Appendix F4

Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas – UPDATED

ESA

HydroBio
Advanced Remote Sensing

Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping Near Bristol and Cadiz Playas, San Bernardino, California

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Executive Summary

Vegetation provides stabilization of soils against the action of wind erosion, particularly in desert environments such as the Cadiz Valley region. Groundwater pumping for export has been proposed. Such pumping has the potential to induce localized declines in water tables that would affect any vegetation that is partially reliant upon groundwater.

This analysis was conducted by locating the most likely vegetation in the area potentially affected by the planned groundwater pumping. This "most likely" cover was identified by its higher activity (denser growth, larger plants) than all other locations around the Bristol Playa. Observations of the Cadiz Playa indicated that this region could be eliminated from concern because the vegetation around the playa is generally no more verdant than the surrounding area, hence obviously receiving no promotion from groundwater.

A curve for depth to water (DTW) versus elevation was reconstructed from hydrographic data collected in the region of the Cadiz Ranch. A DTW point was added on the Bristol Playa that was reconstructed using photogrammetry. Together, these points describe a highly linear relationship of DTW versus elevation above sea level (r2 = 99.9%). With this robust and accurate relationship, predicted DTW at the lowermost edge of the higher vegetation cover was 65 feet, about 40 feet deeper than the highest recorded rooting depths for four wing saltbush. The promotional effect of periodic surface flows from the upstream catchments is hypothesized for the apparent promotion of this vegetation.

In summary, there is no connection of vegetation with groundwater in the region of Cadiz and Bristol Playas, hence, no vegetation will be affected by changes in water table elevation.

1. Introduction

Phreatophyte is a term for plants that use groundwater. Especially in an arid climate such as exists in the region of Cadiz , phreatophytic vegetation will tend to be much greener

than other vegetation that receives only rain. There are three shrub species that grow around the Bristol Playa: creosote bush [*Larrea tridentata*], cattle saltbush [*Atriplex polycarpa*] and four wing saltbush [*Atriplex canescens*]. Creosote bush and cattle saltbush are not phreatophytes. Four-wing saltbush is a facultative phreatophyte, meaning it can benefit from but does not require shallow groundwater (DOE, 1998). It would be this species that would have connection with the groundwater, if such a connection exists.

Vegetation Sensitivity to declines in water table elevations due to groundwater pumping is well known (Munoz-Reinoso, 2001; Cooper et al., 2006; Patten et al., 2008). The region adjacent to the Bristol Playa was evaluated to determine whether the vegetation is phreatophytic and could, therefore be impacted by export pumping from the Cadiz Groundwater Conservation, Recovery, and Storage Project (Project). This zone had both elevated vegetation cover and nearby DTW measurements.

The area identified for this analysis includes the Bristol Playa extending up the Orange Blossom and Fenner Gap washes (Figure 1). The Orange Blossom and Fenner Gap are a source of water supply that drains by gravity, either surface or subsurface down gradient toward the Bristol Playa. This report identifies the vegetation and DTW patterns associated with these features, and investigates the potential interactions between groundwater and vegetation.

The magnitude of the groundwater supply for phreatophytes determines their sensitivity in the event of a decrease in supply due to water table decline. Thus, in order to understand the functional connection of vegetation with the water table, the region with the highest native vegetation cover around Cadiz and Bristol Playas was selected for comparison to depth to water (DTW) at the lowest elevation boundary for the high vegetation cover. This location corresponds with edge of the promoted vegetation along the margin of the playa.

Water tables were reconstructed using hydrograph data from the wells indicated on Figure 2. Elevation contours were reconstructed using digital elevation model (DEM) data (USGS 2010). The hydrographs were contained in GSSI (2009).

The analysis began after observations of both Cadiz and Bristol playas on air photos and from aircraft. The Cadiz Playa lacks any indication of verdant cover except for Russian thistle in the dunes around the north through northeast portions of the Playa where it may receive discharge from distributaries of the Fenner Wash or draining into the dunes that this plant has colonized.

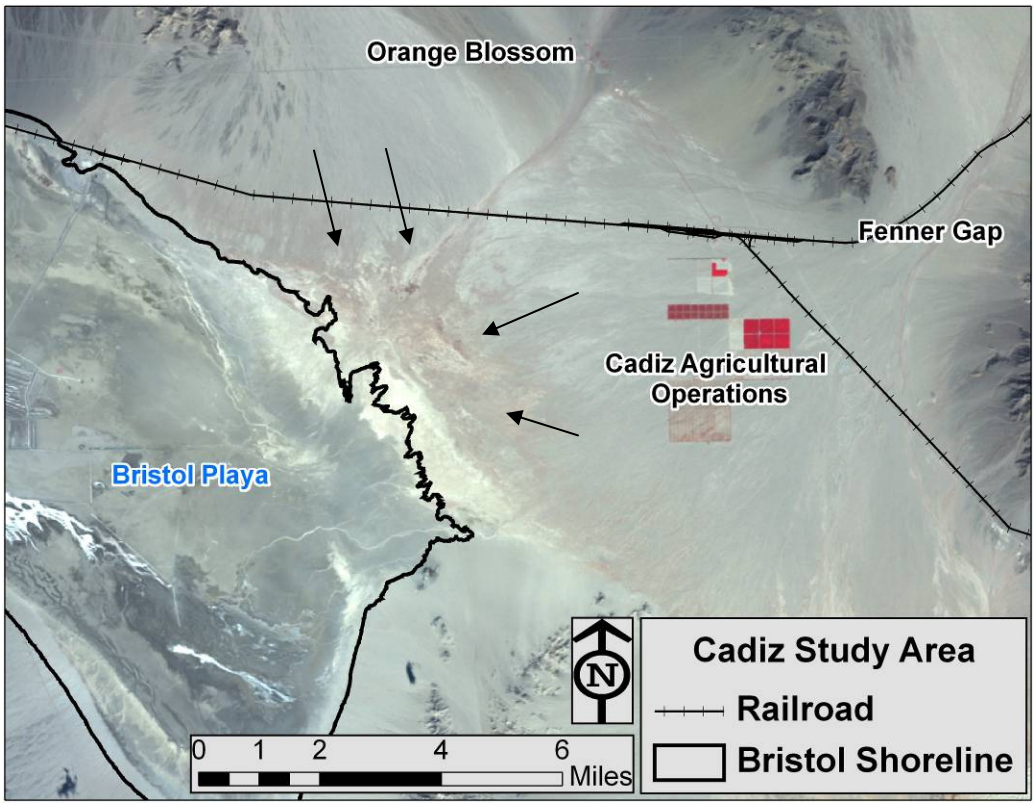

Figure 1. The location of key landmarks and the general extent of the study area. The region north of the Bristol Playa margin is the logical place to look for phreatophyte vegetation and groundwater interaction because the most verdant native vegetation is located there—this appears as the pinkish region of the Orange Blossom Wash in this false color portrayal.

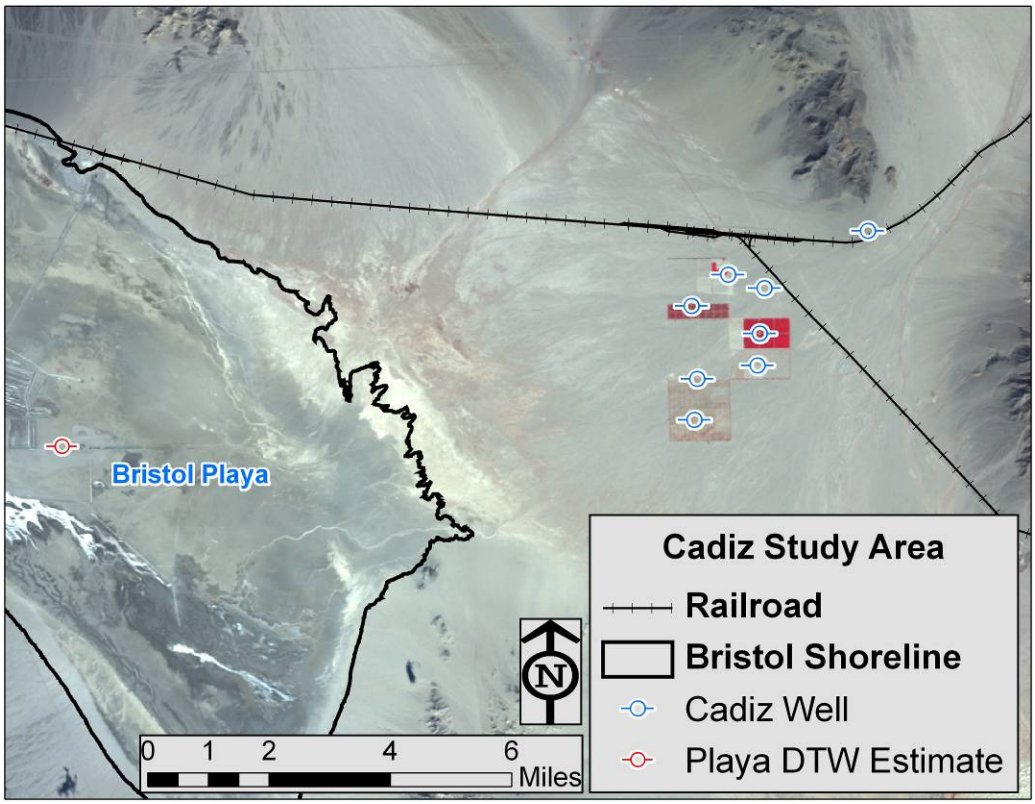

Figure 2: Location map with Bristol Playa margin indicated and location of test wells relative to the land surface contours.

2. Vegetation Analysis

Water is the most limiting factor for vegetation growth in arid environments and so any vegetation that receives water in excess of the small amount of precipitation in this arid climate should contrast by having a higher greenness level than the surrounding low vegetation activity in the adjacent desert. The native vegetation with the highest vegetation vigor was identified using remote sensing. A Landsat TM image was processed to reflectance and converted to normalized difference vegetation index (NDVI) that displays the greenness of the vegetation. The area of the highest natural vegetation cover in the study region was identified in contrast to the vegetation of the surrounding desert (Figure 3). This area corresponds to the lower Orange Blossom wash and a region along the northern margin of the Bristol Playa. No such areas were found around the remainder of Bristol Playa and were also not seen from the region around Cadiz Playa.

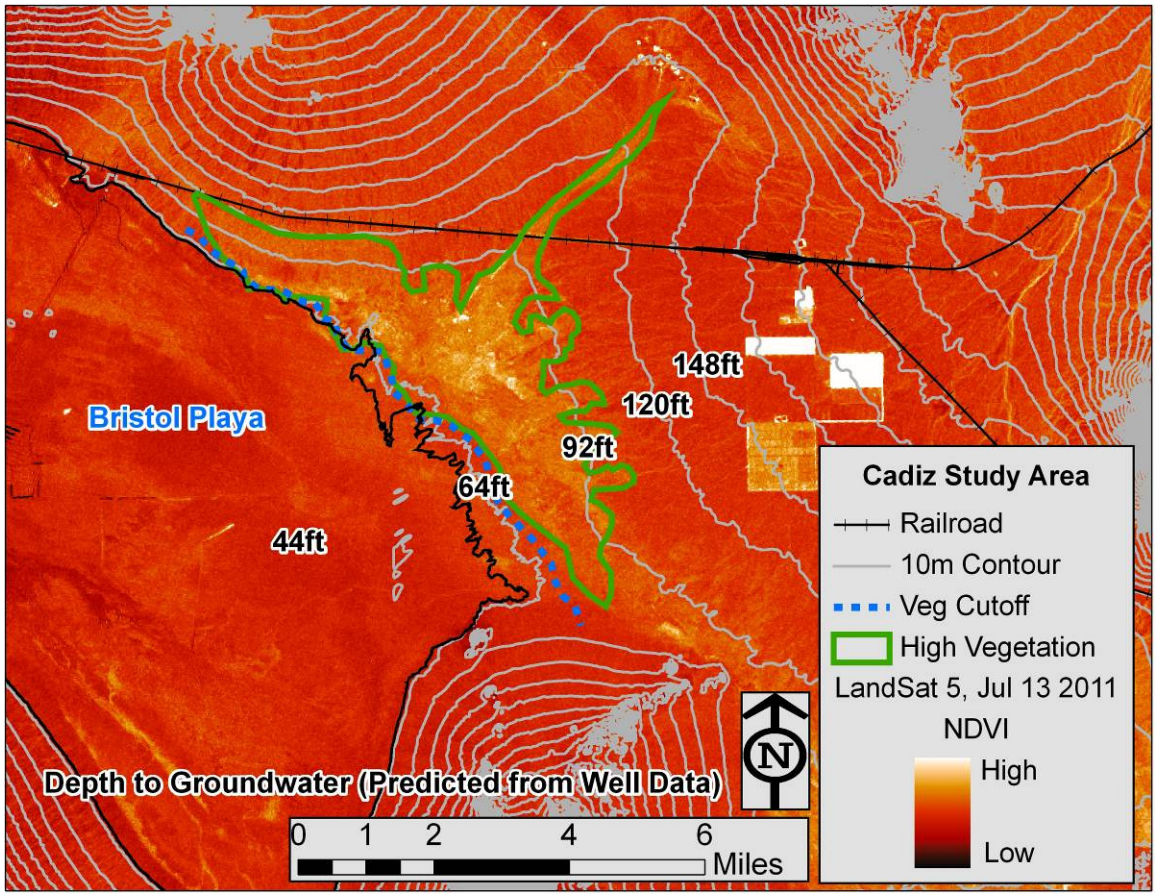

Figure 3. NDVI vegetation density acquired from LandSat 5 TM imagery. There is little evidence suggesting DTW influences vegetation density surrounding the Cadiz Agricultural Operations corner of the Bristol playa. The highest cover of vegetation corresponds to the verdant agriculture at the Cadiz Ranch. The dashed line shows the position of the edge of the higher vegetation vigor to be compared to DTW reconstruction.

Figure 4 shows an aerial view of the zone of higher vegetation vigor. Ground visits indicated that the vegetation cover there consists of all three species mentioned above.

Figure 4. An aerial oblique perspective from the Bristol Playa shoreline looking north. The zone of high vegetation visible in this image is delineated in Figure 3. If this vegetation is phreatophytic then groundwater must be within reach of plant roots

3. Depth to Water Analysis

DTW was reconstructed along an elevation gradient between the Cadiz Agricultural Operations and the Bristol Playa (contours shown on Figure 3). Depth to groundwater data were obtained from the Eleventh Annual Groundwater Monitoring Roport January – December 2008 produced by Cadiz Valley Agricultural Development (GSSI, 2009). DTW, reference elevation, and groundwater elevation are available in tabular format in the report. In the absence of precise well location data, the location map included in GSSI (2009) was used, along with aerial and satellite imagery and a digital elevation model, to locate wells precisely as possible (generally within about 200 feet) that are described in the report. Uncertainty on exact location had no bearing on the interpretation since the elevation and depth to water of each well could be calculated directly from the GSSI (2009) data.

All available DTW data were plotted on Figure 5. DTW points were available for areas in proximity to the Cadiz Agricultural operations (Pink points in Figure 5) but were not available for elevations approaching or on the Playa. DTW was estimated on the playa using oblique aerial photography of known locations as reference points on the ground (Blue point in Figure 5, calculations in next section). To interpolate between these points, a linear regression was applied to the measured and estimated DTW points. The relationship is extremely strong (r^2 = 99.9%), and allows interpolation of DTW at the position of the lower elevational boundary elevation of the higher vigor shrub area shown in Figure 3, likely within a couple feet of actual.

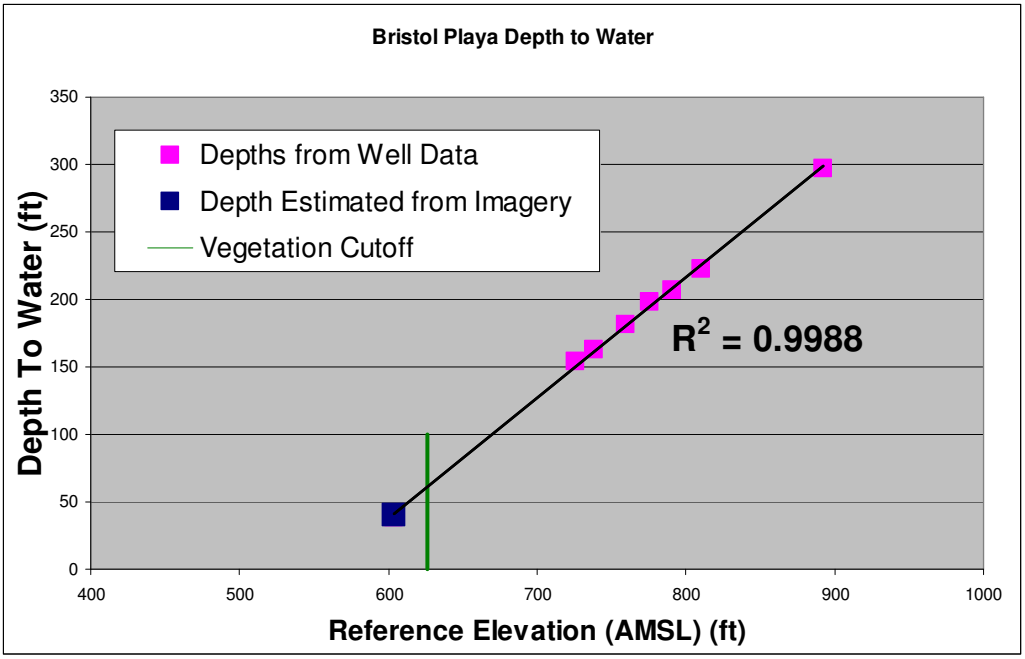

Figure 5. DTW data acquired from GSSI (2009) are displayed in pink, and DTW estimated from oblique aerial imagery is displayed in blue. The strong linear relationship supports interpolation between measured points.

4. Estimated Depth to Groundwater—Bristol Playa

To interpolate DTW values between the Cadiz Agricultural Operations and the Bristol Playa, a data point on the Bristol Playa was required (far more robust than extrapolation). In the absence of available DTW records on or immediately surrounding the Bristol Playa, we chose to estimate DTW using oblique aerial imagery that was obtained on August 23, 2011. The occurrence of groundwater was visible at several points on the Bristol Playa where pits are excavated for saltworks operations.

Many pits exist near the saltworks facility on Bristol Playa and these were not chosen for analysis because watertables may have been influenced by local operations. A pit excavated in the lakebed away from the operations was chosen that intersected the groundwater surface (Figures 6 and 7). No evidence of pumping infrastructure, or influence of local operations was apparent in the area which suggests the water level in the pit represented the actual water table surface.

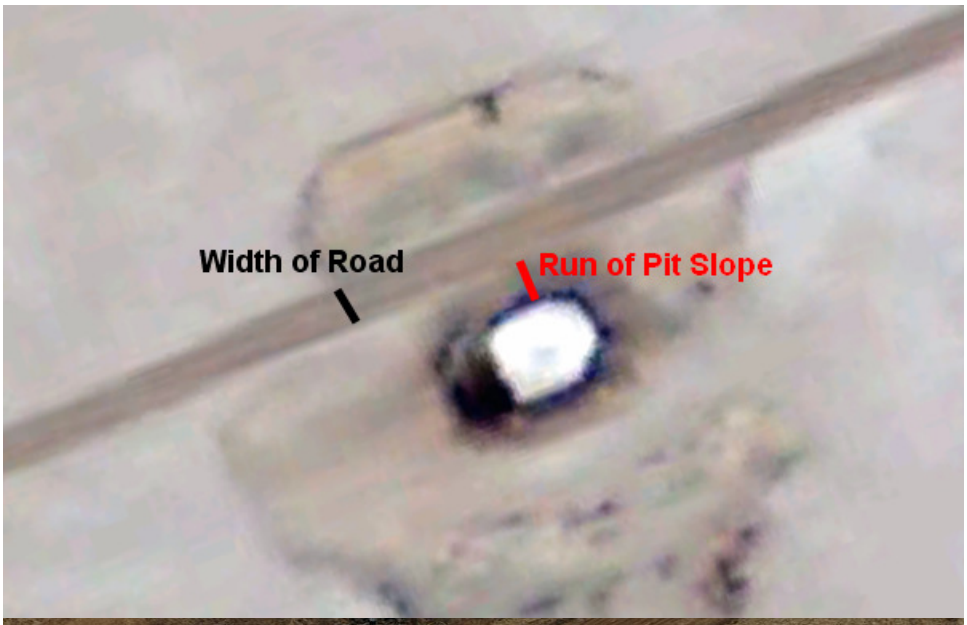

Figure 5. Google Earth image of a pit on Bristol playa. Imagery is used to establish scale and a baseline for estimation.

Figure 6. Oblique air photo captured on August 23, 2011 to estimate angle of pit wall and confirm water table.

An oblique aerial image coupled with Google Earth imagery was used to estimate the angle of the pit wall and to confirm the water table. A scene from Google Earth (nadir or near nadir) was used to measure the horizontal run of the pit face slope. Analysis of the aerial oblique imagery suggested the slope of the pit face was about 60˚. Correcting for the run of the pit face slope with a tangent function yielded a depth of 35 feet at a known elevation. This point was added to the measured well data (Figure 5). With the strong linear relationship obtained, DTW was confidently interpolated at the lower boundary of the higher vegetated area (dotted line in Figure 3): 65 feet.

5. Conclusions

DTW at the lowermost ecotone of the higher shrub zone was 65 feet—because it is on the down gradient boundary, this is the potential minimum estimated DTW beneath the region identified with higher vegetation activity that appeared to have the highest potential for groundwater connection. Excavations of four wing saltbush showed a maximum depth of 25 feet only on rare occasions when soils and hydrology permit but average about 13 feet (Foxx 1984). Based on measured and estimated DTW, the shallowest watertable position is 40 feet below the record rooting depth for the only species that could be potentially affected by groundwater decline. The higher vegetation in the wash is likely the result of periodic resupply by surface flows from Orange Blossom Wash and other similar wadis.

6. References

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