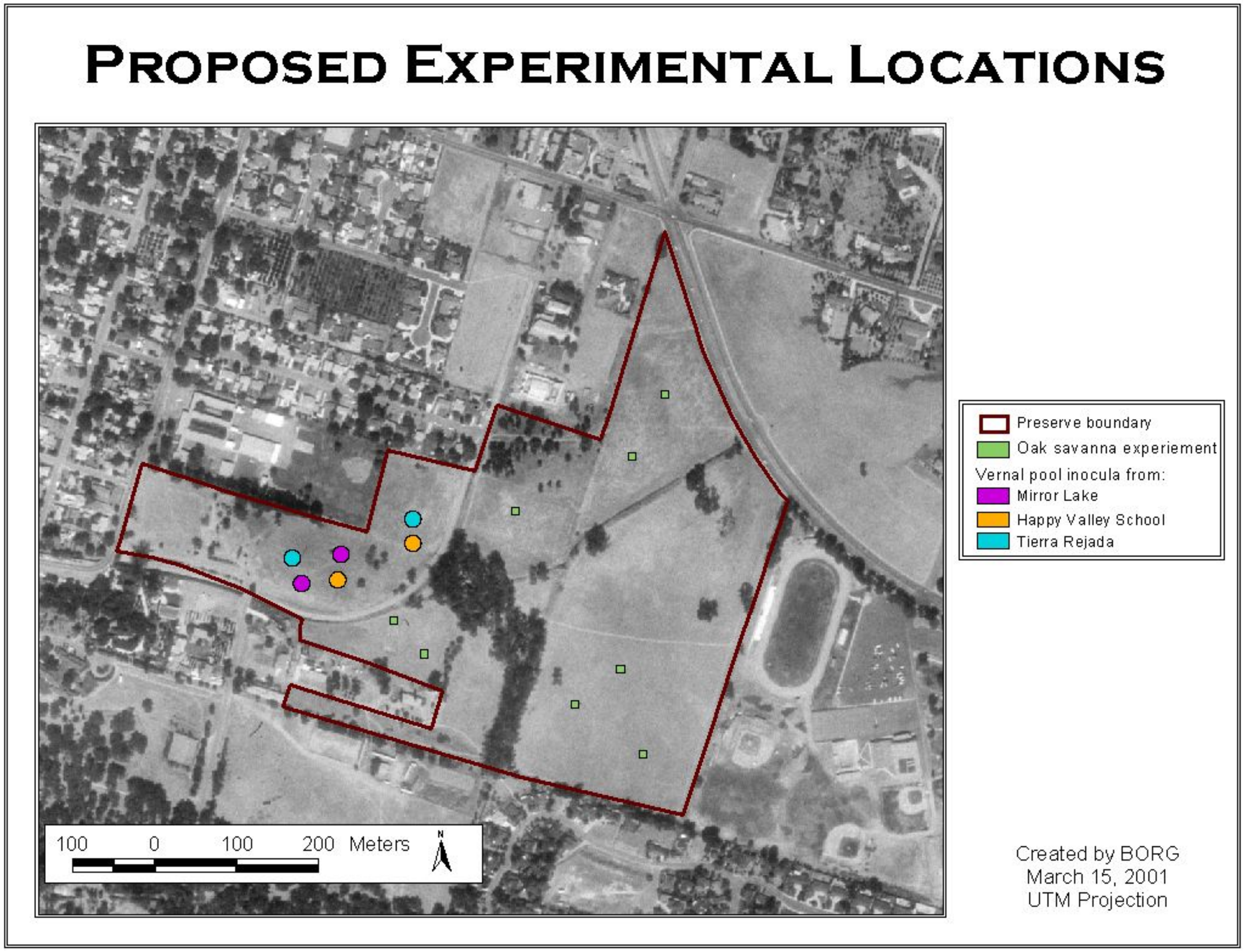


Figure 3.3. Proposed habitat restoration areas

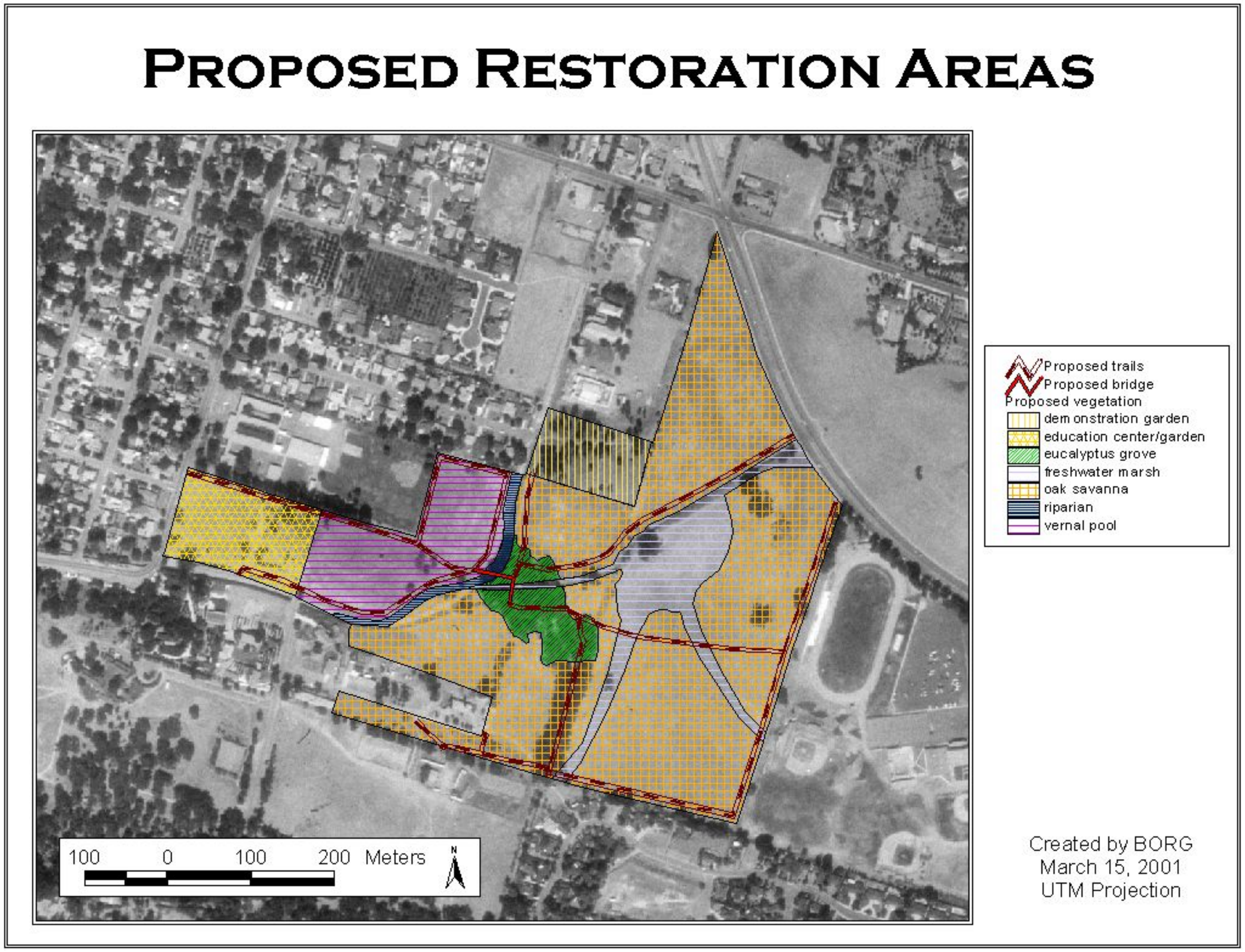


Figure 4.1. Regional vernal pools

Figure 4.2. Reference vernal pools

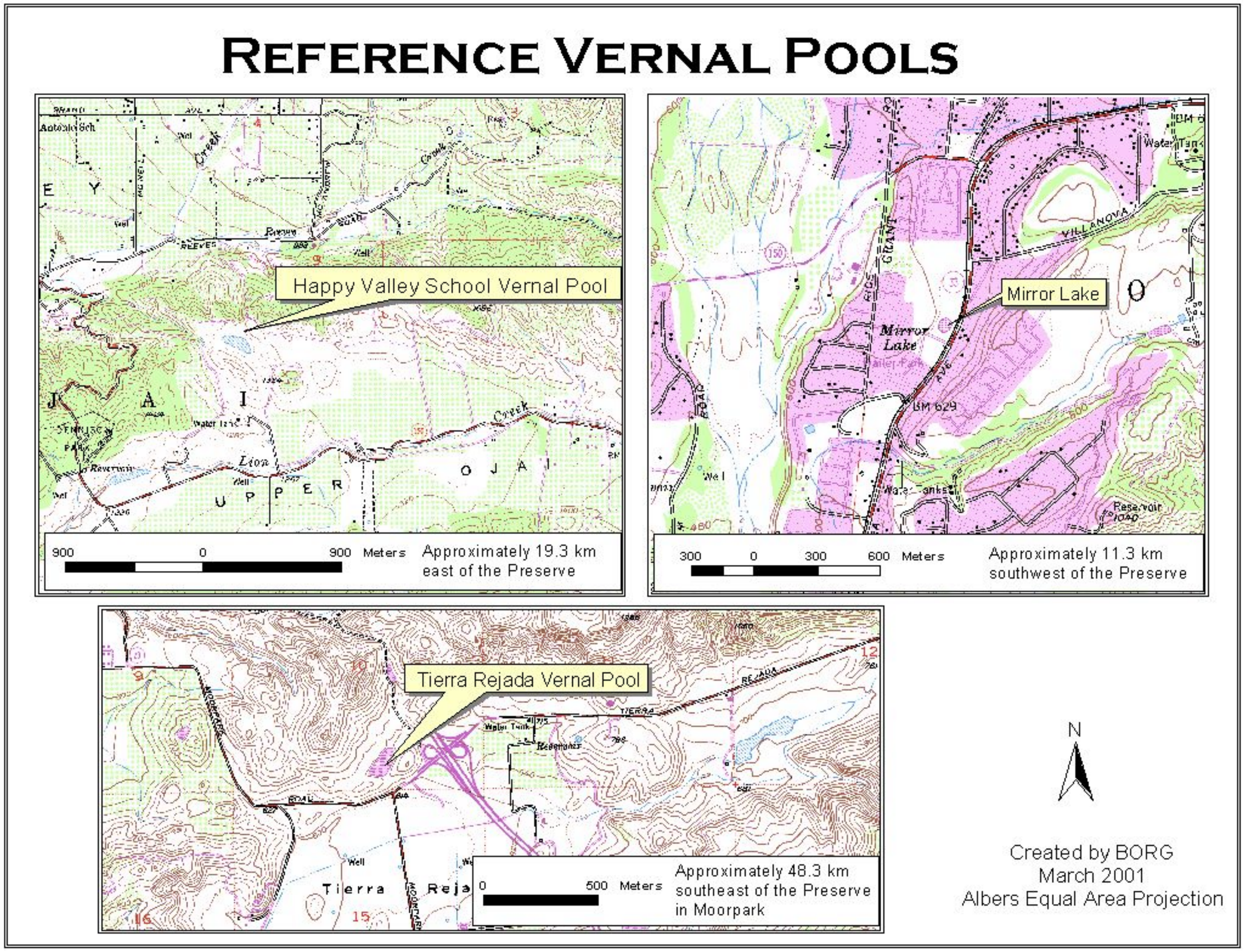


Figure 5.1. Water budget of the Preserve

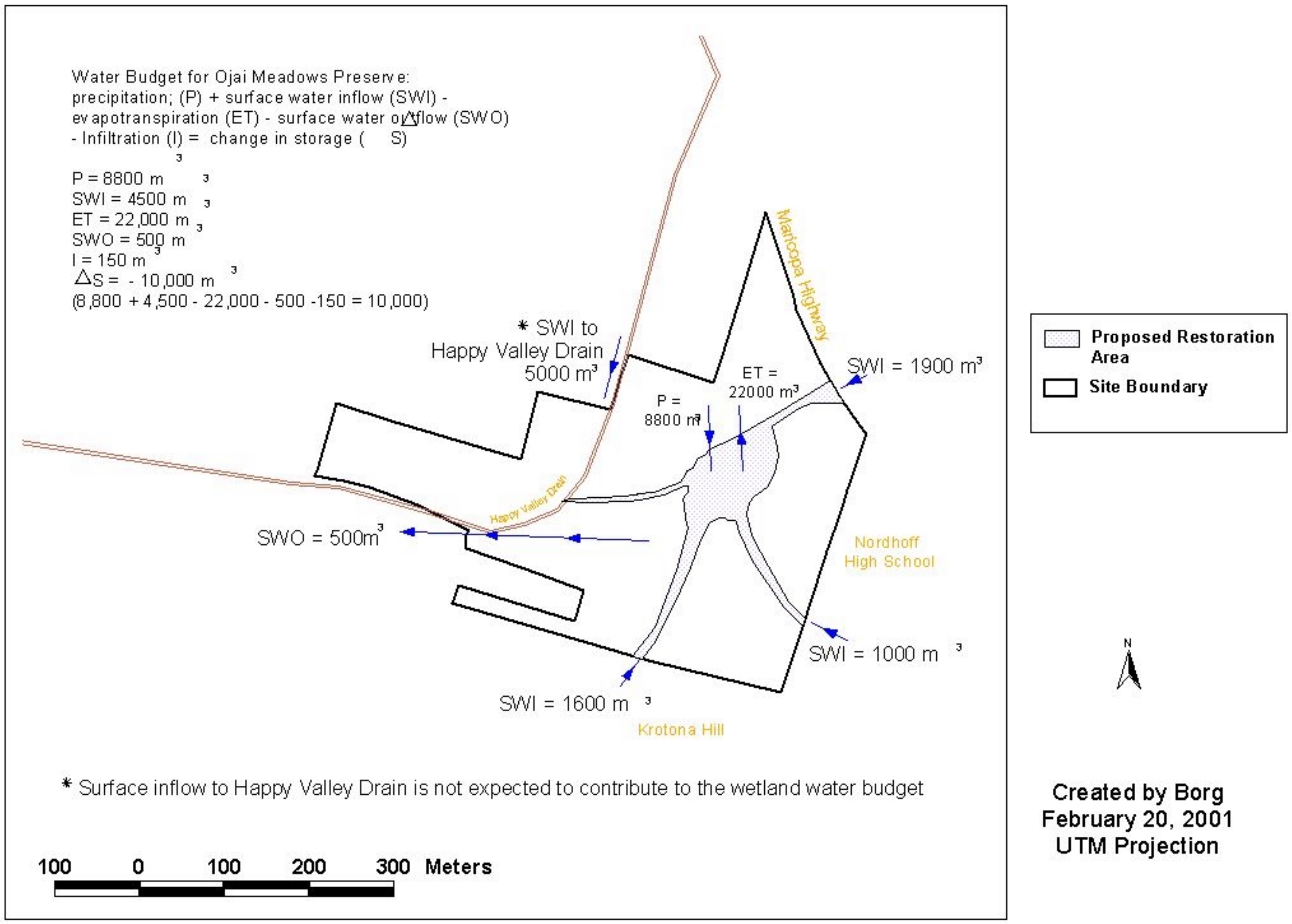


Figure 5.2.   Water balance

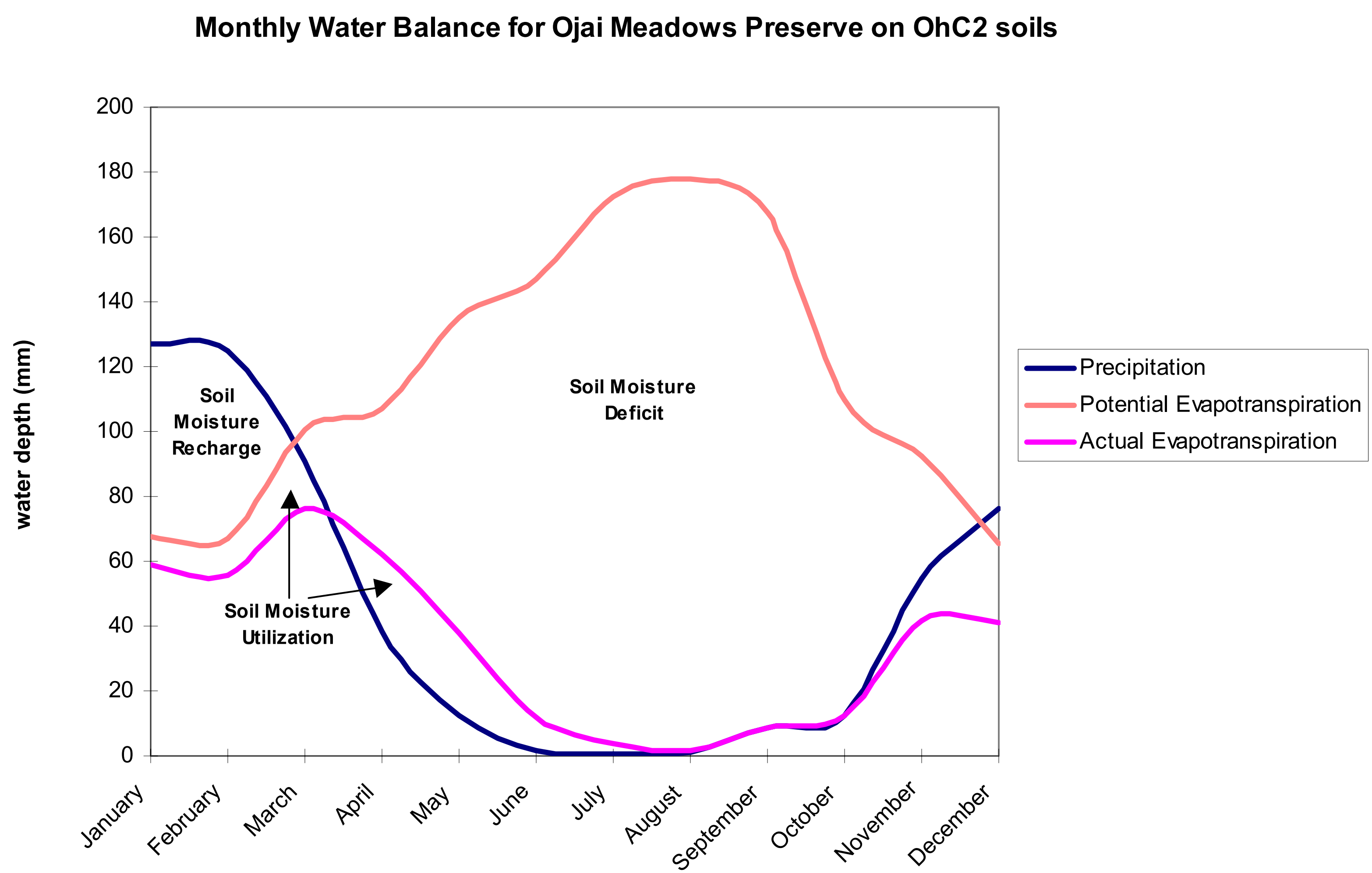


Figure 5.3.   Proposed wetland

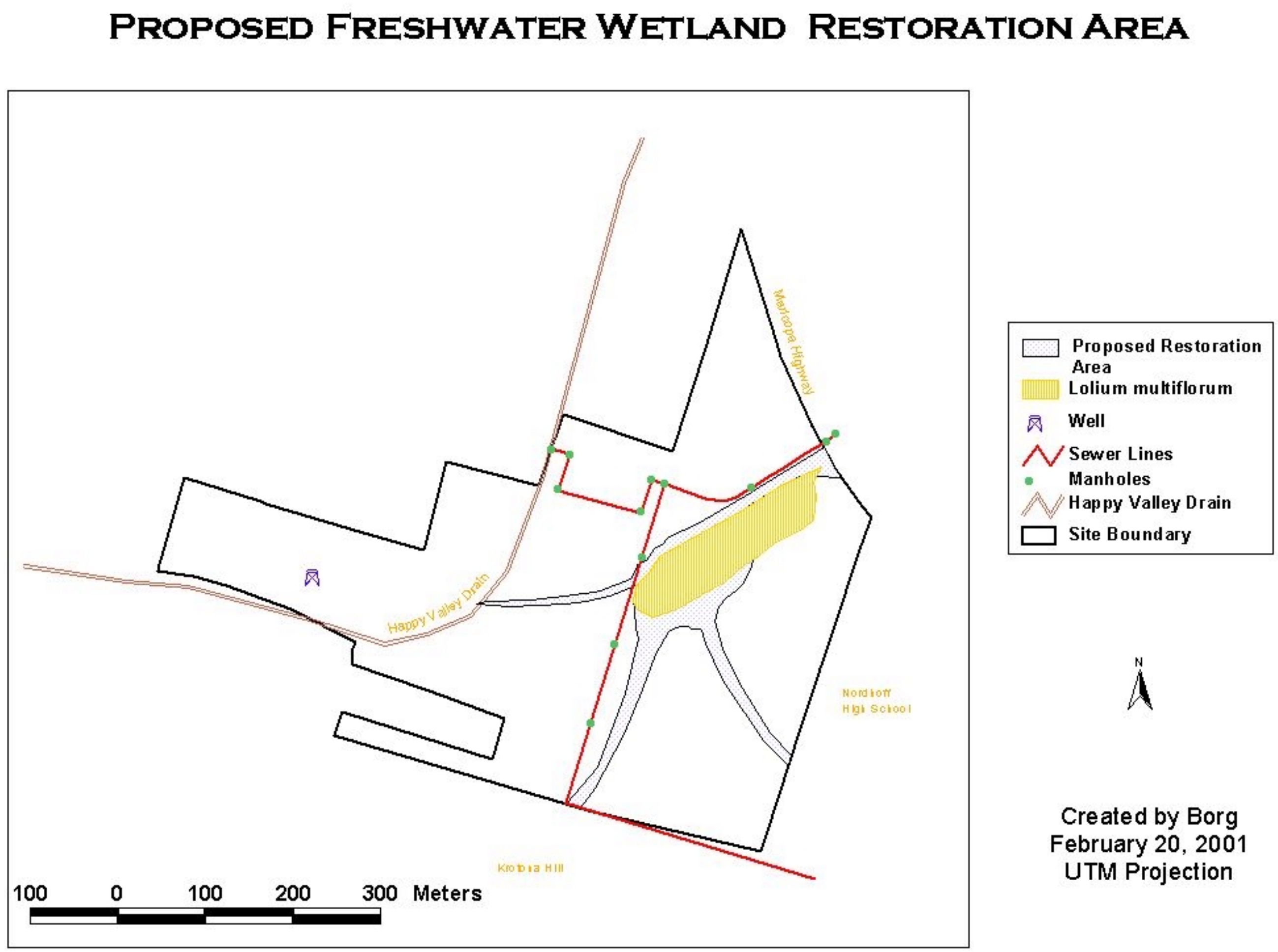


Figure 5.4. Proposed management for freshwater marsh

Proposed Alterations for Freshwater Marsh Restoration

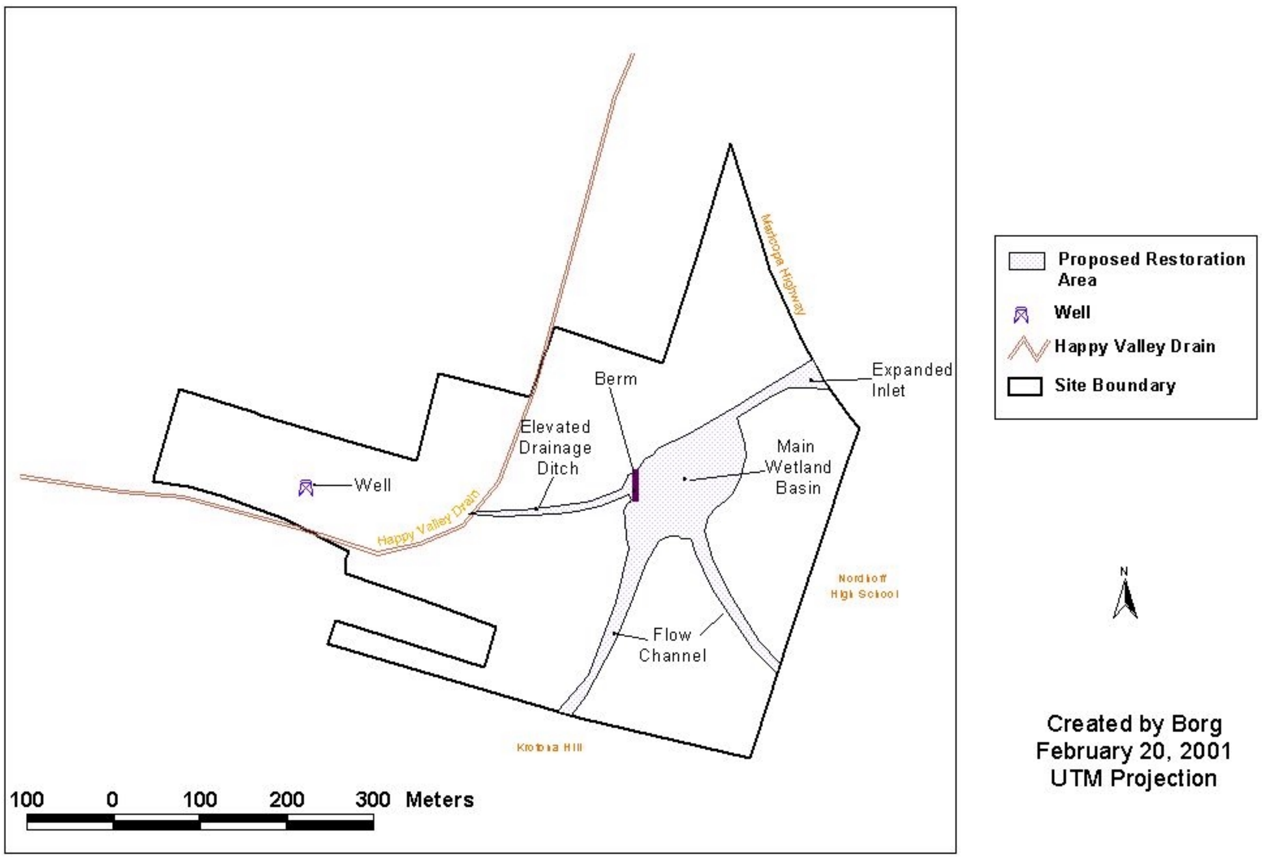


Figure 6.1. Meander geometry

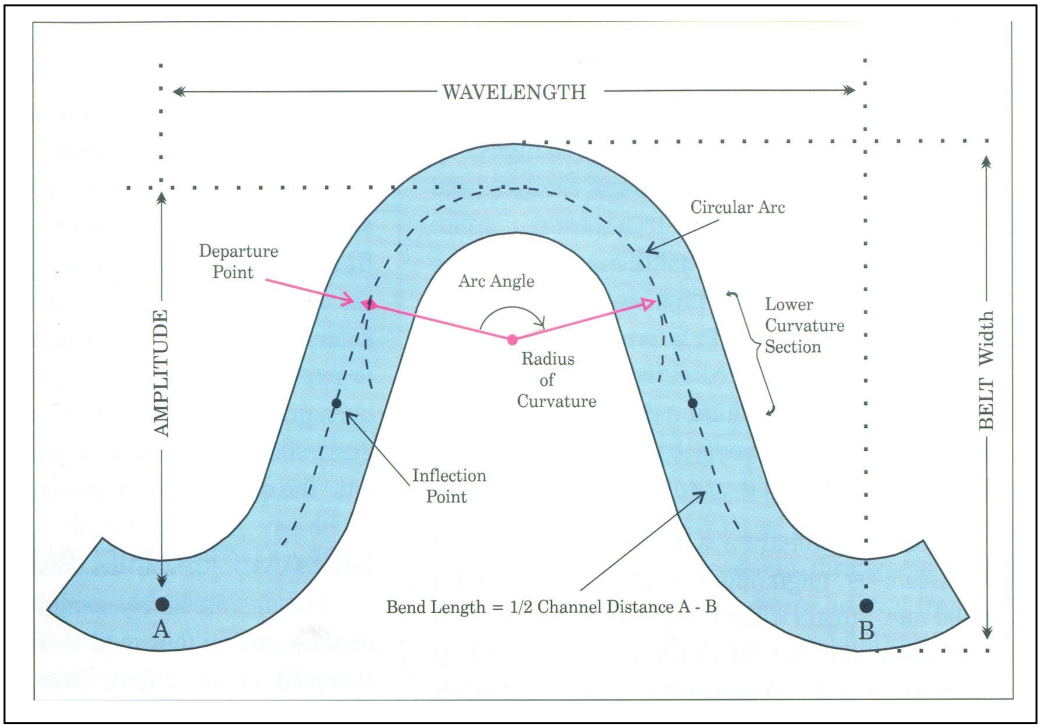


Figure 6.2. Proposed cross-sectional channel.

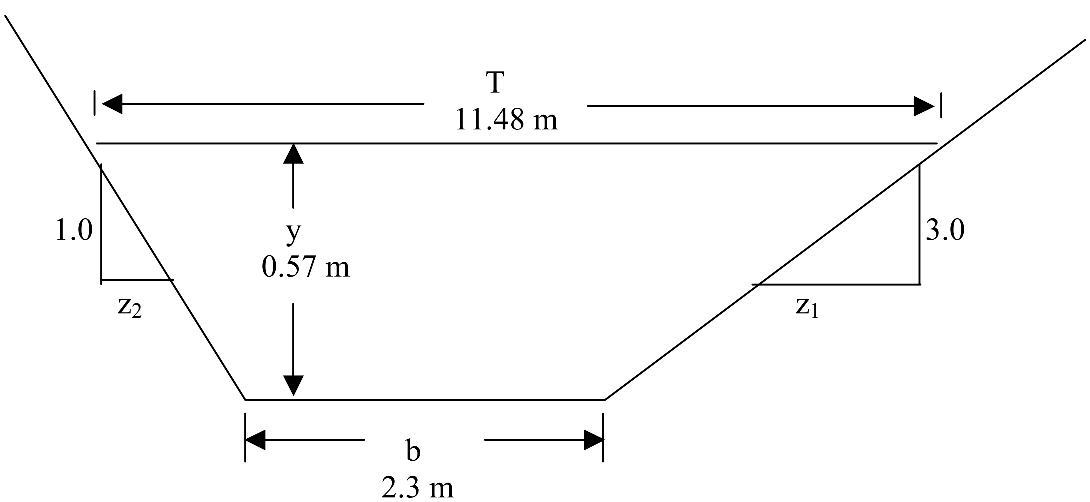
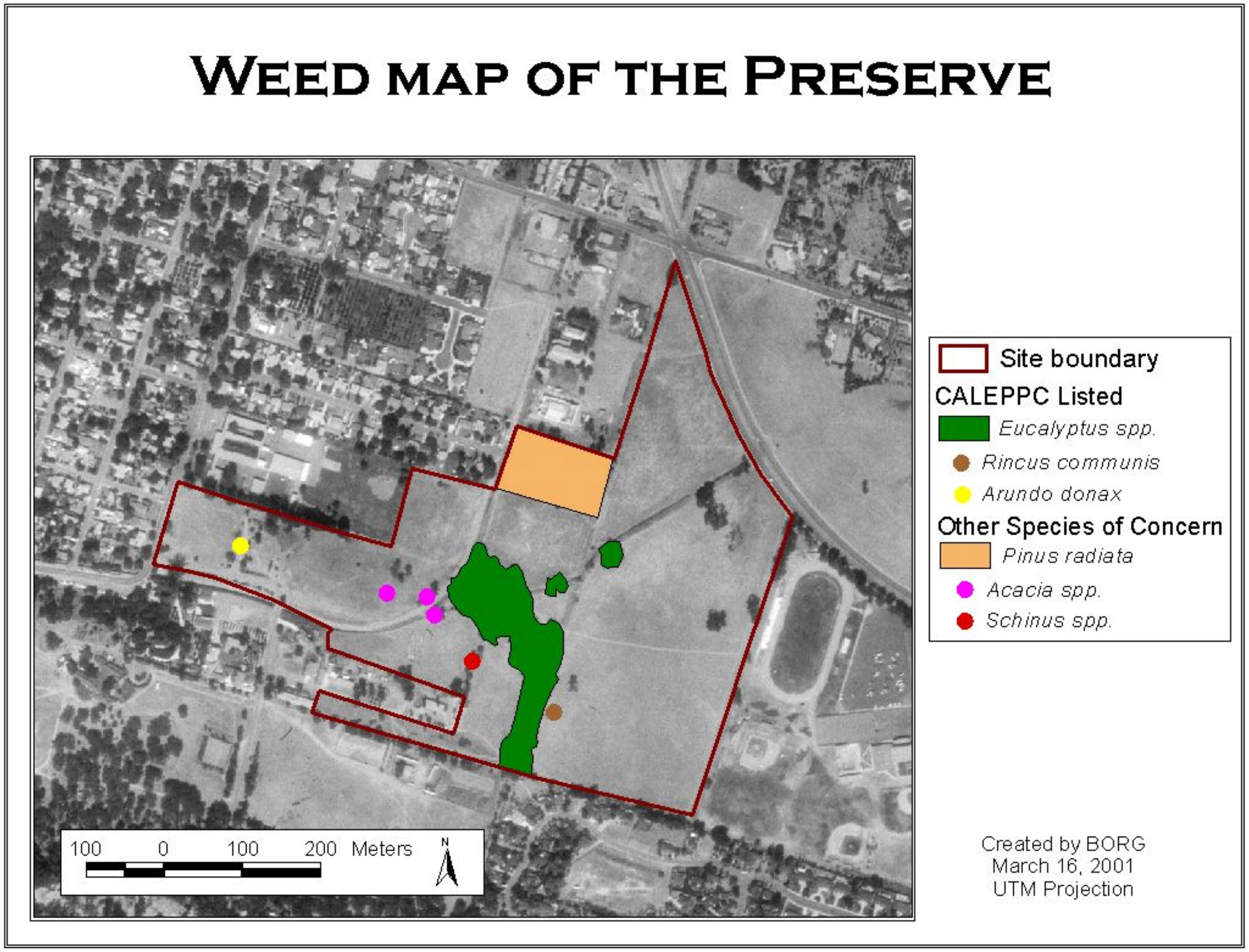


Figure 9.1. Weed map of the Preserve



METHODS

Soil Analysis method

Design of Survey:

The soil survey conducted by BORG was undertaken by drawing a total of six transects in an east-west direction across the entire Preserve. The transects, labeled A through G, were spaced at intervals of 45 to 70 meters, depending on topography. Soil samples were taken along each transect at intervals of 14 to 37 meters, and numerically labeled. Each soil sample was gathered by digging a 36 cm hole with a hand auger and carefully extracting the soil from the bottom 5 cm of the hole. Therefore, the samples were taken from soil depths of 30 to 36 cm. The extracted soil was then placed into clear plastic bags and set aside for analysis. The exact coordinates of each sampling site was logged into a Garmin® global positioning unit. These GPS readings would be utilized later to create a GIS map of the soils contained within the Preserve.

Analysis:

The soil samples were transported offsite where they could be analyzed in order to identify key characteristics (sand, silt and clay contents) necessary for determining overall soil type. The method employed was Texture-by-feel Analysis (Thien, 1979). For each sample, approximately 25 g of soil was placed into the hand of the BORG researcher. Water was added drop wise until all particles were moist and the soil was able to remain in a ball when squeezed. The wet soil was then placed between the thumb and forefinger, and squeezed to form a ribbon of uniform thickness and width. The ribbon was allowed to extend until breaking under the force of its own weight. A ribbon of less than 2.5 cm long is considered weak, and therefore consists of sandy loam, silt loam or loam soil, depending on further texture analysis. A ribbon of 2.5 to 5 cm long indicates the soil is sandy clay loam, silty clay loam or clay loam. Next, an excessively wet, small pinch of soil was rubbed between the palm and forefinger. A gritty texture indicates the soil is sandy loam or sandy clay loam, depending on the length of the ribbon. A very smooth texture indicates silt loam or silty clay loam soil. The soil is considered to be loam or clay loam if neither grittiness nor smoothness predominates. Lastly, the GPS readings and determined soil texture for each sample were input into ArcView® to create a GIS soil map of the entire Preserve.

APPENDIX A: REPORTS

David Magney Environmental Consulting

GENERAL GEOLOGY, HYDROLOGY, AND SOILS OF THE OJAI MEADOWS PRESERVE, OJAI, CALIFORNIA

Prepared for:

Ojai Valley Land Conservancy
Land Committee

Mission Statement

To provide quality environmental consulting services with integrity that protect and enhance the human and natural environment

January 2001

This document should be cited as:

David Magney Environmental Consulting. 2001. General Geology, Hydrology, and Soils of the Ojai Meadows Preserve, Ojai, California. January 2001. (PN 00-0031.) Ojai, California. Prepared for Ojai Valley Land Conservancy Land Committee, Ojai, California.

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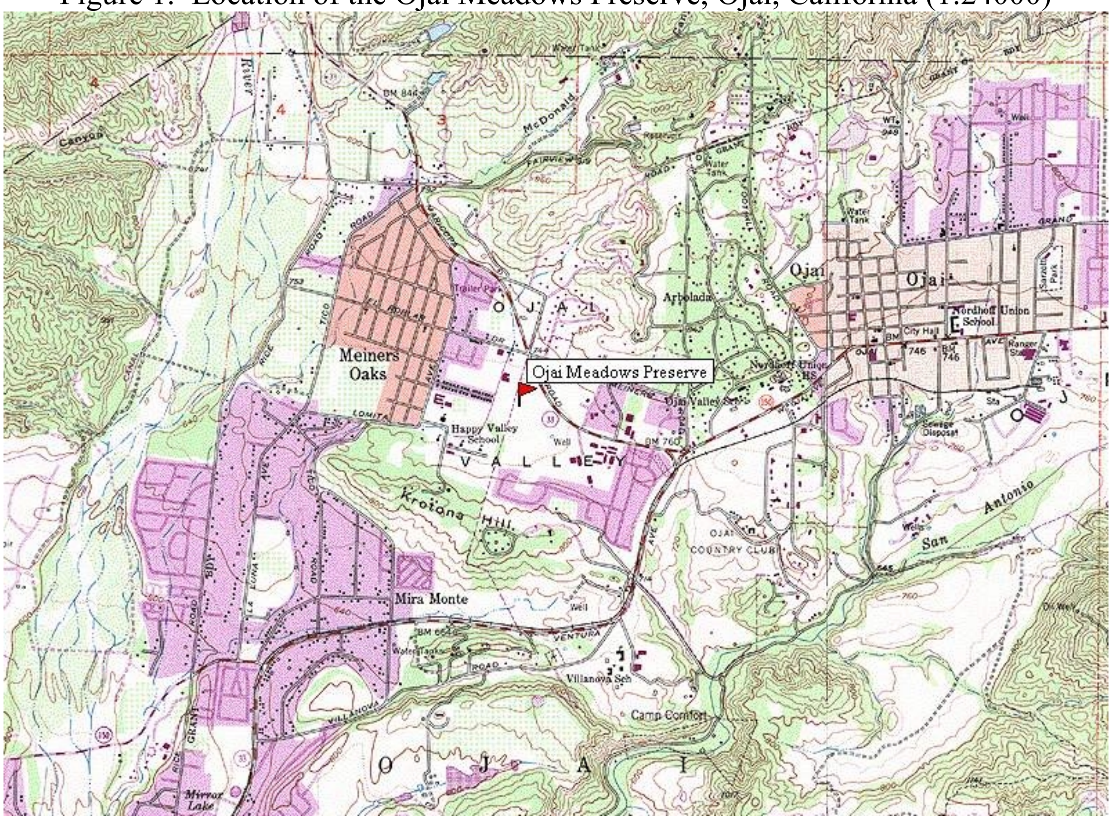
INTRODUCTION

This report details David Magney Environmental Consulting's (DMEC's) findings of fact and judgment regarding the general geology, hydrology, and soils of the Ojai Meadows Preserve, Ojai, California. The Ojai Meadows Preserve is located between Ojai and Meiners Oaks, California (Figure 1, Location of the Ojai Meadows Preserve, Ojai, California [1:24000]).

On 16 January 2001, Mark Cable Rains of DMEC conducted a field reconnaissance of the Ojai Meadows Preserve, the Happy Valley Drain Watershed, and the surrounding area. On 17 January 2001, Mr. Rains, Lara Wood, and Melanie Dunbar (both of the University of California, Santa Barbara [UCSB] Bren School) conducted a detailed field reconnaissance and described soils at two pits on the Ojai Meadows Preserve. Additional efforts have been conducted previously by various staff and students from UCSB and results of these efforts are incorporated herein.

Figure 1. Location of the Ojai Meadows Preserve, Ojai, California (1:24000)



RESULTS AND DISCUSSION

Geology

The Ojai Meadows Preserve is located on ancient stream terrace and alluvial fan deposits of Pleistocene and Holocene age. The ancient stream terrace deposits, deposited by the Ventura River, predominate. Originally, the stream terrace extended down valley from the toe of Nordhoff Ridge to the western toe of Sulphur Mountain.

Krotona Hill, possibly caused by uplift along a blind thrust fault, now provides substantial relief to the stream terrace deposits. A finger of alluvial fan deposits from Nordhoff Ridge overlies the old stream terrace deposits on the north end of the Ojai Meadows Preserve.

Hydrology

The potential water sources to the Ojai Meadows Preserve include direct precipitation and local storm water discharge; Happy Valley Drain, a seasonal stream with a drainage area of approximately 0.90 square mile; local groundwater flow systems from the uplifted Nordhoff Ridge toe slope (West Hills) and Krotona Hill; and a regional groundwater flow system from Nordhoff Ridge. The local and/or regional groundwater flow systems may provide most of the shallow groundwater that is available late in the growing season. The depth to groundwater at the preserve is not precisely known.

Happy Valley Drain is incised in the stream terrace and alluvial fan deposits and does not flood the Ojai Meadows Preserve except at extremely high discharges. This incision is, in part, a natural effect caused by high rates of regional and local uplift. However, anthropogenic activities, such as the straightening and channelization of Happy Valley Drain, have exacerbated this effect.

SOILS

General Soils

The mapped soils of the Ojai Meadows Preserve are in the Ojai-Sorrento, heavy variant association. This association is characterized by level to moderately steep, well-drained and moderately well-drained soils (Edwards et al. 1970).

Most of the Ojai Meadows Preserve is mapped as Ojai very fine sandy loam, 2 to 9 percent slopes, eroded (Figure 2, Soils Map and Soil Texture). Soils in the Ojai series formed on old, partially dissected stream terraces in alluvium derived from sedimentary rock (Edwards et al. 1970). The finger of alluvial fan deposits that overlie the old stream terrace deposits on the north end of the Ojai Meadows Preserve (near State Route 33) are mapped as Sorrento clay loam, heavy variant, 2 to 9 percent slopes (Figure 2). Soils in the Sorrento series formed on alluvial fans in alluvium derived predominantly from sedimentary rocks (Edwards et al. 1970).

Figure 2. Soils Map and Soil Texture[1]

Field efforts indicate that the soils maps are generally correct. Soil Pit Ojai Meadows Preserve-1, located on the northeast portion of the Ojai Meadows Preserve, is similar to the typical Ojai series profile (Table 1, Soil Profile Ojai Meadows Preserve-1; Figure 3a, Ojai Series Typical Soil Profile; Figure 3b, Soil Profile Ojai Meadows Preserve-1). Soil Pit Ojai Meadows Preserve-2, located on the northwest portion of

[1] From Edwards et al. 1970 and UCSB Data

the Ojai Meadows Preserve, is similar to the Sorrento series profile (Table 2, Soil Profile Ojai Meadows Preserve-2; Figure 4a, Sorrento Series Typical Soil Profile Figure 4b, Soil Profile Ojai Meadows Preserve-2).

Figure 2. Soils Map and Soil Texture[2]

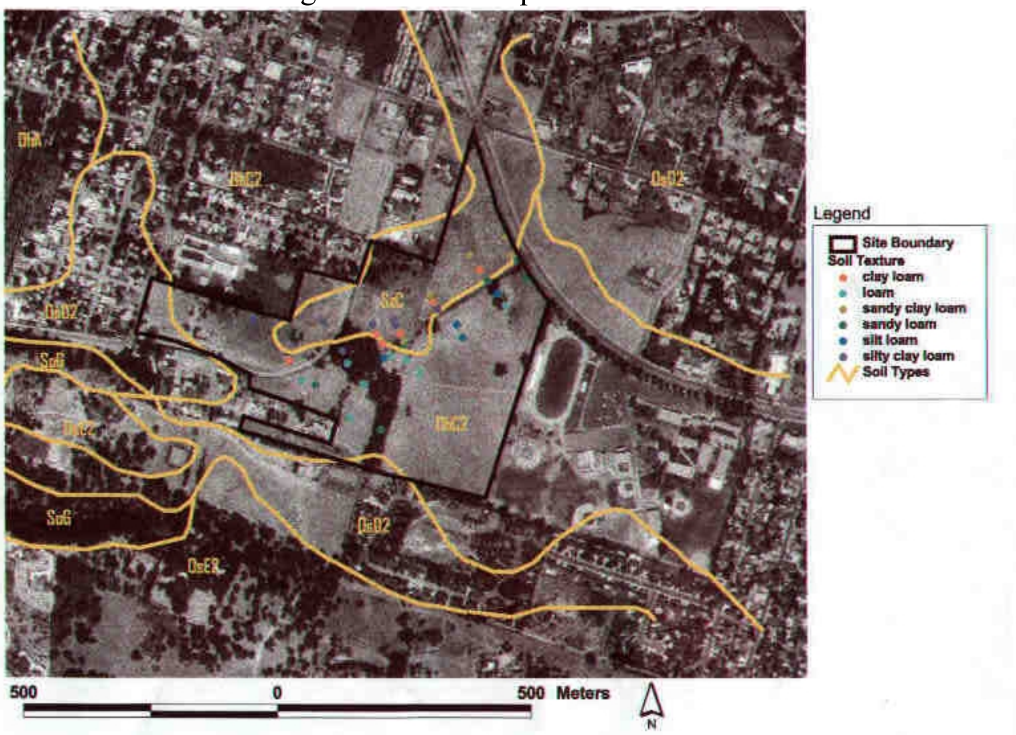


Table 1. Soil Profile Ojai Meadows Preserve-1

Depth	Horizon	Description
0-7 inches	Ap	Matrix color 10YR2/2; very fine sandy loam; moderate, subangular blocky structure; slightly sticky; slightly plastic
7-32	B1	5YR3/3; common, distinct mottles; sandy clay loam; moderate, massive structure; sticky; slightly plastic; saturated at 22 inches
32-40	B2	5YR3/1; common, distinct mottles; sandy clay loam; strong, massive structure; slightly sticky, slightly plastic; saturated

Table 2. Soil Profile Ojai Meadows Preserve-2

Depth	Horizon	Description
0-7 inches	Ap	Matrix color 10YR3/2; sandy clay loam; moderate, subangular blocky structure; slightly sticky; plastic

[2] From Edwards et al. 1970 and UCSB Data

Depth	Horizon	Description
7-12	A1	10YR2/2; clay loam; moderate, platy structure; slightly sticky; plastic
12-30	AC	10YR2/2; clay loam; strong, subangular blocky structure; slightly sticky; plastic; restricts root growth
30-40	C	10YR2/1; clay; strong, subangular blocky structure; sticky, very plastic; restricts root growth

Hydric Soils

Neither the Ojai and Sorrento soils nor their known inclusions are listed as hydric soils (Soil Conservation Service 1987). However, hydric soils occur on the Ojai Meadows Preserve at mapping scales that are below the resolution of the soil survey. Hydric soils occur in small topographic depressions where the water table is close to the ground surface and where surface water collects due to high intensity direct precipitation and/or overbank flow; in the drainage ditch; and below the bankfull stage in the portion of Happy Valley Drain that has a natural bed and bank.

The hydric soils in the small topographic depressions are Ojai series soils that are hydric by virtue of being ponded and/or flooded for long or very long duration during the growing season. They have moderately low saturated hydraulic conductivity and likely would not perch water for long or very long duration. Thus, ponding and/or flooding for long or very long duration likely are associated with seasonally high water tables.

The drainage ditch is excavated on Ojai series soils and the distal end of Sorrento series soils. Being alluvial fan deposits, the extreme distal end of the Sorrento series soils likely are thin. Thus, it is probable that excavation is sufficiently deep such that the hydric soils in the drainage ditch are almost entirely formed on excavated Ojai series soils and/or Ojai series parent materials. These soils are hydric by virtue of being ponded and/or flooded for long or very long duration during the growing season. They have moderately low saturated hydraulic conductivity and likely would not perch water for long or very long duration. Thus, ponding and/or flooding for long or very long duration likely are associated with seasonally high water tables.

Happy Valley Drain dissects Ojai series soils and the distal end of Sorrento series soils. However, the channel bed has been scoured and filled with what is more appropriately termed Riverwash, which consists of stratified fluvial sediments composed of stony and gravelly sand with relatively small amounts of silt and clay. They have moderately high hydraulic conductivity and likely would not perch water for long or very long duration. Thus, ponding and/or flooding for long or very long duration likely are associated with seasonally high stream discharges and/or water tables.

Figure 3a. Ojai Series Typical Soil Profile[3]

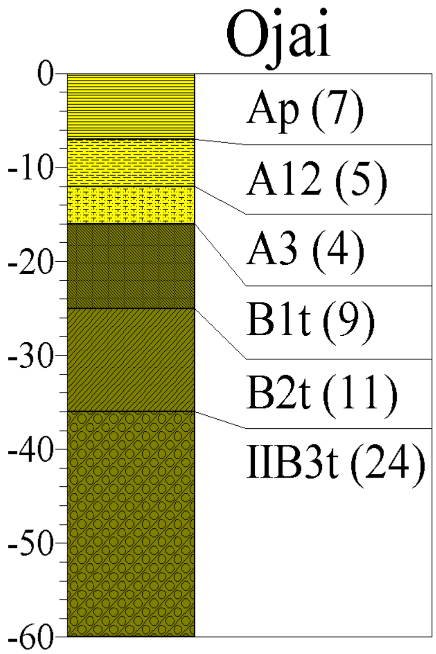


Figure 4a. Sorrento Series Typical Soil Profile

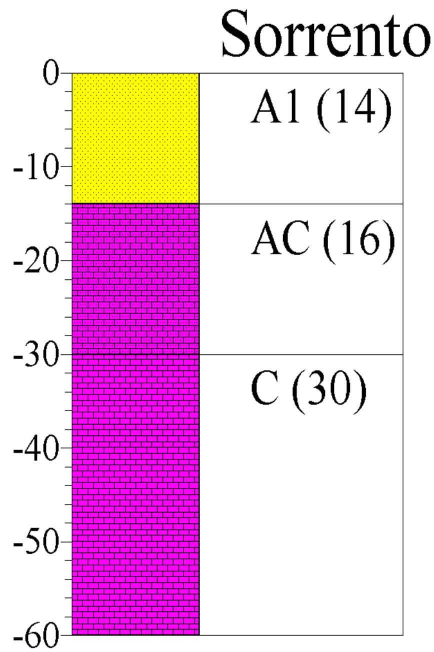
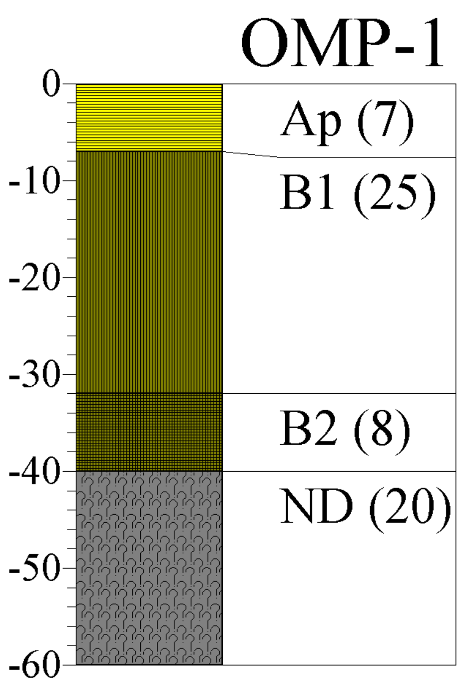
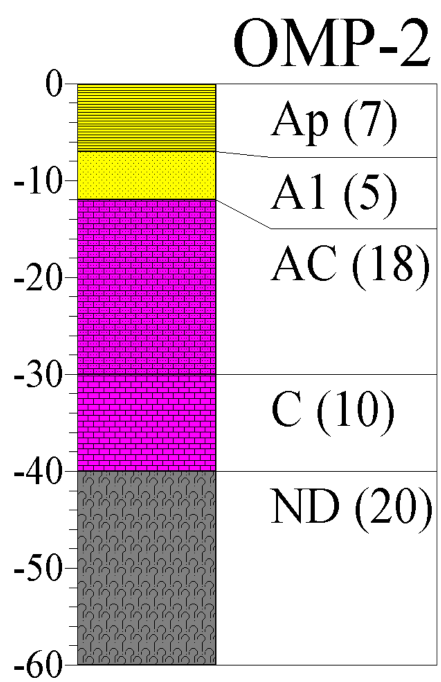


Figure 3b. Soil Profile Ojai Meadows Preserve-



1[4]

Figure 4b. Soil Profile Ojai Meadows Preserve-2



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[3] Edwards et al. 1970

[4] ND indicates No Data

CONCLUSIONS AND RECOMMENDATIONS

This section discusses conclusions, implications, and recommendations as they relate to habitat restoration and management of the Ojai Meadows Preserve, in relation to the geologic, hydrologic, and soils conditions of the property.

Conclusions and Implications

Since the intent of the Land Committee is to restore natural ecological conditions and to increase habitat diversity to the site, as well as provide educational and passive recreational opportunities to the Ojai community, a suite of habitat types have been considered for the preserve. The physical constraints of the geology, hydrology, and soils of the site constrain the habitats that can be created or restored onsite.

Historically, the preserve has supported Valley Oak Savannah, Annual Grassland, Coyote Brush Scrub, Freshwater Marsh, and Arroyo Willow Riparian Scrub habitats. The last two types currently are restricted to the drainage ditch originating at State Route 33, and have likely always been a minor component of the site. Fire hazard control has resulted in the temporal elimination of the Coyote Brush Scrub vegetation from the site during the last decade. The Annual Grassland has been disked annually, increasing its ruderal characteristics and preventing perennial species to colonize or dominate the site. The annual disking has also prevented oak regeneration onsite, as all seedlings within the savannah were plowed under.

There are almost no examples of natural vegetation in the Ojai Valley that has not somehow been influenced by human activity. Nearly all the land in the Ojai Valley has been disturbed at some time over the last 150 years, especially those areas that once contained native grasslands. This condition makes it difficult to determine precisely what a natural grassland ecosystem in the Ojai Valley should include; however, examples outside the Ojai Valley, such as in the Santa Barbara and Sulphur Mountain areas, can provide clues that may be useful for the Ojai Meadows Preserve restoration.

The geology indicates that the site consists of ancient stream terrace and alluvial fan sediments that originated from the ancient bed of the Ventura River and Nordhoff Ridge to the north. The alluvium is relatively deep and porous.

Ground water is relatively shallow, at least seasonally, in portions of the preserve, observed at 22 inches depth during one site visit in January 2001. Ground water discharge from the surrounding uplands probably dominates shallow ground water recharge on the site. Seasonal surface flows enter the site via State Route 33 from the northeast and the Happy Valley Drain from the north. Minor amounts of surface runoff come from Nordhoff High School to the east and Krotona Hill to the south.

The soils on the preserve are relatively fine grained. However, the soils drain relatively freely above the water table. Absent a shallow water table, the soils would not pond water for a long enough duration to maintain permanent open water. A shallow water table is present seasonally, which may support extensive seasonal wetlands without modification of the soils.

Recommendations

A basic water budget for the site should be calculated. This will provide basic information necessary for the determination of a) the final project objectives and b) the amount, if any, of additional water needed to meet the final project objectives.

Groundwater head should be monitored for at least one full water year. Several monitoring wells should be established onsite. Monitoring wells should be placed to a depth of four to six feet below ground surface. Monitoring wells should be monitored at quarterly or shorter intervals. Nordhoff science class students, UCSB Bren School students, and/or Conservancy volunteers could conduct the monitoring, using appropriate field data logs. Training on proper monitoring measurements and documentation should be provided for all persons conducting the monitoring to maintain quality control of all data gathered.

Surface runoff volumes and floodprone areas should be estimated or calculated for several precipitation year events, such as the: 2-year event, 5-year event, 10-year event, 20-year event, and 100-year event. This will help in identifying surface water ponding and groundwater recharge opportunities.

Climatic records need to be obtained for use in determining precipitation and evapotranspiration characteristics. These can be obtained from the Ventura County Flood Control District.

In the event insufficient shallow groundwater is present at the preserve to sustain permanent open water onsite, and open water habitat is of high importance to the Ojai Valley Land Conservancy, various methods to pond water for permanent open water area(s) should be determined, such as using clay liners in excavated pools, or other methods. Also, costs to provide supplemental water to maintain the open water area(s) need to be determined in order to provide an estimate of costs to maintain such environments. Various options for habitat restoration and creation should be carefully evaluated before any specific plan is adopted.

Since Nordhoff High School desires to discharge excess runoff directly onto the Ojai Meadows Preserve, contributions of additional surface runoff from Nordhoff need to be calculated to determine how this additional runoff may contribute to the maintenance of proposed onsite wetlands and upland habitats. Water quality issues from this discharge must be analyzed and considered before any such discharge is incorporated into the habitat restoration plan.

References Cited

Edwards, R.D., D.F. Rabey, and R.W. Kover. 1970. Soil Survey of the Ventura Area, California. U.S. Department of Agriculture, Soil Conservation Service, in Cooperation with the University of California Agricultural Experiment Station.

Soil Conservation Service. 1987. Hydric Soils of the United States. U.S. Department of Agriculture, Soil Conservation Service, in Cooperation with the National Technical Committee on Hydric Soils.

Acknowledgements

This document was written by Mark Cable Rains and David Magney. Mr. Magney managed the project and edited the report. Mr. Rains conducted the field efforts. Lara Wood and Melanie Dunbar of the UCSB Bren School assisted in the field efforts.

APPENDIX B: EDUCATION PROGRAMS AND ACTIVITIES

GROUNDWATER MONITORING PROGRAM

Groundwater monitoring provides key quantitative information in the evaluation of riparian and freshwater marsh restoration. Groundwater depths are measured from wells, and the data are used to calculate the approximate volume of water entering the wetland area. The data are also used in the evaluation of the riparian restoration. Well-constructed riparian zones recharge the groundwater causing the groundwater level to rise over time. Measurements of the groundwater depths should be taken twice a month. The depth-to water measurements are made by using a measuring tape to find the distance from the top of the well to water.

Groundwater Monitoring Activity

Objectives:

- Learn the importance of groundwater to wetlands.
- Understand how groundwater moves under the surface.
- Learn how to monitor depth to groundwater.

Materials:

- Measuring tape (10 m)
- Clipboards, pencils, extra paper
- Data sheets
- Soil texture information sheets
- 10 large glass jars
- 10 Ziploc® bags
- 1 bag of gravel
- Gallon of water

Activity Description

Each leader will lead a group of students (3-4) through the process of measuring the depth to groundwater and recording the data. At each well, have the students fill a Ziploc® bag with soil from the area surrounding the well. Discuss different types of soil texture and how water moves through them. Each team of students should measure the depth to groundwater at 1-2 sites. After the well measurements are taken, have all the groups re-gather. Separate the groups into 2-3 students per jar. Fill the glass jars with soil and then gravel then soil. Have each student record what type of soil he or she has (i.e. predominately clay, silt, sand). Pour water into the jars. Have the students observe and time the water moving through the jar. The students should write down their observations, then share their results.

Background Information

Soil texture refers to the percentage of sand, silt and clay particles in soil. There are two basic methods for classifying soil texture: a mechanical method, which is done in a laboratory with different sized sieves to characterize texture; and a feel method, which is primarily done in the field using a flow chart. Both methods are based on the size of the soil particles. Soil particles sizes are generally grouped into the following size classes: sand particles are 2.0 mm to 0.5 mm, silt particles are 0.5 mm to 0.002 mm, clay particles are < 0.002 mm.

Some questions to cover:

Why is this important?
Particle size affects the porosity (how quickly the water moves through the soil) and the particle surface area (how much water can be held) of the soil. Therefore, soil texture is an important factor in determining the hydrology and plant growth of an area.

Which soils will hold the most water?
Clay then silt then sand

Through which soils will water move the most quickly?
Sand then silt the clay

PHOTO MONITORING PROGRAM
(Developed by the Golden Gate National Recreation Area; http://www.nps.gov/goga/parklabs/04_teacher/curriculum/curricula.html)

Photo monitoring is a critical component of the qualitative monitoring of restoration sites, providing easy to interpret visual information. The information is used to assess restoration efforts and to inform the public. This information assists in planning the restoration work and in determining the relative success. It is one of the best ways to summarize the "story" of a restoration effort. Photo monitoring also aids in the evaluation of habitat health over time. In this sense, it is a highly useful tool, which helps to document the changes at a site and adjust or implement management techniques. Such changes may be due to natural processes or may be the result of human disturbance.

Each class should adopt a specific area or restoration effort to monitor. We recommend that the trails, flooding, and vegetation be photo monitored at the Preserve. The trails and vegetation should be photo monitored once a year in the spring.

Photo Monitoring Activity

Objectives:

- Understand WHY photo monitoring is done, and be able to name some advantages and disadvantages of this type of monitoring.
- Learn HOW photo monitoring is done.
- Master basic compass skills, map reading, and the use of a meter wheel.

Materials:

- 2 meter wheels
- Compasses
- Clipboards
- Cameras
- Film
- Data sheets
- Pencils
- Monitoring point location information
- Photos from last year

Activity Description

Each leader will lead a group of 3-6 students through the process of using the map, compass, meter wheel, and site description to locate a site, take a photo and complete the data sheet. Disturbance, possible effects, and the advantages of having photo-documentation are general topics that can be covered in the field while photo monitoring. It is also important to discuss the disadvantages of qualitative monitoring methods. A discussion on scientific methodology, the use of qualitative data, and the ramifications of its use in management practices are good topics for higher-grade levels.

Some questions to cover:

What types of changes can we observe with photo monitoring?
Height of plants, dominant plants, trail erosion, flooding, etc…

What is hard to observe?
Plant diversity and density, wildlife, etc…

At what time of year is it best to photo monitor?
It depends on the site, but every year photos should be taken at the same time of year to provide consistency. Since the landscape appears different during different seasons, pictures should be taken during the same season every year. For example, if the photo-monitoring project is focused on capturing vegetation, take into consideration the life cycles of the plants. It is best to take pictures during peak blooms because it is easy to see how much area plants cover. For example, when pampas grass is in peak bloom it covers hillsides with its large plumes, making it very easy to compare its range from year to year.

What other factors must we consider?
- Time of day or position of the sun. A good photographer does not take photos into the sun, so depending on the direction of the photo-shoot, different times of day will be better. For example, take west-facing photos in the morning. Moreover, take pictures on sunny days to avoid shadows.
- Type of film. Color gives more information although black and white lasts longer; prints fade faster than slide film.
- Focal length. To ensure consistency make sure you always use the same focal length.

What types of changes would tell us we should continue our current restoration strategies?
Natives dominate the site

What types of changes would tell us we need to change our restoration strategies?
Erosion on trails

What makes a good photo-monitoring site? How were these sites chosen?
Think about where you are interested in observing changes. This may or may not be where you are doing restoration work. Always think long-term. Fifty years from now, photo-monitoring data for some sites may be useful. Choose sites that are easy to relocate, and use references that will remain for many years.

Have things changed since last year?

Ask students to compare what they see this year to past photos, and interpret any changes they see. Role-play being the site managers who will use the photos to make decisions.

REVEGETATION PROGRAM

There are many opportunities for students to be involved in revegetation activities, specifically through a Classroom Propagation Program and Outplanting Program to be used by teachers.

CLASSROOM PROPAGATION PROGRAM

The classroom propagation program allows students to closely examine the plant species of the restoration site. The propagation program is also an effective way to supply a large number of plants to the restoration. The principal activity of the classroom propagation program is growing the plants. However, classes can expand the activity to incorporate other subjects such as math, art and writing.

Propagation Activity (developed by the Golden Gate National Recreation Area http://www.nps.gov/goga/parklabs/04_teacher/curriculum/curricula.html)

Classrooms participate in the planting and revegetation efforts of the restoration by growing and planting native plants from the area. Seeds can either be purchased from a local grower or collected in the field from the Preserve or other local areas. Specific seed collection and storing guidelines should be followed if the seeds are collected, and additional planning by the classroom teacher is needed to incorporate all the elements into the propagation program. Planting kits can be purchased or plants can be grown in the nursery onsite, once it is developed.

Objectives:

- To learn how a wetland plants develop
- To propagate native species for the restoration site

Materials:

- Potting containers (9-10 cm)
- Soil (sunshine mix)
- Several potting trays (seedling flats)
- Watering device
- Possibly fertilizer (such as Miracle Grow)
- Petri dish (5)
- Blotter paper
- Seeds
- Clear plastic humidity domes

Background Information

Seeds are the main method by which plants reproduce. Seeds from different species of plants vary greatly in size, shape, and structure. Nearly all seeds are surrounded by one or two seed coats (testa), which help to protect the embryo from damage. The outer seed coat is usually dry and hard. Regardless of their size, shape, or structure, all seeds have three basic parts -- the embryo, food storage tissues, and seed covering. The embryo is a new plant formed from the union between a male and female gamete during fertilization. It consists of an embryo axis, which has a growing point at both ends -- one develops into the shoot and one develops into the root -- and one or more seed leaves (cotyledons) attached to the embryo axis. Plants can be classified according to the number of cotyledons they have. For example, monocotyledonous plants, like the California bulrush have one cotyledon whereas dicotyledonous plants such as the valley oak have two cotyledons. The successful germination of a seed and the emergence above ground of the resulting seedling depend on energy produced from complex storage products (carbohydrates, fats, oils, and proteins) laid down in the seed by the mother plant.

Activity Description

The first step is to rinse and dry the seeds. Seeds should initially be sowed into flats. When the seedlings emerge and reach approximately 2-5 cm in height, the seedlings should be transplanted to 9-10 cm pots. The flats and the seedling pots should be stored in a warm, moist environment without direct sunlight. The clear plastic humidity domes will provide moister conditions and reduce the need for watering. The plants should be monitored every other day, and watered and fertilized as needed.

To more closely examine the germination of a seed, the class will grow five seeds in petri dishes. Have students "sow" seeds by placing blotting paper in the base of a petri dish. Moisten the paper and place the seed in the center. The petri dish should be kept out of direct sunlight, and the blotting paper should be kept moist. The students should record their observations daily. The students should record when or if the see the major parts of the seed identified above as well as how long the seed took to germinate.

Associated Propagation Activities

Additional activities that can be incorporated into the propagation activity are listed below:

Calculation of Survival/Mortality Rates

The mortality rate helps determine the number of plants to grow in order to meet the target number of plants needed for the restoration site. The propagation mortality rate is the percentage of plants that will not survive sowing. This percentage varies for each plant and is determined by a germination test. For the germination test, a flat of 100 seeds is sown and the number of sprouts that emerge are counted. The survival rate is the number that emerges, and the mortality rate is 100 minus the survival rate. The number of plants needed to grow is the number of plants needed for outplanting multiplied by the survival rate then divided by the survival rate. To calculate the mortality rate, the number of seedlings that emerge are subtracted from a hundred. The remainder is the mortality rate.

Example Problems:

- Have the students calculate the number plants that should be propagated if the there is only 65% survival rate and 2,000 plants are needed for the revegetation effort.
- Have the students calculate the number of plants that can be propagated if there is a 60% survival rate and the nursery has collected 3000 seeds.

Outplanting Program (developed by the Golden Gate National Recreation Area; http://www.nps.gov/goga/parklabs/04_teacher/curriculum/curricula.html)

Planting at restoration sites encourages the rapid establishment of natives. Sites left to revegetate gradually over time can take many years. Competition from exotics may reduce the native abundance. Repeated visits must be made to the site to prevent the establishment of invasive weedy species, which may out-compete native seedlings. Additionally, many disturbed areas no longer have a native seed bank remaining in the soil. Introducing plants at the restoration site accelerates the natural succession process. The plant community will reach a state of resiliency faster and provide habitat more rapidly for other members of that system. For example, introducing valley oak seedlings (*Quercus lobata*) to the Preserve provides habitat for many avian species, such as the acorn woodpecker.

Revegetation Methods: Transplanting and Direct Seeding

Outplanting and direct seeding are the two methods that can be used by school groups to revegetate a site. Outplanting is the process of planting plants, which have been raised in the nursery and are already relatively mature. Direct seeding is the process of sowing seed onsite and letting them to germinate and develop naturally.

Propagules (seeds and cuttings) for revegetation are collected from the site itself or from the immediate surrounding area. The closer to the site the better, as it has been found that the **genotype** (genetic makeup) of plants can change within a very short distance. Sometimes seeds or cuttings of the required species are not available and substitute species are used.

Planting Activity

Objectives:

- To assist with revegetation efforts.
- To understand the role of revegetation.
- To examine various plant adaptations and compare plant species.

Materials:

- Journal question sheet
- Shovels, rakes, picks, gloves
- Plants and seeds
- Adaptation cards
- Clipboard, paper, pencils

Activity Description

Each leader should take 3-4 students. .The leader should have a plant adaptation card that lists the type of plant and its life history. .The groups should be divided so that at least two groups have the same plant adaptation card. .In the field, try to find that particular species. .Take 10 minutes to describe the species and any particular adaptations it has. .Re-group with the other team that has the same plant adaptation card. Discuss the adaptations they found and how it would be beneficial for the habitat in which it is found.

Some key adaptations to point out:

- Hollow stems
- Fibrous root systems
- Tap roots
- Seed modifications

Proper handling of the plants

Transplanting can disturb root systems quite extensively. Roots are the principal pathways by which plants take up water and nutrients, and damage to the root hairs will reduce the plant's ability to establish. Although plants do survive rough handling when outplanted, they will respond better if they are handled with care. Once outplanted in its natural habitat, the plant will not be watered or given fertilizer. Therefore, the more developed the root system, the better the plant will be able to access water and nutrients available in the soil.