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Memorandum

To: **DOCKETS**

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Subject: **CPV Sentinel Energy Project (07-AFC-3)**

The following document was submitted to California Energy Commission staff at the CPV Sentinel Issue Identification Hearing held in the City of Desert Hot Springs on October 5, 2007. This information, titled "Relationship Between Groundwater and Mesquite Biotic Communities in Mission Creek Groundwater Sub basin, Riverside County, California" was submitted by Ms. Joan Taylor representing the local Sierra Club.

Enclosure

Relationships Between Groundwater and Mesquite Biotic Communities in the Mission Creek Groundwater Subbasin, Riverside County, California

SUMMARY

Groundwater-dependent ecosystems of the Coachella Valley and the desert southwest have been and continue to be adversely affected by increases in distance to groundwater caused by well pumping. As groundwater levels decrease these ecosystems become degraded or are eliminated. Biotic communities such as mesquite woodlands are dependent on shallow water tables (Jarrell and Virginia 1990), and reductions in water availability can reduce the extent of these vegetation communities or cause compositional shifts from more mesic to more xeric species (Rood and Mahoney 1990, Stromberg and Patten 1990, Stromberg *et al.* 1993). For example, mesquite forests historically covered more land area than any other riparian community type in the southwestern U.S., but they have been reduced to remnant status largely because of water developments (Stromberg 1993). Groundwater levels in important portions of the Coachella Valley, such as along the Banning Fault, need to be maintained or restored to conserve essential ecosystems and co-adapted species of the valley.

It is estimated that mesquite hummocks occupied 3,363 hectares (8,309 acres) of the Coachella Valley floor in 1939, but were reduced to 352 hectares (870 acres) by 1998, a decline of almost 90 percent (Coachella Mountains Conservancy 2003). Evidence (e.g., MSWD 2000, MSWD 2004, CVAG 2003, CVWD 2004) indicates that mesquite hummocks occurred along the Banning Fault where groundwater naturally (historically, i.e., the 1950's) was within 10 to 15 meters (33 to 49 feet) of the ground surface. However, in nearby areas along the fault where groundwater naturally/historically occurred at distances greater than 15 meters (49 feet), mesquite hummocks did not occur. Based on the analysis provided below, mesquite hummocks in the Coachella Valley are expected to be present in the future in moderate-function ecological condition where groundwater remains within 15 meters (49 feet) of the ground surface, and high-function condition when groundwater is maintained within 10 meters (33 feet) of ground surface. Additional groundwater overdraft pumping in the Mission Creek Groundwater Subbasin (MCGS or Subbasin) would cause further reductions in the groundwater table under the mesquite hummocks along the Banning Fault. This is expected to cause a significant portion of these mesquite hummocks and their associated dune-dependent communities to be degraded or lost. Reduced groundwater pumping and/or groundwater replenishment with imported water are necessary to arrest and reverse decreasing groundwater levels and to avoid the resultant detrimental ecological conditions in the Subbasin.

INTRODUCTION

Rapid population growth in semiarid regions of the western United States is increasing the demand for water for human uses (Scott 2000). Therefore, humans living in dryland

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areas increasingly rely on regional aquifers as a source of fresh water due to the limited availability of surface water sources. In the Coachella Valley, as elsewhere, groundwater is mined from valley aquifers to meet this demand, which results in decreasing groundwater levels. Groundwater-dependent ecosystems, such as fan palm oasis and mesquite hummocks, are vulnerable to these decreases because they are supported by near-surface groundwater (Scott 2000).

In arid regions such as the Coachella Valley, the extreme spatial and temporal variations in moisture available to plants play a critical role in determining the patterns of dominant plant species distribution and ecosystem function (Snyder *et al.* 1997). Human alterations of groundwater-dependent ecosystems in the western U.S. through groundwater pumping have produced dramatic changes in stand structure and species composition of these ecosystems (Stromberg and Patten 1990). Streams in arid climates subject to withdrawal of groundwater inputs (stream diversion), show declining vigor of riparian vegetation as alluvial groundwater level decreases and stream flow are reduced (Stromberg *et al.* 1996). Thus, the human use of this water results in the replacement of groundwater-dependent ecosystems of high biological productivity with less productive xeric biotic communities. The loss of these biological "hotspots" eliminates co-adapted plants and wildlife.

COACHELLA VALLEY

The Coachella Valley is underlain by several large subsurface aquifers, known as subbasins, with boundaries that are generally defined by tectonic faults which restrict the lateral movement of water (City of Palm Desert 2003). The Upper Coachella Valley exemplifies the kind of rapid population growth many regions in the Southwest have been experiencing (Minichiello 2004). In 2000, the population of the Upper Valley numbered just under 159,000 permanent residents, plus around another 100,000 seasonal (winter) residents (Minichiello 2004). Only considering the permanent residents, in the last six years the Upper Valley has been experiencing an annual growth rate of approximately 2.6 percent (Minichiello 2004).

In response to population growth in a portion of the Upper Valley, the Mission Springs Water District (MSWD or District) withdrew 1,400 acre-feet from the MSGS in 1978, 4,834 acre-feet in 1988, and 7,096 acre-feet in 1998 (MSWD 2000). The groundwater level in the Subbasin (near the Banning Fault) has dropped from 232 meters (760 feet) above sea level in 1955 to 218 meters (715 feet) above sea level in 1998, a groundwater level drop of 14 meters (46 feet) over a period of 43 years (MSWD 2000). The water level in the subbasin is projected to drop to 212 meters (695 feet) above sea level by 2005, a total drop of 20 meters (66 feet) over a 50-year period (MSWD 2000). The water level drop is expected by the MSWD to accelerate in the future, as demands are increasing (MSWD 2000). The MSWD predicts a groundwater withdrawal by the District of 10,297 acre-feet of water from the MSGS in 2005 (MSWD 2000).

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PROPOSED PROJECT

The proposed project includes the installation and operation of a 7,571 liter (2,000 gallon) per minute groundwater production well approximately 300 meters (1,000 feet deep), two 7.6 million liter (2.0 million) gallon water storage reservoirs, a booster pump station, and distribution pipelines to deliver supplied water from the proposed reservoirs to customers in MSWD's "900 and 1,700-foot service zones"; this project is otherwise known to MSWD as the 900 Zone Project (MSWD 2004). Two 4,500 liter (1,200 gallon) per minute pumps are proposed to be installed and operated initially, with potential installation and operation of a third pump. The proposed production well, booster station, and reservoirs would be located on a 2-hectare (5-acre) parcel west of Little Morongo Road in Section 11, T3S, R4E, approximately 0.8 kilometer (0.5 mile) south of the City of Desert Hot Springs in Riverside County. The proposed water transmission lines would be constructed within existing easements or rights of way in areas ostensibly devoid of native vegetation.

Associated with expectations of growth and development in its service area, the MSWD Master Plan (MSWS 2000) identified a 16,357 liter (4,321 gallon) per minute shortfall of water service by the year 2005, compared to existing water service capacity for the MSWD. This 900 Zone Project is proposed to partially accommodate these water supply demand expectations. The proposed well and pumps would extract groundwater from the MCGS.

The proposed project would increase extraction in the Subbasin by 2,429 acre-feet per year (MSWD 2004). The proposed project would result in an initial annual lowering of the groundwater table of approximately 0.09 meter (0.3 feet) per year along portions of the Banning Fault; this lowering would accelerate in future decades (MSWD 2004). The estimated groundwater level drop (considering all extractors) from natural levels due to overdraft in the Subbasin since 1955 is currently about 18 meters (60 feet), and is projected to drop to 24 meters (80 feet) by 2010, and to 91 meters (300 feet) by 2050 (MSWD 2000). At the current rate of extraction (assuming no acceleration in pumping rates attributed to the proposed project and other extractors) of 14,700 acre-feet per year without the project, the MCGS aquifer would likely be depleted within 90 years. If past trends continue [when the groundwater extraction proposed is combined with the existing and planned pumping of the MSWD, Coachella Valley Water District (CVWD), Desert Water Agency (DWA), and private extractors], by 2050 the MCGS would have less than a third of original capacity (aquifer volume) (MSWD 2000). No safe yield of groundwater extraction has been established for the Subbasin (MSWD 2004). The proposed project would increase the current overall extractions by about 18 percent (MSWD 2004). The MSWD commits to pursue obtaining imported Colorado River water from the Desert Water Agency for recharge of the MCGS at a ratio of 1.2:1 (imported water to project extracted water) if legally and technically feasible (MSWD 2004). Because MSWD does not have entitlement or contract to imported water for the MCGS, the delivery of this water is not assured; as such, this commitment may not mitigate project impacts. The proposed project's contribution to continued overdraft of the MCGS would be "unavoidable because adequate mitigation is not available" (MSWD 2004).

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ANALYSIS

Mesquite Natural History

Individual Mesquite Plants

Mesquite is a shrub to medium-sized tree that was once widespread in the deserts of California (Bainbridge and Virginia 2002). Most mesquite plants are phreatophytes (plant with their roots in the water table) (Phillips and Comus 1999). The mesquite hummocks of the Coachella Valley are composed of phreatophytic honey mesquite (*Prosopis glandulosa*) individuals in relatively close proximity to each other. Mesquite is deciduous in winter and during severe drought stress (Bainbridge and Virginia 2002, Sosebee and Wan 1989). Whether single- or multi-stemmed, mesquite trees produce branches that typically form a canopy with a diameter twice the height of the plant (Wilson *et al.* 2001).

Mesquite can be long-lived in favorable sites (Phillips and Comus 1999), in honey mesquite, longevities of more than 100 years have been documented (Bowers *et al.* 1995). Transpiration and photosynthetic rates are higher on wetter sites (Sosebee and Wan 1989). The bulk of the root systems of most trees in the western U.S.–including mesquite–are confined to the upper meter of soil (Phillips and Comus 1999), yet mesquite can develop relatively deep roots. Sosebee and Wan (1989) indicate that the deep taproot of honey mesquite plays a significant role in water uptake only during extended droughts, not for normal transpiration functioning of the plant. In the Mojave and Sonoran deserts, rainfall is generally insufficient to provide adequate surface soil moisture for honey mesquite to survive (Sosebee and Wan 1989, MSWD 2004). Under these conditions, honey mesquite is a phreatophyte occupying areas where adult plants have access to permanent underground water (Sosobee and Wan 1989).

Mesquite tree size and shape are correlated with subsurface water characteristics (Wilson *et al.* 2001.). Large adult trees develop and survive when mesquite roots are able to reach stable groundwater supplies. Taproots of adult mesquite can generally reach 12 to 13 meters (39 to 43 feet) when subsurface water is available (MSWD 2004, Fisher *et al.* 1959). Maximum mesquite growth has been measured on deep soils with groundwater within 10 meters (33 feet) of the surface (Sharifi *et al.* 1982, Bainbridge and Virginia 2002). Stromberg *et al.* (1993) compared velvet mesquite (*P. velutina*) aboveground characteristics to available water and found that the height of stands in riparian areas was inversely related to depth to the water table; trees were under 8 meters (26 feet) tall where the groundwater depth was greater than 15 meters (49 feet), but grew to over 12 meters (39 feet) tall where the depth to groundwater was less than 15 meters. Nilsen *et al.* (1983) found honey mesquite in the Sonoran Desert of southern California (15 kilometers/9 miles west of the southern end of the Salton Sea) acquired its water from a groundwater source 4 to 6 meters (13 to 20 feet) deep. At Casa Grande National Monument in Arizona, groundwater supporting a mesquite bosque was naturally (before groundwater pumping began) 4 to 5 meters (13 to 16 feet) below the ground surface (Nabhan 2001, Nabhan and Holdsworth 1998). Stromberg *et al.* (1993) indicated that "structurally rich" velvet mesquite stands required groundwater depths of about 6 meters (20 feet) or less.

Mesquite Communities

Mesquite woodlands were once extensive in the Coachella and Imperial valleys and along the Colorado River (Bainbridge and Virginia 2002). Extensive losses in distribution of mesquite hummocks are noted for the Coachella Valley from 1939 to 1998 (CVAG 2003). Mesquite forests are one of the aridland riparian ecosystems that are threatened by groundwater pumping and other types of water development (Stromberg *et al.* 1993). Urban development often taps shallow groundwater associated with groundwater basins, which can cause a gradual decline in associated riparian forests (Stromberg *et al.* 1992).

The mesquite hummocks biotic community is composed of large clumps of low growing honey mesquite shrubs that form hummocks over sand dunes or occur on level terrain (CVAG 2003). Mesquite hummocks are associated with high soil moisture or springs, often associated with fault areas (CVAG 2003). Mesquite hummocks are widely scattered in the Coachella Valley, often in isolated patches associated with higher groundwater levels (CVAG 2003). These hummocks occur in the Coachella Valley in the vicinity of Willow Hole and on the Coachella Valley Preserve, along the southern base of the Indio Hills associated with the San Andreas Fault. Mesquite hummocks were formerly widespread from La Quinta south to the Salton Sea but are now restricted in this area to undeveloped lots amid urban or agricultural lands (CVAG 2003). Water table decreases are associated with reduced occurrence of these hummocks on undeveloped sites (CVAG 2003). Remaining mesquite hummocks are highly fragmented and often senescent, likely due to lack of water resources (CVAG 2003). Sensitive and listed species directly associated with mesquite hummocks are the Coachella Valley round-tailed ground squirrel, Palm Springs pocket mouse, Le Conte's thrasher, Crissal thrasher, Coachella Valley grasshopper, and Coachella Valley milk-vetch (CVAG 2003).

Threats to the mesquite hummock community include depletion of the groundwater and fragmentation (CVAG 2003). Depletion of groundwater reduces or effectively eliminates water available to individual adult mesquite plants, even with the long taproots that adult mesquite typically develop. Lack of available water in various mesquite hummock areas in the Coachella Valley is evident by decadent and declining mesquite (CVAG 2003).

Available evidence, including estimated historic groundwater levels (extrapolated from MSWD 2004 and MSWD 2000) and the data cited herein, indicate that mesquite hummocks along the Banning Fault occur where groundwater naturally (historically) was within 10 to 15 meters (33 to 49 feet) of the ground surface. Scrutiny of 1953 and 2001 aerial photos of the Banning Fault indicate that mesquite hummocks that were/are naturally farther from the groundwater table showed substantially similar leaf cover density (leaf area index) in 1953 to hummocks that were naturally very close to ground water, but these same groups of hummocks showed substantially different leaf cover density in 2001, with the hummocks farther from groundwater showing less leaf cover density. "Biological integrity" (Karr 1991) of mesquite hummocks in the Coachella Valley is likely maintained in moderate-function ecological condition where groundwater remains within 15 meters (49 feet), and high-function condition when groundwater is maintained within 10 meters (33 feet).

Effects of Groundwater Decreases on Mesquite

Ecological changes resulting from hydrologic alterations (e.g., reduced biomass, alien species invasion, and ecotonal shifts) have been studied in groundwater-dependent plant communities (Allen-Diaz 1991, Stromberg *et al.* 1996, Castelli *et al.* 2000) and for individual plant species (Shafroth *et al.* 2000, Horton and Clark 2001), but long-term effects on vegetation dynamics have not been documented (Elmore *et al.* 2003). The effects for increases in distance to groundwater for the biotic community of mesquite hummocks range from loss of recruitment or temporary drought stress, to changes in plant cover or floristic composition, to dominant plant die-off and community type-conversion. Plant die-off/community type-conversion is the threshold at which community resilience is exceeded such that the community is wholly altered (Scheffer *et al.* 2001). Decreasing groundwater levels primarily affects mesquite communities through a reduction of (1) the shallow water table necessary for mesquite recruitment, and (2) the long-term maintenance of established adult woody vegetation (Stromberg 1992).

Effects of Groundwater Decreases on Mesquite Adult Individuals

Mesquite are tolerant of adverse conditions (Bainbridge and Virginia 2002) yet relatively moderate groundwater decreases will substantially stress or kill adult mesquite individuals (Stromberg *et al.* 1992). The greatest influence of severe water stress conditions on individual plants in the short-term (such as during a drought) is reduced photosynthesis and reduced or stopped carbohydrate translocation (Sosebee and Wan 1989). Most large floodplain mesquites die if the water table drops below 13 meters (43 feet) (Phillips and Comus 1999). Studies on the effects of groundwater decreases on velvet mesquite found that a reduction in groundwater levels greater than 15 meters (49 feet) below the soil surface resulted in substantial water stress and death of the plant (Stromberg *et al.* 1992). Stromberg *et al.* (1993) indicated that when the water table occurred below 6 meters (20 feet), continual and quantifiable reduction in tree stature resulted. None of these citations indicate an effective ability of mesquite individuals to adapt to groundwater artificially lowered to more than 15 meters (49 feet) of the ground surface.

Effects of Groundwater Decreases on Mesquite Communities

Numerous examples are known of the effects of general groundwater decreases on mesquite-dominated ecosystems. In combination with water diversion, groundwater pumping has affected nearly all river valleys in Arizona's portion of the Sonoran Desert (Nabhan and Holdsworth 1998); as a result, large expanses of riparian forest and mesquite woodlands have died as groundwater levels decreased (Nabhan and Holdsworth 1998). While other biotic communities are also affected by water table decreases, the full relationship between their vegetation changes and lowering groundwater levels is still largely unexplored (Bahre 1991). Nevertheless, it is clear that groundwater pumping immediately outside protected areas can devastate the vegetation within them (Nabhan and Klett 1994), and ultimately effect faunas (Nabhan and Holdsworth 1998).

In the area around Casa Grande, Arizona, groundwater levels have dropped up to 150 meters (492 feet) since 1920 (ADWR 1994a). In the 1940s this agriculture-induced drawdown became the principal cause of the death of the once extensive mesquite bosque at Casa Grande National Monument (Judd 1971). At the Monument the first well was dug in 1902, and water was only 4 to 5 meters (13 to 16 feet) below the mesquite woodland (Nabhan 2001, Nabhan and Holdsworth 1998). Although mesquite adults at the site survived a period (1900 to 1930) when the water table decreased by about 11 meters (36 feet), all the mesquite trees died during a period (1930 to 1950) when the water table dropped about 1 meter (3 feet) per year to a depth of 33 meters (108 feet) (Judd 1971, Stromberg 1993). A heavy infestation of mistletoe developed immediately prior to death (Judd 1971). Although the mistletoe may have hastened plant death, the infestation was probably a response to stressed condition of the plants rather than the sole cause of plant death (Stromberg 1993). Other co-occurring stresses that can occur during times of water stress include reduction of nitrogen fixing activity (Stromberg 1993). Similarly, the creation of the Costa de Hermosillo Irrigation District in Mexico, and the resultant use of groundwater, was noted as the direct cause of the loss of the extensive mesquite bosques in the delta of the Rio Sonora (Nabhan and Holdsworth 1998).

The Surprise Spring Basin is the main source of water for the Twentynine Palms U.S. Marine Corps Base in San Bernardino County, California (Londquist and Martin 1991). The groundwater system includes numerous faults in the area, many of which act as barriers to groundwater movement. Prior to 1953, groundwater was discharged from the basin by transpiration of mesquite, discharge of Surprise Spring, and as outflow across Surprise Spring Fault (Londquist and Martin 1991). Soon after groundwater pumping began in 1953, the spring stopped flowing, and by 1985 almost all of the mesquite had died (Londquist and Martin 1991). From 1953 through 1985, approximately 66,500 acre-feet of groundwater was pumped from the basin, causing groundwater decreases as great as 30 meters (98 feet) near Surprise Spring (Londquist and Martin 1991).

Extensive areas of mesquite communities throughout the southwestern U.S. have been eliminated by lowering of water tables (Phillips and Comus 1999). The citations noted above indicate that mesquite communities do not effectively adapt to groundwater levels artificially lowered to more than 15 meters (49 feet) of the ground surface. Groundwater levels close to natural/historic levels are essential to maintaining existing/remnant mesquite communities. Relatively moderate groundwater decreases will degrade mesquite individual and community productivity, likely degrading ecosystem values for sensitive species such as the Coachella Valley round-tailed ground squirrel. No available evidence indicate that adult mesquite functionally adapt to substantial decreases in groundwater, and most evidence points to severe degradation or elimination in the long-term when groundwater drops deeper than 15 meters (49 feet) from the ground surface. An increase in the distance to groundwater will degrade or eliminate mesquite community functions for concomitant portions of the community already at or near the edge of distance-to-groundwater limitations. Even if a lowering of groundwater tables, compared to natural conditions, does not eliminate a mesquite community outright (type-conversion), it will likely cause a degradation in function (in both the short- and long-term) and generally cause a contraction of a mesquite community in extent (in the long-term). Most analyses of groundwater decreases on vegetation communities fail to consider these long-term implications, but instead focus on the presumed adaptability/survivability of existing adult plants.

Effects of Groundwater Decreases on Mesquite Recruitment

As noted above, natural groundwater levels relatively close to the surface are essential to mesquite recruitment. Mesquite hummocks and bosques typically occur in areas where mesquite roots can reach groundwater during the establishment period (wet period) relied upon for survival by younger plants. When the natural dry period of the climate cycle occurs before younger plants have tapped into consistently moist soils, seedlings typically do not survive (Sosebee and Wan 1989). Recruitment appears to occur as flushes or spurts after atypically wet years (Sosebee and Wan 1989). Relatively minor increases in distance to groundwater will preclude future recruitment of replacement mesquite individuals, even when some of the larger adult mesquite individuals in a community would continue to utilize the lowered water table. Recruitment of new individuals into a population needs to equal mortality to maintain a community in the long-term.

The seedling stage is the most vulnerable period in the life cycle of honey mesquite (Sosebee and Wan 1989). Survival of seedlings depends on the ability of the roots to grow into wet soil; this is critical since the surface soil usually dries very rapidly (Sosebee and Wan 1989). Seedlings are very susceptible to water stress because of the lack of development of anatomical and morphological features that conserve water (Sosebee and Wan 1989). Germination of seeds and seedling establishment depends on several factors, one which is adequate soil moisture (Sosebee and Wan 1989).

Most individual adult mesquite near the patch edge or ecotone of a mesquite community are naturally (or currently) at the functional limit of areas ecologically supportive of mesquite. These are edge areas where conditions for survival (or effective competition) are already marginal for at least one important life history stage (such as seedlings) of the dominant plants of the community. Maintaining groundwater levels close to natural or historic levels is necessary to sustain the extent of a mesquite community in the long-term.

Although exceptional mesquite individuals are notable for extremely deep roots of up to 50 meters (160 feet) (Phillips 1963, Phillips and Comus 1999), and despite the often supposed adaptability of individual adult mesquite plants based on extended deep roots, a linear relationship exists between increases in distances to groundwater and the short- and long-term degradation of ecological functions of mesquite communities. Maximum mesquite growth has been measured on deep soils with groundwater within 10 meters of the surface (33 feet) (Sharifi *et al.* 1982, Bainbridge and Virginia 2002). Substantial differences in height and size of adult mesquite trees have been related to depths to the water table, with significant tree size reductions when the distance to groundwater was naturally greater than 15 meters (49 feet) (Stromberg *et al.* 1993). Of the mesquite trees growing in floodplain communities, one study noted that most of the large mesquites died when the water table was artificially dropped to below 13 meters (43 feet) of the ground surface (Phillips and Comus 1999). Studies on the effects of groundwater decreases on velvet mesquite found that an artificial reduction in groundwater levels to greater than 15 meters (49 feet) below the soil surface resulted in substantial water stress and death of the plant (Stromberg *et al.* 1992). Even if adult mesquite have the ability to grow deep roots, groundwater reductions to below 15 meters (49 feet) of the soil surface limit or eliminate the productivity of individual mesquite plants and preclude recruitment of seedlings, resulting in long-term degradation of the ecosystem functions of the mesquite community.

Therefore, maintenance of self-sustaining mesquite communities in the Coachella Valley will require maintenance of relatively natural groundwater levels. Restoration of self-sustaining mesquite communities in the Coachella Valley where they have declined due to groundwater decreases will require re-establishment of natural groundwater levels.

<u>Mesquite and Aeolian Sand</u>

Mesquite hummocks are highly important to sand accumulation and dune formation/maintenance in high energy wind fields. Within the Coachella Valley, sand dunes accrete in and downwind of mesquite stands (MSWD 2004). These sand dune biotic communities provide core ecological values and/or dispersal linkages for listed and sensitive species, including the flat-tailed horned lizard, Coachella Valley fringe-toed lizard, Le Conte's thrasher, Coachella Valley round-tailed ground squirrel, Palm Springs pocket mouse, Coachella Valley milk-vetch, Coachella Valley giant sand-treader cricket, and Coachella Valley Jerusalem cricket (CVAG 2003). The Coachella Valley was once dominated by nearly 260 square kilometers (100 square miles) of sand dunes; today less than 5 percent of that ecosystem may remain in viable condition (CNLM 2004). Restoration of undeveloped remnant dune areas to viable condition would require re-establishment of natural physical processes (fluvial and/or aeolian) that provide sand source and transport functions that supply the continual sand essential to this dynamic ecosystem.

Mesquite thickets form bosque or hummock communities in many dune systems, creating unique ecological communities within the dunes (Dorweiler 1997) and maintaining the dunes themselves by capturing sand. The shrubs accumulate aeolian sand entrained by the wind from upwind source areas by interrupting the force of the wind, depositing blowing sand around its base (Harris 2003). The mesquite plants cause a partial obstruction to airflow, reducing the wind velocity, causing some of the entrained sand to fall from suspension and gradually accumulate on the downwind side of the shrub. The sand is deposited around the base of the shrubs forming and maintaining hummocks, and supporting local downwind sand dunes. The mesquite hummocks in the northern Coachella Valley are key to maintaining the local sand dune ecosystems that form and are maintained around and downwind of the community.

CVWD Groundwater Management Plan, Water Table Levels, and the Biotic Communities of the Coachella Valley

Several natural communities that support the species proposed to be covered under the draft CVAG MSHCP are strongly affected by groundwater levels: mesquite hummocks, Sonoran cottonwood-willow riparian forest, southern arroyo willow riparian forest, southern sycamore-alder riparian woodland, mesquite bosque, and freshwater marsh. Of these, freshwater marsh is probably most strongly affected by agricultural drainage, wastewater effluent, and urban runoff; those ecosystems used by bird species adjacent to the head of the Salton Sea are more affected by its water levels than groundwater; and the Sonoran cottonwood-willow riparian forest, southern arroyo willow riparian forest, southern sycamore-alder riparian woodland, and mesquite bosque appear to be mostly out of the area of active groundwater management. Therefore, the natural community type most affected by groundwater withdrawals in the draft CVAG MSHCP plan area is mesquite hummock (Noss *et al.* 2001). The CVWD Water Management Plan calls for a "preferred Alternative 4", which differentially affects the Upper Valley from the Lower Valley (division line at approximately perpendicular to the Valley at La Quinta). The distinction between the two areas is that the Upper Valley is mainly a tourism-based economy with water used for urban environments, domestic and resort usage, and golf courses, whereas the Lower Valley is heavily dominated by agriculture. Alternative 4 calls for elimination of groundwater overdraft throughout the basin by importing and recharging water from the Colorado River, eliminating the decrease in groundwater levels in the Upper Valley, increasing groundwater levels in the Lower Valley, and promoting water conservation (Noss *et al.* 2001). All the alternatives are compared using a groundwater flow model that excludes the Desert Hot Springs (MCGS) area, which is one of the key areas with respect to the draft MSHCP (Noss *et al.* 2001).

Mesquite hummocks are found in two distinct places with regards to groundwater: on or near active faults, such as the San Andreas, and scattered among sand dunes on the valley floor. Mesquite hummocks near active faults are not directly addressed by the CVWD Water Management Plan, and are likely the most threatened of the two types owing to planned and proposed groundwater pumping for the rapidly enlarging cities of Desert Hot Springs, Cathedral City, and Indio (Noss *et al.* 2001). Alternative 4 calls for eliminating the decrease in groundwater in the Upper Valley outside the Subbasin; the flow model and planning process apparently did not cover the Subbasin that supports the mesquite hummocks along the Banning Fault (Noss *et al.* 2001).

Alternative 4 claims to positively affect the remaining mesquite hummocks scattered around the floor of the Lower Coachella Valley. Although groundwater overdraft has been extensive, restoration of groundwater levels (as stated in the preferred alternative) could save these unique biotic communities and possibly aid many of the target species in the MSHCP.

Mesquite Hummocks and Groundwater Monitoring

Further quantification of relationships between mesquite trends and water availability is important from several perspectives. As a management tool, models and monitoring that relate vegetation structure/patterns (such as leaf area index/vegetation volume, seed production, and recruitment) and species associations to water table depth could be used to predict effects of groundwater pumping on groundwater-associated ecosystems and define minimum depths for maintenance of these ecosystems with a high degree of ecological integrity (Karr 1991, Stromberg *et al.* 1993). From a basic ecological perspective, such information is important because it lends insight into the range of variability inherent in groundwater-associated species, and the extent to which their size, productivity, viability, and recruitment can be limited by water (Stromberg *et al.* 1993). Empirical models using both hydrologic data and vegetation structure/patterns have important implications for groundwater-associated ecosystems (Stromberg *et al.* 1993).

The models developed by Stromberg *et al.* (1993) indicate that "structurally rich" velvet mesquite stands require groundwater depths of about 6 meters (20 feet) or less, and that when the water table decreases below this depth, continual and quantifiable decline in tree stature will occur. Similar relationships to groundwater could be developed with parameters such as leaf area index and vegetation volume (Stromberg *et al.* 1993). Because some of these structural parameters also are used to measure the function of avian habitats (Mills *et al.* 1991), the effects of water table decreases on the density of breeding birds could be estimated by extension (Stromberg *et al.* 1993). These or other similar parameters could be utilized to estimate by extension effects of groundwater decreases on other wildlife species as well.

Mission Springs Water District

The MSWD has a service area of 350 square kilometers (135 square miles), including approximately 9,000 services (MSWD 2004). The MSWS updated its master plan from 1980 with the 2000 Water Master Plan (MSWD 2004). The 2000 Water Master Plan forecasts that the MSWD system would experience a water supply shortfall of about 16,357 liters (4,321 gallons) per minute in the year 2005. Nearly all domestic water supplied by MSWD is extracted from the MCGS via deep wells. The MCGS is experiencing overdraft due to the volume of groundwater being extracted by various water producers, including MSWD (MSWD 2004).

The MSWD furnishes water to the communities of Desert Hot Springs, North Palm Springs, West Garnet, Painted Hills, Mission Lakes County Club, Desert Crest Country Club, Dillon Mobile Home Park, a small portion of Palm Springs near Interstate-10 and Indian Road, and other areas.

Mission Creek Groundwater Subbasin

Historic and current data indicate that groundwater overdraft of the Subbasin has resulted in a 17 meter (56 feet) or greater decrease in groundwater elevations (MSWD 2004, MSWD 2000), ostensibly from 1935-1936 levels. The 1935-1936 levels are considered to be steady-state, pre-development conditions (DWR 2003). Currently modeled groundwater levels in the MCGS range from depths of over 60 meters (197 feet) in the northwest portion of the subbasin, to at the ground surface along the Banning Fault in southeast portion of the subbasin near the Desert Dunes Golf Course easterly of Palm Drive (Seven Palms Oasis) and at Willow Hole (MSWD 2004).

The Subbasin is in the northwestern part of a large structural trough that includes the Sea of Cortez (DWR 2003). The west-trending Banning and northwest-trending Mission Creek faults are the major groundwater controls in the subbasin (DWR 2003). Both act as barriers to groundwater movement as these faults have folded sedimentary deposits, displaced water bearing deposits, and caused once permeable sediments to become impermeable (DWR 1964).

Groundwater levels have been decreasing since the early 1950's due to groundwater extractions (DWR 1964, Slade 1981). Groundwater data indicate that since 1952, water levels have decreased at a rate of 0.15 to 0.46 meters (0.5 to 1.5 feet) per year (CVWD 2000). In 1971 the U.S. Geological Survey determined water levels within the subbasin and found a semi-flat gradient to exist making groundwater movement slow with general movement to the southwest (DWR 2003). Current water levels vary in domestic wells from 42 to 220 meters (138 to 722 feet) below ground surface with an average depth to water being 113 meters (371 feet) (MSWD 2000).

Groundwater extractions for the year 2000 within the subbasin were 8,923 acre-feet by the MSWD (MSWD 2000) and 3,176 acre-feet by the CVWD (Levy 2002). Estimated average seasonal tributary runoff (inputs) to the subbasin is 6,000 acre-feet per year (DWR 1964). Groundwater management: The MSWD, CVWD, and DWA have wells within the subbasin (DWR 2003). The subbasin is not adjudicated, but is managed due to the overdraft conditions (DWR 2003). Management concerns to slow or stop overdraft include the recent construction of groundwater recharge spreading grounds in the northwestern portion of the subbasin (DWR 2003). The recharge water source would come from the Colorado River Aqueduct, if water is available (DWR 2003).

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