Potential Effects of Groundwater Withdrawal on Wetland, Deepwater, and Riparian Habitats

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Classification. The U.S. Fish and Wildlife Service (Service) defines wetlands as lands "transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin et al., 1979, p. 3). For classification purposes, wetlands must have one or more of three attributes: 1) at least periodically, the land supports predominantly hydrophytic plants; 2) the substrate is predominantly undrained hydric soil; and, 3) the substrate is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al., 1979, p. 3). The Service further defines deepwater habitats as "permanently flooded lands lying below the deepwater boundary of wetlands" (Cowardin et al., 1979, p. 3).

Riparian habitats are defined by the Service as "plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways) . . . which have one or both of the following characteristics: 1) distinctively different vegetative species than adjacent areas; and, 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms. Riparian areas are usually transitional between wetland and upland" (Service, 1997). There are many other definitions of "riparian" used by various federal agencies; the Bureau of Land Management and U.S. Forest Service include "wetlands," as defined by the Service within their concepts of "riparian (National Research Council 2002, p. 31).

For regulatory purposes under Section 404 of the Clean Water Act, the U.S. Army Corps of Engineers (ACOE) and Environmental Protection Agency (EPA) identify wetlands based on a indicators and procedures similar to those used by the Service, but they typically require that all three attributes be met for an area to be designated a wetland (ACOE, 1987, pp. 13-15). The ACOE now requires the use of an Interim Supplement to the 1987 manual for the Arid West Region, which includes all of the Great Basin (ACOE, 2006). This supplement is based on the three-factor approach (hydrophytic vegetation, hydric soil, and wetland hydrology) used in the 1987 manual but takes into consideration regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors important to the identification and functioning of wetlands (ACOE, 2006, p. 1). Where differences between the two documents occur, the regional supplement takes precedence (ACOE, 2006, p. 1).

Hydrophytic Vegetation. All three agencies (Service, ACOE, and EPA) rely on a method, developed by the Service (Reed 1988; Tiner 1991), to identify the dependency of plant species on soil moisture using five basic levels of wetland indicator status, as follows:

- Obligate Wetland (OBL). Occur almost always (estimated probability >99%) under natural conditions in wetlands.

- Facultative Wetland (FACW). Usually occur in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.

- Facultative (FAC). Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).

- Facultative Upland (FACU). Usually occur in non-wetlands (estimated probability 67%-99%), but occasionally found in wetlands (estimated probability 1%-33%).

- Obligate Upland (UPL). Occur in wetlands in another region, but occur almost always (estimated probability >99%) under natural conditions in non-wetlands in the region specified.

Phreatophytic Vegetation. Some plant species, while not typically considered to be indicative of wetland or riparian vegetation, nevertheless depend on groundwater which they access through extensive, deep root systems. Greasewood (*Sarcobatus vermiculatus*) and rabbitbrush (*Chrysothamus* spp.) are common Great Basin species known to be phreatophytes. Another species common to the western United States, Rocky Mountain juniper (*Juniperus scopulorum*) is known to occur as a phreatophyte on the floors of Spring Valley and the White River Valley in White Pine County. Known locally as "swamp cedars," such occurrences are unique to these two valleys and may comprise a distinct ecotype (Charlet 2006, pp. 9-15; Lanner 2006; Smith 1994, pp., 3, 5).

Hydric Soil. The National Technical Committee for Hydric Soils defines a hydric soil as a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA-SCS 1994). Lists of hydric soils that occur in White Pine, Lincoln, and Nye Counties are available from the Natural Resources Conservation Service (NRCS 2007). Several dozen map units in White Pine and northeastern Nye Counties include hydric soil components that comprise from one percent to 100 percent of the map unit; typical landforms on which these soils are located include playas, lake plains, drainageways, swales, and depressions. Most of these soils are poorly drained or very poorly drained and have a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 inch/hour in any layer within a depth of 20 inches (NRCS 2007).

In northern Lincoln County, there are 10 map units that include hydric soil components in similar landform settings. Within the Paharanagat-Penoyer area of Lincoln County, 15 map units include hydric components that comprise between 5 and 100 percent of the map unit. Typical landforms on which these soils occur include basin floors, lake plains, and playas. In total, these map units comprise 15,755 acres or about six percent of the Pahranagat-Penoyer area. As in White Pine and northeastern Nye Counties, most of these soils are poorly drained or very poorly drained and have a water table at a depth of 1.0

foot or less during the growing season if permeability is less than 6.0 inch/hour in any layer within a depth of 20 inches (NRCS 2007).

Wetland Hydrology. Most of the basin floors within the area potentially affected by groundwater withdrawal are comprised of basin fill of unconsolidated and weakly consolidated deposits of gravel, sand, silt, and clay derived from the adjacent mountains (Harrill et al. 1988). Three types of groundwater flow systems have been identified in the Great Basin: local, intermediate, and regional; any of these can be considered the "major flow system" if it conveys the largest percentage of groundwater in the area. Within the potential project area, subsurface water flows from Cave Valley southwest toward the Kirch Wildlife Management Area along the White River Valley of northeastern Nye County, south toward the Key Pittman Wildlife Management Area, and from Dry Lake and Delamar Valleys toward Pahranagat National Wildlife Refuge (Harrill et al. 1988, map sheet 2).

Extensive areas where shallow water is consumed by evapotranspiration occur in the White River and Pahranagat Valleys (Harrill et al. 1988, map sheet 2). Such areas are likely to be dominated by wetland, deepwater, riparian, and/or phreatophytic vegetation. The technical standard for meeting the wetland hydrology criterion for regulatory purposes requires 14 or more consecutive days of flooding or ponding, or a water table 12 inches or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (i.e., a 50 percent or higher probability)(National Research Council 1995 *as cited in* ACOE 2006, p. 53). However, non-regulatory wetlands, riparian habitats, and areas of phreatophytic vegetation may still be influenced by changes in wetland hydrology.

Synthesis. The above discussion of the relevance of hydrophytic and phreatophytic vegetation, hydric soil, and wetland hydrology allows for some general predictions to be made regarding the potential effects of groundwater withdrawal on wetland, deepwater, riparian and phreatophytic habitats. Most such habitats within the potential project area lie on relatively broad, flat valley floors. Large areas of open water, i.e., deepwater habitats, are typically spring-fed and occur only at Kirch Wildlife Management Area, Key Pittman Wildlife Management Area, Upper and Lower Pahranagat Lakes, and at the Geyser Ranch in Lake Valley. Wetland and riparian areas are found adjacent to the lakes, or associated with isolated springs. Phreatophytic vegetation is often associated with playa edges, although it also occurs in other areas where groundwater is accessible to the roots of phreatophytic plant species.

The generally level terrain associated with the floors of the White River and Pahranagat Valleys constrains the overall configuration of wetlands to broad, shallow basins or linear channels. Because the wetlands on these valley floors tend to be linear and relatively shallow, even relatively small changes in groundwater levels can affect plants that depend on ponding, flooding, or saturated soils to be present for extended periods during the growing season. The effects of groundwater drawdown are most pronounced at the wetted perimeter of a wetland where its area tends to be greatest and the hydrophytic plants are at the dry end of their tolerance range. As the depth to groundwater level increases, the wetted perimeter contracts generally contracts toward the center of the wetland where the saturation is typically greatest. As the perimeter dries, the facultative wetland and facultative plants typical of the transition zone between wetland and upland habitats are replaced by facultative upland and obligate upland plant species (Cooper *et al.* 2006). Thus, plants that depend on more saturated soils, such as *Juncus balticus* (FACW), *Potentilla fruticosa* (FACW) and *Distichlis spicata* (FAC), may be replaced by *Leymus cinereus* (FACU), *Sarcobatus vermiculatus* (UPL), or *Chrysothamnus nauseous* (UPL), the latter two being phreatophytes (Miller et al., 1982). Likewise, the area in which obligate wetland plants are supported may shrink as water levels decline and obligate wetland plants may be replaced by facultative wetland or facultative plants. Exposed soil surfaces may also be colonized by weeds. In extreme cases, deepwater and wetland habitats may disappear entirely as groundwater levels decline. Where the soils are naturally of high salinity, as is typical of soils in the Great Basin, few plant species may be able to colonize newly exposed surfaces leading to dust bowl conditions such as exist in the former Owens Lake area of eastern California.

The above description of potential effects is simplified in that it takes into consideration only the effects of changes in the amount of water. A more realistic model also has to take into consideration other factors known to be important in wetland and riparian function: timing, frequency, and duration (Richter et al. 1996). These factors, in combination with individual species differences (Naumberg et al., 2005) are of particular importance to the vegetative components of wetland and riparian habitat. In particular, key stages in plant reproduction may depend upon the timing, frequency, and duration of water availability. Cottonwoods and willows provide a well-known example of these critical interactions. Seeds of these woody species, common to riparian and shrub-dominated wetlands throughout the Great Basin, are typically released in late-spring and dispersed by wind and/or water. These seeds require a moist, exposed mineral surface on which to germinate and require continuously moist substrate during at least the first week of growth (Fenner et al. 1985, p. 135; Scott et al. 1996, p. 328; Lite and Stromberg 2005). Because the seeds tend to lose viability within a few weeks under field conditions (Scott et al. 1996, p. 328), the availability of suitable habitat for germination depends on the frequency, timing, and duration of water within the parameters under which they evolved. The lack of a wetted mineral surface at the right time and for the right length of time and at a frequency sufficient to provide for sustained regeneration can lead to the loss of habitat over time as older plants die and are not replaced.

The variety of life forms also influences the potential outcome of changes in water available to wetland, riparian, and phreatophytic plants. Herbaceous species tend to relatively shallow rooted and, therefore, can be expected to be among the first species to be affected by changes in the amount, frequency, timing, and duration of available water. Wetland shrubs, which are typically deeper rooted may not immediately show signs of mortality but, during extended periods when one or more of these factors of water availability are not met, may demonstrate signs of drought stress such as leaf loss or early induced dormancy (Naumberg 2005). Established trees and deeper-rooted phreatophytic shrubs are likely to be the last to demonstrate the effects of gradual groundwater drawdown although, as noted above, stand regeneration may be affected by changes in the amount, frequency, timing and duration of surface water (Fenner et al. 1885, p. 135).

Drying and shrinking wetlands, deepwater, and riparian areas have consequences not only on plant species composition and richness, but also affect their functional values as wildlife habitat. The relative contribution of these habitats greatly exceed the proportion of the landscape they occupy (National Research Council 2002, p. 109). This is particularly true in the arid Great Basin where riparian areas *sensu lato*, i.e., as defined by the U.S. Forest Service to also include Service "wetlands," comprise less than one percent of the landscape (Chambers and Miller 2004, p. 1). Moreover, more than 50 percent of such habitats in the Great Basin are estimated to be in poor ecological condition (Jensen and Platts 1990 *as cited in* Chambers and Miller 2004, p. 1). Great Basin riparian areas account for much of the region's biodiversity and are known to provide habitat for diverse organisms (Chambers and Miller 2004, p. 1). Bird species richness in Nevada is highest in wetlands and fourth highest in riparian habitats (Floyd et al. 2007, p. 33). The loss of even small amounts riparian and wetland habitats in the Great Basin, therefore, can have significant consequences to flora and fauna both locally and to the Great Basin as a whole.

Parish's phacelia (*Phacelia parishii*)
Parish's phacelia is a former federal category 2 candidate species which occurs primarily on playa edges that are saturated in the spring. Category 2 included taxa for which information in our possession indicated that a proposed listing rule was possibly appropriate, but for which sufficient data on biological vulnerability and threats were not available to support a proposed rule. Parish's phacelia was dropped from candidacy in the Candidate Notice Of Review published on February 28, 1996 (61 FR 7596), in which we adopted a single category of candidate species defined as follows: "Those species for which the Service has on file sufficient information on biological vulnerability and threat(s) to support issuance of a proposed rule to list but issuance of the proposed rule is precluded."

In 1997, the Service contracted for a status survey report on Parish's phacelia through the Nevada Natural Heritage Program (Smith 1997). The contractor relocated six historical sites for the species in Nevada and discovered six new sites for a total of 12 known Nevada sites; he was unable to relocate two historical sites (Smith 1997, Table 1A). Moreover, the species was not found at 29 other sites searched in White Pine, Lincoln, Clark, and Nye Counties. Three sites are known in California and four sites in Arizona (Smith 1997, Table 1B). Nevada population sizes, like those of many annuals, are quite large and in some years may number in the millions (Smith 1997, Table 1A). More relevant to its conservation status, however, is the relatively small total area occupied by the species. In total, only 4,596 acres of habitat for the species are known in Nevada, with 60 percent of this occurring at only two sites (Smith 1997, Table 1A).

The distribution of these sites in Nevada and California is shown in Figure 1 (NNHP 2007; CNDDB 2007). Note that they fall into two general geographic clusters. All of the known sites in the northern cluster are in areas where they may be impacted by proposed

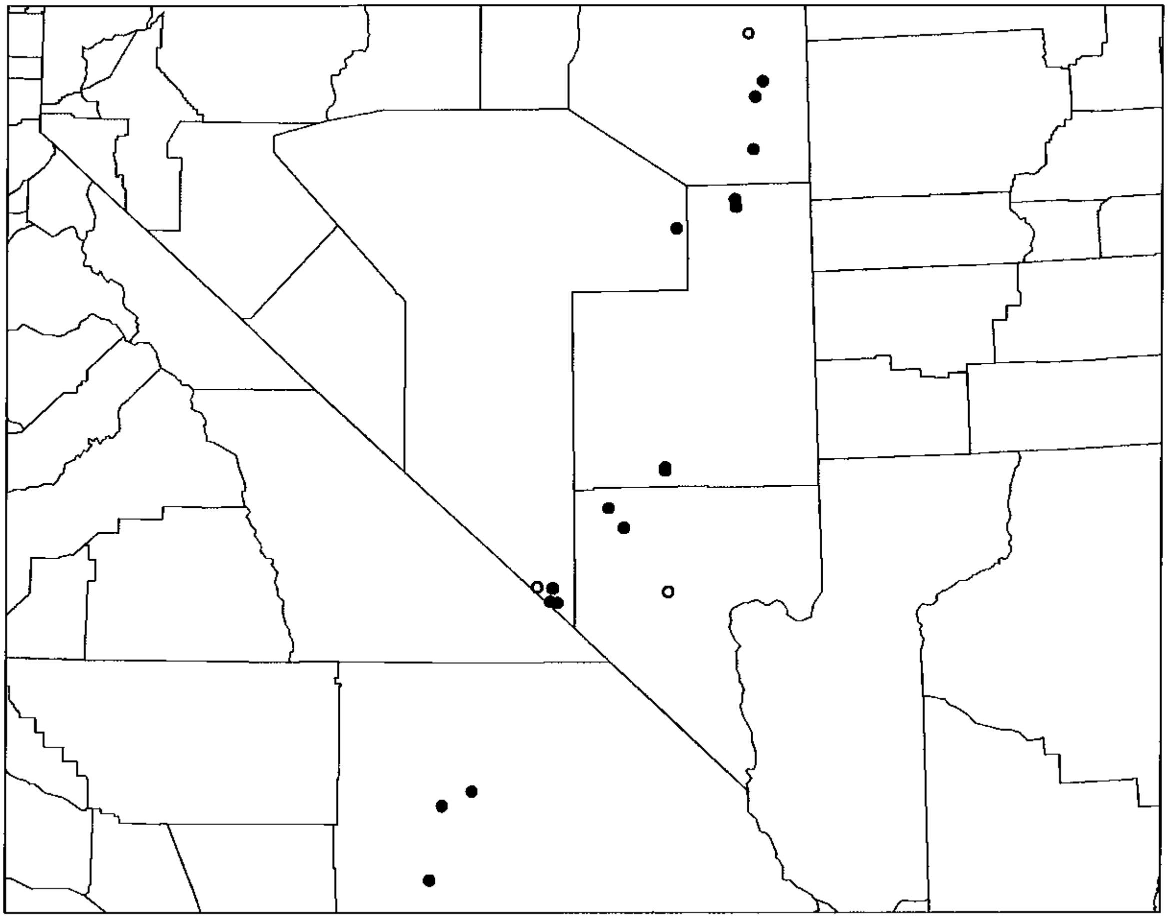

Figure 1. Distribution of Parish's phacelia in Nevada and California. Empty circles are historical locations no longer considered extant.

groundwater development projects (Figure 1, Table 1). Although the shallow root system of Parish's phacelia makes it unlikely that they are entirely dependent on near surface groundwater, any disruption of surface flow to their playa habitat is of significant concern. Less surface flow reaching the playa would diminish the size of the already small habitat. The many small populations are particularly susceptible to local extirpation.

The situation for the southern cluster is only slightly better. Four of the five sites in southern Nye County are within the city limits of Pahrump, while the fifth occurs along the Nevada/California state line, where urban development has also been proposed (Table 1). The four sites in northern Clark and adjacent Lincoln County are on the Desert National Wildlife Refuge, but three are within the Nellis Air Force Base overlay. The status of these populations is uncertain. One of the California populations was estimated to be comprised of 30,000 individuals in 1991 and was within an area used for tank training (Service 1991). We have no information on the other two California populations, nor do we have any data on the Arizona populations.

Table 1. Distribution of 16 known and historic locations of Parish's phacelia (*Phacelia parishii*) in Nevada. (NWR=National Wildlife Refuge; AFB=Air Force Base).

County	Location	Last Observed	Area (acres)	Estimated No. of Individuals	Minimum Elevation	Maximum Elevation
White Pine	Spring Valley	1906		Collection	5750	5750
White Pine	Spring Valley	1995	25	300,000	5578	5585
White Pine	Spring Valley	1995	72	25,000	5598	5605
White Pine	Spring Valley	1995	384	2,000,000	5750	5750
Lincoln	Lake Valley	1995	710	1,000;000	5915	5922
Lincoln	Lake Valley	1995	164	700,000	5917	5918
Nye	White River Valley	1995	86	20,000	5164	5170
Lincoln	Desert NWR	1995	31	150,000	3206	3210
Lincoln	Desert NWR	1995	42	150,000	3206	3210
Clark	Desert NWR/Nellis AFB	1995	1388	30,000,000	3014	3020
Clark	Desert NWR/Nellis AFB	1995	186	1,000,000	3035	3039
Nye	Stewart Valley	1998	?	Extant	2490	2490
Nye	Pahrump	1995	1.2	500;000	2570	2572
Nye	Pahrump	1995	1388	1;000;000	2490	2552
Nye	Pahrump	1995	120	500;000	2572	2585
Clark	Las Vegas Valley	1979		Collection	2190	2190

The annual habit, hydrologic dependency, and habitat specificity of Parish's phacelia as shown by the narrow elevation band in which it typically occurs (Table 1), in combination with the widely dispersed pattern of its distribution (Figure 1) and the small area of individual sites (Table 1) make it particularly susceptible to local extirpation and at risk of extinction throughout a significant portion of its range. The current project has the potential to affect the only known site in the White River Valley of Nye County, while other projects pose a similar threat to those in Spring and Lake Valleys. Urban development poses a threat to all southern Nevada sites save those on the Desert National Wildlife Refuge and Nellis Air Force Base. These four sites comprise only slightly more than one-third of the estimated overall habitat area of the species in Nevada and are all located within a very small portion of its overall range. In my opinion, the existing threats to this species justify its listing as an endangered species under Nevada statute. We lack sufficient information on the status of the California and Arizona populations, as well as an adequate understanding of the significance of the potential threats to all sites, to determine whether a federal listing may be warranted at this time. I believe that the current project, in combination with other proposed projects, has the potential to contribute to a need for a federal listing of Parish's phacelia.

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References Cited

Chambers, J.C., and J.R. Miller. 2004. Restoring and maintaining sustainable riparian ecosystems: the Great Basin Ecosystem Management Project. Pp. 1-23 *in* J.C Chambers and J.R. Miller, Eds. Great Basin Riparian Ecosystems. Society for Ecological Restoration International. Island Press, Washington, D.C.

Charlet, D.A. 2006. Effects of interbasin water transport on ecosystems of Spring Valley, White Pine County, Nevada. Exhibit 3030 submitted to the Office of the State Engineer of the State of Nevada in the matter of Applications 54003 through 54021, inclusive, filed by the Las Vegas Valley Water District to appropriate waters of Spring Valley Hydrographic Basin, Lincoln and White Pine Counties, Nevada. 25 pp.

Cooper, D.J., J.S. Sanderson, D.I Stannard, and D.P. Groeneveld. 2006. Effects of long-term water table drawdown on evapotranspiration and vegetation in an arid region phreatophyte community. Journal of Hydrology 325:21-34.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 20240. 131 pp. http://www.fws.gov/nwi/Pubs_Reports/Class_Manual/class_titlepg.htm.

Fenner, P., W.W. Brady, and D.R. Patton. 1985. Effects of regulated water flows n regeneration of Fremont cottonwood. Journal of Range Management 38:135-136.

Floyd, T., C.S. Elphick, G. Chisholm, K. Mack, R.G. Elston, E.M. Ammon, and J.D. Boone. 2007. Atlas of the Breeding Birds of Nevada. University of Nevada Press, Reno and Nevada. 581 pp.

Harrill, J.R., J.S. Gates, and J.M. Thomas. 1988. Regional aquifer systems of the Great Basin. U.S. Department of the Interior, U.S. Geological Survey Hydrologic Investigations Atlas HA-694-C. 2 map sheets.

Lanner, R.M. 2006. The effect of groundwater pumping proposed by the Southern Nevada Water Authority n the "Swamp Cedars" (Juniperus scopulorum) of Spring Valley, Nevada. Exhibit 3040 submitted to the Office of the State Engineer of the State of Nevada in the matter of Applications 54003 through 54021, inclusive, filed by the Las Vegas Valley Water District to appropriate waters of Spring Valley Hydrographic Basin, Lincoln and White Pine Counties, Nevada. 2 pp.

Lite, S.J. and J.C. Stromberg. 2005. Surface water and ground-water thresholds for maintaining *Populus-Salix* forests, San Pedro River, Arizona. Biological Conservation 125:153-167.

Miller, R.F., F.A. Branson, I.S. McQueen, and C.T. Snyder. 1982. Water relations in soils as related to plant communities in the Ruby Valley, Nevada. Journal of Range Management 35:462-468.

National Research Council. 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, D.C. 428 pp.

National Research Council. 1995. Wetlands: characteristics and boundaries. National Academy Press, Washington, D.C.

Natural Resources Conservation Service (NRCS) 2007. Soil Data Mart. http://soildatamart.nrcs.usda.gov/ (accessed on November 6, 2007).

Naumberg, E., R. Mata-Gonzalez, R.G. Hunter, T. McClendon, and D.W. Martin. 2005. Phreatophytic vegetation and groundwater fluctuations: a review of current research and application of ecosystem response modeling with an emphasis on Great Basin vegetation. Environmental Management 35:726-740).

Reed, P.B., Jr. 1988 National list of plant species that occur in wetlands: 1988 national summary and 1993 supplement. Biological Report 88(24). U.S. Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/nwi/plants.htm.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10:1163-1174.

Scott. M.L., J.M. Friedmann, and G.T. Auble. 1996. Fluvial process and the establishment of bottomland trees. Geomorphology 14:327-339.

Smith, F.J. 1994. Status report on *Frasera gypsicola* (Sunnyside green gentian). Unpublished report submitted to the Nevada Natural Heritage Program and the U.S. Fish and Wildlife Service. Western Ecological Services, Inc., Millville, UT. 12 pp., plus appendices. On file at Nevada Fish and Wildlife Office, Reno, NV.

Tiner, R. 1991. The concept of a hydrophyte for wetland identification. BioScience 41:236-247.

U.S. Army Corps of Engineers. 2006. Interim regional supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region. J.S. Wakeley, R.W. Lichvar, and C.V. Noble, eds. ERDC/EL TR-06-16. U.S. Army Engineer Research and Development Center, Vicksburg, MS. 122 pp. http://www.usace.army.mil/cw/cecwo/reg/reg_supp.htm.

U.S. Army Corps of Engineers. 1987. Wetlands Delineation Manual. Department of the Army Environmental Laboratory, Vicksburg, MS. 100 pp., plus appendices. http://el.erdc.usace.army.mil/elpubs/pdf/wlman87.pdf

U.S. Department of Agriculture Soil Conservation Service (USDA-SCS). 1994. Changes in hydric soils of the United States. 59 Federal Register 35680-36681, July 13, 1994.

U.S. Fish and Wildlife Service. 1997. A system for mapping riparian areas in the Western United States. National Wetlands Inventory, Lakewood, CO. 15 pp.

U.S. Fish and Wildlife Service. 1991. Survey for four federal candidate plants: Parish's phacelia (*Phacelia parishii*), Mohave monkeyflower (*Mimulus mohavensis*), Barstow wooly sunflower (*Eriophyllum mohavensis*), and Lane Mountain milkvetch (*Astragalus jaegerianus*) in the Ft. Irwin/BLM Land Acquisition Study Area. Ventura Field Office, California. 11 pp., plus appendices.