Hydrologic Regime, Vegetation, Impact Analysis, and Restoration Concepts for the Rodeo Beach Wetland complex: Golden Gate National Recreation Area, California

By:

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Introduction

The Rodeo Beach wetland complex historically extended through much of the Rodeo Creek watershed bottom (Figure 1). However, the watershed has been impacted by a range of activities including ditching, filling, road construction and plowing (Shaw 2005). The impacts began with agricultural land uses in the late 1800's including the installation of a ranch road across the wetland complex (Figure 1). The wetland above the road is supported largely by discharging ground water which produces sheet flow toward the south and nearly perennial soil saturation across the valley bottom supporting a highly productive wet meadow (cover photo). The ranch road created a barrier to sheet flow and channeled water east toward the culvert on the upgradient side of the road. This channeled water eroded deeply into the wetland. The eroded channel head cut in many places creating a network of deep channels. At the culvert, installed in a concrete headwall, water flows in a single channel toward the Surfer Parking lot. The sheet flowing water source that would have saturated the wetland where the Surfer Parking lot occurs today (Figure 1) was intercepted by the road, channelized into a culvert, and no longer reaches most of the now-dry land below the ranch road. The ranch road fill and headwall exist today and continue to impact the area below the road. Channelized flow from the culvert eroded deeply into the valley producing a gully that is as much as 10 feet deep. Most water moving south from the concrete headwall flows in this deep gully and has lowered the water table in the area below the headwall. The creek flows in an underground culvert through the Surfer lot.

The US Army occupied the site beginning in the early 20th century and modified the landscape by widening the ranch road, and may have hardened the headwall with a concrete structure for a road crossing, digging drainage ditches down valley and possibly up-valley of the road (Figures 2, 3, 4, and 6), and grading the lower valley to create a parade grounds (Figure 5). Today the upper (northern) portion of the wetland has a water table near the soil surface and supports a productive plant community dominated by the bulrush *Scirpus microcarpus* and is relatively intact hydrologically. However, the central (adjacent to the gully) and lower (southern) portions (Surfer Parking Lot) of the wetland are highly impacted and in many areas lack wetland hydrologic regimes and wetland vegetation.

This report provides data collected during 2006-2008 to characterize the hydrologic regime, vegetation, soils, and impacts to the landscape, and provides a framework for a restoration plan for wetland hydrologic regime, vegetation and functions.

Figure 1. 1913 photo (top) of the Rodeo Beach wetland complex and ranch buildings, matched in March 2007 (bottom). White arrows indicate the location of the Surfer parking lot, which appears to have been a wet meadow in 1913. White dotted lines indicate the transverse ranch road location.

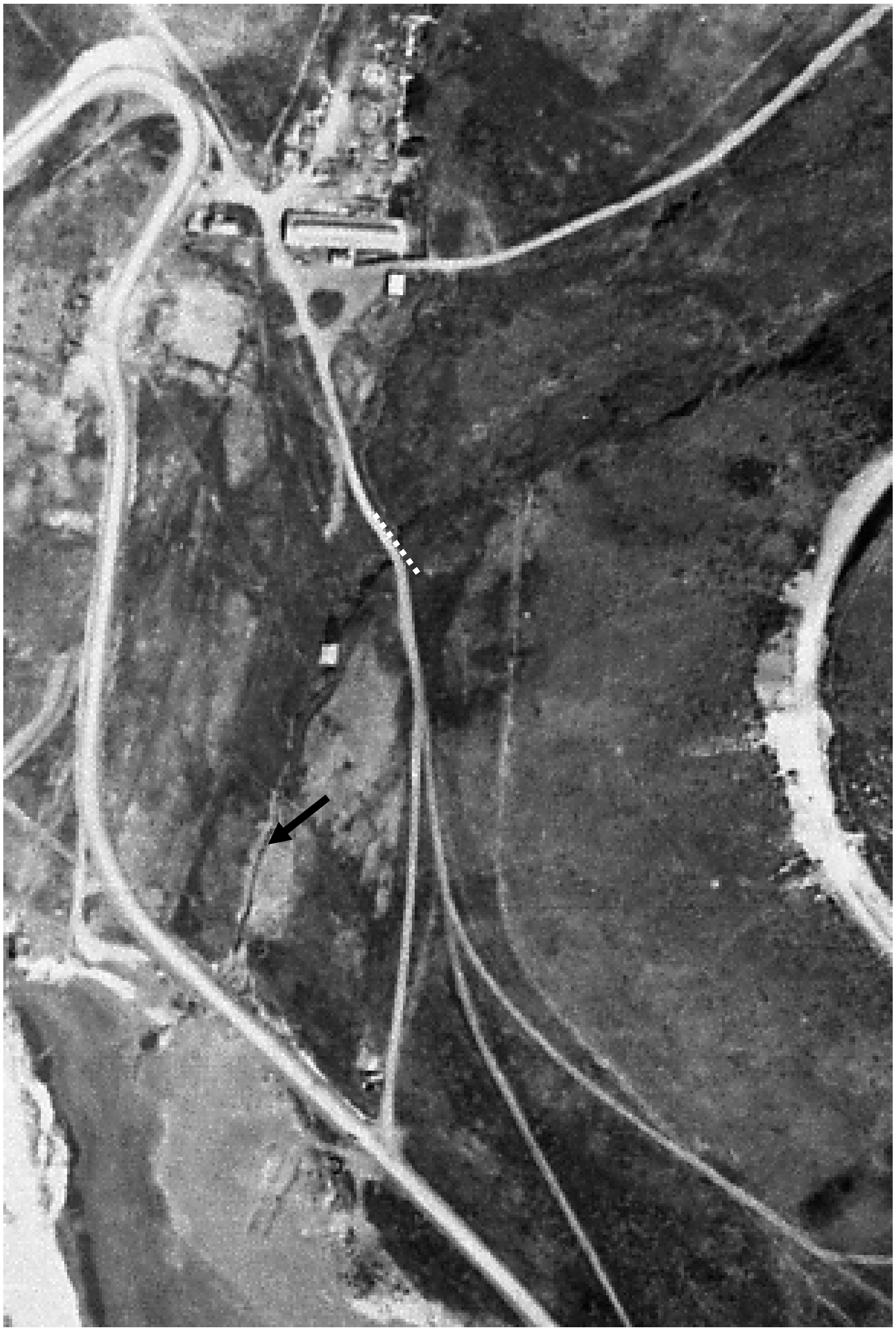


Figure 2. 1940 air photo (north is up). White dotted line indicates the location of the headwall, black arrow indicates a drainage ditch. Note the small building between the arrow and headwall that is visible in figures 3 and 4.

Figure 3. March 25, 1938 oblique ground photo looking south, showing the transverse road crossing (white dotted line) and a building (black arrow) next to a willow-lined channel. The channel extends beyond the building towards the ocean as seen prominently in figure 2. The white arrow highlights a channel in what appears to be the topographic low and natural historic main drainage area.

Figure 4. August 31, 1938. Looking southeast to the area down valley (south) of the ranch road (out of frame left). Arrows highlight drainage features visible in Figures 2 and 3. Black arrow shows a ditch below the small building. White arrow points to a natural historic drainage.

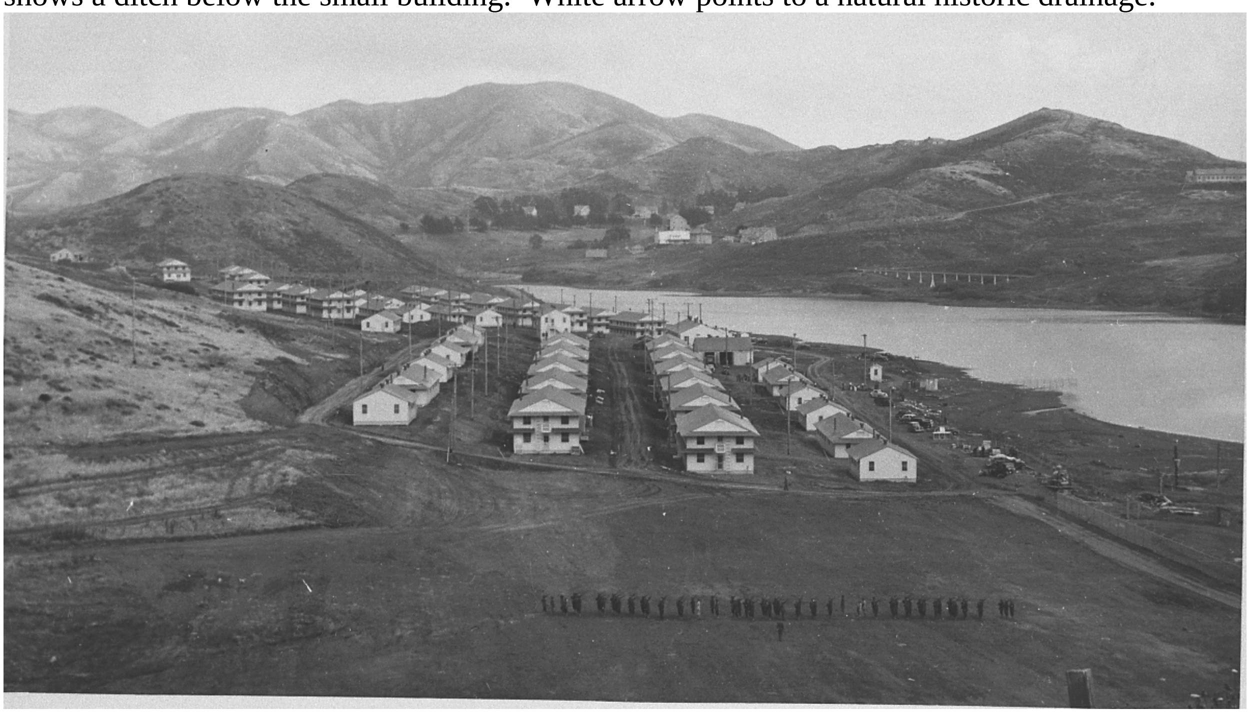


Figure 5. June 24, 1941. Showing entire lower wetland graded for use as a parade ground. No drainage features are apparent and it is likely that at this time the discharge from the headwall culvert (out of frame to the left) was conveyed to the lagoon (at right) in a buried culvert.

Figure 6. *Ca*. 1980 oblique airphoto. North and upvalley are to the left. Note the transverse road and headwall crossing (white dotted line), and large rectangular zone (A) in what is now perennial wetland that in the photo appears dry and surrounded by green-vegetated, linear-edged features that may be remnant drainage ditches. Note also that the transverse road ends near the black arrow and the drainage pattern below it suggests that a ditch running along the road conveyed water to this point. The larger drainage network, across the bare area that is now the gravel parking lot, drains to a low point marked by the white arrow, roughly in the same location as the natural drainage seen in Figures 3 and 4.

Approach

Hydrologic Analysis: We installed 43 ground water monitoring wells and staff gauges in the study area. The wells are in transects that span the valley from east to west perpendicular to the main flow path of surface and ground water and cross both the saturated upper valley and the dewatered middle and lower valley (Figure 7). Wells in the upper and middle sections were installed by hand augering. The wells in the parking lot were installed in pits excavated using a backhoe. The texture, color, and composition of soil horizons were recorded by depth during well digging. Wells were constructed from hand slotted 2 inch inside diameter PVC pipe. Each well is fully slotted along its length and has a perforated bottom cap. Two wells were fitted with Global Water WL-15 water level recording devices to collect hourly water table depth data, while other wells were hand read approximately monthly using an electronic tape. Five staff gauges, constructed of steel fence posts, were installed in headcut streams crossed by transects.

Hydrographs were constructed for each monitoring well and staff gage to display the seasonal pattern of water level variation relative to the ground surface. Using a total station we conducted a detailed topographic survey of the entire wetland complex, including all monitoring wells and staff gauges. These data are used to topographic maps, cross sections, and to place water, soil, and vegetation data in a spatially explicit format.

Soil Analysis: Soils were analyzed at each hand-installed monitoring well as described above. In addition, a backhoe was used to open holes in the Surfer parking lot area, and soil stratigraphy was analyzed in the open trenches. Soil features such as mottles, gleying, and oxidized rhizospheres that indicate wetland soils are useful in determining which areas were dewatered or buried wetlands. Most importantly the location and thickness of fill layers were identified and recorded, as well as the location of weathered bedrock. Soil data were used to identify the original wetland surface horizon and to determine the nature of subsurface flow and the suitability of regraded surfaces to support wetland plants.

Soil Seed Bank Analysis: During the soil stratigraphic analysis, we collected five soil samples from pits below the ranch road, in what appeared to be a dewatered wetland. One soil sample was collected from a potentially buried wetland soil and the other four were surface soils. Each soil was spread approximately 1-2 cm thick onto an individual tray ~600 cm^2 in size, and kept saturated to promote seed germination. We identified germinating plant to species and created a species list for each soil sample. The samples were used to provide an indication of species in the soil seed bank from past vegetation.

Vegetation Analysis: In a 3 meter radius plot around each monitoring well, we made a list of all vascular plant species and estimated percent canopy coverage by species. The data were entered into a spreadsheet and arranged to show the floristic relationships among plots. These data were used to identify plant communities occurring in the study area and appropriate species for the restoration plan.

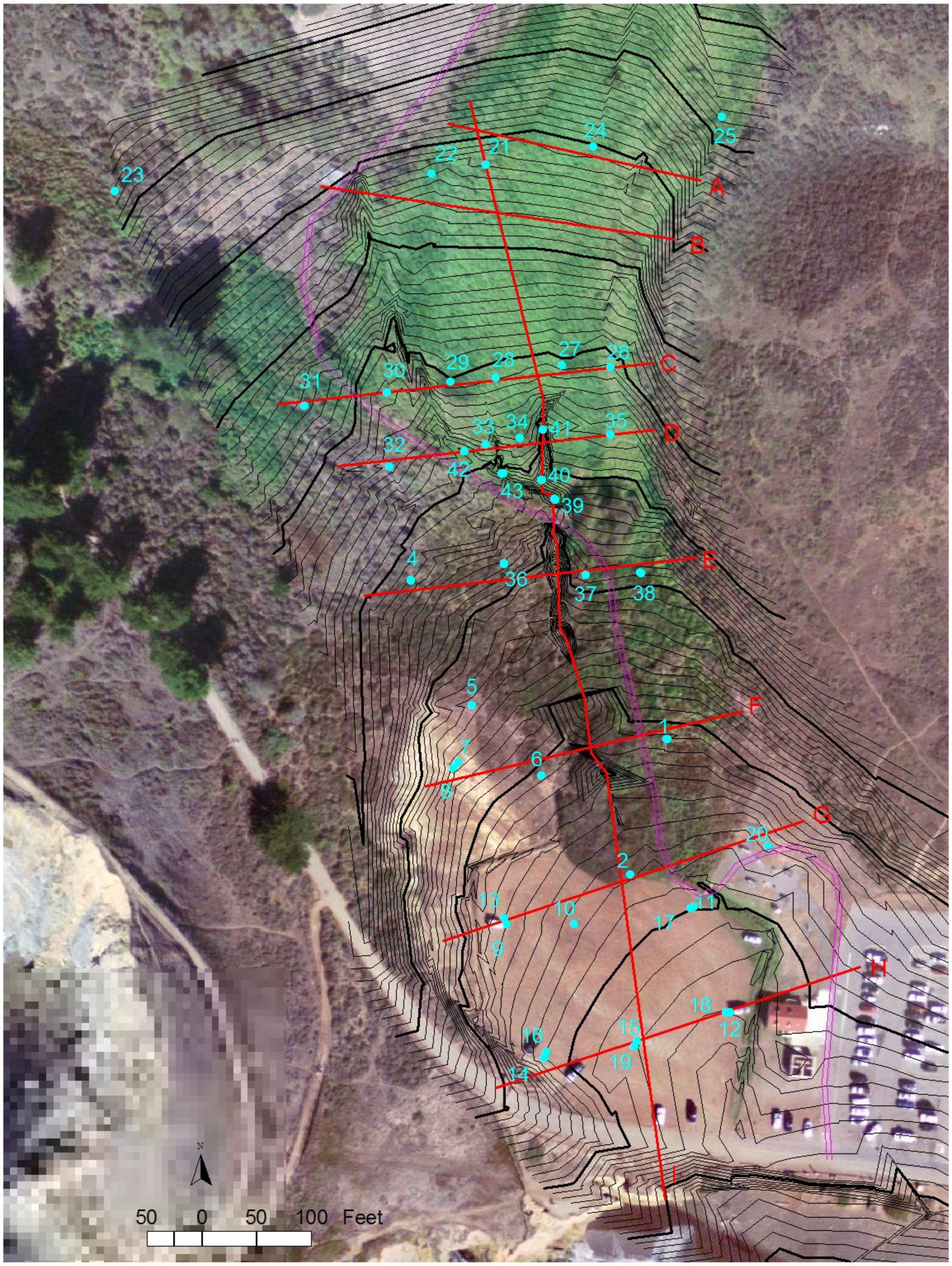


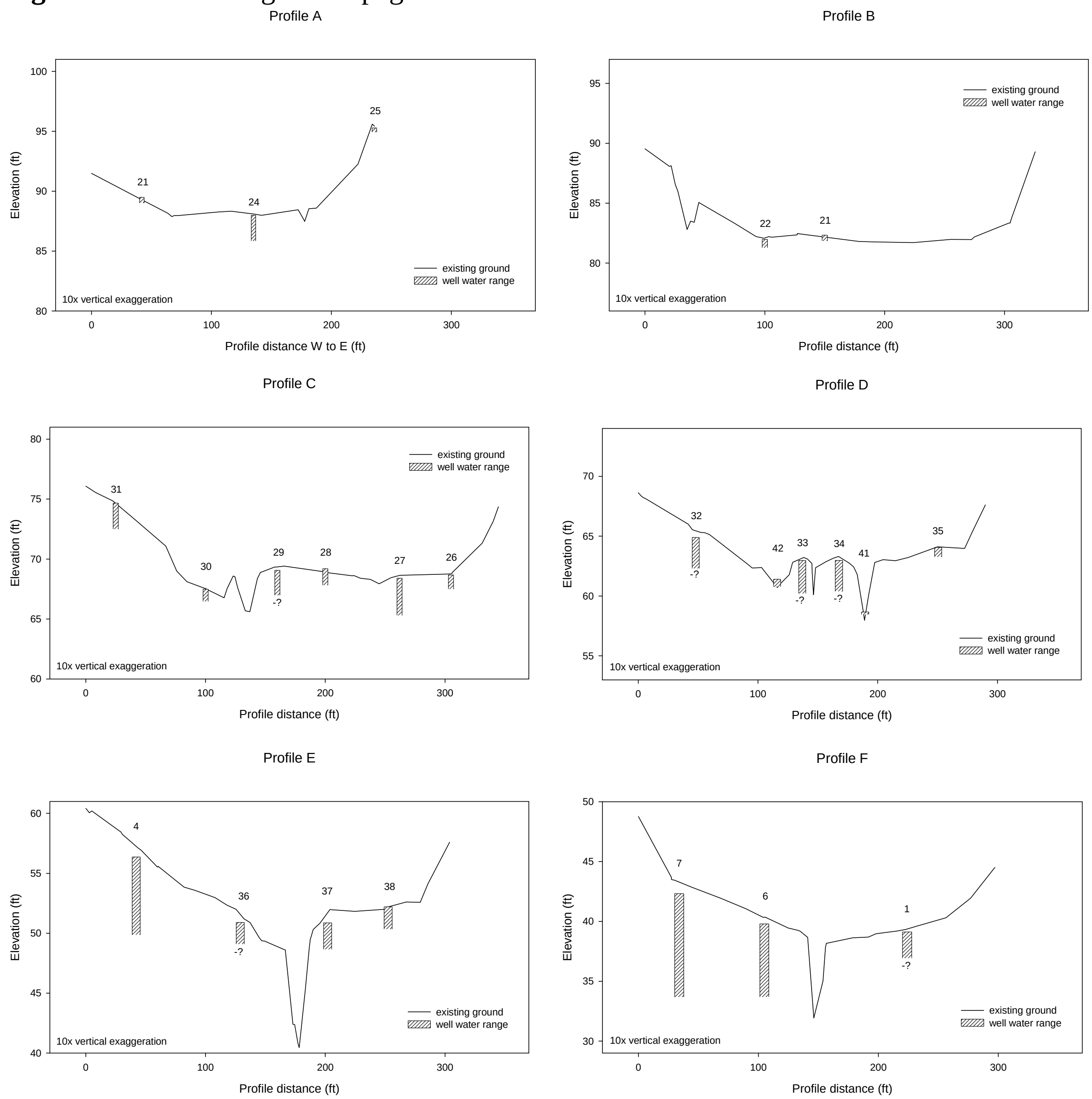
Figure 7. Existing topography and location of monitoring wells and staff gauges (blue dots and numbers) in the study area. Red lines and letters indicate transects described later in this report. The double purple line indicates the location of the former ranch road. A concrete headwall with culvert is located along this road just south of staff gauge 39.

Development of the Restoration Plan

The goal of a wetland restoration project is to recreate the pre-disturbance hydrologic regime, soil forming processes, vegetation, and ecological functions. This typically requires recreating the pre-disturbance landscape contours, and surface and ground water flow paths by filling ditches and channels, and bringing the water table back to its former elevation and flow patterns. Then, and only then, can the wetland function hydrologically as it did prior to disturbance, and wetland plants can be introduced. Restoration of the hydrologic regime will create the highest probability of plant propagule survival, spread and growth, and success in recreating a plant cover and biomass production similar to what existed prior to impact.

Topographic data were used to create a detailed map of the existing topography (Figure 7). We accurately surveyed ditches, channels, areas of incision, culverts and other obstructions or changes to water flow. We compared well hydrographs for the relatively intact area above the head-cuts and ranch road to areas below the head-cut and road to identify hydrologic changes that have occurred due to channel incision and other hydrologic impacts. Cross sections A and B (Figures 7 and 8) are through the largely intact upper meadow and wells along these transects show relatively small water level ranges throughout the 16 month sampling period. Cross sections C and D are above the ranch road and headwall but cross several headcutting channels that have eroded into the upper wetland. Staff gauges 41 and 42 show relatively constant shallow water flowing in these channels (although these hand-read data did not include analysis during rain events, see Figure 10 for a discharge curve showing peak flows). Several wells in transect C and all but the easternmost well in D, well 35, have water level ranges of 3 feet or more. The water table at these transects drops further due to the presence of the headcutting channels, which rapidly drain the surrounding soil. A relatively intact sheet flow system with no major channels persists along the east side of the meadow and maintains high water levels in well 35. Cross sections E and F are located below the ranch road and headwall and cross the gully that formed below the headwall culvert. The water level on the east side of the gully is higher than on the west, indicating that the eastern sheet flow system maintains higher water levels than occur on the west side of the gully. On the west, water levels drop up to 8 feet below the surface due to the ranch road intercepting sheet flow from the upper meadow, which would have irrigated this western area, and directs this water through the culvert and into the gully. Profiles G and H cross the Surfer parking lot and have widely variable water tables that were near the ground surface on some dates and up to 8 feet below the ground surface on other dates. A longitudinal (N to S) profile of the study area (Figure 9) illustrates the level of incision from the headcutting streams above the headwall and the gully below it.

Figure 8. Below. Legend on page 11.



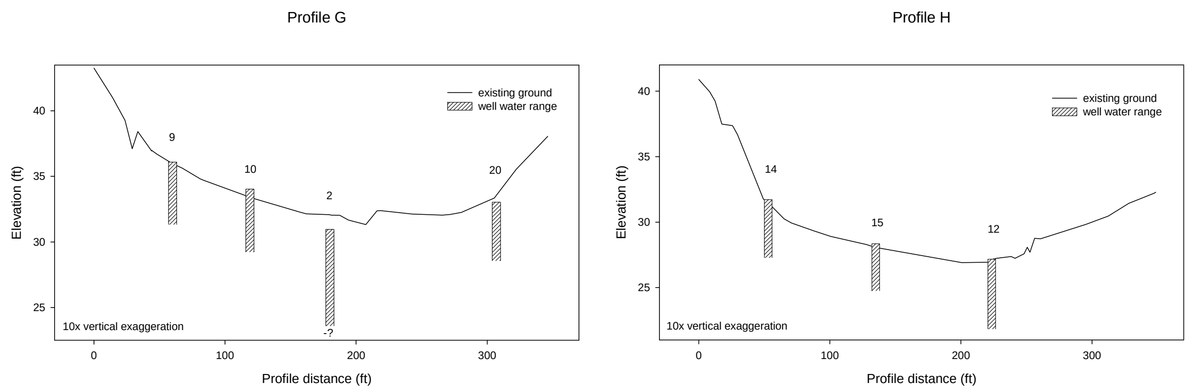


Figure 8. Rodeo wetland valley cross-sections A through H, for map location see Figure 7. Westernmost point along each transect is at 0 on the X axis. Solid line is existing ground surface, diagonal-striped bars indicate full water level range (minimum to maximum water levels) as measured in the indicated well numbers located along each transect. The '-?' below some wells indicates that the well went dry and the lowest water level may have dropped lower than we were able to measure.

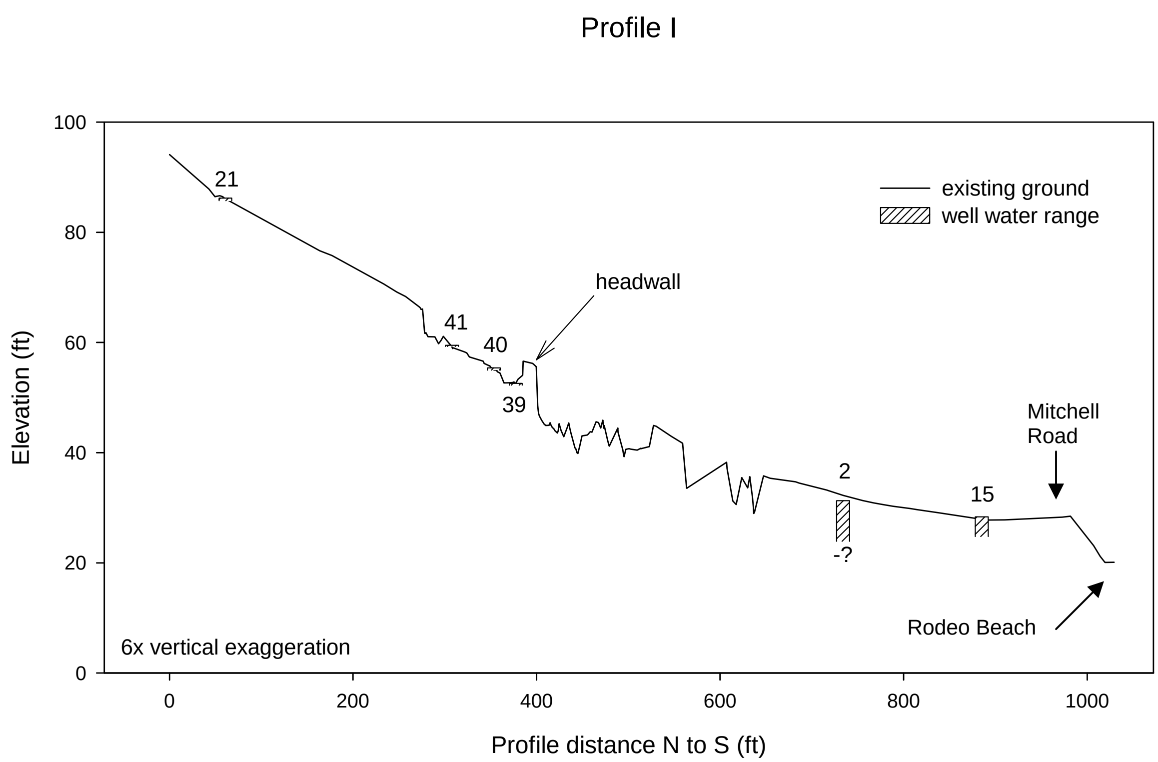


Figure 9. A longitudinal profile (see Figure 7) of Rodeo wetland that shows the relatively smooth and gradual upper wetland slope from well 21 to well 41, the head cutting channels at staff gauges 39 to 41, the headwall below 39 and the large erosion gully below, and the even parking lot with deep low-water water table at wells 2 and 15.

Well hydrographs for the study period illustrate that the wetland area above the ranch road and culvert (Figure 10) has relatively stable, shallow water tables when compared to the lower wetland (Figure 11) and parking lot (Figure 12). There is a marked seasonality of water levels in all wells except in the upper wetland, where water levels are stable year around. During the dry season water levels drop and quickly rise to near the soil surface when the rainy season begins. In the unresponsive upper wetland wells, water levels remain perennially high, and show only a small response to rain events, because they are kept permanently saturated by groundwater flow. Discharge measured at the headwall culvert is dominated by storm runoff peaks where water concentrated by the ranch road and head cutting channels passes through the culvert and into the eroded gully.

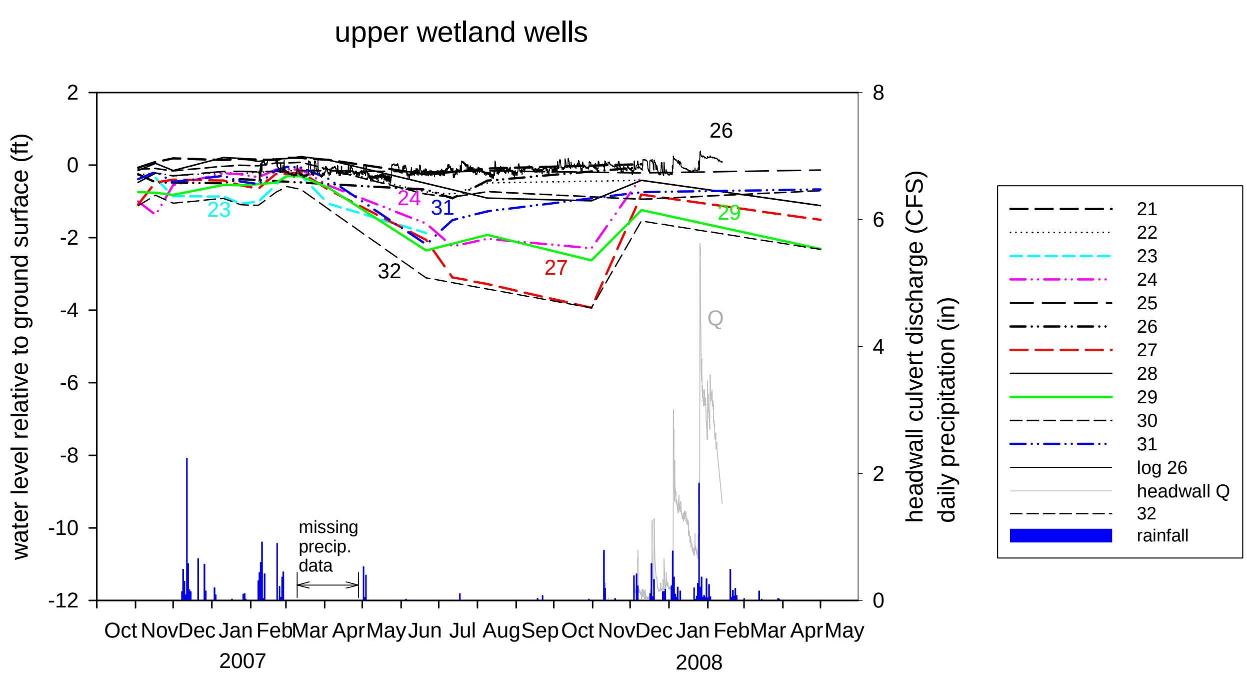


Figure 10. Hydrographs for the wells of the upper wetland. Precipitation and discharge measured at the headwall culvert from Nov 2007 to Feb 2008 are shown at the bottom and reference the right Y-axis.

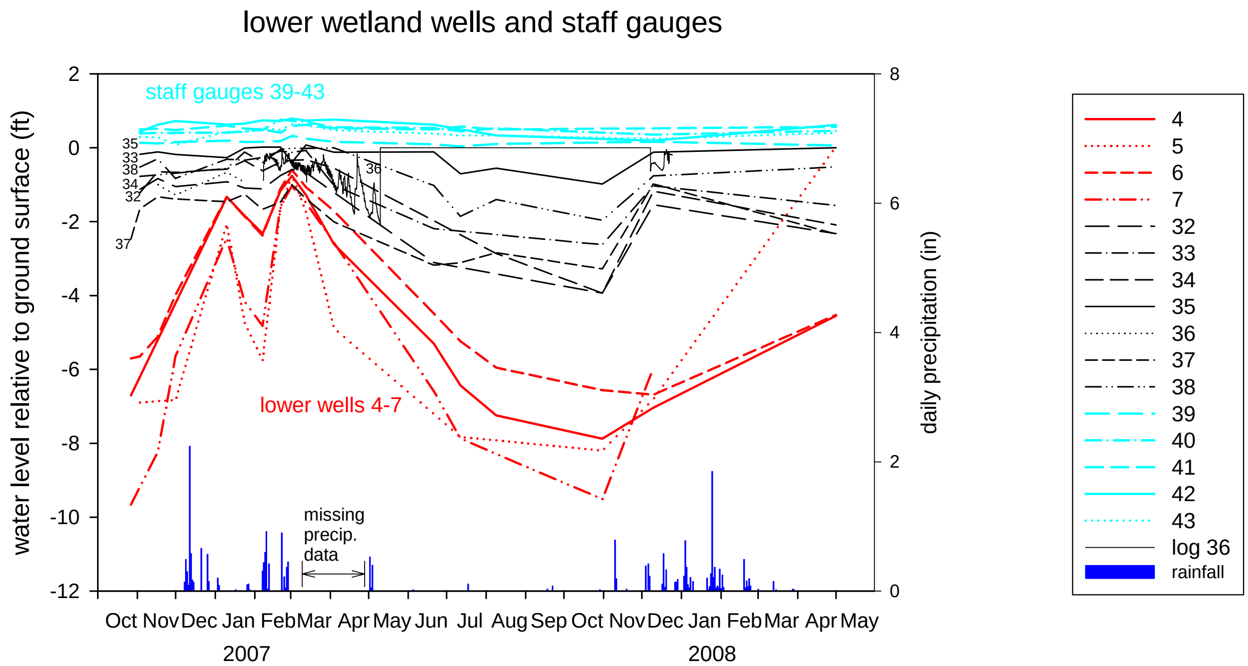


Figure 11. Hydrographs for the wells of the lower wetland. Precipitation is shown at the bottom and references the right Y-axis.

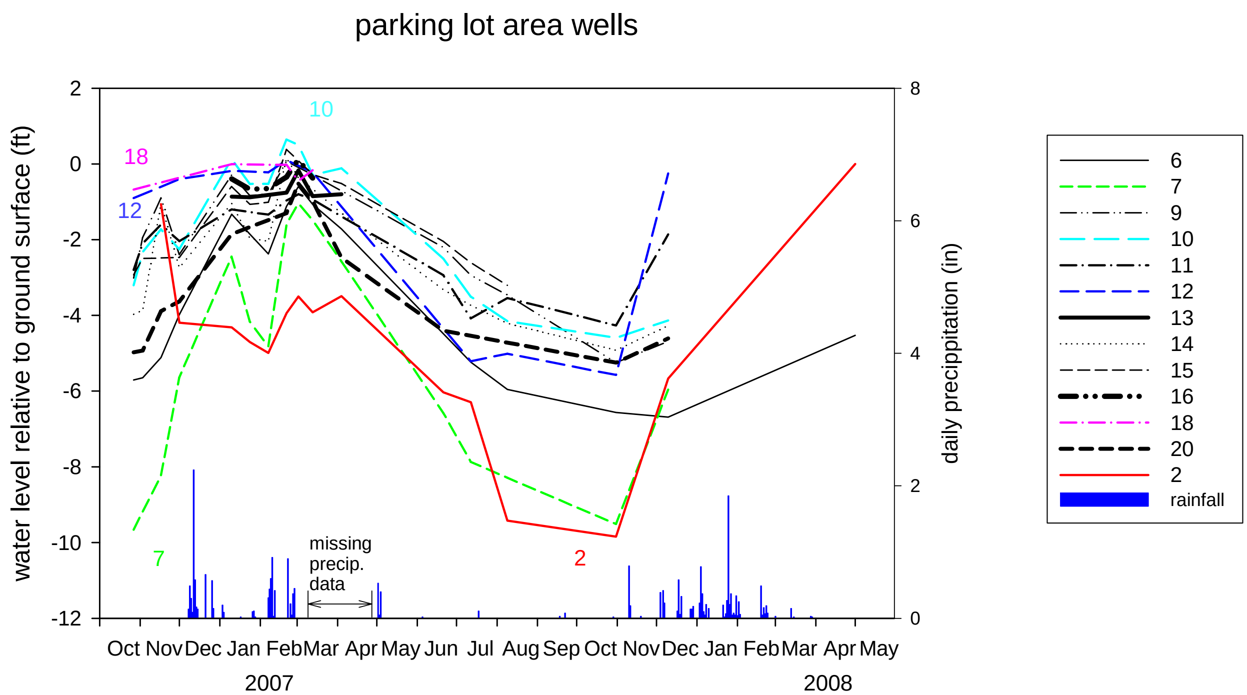


Figure 12. Hydrographs for the wells of the parking lot area. Precipitation is shown at the bottom and references the right Y-axis.

Our vegetation data highlight the striking hydrologic contrast between the upper wetland and the area below the ranch road (Table 1). The saturated upper wetland sites (highlighted in yellow) are dominated by *Scirpus microcarpus,* while dry sites at the margins or in areas dried by gullies are dominated by *Vicia gigantea* or *Juncus patens*. Restoration of the sheet flow hydrologic regime would create suitable conditions for the entire lower valley to support a *Scirpus microcarpus* dominated vegetation community. Surface soil samples analyzed for their soil seed indicated that no desirable wetland plants of the *Scirpus* community emerged, indicating that a restored lower wetland will need to be planted to ensure rapid establishment of the desired community.

To restore the Rodeo wetland, existing water diversion features such as culverts, ditches, and the ranch road must be removed, and erosion gullies must be filled. Historically, this landscape supported a sheet flow system and the wetland extended from above the ranch road to the beach. Currently, water is prevented from sheet flowing down valley by the ranch road. Water that contacts the road is channeled into a culvert in the headwall road-crossing, where it has had sufficient energy and time to destroy most of the culvert and erode a large gully. Smaller head-cutting channels extend above the headwall into the intact wetland (Figure 13). The filling of these gullies and the removal of the ranch road and headwall are critical to restoring the hydrologic regime of the Rodeo wetland.

In addition, a portion of the lower valley that is now the gravel parking lot should be graded to allow sufficient flat-valley width for a continuous sheet flow system. Historically, the Rodeo wetland would have been wider than the parking lot in an eastern direction. However, this area now is the paved parking lot and has public bathrooms. If these constructed features are left in place, as is likely, some expansion of the wetland to the west side of the gravel parking lot can be achieved in order to restore a similar area of wetland as occurred historically. A permanent berm along the eastern edge of the wetland where it abuts the bathrooms and paved lot may need to be built and maintained to prevent flooding of these facilities. Currently a ditch runs along this boundary keeping water from flooding the structures. The water in this small ditch, along with most of the water that comes down the gully from the upper wetland, is collected in two culverts that pass under Mitchell Road and drain to the beach. Point collection features such as culvert inlets are undesirable because they concentrate water, making it more energetic and likely to cause erosion.

Part of the full restoration of the Rodeo Wetland should include broad passage for water under Mitchell Road, either in the form of permeable road base, or an overpass such as a 40’ railcar span or other simple bridge. This will ensure that neither head cutting due to concentrated flow at a culvert inlet, nor deep standing water as a result of a blocked culvert inlet, impairs the target hydrology of sheet flow over what is now the gravel parking lot.

We recommend that the primary restoration goal be to reestablish the sheet flow hydrologic system extending from the upper wetland above the transverse road down to Mitchell Road. To achieve this hydrologic restoration all channels, gullies, ditches, and other water conduits need to be filled in and the ground surface leveled across the valley (Figure 14). This will allow water to sheet flow down valley saturating the entire valley width and preventing channelization and erosion to occur. The areas to be filled (shown in red) will require 2100 cubic yards of compacted soil material. However, the cutting and regrading of the gravel parking lot and the transverse road will generate 2000-2300 cubic yards of material that can be used to fill the gullies. If additional fill material is required for the gully filling, or if less material than expected is generated on-site, an off-site mitigation project approximately 1 mile from Rodeo wetland will be generating significant suitable fill material. In addition, planting of seedling *Scirpus microcarpus* and other taxa are needed immediately following the grading.

Finally, the substrate present under the Surfer Parking Lot is primarily composed of chert fill and native clays. The extensive modification of the site left little to no historic wetland soil present under the parking lot. Therefore, it is likely that some surface treatment and soil amendment will be necessary following grading to ensure good water infiltration and plant establishment.

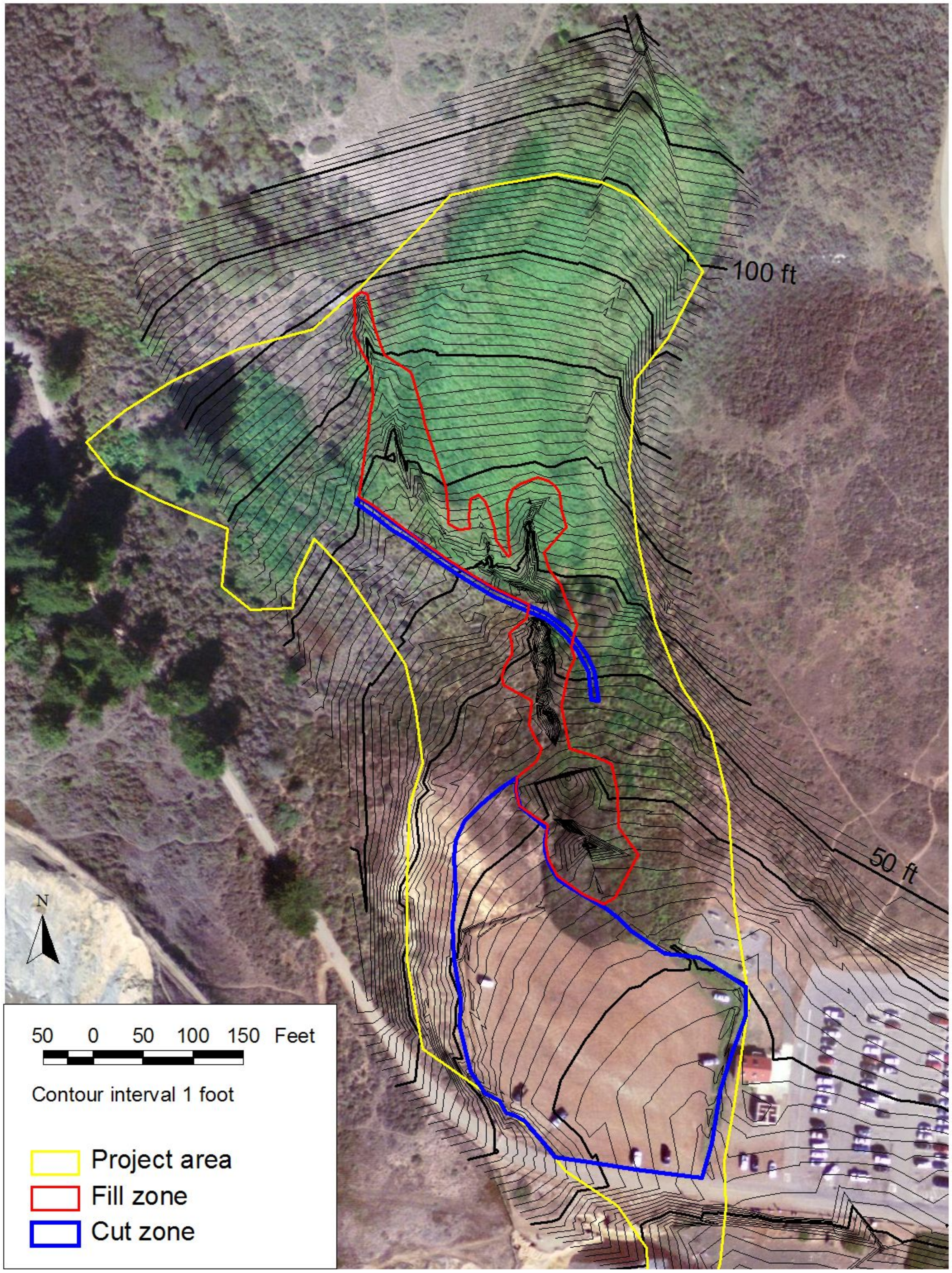


Figure 13. Topographic map showing the existing land surface for Rodeo wetland. The area in red delineates the fill zone where gullies and holes will be filled, and the areas in blue are cut zones where material will be removed.

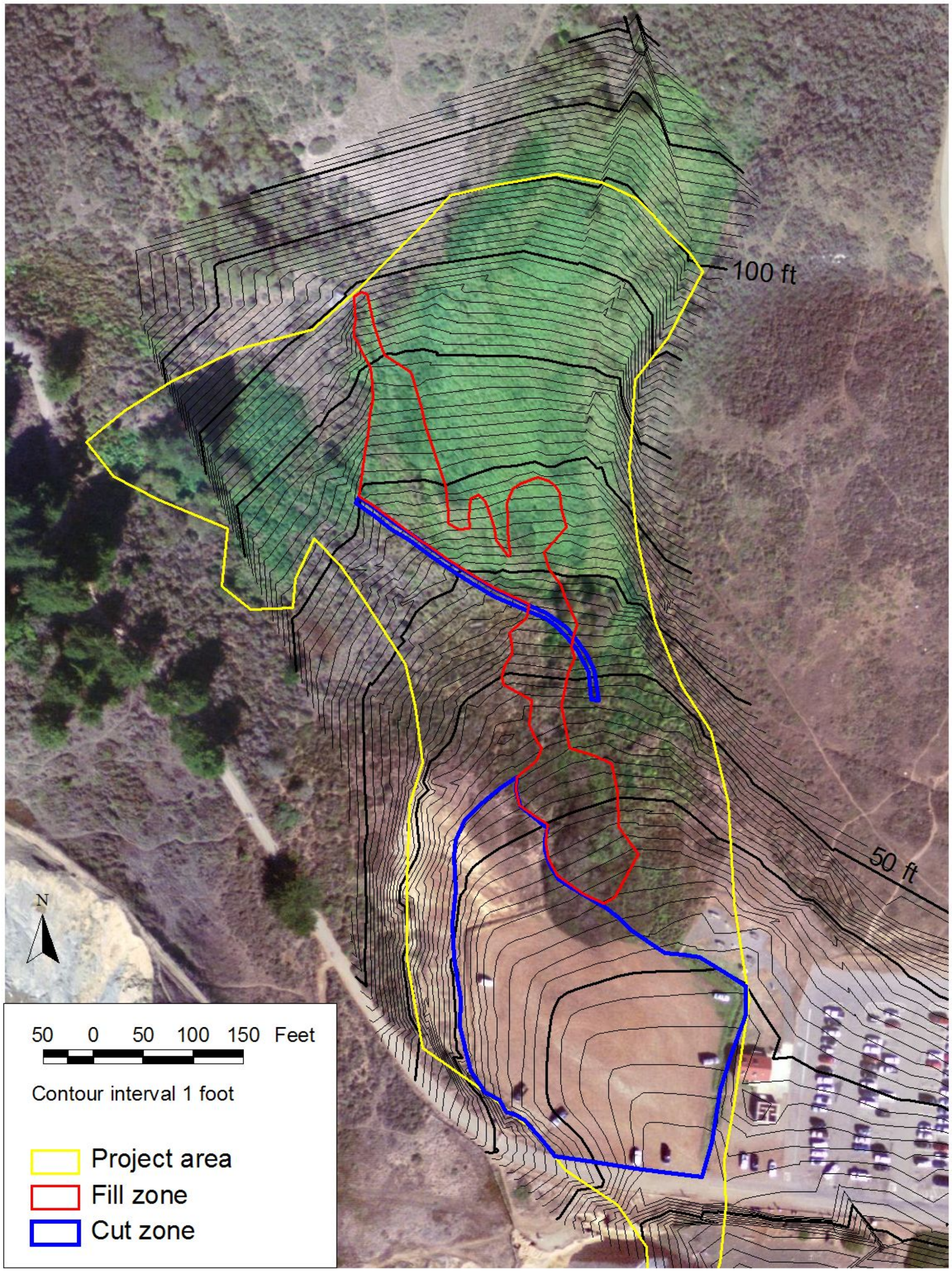


Figure 14. Topographic map showing the proposed post-construction land surface configuration for Rodeo wetland. The area in red delineates the fill zone, the areas in blue are cut zones where material will be removed.

Table 1. Percent cover by plant species for 3 m radius plots centered on each monitoring well. Colors indicate plots with similar vegetation composition. Plots in yellow are generally dominated by *Scirpus microcarpus*, with varying amounts of cover by *Delairea odorata*, *Oenanthe sarmentosa*, and *Equisetum telmateia*; plots in orange are dominated by *Vicia gigantea* with varying cover of *Delairea* and *Equisetum*, while plots in blue were dominated by *Juncus patens*.

WELL #	21	24	26	30	35	28	33	42	41	43	40	39	22	25	37	34	27	29	32	31	38	1	4	6	36
Scirpus microcarpus	100	100	100	100	100	90	80	40	30	20	20	10	50	50		15	2								
Oenanthe sarmentosa	25		30	40	10		2	20		10			15		10				2	35	40	15			
Equisetum telmateia ssp. *braunii*		65	25	20	20	15	50						5	40	70	2	8	5	20	20					
Delairea odorata	60	60	5	40		80	60	10	10				40	20		90	40	95	2	30	15				2
Vicia gigantea	25						15	10					70	80	25	80	95	85	50	35					
Juncus patens																				15	100	80	25	30	45
Stachys ajugoides		20				60																			
Rubus ursinus				1			3												5				10		5
Urtica dioica													20						5	10	5				
Mimulus guttatus					3															20	5				
Carex harfordii															5						10	80	1		20
Raphanus sativus															20				10						3
Cirsium vulgare																						1	1		
Holcus lanatus			1												20							15	5	35	5
Festuca arundinacea															20							15	5	35	
Baccharis pilularis																							20		2
Conium maculatum																			1						
Athyrium filix-femina var. *cyclosorum*				2										2						1					
Rumex conglomeratus			5	1		5			5						1		20								
Galium sp.																			1						