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The Watershed Institute

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Hollister Hills SVRA

Sediment Basin Volumes:

Water Year 2016

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Executive Summary

Hollister Hills State Vehicular Recreation Area (SVRA) manages their erosion through Best Management Practices (BMPs) such as sediment retention basins. Sediment retention basins effectively trap eroded sediment from the uplands to prevent it from polluting the lower watershed. These basins are frequently cleaned out to replenish the eroded trails.

This report estimates how much sediment a subset of the basins is able to retain. Following the 2016 water year, we surveyed five basins with a combination of total station and RTK GPS.

All basins had more sediment deposited than in previous water years because of a higher precipitation winter and a larger amount of runoff. We approximated that the five basins retained a total of 947 m^3 (1237 yd^3) or 1543 tonnes of sediment (assuming a bulk density of 1.63 tonnes/m^3) after receiving 19.3 in of rain in the 2016 water year.

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1 Introduction

1.1 Background

As part of its ongoing effort to improve park resource management, Hollister Hills State Vehicular Recreation Area (HHSVRA) contracted the Watershed Geology Lab at California State University Monterey Bay to estimate sediment retained by sediment basins within the park. This report presents basin volumes and estimates of the volume of sediment retained following the 2016 water year (WY) (October 1, 2015 to September 30, 2016). Teaby et al. (2013) presented the previous basin survey report following the 2013 water year. The Radio Ridge rain gage in HHSVRA captured 490 mm (19.3 in) of rain in water year 2016. This is the first water year since 2011 where precipitation was above the annual average (11.3 in, Smith et al. 2016). The results presented here summarize the approximate volume of retained sediment following the first average runoff event following several years of drought.

1.2 Study Area

HHSVRA is located in San Benito County, 35 miles east of Salinas and south of the City of Hollister. The park offers outdoor recreation to picnickers, campers and riding enthusiasts (Fig. 1). The sediment basins in this study trap sediment derived from the watershed slopes and trails before it enters Bird Creek, the main stream channel leaving the SVRA.

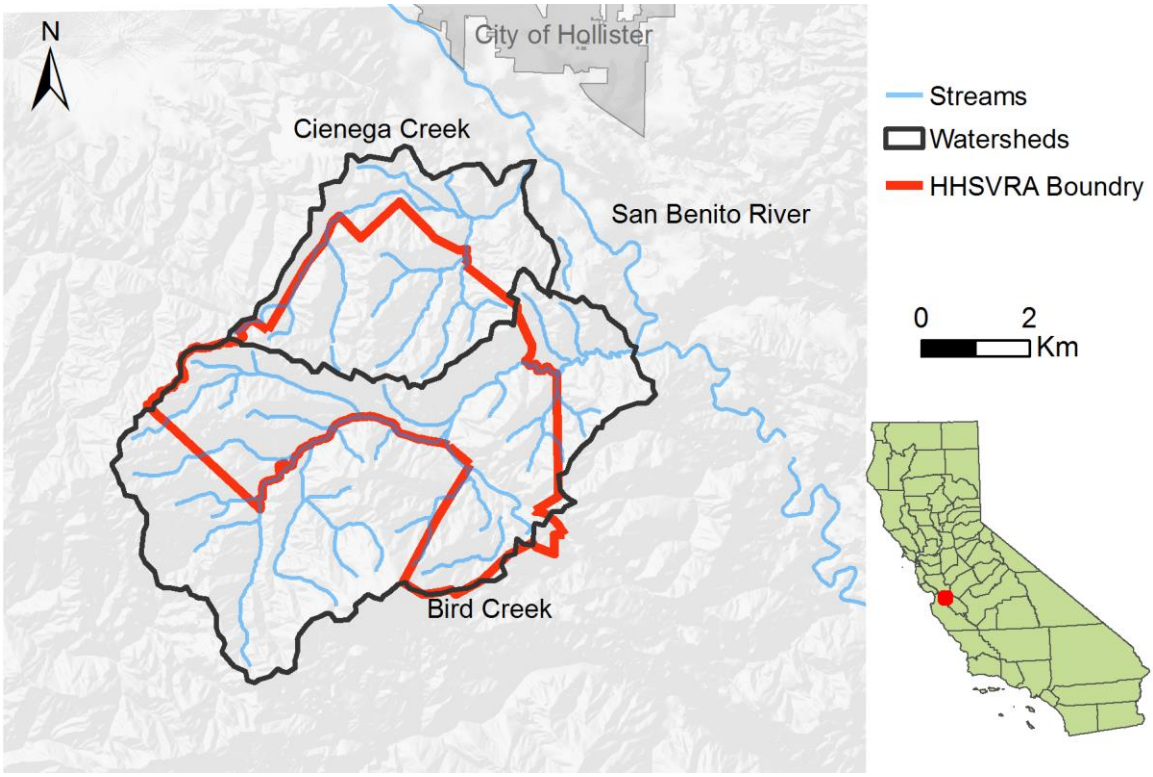

Figure 1. Location map for Hollister Hills State Vehicular Recreation Area and the Bird Creek watershed.

1.3 Goals

HHSVRA best management practices include trapping eroded sediment in retention basins located throughout the park. Sediment is removed from the basins on a multi-year time frame as part of long-term sediment management. Many basins were scheduled for cleanout in Fall 2016. This cleanout cycle was targeted to initiate a long-term program for more precise accounting of sediment retention. The goals of this study were to determine the volumes of the retention basins and estimate the sediment retention since the previous surveys in 2012 and/ or 2013. Precise total station and RTK GPS surveys were used to establish basin volume, and a variety of techniques were used to determine sediment retention since the pre-runoff surveys.

2 Methods

2.1 Surveyed Basins

The current study included a subset of 5 of 11 previously surveyed sediment basins located within the HHSVRA (Fig. 2). The subset of basins chosen for analysis included: Grand Prix 1 (GP1), Office, Scandia, Super Hill, and Woodwardia (Fig. 2). These basins were initially surveyed between the years of 2012 and 2014 and were used for initial assessment of sediment retention from water years 2013- 2016 depending on the basin. All basins surveyed were selected based on excavation status and park staff suggestions.

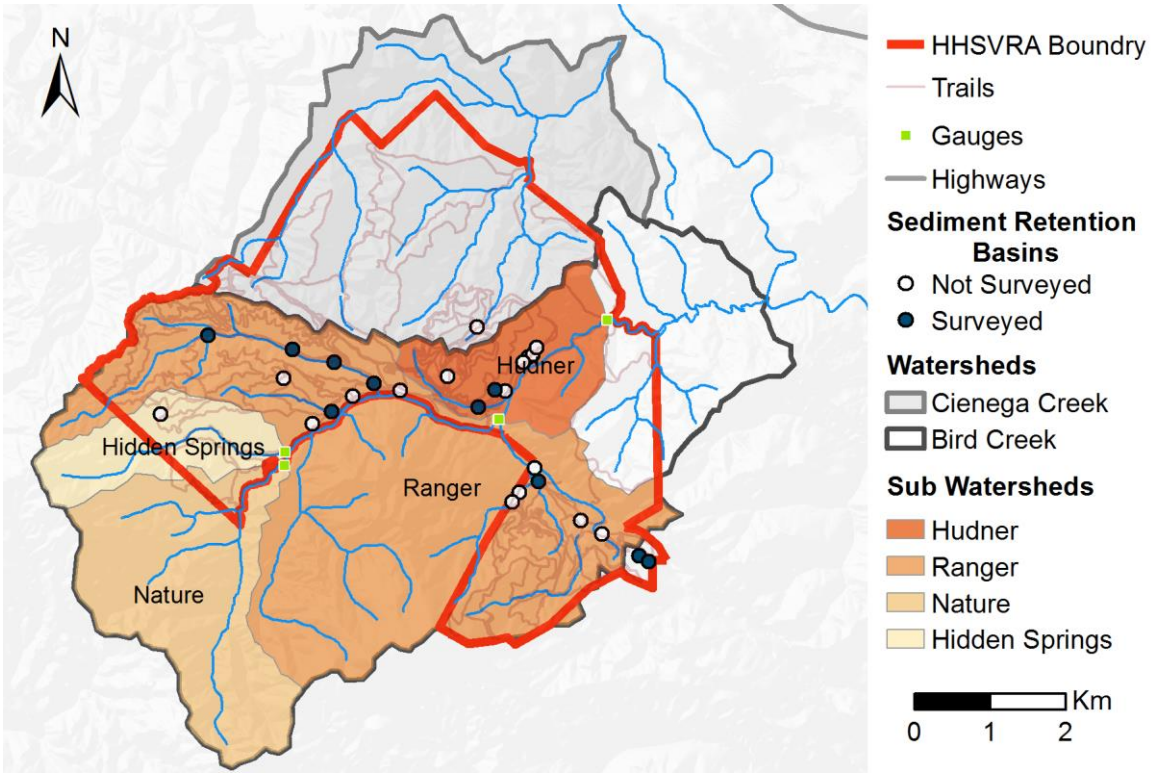

Figure 2. Location of all sediment basins within HHSVRA

Survey Methods

Two types of survey techniques were used to measure the elevation of the selected basins: Real-Time Kinetic (RTK) Global Position System (GPS) and a total station. Both methods utilized a permanent benchmark (BM). Basins located in dense trees, without a clear view of the sky, were surveyed using the total station. Total station surveyed basins included Scandia and Woodwardia. Office, GP 1, and Super Hill basins were surveyed using RTK GPS.

2.2 Surface Modeling

Data points from the total station were downloaded directly as comma separated value files. Data points from the RTK GPS were downloaded and post-processed using the NOAA Online Positioning Unit Service. All data points were used to make a digital elevation model (DEM) of each basin using the Natural Neighbor interpolation tool in ArcMap (v 10.1).

2.3 Sediment Volume Analysis

Net aggradation and degradation of each sediment basin was calculated using the ArcMap Cut Fill tool, by inputting the initial year's DEM as the "before" raster and the most recent DEM as the "after" raster. Some basins point survey coverage was sparse along the edges causing unconstrained topographic interpolation in ArcGIS. To prevent this, basin areas were manually clipped to optimize the analysis for limited slope inclusion, high measured point density between "before" and "after" surveys, and basin floor inclusion, where we hypothesized the majority of the sediment was retained.

If accumulated sediment was too thin to quantify with the previously mentioned survey methods sediment volume was estimated by measuring the thickness of many random positions in the deposit using a millimeter scale and multiplying the averaged thickness by the areal extent of the deposit. The total volume for each basin was converted to mass using an assumed density of 1.63 tonnes/m^3 (Smith et al. 2016).

3 Results

3.1 Basin and Sediment Volumes

Post-winter sediment retention volume was calculated for the five basins that contained new deposits in WY 2016 (Table 1). The total sediment retained between the five basins was approximately 947 m^3 (1237 yd^3). GP 1 retained approximately 13 m^3 (17 yd^3) of sediment, which was over 10 times the amount that was retained in the previous survey in 2013. Office retained approximately 486 m^3 (635 yd^3) or 792 tonnes. Scandia retained 342 m^3 (447 yd^3). Super Hill captured approximately 67 m^3 (88 yd^3) or 109 tonnes of sediment. Woodwardia retained 39 m^3 (50 yd^3)of sediment at 63 tonnes.

Table 1. Summary of all basins surveyed, year surveyed, volume of sediment retained, and mass of retained sediment in tonnes. The initial and final year surveyed refers to when the pre and post runoff surveys were executed, respectively. An asterisk (*) indicates basin surveys that potentially represented an average water year erosion, rather than strictly drought water year. Mass value assumes a basin fill bulk density of 1.63 tonnes/m^3.

	Year Surveyed				
Basin	Initial	Final	Volume (m^3)	Volume (yd^3)	Mass (Tonnes)
Gilmore	2012	2013	10	13	16
GP1*	2014	2016	13	17	22
GP1	2012	2013	1	1	1
GP2	2014				
Lodge Lake	2015				
Office*	2012	2016	486	635	792
Scandia*	2013	2016	342	447	557
Super Hill*	2013	2016	67	88	109
Sycamore	2012	2013	2	2	2
Whoopdeedoo	2012				
Woodwardia*	2012	2016	39	50	63

The following figures show the 2016 DEM and net aggradation and degradation for each basin. For the basins surveyed using the total station, the elevations are in reference to the BM. For the basins surveyed using RTK-GPS, the elevations are vertically referenced (NAVD88).

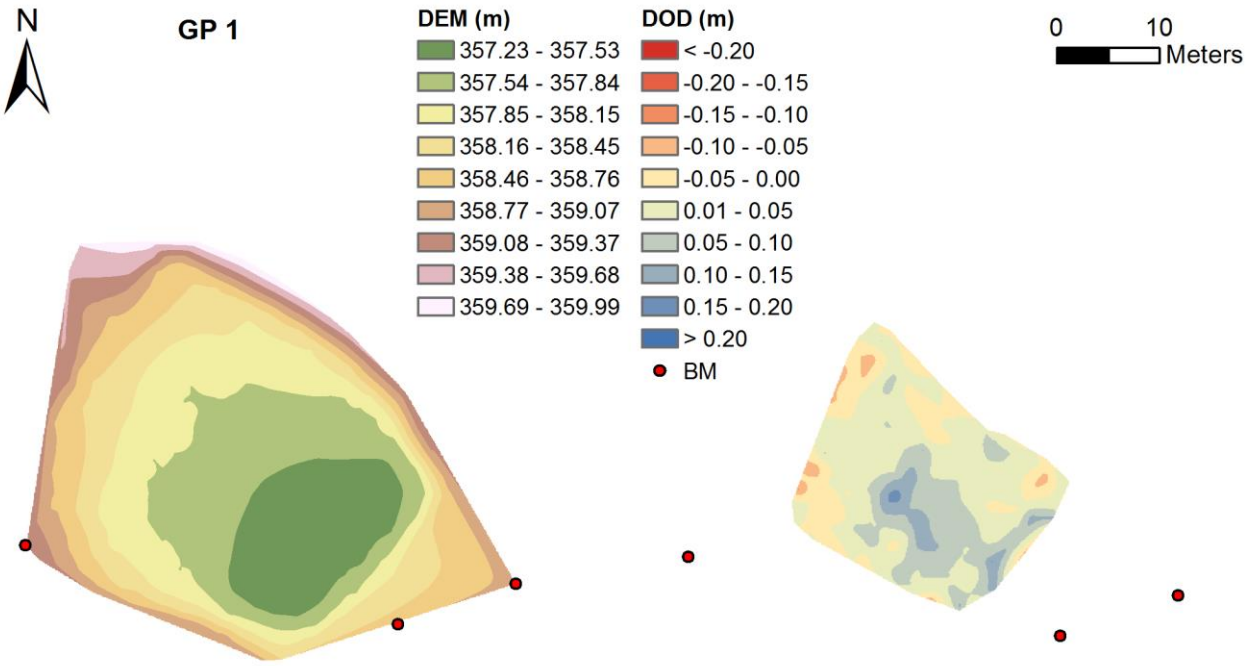

Figure 3. 2016 DEM and net aggradation and degradation (DOD) for each basin surveyed (GP1, Office, Scandia, Super Hill, Woodwardia). Red indicates net aggradation and blue indicates net degradation. The elevations are in reference to a local benchmark (BM).

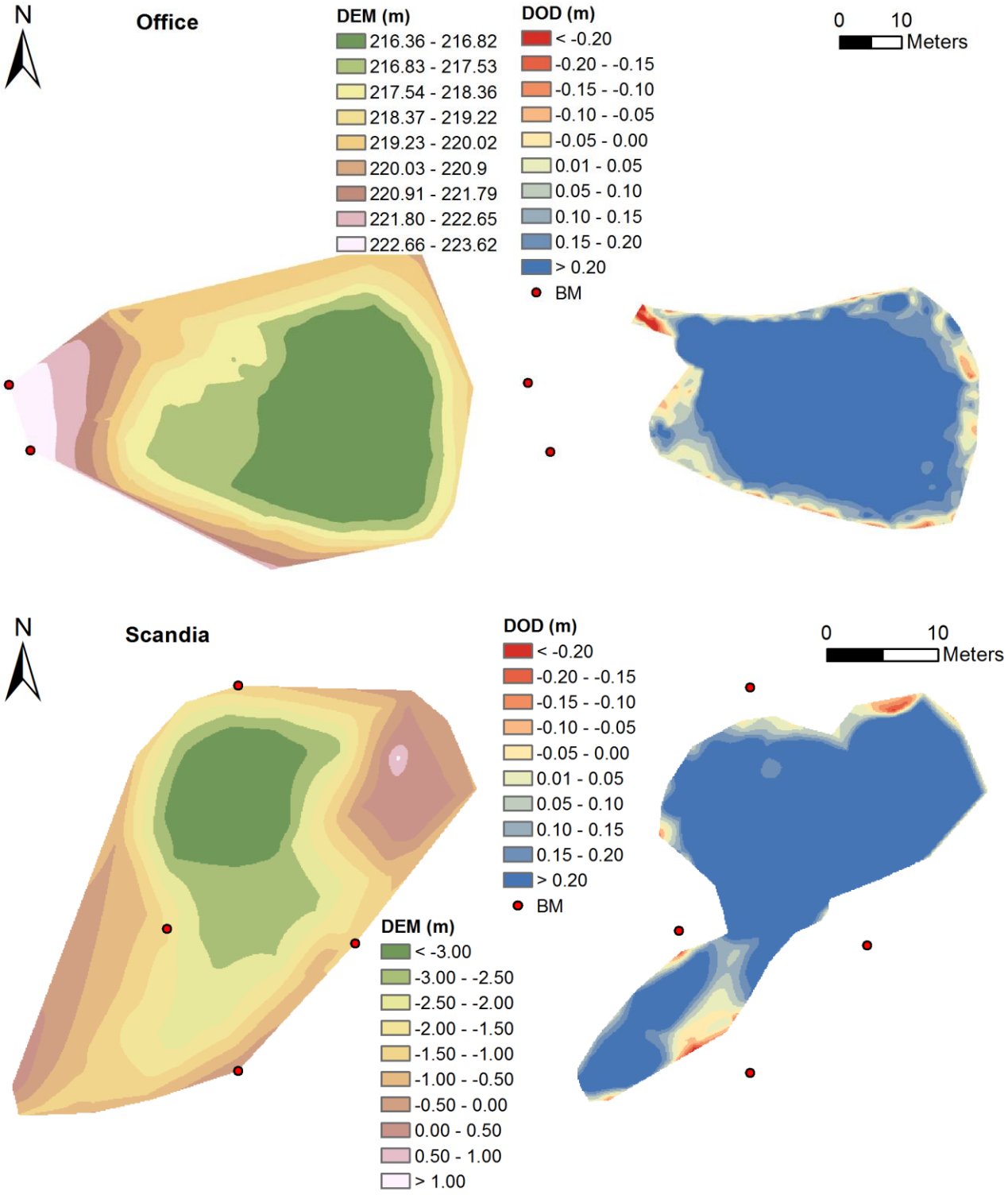

Figure 3 continued

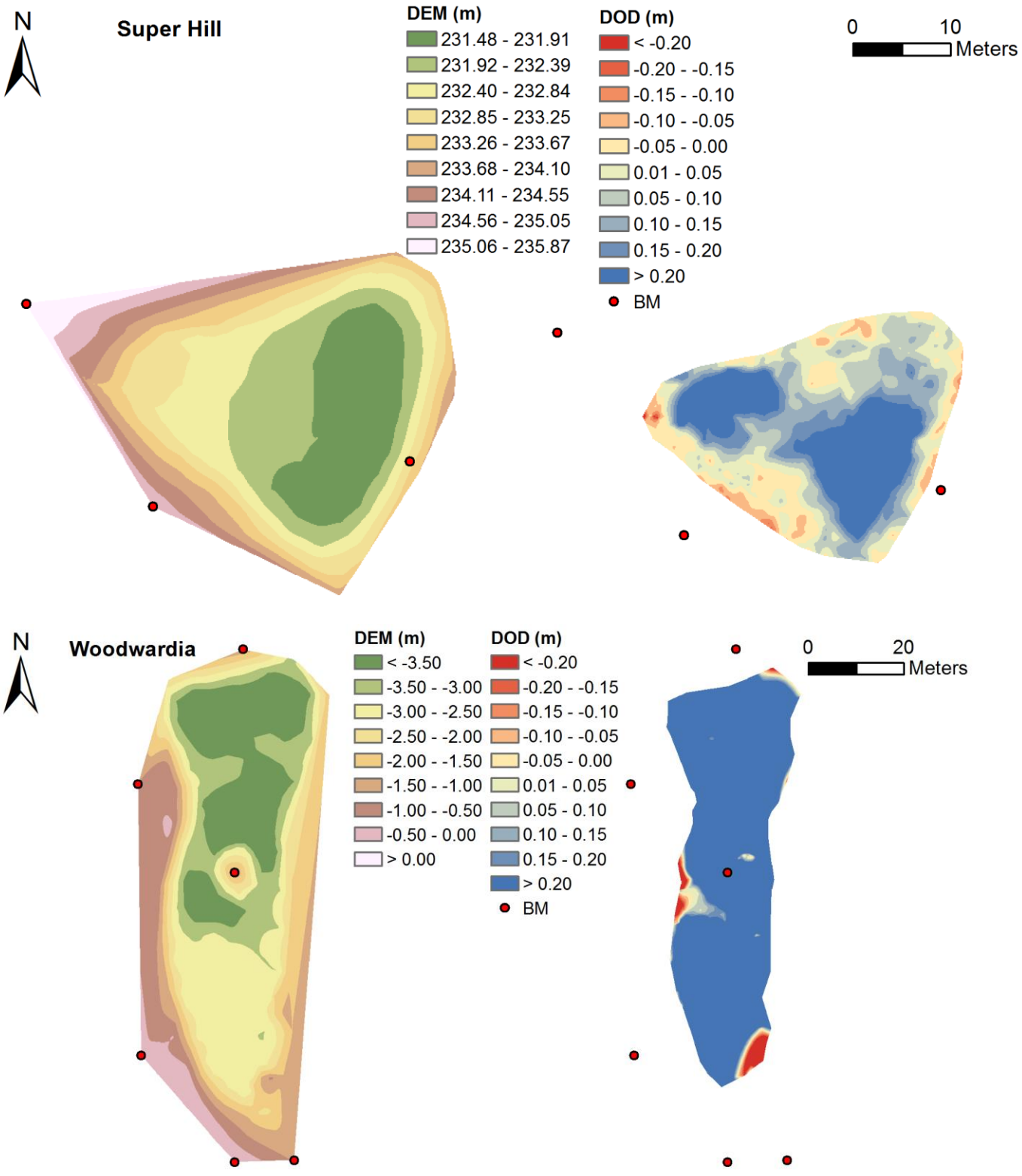

Figure 3 continued

4 References

Nicol C, Smith D, Nitayangkul K, Williams C, Moreland S. 2011. Hollister Hills SVRA Sediment Budget: Water year 2010-2011. The Watershed Institute, California State Monterey Bay, Publication No. WI-2011-04b, 25 pp.

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Smith D, Goodmansen, A. Silveus, J. 2014. Hollister Hills SVRA Sediment Budget: Water Year 2012-2013. The Watershed Institute, California State Monterey Bay, Publication No. WI- 2014-01, 17 pp.

Teaby A, Silveus, J, Smith D. 2013. Hollister Hills SVRA Sediment Basin Volumes: Water year 2012-2013. The Watershed Institute, California State Monterey Bay, Publication No. WI-2014-12, 27 pp.

5 Appendix A – Survey Descriptions

Included below are the survey descriptions for each basin including directions to individual basins, benchmark location and coordinates, spillway location, and any other site-specific information that might be relevant to reproducing the surveys. Taken and modified from Teaby et al. (2013).

5.1 Gilmore Basin

The Gilmore Basin is located in the Upper Ranch. To get to the basin, turn right from Cienga Road, approximately 0.65 miles southeast from the main SVRA entrance. Pass through a gated entrance to the Area 5 Group Campgrounds. Follow the dirt road past the campgrounds towards the hills in a southwest direction and the dirt road will lead to the Gilmore Basin. The basin is surrounded by a wood slat fence, has dirt trails running along both sides, and a large open space on the east side. Gilmore Basin extends approximately 20 meters from north to south, and 60 meters from east to west. The input for the basin is located in the southeast corner of the basin, and the outflow is located in the northwest corner.

As one stands in the middle of the east edge of the basin facing west, there are two distinct oak trees on the other side of the fence, one to the right, and one to the left. The basin's benchmark (BM) is located approximately 2 meters from the base of the tree to the right, and the basin's back-shot (BS) is located 1 meter from the base of the tree to the left. From the basin BM, the BS is located approximately 14 meters to the south, at a bearing of 184°. The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing.

The total station (TS) was set up on the BM and was oriented to a false north using the BS. Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from south to north taking points at the top left of the berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope, right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the east to the west edges of the basin using the same feature class designations for each transect. A more

random survey of topographic features was used to record the gully created by the input in the southeast corner, in an attempt to capture the highly variable topography in that location.

In addition to the BM and the BS, four other monuments from previous surveys were located during the survey. The first monument is located approximately 8 meters from the BM and should NOT be used or mistaken for the BS in future surveys. Two monuments on the southeast slope of the basin were located and included in the survey as "LFT1" (point 8) and "LFT2" (point 11). Additionally, a monument was located on the northwest slope of the basin and included in the survey as "Top Right" (point 94).

Table 2. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Gilmore Basin, obtained from Google Earth.

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	642213.00	4069710.00
Backshot (BS)	BS1	Rebar	642209.00	4069703.00
Inlet	GMI	Pipe	642208.00	4069699.00
Outlet	GMO	Pipe	642159.00	4069761.00

Figure 4. Photograph of the total station and the basin facing west (left), total station and backshot facing south (right), and the basin taken from outlet pipe facing northeast (bottom).

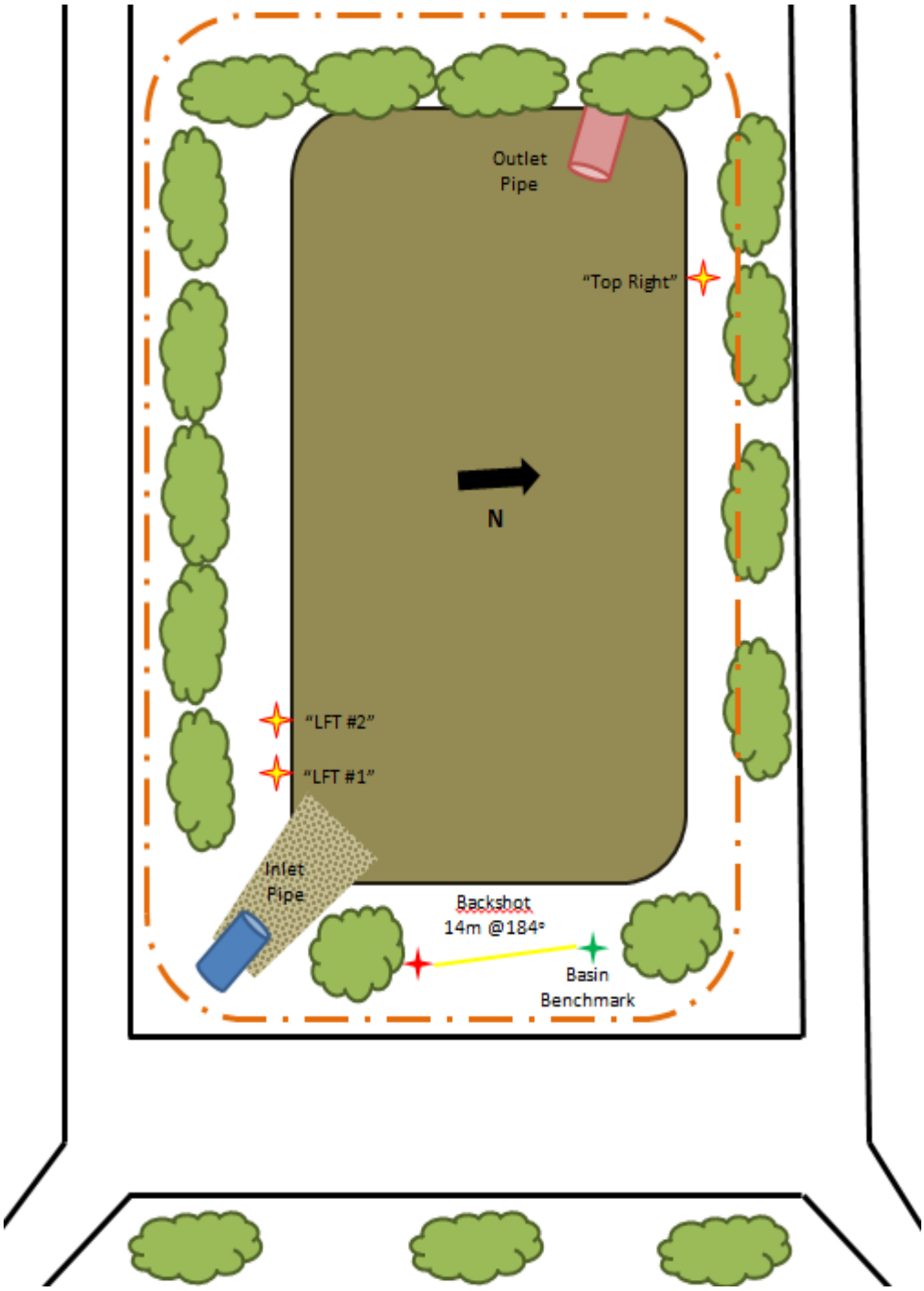

Figure 5. Diagram of Gilmore Basin showing the surrounding roads (black), the fences (orange), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.

5.2 GP Track Basin 1

The GP Basin 1 is located in the Upper Ranch. To get to the basin, travel approximately 1.5 miles, past the Main SVRA Entrance, southeast on Cienega Road to the GP Track Entrance on the right. Once inside the entrance, follow road up and take first left-hand turn up to the day use area above the GP Track. The basin is roughly square and surrounded on the northwest and southwest sides by bushes, with a large circular patch of tall reeds in the northeast corner. The Main Park Road runs along the northwest side of the basin, and a large open field extends from the northeast edge of the basin. The outflow for the basin is located on the southeast side of the basin.

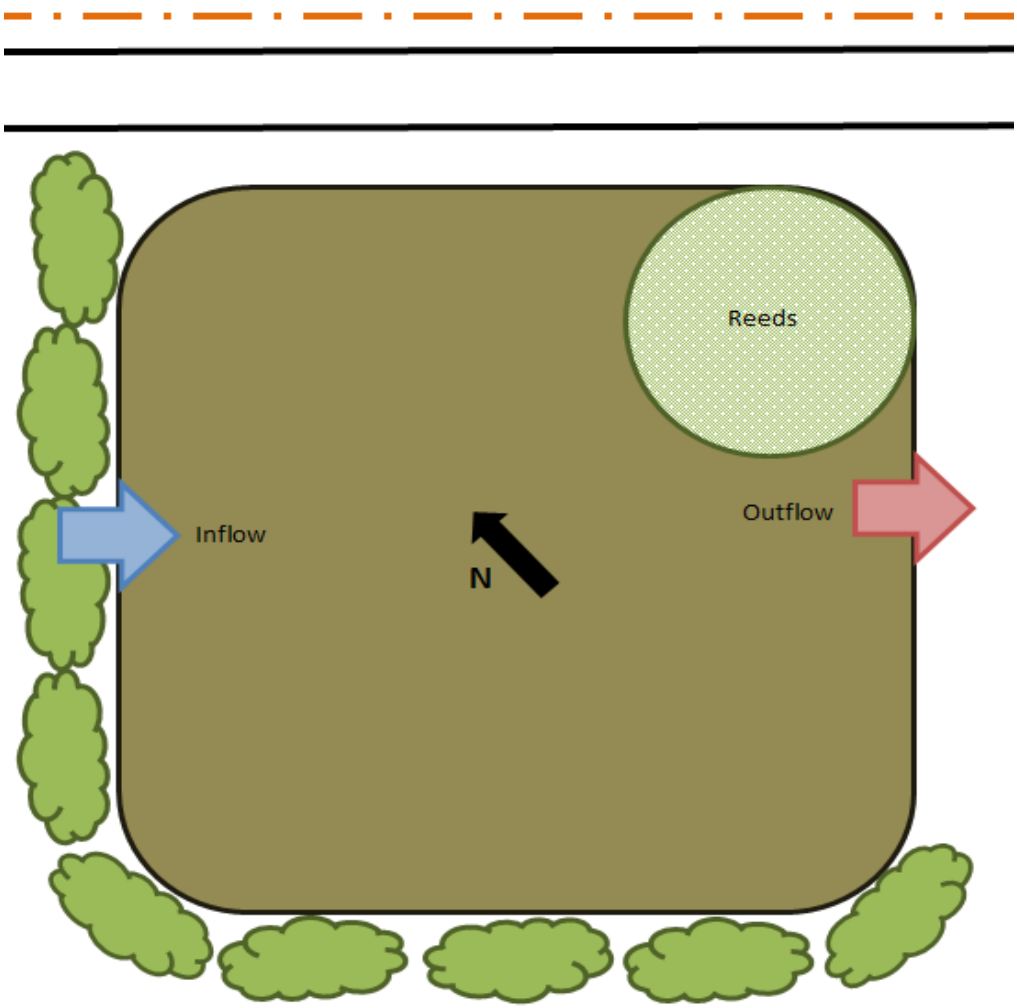

Figure 6. Diagram of GP Track Basin 1

Figure 7. Photograph of the GP 1 Track Basin facing east (left) and the view from the backshot facing the location of the total station (right).

5.3 GP Track 2 Basin

The GP Track Basin 2 is located in the Upper Ranch property by the GP Track in the Special Use Area. To get to the basin, travel approximately 1.5 miles, past the Main SVRA Entrance, southeast on Cienega Road to the GP Track Entrance on the right. Once inside the entrance, travel west along the dirt road towards the GP Track. The basin is located to the north of the entrance to the GP Track next to a large day use and camping area. The basin is closed to off-road vehicles and has a wire gate surrounding it on all sides with gates at the southern and eastern edges. The basin is roughly circular with a diameter of approximately 40 meters, a riprap covered slope as an inflow at the western end, and a horizontal outflow drainpipe at the eastern end. The bottom of the basin slopes up toward the gate at the eastern end of the basin.

The BM is located on the southern side of the basin, just inside and to the right of the southern gate at the edge of the basin rim. The BM is approximately 45 meters from the right post (from inside the gate) of the gate at the eastern end of the basin at a bearing of 274° from the gatepost. Additionally, the BM is 17 meters from a fence post on an interior right angle with a nail and flagging in the top of the post. The BM is at a bearing of 127° from the fence post.

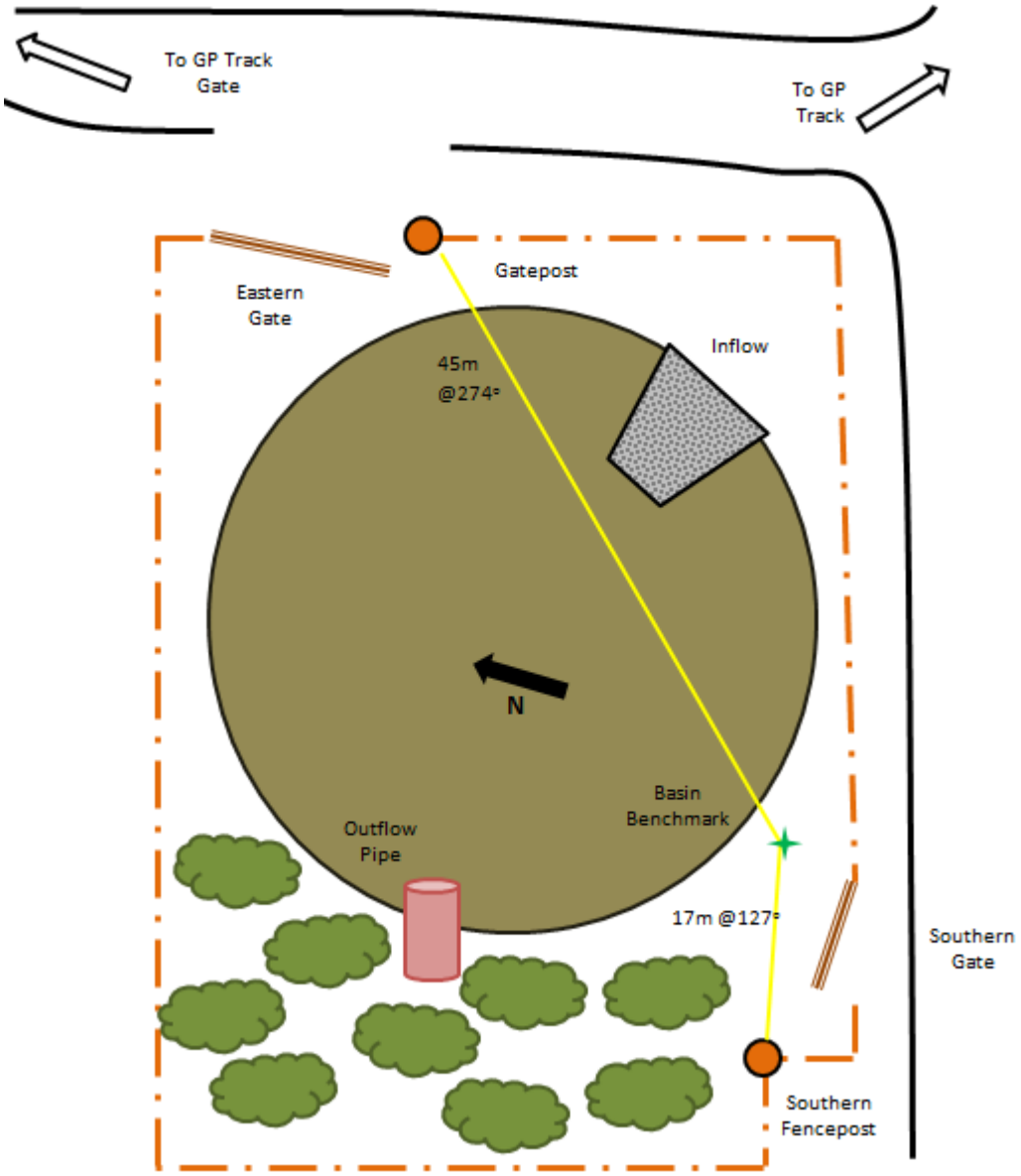

Figure 8. Diagram of GP Track Basin 2 showing the surrounding roads (black), the fences (orange), fence/gate posts (orange circles with black outline), trees (green), inflow area, and outflow pipe (red). The basin benchmark is shown as a green star.

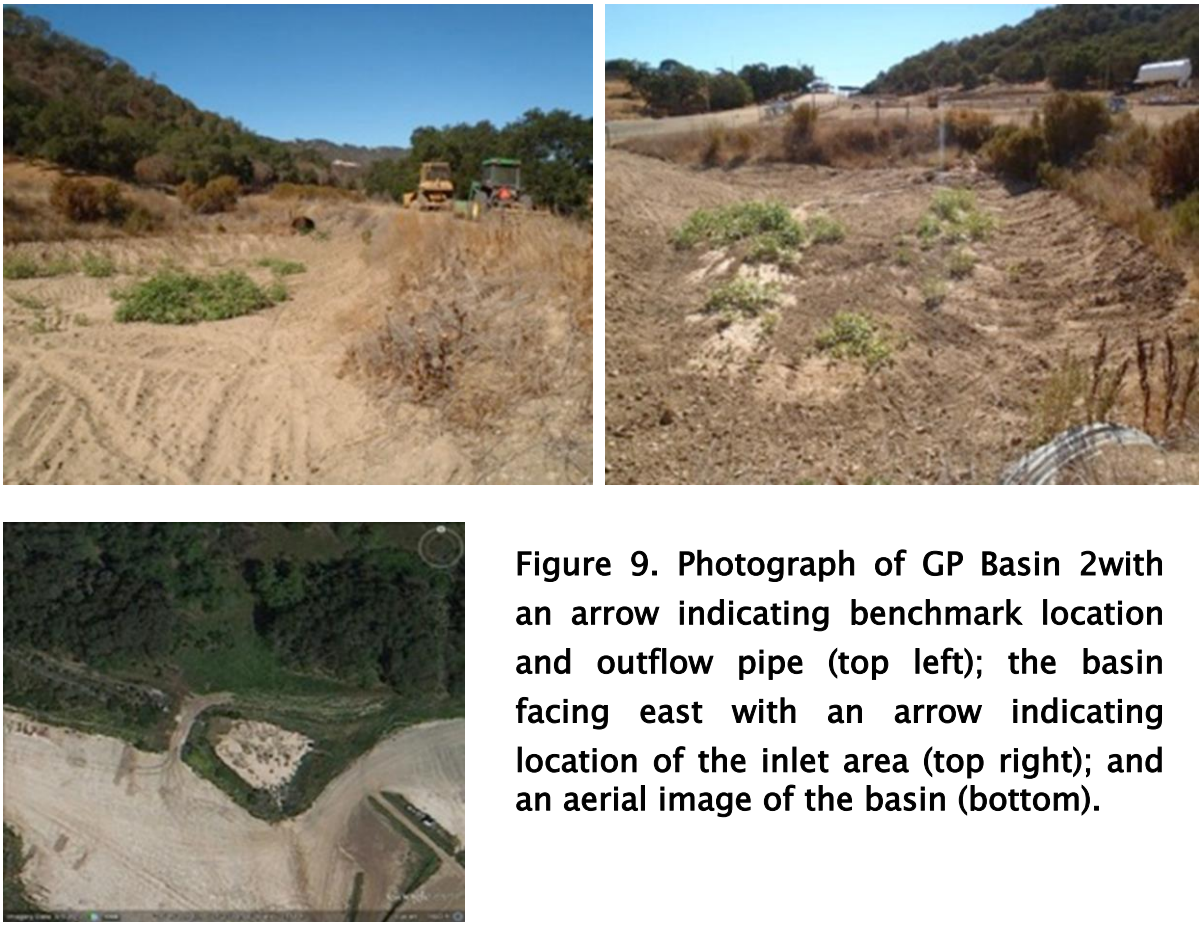

Figure 9. Photograph of GP Basin 2with an arrow indicating benchmark location and outflow pipe (top left); the basin facing east with an arrow indicating location of the inlet area (top right); and an aerial image of the basin (bottom).

5.4 Office Basin

The Office Basin is located in the Lower Ranch Property on the Main Park Road. To get to the basin, travel west on the Main Park Road approximately 300 meters; the basin is on the right side of the road nestled between the Day Use Parking Lot on the eastern side, and a large pullout with a handicap accessible restroom on the western side. The basin is bordered by the Main Park Road on the southern side and dirt trails on the north side, and is surrounded on all sides by a wood slat fence. The basin is trapezoidal with the western edge measuring approximately 20 meters across and the eastern edge approximately 30 meters across. The basin is approximately 50 meters from east to west.

Because of the amount of tall vegetation that can occur near the center of the basin, the basin BM for the survey was placed on the hillside to the south of the basin to ensure good line of sight throughout the survey. The BM is located

across the Main Park Road approximately 35 meters up the slope from the southern edge of the road at the base of a large, solitary oak tree. Two monuments were used for reference during the survey; both pieces of rebar hammered flush to the ground. The first backshot (BS #1) is located on the plateau on the west side of the basin, inside and approximately 5 meters from the wood slat fence. The second backshot (BS #2) is located outside of the wood slat fence on the southern edge, approximately at the middle of the basin at a bearing of 70° from the benchmark on the southern slope.

The TS was set up on the BM and oriented to a false north using the BS on the western side of the basin (BS #1). Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from north to south taking points at the top left of the berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope, right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the north to the south edges of the basin using the same feature class designations for each transect. A more random survey of topographic features was used to record unique features and the around the vegetated plateau in the center of the basin to capture the highly variable topography at that location.

Additionally, the Office Basin was surveyed on at least two other occasions using RTK/GPS equipment. For these surveys, the monument denoted as BS #1 for this survey was used as the BM and points were taken throughout the basin complex, including the monuments used for the TS survey. From these surveys we have the UTM coordinates for BS #1 (641346.45E, 4070719.4N), and for the benchmark (BM #1) on the slope of the southern side (641342.45E, 4070646.9N) used in the total station survey of the basin.

Table 3. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Office Basin, obtained from Google Earth.

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	641345.00	4070652.00
Backshot (BS)	BS1	Rebar	641349.00	4070722.00
Backshot (BS)	BS2	Rebar	641399.00	4070689.00
Inlet	OBI	Channel	641361.00	4070736.00
Outlet	OBO	Channel	641421.00	4070736.00

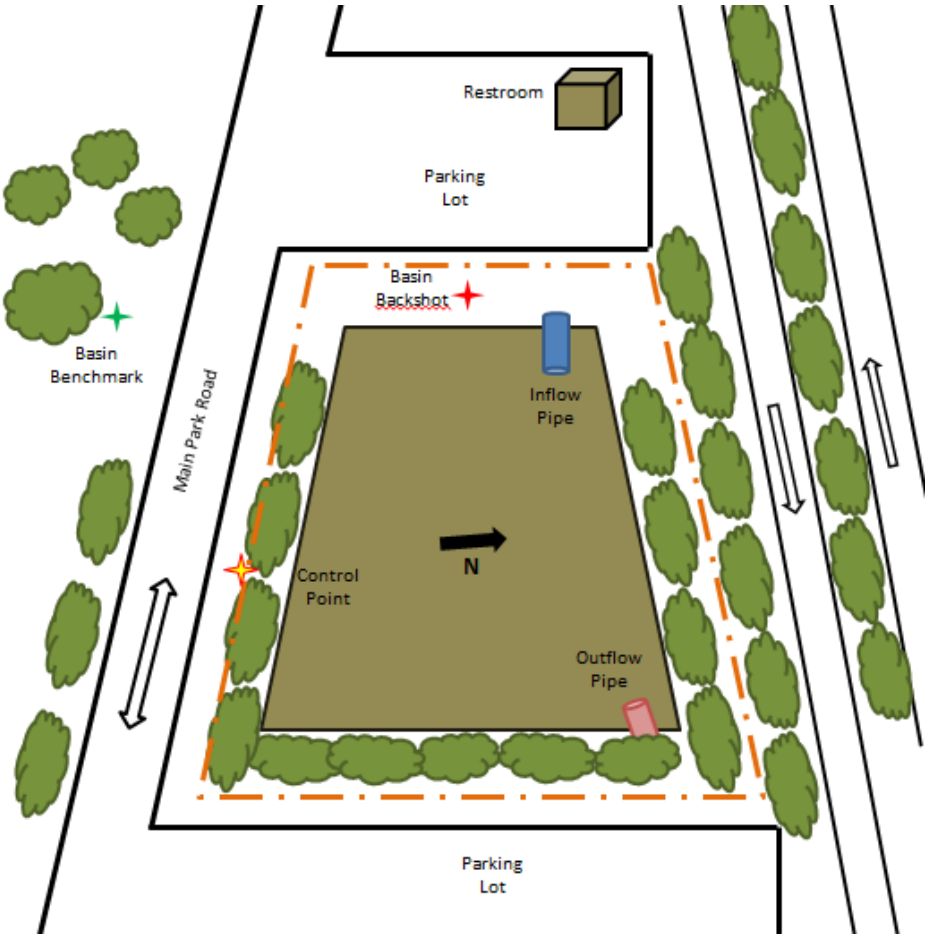

Figure 10. Diagram of the Office Basin showing surrounding roads (black), the direction of travel on roads (black arrows), fences (orange), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.

Figure 11. Ariel photograph of the Office Basin showing the location of the basin benchmark (BM#1) (left); a view of the basin from the basin benchmark (middle); and a view of the basin from the basin benchmark showing the RTK/GPS base station set up on the back-shot used for the total station



Figure 12. Photograph of the location of the basin benchmark (BM #1) from the southern edge of the basin (left); the location of the backshot (BS #1) used for the total station surveys (middle); and the location of the second backshot (BS #2) used for the survey (right).

5.5 Scandia Basin

The Scandia Basin is located in the Lower Ranch property on Harmony Gate Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake, and Scandia Basin is located approximately 1.5 miles up Harmony Gate Road where the road ends. The basin is up the trail to the west about 50 meters from the road terminus and a picnic area. The basin is bordered on the north and south sides by single-track trails and is open to off-road vehicle use. The basin is roughly kidney bean shaped with a smaller upper basin section to the west and a larger lower basin section to the east. Water enters the basin form the west and exits the basin through a standpipe drain located on the eastern edge of the lower basin. The basin is approximately 40 meters long in total. The upper basin is roughly oval in shape, 15 meters long by 10 meters wide, and the lower basin is roughly circular with a diameter of 25 meters. An isthmus on the northern side with a large sycamore tree on it bisects the upper and lower basins.

The BM is located on the western edge of the basin to the side of the single-track trail that continues westward past the basin. The BS was installed on the eastern edge of the basin to the north of the standpipe drain. Two nail monuments were installed at approximately 2 meters height in trees visible from the basin benchmark. The first nail is in the large sycamore tree on the isthmus that bisects

the upper and lower basins, approximately 14 meters away from the BM at a bearing of 18°. The second nail is in an oak tree on the southern side of the basin at a distance of 15.5 meters from the basin benchmark at a bearing of 115°.

The TS was set up on the BM and setup using the quick setup protocol. The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing.

Figure 13. Aerial photograph of the Scandia Basin (left) and a view of the basin from location of the total station facing east (right).

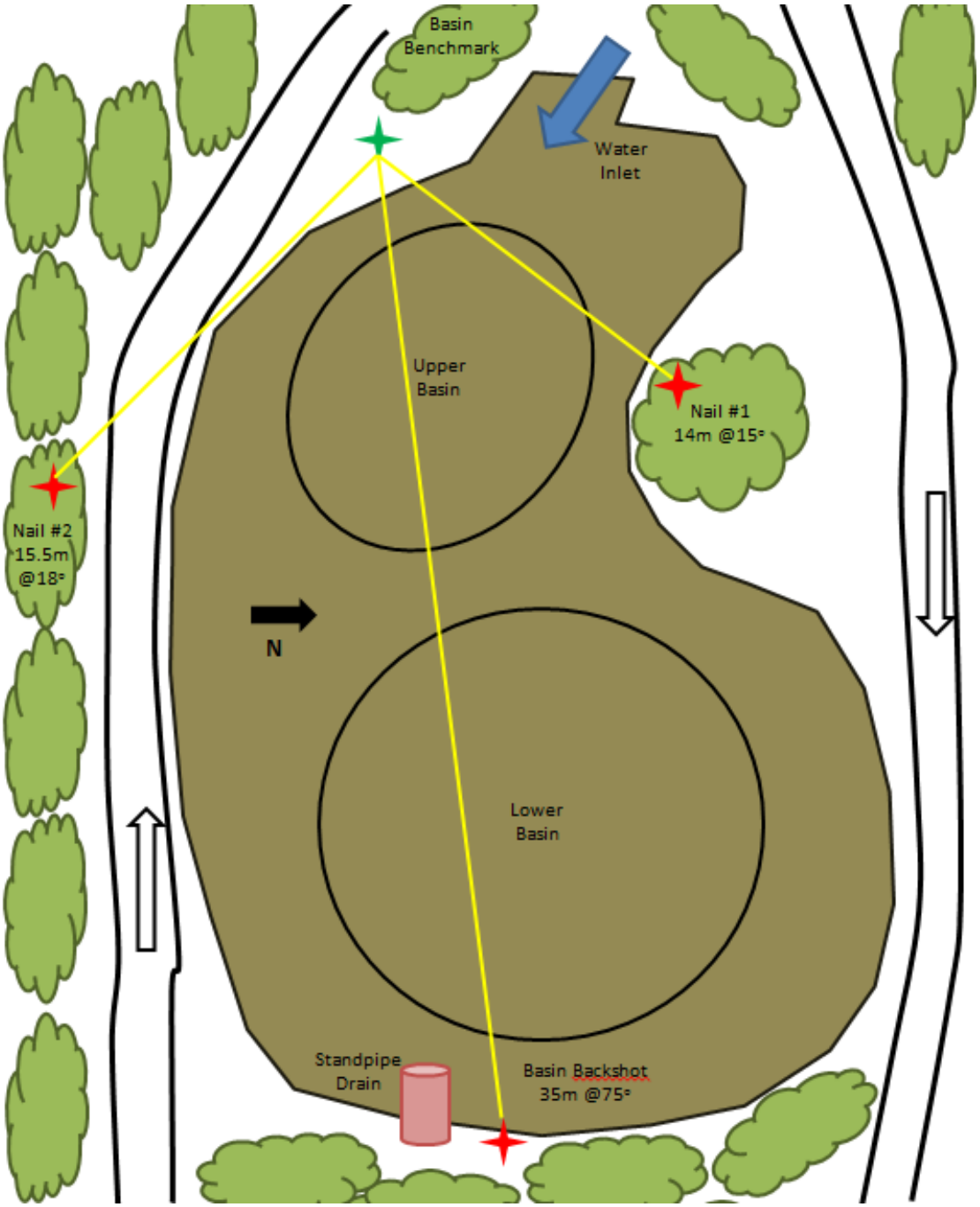

Figure 14. Diagram of the Scandia Basin showing surrounding roads (black), the direction of travel on roads (black arrows), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star and the backshots as red stars.

5.6 Super Hill Basin

Super Hill basin is located northeast of Office Basin on the Lower Ranch Property at the junction of Lower Field Return and Super Hill Trail. To get there, a side-by-side is recommended, but a 4x4 truck can navigate the tight turns reasonably well. From the Main Road take Lower Field Trail going northeast. As of 2016 there is a place to turn up Super Hill trail going due north. Super Hill trail is a black diamond trail with two steep inclines. Go up the first ascent to the flat area between crests. At the north end of the flat area, before reaching the second ascent, the Super Hill sediment basin is on the northeast side of the trail (on the right when facing down trail).

Super Hill basin is triangle in shape with the apex facing approximately west. This small basin drains Super Hill Trail and is sometime subject to minor erosion from motorcycle riding within the basin. A small gully is forming in the west side of the basin between the trail and the basin, where runoff inflows. We captured this gully as well as the perimeter trail.

There are two benchmarks on the west side (closest to the trail) as capped rebar on either side of the basin's "triangle point." The RTK was set on the north BM located immediately next to coyote bush, halfway between the trail and the sediment basin. The south BM, used as a BS, is located due south of the BM on what used to be a vegetated peninsula. The spillway is located on the east side slope of the sediment basin as a vertical culvert with holes on the side.

Table 4. OPUS corrected coordinates (UTM) of benchmarks, backshots, and monuments and features of Super Hill Basin.

Description	Name	Type	Easting (UTM)	Northing (UTM)	Elevation (UTM)
Benchmark (BM)	BM1	Rebar	641604.455	4070949.966	234.951
Backshot (BS)	BS1	Rebar	641604.455	4070949.966	234.951
Outlet	SHO	Pipe	641630.817	4070954.572	233.055

Figure 15. Overview of Super Hill Basin from the southeast (top left). Standing on the inflow trail and facing the spillway of Super Hill (top right). Super Hill's spillway culver (bottom left). RTK on top of BM next to Super Hill trail (bottom right).

Figure 16. BM with RTK (left) and BS (right).

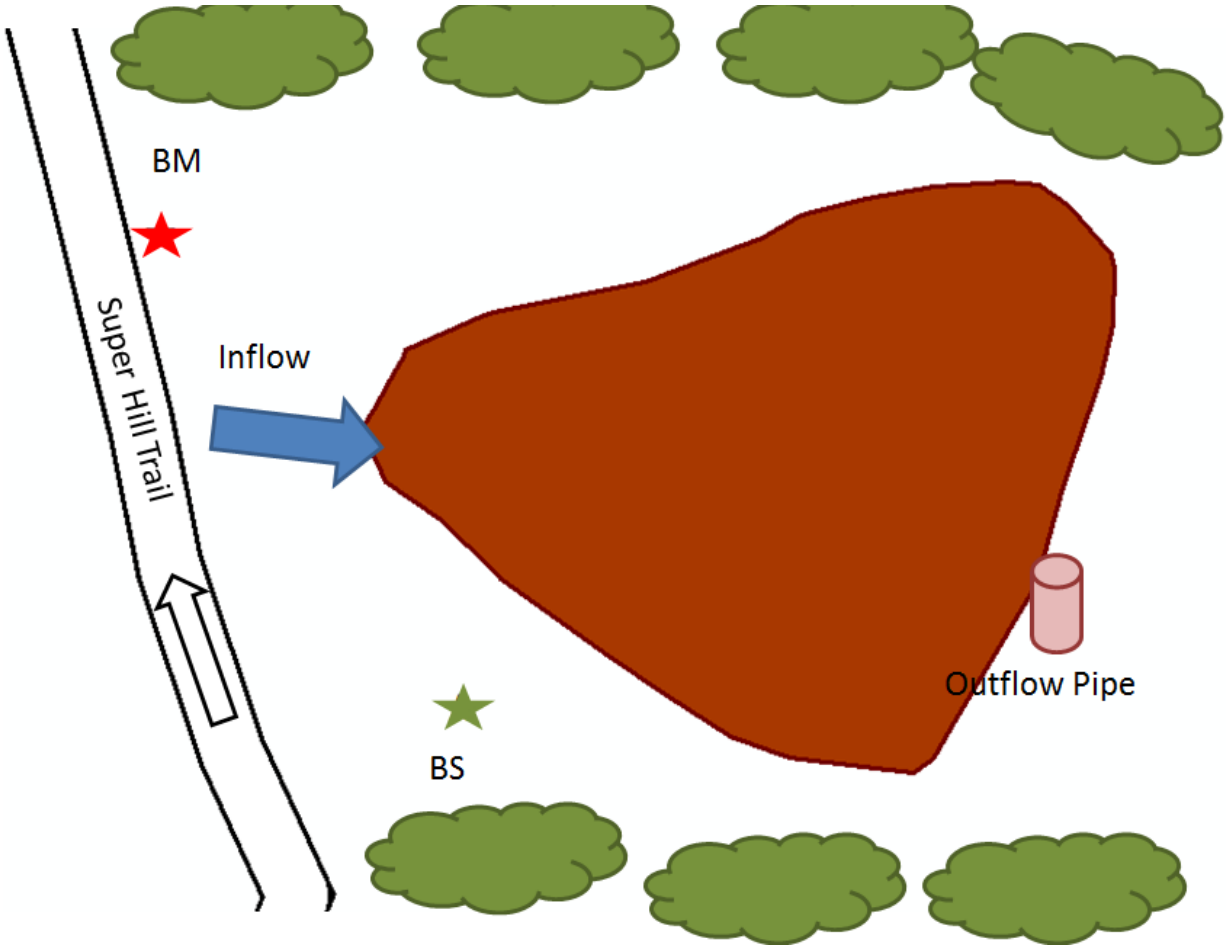

Figure 17. Diagram of Super Hill Basin showing surrounding roads (black), fences trees (green), inflow (blue), and outflow pipe (red). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.

5.7 Sycamore Basin

The Sycamore Basin is located in the Lower Ranch property on Harmony Gate Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake and Sycamore Basin is located approximately 0.3 miles up Harmony Gate Road on the left. The basin is roughly oval with a channel cut island on the western edge. The basin is surrounded by a wood slat fence, has dirt trails running along both sides, and a trail crossover on the east edge. The basin is approximately 40 meters from north to south and 20 meters from east to west. Water enters the basin through the channel on the western edge and exits through the outlet pipe located in the southeast corner of the basin.

The BM is located inside the fence perimeter, about half way between the north and south edges, and about 1 meter west of the fence. The BS is a piece of rebar in the ground, 27 meters from the BM at a bearing of 330°. Nail #1 is located in an oak tree about 1.9 meters from the ground, is approximately 23 meters to the north, at a bearing of 337° (points 2 and 190). Nail #2 is located in an oak tree is located on the southwest face of a hillside bordering the basin is at a bearing of 222° from the BM, at a distance of approximately 30 meters (points 4 and 133).

The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing. Using a prism pole and prism, oval transects of the basin were surveyed by taking points along similar elevations around the ring of the basin, and then moving down the slope of the basin in a concentric manner. Survey points of the general shape of the basin were taken approximately every square meter, and more a random survey of topographic features was used to record the channel cut island created by the input on the western edge in an attempt to capture the highly variable topography in that location.

Table 5. Approximate coordinates (UTM) of monuments and features of the Sycamore Basin from Google Earth.

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	639504.00	4071311.00
Backshot (BS)	BS1	Nail	639499.00	4071327.00
Inlet	SBI	Channel	639483.00	4071308.00
Outlet	SBO	Pipe	639504.00	4071298.00

Figure 18. The Sycamore Basin viewed from the southeast corner of the basin showing the channel cut island (left); the location of the basin benchmark near the fence at the center of the eastern edge of the basin (middle); and the location of the nail in the oak tree used for the backshot in the northeast corner of the basin (right).

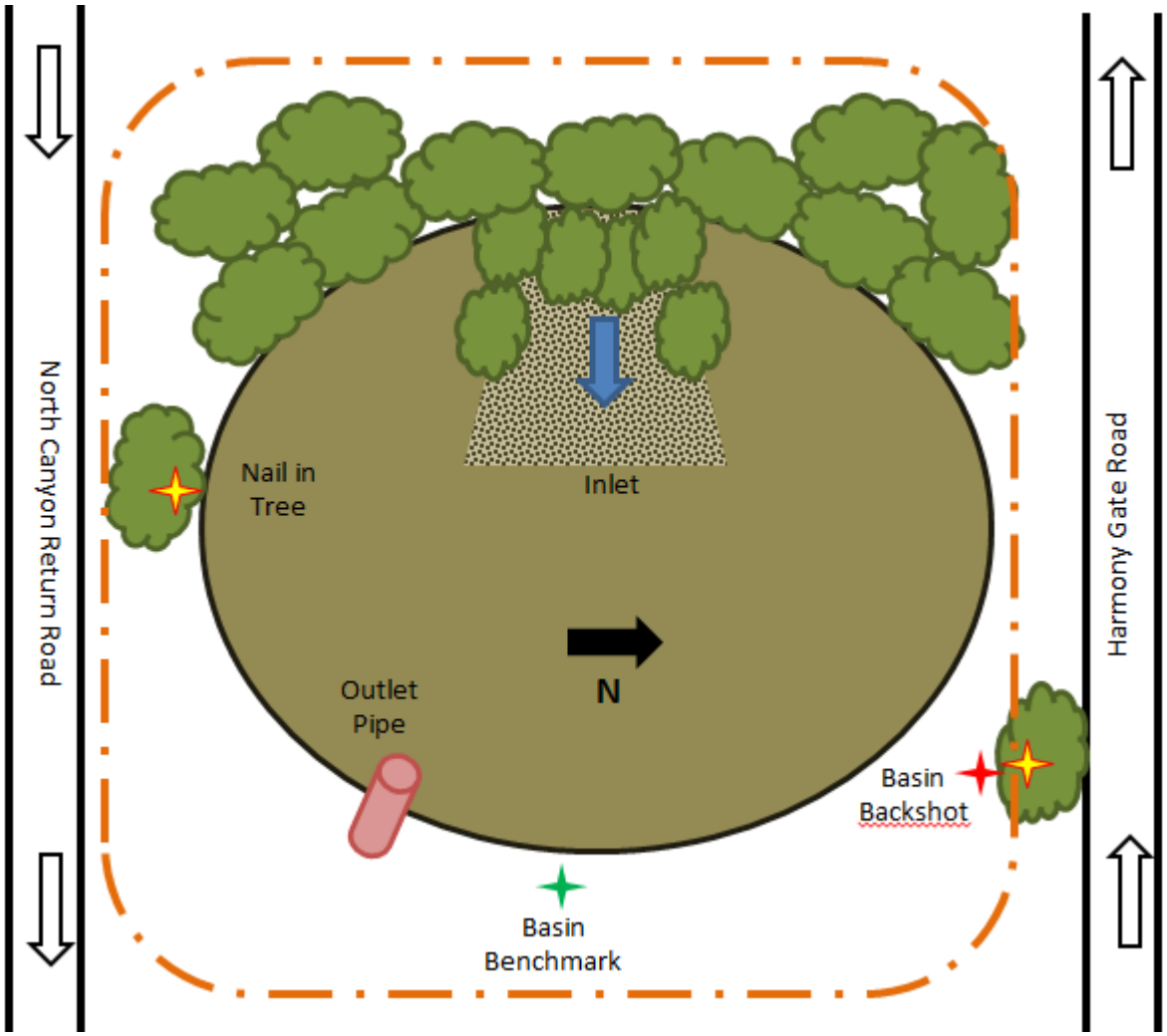

Figure 19. Diagram of the Sycamore Basin showing surrounding roads (black), fences (orange), trees (green), inflow (blue), outflow pipe (red), and channel cut island (dark brown). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.

5.8 Vineyard Basin

The Vineyard Basin is located in the Upper Ranch property between Garner Flat Road and McCray Road. To get to the basin, travel approximately 1 miles southeast on Cienenga Road from the Main SVRA Entrance. Take on right on McCray Road into the Upper Ranch Entrance where an old white schoolhouse (Vineyard Schoolhouse) sits to the right. Go through the gate and proceed up McCray Road approximately 0.5 miles to the intersection of McCray and Garner Flat Road. The basin will be to the northwest of this intersection. There is a large flat area to the east of the basin to park and set up survey equipment.

Vineyard Basin is a relatively large basin shaped like a rounded rectangle with a length of approximately 80 meters and a width of approximately 40 meters. The basin is steeply sloped on both the east and west sides with an inflow to the south and a standpipe drain at the northern end of the basin. The inflow is a relatively steep slope protected by large rocks (riprap), while the northern end of the basin is closed with a wire tied rock dam. The BM is located on the east side of the basin approximately half way down the eastern side. The BM is approximately 20 meters away from a medium sized oak tree growing next to a wood slat fence on the eastern edge of the parking area at a bearing of 330° from the oak tree. A basin control point is located on the east side of the basin approximately 20 meters to the north of the basin benchmark. The RTK/GPS base station was set up on the BM and the basin was surveyed using RTK/GPS.

Figure 20. Aerial photograph of the Vineyard Basin (left) and the location of the RTK benchmark and backshot (right) on the top east edge of the basin.

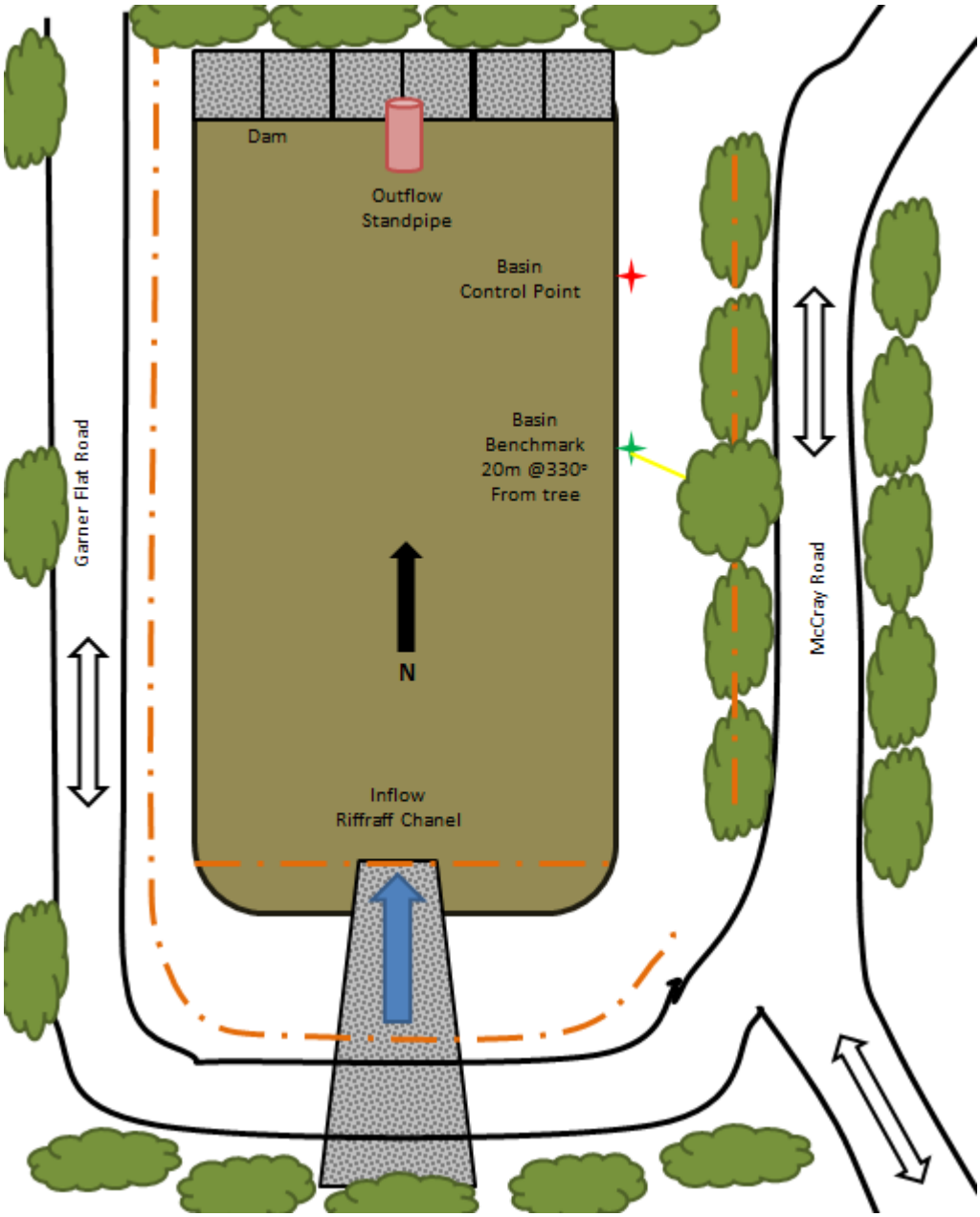

Figure 21. Diagram of the Vineyard Basin showing surrounding roads (black), the direction of travel on roads (black arrows), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star and the backshot as red stars.

5.9 Whoopdeedoo Basin

The Whoopdeedoo Basin is located in the Lower Ranch property on Long Canyon Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake, travel approximately 0.3 miles on Harmony Gate Road and then turn right onto Long Canyon Road. Whoopdeedoo Basin is located at the entrance to Long Canyon Road on the right. Whoopdeedoo is a large and deep basin bordered on the south side by Long Canyon Road with dirt trails bordering all other sides of the basin. The basin is trapezoidal with the narrow end at the western edge where the inlet pipe is located, with a triangular alluvial fan cut with multiple dykes channeling water into the basin. The outlet of the basin is located in the northeast corner of the basin next to a dirt trail and covered in thick coyote bushes. Unlike other basins in this survey, the outlet is a vertical drainpipe cut with outlet ports. The outlet pipe leads to a concrete channel with a cross section of approximately one square meter and a length of approximately 10 meters.

The RTK/GPS base station was set up on the single basin benchmark located in the northeast corner of the basin next to the concrete channel. The UTM coordinates for the benchmark established by the RTK/GPS unit during the survey are 639401.56E, 4070719.4N.

Table 6. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Woopdeedoo Basin, obtained from Google Earth.

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	639490.00	4070658.00
Inlet	WDI	Pipe	639409.00	4070658.00
Outlet	WDO	Pipe	639486.00	4070658.00

Figure 22. View of the western side of the Whoopdeedoo basin and the basin inlet from the basin benchmark (left); the basin benchmark located in the northeastern corner of the basin and next to the concrete culvert (middle); and view of the concrete culvert that diverts water from the basin outlet (right).

Figure 23. Arial photograph of the Whoopdeedoo Basin showing its trapezoidal shape (left); view of the western side of the basin and the basin inlet from the basin benchmark (middle); and view of the eastern side of the basin from the basin benchmark (right).

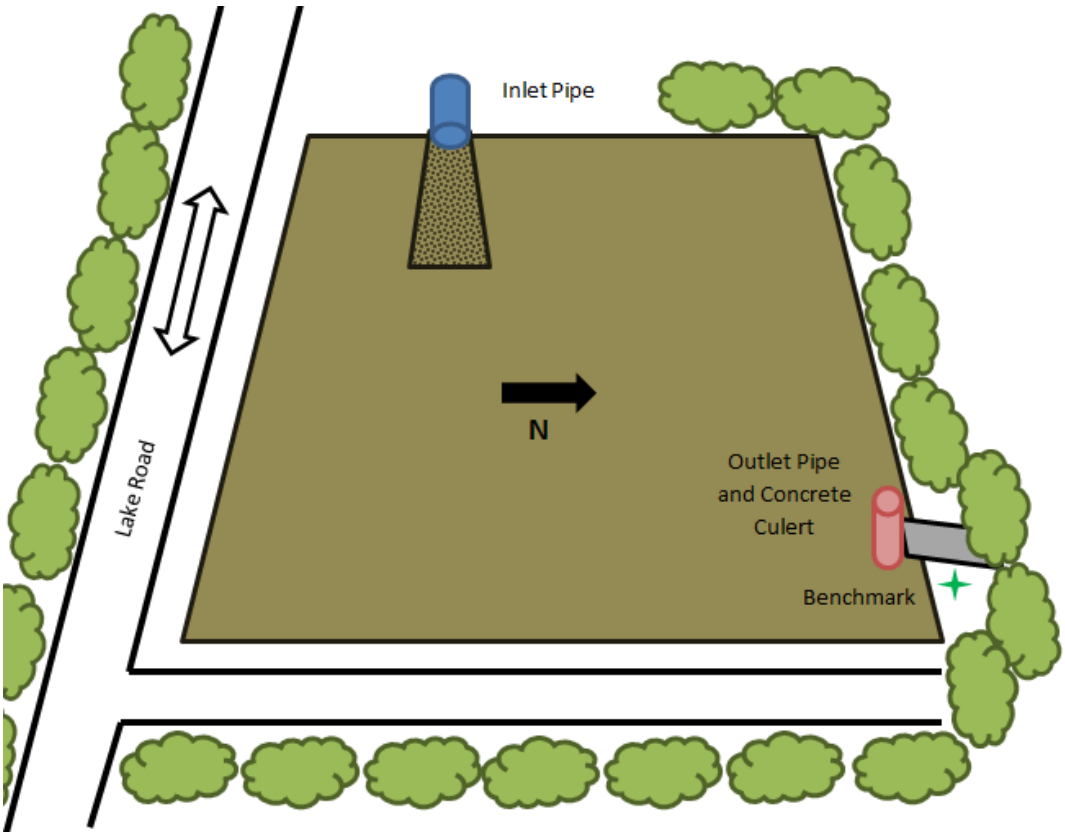

Figure 24. Diagram of the Woopdeedoo Basin showing surrounding roads (black), direction of travel on roads (black arrows), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark used for RTK/GPS is shown as a yellow star with a red border in the northeastern corner of the basin.

5.10 Woodwardia Basin

The Woodwardia Basin is located in the Lower Ranch property on Harmony Gate Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake and Woodwardia Basin is located approximately 0.5 miles up Harmony Gate Road on the left. The basin is bordered on both sides by dirt trails and wood slat fences, with a large island and a wood slat fence bisecting the basin. A trail crossover from east to west borders the southern edge. The northern section is predominantly filled with dirt and is used heavily by off-road vehicles, while the southern section is covered with wetland vegetation. Extreme caution should be

used when working in the northern section of the basin. The basin is approximately 60 meters long from north to south, and 30 meters from east to west. Water enters the basin through a channel in the northwest corner, and exits through the outlet pipe in the southwest corner of the basin.

Due to the length of the basin and the island with large trees in the middle of the basin, two benchmarks and total stations were used to survey the basin, one at the northern end and one at the southern end of the basin. The north basin benchmark (BM #1) is chiseled into a rock at the base of a large oak tree in the northeast corner of the basin. The south basin benchmark (BM #2) is a piece of rebar located at the top of the berm approximately half way across the southern edge of the basin. The BS is chiseled into a large rock located in the center of the island that bisects the basin and was used as the BS for both BMs. The BS is approximately 30 meters from the northern benchmark (BM #1) at a bearing of 125°, and approximately 30 meters from the southern benchmark (BM #2) at a bearing of 306°. The northern TS was setup on BM #1 and assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS (125°) was used as the false northing. The southern TS was setup on BM #2 with a position of 86.808, -62.816, -1.172 (E,N,Z) and the direction from the BM to the BS (306°) was used as the false northing.

There are 5 monuments used for reference in the Woodwardia Basin complex. Monuments 1 through 3 are nails in trees used for reference with the northern BM, and nails 4 and 5 were used for reference for the southern BM. All nail monuments are hammered flush to the tree surface, and located approximately 2 meters from ground level facing the appropriate BM. From the northern BM, Nail #1 is approximately 20 meters southwest at a bearing of 145°. Nail #2 is approximately 15 meters west at a bearing of 215°, and Nail #3 is approximately 20 meters east at a bearing of 80°. From the southern BM, Nail #4 is approximately 20 meters northeast, and nail #5 is approximately 20 meters east; no bearings for these monuments are currently available and should be obtained during the next survey. The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing

Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from west to east taking points at the top left of the

berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope, right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the north to the south edges of the basin using the same feature class designations for each transect. A more random survey of topographic features was used to record unique features and the around the island in the center of the basin to capture the highly variable topography at that location.

Table 7. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Woodwardia Basin, obtained from Google Earth.

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rock	638881.00	4071508.00
Benchmark (BM)	BM2	Rebar	638961.00	4071455.00
Backshot (BS)	BS1	Rock	638917.00	4071484.00
Backshot (BS)	N1	Nail	638893.00	4071488.00
Backshot (BS)	N2	Nail	638866.00	4071503.00
Backshot (BS)	N3	Nail	638910.00	4071512.00
Backshot (BS)	N4	Nail	638944.00	4071488.00
Backshot (BS)	N5	Nail	638974.00	4071478.00
Inlet	WWI	Channel	638855.00	4071512.00
Outlet	WWO	Pipe	638948.00	4071450.00

Table 8. Approximate location of the backshot and reference monuments of the Woodwardia Basin taken from the northern benchmark (BM #1).

Description	Name	Type	Reference	Distance (m)	Bearing (X^{o})
Backshot (BS)	BS1	Rock	BM #1	30	125
Monument (N)	N1	Nail	BM #1	20	145
Monument (N)	N2	Nail	BM #1	15	215
Monument (N)	N3	Nail	BM #1	20	80

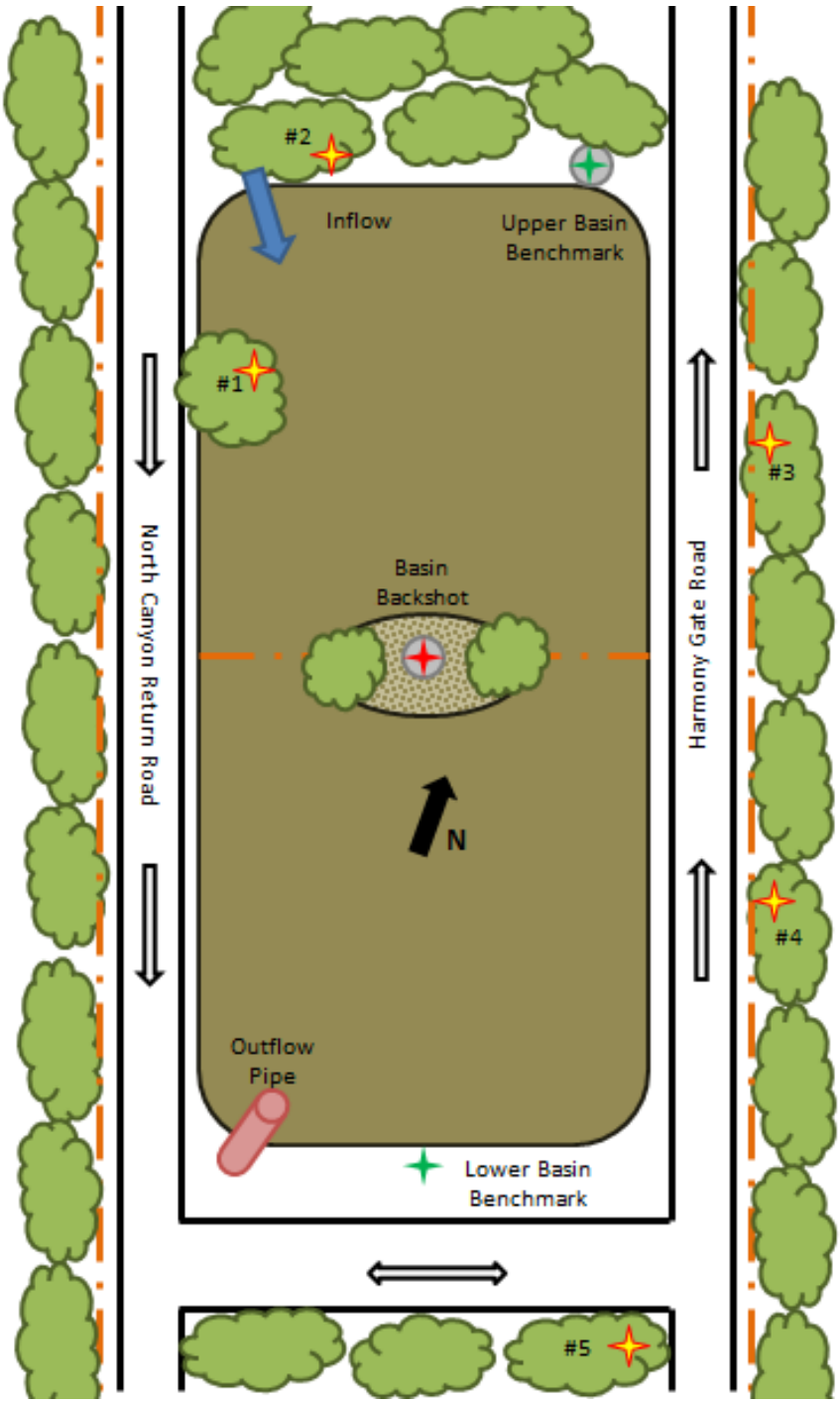

Figure 25. Diagram of the Woodwardia Basin showing surrounding roads (black), fences (orange), trees (green), rocks (grey), inflow (blue), and outflow pipe (red). The basin benchmarks are shown as a green stars, the back-shot as a red star, and additional survey monuments are shown as yellow stars with red borders. Numbers indicating monument identifications have also been included.

Table 9. Approximate location of the backshot and reference monuments of the Woodwardia Basin taken from the southern benchmark (BM #2).

Description	Name	Type	Reference	Distance (m)	Bearing (X^{o})
Backshot (BS)	BS1	Rock	BM #1	30	306
Monument (N)	N4	Nail	BM #1	20	NE
Monument (N)	N5	Nail	BM #1	20	E

Figure 26. The Woodwardia Basin viewed from the northeastern corner of the basin showing the northern benchmark and the island that bisects the basin (left), the northern benchmark (middle), and the island in the middle of the basin with the large rock on which the backshot is located (right).

Figure 27. The tree with monument #1 (far left), the tree with monument #2 (middle left), the tree with monument #3 (middle right), and the view from the southern benchmark (BM #2) showing the basin, the island, and the location of the northern benchmark (BM #1) in relation to the southern benchmark (far right).