UC Berkeley
Graduate student research papers

Title
Ecological Appraisal of an Urban Creek Daylighting Project: Wildcat Creek at Davis Park

Permalink
https://escholarship.org/uc/item/17s7q641

Author
Lennon, Amber

Publication Date
2022-10-01

eScholarship.org Powered by the California Digital Library
University of California

Ecological Appraisal of an Urban Creek Daylighting Project: Wildcat Creek at Davis Park

Final Draft

Amber Lennon, Heather Nelson, & Chris Nygard

We conducted an appraisal of an urban creek daylighting project in San Pablo, California, to evaluate the ecological integrity of the restoration, understand if the project achieved its goals, and recommend planning guidelines for future projects. This 2013 project in John Herbert Davis Park daylit a 550 foot culverted section of Wildcat Creek, with objectives to improve flood control, create riparian and fish habitat, and expand trail access. We analyzed current project conditions by surveying vegetation at 8 transects, surveying vegetation by planting section, conducting 2 bird counts, mapping the creek bed and vegetation cover, and recapturing 15 photopoints. We compared results with initial plans and monitoring, which continued for 5 years.

We found that the project created a riparian vegetation community with habitat supporting bird abundance, density, species richness, and diversity. Willow trees make up 80% of the overstory plants, as a result of an initial 560 willows planted. Overstory vegetation developed an almost fully closed canopy over the creek; we found 95% canopy cover. Little of the planted understory has survived, which we attribute to shade, human use, and competition from invasives. Invasive species dominated the understory composition, including Algerian ivy, veldt grass, and kikuyu grass. We found the surface cover consists primarily of live woody, non-woody vegetation, and vegetation litter. We did not observe streambed conditions for fish habitat given the seasonal lack of water.

The project succeeded in increasing longitudinal connectivity through robust initial monitoring, extension of Wildcat Creek Trail, providing riparian habitat to support bird life, and constructing a channel and floodplain with an 100 year flood capacity. However, the project failed in overgrowth of vegetation, lack of continued monitoring funds, and death of the planted understory, in conjunction with invasive encroachment. Canopy overgrowth has additionally facilitated lack of bank-to-bank visibility, thereby encouraging encampments and dumping, resulting in decreased safety.

At the site, we recommend thinning willow density and management for invasives. We also recommend appending guidelines for project planning and monitoring of urban creek restorations into the next version of the Wildcat Creek Restoration Action Plan for the City of San Pablo. We propose the following potential guidelines: centering principles of longitudinal and lateral connectivity, considering site-specific opportunities and constraints; selecting planting palettes appropriate for long term public and ecological use; planning for long-term physical, ecological, and social monitoring; and creating quantitative objectives prior to project implementation.

INTRODUCTION

Creeks in Mediterranean climates provide habitat for unique plant communities as a result of climatic conditions, nutrient availability and cycling, and highly variable flow regimes (Lewis et al., 2009, Kondolf et al., 2013). However, they experience intensive human impacts, which reduce ecological functionality while increasing non-native species frequency (Stella et al., 2013). Meyer et al. (2005) coined the term "urban stream syndrome," to describe general urban stream conditions: high nutrient and pollutant concentrations, flashy hydrographs, low biotic diversity indices, simplified channel morphology, and high presence of tolerant species.

To mitigate human impacts, investments in urban waterway restoration have increased in popularity. Urban restoration projects often seek to increase or restore ecological integrity, achieved when an ecosystem exhibits trophic complexity and species diversity and can sustain itself against persistent disturbances or return to a reference state after temporally limited disturbances (Utz et al., 2016). They often fail to meet this goal, lacking effective long-term monitoring plans and quantitative success metrics. Additionally, sediment and stormwater inputs, often not altered, may reverse restorations, causing bank failure, undercutting, and channel straightening (Bernhardt & Palmer, 2007).

In December 2005, homes on Folsom Avenue near Davis Park in San Pablo, California experienced flooding during a 21-year storm event (Figure 1). Water levels in both Wildcat Creek and nearby San Pablo Creek rose beyond storm drain system capacity (MIT 4.213 Adv. Sem. Urban Nature and City Design, 2012). With community advocacy and existing city consideration, planning for a daylighting project at the park ("the project") began by 2008 (Table 1). Wildcat Creek flows east to west in Davis Park for approximately 1,200 linear feet, eventually draining into San Francisco Bay. Before daylighting, the creek entered the eastern

edge of the park through a buried double culvert, continuing belowground for approximately 550 linear feet. Upstream and downstream of the park, Wildcat Creek flows in an unlined trapezoidal channel, historically modified from its natural condition in 1986 due to flooding (Waterways Restoration Institute, 2001). Lower income, minority communities predominantly populate the flood-prone alluvial plain containing the project area (The Urban Creeks Council, 2010) within the larger Wildcat Creek watershed (Figure 2).

Daylighting projects, such as this one, where a designed streambed replaces a removed culvert, offer particular opportunities in controlling ecological and social benefit. We wanted to analyze change in quantitative ecological benefit of the project, while considering success in objectives and in vertical, lateral, and longitudinal continuity (Kondolf et al., 2006). Project objectives included (1) restoring riparian habitat on the banks, (2) addressing "fish habitat needs which includes a shading canopy with overhanging willow or other riparian low to mid story plants to assure some cover from wildlife predators and human activity" (Wood Biological Consulting, 2014 and The Urban Creeks Council, 2010), (3) enabling the stretch to offset flooding from 100 year flows, and (4) expanding Wildcat Creek Trail, part of a larger effort to create a contiguous trail along Wildcat Creek. We also aimed to supplement the 2010 Wildcat Creek Restoration Action Plan (The Urban Creeks Council, 2010) for the City of San Pablo with top-down guidance for ecologically sound restoration planning.

METHODS

Interviews

First, we contacted Kristen Van Dam, Ecological Services Coordinator for Wildland Vegetation Management at the East Bay Regional Parks District, who introduced us to Karineh Samkian and Rich Walkling. Samkian, an Environmental Program Analyst for the City of San

Pablo Public Works Department, served as the lead biologist from the City of San Pablo to review the project plan and post-project monitoring. Walkling, the Planning Director and Chief Financial Officer for Restoration Design Group, acted as the design project manager. We interviewed Samkian and Walkling on November 3rd, 2022. We asked them questions regarding project objectives, cross section locations, sediment and vegetation maintenance concerns, and the planting selection. We considered their responses in interpretation of our vegetation sampling results, photopoint comparisons, and mapping comparisons.

Literature and Report Review

We reviewed the plans and projects carried out in and around Wildcat Creek and San Pablo Creek to contextualize the project. We created a chronology of events and a table of literature and reports using references provided by our interviewees, Karineh Samkien and Rich Walkling, cross-referencing other mentioned documents, and additional internet searching.

Vegetation Sampling

We conducted eight vegetation cross-sectional surveys to determine species composition of vegetation, using sampling methods based on those suggested by the USDA to monitor riparian vegetation (Winward, 2000). We established eight transects at 50 foot intervals "perpendicular to the grade in a riparian complex in such a way as to cross the entire riparian area" (Winward, 2000). We offset or skipped transects due to encampments (Figure 6). We sampled vegetation on October 31 and November 18, 2022 (Figure 8).

Along the eight transects, we used a line point intercept method at 2 foot intervals to calculate percent surface type cover. We adapted the categories for surface type from California Native Plant Society (2019) protocol for vegetation assessment: water, live vegetation (non-woody), live vegetation (woody), dead vegetation, litter, concrete, trash, boulder (rock

larger than 60 centimeters in the largest dimension), stone (rock between 25 and 60 centimeters in the largest dimension), cobble (rock between 7.5 and 25 centimeters in the largest dimension), gravel (rock between 2 millimeters and 7.5 centimeters in the largest dimension), and fines (bare ground and fine sediment less than 2 millimeters in the longest dimension). We differentiated litter, detached from the original plant, from dead vegetation, connected to the original plant. We rounded each percentage to the nearest whole number. When a point on the intervals fell on live vegetation, either woody or non-woody, we recorded the understory species, strata (tree, sapling, seedling, shrub, herb, or non-vascular), and the number of times a point landed on each species. For overstory, we recorded the species and the number of times we observed each species overhead at 5 foot intervals along each transect. For understory and overstory species, we calculated percent species abundance by dividing total number of individuals of a species by total number of all individuals of all species and multiplying that by 100 for each species.

To evaluate vegetation composition and cover, we compared results from percent cover type, understory species cover and composition, and overstory species composition to the riparian planting schedule in the initial plan (Restoration Design Group, 2012). Additionally, we walked through each planting zone (Figure 6) and compared the original plant schedule in each of the monitored zones (Appendix 1) to the current plant composition of the area. We noted the number of selected species and/or made ocular estimates of the percent cover of each tree, shrub, and groundcover species in planting zones F, M, L, Q, S, R, W, V, and Y.

Bird Survey

We conducted a bird identification count to the species level. This compared bird use of the project area to results of a riparian restoration study in Contra Costa County (Hartman et al., 2009), considering bird use in the fall 2022 migration period. We walked the project area in the

bed of Wildcat Creek and the adjacent Wildcat Creek Trail, counting bird species seen or heard in the area and the number of each. We used the Merlin Bird ID phone app to aid identification.

Our monitoring consisted of two surveys with two observers, between 9AM and 11AM on October 31th and November 18th, 2022. Both surveys began on the south side of the Davis Park Ballfields, crossed the east Davis Park Pedestrian Bridge, went east along the San Francisco Bike Trail, and continued east to the 23rd Street pocket park (Figure 5). Each survey lasted 30-40 minutes and covered 0.4-0.5 miles. We calculated bird abundance (total individual birds per site), bird density (total birds per acre), and species richness (total species per site) on the approximately 1.2 acres (Wood Biological Consulting, 2018).

Photopoint Comparisons

We selected fifteen photopoints on the site for comparison (Figure 7). Restoration Design Group previously monitored each annually, from 2012 to 2017. Each in-bed photo set ("C" points, Appendix 4) contains four sets per point, while each external photo set ("T" points, Appendix 4) contains three. We took photographs midday on November 18th, 2022, from 11AM to 1PM on an iPhone 7. We used the map provided by Restoration Design Group (2015, 2017) to approximate the correct location, then referenced existing photos for precise alignment.

Mapping Comparisons

To plot the current streambed structure, we walked the streambed within the project site and recorded points with the location, width, and azimuth parallel to the channel every 40 feet. We defined width as contiguous bed without encroaching vegetation or significant incline (Figure 3). We also recorded location and width of root wads, vegetation transect locations, encampment locations, and dimensions of an incision. We took geotagged photographs of other notable features. We recorded our approximation of width and characteristics for all riffles.

We compiled this information in ArcGIS 3.0 (Figure 4). We used Google Earth imagery to map vegetation cover and notable site features. We used Restoration Design Group (2012) plans to map planting zones and determine project limits.

RESULTS

Surface Cover & Vegetation

For percent surface cover type, no transect points landed on water or concrete, so we reduced possible surface cover types from 12 to 10 (Table 3). Line point sampling along the transects revealed three main surface cover types: live vegetation (non-woody), live vegetation (woody), and litter. The litter that we found consisted mostly of willows and cottonwood leaves. Transects 2, 4, 7, and 8 had trash for 3-5% surface cover, and all transects, except transect 1, had at least 5% fine surface cover (Table 3).

Algerian ivy (*Hedera canariensis)* had the highest abundance among understory species along the 8 transects, at 26% (Table 4). Veldt grass (*Ehrharta erecta*, 20%), kikuyu grass (*Cenchrus clandestinus*, 12%), and willow (*Salix* spp., 11%) had the next highest abundance among understory species. The least abundant species consisted of California wildrose (*Rosa californica*, 1%), Western thimbleberry (*Rubus parviflorus*, 1%), white alder (*Alnus rhombifolia*, 1%), and French broom (*Genista monspessulana*, 1%) (Table 4).

Willow had the highest abundance among overstory vegetation, consisting of 80% of the overstory (Table 5). The plans showed three willow species planted: Scouler's willow (*S. scouleriana*), red willow (*S. laevigata*), and arroyo willow (*S. lasiolepis*), but the planting schedule did not differentiate location or species planted (Restoration Design Group, 2012) (Appendix 1). The least abundant species consisted of boxelder maple (*Acer negundo*), creek

dogwood (*Cornus sericea*), and Monterey pine (*Pinus radiata*) (Table 5). Canopy covered 95% of the transects, and only Transect 7 had points with no canopy cover (Table 5).

Bird Survey

In our first survey on October 31, we counted sixteen species and 64 individual birds. During our second survey on November 18, we counted 21 species and 60 individual birds. Overall, we observed a species richness of 27 between the two surveys (Table 6). We found 62 birds as the mean bird abundance. We calculated 51.7 birds per acre for bird density.

Photopoint Comparisons

Appendix 4 displays photopoint comparisons over time. Photopoints show substantial vegetation growth, with variability in density. As seen by in-bed photopoints C3 through C9, the willow-dominated canopy has matured and created vertical space within the creek and along the banks. T photopoints show lateral vegetation growth over time, most significantly between 2017 and 2022, towards both the trail to the right and the park to the left.

Invasive plant species encroach the site from the upstream and downstream ends of the daylit section, visible in points C4 and C10. Points T3 and T4 additionally show invasive encroachment from the fence lines atop the high banks to the left. In-bed photopoints show trash throughout the project area (C3 through C9), and we also observed e-waste.

Mapping Comparisons

Figures 1 through 3 illustrate mapping results. The bed has shifted (Figure 5 vs. Figure 8); some straightening has occurred from the orange numbers 1 to 2 and 4 to 5, as labeled in Figure 8. An in-bed incision has occurred just east of the bridge (Figure 5). This begins in the streambed about 20 feet east of the Davis Park pedestrian bridge, with the cut extending 19 inches deep into the bed and 13 inches wide, and beginning approximately nine feet downstream

from riffle 5. The root wads have stayed intact, but the left bank near root wad 3 (Figure 7, farthest downstream) appears cut down 12-18 inches below the root wad. Cobble and gravel from the riffle covers some of the cut bottom. The streambed has scoured and slightly increased the grade downstream of the riffle. Three encampments currently sit on the banks, one on the right and two, more permanent, on the left (Figure 7).

All riffles shifted downstream, as detailed in Table 7. In riffle 3, boulders aggregated or washed downstream and the riffle migrated downstream 20 to 30 feet, now ending at the midpoint of root wad 2 (Figure 8). An encampment sits above riffle 3 on the left bank. Only one boulder remains in riffle 5. The other boulders have aggregated or washed downstream; we observed 4 boulders 20 feet downstream of the pedestrian bridge. A deteriorated mattress and major debris sit in the middle of riffle 5, 18 inches above the streambed. This creates a partial check dam, with the left side cut around the dam.

DISCUSSION

Surface Cover & Vegetation

The prevalence of leaf litter, trash, and fine sediment surface cover types correspond to high levels of human use and encampments. The City of San Pablo clears obstructions from the creekbed, including encampments and large debris, each year before September rains (K. Samkian, Environmental Program Analyst, Public Works Dept, City of San Pablo, personal communications, Nov 3, 2022); however, smaller trash and residual human impacts persist, in the form of trails and bare ground from tents or tarpaulins. We estimate that 25% of the left bank longitudinal corridor and floodplain on the lower half of the project area consists of bare ground.

The Regional Water Quality Control Board required doubled willow planting in the bank top fascines, with the intention of improving ecological quality. The 560 willows planted along

the creek, as well as cottonwoods and alders, have created a dense overstory with little sunlight and open space (Table 5). Extensive overstory vegetation decreases sightlines, often ideal for encampments (R. Walkling, Planning Director & CFO, Restoration Design Group Inc., Berkeley, CA, personal communications, Nov 3, 2022). Furthermore, willows only live around 20 to 25 years (R. Walkling, Planning Director & CFO, Restoration Design Group Inc., Berkeley, CA, personal communications, Nov 3, 2022). The willows planted in 2012 will likely live for another 10 to 15 years, after which they may die and fall, a risk for those who shelter there or recreate nearby. The number of willows planted and proximity of the creek to the trail and park exacerbate this hazard. We observed some juvenile willow, creek dogwood, and white alder trees along the bank and flood plain (Appendix 2), but shade and competition may impede their survival and maturation.

The Regional Water Quality Control Board additionally mandated the extent of understory planting, a cost not yielding long term benefit. Despite over 200 creek dogwoods (*Cornus sericea*) and over 200 California blackberries initially planted, we observed few (Appendix 1 and 2). Other shrubs planted in 2013 and minimally observed included snowberry (*Symphoricarpos albus*), coyote brush (*Baccharis pilularis*), and California rose (*Rosa californica*). Groundcover and vining species planted represented very little of the understory. High mortality of the planted shrubs and groundcover most likely comes from the destruction of plants and increased soil compaction from extensive human activity in the area, shading from the overstory, and invasive competition; this agrees with observations by Samkian and Walking (K. Samkian, Environmental Program Analyst, Public Works Dept, City of San Pablo, personal communications, Nov 3, 2022 and R. Walkling, Planning Director & CFO, Restoration Design Group Inc., Berkeley, CA, personal communications, Nov 3 and 8, 2022). Invasive species, such

as Algerian ivy, Himalayan blackberry, and non-native grasses can easily outcompete native and planted understory species. Samkian noted that invasive ivy and blackberry also contribute little to erosion prevention due to short root systems. Other notable invasive species found on site included French broom (*Genista monspessulana*), blackwood acacia (*Acacia melanoxylon*), and fennel (*Foeniculum vulgare*).

We conducted vegetation surveys at the beginning of the dormant and non-productive season for many riparian species planted in the project area. Therefore, we note that our study may have found fewer species than present on site, with more species following winter rains and in spring.

Bird Survey

We used the bird survey as an additional indicator to measure ecological diversity and restoration success. We compared our results to the Hartman et al. (2009) study, which examined bird response to urban riparian restoration and identified factors promoting greater bird benefits through restoration. The 2009 study took place at five riparian restoration sites in Contra Costa County, California: (1) Rheem Creek at Contra Costa College, (2) Wildcat Creek at Rumrill Avenue, (3) Lower Wildcat Creek at Verde School, (4) Baxter Creek at Poinsett Park, and (5) Baxter Creek at Booker T. Anderson Jr. Park.

This project area supported bird life comparably to the Hartman et. al (2009) study. We observed mean bird abundance of 62 birds, bird density of 51.7 birds per acre, and species richness of 27 species. In comparison, Hartman et al. (2009) found bird density at restored sites ranged from 4.4 to 45.8 birds/acre and species richness ranged from 9 to 22 species. We conducted two samples of 30 to 40 minute surveys over two weeks in the fall season. In comparison, the 2009 study consisted of five to twenty minute surveys at five sites over eleven

sampling periods in the spring migration, nesting, and summer season. However, differences in sampling schema, time of year, and habitat could confound comparison of the two studies.

Hartman et al. (2009) found benefits of restoration efforts to riparian bird communities vary depending on many factors, including type of restoration, time since restoration, patch size, degree of connectivity, vegetation features, surrounding land use, and water flows. Area of their study sites ranged from 0.24 to 3.47 acres, while our project created over 1.2 acres of nearly continuous riparian habitat. Hartman et al. (2009) also positively correlated restoration age (7-13 years) to the likelihood of supporting greater bird abundance, density, species richness and diversity. With 9 years since restoration in the project, current bird abundance and richness should reflect approximate capacity.

Similar in size to the second largest Harmon et al. (2009) sites, the project site parallels the 2009 finding that larger sites support greater bird diversity. However, in contrast to the 2009 study, our findings imply that a 1.2 acre site can have high bird density. Habitat patch size and land pattern can directly influence probability of occurrence and abundance of a particular species (Hartman et al., 2009). We speculate that the relatively small restored area, surrounded by a large light commercial, residential, and open recreational area, may create an island-like concentration of resources for birds.

Photopoint Comparisons

Photopoints show current obstruction of visual continuity between the trail, creekbed, and park, paralleling the vegetation map (Figure 6). 2015 marked a notable change to decreasing visibility (Appendix 4 and Figure 9). From 2015 to 2017, growth of dense, young willows continued. This density may have discouraged some human use. However, due to the vertical growth since 2017, humans can now easily navigate the creek bed and banks, making them more

desirable for unhoused people (Figure 9). We observed long-term human use in multiple locations (Figure 7). Vegetation growth may benefit species in the creek during flow that require shade, supporting the objective of fish habitat, and additionally provide habitat for birds and mammals. However, vegetation and fencing currently fail to prevent intensive human impacts on the understory, not meeting that objective. Vegetation sampling data supports the encroachment of invasive plant species visible in photopoints. Evident invasive species growth poses a long term, continuous management issue. The accumulation of waste seen poses a pollution issue, likely contributed to by unhoused people (Figure 10). Human use has likely caused the observed bank compaction throughout the site, as visible on the left bank in Figure 9.

Mapping Comparisons

Expansion of vegetation from initial idealizations (Appendix 3), shown through mapping aerial vegetation (Figure 6) over time, has resulted in nearly contiguous overstory habitat. However, this canopy homogeneity, with minimal sunlight reaching the creek bed, may provide less potential habitat diversity. Lateral growth may also pose a maintenance hazard as it encroaches over the trail and field.

Heterogeneity of bed width has overall remained since project implementation. We hypothesize that the in-bed incision (Figure 5) may result from a shift in soil, in type or compaction, or a decrease in bank width from the project site to downstream off-project. Wood Biological Consulting (2018) reported in 2017 that the channel (riffles and runs) experienced minor adjustments of less than a foot, with some areas aggregating and some incising. Riffles have now migrated significantly, ten feet or more (Table 7, Figure 7), with large boulders shifting downstream. The project plan (Restoration Design Group, 2012) shows layered brush backing the root wads, allowing willows to establish. We found mostly bare ground in the three areas

up-slope of each root wad; informal trails pass through or upstream of each, showing human impact on the project objectives. The noted cutting down of the left bank below root wad 3 (Figure 8) could indicate that the pool underneath the root wad has extended and the streambed grade has increased in riffle 5. These areas may need planting to prevent erosion during a wet year. Movement of boulders could have arrived from either bank erosion upstream of the project or from the project's original riffles. Overall, we preliminarily consider the flood risk objective met, and have no significant concerns about the creek structure shifting (Figure 5 vs. Figure 8). We expected natural movement of riffles and the creek bed, and some straightening due to the urbanized area.

CONCLUSIONS

The project successfully increased longitudinal connectivity of the Wildcat Creek Trail and riparian habitat, as well as vertical connectivity of the streambed. The trail drew more people into Davis Park and the surrounding area (K. Samkian, Environmental Program Analyst, Public Works Dept, City of San Pablo, personal communications, Nov 3, 2022), and serves as an additional piece of the expanding urban greenway. The project also had a relatively strong monitoring plan, although the Regional Water Quality Control Board waived the second half of monitoring due to budget constraints. Overall, the robust initial monitoring allowed for more ease and accuracy in appraisal than the typical restoration project. The project created a riparian vegetation community, providing habitat to support bird abundance, density, and species richness. The stretch maintains the capacity for 100 year flood flow from our preliminary analysis, fulfilling community need for increased flood protection.The project has generally met its objectives, but could benefit from future maintenance and public engagement.

Nonetheless, the project fell short in some regards. Regional Water Quality Control Board regulations included doubling the number of willows and intensive understory planting requirements, which hindered Restoration Design Group's project visualization and created the following issues. Lack of bank to bank visibility facilitates dumping and encampments and can make park or trail feel unsafe for some individuals. Designers created no areas within the daylit stretch for casual public interaction with the creek; however, the site receives extensive, unintended human use due to the density of vegetation. The majority of the planted understory died or decreased in composition due to willow shading, competition from non-native species, and human use, proving a wasted investment. Vegetation would benefit from increased diversity and heterogeneity throughout the project area. Additionally, a lack of quantified project objectives led to difficulty in directly quantifying success.

We suggest the following actions, summarized in Figure 11. For project site action, we recommend thinning willow density. This would lower maintenance investments, especially adjacent to the trail and park, and increase visibility and safety. We also recommend removing non-native species to increase the success of planted understory species. For potential actions in developing broader guidelines, we propose appending the following recommendations for project planning and monitoring to "Recommended Actions" within the Wildcat Creek Restoration Action Plan (The Urban Creeks Council, 2010) for the City of San Pablo. First, urban restoration projects should center principles of longitudinal and lateral connectivity in planning, considering site-specific opportunities and constraints. Effective restoration must consider watershed-level geomorphic issues, such as altered sediment budgets, as well as human use. Second, planners should select planting palettes in consideration of long term change and the urban setting, providing public and ecological benefit. By visualizing vegetation growth over

time, stakeholders may better understand projects, and planners may make planting choices that better meet objectives. Considering multiple, adaptive planting phases may yield better survival. Plans also need to consider invasive species an inevitable reality. Third, plans should include long-term monitoring, considering physical, ecological, and social monitoring to manage adaptively. Photopoint monitoring yields cheap and highly effective results for understanding change over time. Social monitoring, engaging with community members, rarely happens, but could provide great insight into project issues not seen by managers or planners. An involved community may also better support ecological stewardship. Fourth, plans should ideally budget cost-effective, long-term monitoring prior to implementation, creating clear objectives and a monitoring plan in advance. With future post-project analyses, the Action Plan can continue to better adapt specific guidance beyond our preliminary outline.

REFERENCES

Bernhardt, E. S., and M. A. Palmer. 2007. Restoring streams in an urbanizing world. *Freshwater Biology*, 52(4), 738–751. https://doi.org/10.1111/j.1365-2427.2006.01718.x

California Native Plant Society. 2019. CDFW-CNPS Protocol for the Combined Vegetation Rapid Assessment and Relevé Field Form.

Collins, L. M., R. M. Grossinger, L. J. McKee, A. Riley, and J. N. Collins. 2001. Wildcat Creek Watershed: A Scientific Study of Physical Processes and Land Use Effects. SFEI Contribution No. 363. San Francisco Estuary Institute: Richmond, CA.

Hartman, A., J. Demers, J. Scullen. 2009. Bird Use of Urban Riparian Restoration Sites in Contra Costa County, CA: 2009 Interim Report. San Francisco Bay Bird Observatory.

Heller, A. 2017. Wildcat Creek Restoration and Greenway Trail. California State Coastal Conservancy.

Lewis, H., T. K., J. D. Schade, and N. B. Grimm. 2009. Biogeochemical Function and Heterogeneity in Arid-Region Riparian Zones. Digital Commons @ University of South Florida.

Kondolf, G. M., A. Boulton, S. O'Daniel, G. Poole, F. Rahel, E. Stanley, E. Wohl, A. Bång, J. Carlstrom, C. Cristoni, H. Huber, S. Koljonen, P. Louhi, and K. Nakamura. 2006. Process-Based Ecological River Restoration: Visualizing Three-Dimensional Connectivity and Dynamic Vectors to Recover Lost Linkages. *Ecology and Society*, *11*(2). https://doi.org/10.5751/ES-01747-110205

Kondolf, G. M., K. Podolak, and T. E. Grantham. 2013. Restoring mediterranean-climate rivers. *Hydrobiologia* 719:527–545.

Meyer, J. L., M. J. Paul, and W. K. Taulbee. 2005. Stream ecosystem function in urbanizing landscapes. Journal of the North American Benthological Society, 24(3), 602–612. https://doi.org/10.1899/04-021.1

MIT 4.213 Adv. Sem. Urban Nature and City Design. 2012. Urban Stream Daylighting and Restoration - The evolution of long term project management for four urban watersheds in the East San Francisco Bay Area.

Restoration Design Group. 2012. Wildcat Creek Daylighting at Davis Park: Creek Restoration and Site Improvement Plans.

San Francisco Estuary Institute. 2001. Wildcat Creek Watershed - A Scientific Study of the Physical Processes and Land Use Effect.

Stella, J. C., P. Rodríguez-González, S. Dufour, and J. Bendix. 2013. Riparian vegetation research in Mediterranean-climate regions: common patterns, ecological processes, and considerations for management. *Hydrobiologia* 719:291–315.

The Urban Creeks Council. 2010. Wildcat Creek Restoration Action Plan: Version 1.3.

Utz, R. M., K. G. Hopkins, L. Beesley, D. B. Booth, R. J. Hawley, M. E. Baker, M. C. Freeman, and K. L. Jones. 2016. Ecological resistance in urban streams: The role of natural and legacy attributes. *Freshwater Science*, 35(1), 380–397. https://doi.org/10.1086/684839

Walkling, R. 2015. 2015 Geomorphic Monitoring Report.

Walkling, R. 2017. 2017 Geomorphic Monitoring Report.

Waterways Restoration Institute. 2001. Lower Wildcat Creek Restoration Project: Designed and Constructed in 2000 Richmond, CA.

Winward, A. H. 2000. Monitoring the vegetation resources in riparian areas. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. https://doi.org/10.2737/RMRS-GTR-47

Wise, S., P. Alexander, and M. Graul. 2007. Fisheries Habitat Inventory & Assessment for Lower Wildcat Creek. East Bay Regional Park District.

Wood Biological Consulting, Inc. 2014. Riparian Restoration Monitoring Report for the Wildcat Creek Daylighting Project at Davis Park, City of San Pablo, Contra Costa County.

Wood Biological Consulting, Inc. 2018. Riparian Restoration Monitoring Report for the Wildcat Creek Daylighting Project at Davis Park, City of San Pablo, Contra Costa County.

FIGURES

Table 1. Chronology of Events Pertinent to the Davis Park Daylighting Project.

1921	Jewel Lake, in the upper canyon, built as a reservoir.
1938	Lake Anza, in the middle canyon, formed from the creation of Tilden Park Dam. Both Jewel Lake and Lake Anza serve as sediment impoundments and barriers to fish passage (The Urban Creeks Council, 2010).
1955	First major flood of Wildcat Creek in this century. (SFEI, 2001)
1982	Second major flood of Wildcat Creek in this century, with a new lobe of silt and sand deposited across the backshore of Wildcat Marsh. (SFEI, 2001)
1984	Urban Creeks Council co-founded by Ann Riley and Carole Schemmerling, to suggest alternatives to a proposed concrete flood control channel in North Richmond.
1986	Wildcat-San Pablo Creeks Watershed Council founded, motivated by “address(ing) recurring flood damages. . . and to develop a strategy for flood protection and stormwater management while protecting and enhancing the riparian and instream habitat and recreational resources” (The Urban Creeks Council, 2010).
6/2001	San Francisco Estuary Institute completes "Wildcat Creek Watershed: A Scientific Study of Physical Processes and Land Use Effects,” the first watershed level analysis of its kind.
2004	Development of a comprehensive Wildcat Creek Restoration Action Plan by the Urban Creeks Council for the Wildcat-San Pablo Creeks Watershed Council begins, with funding from (The Urban Creeks Council, 2010).
12/2005	Homes on Folsom Avenue near Davis Park experienced flooding as a result of a 21-year storm event. Water levels in both Wildcat Creek and nearby San Pablo Creek became too high for flood waters to flow into the storm drain system.
2008	Earliest known development of project plans at Davis Park by Restoration Design Group (The Urban Creeks Council, 2010, p. 34).
4/26/2010	Urban Creeks Council publishes the Wildcat Creek Restoration Action Plan, a watershed level document recommending future projects.
5/11/2012	Restoration Design Group finalized bid set for Davis Park daylighting project.
7/11/2012	First monitoring survey by Restoration Design Group took place.
7/2012	Davis Park daylighting project broke ground.
1/22/2013	Second monitoring survey by Restoration Design Group took place.
9/2013	Left bank failure occurred downstream of Davis Park occurred directly downstream of the daylighting project during construction, as well as failure of the bridge to the west - repaired by the city.

10/30/2013	Channel work completed on Davis Park daylighting.
11/2013 to 12/2013	Vegetation planting begins and completes at the project site.
12/2013	First monitoring survey by Wood Biological Consulting took place.
9/22/2014	Third monitoring survey by Restoration Design Group took place.
12/2014	Second monitoring survey by Wood Biological Consulting took place.
11/25/2015	Fourth monitoring survey by Restoration Design Group took place.
12/2015	Third monitoring survey by Wood Biological Consulting took place.
2015	Mini-park built off 23rd street park directly upstream of the daylit stretch, connecting Wildcat Creek Trail to 23rd street and increasing longitudinal continuity.
11/16/2016	Fifth and last monitoring survey by Restoration Design Group took place.
12/2016	Fourth monitoring survey by Wood Biological Consulting took place.
12/2017	Fifth and last monitoring survey by Wood Biological Consulting took place.
11/4/2022	We sampled vegetation with transects and mapped the stretch.
11/18/2022	We captured geophotos, survey planting zones, and survey birds at the site.

Table 2. Relevant Publications to the Davis Park Daylighting Project.

Author (Date Published)	Document Title	Analyses	Conclusions
Waterways Restoration Institute (2001)	Lower Wildcat Creek Restoration Project: Designed and Constructed in 2000 Richmond, CA	Discusses history of Lower Wildcat Creek and applied restoration project.	Informs about new design parameters for the channel upstream and downstream of 3rd St, directly below Davis Park.
San Francisco Estuary Institute (6/01)	Wildcat Creek Watershed - A Scientific Study of the Physical Processes and Land Use Effects	Analyzes comprehensive, watershed-level physical conditions in the Wildcat Creek Watershed.	Effectively quantifies conditions throughout the watershed, creating baseline data critical for future reference. Projects trends in physical change. Notes management of sediment must include consideration of short and long term inputs. Proposes continued research and monitoring program.
East Bay Regional Park District (2/07)	Fisheries Habitat Inventory &	Study designed to identify and assess barriers to salmonid migration, identify existing	Evaluates migrational barriers at nine sites, including Davis Park, and concludes that further study of water

	Assessment for Lower Wildcat Creek	spawning and rearing habitat, assess existing fisheries populations & suggest enhancement to existing habitat conditions.	velocity, community investment, and riparian buffer zones beneficial.
The Urban Creeks Council (4/26/10)	Wildcat Creek Restoration Action Plan ver 1.3 (WRAP)	Watershed-focused planning document for Wildcat Creek Restoration within the City of San Pablo. Physical, hydrologic, and biological conditions along Wildcat Creek assessed.	Identifies a priority-based series of restoration projects to best fit goals of flood damage reduction along with riparian function. Recommends replacement of restrictive stream structures, planning for 100 year flows, improving stormwater management, removing fish barriers, and connecting Wildcat Creek Trail.
MIT 4.213 Adv. Sem. Urban Nature and City Design (2012)	Urban Stream Daylighting and Restoration	Describes evolution of long term project management for four urban watersheds in East San Francisco Bay Area, including the Wildcat Creek Watershed.	For the Wildcat Creek Watershed, to meet the goals of reducing flooding, improving habitat, and increasing opportunities for recreation, recommends removing in-stream structures that constrict flow and add open span bridge structures
Restoration Design Group (12/21/15)	2015 Annual Geomorphic Monitoring Report for the Wildcat Creek Daylighting Project	Provides the 2015 annual monitoring report, including cross section data and management recommendations.	Given the lack of storm events since the daylighting, notes little instability or geomorphic issues. Identifies some sediment deposition and mild incision but no erosion.
Coastal Conservancy (9/28/17)	Wildcat Creek Restoration and Greenway Trail	Identifies a need to provide urban access to green space in the surrounding community.	Recommends widening and restoring 2,200 linear feet of Wildcat Creek, to construct a bicycle and pedestrian greenway trail.
Restoration Design Group (9/23/17)	2017 Annual Geomorphic Monitoring Report for the Wildcat Creek Daylighting Project	Provides the 2017 annual monitoring report, including long profile, photo monitoring, and management recommendations.	Similar to 2015, notes little instability and no erosion. Recommends a vegetation management plan, as the overstory matures and becomes more dense to thin the overstory, increasing site lines.
Wood Biological Consulting, Inc. (2018)	Riparian Restoration Monitoring Report for the Wildcat Creek Daylighting Project at Davis Park: City of San Pablo, Contra Costa County	Displays monitoring comparisons of photopoints from December 2013, 2014, 2015, 2016, and 2017.	Reveals the vegetative and geomorphic conditions of the daylighting project over time.

Table 3. The percent surface cover type shown rounded to the nearest percent whole number, with each transect having a total of 100%.

Transect number	Live vegetation (non-woody)	Live vegetation (woody)	Dead vegetation	Litter	Trash	Boulder (>60cm)	Stone (>25-60cm)	Cobble (>7.5-25cm)	Gravel (>2mm-7.5cm)	Fines (<2mm)
1	22	33	0	41	0	0	0	0	4	0
2	34	17	9	14	3	0	3	3	3	14
3	42	16	0	26	0	0	3	3	5	5
4	47	12	0	26	3	3	0	0	0	9
5	33	7	7	30	0	0	0	4	0	19
6	29	29	5	18	0	0	0	3	0	16
7	24	3	11	38	5	0	0	3	0	16
8	0	29	7	42	3	0	0	0	3	16

Table 4. Understory species abundance. Species sorted in the table from highest to lowest abundance by percent.

Understory common name	Understory scientific name	Percent abundance
Algerian ivy	*Hedera canariensis*	26
Veldt grass	*Ehrharta erecta*	20
Kikuyu grass	*Cenchrus clandestinus*	12
Willow	*Salix spp.*	11
Valley sedge	*Carex barbarae*	10
Himalayan blackberry	*Rubus armeniacus*	9
California blackberry	*Rubus ursinus*	8
California wildrose	*Rosa californica*	1
Western thimbleberry	*Rubus parviflorus*	1
White alder	*Alnus rhombifolia*	1
French broom	*Genista monspessulana*	1

Table 5. Overstory species abundance. The common and scientific names for each overstory species provided. The species sorted in the table from highest to lowest abundance by percent rounded to the nearest whole number. The number of times each species found along the transect found in Appendix 2.

Overstory common name	Overstory scientific name	Percent abundance
Willow	*Salix* spp.	80
White alder	*Alnus rhombifolia*	6
Fremont cottonwood	*Populus fremontii*	4
No canopy cover		4
Boxelder maple	*Acer negundo*	2
Creek dogwood	*Cornus sericea*	2
Monterey pine	*Pinus radiata*	2

Table 6. Bird observations from October 31 and November 18, 2022.

Common Name	Scientific Name	Oct 31	Nov 18
Rock Pigeon	*Columba livia*	0	2
Canada Goose	*Branta canadensis*	7	0
Anna's Hummingbird	*Calypte anna*	2	3
Ring-billed Gull	*Larus delawarensis*	4	1
Red shouldered Hawk	*Buteo lineatus*	0	1
Downy Woodpecker	*Dryobates pubescens*	0	1
Black Phoebe	*Sayornis nigricans*	1	2
California Scrub-Jay	*Aphelocoma californica*	0	5
American Crow	*Corvus brachyrhynchos*	5	12
Common Raven	*Corvus corral*	0	2
Chestnut-backed Chickadee	*Poecile rufescens*	2	2
Ruby-crowned Kinglet	*Corthylio calendula*	0	1
Red-breasted Nuthatch	*Sitta canadensis*	0	1
Bushtit	*Psaltriparus minimus*	7	0
Bewick's Wren	*Thryomanes bewickii*	1	1
Hermit Thrush	*Catharus guttatus*	0	1
American Robin	*Turdus migratorius*	2	1
Cedar Waxwing	*Bombycilla cedrorum*	3	0
House Sparrow	*Passer domesticus*	8	0
House Finch	*Haemorhous mexicanus*	7	0
White-crowned Sparrow	*Zonotrichia leucophrys*	6	6
Golden-crowned Sparrow	*Zonotrichia atricapilla*	2	0
Song Sparrow	*Melospiza melodia*	0	5
California Towhee	*Melozone crissalis*	0	1

Orange-crowned Warbler	*Leiothlypis celata*	0	1
Yellow-rumped Warbler	*Setophaga coronata*	6	10
Townsend's Warbler	*Setophaga townsendi*	1	1
# of Species		**16**	**21**
# of Individuals		**64**	**60**

Table 7. Observed Riffles on November 18, 2022. Riffle numbers correlate to Figure 8.

	Riffle 1	**Riffle 2**	**Riffle 3**	**Riffle 4**	**Riffle 5**
Length	40 ft	60 ft	40 ft	32 ft	43 ft
Width - Widest	12.5 ft	7.5 ft	12.2 ft	11.3 ft	16.1 ft
Width - Narrowest	10.7 ft	5.5 ft	10.5 ft	7.2 ft	9.9 ft
# Boulders in place	2	2	0	3	1
Boulder height above bed	9.75 in	5.5 in	NA	3.4 in	1.5 in
Comments	Full of cobble and gravel. Cobble build-up upstream of the riffle.	Upstream portions of the riffle washed downstream.	Boulders either buried or washed downstream. Riffle migrated downstream. Riffle ends at root wad 2. Urban camp sits above riffle on left bank. No understory plants on or near campsite bank, bank top or floodplain.	Riffle now situated between two occupied campsites.	Boulders either buried or washed downstream. Mattress and major debris in the middle of the riffle sits 18 inches above the streambed. Creates a partial check dam with a left side cut around the dam.

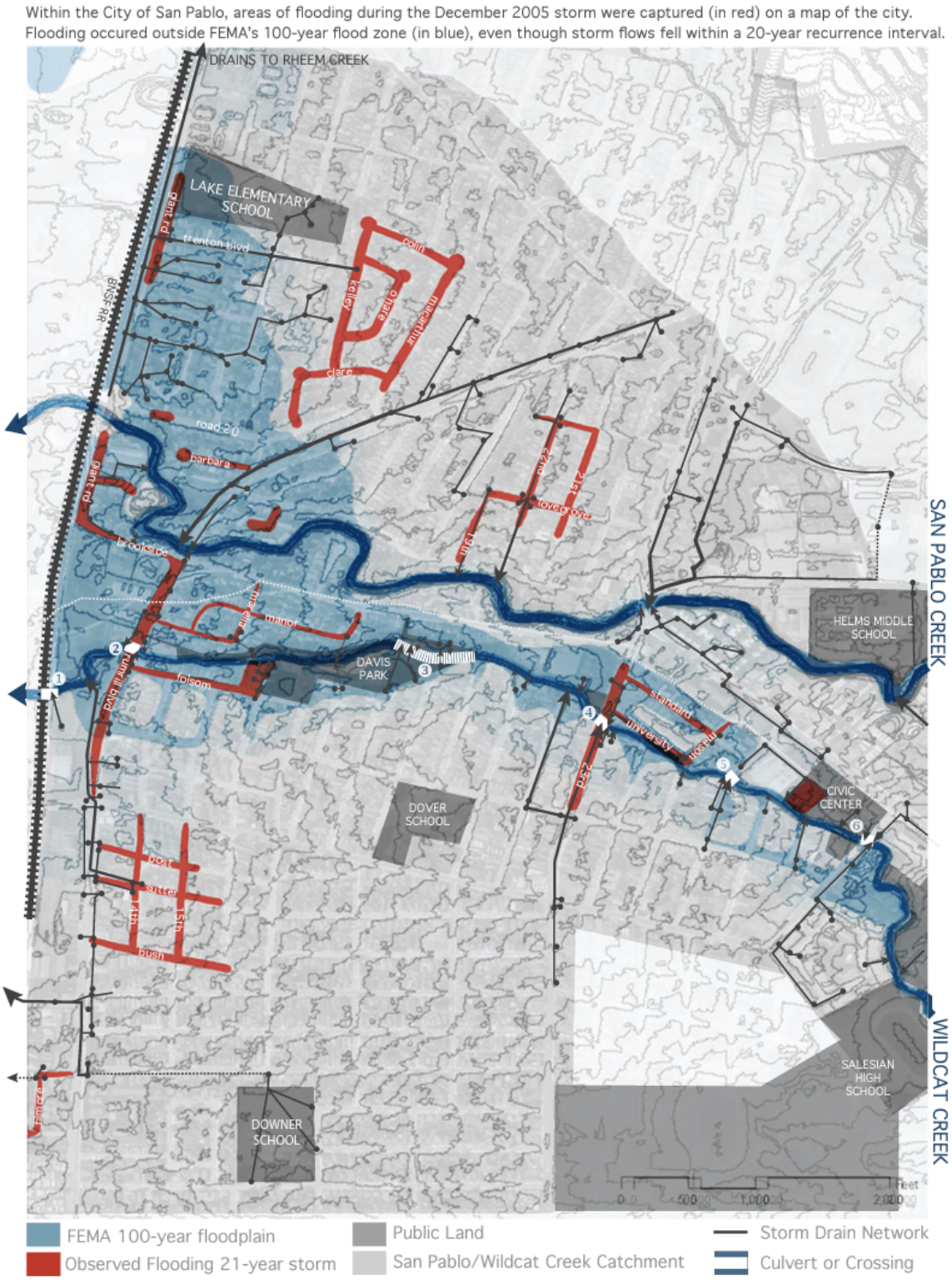


Figure 1. Map from 2010 Wildcat Creek Restoration Action Plan (The Urban Creeks Council, Figure 7-5) depicting flooding from the 2005 21-year storm event, noting our project site, Davis Park.

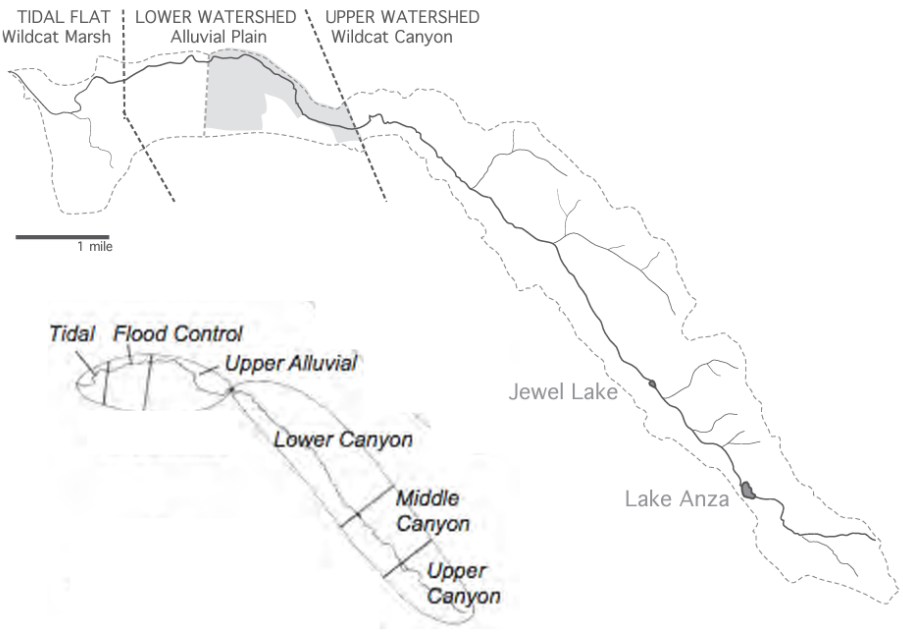


Figure 2. Map from 2010 Wildcat Creek Restoration Action Plan (The Urban Creeks Council, 2010, Figure 2-3) depicting the Wildcat Creek Watershed. The lower watershed contains our project site.

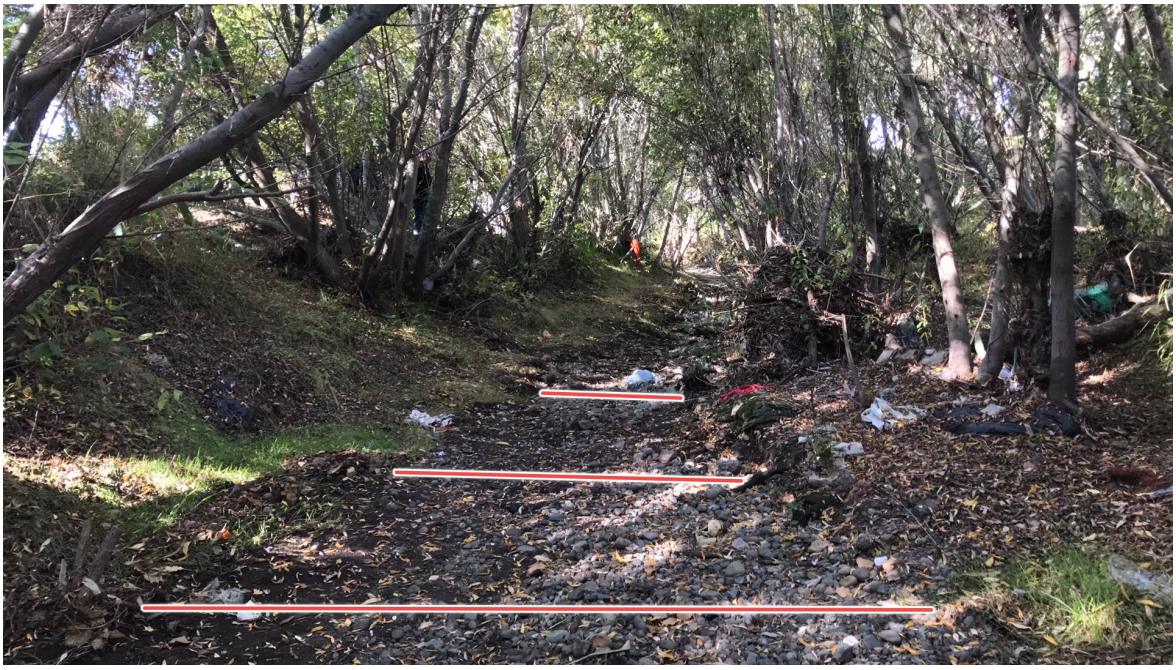


Figure 3. Example of how we measured width on site, with three theoretical measurements in red (image from C6 downstream, Appendix 4).

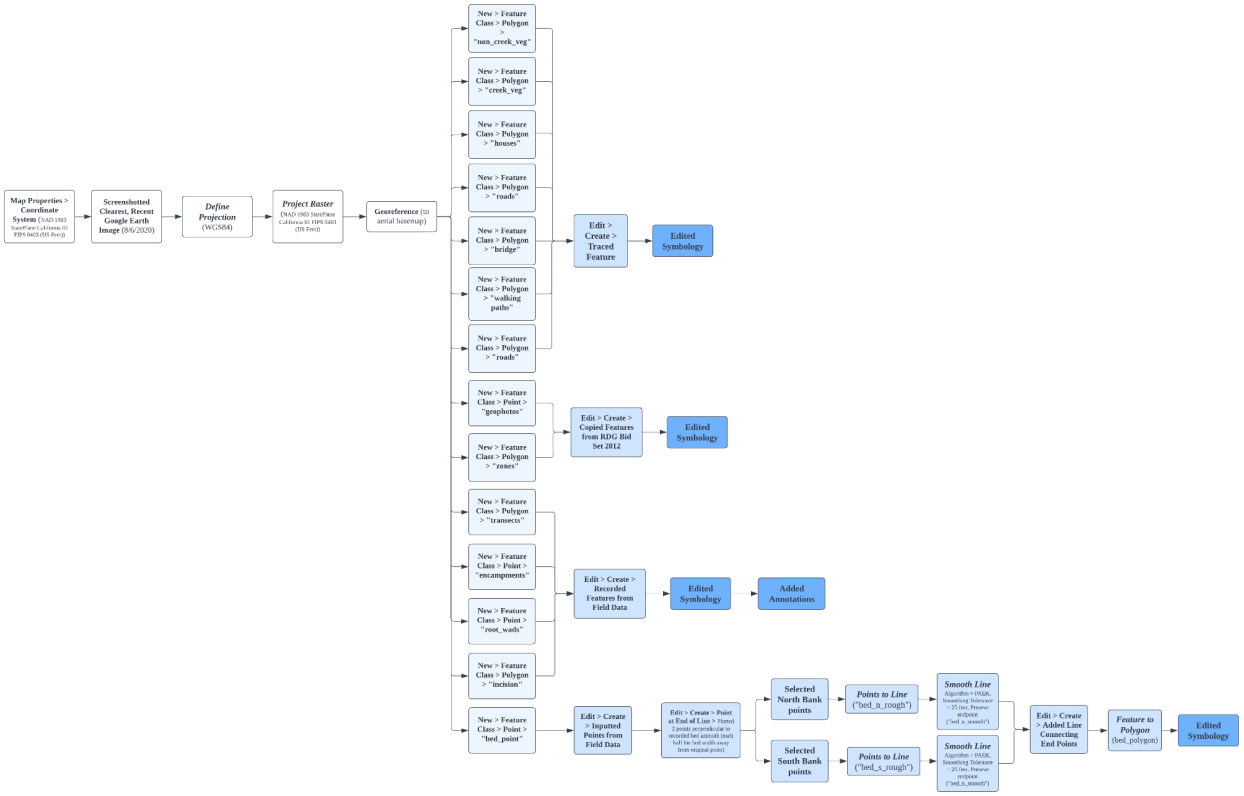


Figure 4. Flowchart depicting mapping process in ArcGIS Pro.

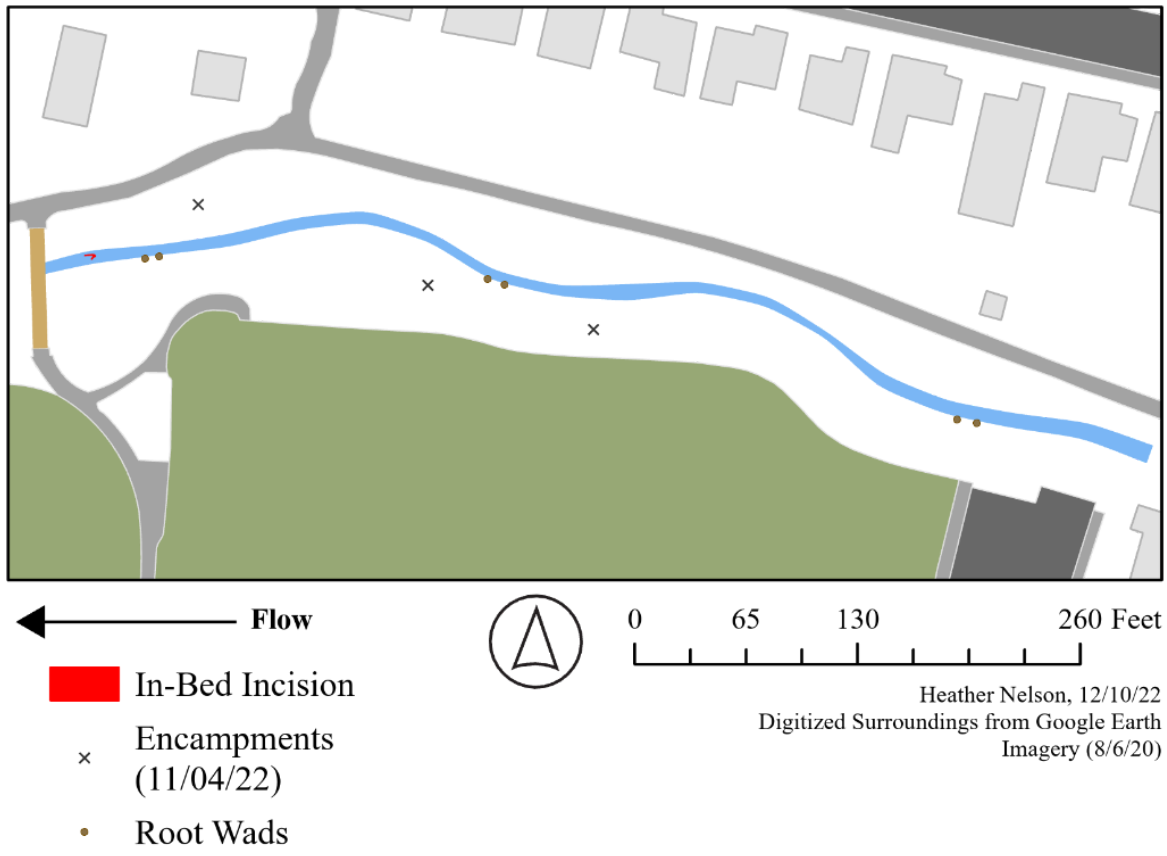
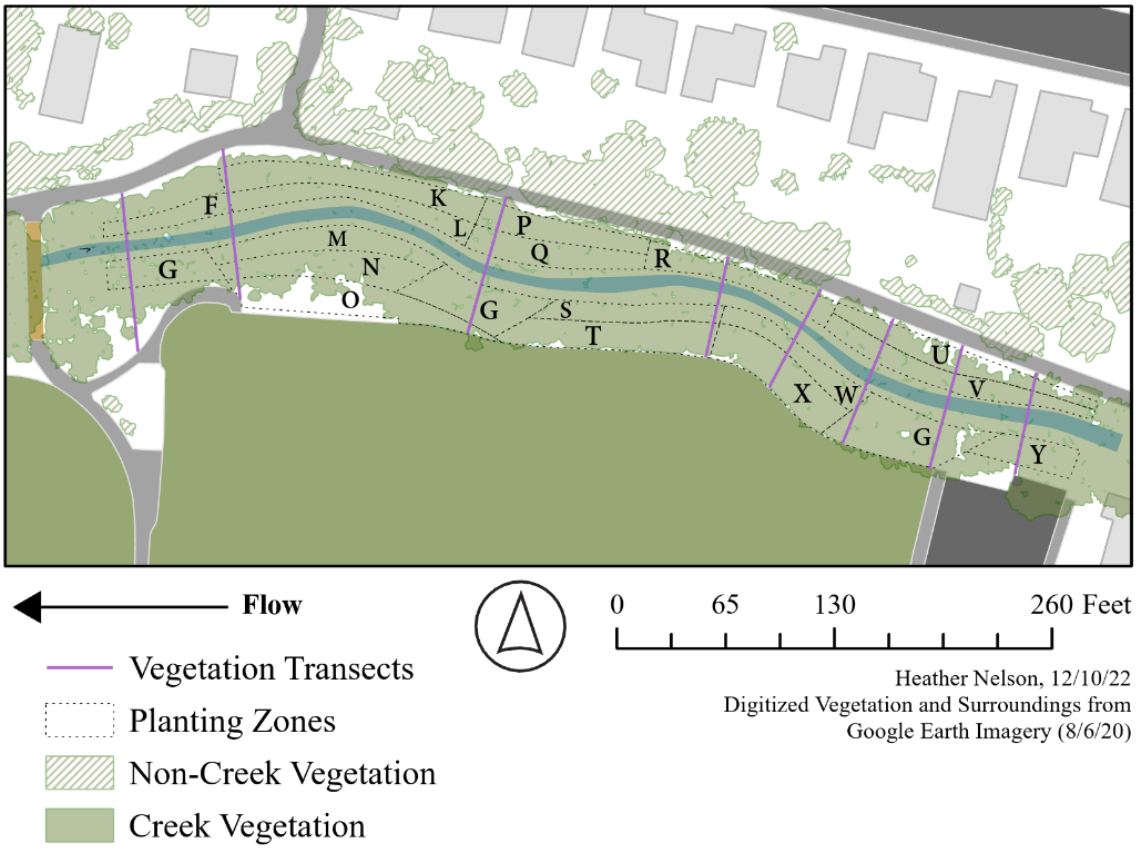




Figure 5. Map of current creek bed and features of project site, with photograph of in-bed incision.



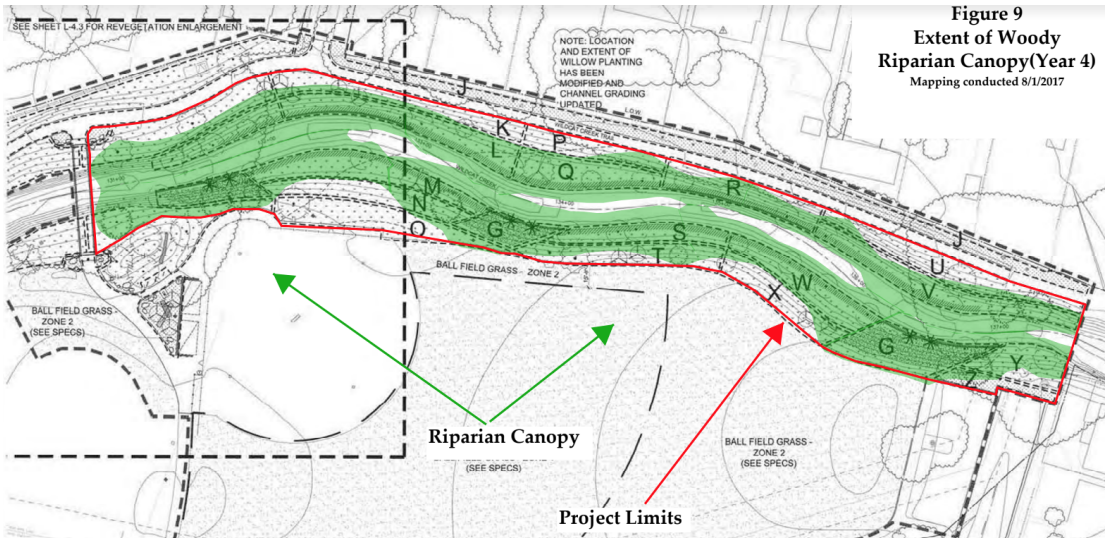


Figure 6. Canopy cover from 2017 project monitoring (top) by Wood Biological Consulting and canopy cover in 2020 (bottom).

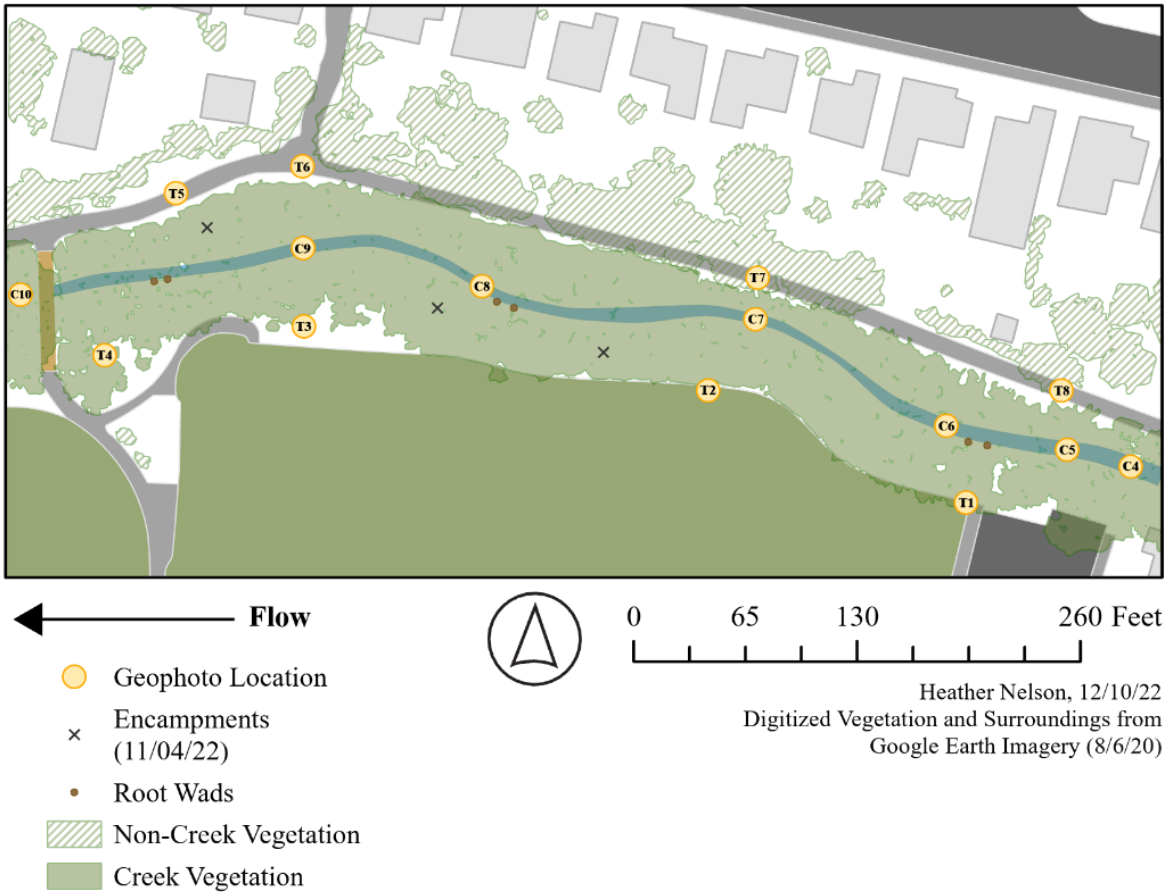


Figure 7. Photopoint map of project site (corresponds to photos in Appendix 4).

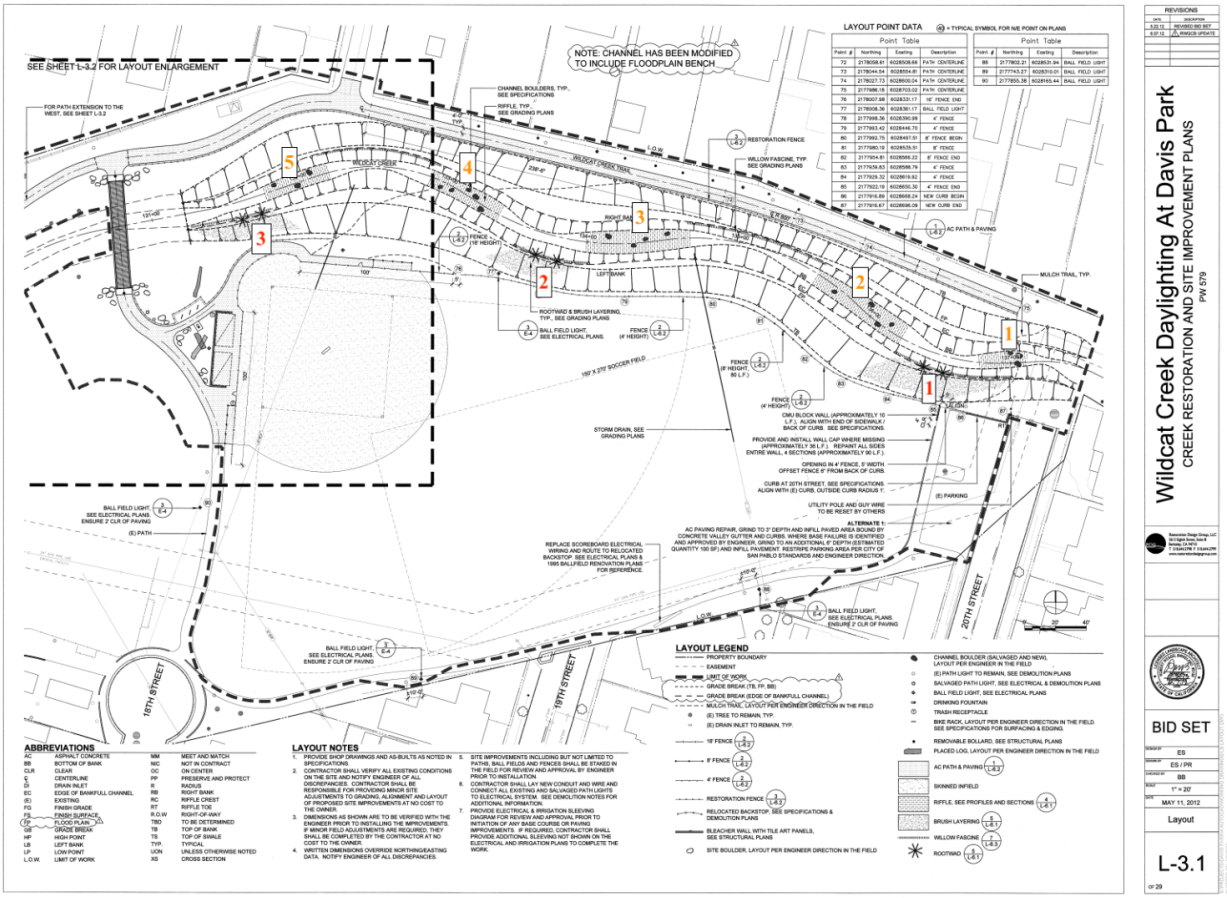


Figure 8. Restoration Design Group (2012) Site Design, with added labels for riffle numbers – in red – and root wad numbers – in orange – as referenced.



Figure 9. Two examples of vegetation change, from C6 downstream (top) and T1 cross-stream (bottom) between 2013 (project implementation), 2017, and 2022. With willow maturation, human mobility on the banks has increased, in conjunction with visual disconnectivity from the trail and field to the creek bed (full photopoint results in Appendix 4).



C4, Downstream: November 18, 2022



C6, Downstream: November 18, 2022



C8, Upstream: November 18, 2022



C10, Upstream: August 11, 2017



C10, Upstream: November 18, 2022



C8, Right Bank: November 18, 2022

Figure 10. Examples of trash throughout photopoints, particularly in 2022 when the willows had matured further (full photopoint results in Appendix 4).

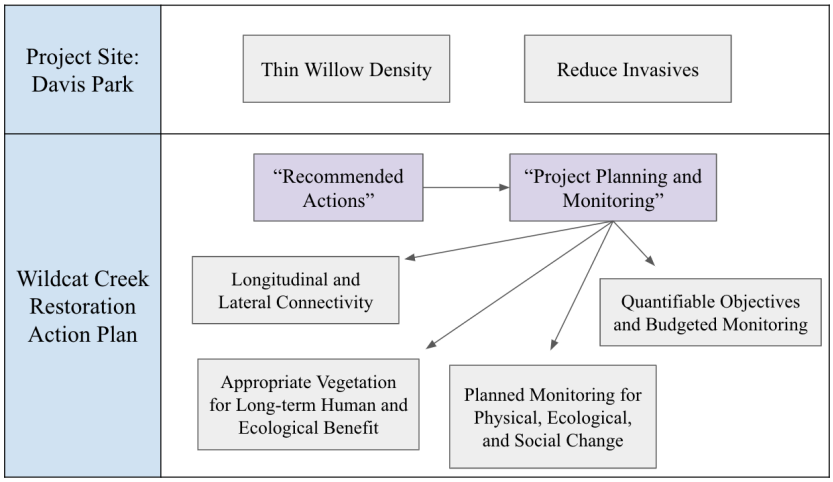


Figure 11. Summarized recommendations for the project and to append to the next iteration of the Wildcat Creek Restoration Action Plan.

APPENDIX

Appendix 1. Plant schedule and original planted vegetation quantities in each planting zone, adapted from Restoration Design Group (2012). The plan aggregated all three willow species together with 560 willow cuttings planted, recorded as shown in the second table.

Scientific name	Common name	Planting zone																									
Trees		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Species quantity
Acer macrophyllum	bigleaf maple					2															2							4
Acer negundo	boxelder								3						1								2			1		7
Aesculus californica	California buckeye			1		1				3		4									2				2			13
Alnus rhombifolia	white alder						2	3					3	3				1	1	3			3	3		1		23
Fraxinus latifolia	Oregon ash						3											1	1					1				6
Juglans hindsii	northern California black walnut	1		1										1				1										4
Quercus Agrifolia	coast live oak	3	1						4						1	2						1						12
Sambucus nigra var. caerulea	blue elderberry												1								1				1			3
Shrubs																												
Baccharis pilularis	coyote brush	14	2	6		6			7	4	3				4	2									3			51
Cornus sericea	creek dogwood						15						28	32				26	28	30			30	28		12		229
Epilobium canum	California fuchsia					9				3							15					7			3		6	43
Eriogonum fasciculatum	California buckwheat																8					15			5			28
Heteromeles arbutifolia	toyon	12	1	4													2				1	3						23
Holodiscus discolor	oceanspray	14				5			4	4			1		8						2	2						40
Mimulus aurantiacus	sticky monkeyflower					12			2	6							4		3		3	5						35
Mimulus cardinalis	scarlet monkeyflower						3						2							1			3	2				11
Morella californica	California wax myrtle	8							4							1						1						14
Physocarpus capitatus	ninebark		3				5						6	8				5		9			4					40
Rhamnus californica	California coffeeberry	15		5		3				6	6	3																38
Ribes sanguineum	red-flowered currant			3					4	5	9		2									5	3	3	5	6		45
Rosa californica	California rose					12			9		23		2	1			5		3			5	3		9			72
Rubus parviflorus	thimbleberry								8					2	4						3			2	3			22
Rubus ursinus	California blackberry	40	25				8		12		42	2	3		12		9	5		3	5	6	6	3		18	9	208
Symphoricarpos albus	snowberry	1	5	5		2						5			3						3		3	2				29
Groundcovers/vines/ferns																												
Artemisia douglasiana	mugwort						3						6	5						6			16			4		40
Aster chilensis	California aster		4	3												4	4				8	8				5		36
Carex barbarae	Santa barbara sedge						5						6	10				7	4	4			10	12		8		66
Carex praegracilis	field sedge	25						15	25	15						65		8			5				3		4	165
Festuca californica	California fescue		4	8	20	6			25		25	14			5	17	14				6	7			15			166
Fragaria vesca	woodland strawberry				8					25	4	25			25						12	5					4	108
Heracleum maximum	cow parsnip		2			2								4				2			3		2	1				16
Iris douglasiana	Douglas iris				6						14	9			16	4	15				5	9					16	94
Juncus effusus	common rush						3						2	3				5	2	5			6	5		4		35
Juncus patens	grey rush	6									8	2			15	5	2				4	6				12	7	67
Leymus triticoides	creeping wild rye						20						30	40		100		35			45		60	30		40		400
Polystitchum munitum	western sword fern		5						4	4																		13
Scrophularia californica	bee plant		6	4		2						18			10		3	3			25		2		15		3	91
Sisyrinchium bellum	blue eyed grass				18																		3					21
Vitis californica	California grape	5	4				1				6							1			1					1		19
Woodwardia fimbriata	giant chain fern			2															2				3	1		1		9
Planting zone quantity		144	62	42	52	62	68	18	111	75	140	82	92	109	104	200	81	100	44	61	136	85	159	93	64	113	49	2346

Cuttings		Total
Salix laevigata	red willow	
Salix lasiolepis	arroyo willow	
Salix scouleriana	scouler willow	
		560

Appendix 2. The common and scientific names for each understory species, as well as the number of times we found each species along each transect according to the line point sampling method. Transects numbers refer to transects from right to left in Figure 6.

Transect number	Strata	Understory common name	Understory scientific name	Count
Transect 1	Shrub	Algerian ivy	*Hedera canariensis*	9
	Herb	California blackberry	*Rubus ursinus*	2
	Herb	Himalayan blackberry	*Rubus armeniacus*	4
Transect 2	Herb	California blackberry	*Rubus ursinus*	4
	Herb	Himalayan blackberry	*Rubus armeniacus*	6
	Tree	Willow	*Salix spp.*	4
	Herb	Veldt grass	*Ehrharta erecta*	2
	Shrub	Algerian ivy	*Hedera canariensis*	2
Transect 3	Herb	Veldt grass	*Ehrharta erecta*	6
	Tree	Willow	*Salix spp.*	6
	Herb	California wildrose	*Rosa californica*	2
	Herb	Kikuyu grass	*Cenchrus clandestinus*	8
Transect 4	Herb	Kikuyu grass	*Cenchrus clandestinus*	5
	Herb	California blackberry	*Rubus ursinus*	2
	Herb	Veldt grass	*Ehrharta erecta*	3
	Shrub	Algerian ivy	*Hedera canariensis*	2
	Tree	Willow	*Salix* spp.	2
	Herb	Valley sedge	*Carex barbarae*	6
Transect 5	Herb	California blackberry	*Rubus ursinus*	2
	Tree	White alder	*Alnus rhombifolia*	1
	Herb	Veldt grass	*Ehrharta erecta*	6
	Shrub	Algerian ivy	*Hedera canariensis*	1
	Herb	Western thimbleberry	*Rubus parviflorus*	1
Transect 6	Herb	Kikuyu grass	*Cenchrus clandestinus*	3
	Herb	Valley sedge	*Carex barbarae*	6
	Tree	Willow	*Salix* spp.	2
	Herb	Veldt grass	*Ehrharta erecta*	2
	Herb	Algerian ivy	*Hedera canariensis*	9

Transect 7	Herb	Veldt grass	*Ehrharta erecta*	6
	Herb	Himalayan blackberry	*Rubus armeniacus*	1
	Herb	French broom	*Genista monspessulana*	1
	Shrub	Algerian ivy	*Hedera canariensis*	1
	Herb	Valley sedge	*Carex barbarae*	1
Transect 8	Shrub	Algerian ivy	*Hedera canariensis*	9

The common and scientific names for each overstory species, as well as the number of times we found each species along each transect according to the line point sampling method.

Transect number	Overstory Common Name	Overstory Scientific Name	Count
Transect 1	Monterey pine	*Pinus radiata*	1
	Willow	*Salix* spp.	4
Transect 2	Willow	*Salix* spp.	7
Transect 3	Willow	*Salix* spp.	6
Transect 4	Boxelder maple	*Acer negundo*	1
	Willow	*Salix* spp.	2
	Creek dogwood	*Cornus sericea*	1
	Fremont cottonwood	*Populus fremontii*	2
Transect 5	White alder	*Alnus rhombifolia*	2
	Willow	*Salix* spp.	3
Transect 6	Willow	*Salix* spp.	7
Transect 7	Willow	*Salix* spp.	5
	No canopy cover		2
Transect 8	White alder	*Alnus rhombifolia*	1
	Willow	*Salix* spp.	5

Tree, shrub, and groundcover species planted in specific planting zones, as well as plants observed and percent cover in the area on November 18th, 2022.

Area Y			
TREES		Observed 11/18	% COVER IN AREA 11/18

Acer negundo	Boxedler	0	
Alnus rhombifolia	White alder	0	
Salix spp.	Willow	24	
Populus spp.	Popular	1	
SHRUBS			
Cornus sericea	Creek dogwood	0	0
Ribes sanguineum	Red-flowering currant	0	0
Rubus ursinus	California blackberry	0	0
GROUNDCOVERS/VINES/FERNS			
Artemisia douglasiana	California mugwort	11	<1
Aster chilensis	California aster	0	0
Carex barbarae	Valley Sedge or Santa Barbara Sedge	0	0
Juncus effusus	Soft rush or common rush	0	0
Juncus patens	California gray rush or spreading rush	0	0
Leymus triticoides	Creeping wild Rye	0	0
Sisyrinchuim bellum	Western blue-eyed grass	0	0
Vitis californica	California grape	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		<30
Genista monspessulana	French broom		<1
Ehrharta erecta	Veldt grass		20
Foeniculum vulgare	Fennel		<1

Area V			
TREES		Observed 11/18	% COVER IN AREA 11/18
Acer negundo	Boxedler	1	
Alnus rhombifolia	White Alder		
Fraxinus latifolia	Oregon Ash	5 juvenile	
Populus spp.	Populus	1	

Salix spp.	Willow	42	
SHRUBS			
Cornus sericea	Creek dogwood	17	<1
Mimulus cardinalis	Scarlet monkeyflower	0	0
Physocarpus capitatus	Pacific Ninebark	0	0
Ribes sanguineum	Red-flowering currant	0	0
Rosa californica	California rose	0	0
Rubus ursinus	California blackberry		3
Symphoricarpos albus	Common snowberry	0	0
GROUNDCOVERS/VINES/FERNS			
Juncus effusus	Soft rush or common rush		<1
Juncus patens	California gray rush or spreading rush	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		12
Genista monspessulana	French Broom		<1
Ehrharta erecta	Veldt Grass		3
Rubus armeniacus	Himalayan Blackberry		2
Bromus diandrus	Ripgut broome		<1

Area W			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	0	
Fraxinus latifolia	Oregon Ash	0	
Salix spp.	Willow	20	
Populus spp.	Poplar	2	
SHRUBS			
Cornus sericea	Creek dogwood	4	<1
Mimulus cardinalis	Scarlet monkeyflower	0	0
Ribes sanguineum	Red-flowering currant	0	0

Rubus parviflorus	Thimbleberry	11	<1
Rubus ursinus	California blackberry	0	0
Symphoricarpos albus	Common snowberry	0	0
GROUNDCOVERS/VINES/FERNS			
Carex barbarae	Valley Sedge or Santa Barbara Sedge	15	<1
Heracleum lanatum	cow parsnip	0	0
Juncus effusus	soft rush or common rush	0	0
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
Woodwardia fimbriata	Giant Chain Fern	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		3
Genista monspessulana	French Broom		<1
Ehrharta erecta	Veldt Grass		10
Acacia spp.	Acacia	2	<1

Area R			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	3	
Fraxinus latifolia	Oregon Ash	1	
Salix spp.	Willow	33	
Populus spp.	Poplar	8	
SHRUBS			
Cornus sericea	Creek dogwood	16	<1
Mimulus cardinalis	scarlet monkeyflower	0	0
Rubus ursinus	Pacific Blackberry or California B.	11	3
GROUNDCOVERS/VINES/FERNS			
Carex barbarae	Valley Sedge or Santa Barbara Sedge		<1
Juncus effusus	soft rush or common rush	3	<1

Woodwardia fimbriata	Giant Chain Fern	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		2
Genista monspessulana	French Broom	8	<1
Ehrharta erecta	Veldt Grass		15

Area S			
TREES		Observed 11/18	% COVER IN AREA 11/18
Acer negundo	Boxedler	1	
Alnus rhombifolia	White Alder	0	
Populus fremontii	Cottonwood	2 + 2 juvenile	
Salix spp.	Willow	61	
SHRUBS			
Cornus sericea	Creek dogwood	17 mostly juvenile	
Mimulus cardinalis	Scarlet monkeyflower	0	0
Physocarpus capitatus	Pacific Ninebark	0	0
Rubus parviflorus	Thimbleberry	1	<1
Rubus ursinus	California blackberry	yes	<1
GROUNDCOVERS/VINES/FERNS			
Artemisia douglasiana	California mugwort	0	0
Carex barbarae	Valley Sedge or Santa Barbara Sedge	~75	1
Juncus effusus	soft rush or common rush	0	0
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
Scrophularia californica	California bee plant	0	0
Vitis californica	California grape	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		7

Rubus armeniacus	Himalayan Blackberry		<1
Ehrharta erecta	Veldt Grass		10

Area Q			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	3	
Fraxinus latifolia	Oregon Ash	0	
Juglands hindsii	N. California Walnut	0	
Populus fremontii	Cottonwood	4	
Salix spp.	Willow	28	
SHRUBS			
Cornus sericea	Creek dogwood	18	2
Physocarpus capitatus	Pacific Ninebark	0	0
Rosa californica	California rose	3	<1
Rubus ursinus	California blackberry	0	0
GROUNDCOVERS/VINES/FERNS			
Carex barbarae	Valley Sedge or Santa Barbara Sedge	14	<1
Carex praegracilis	Clustered Field Sedge	12	<1
Heracleum lanatum	cow parsnip	0	
Juncus effusus	soft rush or common rush	3	<1
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
Scrophularia californica	California bee plant	0	0
Vitis californica	California grape	0	0
Fragaria vesca	Woodland strawberry	1	<1
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		3
Genista monspessulana	French Broom		<1
Pennisetum clandestinum	Kikuyu grass		<1

Ehrharta erecta	Veldt Grass		<1

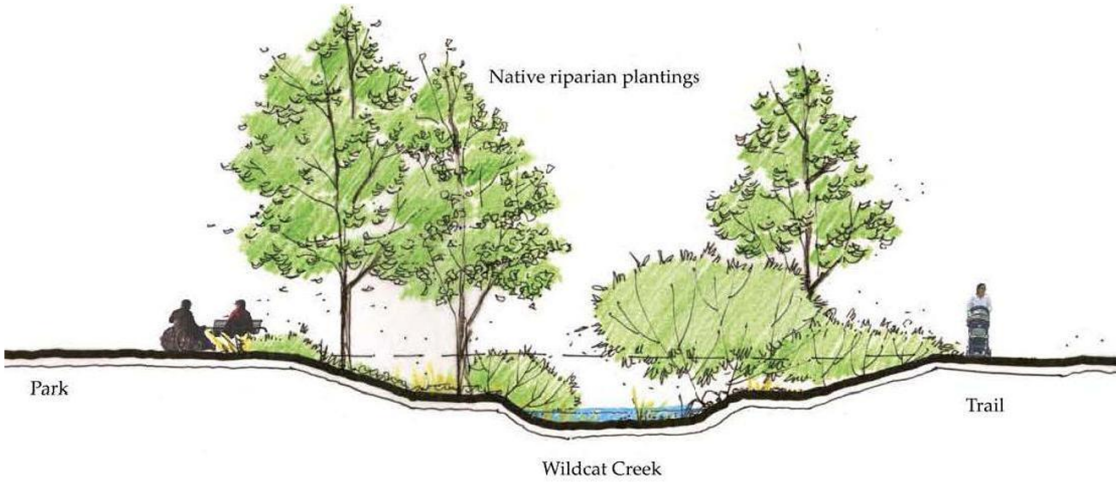
Area L			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	5	
Juglands hindsii	N. California Walnut	1	
Populus fremontii	Cottonwood	1 juvenile	
Sambucus nigra	Blue Elderberry	0	
Salix spp.	Willow	37	
SHRUBS			
Baccharis pilularis	Coyote Brush	3	
Cornus sericea	Creek dogwood	12	
Holodiscus discolor	Ocean spray	0	
Mimulus cardinalis	Scarlet monkeyflower	0	
Physocarpus capitatus	Pacific Ninebark	0	
Ribes sanguineum	Red-flowering currant	0	
Rosa californica	California rose	0	
Rubus ursinus	California blackberry		3
GROUNDCOVERS/VINES/FERNS			
Artemisia douglasiana	California mugwort	6	<1
Carex barbarae	Valley Sedge or Santa Barbara Sedge	32	1
Juncus effusus	Soft rush or common rush	8	<1
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		3
Genista monspessulana	French Broom	22	<1
Rubus armeniacus	Himalayan Blackberry		1

Pennisetum clandestinum	Kikuyu grass		2
Ehrharta erecta	Veldt Grass		5
Foeniculum vulgare	Fennel	5	<1

Area M			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	3	
Fraxinus latifolia	Oregon Ash	1	
Juglands hindsii	N. California Walnut	1 juvenile	
Populus fremontii	Cottonwood	5	
Salix spp.	Willow	50	
SHRUBS			
Cornus sericea	Creek dogwood	1	<1
Physocarpus capitatus	Pacific Ninebark	0	0
Rosa californica	California rose	0	0
Rubus parviflorus	Thimbleberry	6	<1
Rubus ursinus	California blackberry	0	0
GROUNDCOVERS/VINES/FERNS			
Artemisia douglasiana	California mugwort	0	0
Carex barbarae	Valley Sedge or Santa Barbara Sedge	14	2
Heracleum lanatum	Cow parsnip	0	0
Juncus effusus	Soft rush or common rush	0	0
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		20
Ehrharta erecta	Veldt Grass		2
Foeniculum vulgare	Fennel	1	<1

Area F			
TREES		Observed 11/18	% COVER IN AREA 11/18
Alnus rhombifolia	White Alder	5	
Fraxinus latifolia	Oregon Ash	1	
Populus fremontii	Cottonwood	1 juvenile	
Salix spp.	Willow	23	
SHRUBS			
Cornus sericea	Creek dogwood	2	<1
Mimulus cardinalis	Scarlet monkeyflower	0	0
Physocarpus capitatus	Pacific Ninebark	0	0
Rubus ursinus	California blackberry	11	2
GROUNDCOVERS/VINES/FERNS			
Artemisia douglasiana	California mugwort	0	0
Carex barbarae	Valley Sedge or Santa Barbara Sedge	6	<1
Juncus effusus	Soft rush or common rush	7	<1
Leymus triticoides	Creeping Wild Rye or Beardless Wild Rye	0	0
Vitis californica	California grape	0	0
INVASIVE PLANTS			
Hedera canariensis	Algerian ivy		3
Genista monspessulana	French Broome		<1
Rubus armeniacus	Himalayan Blackberry		4
Ehrharta erecta	Veldt Grass		1
Foeniculum vulgare	Fennel		<1

Appendix 3. Initial project visualizations from Restoration Design Group (2012).





Appendix 4. Photopoint monitoring carried out from 2012 to 2022.

C4: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C4: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C4: Right Bank



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C4: Left Bank



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C5: Upstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C5: Downstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C5: Right Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C5: Left Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C6: Upstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C6: Downstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C6: Right Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C6: Left Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C7: Upstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C7: Downstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C7: Right Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C7: Left Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C8: Upstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C8: Downstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C8: Right Bank

No Photo
(creek channel not yet excavated)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C8: Left Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C9: Upstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C9: Downstream

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C9: Right Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C9: Left Bank

No Photo
(creek channel not yet excavated)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C10: Upstream (Downstream of Project Area)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C10: Downstream (Downstream of Project Area)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C10: Right Bank (Downstream of Project Area)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

C10: Left Bank (Downstream of Project Area)



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T1: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T1: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T1: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T2: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014

No photo

November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T2: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T2: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T3: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016

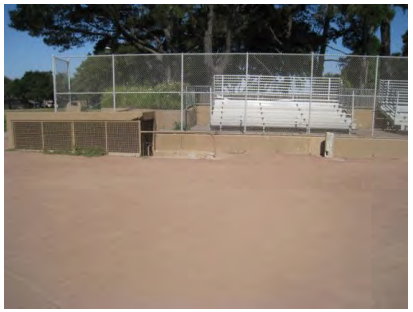


August 11, 2017



November 18, 2022

T3: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T3: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T4: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T4: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T4: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T5: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T5: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T5: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T6: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T6: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T6: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T7: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T7: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T7: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T8: Upstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T8: Downstream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022

T8: Cross-stream



July 11, 2012 (Pre-project)



January 22, 2013



September 22, 2014



November 25, 2015



November 16, 2016



August 11, 2017



November 18, 2022