A Draft Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Vernal Pool Depressional Wetlands in Southern California

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ABSTRACT: This Draft Guidebook is an assessment tool that focuses on the functioning of vernal pool wetlands within the Southern Californian eco-region, specifically San Diego County. Its purpose is to provide trained practitioners the means to achieve efficient, reproducible and logical functional assessment results for vernal pool wetlands in San Diego County, California. Results of these assessments can then be used in a variety of ways, such as evaluation of sites for restoration potential, assessment of impacts from existing or proposed projects and monitoring restoration success. Due to the high degree of variability experienced by temporary wetlands in arid climates, we have developed both direct and indirect functional indices for four of the five functions we identified. Direct assessments can only be made when there is sufficient precipitation to elicit the responses that demonstrate function, and we have sought to objectively define "sufficient." Consistent with an HGM approach, use of this Draft Guidebook should be confined to the geographic region and hydrogeomorphic class, subclass and pool types for which it was developed. Use of this methodology outside the boundaries of the reference domain is wholly inappropriate. We are hopeful that our approach can be modified for other pool types within the region, and to vernal pools in other parts of California and Oregon.

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5 Assessment Protocols

Overview

Previous chapters of this guidebook provided (a) background information on the HGM Approach, (b) wetland variables that are indicators of the level of function, (c) the assessment models consisting of those indicator variables, and (d) use of those indicators and models to describe level of function. This chapter provides the specific protocols that should be followed to conduct a functional assessment of vernal pool depressional wetlands in southern California. These protocols were designed for, and will generally be used within, the context of the permit review process under Section 404 of the Clean Water Act. They may also be used for any other wetland management goals or objectives (*e.g.*, restoration, monitoring) that require independent measures of function for vernal pool wetlands in southern California.

The typical application of this guidebook involves the examination of preproject conditions and forecasting of one or more postproject scenarios. To evaluate likely project impacts, the functional capacity of a wetland is assessed under preproject conditions and compared with the functional capacity under proposed postproject conditions. Data for the preproject assessment are frequently collected under existing conditions. Although data for the postproject assessment are normally based on predictions, an actual postproject assessment may occur. A skeptical, conservative, and well-documented approach is required in defining postproject conditions.[1] This recommendation is based on the often-observed lack of similarity between **predicted** or “engineered" postproject conditions and **actual** postproject conditions.

This chapter is organized into the three main steps necessary to conduct an HGM functional assessment using this guidebook:

Preliminary tasks and assembly of preexisting data

a. Define the purpose and objectives of the assessment.

b. Characterize and collate preexisting data.

[1] Although HGM guidebooks are designed, in part, for use in rapid assessments by junior field scientists, experience has shown that adequate understanding of likely postproject conditions requires significant experience with vernal pool functions and their variations in a range of seasons and years. The prevalence of listed species within the pools compounds the urgency for seasoned interpretation of 1) both pre- and post-project functions and conditions, 2) any ongoing reduction in the number of viable pools, and 3) the difficulty in repairing vernal pools if the unique substratum supporting them is disrupted. This third point makes vernal pools nearly unique amongst the wetland types of the U.S., especially since the substrate may have taken hundreds of thousands or millions of years to develop.

c. Screen for red flags.

d. Define the Wetland Assessment Area (WAA).

e. Determine the Subclass and Type.

f. Describe the precipitation regime.

b. Collection and recording of data

a. Construct base maps.

b. Collect hydrologic, soil and geomorphic data.

c. Collect floral and faunal data.

c. Data entry and analysis

a. Enter and analyze data.

b. Apply the results of the assessment.

Preliminary Tasks and Assembly of Preexisting Data

Statement of Purpose and Objectives

Begin the assessment process by unambiguously stating the purpose and objectives of the assessment. This statement will often be as simple as "The purpose of conducting this assessment is to rigorously project how the proposed project will impact wetland functions." Other potential objectives could be to (a) compare several wetlands as part of alternatives analysis, (b) minimize project impacts, (c) document baseline conditions at the wetland site, (d) establish mitigation requirements, (e) evaluate mitigation success, or (f) evaluate the effects of a wetland management program. A clear statement of the objectives will facilitate communication among the people conducting the assessment and will help to establish the approach taken in conducting the assessment. Of course, the specific approach will probably be different depending on whether the project is a Section 404 permit review, an Advanced Identification (ADID), Special Area Management Plan (SAMP), field work as part of a General Plan or HCP monitoring program, or for some other purpose. For this and other preliminary tasks, complete the Wetland Assessment Area Data Form (Appendix C.1).

Collate Preexisting Data

Site characterization involves describing the project area in terms of climate, landform and geomorphic setting, hydrology, vegetation, soils, land use, groundwater features, surficial geology, urban areas, potential impacts, and any other relevant factors. The characterization should be written and accompanied by base maps and figures that show the project boundaries, local scale topography, jurisdictional wetlands, WAA, proposed impacts, and other important features. Other maps and/or aerial photographs (*e.g.*, NWI, Soil Survey) should be reviewed to obtain information on jurisdictional wetlands within the project boundaries, soil types, plant communities, and adjacent location(s) of impacts. The following source materials and information are typically needed to provide an effective precharacterization of a vernal pool wetland site to complete an assessment efficiently. This list does not preclude use of other materials or information sources but rather describes the minimum needed to characterize a site and complete the assessment:

Topographic maps covering the wetland and the surrounding landscape

- USGS Quadrangle 1:24,000 maps
- 1:2400 topographic or orthophoto topographic maps (County of San Diego)

National Wetlands Inventory maps (1:24,000 and 1:100,000 scale) covering the wetland and the surrounding landscape.

- historical and current aerial photographs
- National Aerial Photography Program (NAPP)
- National High Altitude Photography (NHAP)
- digital orthophotographs covering the wetland and the surrounding landscape
- historic aerial photographs (1928 in San Diego County)

Climatic records (County of San Diego; NWS forecast offices-NOAA)

Soil survey maps (USDA).

Land use history validated through

- historical aerial photographs
- archival maps and data

Surveys and reports

- biological surveys
- environmental documents (EIS, EIR, ACOE permit applications, etc.)
- geotechnical or hydrological reports
- mitigation project proposals and/or reports
- research papers
- prior restoration or creation project reports
- proposed projects (current or prior)

For areas in southern California beyond San Diego County, related information can be obtained from the flood control district or community development agency of the pertinent county.

Following the site characterization steps, immediately check for Red Flag conditions or features that may be inherent to the reference domain.

Screen for Red Flags

Red flags are features within, or in the vicinity of, the project area that merit special recognition or protection based on objective criteria (Table 5.1). Many red flag features, such as those based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Screening for red flag features represents a proactive attempt to determine if the wetlands or other natural resources in and around the project area require special consideration or attention that may preempt or postpone an assessment of wetland function. The assessment of wetland functions may not be necessary if the project is unlikely to occur as a result of a red flag feature. For example, if a proposed project has the potential to impact a threatened or endangered species or habitat, an assessment of wetland functions may be unnecessary since the project may be denied or modified strictly on the impacts to threatened or endangered species or habitat. Detailed discussion of red flag features is outside the scope of this guidebook. The purpose and scope of the assessment would determine which of the red flags would require consideration.

Define the Wetland Assessment Area (WAA)

The WAA is an area of wetland within a project area that belongs to a single regional wetland subclass and geomorphic pool type, and is relatively homogeneous with respect to the site-specific criteria used to assess wetland functions (*i.e.*, hydrologic regime, vegetation structure, topography, soils, successional stage, land use, etc.). In most project areas, there will be just one WAA representing a single regional wetland subclass as illustrated in Figure 5.1. However, as the size and heterogeneity of the project area increase, it may be necessary to define and assess multiple WAAs within a project area. If a WAA encompasses distinctly different wetland subclasses, regardless of whether they are a result of natural variability or anthropogenic alteration, then multiple WAAs should be designated and assessed separately.

At least three situations necessitate defining and assessing multiple WAAs within a project area. The first situation exists when widely separated wetland patches of the same regional subclass occur in the project area (Figure 5.2). The second situation exists when more than one regional wetland subclass occurs within a project area (Figure 5.3). The third situation exists when a physically contiguous wetland area of the same regional subclass exhibits spatial heterogeneity with respect to hydrology, vegetation, soils, disturbance history, or other factors that translate into a significantly different value for one or more of the site-specific variable measures. These differences may be a result of natural variability, differences in pool type or cultural alteration (*e.g.*, farming, urban development, hydrologic alterations) (Figure 5.4). Designate each of these areas as a separate WAA and conduct a separate assessment on each area.

Table 5.1. Red Flag Features and Respective Program, Agency Authority

Red Flag Features	Authority[1]
Native Lands and areas protected under American Indian Religious Freedom Act	A
Hazardous waste sites identified under CERCLA or RCRA	I
Areas protected by a Coastal Zone Management Plan	E
Areas providing Critical Habitat for Species of Special Concern	B, C, I, L
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or flood prone areas	J
Areas with structures/artifacts of historic or archeological significance	G
Areas protected under the Land and Water Conservation Fund Act	K
Areas protected by the Marine Protection Research and Sanctuaries Act	B, D
National wildlife refuges and special management areas	C
Areas identified in the North American Waterfowl Management Plan	C, L
Areas identified as significant under the Ramsar Treaty	H
Areas supporting rare or unique plant communities	C, H, L
Areas designated as Sole Source Groundwater Aquifers	I, M
Areas protected by the Safe Drinking Water Act	I, M
City, County, State, and National Parks	D, F, L, M
Areas supporting threatened or endangered species	B, C, H, I, L
Areas with unique geological features	
Areas protected by the Wild and Scenic Rivers Act	
Areas Protected by the Wilderness Act	

[1] Program Authority/Agency
A = Bureau of Indian Affairs
B = National Marine Fisheries Service (NMFS) or National Oceanic and Atmospheric Admin.
C = U.S. Fish and Wildlife Service
D = National Park Service (NPS)
E = California Coastal Commission and Bay Conservation & Development Commission
F = California Department of Parks and Recreation
G = State Historic Preservation Officer (SHPO)
H = California Natural Heritage Program
I = U.S. Environmental Protection Agency
J = Federal Emergency Management Administration
K = Natural Resources Conservation Service
L = California Department of Fish and Game
M = Local government agencies

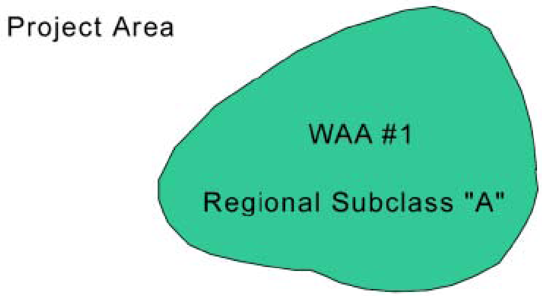


Figure 5.1. A single WAA within a project area.

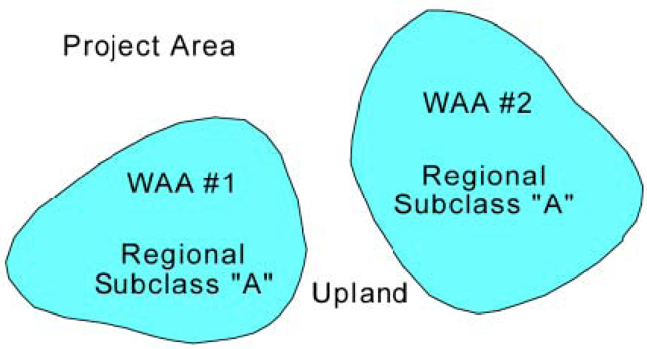


Figure 5.2. Spatially separated WAAs from the same regional wetland subclass within a project area.

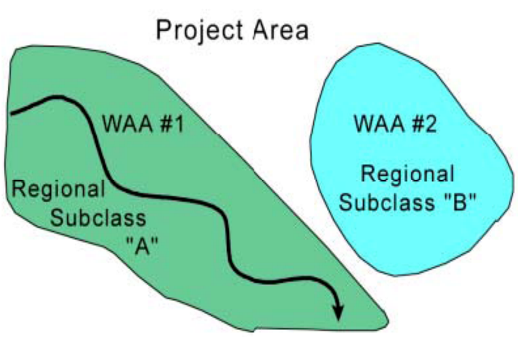


Figure 5.3. More than one regional wetland subclass within a project area.

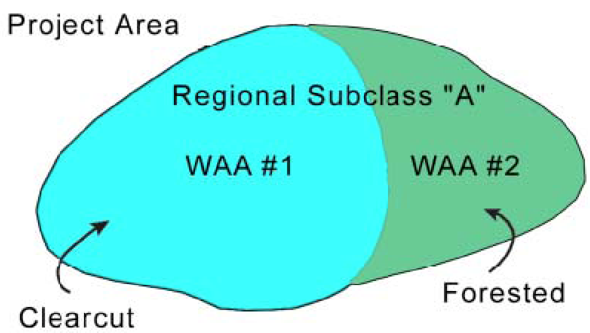


Figure 5.4. WAA defined based on differences in site-specific characteristics.

There are elements of subjectivity and practicality in designating what constitutes a "significant" difference in portions of the WAA. Field experience with the regional wetland subclass under consideration should provide a sense of the range of variability that typically occurs and the “common sense" necessary to make reasonable decisions about defining multiple WAAs. Splitting an area into many WAAs in a project area based on relatively minor differences may lead to an impractical increase in sampling and analysis requirements. In general, differences resulting from natural variability within vernal pool types (Table 5.2) should not be used as a basis for dividing a continuous wetland area into multiple WAAs. However, zonation caused by different hydrologic regimes or disturbances caused by rare and destructive natural events should be used as a basis for defining WAAs, as should different geographies and age/origins (*i.e.* differences in pool types).

Determine the Wetland Subclass and Pool Type

The first task is to determine whether or not the wetland(s) to be assessed occur in topographic depressions on a soil surface with slope < 5 %. Determination of the subclass can generally be completed prior to the site visit using topographic maps of appropriate scale. Vernal pool wetlands in southern California may be <10 cm deep, indicating topographic or orthophotographic maps of 1:2400 scale with contours no greater than 2 ft should be used. The geomorphic origins of vernal pools vary considerably, affecting the soil series, landscape position, hydrology and vegetation of the WAA. It is important to assess the wetlands in the context of their geomorphic origin. Table 5.2 presents a 4 x 6 matrix of different geographies and age/origins, with a potential for 24 different pool types. We have identified locations for 16 types. To assign the type(s) within the WAA, refer to the type descriptions in Table 5.3 and the following section, “Major Vernal Pool Classes of Origin.”

Table 5.2. Matrix of Vernal Pool types in Southern California

Age & Origin	**Geography**			
	Coastal Mesa	Inland Valley	Inland Mesa	Large Depression
Pedogenic	Miramar* Otay Mesa Wire Mesa (Pendleton) Isla Vista#	upper Ramona (Santa Maria Crk) San Marcos small pools at Skunk Hollow	Valle de las Palmas (Baja MX) Wire Mt./Oscar One (Pendleton) Sunrise Hwy	Cuyamaca Little Lagunas
Tectogenic	X	Skunk Hollow (Riverside Co.)	Moorpark (Ventura Co.)	X?
Landslide	Otay Mesa Chiquita/San Clemente (Orange Co.)	X	X	X
Alluviated	Otay Valley Proctor Valley	lower Ramona (Santa Maria Crk) Marron Valley San Marcos Fairview Park (Orange Co.) Hemet	X	Cuyamaca?
Dune dammed	Carlsbad Carmel Mt. (Del Mar) Ellwood Beach# West Bluff (Pendleton)	X	X	X
Bedrock	Colonet (Baja MX)	Tenajas (Riverside Co.)	Santa Rosa Plateau (Riverside Co.)	North LA Co.

*Shaded cells were sampled for reference data. X= no example identified.
Blend of two pool types: Ellwood Beach and Isla Vista pools are a full continuum between dune-dammed (see Napolitano and Hecht 1991) and pedogenic (Ferren and Prichett 1988).

Table 5.3. Description of Age and Origin of Vernal Pool Types in Southern California

Age & Origin	Description
Pedogenic	Vernal pools formed on old or very old terraces or deeply weathered crystalline bedrock by pedogenic processes are the most numerous and widespread. Several types of pedogenic pools are known from Southern California. In all cases, they have developed over restrictive layers created as the soils have matured and which perch winter water near the soil surface.
Tectogenic	Tectonic activity has directly or indirectly created local sediment-filled depressions, which sustain vernal pools along active faults. The restrictive, or "perching" horizon supporting seasonal ponding is formed from lake sediments or ponded clays deposited in the tectonogenic depression, commonly over periods of thousands or tens of thousands of years. These pools tend to be among the largest and deepest, and are supported watersheds of (typically) 20 to 200 acres; they are distinguished by drawing much of their inflow from the steeper slopes with thinner soils near the edges of their watersheds rather than those surrounding the basin.
Landslide	A number of vernal pools have developed in depressions within or at the heads of landslides. As with the tectonogenic pools, inflow may originate from steeper areas at the edges of the contributing watershed, and are generally most vulnerable to changes and disturbance at the edges of their
Alluviated	Alluviated pools are formed when floodplain or natural-levee deposits left by floods on nearby streams or alluvial fans/aprons dam their outlets.
Dune dammed	Winds produce dunal depressions, which can develop into vernal pools. More commonly, it is dunes advancing over old terraces or floodplain can obstruct drainage and form dune-dammed pools. Some vernal pools are sharply elongated in the direction of the prevailing wind, presumably by waves. In many cases, the obstructing dunes or the eroding winds were formed under mid-Holocene or Pleistocene conditions, with soil-forming processes augmenting the pool-forming effects.
Bedrock	A few pools are not sedimentary – for example the tenajas of Riverside County or the tanques of the Santa Rosa Plateau, but these seem to be relatively rare in Southern California.

Major Vernal Pool Classes of Origin

Most southern Californian vernal pools are formed on sedimentary[2] (depositional) surfaces formed by (a) pedogenic processes in old soils, (b) movements along faults (in geologic parlance, "tectonic offset and co-seismic subsidence"), (c) landsliding, (d) alluviation or differential sedimentation along drainageways, and (e) dune-dammed pools formed by aeolian (windblown) scour or deposition. Although most pools have a clearly dominant genetic class, some have a compound origin involving forms and functions associated with two classes. Wind erosion can magnify effects of each.

Vernal pools formed on old terraces or crystalline bedrock deeply weathered by pedogenic processes are the most numerous and widespread (See Figure 3.2). Several types of pedogenic pools are known from southern California. In all cases, they have developed over restrictive layers created as the soils have matured and which perch winter water near the soil surface. Sometimes the restrictive layers are created by a claypan, formed by downward movement of clays and their accumulation in the subsoil ("illuviation") (Nikiforoff 1941). In other cases, the restrictive layers have formed as duripans of lime ("calcareous horizons" or, in some cases, "caliche") or iron-silica cementation ("ferricrete" or "silcrete") (*cf*., Abbott 1984, Abbott and Fink 1975, Nikiforoff 1941). Pedogenic pools tend to be quite ancient, often developing on surfaces that are upwards—and often much upwards—of 100,000 years old. Pools of this type normally draw most of their inflow from rain on and near the pool surface, unless they are part of a vernal pool complex, where drainage from pools upstream may also contribute substantially.

Tectonic activity has directly or indirectly created local sediment-filled depressions that sustain vernal pools along active faults. Examples include Skunk Hollow in Riverside County, the Moorpark vernal pond in Ventura County, and one or two of the Chiquita Ridge pools in Orange County. The restrictive, or "perching" horizon supporting seasonal ponding is formed from lake sediments or ponded clays deposited in the tectonogenic depression, commonly over periods of thousands or tens of thousands of years. These pools tend to be among the largest and deepest, and are supported by watersheds of (typically) 20 to 200 acres. They are distinguished by drawing much of their inflow from the steeper slopes with thinner soils near the edges of their watersheds rather than those immediately surrounding the basin.

[2] A few pools are not sedimentary – for example the *tenajas* of Riverside County or the *tanques* of the Santa Rosa Plateau, but these seem to be relatively rare in southern California.

A number of vernal pools have developed in depressions within or at the heads of landslides. The southern Otay Mesa and most of the Chiquita Ridge/San Clemente pools share this origin. The landslides frequently develop in fractured mudstones or shales, often those assigned to the Monterey, Modelo or Otay formations, which tend to weather to heavy clays that deposit in and seal the depressions. As with the tectonogenic pools, inflows may originate from steeper areas at the edges of the contributing watershed, and are generally most vulnerable to changes and disturbance at the edges of their contributing area. We believe that many of these landslide occurred when sea level – and the valley floor adjacent to the slide – were lower during the glacial ages, mainly the most recent ones that peaked either about 18,000 or 55,000 years ago. The slides are relict from a former climate, but the ponding areas in their headscarps or in their toes remain.

Some pools are formed when floodplain or natural-levee deposits left by floods on nearby streams or alluvial fans/aprons dam their outlets. Examples of these alluviation **pools** include some of the lower-lying Ramona pools and the Fairview pool complex in Orange County. An active alluvial apron controls the depth of the Tierra Rejada pool in Moorpark, Ventura County (principally tectogenic). Many other seasonal or lagoonal wetlands throughout southern California are formed or governed by similar processes.

Winds produce dunal depressions, which can develop into vernal pools. More commonly, it is dunes advancing over old terraces or floodplain that obstruct drainage and form dune-dammed pools[3]. Some vernal pools are sharply elongated in the direction of the prevailing wind, presumably by waves. In many cases, the obstructing dunes or the eroding winds were formed under mid-Holocene or Pleistocene conditions, with soil-forming processes augmenting the pool-forming effects. Many of the Santa Barbara County pools (both Ellwood and Isla Vista) have been ponded in part by cliff-head dunes advancing over marine terraces, a pattern that may also occur at Carlsbad (Poinsettia Station) and elsewhere in San Diego County. Pools of this type normally draw most of their inflow from rain on and near the pool surface, with relatively less water contributed from outlying portions of the watershed—except for the once-encroaching dunes that tend to release rain slowly into the pools, especially late in the season. Hence, dune-dammed pools tend to be vulnerable to disturbance that compacts or covers the recharge areas in the dune deposits.

Describe the Recent Precipitation Regime

As indicated in earlier chapters, southern California's climate is highly variable both within and between years. Precipitation is so sparse and strongly seasonal that there is a substantial probability an assessment may be proposed when conditions are too dry for a full assessment. During the yearly drought period (summer) or in the rainy season of a dry year or after a string of drier-than-average

[3] See Joseph Silveira's "Vernal Pools and Relict Duneland at Arena Plains" in *Fremontia* (2000).

years, a full assessment employing direct observations of function is not possible (See "Direct and Indirect Data" section). The wetland edge cannot be reliably determined, prior- and current-year vegetation may be indistinguishable from one another and much or all of the characteristic flora and fauna could be dormant and cryptic. Indirect measures (microtopography, soil type, disturbance types and levels) can be taken regardless of moisture conditions. Direct measures (hydrology, biogeochemical processes and presence of characteristic plant and animal species) can only be fully assessed under specific conditions. Given the soil type and topography, ponding may be deemed likely after sufficient rainfall, but only the presence of standing water and a seasonal hydrograph can fully describe the pool's hydrological properties. Ponding can be affected by variables that cannot be assessed in the field. Examples would be "leaky bottoms," subsurface hydrological connections and soil profile anomalies. If there are multiple or long-duration ponding events, composition of the aquatic invertebrate fauna changes as the season progresses. One sample during the rainy season is inadequate to characterize the faunal composition. Plant species are less problematic if there has been sufficient moisture to trigger germination and sampling is done before the seasonal drought intensifies. Soil moisture buffers the aboveground variability due to sporadic rain events or early cessation of the seasonal rains.

Collection and Recording of Data

Information and data used to assess the functions of vernal pool depressional wetlands in southern California are collected at several different spatial scales. Data on landscape scale variables such as land use and catchment area should be collected from aerial photographs, maps and other sources prior to the site visit then confirmed on-site. Information about the WAA in general is collected during a walking reconnaissance of the WAA. Finally, detailed site-specific data are collected in and around each basin. If the WAA is large, detailed data should be collected from a number of representative locations throughout the WAA.

The exact number and location of these data collection points are dictated by the size and heterogeneity of the WAA. If the WAA is relatively small (*i.e.*, less than 2-3 acres) and homogeneous with respect to the characteristics and processes that influence vernal pool wetland function, then 3 or 4 basins representing different size classes and landscape positions are probably adequate to characterize the WAA. As the size and heterogeneity of the WAA increases, more basins are required to accurately represent the site. If sensitive or endangered species are potentially present, all basins will need to be assessed. Assessment of the hydrologic function, if appropriate for the WAA, will influence the choice of pools to be assessed.

As with defining the WAA, there is an element of subjectivity and practical limitations in determining the number of sample locations for collecting site-specific data. Experience has shown that, with adequate preparatory work, the time required to complete an assessment at a several-acre WAA is 2-4 hr for a team of 4-5 people. Training and experience will reduce the required time to the lower end of this range. The vernal pool flora and fauna include a wide array of species that vary depending on pool type and that require substantial expertise to sample and identify even under optimal conditions. Thus, additional training is required than would be necessary in less diverse and specialized wetland subclasses. Full identification of the aquatic invertebrate fauna would require laboratory analysis of the field samples. Skilled workers can process a sample in less than a day, but larger, more complex samples can take two days or more.

Direct and Indirect data

Indirect data can be taken at any time of the rainfall year (July 1-June 30) or in a run of dry or wet years. By definition, indirect data are taken on persistent indicators that have a strong correlation with actual function but do not directly measure the function itself. For example, a depression in a landscape with slope <5%, combined with an undisturbed soil profile having drainage-impeding layers, is likely to pond water during the rainy season (Bauder and McMillan 1998). However, direct observation of the water storage function must be taken on actual ponding events (depth, number and duration) and presented as a seasonal hydrograph.

Full functional assessments employ direct data, and they cannot be made unless there has been sufficient precipitation to elicit the responses being assessed (Table 5.4). In order to decide whether or not conditions for the collection of direct data have been met, the appropriate sections on the Pool Scale Base Map data form need to be completed (Appendix C.2) using the Precipitation Regime Context and Data Collection Guidelines (Appendix D.1). At a minimum, there must be one ponding event of at least 48 hours duration to demonstrate a basin's ability to hold water. To support a full life cycle for San Diego fairy shrimp, at least ten consecutive days of ponding are usually required. Water temperatures affect the required ponding duration by impacting developmental rates, especially of the aquatic fauna.

Germination of much of the characteristic vernal pool flora occurs without ponding if soils are sufficiently moist, but some annuals may require standing water, however shallow (Bauder 1992). Many plant species commonly associated with coastal San Diego vernal pools do not germinate during dry winters that tend to be warmer as well (Bauder 2000). Herbaceous perennials may not resume growth in very dry years. If rainfall is sparse, the window of opportunity for proper identification of

Table 5.4. Conditions for Collection of Data to Make Direct Estimates of Function*

Function 1 Surface and Sub-surface Water Storage

The water storage function can only be estimated directly in years with total seasonal precipitation ≥ 14 cm. There must be at least one ponding event ≥ 48 hours.

Function 2 Hydrologic Networks

A minimum of 5 cm of precipitation in a two-week period is usually required to trigger ponding in pools at lower elevations in a network, an additional 4-5 cm for ponding in mid-network basins, and another 4-5 cm to fill basins in the entire network, from highest to lowest elevation. This was tested in a network of 10 pools with a maximum linear drainage pathway of 105 m and a drop in elevation of 0.88 m from the bottom of the highest pool in the network to bottom of the lowest pool. Hydrological data taken over a 20-year period in coastal pools on soils of pedogenic origin were supplemented by intense monitoring of the entire network during one year. Surface hydrologic networks are rarely evident in dry years (<25 cm of seasonal precipitation).

Function 3 Biogeochemical Processes

Unknown

Function 4 Maintenance of the Characteristic Plant Community

If water is standing too deeply or the dry phase succeeds a year of below average precipitation, direct evaluation of function cannot successfully be estimated. In drier-than-average rainfall years, some important species may not germinate or renew growth, or be depauperate or fail to flower if they do grow. These conditions result in a telescoped field season and difficulty in identifying species. Given the extreme variability of the climate, pools will need to be surveyed in at least two separate years to estimate this function directly.

Function 5 Maintenance of the Characteristic Faunal Community

The faunal index can only be estimated directly if the maximum depth of the basin is ≥ 0.07 m and there must be continuous ponding for ≥ 2 weeks. For indirect assessment, the maximum depth of the pool must be ≥ 0.15 m. For full direct community assessment, repeat samples throughout the season must be collected.

***These guidelines have been developed and tested on vernal pools in coastal San Diego on soils of pedogenic origin. They may or may not apply to other pool types (age and origin) in different locations (sub-regional climates).**

key species that have germinated or initiated growth may be very narrow and require years of observations spanning an array of precipitation regimes, both in total amount and pattern of rainfall.

Detailed specifications for the collection of direct data are discussed in the sub-section devoted to direct data collection.

Collection of Indirect Data

<u>Construction of On-site Base Maps</u>

Landscape Scale Base Map

Site characterization begins with the preparation of base maps for each WAA or PWAA. The objective in the development of the landscape-scale base map(s) is to (a) measure the aerial extent of the current type and level of disturbance in and around the WAA, and (b) place the wetlands in context, noting important landscape features such as drainage networks, roads, culverts, water control structures and signs of past land use such as fire, tillage, type conversion or grazing. Base maps should initially be developed in the office from preexisting maps, aerial photographs or digital elevation models (DEMs). In order to assess landscape level disturbances, the base map should extend in a circle (1 km radius) centered on each pool. Wetland delineation maps may exist that have been completed for the WAA, or such delineation can be integrated into this procedure. Use Table 5.5 as a guide to the types of disturbance that need to be documented in order to score each basin for its landscape-level disturbance. A more detailed list of disturbances levels and types can be found in Appendix D.2.

On the landscape map/photo/DEM (or LiDAR):

- Identify approximate pool boundaries and shapes on aerial photos, if possible
- Identify surrounding drainage networks, including swales, channels, and inferred flow directions
- If present, indicate disturbance areas that may affect drainage directions, including signs of fire, cattle grazing or subtle evidence of tillage, of managed vegetation ("chaining" or mechanical conversion to grasslands) or trenching for pipelines.

Pool Scale Base Map

The development of accurate base maps for the individual pools is important to the assessment of a number of variables and thus must be done accurately and precisely. Using the methods described below, complete the Pool Scale Base Map Data Form (Appendix C.2). Complete a sketch of the pool, as outlined in the final step below.

- Using a GPS receiver, record latitude/longitude in the deepest area of the pool.

- Evaluate the inlets, outlets and connections.

  Is a visible surface inlet(s) present? If so, is the inlet(s) a defined channel (with a distinct bed and banks) or a swale (depression without a bed and banks)? Do the inlet(s) appear to be modified? Is an outlet present? More than one? If so, has it/they been modified? How is the inlet supplied? Where does the outlet lead? Are there other pools?

- Evaluate the catchment area

  Starting at the outlet, walk along drainage divide, marking the divide periodically with flagging. Continue around perimeter of pool catchment area until arriving back at opposite side of outlet.

  Sketch catchment perimeter on aerial photograph, designating areas of uncertainty, if any.

  Measure (pace or with tape measure) long and short axes of the catchment to develop an initial estimate of the catchment area. Record the estimate, and keep it in mind during subsequent fieldwork.

  Set the GPS receiver to 'track', and re-walk the catchment perimeter, so the GPS unit records the perimeter. Re-evaluate the chosen drainage divides as you walk, removing flagging as you go.

  In the office, plot GPS track and calculate area (by planimeter, GIS or measuring length and width in mapping software).

Table 5.5. Disturbance Categories

Category	Description*
1	minimal disturbance/no disturbance
2	light to moderate disturbance --not recent, self-recovered or restorable
3	moderate to substantial disturbance --restorable or has been restored; some potential for self-recovery
4	substantial disturbance--restoration potential, but extensive restoration efforts needed
5	substantial disturbance--developed or restoration potential low
6	severe disturbance—surrounding landscape dominated by development;restoration potential minimal to none

*For more complete descriptions see Appendix D.2.

- Establish the following relative elevations using hand-level (or auto-level) and stadia rod and recording elevations on the worksheet

  Outlet(s)

  Deepest location in the pool

  Record maximum depth (Outlet depth minus deepest location in the pool)

- Define pool edge

  A distinct edge may be marked by an abrupt change in the presence or absence of algae and/or debris, vegetation, cobble density, or soil color over a very small distance (~10 cm in small pools to 1 m in large pools) around the majority of the pool perimeter. An indistinct edge does not show a contrast in these features over a small area.

If the edge is indistinct, and the outlet is present, use the elevation of the outlet to establish the edge elevation.

- Establish long and short axes of the pool

  Note: these axes will be used to calculate area and volume, and should reflect the average length and width. Therefore, the ends of each tape measure will not necessarily be at the pool edge.

  Hammer spikes or short rebar at either end of both axes, and attach tape measure, pull tight.

  Record long axis length and short axis length.

  Using calculator, calculate long axis slope, pool area, and pool volume.

  Using compass set to the local declination, record heading of long axis.

- Sketch pool

  If an aerial photograph is at an appropriate scale, sketch directly onto the photo.

  If an aerial photograph is not available, sketch the pool on graph paper, to scale.

  Leave long axis tape measure in place. Using short axis (or a third) tape, record distance to edges of pool at stations along the long axis.

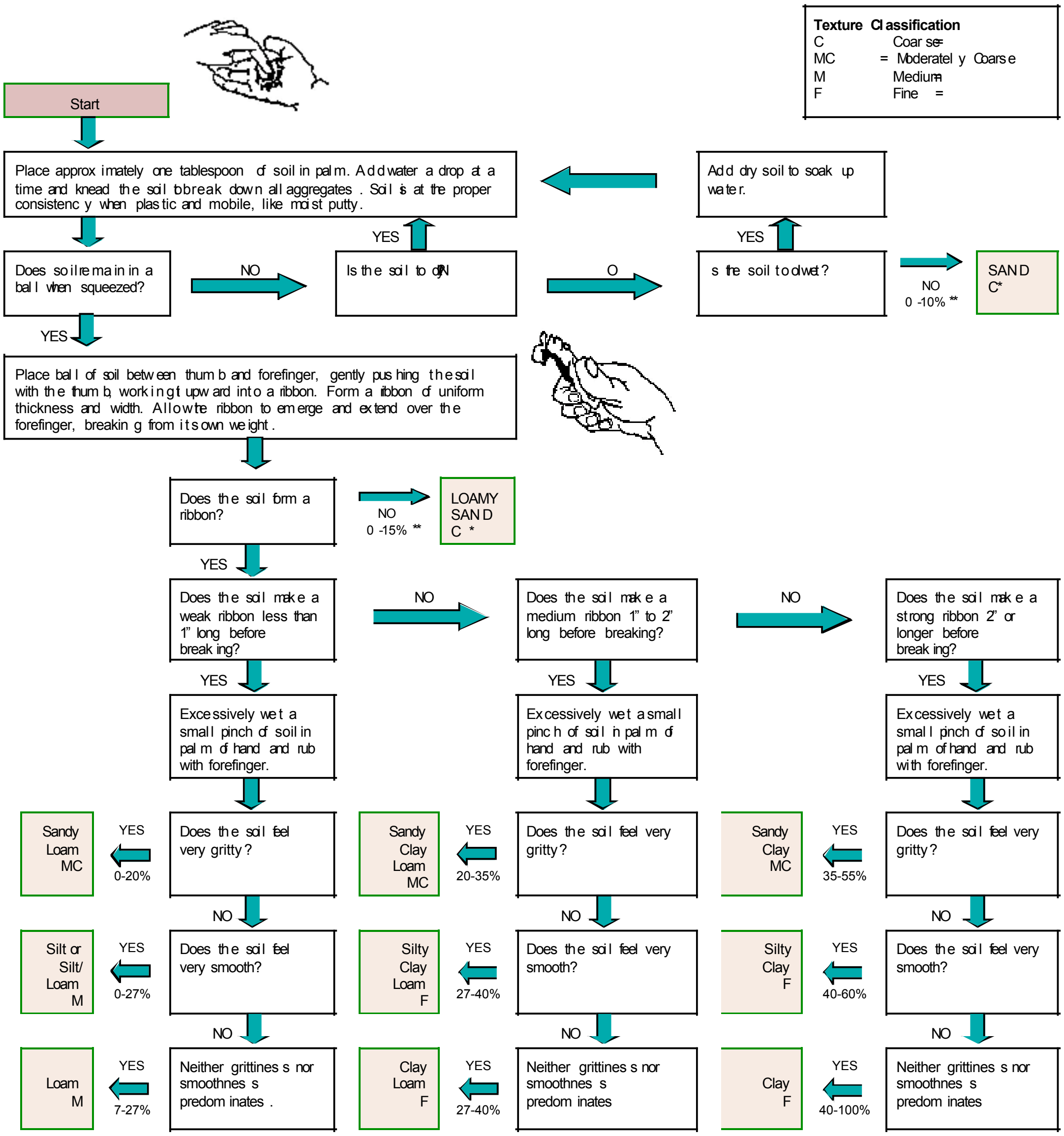
  Show locations of inlet(s), outlet(s), mounds, vegetation communities, surface cracks, sediment scour or deposition areas, areas and types of disturbance, algal mats, high water marks and/or pool edge-defining features.

Evaluation of Soils

- With hand trowel, excavate small pit (3-4 inches deep)
- Classify soils according to NRCS classification system (soil order)
- Conduct 'feel test' to establish texture of the matrix, using the method outlined in Figure 5.5.

Record the result on the Pool Scale Base Map Data Form (Appendix C.2).

More detailed examination of soils along transects from the uplands into the pool basins would be warranted if 1) endangered species with specific soil affinities are present or the habitat is being restored to support them, or 2) confirmation of the presence or loss of a natural gradient in soil texture and nutrients from the uplands into the basin is one of the goals of the assessment. Species distributions within basins correlate with factors related to a pool-scale elevational gradient, including various soil attributes and length of inundation (Bauder 1987a). At a larger scale, they correlate with soil series (Bauder and McMillan 1998).



* Sand Particle size should be estimated (very fine, fine, medium, coarse) for these textures. Individual grains of <u>very fine</u> sand are not visible without magnification and there is a gritty feeling to a very small sample ground between the teeth. Some <u>fine sand</u> particles may be just visible. <u>Medium</u> sand particles are easily visible. Examples of sand size descriptions where one size is predominant are; very fine sand, fine sandy loam, loamy coarse sand.

** Clay percentage range.

Modified from: Thien, Steven J., Kansas state University, 1979 Jour. Agronomy education.

Figure 5.5. Determining soil texture by the "feel method."

<u>Examination of Surface Features</u>

The basin is defined as a topographic depression that ponds water given sufficient rainfall. It comprises the area below the lowest outlet elevation. The periphery is a 20-ft (c. 6 m) wide band extending around and parallel to the edge of the basin. The edge of the basin is equivalent to the elevation of standing water when the basin is filled to capacity or overflowing. The catchment area is the watershed that topographically can contribute to the basin under existing conditions. If the catchment has recently been modified, the original catchment should be estimated, where feasible. It may contain one or more pools. Use the Pool Scale Base Map Data Form (Appendix C.2) to record the following observations on the surface features of the basin, its periphery and catchment.

Basin

- Sediment

  Describe the texture of sediment (a) recently deposited in the pool, and (b) which may be present in any deltas or deposition at the pool inlet. See above for description of soils.

- Cobbles

  Estimate the percent cover of angular, coarse pebbles, cobbles or other discrete larger clasts; these will usually be dispersed at near-equal distances over the bed of the pool (probably a result of shrink-swell of the soils over many years). Pebbles are 2-7.5 cm in diameter and cobbles are 7.5-25 cm in diameter (soil Survey Manual 1993).

- Cracks

  Record the presence of soil cracks (shallow or deep) or their absence. Deep cracks are > 1cm wide and over 1 dm deep.

- Disturbance

  Characterize the location, depth, and percent cover of evidence of any tillage or construction-related disturbance of the restrictive horizon supporting ponding; evidence of trenching (such as for utility lines); ruts or tire tracks that have compacted the soil surface; or fences crossing though the basin or anthropogenic debris in the basin. Appendix D.2 should be used as a guide for the type and level of disturbance that need to be recorded. Record the dominant disturbance for the basin.

Periphery and Catchment

- Disturbance

  Characterize the location, depth and percent cover of disturbance due to tillage, grazing, brushing, trenching (such as for utility lines), bladed roads, hard surfaces, land leveling or ripping, quarrying and artificial landscapes. Appendix D.2 should be used as a guide for the type and level of disturbance that need to be recorded. Record the dominant disturbance for the periphery and the catchment.

- Mounds

  Are mounds present or absent?

<u>Assessment of Disturbance Levels</u>

The basin, periphery and catchment are assessed for the dominant disturbance (Table 5.5, Pool Scale Base Map Data Form Appendix C.2 and Appendix D.2). Entries for the dominant disturbances are the category (1-6) that best describes the condition of the greatest part of the basin, periphery or catchment.

Landscape-level disturbance is assessed in four separate quadrants, using the same disturbance categories as above. The quadrants are 90-degree wedges of a circle (radius = 1 km) centered in the basin. Quadrant 1 = 0-90 degrees, 2 = 90-180 degrees, 3 = 180-270 degrees, and 4= 270-360 degrees. Depending on the WAA, the Landscape-level disturbance scores may be determined in the field using the Landscape-level map or in the office using an aerial photograph. If using the latter, construct an outline of a circle with a radius of 1 km based on the scale of the aerial photograph. Divide the circle into four wedges. Locate each pool in the WAA and place the center of the circle over the middle of each pool and determine the score for each quadrant (Appendix C.3). Disturbance scores are computed by assigning a disturbance category to the entire quadrant (if relatively uniform) or portions of the quadrant and then multiplying by the fraction of the quadrant in this condition if the quadrant is heterogeneous. All sub-scores are then summed to characterize the entire quadrant. For example: 0.50 x 1 + 0.25 x 3 + 0.25 x 5 = 3.50. The minimum disturbance score = 1.0 and the maximum = 6.0. Additional sample calculations are included in Appendix D.2.

Collection of Direct Data

Hydrology

Mark the pool with a rebar (projecting about 30 to 45 cm above the surface) and a metal tag with a unique number, if more than one pool is being followed. Firmly embed the rebar at the lowest elevation in the pool basin, as determined by the microtopographic studies for the base map. Affix a staff plate, visitube[4], ruler, or other vertical measure of sufficient clarity such that depths can be easily read from the shore when the pond is full.[5] The rebar-mounted measure can be used to record maximum pool depth at any given time, as well as provide a clear identifier for the pool. On windy days, water levels should be read at mid level, or midway between the highest and lowest levels observed over a period of time; capillary rise or meniscus effects on the depth reading should be ignored or discounted by the observer.

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[4] Visitubes are machined lengths of clear polycarbonate tubing, scribed at intervals of 0.10 feet, which allow observers to measure not only the depth at the time of observation, but also to note the high-water mark for the storm(s) since the last visit (*c.f.*, White and Hecht 1994). Placing sieved burned cork on the inside of the tubing preserves high-water marks. The cork rises with rising waters in the pool, and then leaves a 'bathtub ring' as the level of the water subsides. The ring can be quickly erased with a swipe from a drugstore bottlebrush or a squirt from a water bottle, resetting the tube for subsequent storms. Cork is replenished as needed, usually once or twice per season. The visitube functions in much the same manner as the crest-stage gauges that have been used for decades by hydrologists on rivers and lakes.

[5] Entering pools when ponded inevitably disrupts the pools and should be avoided, especially for routine measurements. Using an easily read staff plate or visitube, mounted with forethought for observation when ponded, can minimize pool entry; use of binoculars is often helpful, especially if also reading high-water marks. If more than one pool is being followed, plastic bags will be used to cover the data collector's shoes if the pool **must** be entered, and bags will be changed between pools. This prevents the transfer of seeds and cysts between pools.

Water depth will be measured 24 hours after the end of a major storm (c. 0.5 in/1.3 cm of precipitation), and every 3-5 days thereafter until the pool has drained (Bauder 1987a, 2005). Enter data into the Hydrology Direct Assessment Data Form (Appendix C.4).

Automated data collection using dataloggers and probes (or other sensors) can be used to determine water levels. For vernal pools, data should be recorded and stored at 15-minute intervals, or more frequently. Many different types of dataloggers and probes are manufactured, and any field-resilient data-collection array capable of measuring level will likely prove suitable, provided that sufficient field observations are made to validate the data. Measurement frequencies listed above for depth are a minimum for sufficient data to validate the electronic record. Data will be used to develop seasonal hydrographs and establish the hydroperiod. The choice of whether to install a datalogger and appropriate probes will depend upon the type of pool, the nature of the disturbance, and the number of pools at risk.[6] Dataloggers can also be used to characterize event and seasonal changes in salinity (specific conductance) and water temperature. These variables were not used in our model for the Surface and Sub-surface Water Storage function but they can be important in identifying factors that affect the growth rate and mortality of vernal pool invertebrates and in describing linkages between pools in a network or disruption of network connections.

With the exception of bedrock pools and tanques, water moves between pools and their banks in all types of southern Californian vernal pools. Where there is reason to expect or document changes in this function, mini-piezometers will be installed (or alternate means, such as geophysical methods). Such methods will be needed where there is reason to inquire into past or future changes in bank properties, such as heavy compaction or deep trenching within 30 feet of a pool. Piezometers will be installed to the depth of the first restrictive layer, and founded in it. The distance between the pool and mini-piezometer should be no more than 30 feet; experience has shown that distances of 5 to 15 are often most informative in the soil types prevalent in southern California *(c.f.*, Napolitano and Hecht 1991). They will have a perforated zone no thinner than 0.5 feet (15 cm), and an open bottom in contact with the restrictive layer. They will be constructed of casing of a minimum 2-inch diameter, and capped with material compatible with their casing. The annulus between the borehole walls and casing will be filled with sand opposite the perforations, and will be sealed with compacted native clays or bentonite, or as otherwise required by the local county code. The casing shall have a clear mark (reference point, or RP) at its northern tangent from which water-level measurements can be made. The RP shall be surveyed to the staff plate or other depth measure such that water levels may be

[6] We believe that the current standard in southern California now calls for installing an automatic data collection system if a group of more than 3 to 5 pools is being evaluated. Automated systems can also be used on individual pools if so warranted (See Hecht *et al.* 1998; Rains *et al.* 2006).

related to the water levels in the well to the nearest 0.01 feet. With a minimum 2" casing, specific conductance[7] and water temperature measurements may be made using hand meters.

Hydrologic Network(s)

Using the pool scale base maps, draw the catchment area boundaries of each network on the Landscape Scale Base Map. Give each network a unique number, if the WAA has more than one network. Count the number of pools in the network and fill in the Hydrologic Network Data Form (Appendix C.5.)

Complete the Hydrologic Network Data Form with data collected for the Pool Scale Base Maps. If a direct assessment is being made, complete the direct assessment portion of the data form with data collected for the hydrology direct assessment.

Vegetation/Plant Community

Preparation Prior to Fieldwork

Prior to field work, a list of important species that are potentially present in the WAA should be compiled, including all species in Distribution Categories 1-3 listed in Table 5.6, as well as species in Sections A and B of Appendix D.3. Each species should be assigned to a Distribution Category (Table 5.6). If the assessment is being done in a different pool type than one of those used to calibrate this model, the species lists will differ from those used for this analysis. For our analysis, we employed data collected from the central San Diego mesas (Kearny Mesa, Clairemont Mesa and Penasquitos), and two pool types each in Ramona and Otay Mesa (Table 5.2). Suggested sources for species locations, distributions and soil associations are listed in Table 5.7. Field work should be conducted according to the "Guidelines for Assessing the Effects of Proposed Projects on Rare, Threatened, and Endangered Plants and Natural Communities" published by the California Department of Fish and Game (Appendix D.4). Additional information on "Special Plants" (all the plant taxa inventoried by the California Department of Fish and Game's Natural Diversity Data Base) can be found in Appendix D.5. When the species list is complete, species names can be entered into the blank Vegetation Direct Assessment Data Form (Appendix C.6), leaving space for additional species identified in the field, or species names can be entered as they are encountered in the field.

[7] Specific conductance, electrical conductance and electrical conductivity are terms that are functionally synonymous and may be used interchangeably for the purposes of this guidebook. Specific conductance is used preferentially in this document, especially where use of this term can avoid confusion with hydraulic conductivity (permeability).

Field survey

Using the "Pool Scale Base Map," become familiar with the location of the edge of the basin (See Pool Scale Base Map, paragraph e). As a species is identified in the field, its name should be entered into the Species column and its Distribution Category should be entered into the BA (basin) and/or PERI (periphery) location column as appropriate. For example, if *Pogogyne abramsii* (San Diego mesa mint) is found within the basin, a 1 should be entered in the BA column. If it is found above the basin's edge in the 20-ft band surrounding the pool, the 1 should be entered in the PERI column. If it is found in both areas, both BA and PERI columns would be filled in with 1's. For the purposes of this study, the UPLAND plant species are those found in the basin's peripheral band and that are usually found in uplands, as defined by the U.S. Fish and Wildlife Service indicator categories: FACU (Facultative Upland) or UPL (Obligate Upland) (Fish and Wildlife Service 1996).

Table 5.6. Plant Distribution Categories
1= **<u>listed</u>**; endangered, threatened or rare (State or Federal list)(excluding category 6). 2**=** **<u>narrow endemic</u>**; native to an area south of the TransverseRanges in California, including **Baja MX (excluding category 6).** **3**= **<u>regional</u>**; native to the California Floristic Province (excluding category 6). **4**= **<u>New World, Mediterranean climate</u>**; native to the west coast of N/S America (excluding category 6). **5**= **<u>cosmopolitan</u>**; distributed east of the Sierras and/or worldwide, in addition to southern California (excluding category 6). No known introduction into southern California. **6**= **<u>encroaching upland</u>**; species from categories 1-5 that is found in the pool basin but usually occurs in the uplands. **7**= **<u>introduced</u>**; known introduction into California.
Definitions and assignments to distribution categories are based primarily on Hickman, James C., ed. 1993. The Jepson manual: Higher plants of California, University of California Press, Berkeley, CA.

Table 5.7. Suggested Resources for Information on Species Distributions and Soil Affinities
US Fish and Wildlife Service—Carlsbad and Ventura Field Offices
USDA/NRCS—"Soils" website
US Forest Service
California Department of Fish and Game California Natural Diversity Data Base Resource Management—Habitat Conservation Regional offices
California Department of Parks and Recreation—appropriate districts
City of San Diego—Planning Department
County of San Diego—Planning and Land Use Department
SANDAG (San Diego Association of Governments)
San Diego State University Herbarium
San Diego Natural History Museum
California Native Plant Society local chapters vernalpools.org website
Environmental consulting firms
University faculty/researchers

<u>Faunal/Aquatic Invertebrate Community</u>

Sample pool for crustaceans during the wet phase as follows:

Sampling regime

- During the first inundation event of the wet season, the pool should be sampled 10 days from the start of inundation. (The pool must have continuously held water during these 10 days. If the pool dries prior to 10 days, that inundation event cannot be used for direct faunal assessment.)
- Sampling cannot be conducted while it is raining, as crustaceans hide on the bottom due to the surface disturbance. If it is raining on day 10, sampling may be delayed until days 11-14.
- Pool should be sampled every 10 days thereafter until there is no standing water, up to a maximum of three months. (If necessary due to weather, the interval between sampling events may be increased to a maximum of 14 days.)

  Sampling will be repeated for all inundation events throughout the wet season to accurately characterize the full crustacean community.

Sampling will need to be extended to a second year if:

$V_{MAXDEPTH}$ < 0.15 m and < 2 samples were taken during the year. (These samples may be from the same or different inundation events.)

$V_{MAXDEPTH}$ ≥ 0.15 m and < 3 samples were taken during the year. (These samples may be from the same or different inundation events.)

Field methods

- If pool is < 0.30 m deep at the time of sampling, 1 sample (consisting of 3 net sweeps) will be taken as described below.

- If pool is ≥ 0.30 m deep at the time of sampling, 1 sample (3 net sweeps each) will be taken from each of the following locations:

  Deep water (benthic) sample from the deepest portion of the pool

  Just under the surface to middle depths

  Edge of pool

- For each crustacean sample, sweep a standard aquarium hand net through the pool three times (1.0 meter length each) in different locations. If a 1.0-meter sweep is not possible because the pool is too small, the sweep should be as long as possible. Net size (rectangular surface area) should be 10-15 cm^2, although nets as small as 5 cm^2 may be used when there is little standing water. Net should be placed vertically into pond, and very lightly bounced along bottom throughout the sweep.
- Using the crustacean data sampling form (Appendix C.7), record the depth that the net sampled, so that the volume of water sampled may be calculated.
- If the pool is exceptionally shallow, a known volume of water may be scooped out with a small cup and poured through the aquarium net.
- Rinse all material out of net with carbonated soda water (to anaesthetize animals) into a single twirl-top bag, large vial or collection jar. Combine material from all sweeps on the same date into the same bag. Carefully decant all carbonated water. A small, fine sieve may be useful. For samples with significant amounts of algae, add enough 95-100% ethyl alcohol to dilute the sample to approx. 80% ethanol. For samples with little or no algae, fill bag with 80% ethanol. This is best accomplished with a standard laboratory squirt bottle, and small sieve with mesh that at least as fine as the aquarium net. If a vial is used, a funnel with a large opening may be useful.

Laboratory methods

- Within 24 hours of field collection, replace all liquid with 70% ethyl alcohol / 25% water / 5% glycerin in the laboratory. Samples may be stored indefinitely thereafter.
- Separate crustaceans from other material under a dissecting microscope, and sort to species according to Balcer et al (1984), Belk (1975), Cohen (1982), Fugate (1993), Pennak (1989), and Thorpe and Covich (1991). A sufficiently trained taxonomic expert may be able to distinguish more than one morphotype of some cladocerans and ostracods that likely correspond to species. Several unnamed ostracod species are known to exist in pools within the reference area.

All identified crustaceans should be archived for review and possible future research, in properly labeled and curated vials or jars.

SAMPLE LABEL:

Crustacea: Cladocera: *Ceriodaphnia dubia* M011205-2 Marine Corps Air Station Miramar San Diego County, CA HGM pool 29 (complex AA9, pool 139W) coll. 12 January 2005, M. Simovich det. 25 March 2005, M. Simovich

- A reference collection for all samples in a single project should be available for external review upon request, containing up to 5 individuals per species in separate vials. Documentation should be retained that relates individuals in the reference collection to specific ponds and collection dates.
- Taxonomic identifications should be verified with a reference collection maintained by USFWS.
- $V_{CRUSTSPP}$ = the total number of crustacean species identified from all samples and all inundation events, reflecting the complete species list for the pool

Analytical Techniques and Procedures

A variety of methods have been use to develop HGM guidebooks, with a general approach (Butterwick 1998, Smith and Wakeley 2001) as follows:

a. Define inherent functions provided by the habitat

b. Define variables that may relate to one or more functions in a direct (causative) or indirect (statistical, correlative) manner

c. Define one or more Functional Capacity Indices (FCIs) per function using a subset of the variables in an equation, where 0 indicates no function, and 1 indicates the highest possible function.

Criteria used to choose among potential variables and quantitative development of FCIs are rarely addressed in any detail in HGM guidebooks. In practice, many FCIs may be developed based on best expert opinion, without any underlying statistical justification.

Techniques and Procedures Used in developing the Functional Capacity Indices for this Guidebook

For developing this guidebook, we sought whenever possible to take the following approach:

a. Choose a set of 61 pools from across San Diego County that span a full range of functionality and disturbance levels.

b. Collect field data on variables that causally relate to pool function from 28-61 pools, depending on the function.

c. Develop a Direct FCI for each function as follows:

- •1 Using best expert opinion, designate *a priori* a subset of pools that has the highest overall functionality (reference standards), and a subset that has the lowest function.

- •2 Using exploratory data analysis (*e.g.*, examination of scatterplots and boxplots, bivariate correlations, search for natural inflections or breakpoints in the data), ordination, and general linear modeling, develop a preliminary Direct FCI. In this preliminary analysis, only pools chosen in *c*1) were used. The reference standards received an *a priori* FCI of 1, and the lowest function pools received an *a priori* FCI between 0 and 0.25, depending on their status. These FCI scores were consistent with the FCI definitions provided in Appendix D.6. The result was a statistical model in which Direct FCI is calculated as a linear combination of categorical and/or continuous variables that clearly relate to the specific function.

- •3 Validate and calibrate the preliminary Direct FCI on the full set of 61 pools (28-61, depending on the function) using best expert opinion. In this phase, further exploratory data analysis was used to make adjustments to model parameters.

- •4 The Direct FCI is considered to be the best way to assess pool function, although it may not be possible to score it during all seasons of the year. The Direct FCI may also require additional effort and expertise that is not required for the indirect FCI.

d. Develop an Indirect FCI for each function as follows:

- •1 Calculate the Direct FCI for each pool in which appropriate data have been gathered.

- •2 Using exploratory data analysis (*e.g.*, examination of scatterplots and boxplots, bivariate correlations, search for natural inflections or breakpoints in the data), ordination, and general linear modeling, develop a preliminary Indirect FCI. This was estimated as a general linear model in a manner similar to *c*2) above. However, the dependent variable in *c*2) is *a priori* Direct FCI, whereas the dependent variable in *d*2) is the final calibrated Direct FCI from *c*3) above. The independent variables (predictors) in *c*2) are a small set of field-measured variables that directly relate to the function. In contrast, the independent variables in *d*2) are variables that can be measured in the field by any qualified scientist or contractor, in a short time using relatively simple field equipment, during either the wet or the dry phase of the pool.

- •3 Validate and calibrate the preliminary Indirect FCI on the full set of 61 pools using best expert opinion. In this phase, further exploratory data analysis was used to make adjustments to model parameters.

- •4 The Indirect FCI is considered to be a more rapid way to assess pool function than the Direct FCI, and the Indirect FCI may be calculated at any time of year. However, this convenience comes at the cost of reduced accuracy.

We were unable to take this approach with all functions, due to a lack of high quality data to develop the Direct FCI for some functions. As in other published guidebooks, best expert opinion was used in these cases. The following table summarizes the approach used for each function:

Table 5.8. Number of Pools Used for Development of Direct and Indirect FCIs .

Function	Direct FCI development	Indirect FCI development
Surface and Sub-surface Water Storage	45 pools	61 pools
Hydrologic Networks	3 networks	3 networks
Biogeochemical Processes	n/a	n/a
Maintenance of the Characteristic Plant Community	61 pools	61 pools
Maintenance of the Characteristic Faunal Community	28 pools	61 pools

Tables containing the data used for the analyses are available upon request.

Application of the Results of the Assessment

Once the assessment and analysis phases are complete, the results can be used to compare the same wetland assessment area at different points in time, comparing different wetland assessment areas at the same point in time, comparing different alternatives to a project, or comparing different hydrogeomorphic classes or subclasses as per Smith *et al.* (1995).