Title
Tassajara Creek, Twenty Years Later: Long-term riparian vegetation restoration monitoring using field surveys and remote sensing

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Actively incising Lower Tassajara Creek in Dublin, California, was restored as a compound channel in 1999-2000 to mitigate incision and provide flood conveyance capacity to reduce flood risk to an adjacent greenfield residential development. The compound channel design incorporated wide floodplain terraces, planted with native riparian and upland vegetation. Prior geomorphological and ecological studies conducted in the first decade after the restoration project suggested that the project had successfully halted channel incision and that riparian vegetation was developing. I built upon the last vegetation study in 2008, recreating the photo monitoring points and resurveying the established vegetation transects for the Tassajara Creek project's northern reach. I also used remote sensing to quantify changes in vegetation cover over the last decade, finding a 63% increase in vegetation cover. Both field and remote sensing analyses indicated continued tree canopy growth and maturation of the riparian ecosystem in this restored urban stream.

Introduction: Reviewing the Issues

In Mediterranean climates such as that of the San Francisco Bay Area, highly seasonal rainfall leads to episodic flood events, giving rivers naturally braided channels with constantly reforming banks and dynamic floodplain interaction (Cid et al., 2017; Kondolf et al., 2013). Standard practice, however, has been to confine urban streams into concrete channels for flood control, and even river restoration practice, informed by humid-climate rivers, has forced fixed meander forms on restored rivers. Recognizing the incision and channel stability issues from forcing streams into narrow channels, and the ecological co-benefits possible with habitat construction, design and engineering practice is shifting towards allow restored rivers space to spread, migrate, erode, deposit, and reshape themselves based on its natural or novel flood regime (Biron et al., 2014; Kondolf, 2012).

The compound channel is a design approach that gives a wider right-of-way to highly modified urban river reaches. A wide floodplain is excavated around either an existing incised channel or a newly constructed low-flow channel, improving both high water conveyance and ecological function (Tompkins & Falzone, 2012). But while a flourishing riparian vegetation community is a sign of success for a new compound channel restoration project, it can also cause flood control concerns because of potential reduction in flood conveyance capacity, so compound channels require careful monitoring and management. Before planted riparian trees get a chance to grow on the banks, the unshaded low flow channel can become overgrown with emergent vegetation, pushing more flow onto the terrace. Flood conveyance can also be reduced below the design capacity if dense vegetation and riparian trees establish on a terrace designed for herbaceous plants (Haltiner et al., 1996, p. 326).

Streams in urban river reaches, natural or restored, face challenges known collectively as the "urban stream syndrome" (Walsh et al., 2005). Increased catchment imperviousness makes flow events flashier, reaching a higher peak discharge in a shorter amount of time (Tompkins & Falzone, 2012). Sediment transport dynamics are sensitive to catchment land use changes (Cooper et al., 2013), with excess sedimentation causing aggradation and braiding during construction (Booth & Fischenich, 2015, as outlined in their urban channel evolution model) and very little runoff the rest of the time (*ibid.*; Gurnell et al., 2007), risking incision and bank erosion in the stream channel. Riparian floodplain vegetation like cottonwood (*Populus* spp.) and willow (*Salix* spp.) rely on flood regimes to disperse seeds and recolonize in deposited sediment, but alterations in return intervals can allow invasives such as salt cedar (*Tamarix* spp.) to displace them (Stella et al., 2013). While phreatophytic riparian plants adapt to summer drought by extending long roots to reach perennial groundwater, they can still face further desiccation stress from dropping water tables caused by groundwater pumping and catchment imperviousness (Cooper et al., 2013; Stella et al., 2013). In other cases artificial perennial baseflows from irrigation and pipe leaks can create a year-round water supply of questionable quality (or "urban slobber;" Kondolf et al., 2013).

Ultimately, the success of any restoration project depends on factors beyond the site itself. Best practices argue for "process-based restoration" that explicitly considers the intersection of hydrological and ecological processes at the reach and watershed scales. In short, this means having "the right projects in the right places," (Beechie et al., 2010), selecting the appropriate channel forms for a locality (Kondolf et al., 2007) and selecting analogous vegetation reference sites (Van Dam, 2013). This also means targeting the root causes of habitat or ecosystem change, and matching the scale of the restoration to the scale of the problem: watershed-scale issues like flow regime, sediment supply, and water quality may limit the potential efficacy of even the most well-designed reach-scale restoration (Beechie et al., 2010).

For all these reasons, ongoing monitoring is necessary, and in Mediterranean climates, a longer observation period is needed to allow infrequent channel-altering high flow events to test the limits of the design (Kondolf et al., 2007). Beechie (2010) cautions to always expect a lag time between implementation and recovery, and so to always set appropriate expectations in the short term. A long-term monitoring program may consist of periodic post-project appraisals including aerial photography, cross-sectional and longitudinal profiles, floodplain deposition assessment, low-flow and floodplain vegetation transects, peak discharges and hydraulic modeling (Tompkins & Kondolf, 2007). In a compound channel or other project with flood control goals, surveys should assess whether vegetation may be impacting flood control capacity. Where surrounding land use is shifting from agriculture to rapid construction and development to a stable urban environment, aggradation and erosion need to be especially monitored given the risk of a changing sediment supply, and floodplain vegetation needs to be monitored for desiccation due to changing water table levels.

The Tassajara Creek Project

Tassajara Creek drains a 6000-hectare watershed that extends north into the Morgan Territory Regional Preserve in the foothills of Mount Diablo (Exhibit 1). South of Interstate 580, the creek drains into Arroyo Mocho and flows to the San Francisco Bay by way of Arroyo de la Laguna and Alameda Creek.

In the early 1990s, the City of Dublin, California, began planning for eastward greenfield expansion and incorporation, including the 645-acre parcel around Tassajara Creek, north of the freeway, which the County of Alameda received as a result of the Department of Defense base closure (see historic photo, Exhibit 16). Stuart Cook of the County's Surplus Property Authority championed the property's wide undeveloped stream corridor as a chance to give a river "room to move," a rare opportunity for an urban site (Kondolf, pers. comm.). Working with Zone 7 of the Alameda County Flood Control and Water District, the City contracted with Brian Kangas Foulk (BKF) Engineers to create a drainage and flood control plan for Tassajara Creek and the surrounding area. The resulting *Santa Rita Drainage Master Plan* (Brian Kangas Foulk Engineers, 1995) defined a compound channel design and adjacent pedestrian facilities.

Public and city feedback indicated a desire for a natural creek corridor and recreational greenway, so a comprehensive stream restoration plan was developed (Sycamore Associates et al., 1996) which encompassed not only the Santa Rita property, but also reaches as far north as the East Bay Regional Park District property on the Alameda County line.

Following flood concerns with the 1996 plan, UC Berkeley researchers conducted a historic geomorphological assessment (Kondolf & Matthews, 1997), which indicated that although the stream's course had remained stable over the last 150 years, it had experienced significant incision. The incision was likely initiated by cattle grazing in the nineteenth century, which increased surface runoff into the stream by reducing stabilizing vegetative cover. BKF's updated designs, finalized in 1999 (Brian Kangas Foulk Engineers, 1999), incorporated new restoration plan objectives to restore the natural creek corridor while combatting incision (Krofta & Novotney, 2003).

Completed in 2001, Tassajara Creek represents one of several early-2000s compound creek restoration projects in the Bay Area, which also included the Lower Guadalupe River (2004) in San José (Tompkins & Kondolf, 2007) and Lower Silver Creek (2003) in Santa Clara (Tompkins & Falzone, 2012). Antecedent projects provided important precedent and design lessons. For example, the compound Lower Wildcat Creek project (1984), with a bankfull channel and grass-covered flood control terrace, had flood control capacity impacted by dense vegetation growth and excessive terrace incision, eventually needing to be rebuilt (Haltiner et al., 1996; Tompkins & Kondolf, 2007). Subsequent Miller Creek (1985-86) in Marin County and Green Valley Creek (1993) in Fairfield were designed with wider 100-meter overflow terraces, and proved more successful when tested by the major floods of 1986 and 1995 (Haltiner et al., 1996).

Design and construction

The design for lower Tassajara Creek, within the City of Dublin's Santa Rita property, consists of three distinct reaches with contrasting approaches. Designs for all reaches take advantage of the 200–300 ft wide undeveloped right-of-way. Five grade control structures were added throughout these reaches to continue combatting incision and preventing incision farther upstream (Krofta & Novotney, 2003). From south (downstream) to north (upstream):

(1) The reach from I-580 to Dublin Blvd was completely reconstructed as a compound channel: a wide trapezoidal channel designed to carry 100-year flood levels is inset with a new meandering low flow channel designed for the 2-year flow.

(2) The reach from Dublin Blvd to Gleason Ave maintained its original channel, with a wide 100-year floodplain terrace constructed past the 15-year flood line (Exhibit 2). Some

segments of this reach were rerouted to preserve the root structure of old-growth valley oaks (*Quercus lobata*).

(3) A small section north of Gleason Ave was modified minimally with some bank grading (Trinh & Percelay, 2008).

The compound channel was planted with a selection of riparian shrubs dominated by blackberry (*Rubus ursinus*), wild rose (*Rosa californica*), and coffeeberry (*Rhamnus californica*). The plurality of individual trees planted were willow (*Salix* spp.), among a variety of other riparian and upland species (Davis Environmental Consulting, 2001; Trinh & Percelay, 2008) listed fully in Exhibit 3. The flood control district, concerned about the impact of dense vegetation on flood control capacity, originally suggested excluding willow from the plant palette (Sycamore Associates et al., 1996, p. 81) in favor of letting it colonize naturally. However, over 700 individual willows were ultimately planted (Davis Environmental Consulting, 2001).

Unlike preceding compound channel projects in the Bay Area, the Tassajara Creek floodplain terrace was designed to include not just herbaceous vegetation, but also a mature riparian tree and shrub community. The initial stream restoration plan (Sycamore Associates et al., 1996) outlined guidelines for the location of tree and shrub plantings in relation to water table depth. The banks of the low-flow channel (within three feet of the water table) would support willow (*Salix* spp.), while trees planted on the adjacent terrace (three to six feet above the water table) could include cottonwood (*Populus fremontii*), box elder maple (*Acer negundo*), and ash (*Acer negundo*). Higher up the terrace, at 6-10 feet above the water table, sycamore (*Platanus racemosa*), valley oak (*Quercus lobata*), buckeye (*Aesculus californica*), and walnut (*Juglans hindsii*) could be planted. Trees such as coast live oak (*Quercus agrifolia*), which have lower water needs and are subject to root rot from overwatering, would be planted in upland areas 10 feet beyond the water table (Exhibit 4). A temporary irrigation system was established for 3-5 years to support riparian vegetation on the inner floodplain terrace, after which established vegetation would be expected to be self sufficient. Permanent drip irrigation would remain in the trailside upland area (*ibid.*).

While pre-restoration vegetation was minimal, nine valley oaks (*Quercus lobata*) between 18 and 60 feet tall were identified in the initial drainage plan (Brian Kangas Foulk Engineers, 1995) in the northern reach between Gleason Drive and what would become the pedestrian path. Some along the creek edge were slated for removal due to visible deadwood, root erosion, and slope failure, while others in more stable condition were preserved with creek route adjustments made to ensure their stability (visible in Exhibit 16).

Past monitoring efforts

Exhibit 5 outlines the extensive timeline of post-project appraisals conducted on the Tassajara Creek project. A monitoring plan for channel morphology and hydrology was developed initially by Hudzik and Truitt (2001), who established eight standard cross sections with baseline survey data. Soon after, Lave (2002) established a longitudinal profile of the northern reach and resurveyed its cross sections. The monitoring plan was updated by Krofta and Novotney (2003), who provided detailed guidance on the standard transects, resurveyed the southern reach, and resurveyed the longitudinal profile of the northern reach's longitudinal. They identified several issues to keep monitoring through field work and professional assessment, including exposed tree roots indicating erosion, and log jams in the low flow channel. The full monitoring plan recommended continued monitoring at least once per year and after any significant floods (Krofta & Novotney, 2003). Oden and DeHollan (Oden & DeHollan, 2004) resurveyed the northern cross-sections again in 2004.

Tompkins (2006, pp. 234–251) followed up several years later with a series of cross-sectional and longitudinal surveys, in addition to ecological analysis. The report indicated successful survival and recruitment of emergent cattail (*Typha* sp.), bulrush (*Scirpus* sp.) and willow, and a developing pool-riffle sequence, indicating increased aquatic habitat diversity. On the adjacent floodplain, there was significant sedimentation (0.8 ft) tracing back to high flows in 2005, and new colonization of willow, coyote brush (*Baccharis* sp.), wild rose, blackberry, and alder (*Alnus* sp.) in addition to various native and invasive grasses. Hydraulic modeling of this 2005 event indicated that while the low-flow channels were overtopped by their design flows, the broader channel had sufficient capacity to retain 100-year flow in both reaches (*ibid.*).

Butler and Nolan (2007) later conducted a higher-resolution survey of certain cross sections, reporting evidence of incision in some spots and, in others, aggradation attributed to growing channel vegetation reducing flow velocities. High water marks on the floodplain suggested successful lateral connection, braided morphology continued to develop, and evidence of step-pool formation continued. The authors reported an increase in qualitative vegetation density compared to past photos, and transect-based riparian vegetation monitoring conducted soon after (Trinh & Percelay, 2008) suggested additional colonization by fennel (*Foeniculum vulgare*), buckwheat (*Eriogonum fasiculatum*) and others.

Tompkins and Kondolf (2007) concluded from their latest survey that the project was on track to achieve its restoration objectives, given more time. Low-flow channel complexity was "starting to develop" and habitat diversity had "dramatically improved" but was not yet reaching its goal. They also predicted that, while hydraulic modeling concluded that design flow capacity objectives were satisfied, this capacity "could be compromised with expected growth of riparian vegetation." No surveys or on-site systematic post-project appraisals have been published since Tompkins' (reported in Tompkins & Kondolf (2007)) and Butler and Nolan's (2007).

Trinh and Percelay (2008) conducted the most comprehensive vegetation survey to date since the original one-year monitoring from the project consultants (Davis Environmental Consulting, 2001). They carried out new vegetation counts along Davis Environmental Consulting's defined transect lines, which generally mirror but do not perfectly align with the hydrologic cross sections. The survey was conducted in a below-average water year (Exhibit 6). They observed an increase in plant diversity across the site, along with some individual dead plants and a decline in plant numbers in the lowest reach. Denser vegetation in the lowest reach was attributed to its lower flood frequency interval and depth to groundwater.

Monitoring of vegetation by aerial imagery has thus far indicated substantial growth in riparian and floodplain woody vegetation, as of 2004 (Tompkins & Falzone, 2012) and as of 2012 (Kondolf & Atherton, 2013). By 2012, vegetation had increased from 6.3% to 31% in the upper reach, and from 3.5% to 72% in the lower reach, compared to pre-project (1993) levels. No site surveys have been conducted since the record precipitation of 2017, which may have substantially reshaped the channel and modified vegetation growth patterns.

Field monitoring

For this study, I built on prior vegetation monitoring (Davis Environmental Consulting, 2001; Trinh & Percelay, 2008) to characterize the changes in vegetation that have occurred over the 13 years since the site was last surveyed. I focused on the reach north of Dublin Blvd for its accessibility to the open pedestrian path. First, to provide initial qualitative vegetation assessment, on 19 March 2021, I captured new site photos at the northern reach's standard photo monitoring locations established by Davis Environmental Consulting (2001) and previously rephotographed by Trinh and Percelay (2008). These locations are defined in Exhibit 7, and photo monitoring results are shown in Exhibit 8.

I also replicated the vegetation survey transects which were established by Davis Environmental Consulting (2001). The transects roughly approximate those used in hydrologic surveys, but are split on either side of the river channel and begin on the inside of the path rather than crossing it. When replicating these transects in 2008, Trinh and Percelay (2008) provided additional guidance including GPS coordinates for start and midpoints (listed in Exhibit 9 and mapped in Exhibit 10). Where initial transects were unclear due to a not-to-scale map, or where original T-posts were no longer present, they established new transects that approximated the original corridors as much as possible.

The survey procedure is a modified belt transect, with six-foot-wide corridors taken from the top of the bank to the edge of the water (Trinh & Percelay, 2008). Using the given coordinates, I attempted to align the transect lines as closely as possible; and while some belts may not be aligned to the nearest meter, they should closely follow the same corridors and patches. Tree and shrub species within each corridor were recorded along with approximate height and width, and dead specimens were noted. Annual grasses, forbs, and herbaceous plants were noted but not rigorously counted, as the study focuses on the long-term establishment of a perennial riparian tree and shrub community.

The following section summarizes key findings by geographic location. In general, the riparian ecosystem throughout the restoration project appeared healthy and had undergone substantial new growth since the last time it was surveyed. Willow (*Salix* spp.) patches were densely vegetated, making access difficult, and there were many new seedlings of buckeye (*Aesculus californica*), valley oak (*Quercus lobata*), and coast live oak (*Quercus agrifolia*) across the floodplain terrace and upland banks. As of the site visits in March and April 2021, there was very little bare ground, with complete coverage of annual grasses and legumes (e.g. vetch). The addition of substantial populations of mugwort (*Artemisia douglasiana*) and poison hemlock (*Conium maculatum*) is also notable. Exhibit 11 summarizes the results of the vegetation transects.

Detailed observations

The reach to the north of Gleason Ave (Exhibit 12), is the least modified section of the project and does not follow the same 15-year terrace design as areas farther south. Hydrologically, this reach has the steepest gradient, with the highest energy and most erosive flows. The first 35 feet of the Transect 1 survey, starting at the upper path level, passed through a patch of dense hemlock (*Conium maculatum*). Some unidentified dead shrubs were visible throughout. Descending to the creek channel, willows along the channel edge showed extensive root exposure and instability.

Between Gleason Ave and the pedestrian path (Exhibit 13), the riparian corridor is characterized by braided channels and topographic variation. Transect 3 as defined by Trinh and Percelay (2008) descends into an ephemeral side channel that passes by the old growth valley oak (*Quercus lobata*) (Pre-restoration, this section was the main channel, and the stream was re-routed to preserve the root structure of the oak; Exhibit 16). A second transect, which I have labeled Transect 3b, begins at a willow along the first and extends to the north along the side channel to meet the main channel. Along both transects and especially in the side channel, there were many tree and shrub seedings from one to three feet tall, including valley oak (*Quercus lobata*) and coyote brush (*Baccharis pilularis*). Shrubs in the area not previously identified in vegetation studies included California mugwort (*Artemisia douglasiana*) and white horehound (*Marrubium vulgare*). The main channel was flowing steadily and had a defined pool and riffle sequence; watercress (*Nasturtium officinale*) grew along the edge of the water.

Transect 4 is defined to extend down the steep slope on the other side of the main channel. In the time since the last survey, vegetation had grown dramatically, including California coffeeberry (*Frangula californica*), madrone (*Arbutus menziesii*) and willow (*Salix* spp.), making it difficult to continue the transect very far. Along the trail edge, a large blue elderberry (*Sambucus nigra*) of at least 15 feet tall blocked the entrance, and was only 7 feet tall at the time of the 2006 survey. The trail crossing itself was closed to the public for the first site visit, and open again by the time of the second.

South of the trail crossing (Exhibit 14), the site opens up into a wide terrace, and a terrace floodplain ecosystem continues south along the rest of the surveyed reaches. Coyote brush is typical in the outer extents of the floodplain, while California buckeye (*Aesculus californica*), Oregon ash (*Fraxinus latifolia*) and box elder maple (*Acer negundo*) are clustered closer to the channel. Along the channel edge, Fremont cottonwood (*Populus fremontii*) and various willows are common. At the time of the survey, the terrace, which is widest on the east side was covered with annual grasses and vetches.

On the western side of the bank (Transect 5), especially on the slope descent down to the terrace level, I observed many new coast live oak (*Quercus agrifolia*) seedlings, including seven within the 6-foot wide belt transect alone. The black walnut (*Juglans hindsii*) at this site was about twice the height of when it was last surveyed in 2008. The arrowweed (*Pluchea sericea*) observed in 2008 at this and many other sites was no longer present, including beyond the transect belt itself.

Western slopes farther south (Transects 8 and 9; Exhibit 15) had dense willow growth approaching channel banks. These were also the only transects with extant T-posts marking official transect alignment. At the end of Transect 8, there was evidence of high flows having deposited leaf litter, branches and other debris high in the willow thicket, while also partially knocking over the T-post.

On both the eastern and western terraces south of Central Parkway I observed many examples of newly emerged California buckeye seedlings. On Transect 10, Trinh and Percelay (2008) had observed dozens of California wild rose (*Rosa californica*) surrounding a 9-foot box elder maple (*Acer negundo*). This year's survey shows that the density of wild roses had somewhat declined but the box elder maple had grown to a mature 20-foot tree, with additional box elder seedlings sprouting up around it. The low-flow channel slopes beyond were covered in dense mugwort (*Artemisia douglasiana*), an herb not previously identified on the site but quite common across the surveys this year. At the end of this transect, two willow trees were present in 2008; visible stumps indicated their removal in the time since.

While hydrology and changes morphology were not within scope of this survey, changes along the gradient were apparent: in the northern reaches, pool-riffle sequences were visible and flow was turbulent, while farther south, flow was slow and distinct pool-riffle forms not as well developed.

Remote sensing

In addition to field analysis, I used remote sensing methods to quantify changes in canopy cover across the entire restoration site. NAIP (USDA National Agriculture Imagery Program) imagery was imported into Google Earth Engine, a cloud-based platform for remote sensing analysis. NAIP imagery is high resolution (0.6m starting 2016, 1.0m previously), 4 bands (RGB plus near-infrared since 2009) and captured in the early summer when drought-deciduous and winter-deciduous shrubs still have leaves but annual grasses are senescent. I selected the 2009 and 2020 images (Exhibit 17) for their clarity, 4-band availability, lack of intense shadows, and long time horizon.

To visualize change in canopy cover over time, I calculated NDVI[1] for 2009 and 2020 NAIP imagery, applied a threshold of NDVI ≥ 0.20 to indicate vegetation cover, and calculated the difference between 2020 and 2009 cover. This difference could then be broken down by reach and by vertical distance to the low-flow channel, to indicate which parts of the riparian and floodplain ecosystem saw the most growth. I approximated the elevation above the water table by calculating vertical flow distance to the thalweg, derived from the 2007 Alameda County $^1/_9$ arc-second LiDAR DEM.[2] Finally, I created cross-tabulations of vegetation cover versus vertical flow distance, as well as vegetation cover change by reach.[3]

[1] Normalized Difference Vegetation Index; $NDVI = (N - R) \div (N + R)$ where N is near-infrared, R is red
[2] via ArcGIS Spatial Analyst (*Fill → Flow Direction → Flow Accumulation → Flow Distance* (Vertical))
[3] via ArcGIS Spatial Analyst (*Tabulate Area*)

Next, I classified the 2020 imagery in greater detail, with the help of ground truthing during site visits to better characterize the assemblage of specific tree species. While the original detailed planting plan was not available, I cross-referenced the plant palettes from early plans (Brian Kangas Foulk Engineers, 1995; Sycamore Associates et al., 1996) which provide guidance by channel/terrace position and water table depth. For modeling purposes, I assumed water table depth to be equivalent to the stream surface, or approximately, the low-flow channel depth. In addition to shadow, bare ground, and impervious surfaces, I selected the following tree classes, which have visibly distinct spectral signatures: (a) willow; (b) cottonwood; (c) coyote brush; (d) blue elderberry; (e) box elder maple; (f) coast live oak and valley oak; and (g) other hardwoods such as ash and buckeye.

After identifying training polygons based on known trees from site visits, I trained a supervised random forest classifier to differentiate between different groups of tree species with visibly distinct spectral signatures. Luminance[4] and band ratios for near-IR and RGB bands were used as input to the classifier,[5] along with the previously calculated vertical flow distance to help separate tree species like willows and oaks that appear visually similar in the aerial images but occupy very distinct parts of the riparian corridor. The same cross-tabulations by vertical flow distance and by reach were applied to the results. Finally, I intersected the "vegetation gain" area from the first calculation with the 2020 tree classifications from the second calculation, to determine the class breakdown for the increased canopy cover.

Results

The time series analysis (Exhibit 18) confirms the substantial increase in vegetation over the 11 years between 2009 and 2020 imagery. While in 2009 only 40% of the area was covered by vegetation, in 2020 a total of 65% was covered—an increase of 25 percentage points. This trend was most pronounced in the reach between the pedestrian trail and Central Parkway, and in the area 1–2 meters above the low flow channel. In other words, the most significant vegetation growth occurred on the inner 15-year floodplain terrace, which aligns with in-person observations of new seedlings and pronounced tree growth on the terrace, and expectations of where plants can access the water table.

Based on the aerial imagery classification (Exhibit 19), and confirmed by on-site ground truthing, willow and cottonwood remain the dominant tree cover along channel banks, and oaks

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[4] $Luminance = 0.3R + 0.59G + 0.11B$

[5] Prior to classifying, imagery was segmented using the SNIC (simple non-iterative clustering; Achanta & Susstrunk, 2017) algorithm on N, R, G, B bands, seeded with points of local maximum distance from detected edges on the luminance band. The full data prep and classification procedure can be found at https://code.earthengine.google.com/11809f6730147cda88355ef4e2900da5

likewise dominate upland areas, while the intermediate floodplain terrace continues to support a diverse range of tree species. The classes of tree for increased canopy cover mirror the overall types of vegetation present in their respective reaches and distances (Exhibit 20).

Next Steps and Conclusions

The results of this report, including both remote sensing and field analyses, indicate positive developments in the restored Tassajara Creek vegetation community. As recommended in the monitoring plan (Krofta & Novotney, 2003), follow-up topographic surveys are needed to assess the morphologic evolution of the river channel itself. This is important especially in areas where root exposure and potential undercutting was apparent, as a comprehensive topographic survey has not been completed since 2007 (Butler & Nolan, 2007). As the period of construction in the catchment has wound down with the Santa Rita property extensively developed, sediment inflow to the channel may have declined (Booth & Fischenich, 2015). Trash lines in willow branches (*i.e.*, leaves and detritus caught in tree branches during high flows) on the terrace edges provide evidence for the height of past high flows, most likely the floods of 2017. Whether the increasingly dense willow vegetation may be impacting the maximum flood capacity of the channel (Haltiner et al., 1996) is yet unknown.

Additional vegetation monitoring is also needed in the lower reach between Dublin Blvd and I-580, which was not included in this study. Unlike the reaches surveyed here, this section was completely reconstructed down to the low-flow channel itself. Based on past monitoring photos and surveys (Oden & DeHollan, 2004; Trinh & Percelay, 2008), distinct vegetation assemblages are present there, including cattail (*Typha* spp.) freshwater wetlands. The plant communities in the lower reach may not be adequately classified by remote sensing methods trained only on the upper reaches.

Focusing on the floodplain terrace of the second reach, there was no sign of desiccation stress to vegetation, as I observed a vigorous, green vegetation community with substantial new growth, even in this dry year. These results, however incomplete, are an encouraging update on the success and vitality of the Tassajara Creek restoration project 21 years after its completion. As I surveyed the third transect on a Friday morning, cottonwood seeds floated by through sunlight filtered by the surviving valley oak, and the creek bubbled in the nearby channel. A narrow and sparsely vegetated flood control channel has transformed into a mature riparian ecosystem over these two decades, and the latest vegetation monitoring results confirm it is still on the right track, a prime example of what can be accomplished when you “give the river room.”

Tables and Figures

Full vegetation transect survey data are in the Appendix at the very end of the document.

Exhibit 1. Map of study site, catchment area, and regional river network
(original; catchment area calculated from USGS NHD+HR)

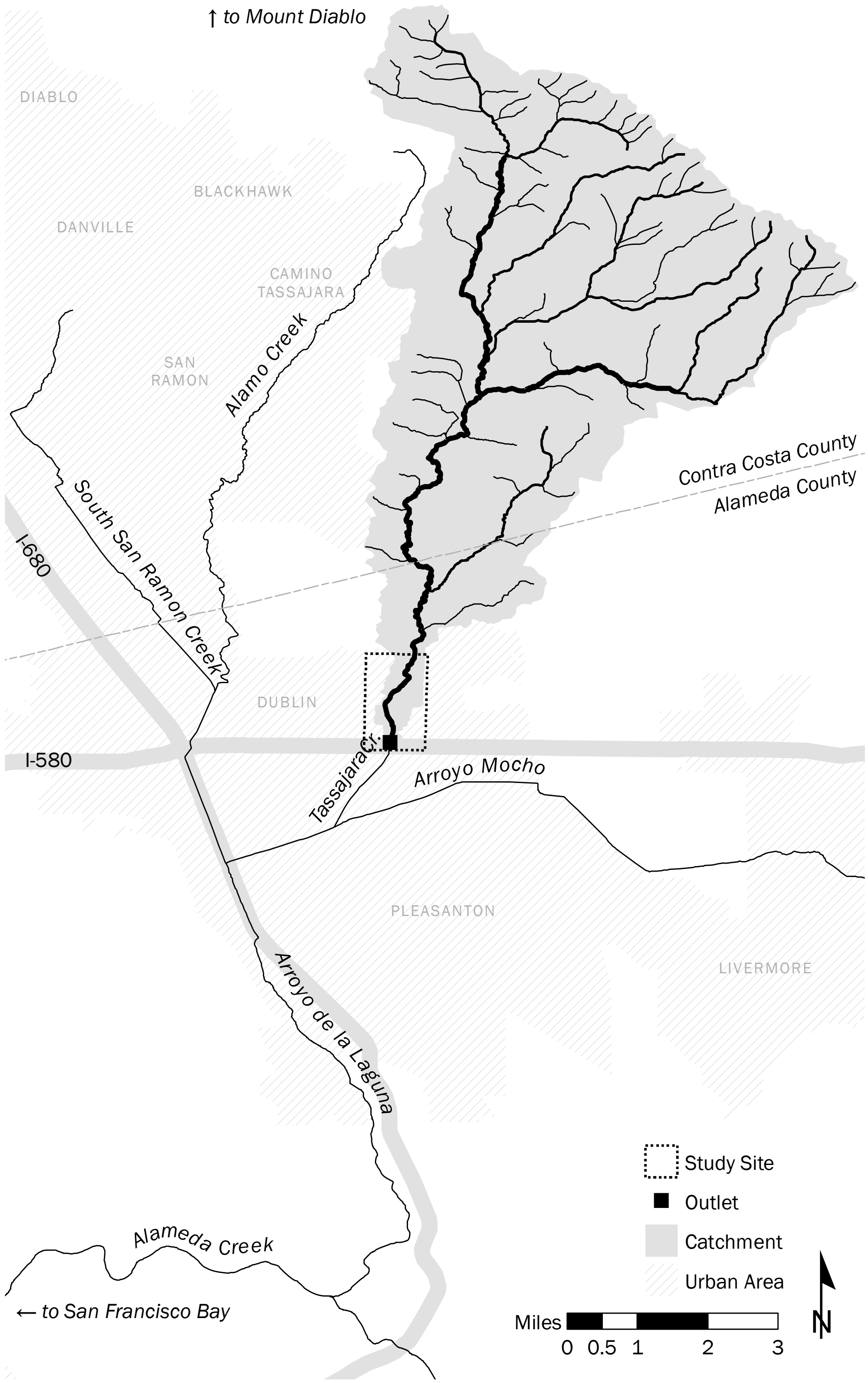
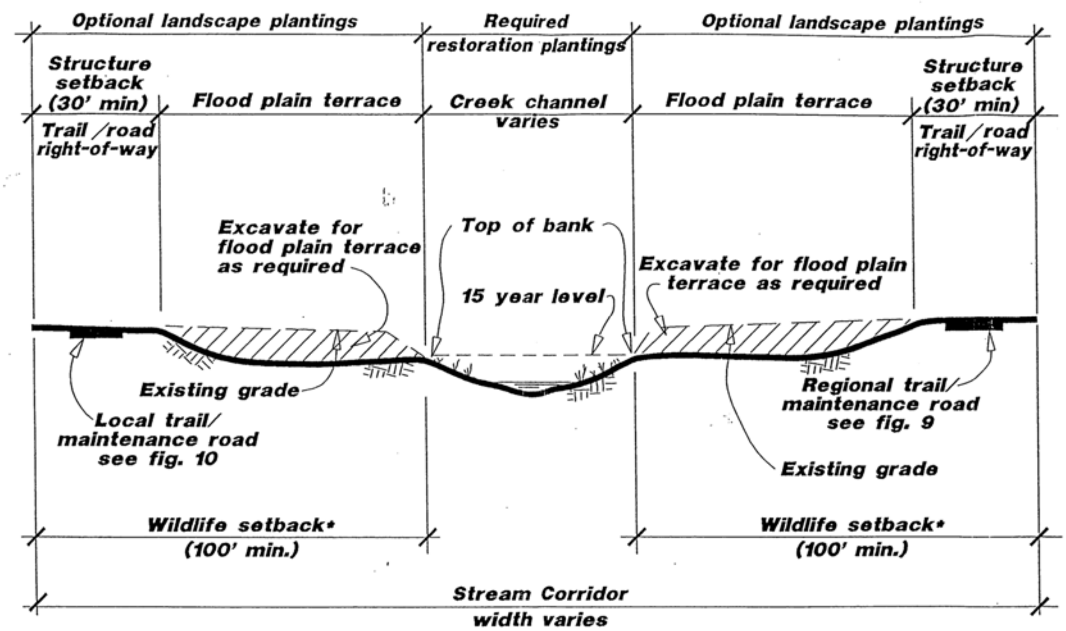


Exhibit 2. Original stream corridor designs

(Sycamore Associates et al., 1996, fig. 3)

(a) Northern reach (Gleason Dr to Dublin Blvd) – section covered in this survey



(b) Southern reach (Dublin Blvd to I-580) – section <u>not</u> covered in this survey

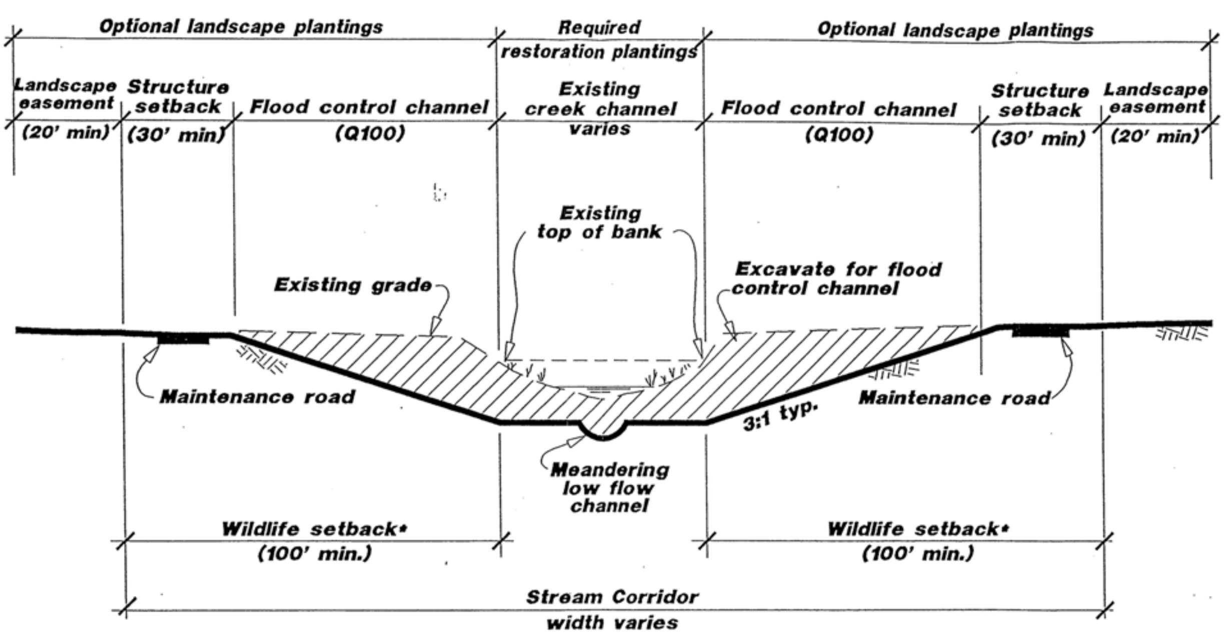


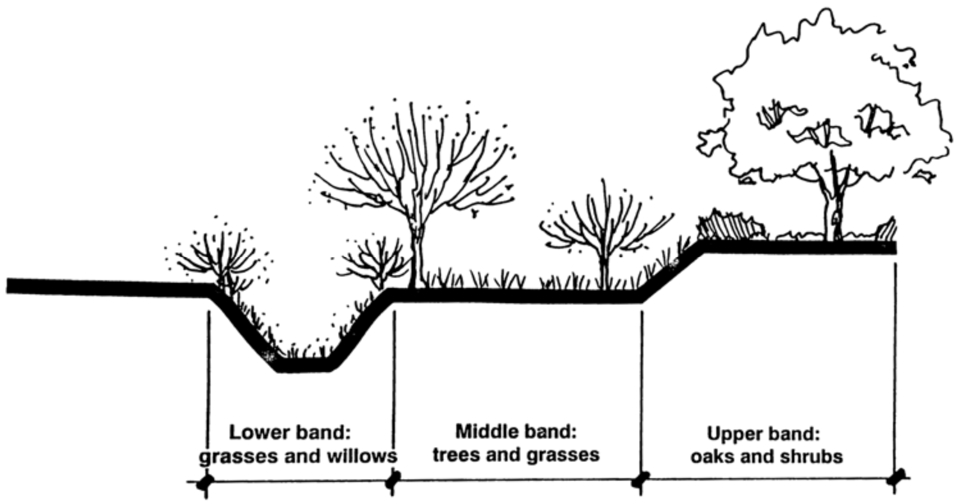
Exhibit 3. Counts of vegetation planted at the original restoration project
(Davis Environmental Consulting, 2001)
with associated zones from *Santa Rita Drainage Master Plan* (Brian Kangas Foulk Engineers, 1995)
and *Eastern Dublin Comprehensive Stream Restoration Program* (Sycamore Associates et al., 1996)

		Davis	*SRDMP*		*EDCSRP*			
		Planted	**Middle** (terrace)	**Upper** (upland)	**Zone 1** <3 ft	**Zone 2** 3-6 ft	**Zone 3** 6-10 ft	**Zone 4** >10 ft
Trees								
Willow*	*Salix* spp.	705	•		•			
Fremont cottonwood	*Populus fremontii*	223	•			•		
Box elder maple	*Acer negundo californicum*	207	•			•		
Oregon ash	*Fraxinus latifolia*	104	*undefined*			•		
California buckeye	*Aesculus californica*	205	•	•			•	
Black walnut	*Juglans hindsii†*	155		•			•	
Western sycamore	*Planatus racemosa*	53	•				•	
Valley oak	*Quercus lobata*	183		•			•	•
Coast live oak	*Quercus agrifolia*	36		•				•
Blue elderberry	*Sambucus mexicana‡*	452		•		*undefined*		
Shrubs								
Pacific blackberry	*Rubus ursinus*	1,595						
California wild rose	*Rosa californica*	1,194						
California coffeeberry	*Rhamnus californica*	1,016						
Coyote brush	*Baccharis pilularis*	435						
Toyon	*Heteromeles arbutifolia*	425						
Snowberry	*Symphoricarpos albus*	377						
California wild grape	*Vitus californica*	298						

** specific species selected by BKF: red willow (Salix laevigata), Pacific willow (Salix lasiandra), Arroyo willow (Salix lasiolepis)*
† a.k.a. Sambucus nigra ssp. caerulea ‡ a.k.a. Juglans californica var. hindsii

Exhibit 4. Planting zones defined in initial plans

(a) *Santa Rita Drainage Master Plan*
(Brian Kangas Foulk Engineers, 1995, fig. 14)



(b) *Eastern Dublin Comprehensive Stream Restoration Program*
(Sycamore Associates et al., 1996, fig. 23)

Zone 1:	< 3	ft to water table
2:	3 – 6	
3:	6 – 10	
4:	> 10	

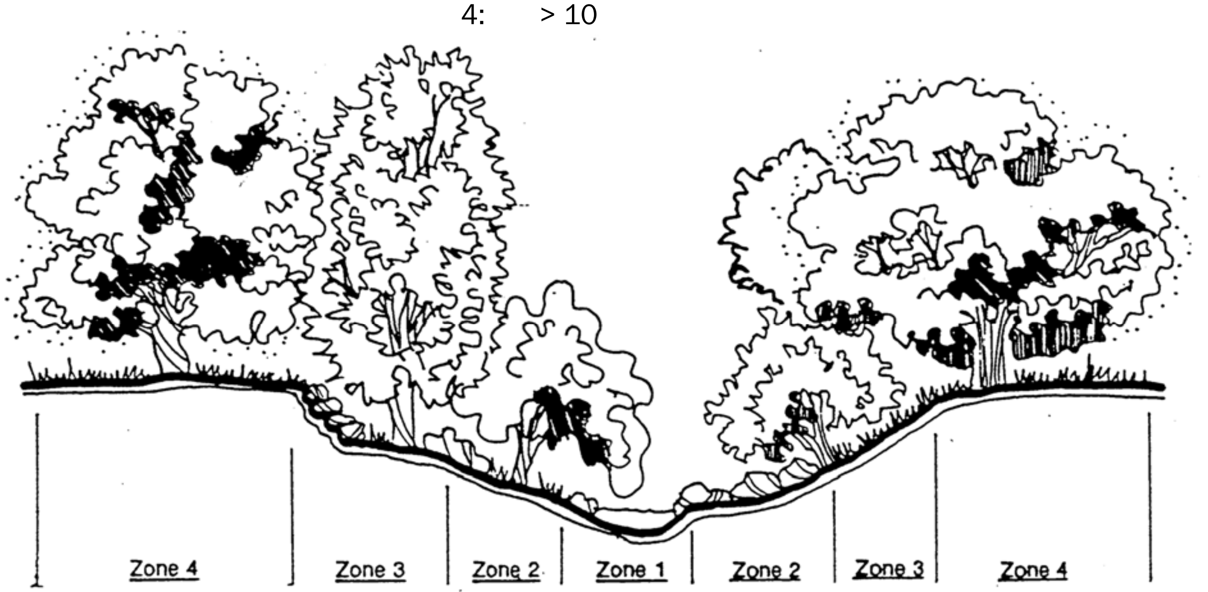


Exhibit 5. Timeline of Tassajara Creek project and post-project appraisals

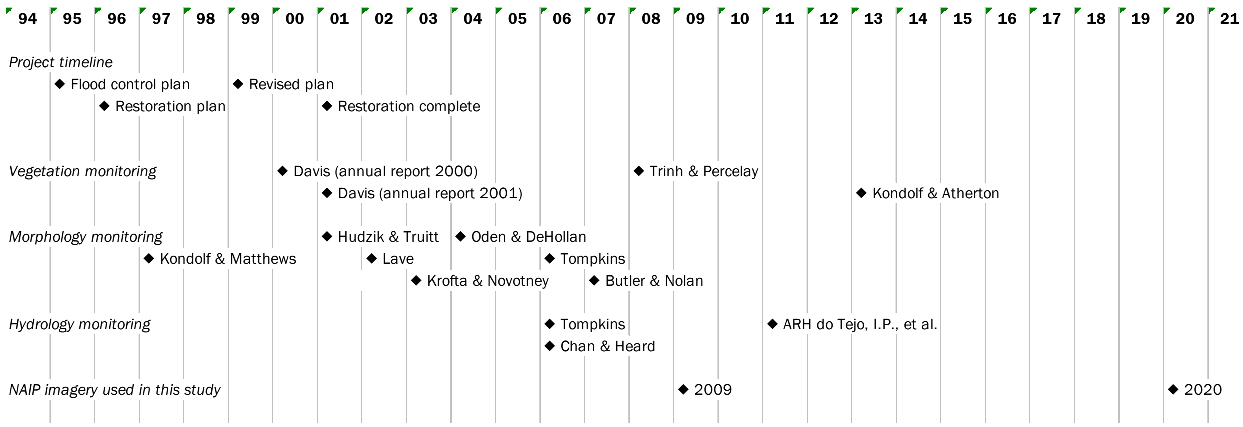


Exhibit 6. Total annual precipitation by water year
(CA DWR CIMIS, station 191: Pleasanton)

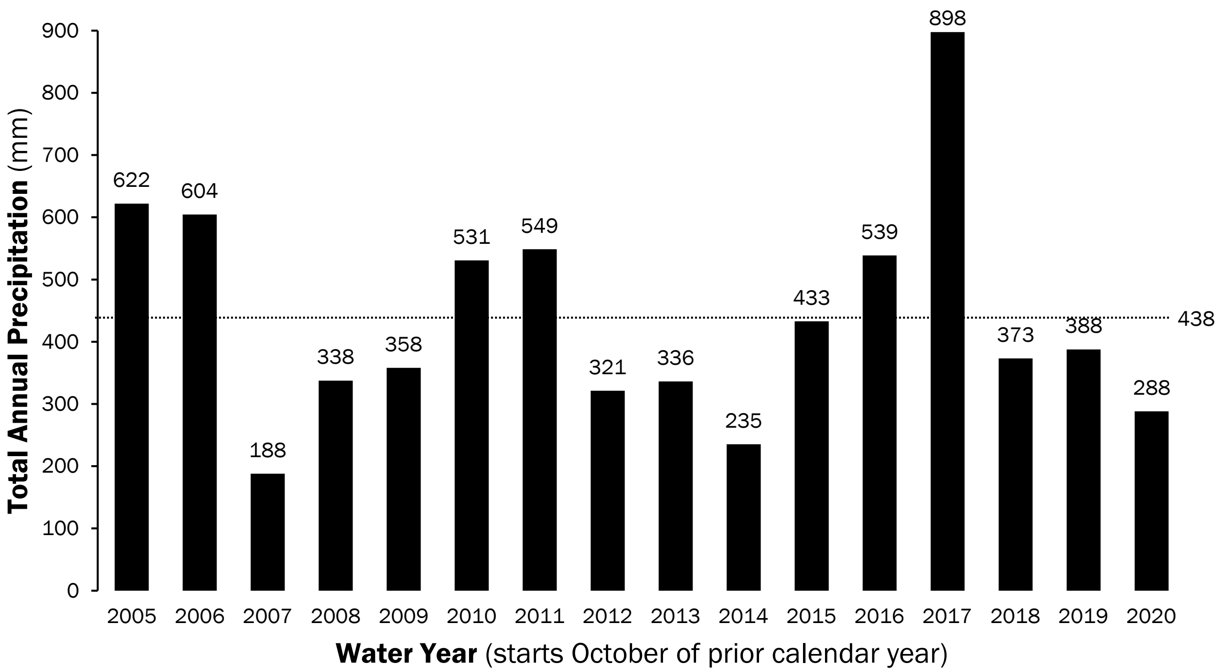
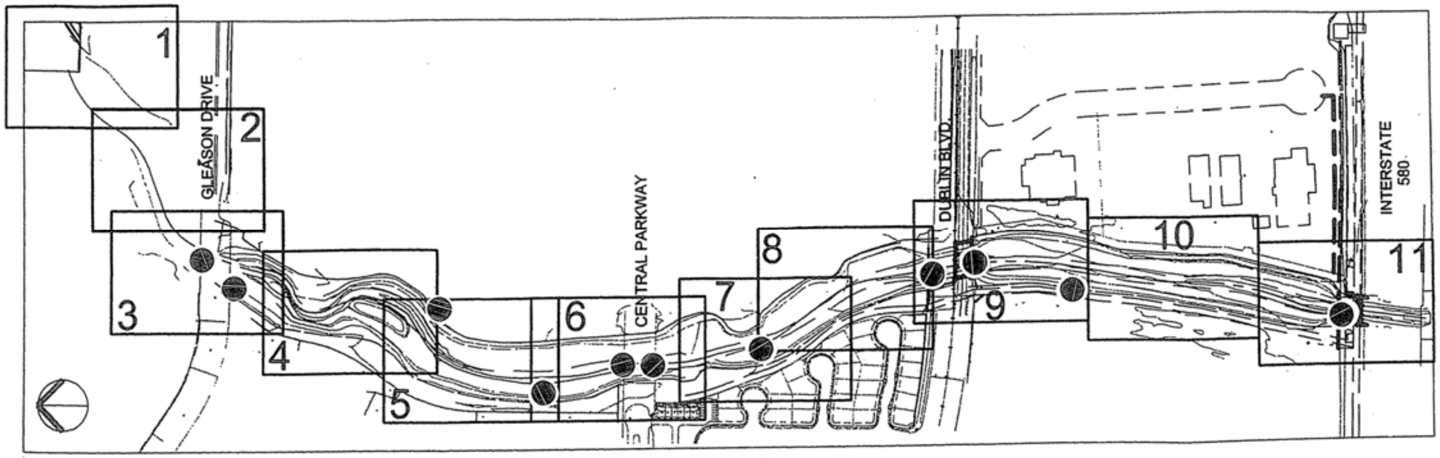


Exhibit 7. Photo monitoring locations

✓ indicates locations photographed in this report.

(original map from Brian Kangas Foulk Engineers, 1999, fig. 4; coordinates from Trinh & Percelay, 2008)



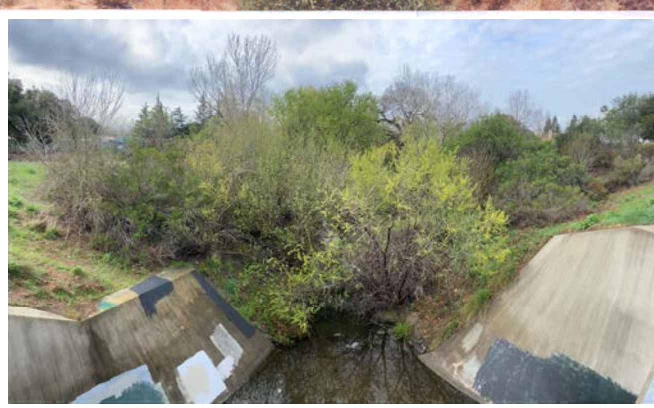
		Description	Latitude	Longitude
		Northern Reach		
✓	1	Upstream View of North from Gleason Drive Bridge	N 37° 42.769’	W 121° 52.701’
✓	2	Downstream View to South from Gleason Drive Bridge	N 37° 42.753’	W 121° 52.710’
✓	3	Upstream View of East Bank Between Gleason Drive and Stairs	N 37° 42.691’	W 121° 52.721’
✓	4	Panoramic Photo from West Bank Between Stairs and Central Parkway	N 37° 42.604’	W 121° 52.805’
✓	5	Upstream View to North of Central Parkway Bridge	N 37° 42.529’	W 121° 52.763’
			N 37° 42.527’	W 121° 52.791’
✓	6	Downstream View to South of Central Parkway Bridge	N 37° 42.512’	W 121° 52.784’
✓	7	Panoramic Photo from West Bank South of Central Parkway	N 37° 42.456’	W 121° 52.781’
✓	8	Upstream View to North of Dublin Boulevard Bridge	N 37° 42.350’	W 121° 52.711
		Southern Reach		
	9	Downstream View to South of Dublin Boulevard Bridge	*undefined*	*undefined*
	10	Panoramic Photo from West Bank South of Dublin Boulevard	N 37° 42.288’	W 121° 52.719’
	11	Upstream View to North from Highway 580 Bridge	N 37° 42.120’	W 121° 52.739’

Exhibit 8. Site Monitoring Photos

(Davis Environmental Consulting, 2001, vs 2021 site visit)

(a) Upstream view to north of Gleason Dr (station 1)

(b) Downstream view to south of Gleason Dr (station 2)



(c) Upstream view from east bank between Gleason Dr and stairs (station 3)

(d) Panoramic view from west bank between stairs and Central Pkwy (station 4)

(e) Upstream view to north of Central Pkwy (station 5)

(f) Downstream view to south of Central Pkwy (station 6)

(g) Panoramic photo from west bank south of Central Pkwy (station 7)

(h) Upstream view to north of Dublin Blvd (station 8)

Exhibit 9. Table of vegetation monitoring transect locations.

✓ indicates locations surveyed in this report.

(originally defined by Davis Environmental Consulting, 2001; adapted from Trinh & Percelay, 2008)

		Description	Latitude	Longitude
✓	1	Upstream of Gleason Bridge Right Bank (West side of Creek)	N 37° 42.806' N 37° 42.793'	W 121° 52.677' W 121° 52.672'
	2	Upstream of Gleason Bridge Left Bank (East side of Creek)	N 37° 42.774' N 37° 42,779' N 37° 42.788'	W 121° 52.667' W 121° 52.669' W 121° 52.675
✓	3a	Downstream of Gleason Bridge Right Bank (West side of Creek) - *trail to tributary bank*	N 37° 42.738' N 37° 42.738' N 37° 42.730'	W 121° 52.737' W 121° 52.733' W 121° 52.722'
✓	3b	Downstream of Gleason Bridge Right Bank (West side of Creek) - *tributary to main channel*	N 37° 42.730' N 37° 42.729'	W 121° 52.722' W 121° 52.718'
✓	4	Downstream (south) of Gleason Bridge Left Bank (East side of Creek)	N 37° 42.723' N 37° 42.725'	W 121° 52.708' W 121° 52.711'
✓	5	Halfway between stairway and Central Parkway bridge on Right bank (West side of creek)	N 37° 42.601' N 37° 42.602'	W 121° 52.802' W 121° 52.789'
✓	6	Halfway between stairway and Central Parkway bridge on Left bank (East side of creek)	N 37° 42.599' N 37° 42.602'	W 121° 52.764' W 121° 52.778'
✓	7	Downstream (South) of Central Parkway bridge on Left bank (East side of creek)	N 37° 42.468' N 37° 42.466'	W 121° 52.742' W 121° 52.765'
✓	8	Downstream (South) of Central Parkway bridge on Right bank (West side of creek)	N 37° 42.464' N 37° 42.466'	W 121° 52.782' W 121° 52.772'
✓	9	Upstream (North) of Dublin Bridge, Right bank (West side of creek)	N 37° 42.409' N 37° 42.412'	W 121° 52.749' W 121° 52.741'
✓	10	Upstream (North) of Dublin Bridge, Left bank (East side of creek)	N 37° 42.422' N 37° 42.412'	W 121° 52.716' W 121° 52.734'
	11	Downstream (South) of Dublin Bridge, Right bank (West side of creek)	N 37° 42.287' N 37° 42.287' N 37° 42.286'	W 121° 52.720' W 121° 52.714' W 121° 52.709'
	12	Upstream (North) of I-580 Bridge, Right bank (West side of creek)	N 37° 42.206' N 37° 42.204'	W 121° 52.733' W 121° 52.721'
	13	Upstream (North) of I-580 Bridge, Left bank (East side of creek)	N 37° 42.202' N 37° 42.204'	W 121° 52.698' W 121° 52.713'
	14	Downstream (South) of Dublin Bridge, Left bank (East side of creek)	N 37° 42.283' N 37° 42.284'	W 121° 52.684' W 121° 52.696'

Exhibit 10. Vegetation monitoring transects

coordinates from Trinh and Percelay (2008), overlayed on ground height from channel (derived from 2007 Alameda County LiDAR DEM) and street outlines from City of Dublin Public Works

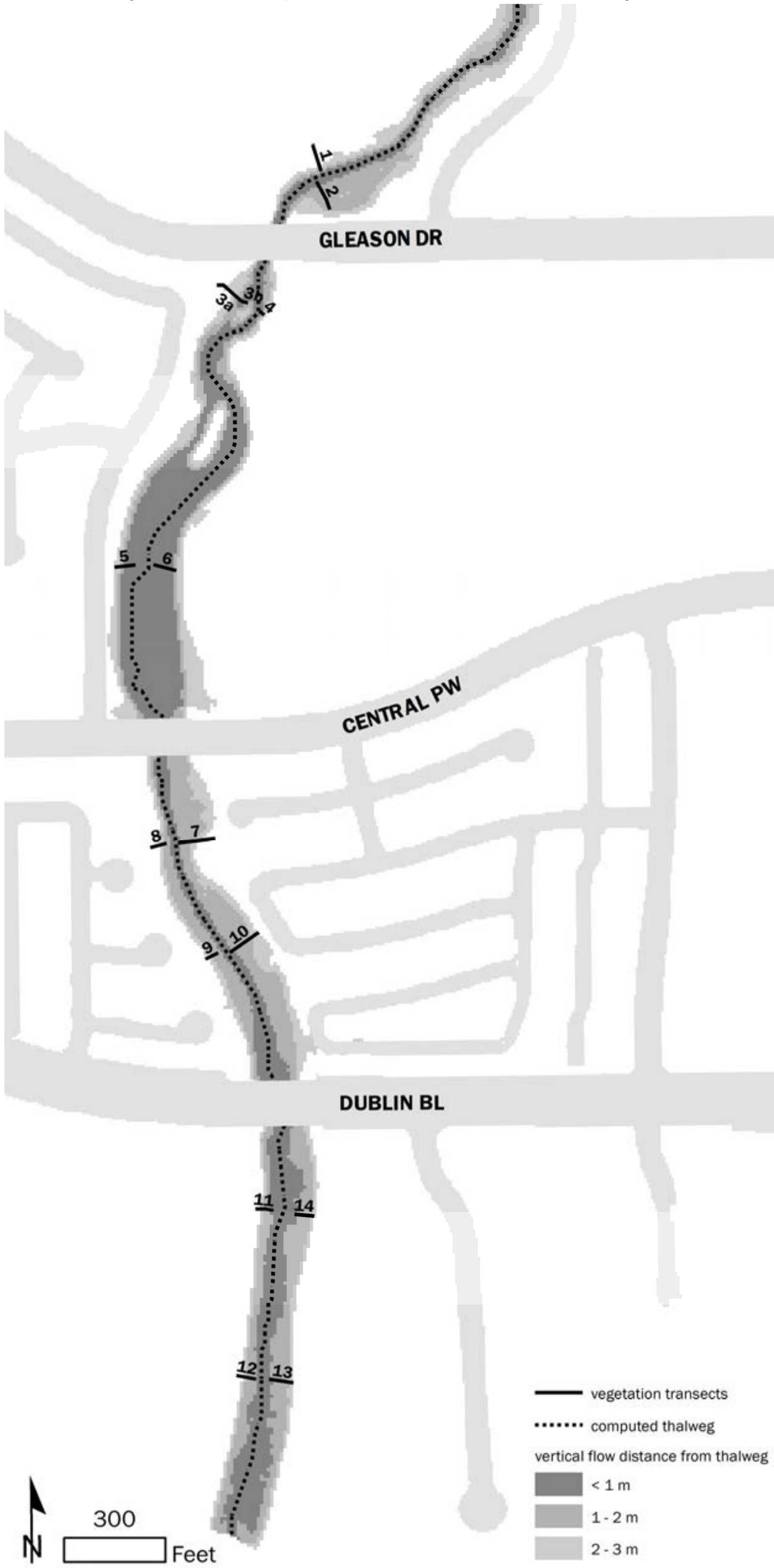


Exhibit 11. Vegetation survey results: Individual plant counts by transect

		1	2	3a	3b	4	5	6	7	8	9	10	Total
Original planting plan													
Coast live oak	*Quercus agrifolia*	-	-	-	-	1	7	-	-	-	-	-	8
Valley oak	*Quercus lobata*	-	-	1	-	-	-	2	-	-	-	-	3
California sycamore	*Platanus racemosa*	-	-	-	-	-	-	-	-	-	-	-	-
California buckeye	*Aesculus californica*	-	-	-	1	-	-	-	-	2	-	1	4
Fremont cottonwood	*Populus fremontii*	1	-	-	-	-	-	-	-	-	-	-	1
Nor. Calif. black walnut	*Juglans hindsii*	-	-	-	-	-	1	-	-	-	-	-	1
Box elder maple	*Acer negundo*	-	-	-	-	-	-	-	-	-	-	4	4
Willow	*Salix spp.*	1	-	1	1	1	-	1	1	1	-	-	7
Oregon ash	*Fraxinus latifolia*	-	-	-	-	-	-	-	-	-	-	-	-
Blue elder	*Sambucus nigra*	-	-	-	-	1	-	-	-	1	-	-	2
Toyon	*Heteromeles arbutifolia*	-	-	-	-	-	2	1	-	-	-	-	3
California coffeeberry	*Frangula californica*	-	-	-	-	1	-	-	-	-	-	-	1
Coyote brush	*Baccharis pilularis*	1	-	2	2	1	2	1	1	-	1	-	11
Snowberry	*Symphocarpus mollis*	-	-	-	-	-	-	-	-	-	-	-	-
California wild grape	*Vitis californica*	-	-	-	-	-	-	-	-	-	-	-	-
Pacific blackberry	*Rubus ursinus*	-	-	1	2	2	2	1	1	1	-	-	10
California wild rose	*Rosa californica*	-	-	1	3	-	-	-	4	1	1	3	13
Newly identified 2008													
Black cottonwood	*Populus trichocarpa*	-	-	-	-	-	-	-	-	-	-	-	-
Arrowweed	*Pluchea sericea*	-	-	-	-	-	-	-	1	-	-	-	1
Lupine	*Lupinus latifolius*	-	-	-	-	-	-	-	-	-	-	-	-
Cattail	*Typha domingensis*	-	-	-	-	-	-	-	-	-	-	-	-
California buckwheat	*Eriogonum fasciculatum*	1	-	-	1	-	-	-	-	-	-	-	2
Curly dock	*Rumex crispus*	-	-	-	-	-	-	-	-	-	-	-	-
Fennel	*Foeniculum vulgare*	-	-	-	-	-	1	1	-	-	-	-	2
Newly identified 2020													
California mugwort	*Artemisia douglasiana*	-	-	-	26	-	13	12	-	-	-	-	51
California sagebrush	*Artemisia californica*	-	-	-	-	-	-	1	-	-	-	-	1
Milk thistle	*Silybum spp.*	2	-	-	-	-	-	-	-	-	-	-	2
Pacific madrone	*Arbutus menziesii*	-	-	-	-	1	-	-	-	-	-	-	1
Poison hemlock	*Conium maculatum*	-	-	4	3	-	-	-	-	-	-	-	7
California scrub oak	*Quercus berberidifolia*	-	-	2	-	-	-	-	3	1	-	1	7
White horehound	*Marrubium vulgare*	-	-	1	1	-	-	1	-	-	-	-	3
Watercress	*Nasturtium officinale*	-	-	-	-	-	-	-	-	-	-	-	-
Unknown (dead shrubs)													
?	*?*	4	-	1	1	-	-	-	-	-	-	-	6
Number of individuals		5	-	12	39	7	20	19	11	5	2	4	124
Number of species		6	-	9	10	7	7	9	6	6	2	4	24

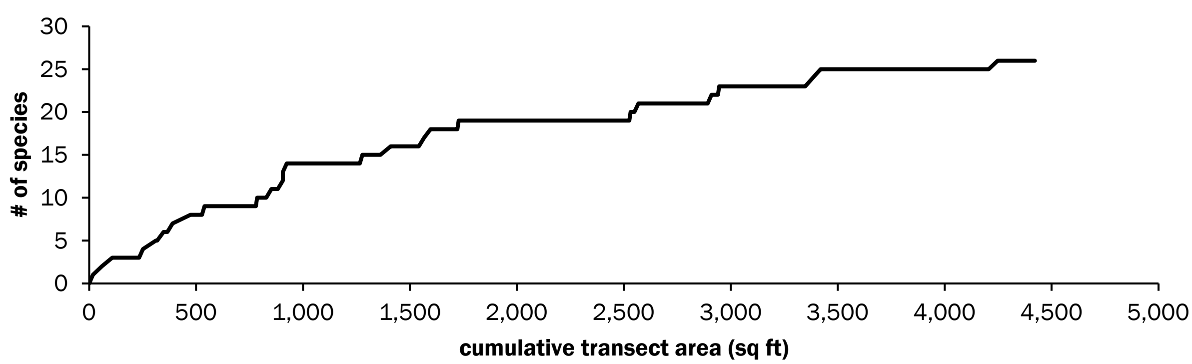


Exhibit 12. Photo observations, north of Gleason Ave

Poison hemlock patch near Transect 1 looking east, with wild turkey (left) and dead shrub (right)

Exposed willow roots and undercutting, end of Transect 1, looking downstream.

Exhibit 13. Photo observations, Gleason Ave to trail crossing

Characteristic panorama looking upstream from near the channel, vegetation and topographic diversity

Extant old-growth valley oak (left, looking downstream) and valley oak seedling (right) along Transect 3b

(left) Watercress growing in the main channel, end of Transect 3b

(right) Mature blue elder tree along Transect 4, looking east, with 4-foot straightedge for scale

Pools and riffles on the main channel, north of the trail crossing looking upstream.

Trail crossing, looking upstream, closed to flooding October through March

Leaf litter collected in the low-flow channel, south of the trail crossing looking downstream.

Exhibit 14. Photo observations, south of trail crossing to Central Pkwy

Dense terrace vegetation (e.g. *Baccharis*) looking west

Transect 6: open grassland near start (left) and dense mugwort at low flow channel edge (right)

Exhibit 15. Photo observations, Central Pkwy to Dublin Blvd

Vegetated terrace with boxelder maple and vetch, looking upstream.

Young buckeye seedlings

Dense willow thicket at end of Transect 8, with trash lines, buckeye saplings, and T-post.

Channel edge at Transect 9, looking east with end of Transect 10 across the channel.

Exhibit 16. Aerial images, 1992 and 2002, for historic reference
(USGS Digital Ortho Quad & High Resolution Orthoimagery)

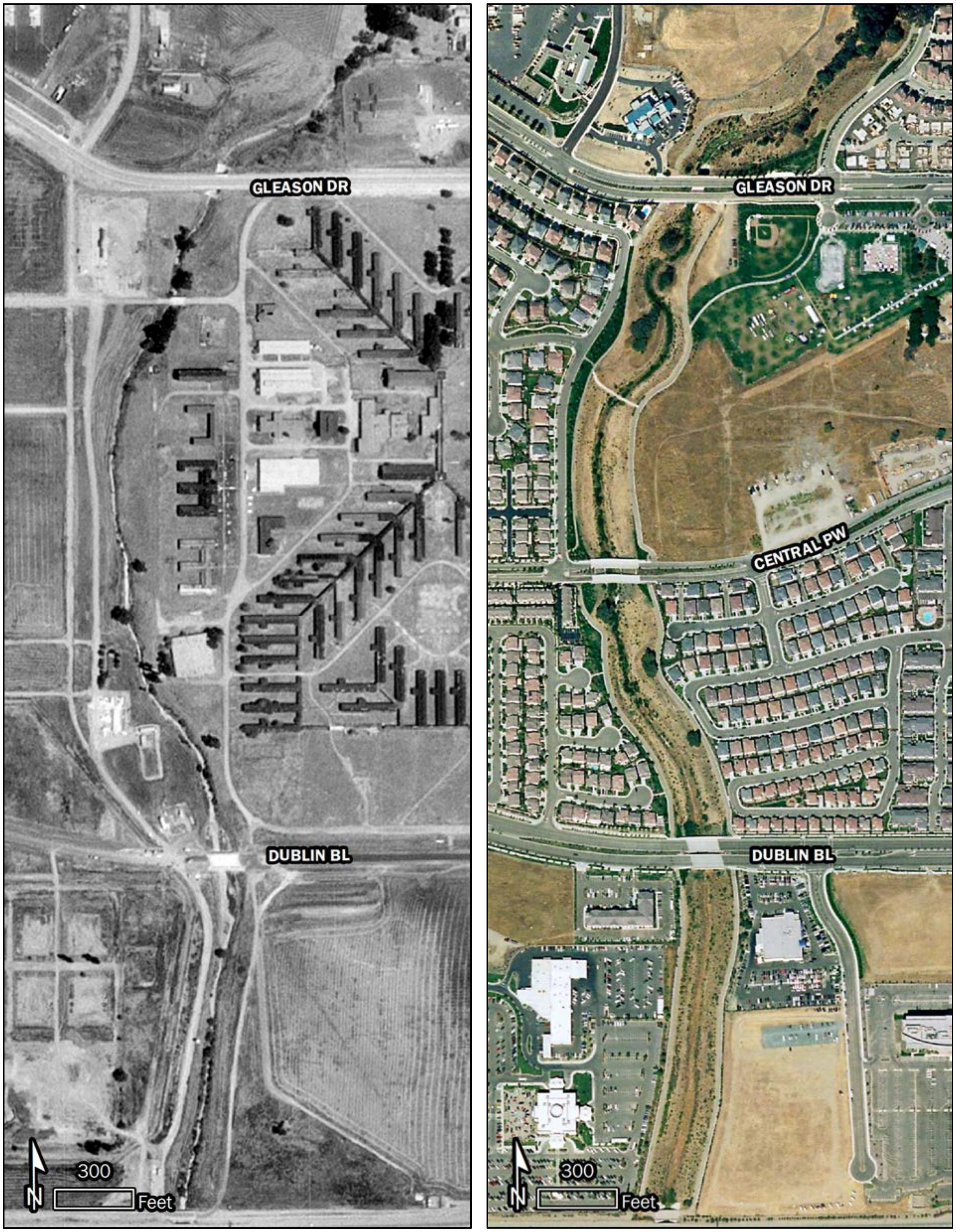
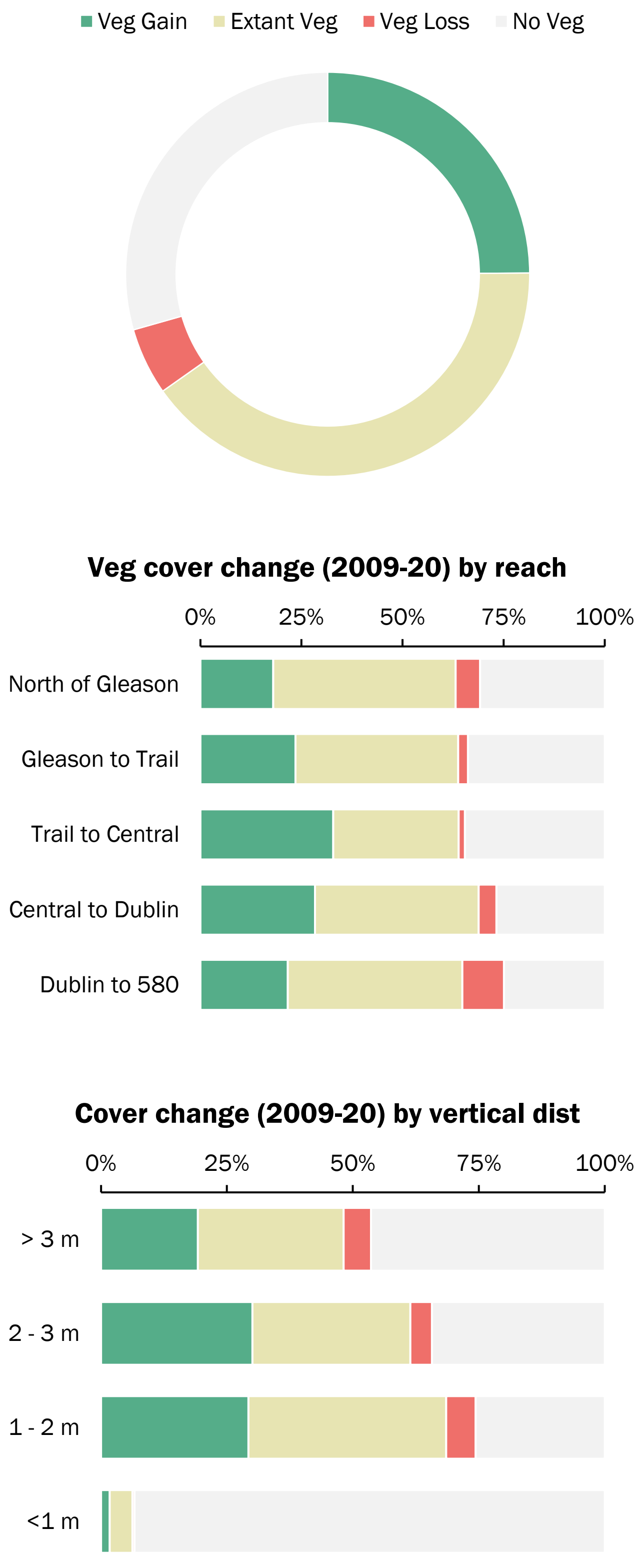


Exhibit 17. Aerial images, 2009 and 2020, used in remote sensing study
(USDA National Agriculture Imagery Program)

Exhibit 18. Remote sensing results: Vegetation cover change (2009-2020)
(via NAIP imagery 2009-2020)



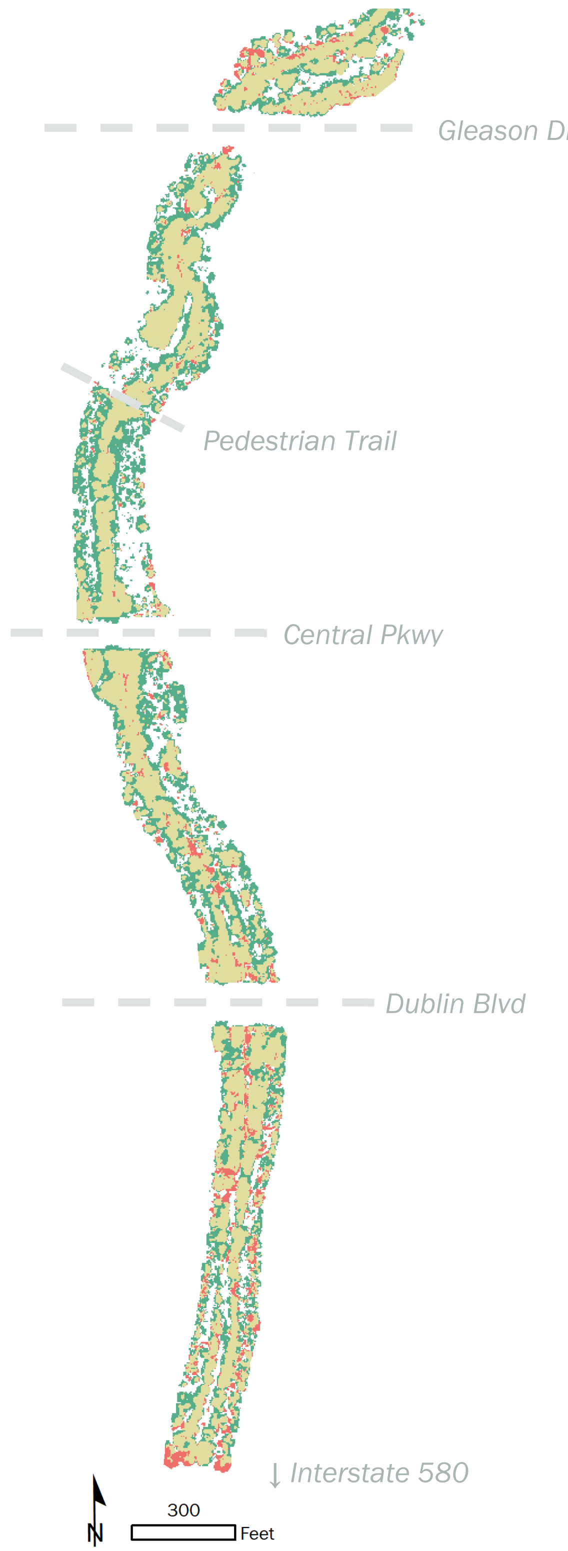
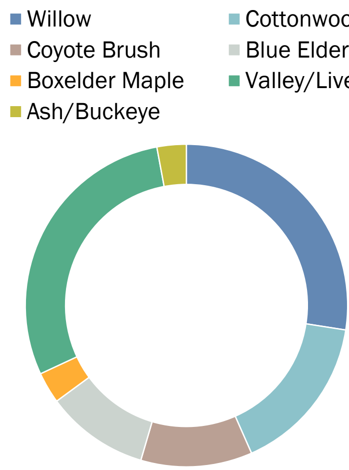
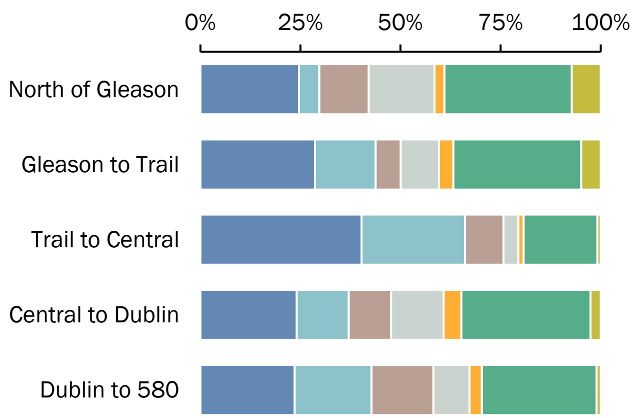


Exhibit 19. Remote sensing results: Classified 2020 vegetation map
(via 2020 NAIP imagery and 2021 ground truth)



Tree classes (2020) by reach



Tree classes (2020) by vertical dist

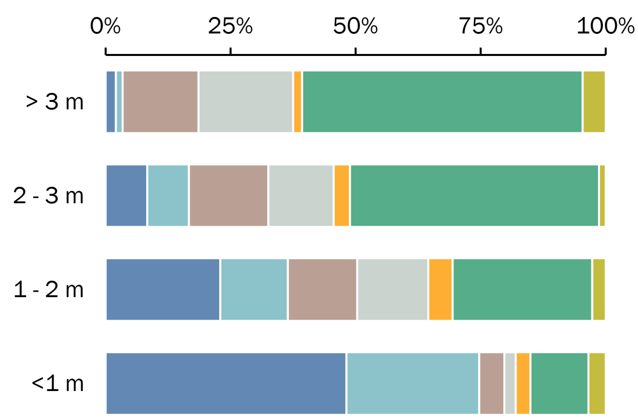
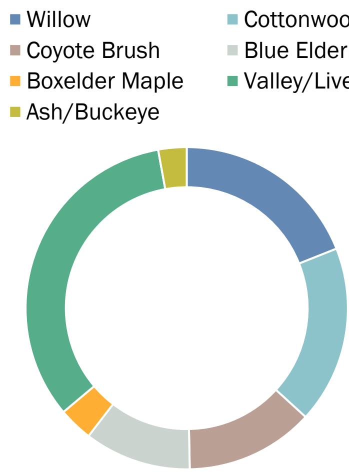
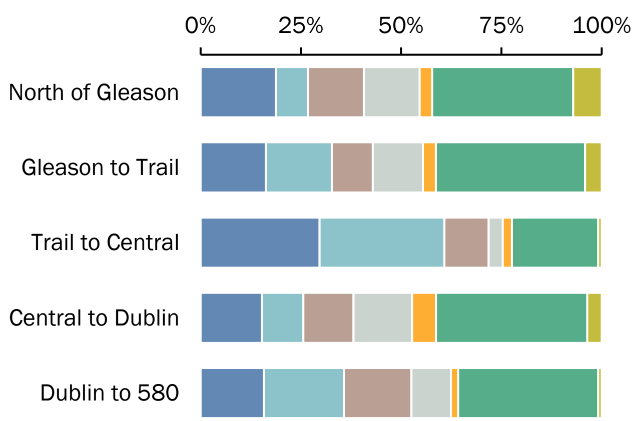


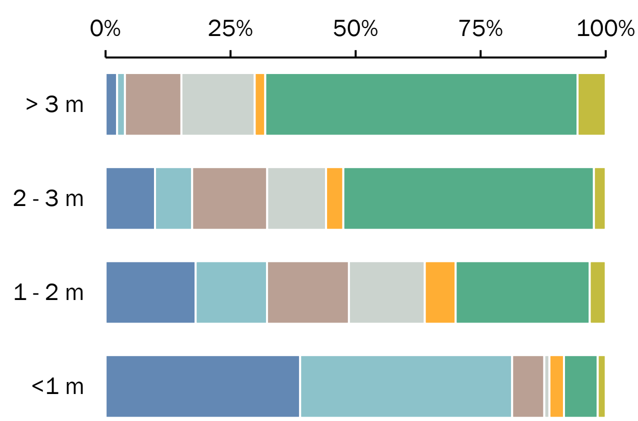
Exhibit 20. Remote sensing results: Classified vegetation gain since 2009
(via 2009-2020 NAIP imagery and 2021 ground truth)



Classes (2020) of veg gain by reach



Classes (2020) of veg gain by vert dist



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Appendix: Transect Survey Data

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T01	0'				(start off path just east of box elder)					
T01	3' – 31'	Patch		100%	Poison hemlock	*Conium maculatum*	2'			saw wild turkey and hare
T01	10' – 17'	Tree	1		Coyote brush	*Baccharis pilularis*	6'	6'		
T01	18'	Shrub	1		?	?	6'		D	
T01	21'	Shrub	1		?	?	7'		D	
T01	22'	Shrub	1		?	?	6'		D	
T01	23'	Shrub	1		?	?	7'		D	
T01	31' – 42'	Patch		100%	Grass (annual)		2'			not recorded elsewhere due to ubiquity and seasonality
T01	33' – 35'	Patch		100%	Poison hemlock	*Conium maculatum*	2'			
T01	39'	Shrub	1		?		7'		D	
T01	42' – 50'	Patch		50%	Milk thistle	*Silybum spp.*	1'			
T01	52'	Tree	1		Fremont cottonwood	*Populus fremontii*	18'			
T01	53'	Shrub	1		Milk thistle	*Silybum spp.*	1'			
T01	58' – 66'	Shrub	1		California buckwheat	*Eriogonum fasciculatum*	4'			
T01	61'	Shrub	1		Milk thistle	*Silybum spp.*	1'			
T01	65'	Shrub	1		Legume/vetch (annual)	*Vicia spp.?*	1'			
T01	79'	Tree	1		Willow	*Salix spp.*	12'			
T03a	0'				(start off path between scrub oak and live oak, bearing toward the willow)					
T03a	9'	Shrub	1		?	?	4'		D	grass cover throughout area
T03a	11' – 17'	Shrub	1		California scrub oak	*Quercus berberidifolia*	8'	6'		
T03a	20'	Shrub	1		California scrub oak	*Quercus berberidifolia*	3'	1'		
T03a	21'				(rebar)					saw 2 hares
T03a	21' – 23'	Patch		20%	Legume/vetch (annual)	*Vicia spp.?*	1'			
T03a	24' – 40'	Patch		20%	Legume/vetch (annual)	*Vicia spp.?*				

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T03a	51'				(adjacent California walnut)					
T03a	52'	Tree	1		Valley oak	*Quercus lobata*	3'	1'		
T03a	54' – 57'	Shrub	4		Poison hemlock	*Conium maculatum*	2'			new growth
T03a	59' – 62'				(crossing log)					
T03a	63' – 72'	Patch		50%	California mugwort	*Artemisia douglasiana*	2'			
T03a	68'	Tree	1		Willow	*Salix spp.*	20'			16" trunk diameter; start of transect 3b
T03a	72'	Shrub	1		California wild rose	*Rosa californica*	4'			
T03a	72' – 77'	Shrub	1		White horehound	*Marrubium vulgare*	3'			
T03a	75'	Shrub	1		Pacific blackberry	*Rubus ursinus*	4'			
T03a	83'	Shrub	1		Coyote brush	*Baccharis pilularis*	7'	8'		
T03a	93'	Shrub	1		Coyote brush	*Baccharis pilularis*	5'	5'		
T03a	93'				(dry tributary channel thalweg)					
T03b	0'				(start at base of the willow in transect 3a, now heading toward the main channel)					
T03b	1'	Shrub	8		California mugwort	*Artemisia douglasiana*	1'			
T03b	3'	Shrub	3		California mugwort	*Artemisia douglasiana*	1'			
T03b	5'	Shrub	1		California wild rose	*Rosa californica*	3'			
T03b	5' – 9'	Shrub	12		California mugwort	*Artemisia douglasiana*	2'			
T03b	7' – 11'	Shrub	1		White horehound	*Marrubium vulgare*	4'			
T03b	8'	Shrub	1		Poison hemlock	*Conium maculatum*	2'			
T03b	10'	Shrub	1		California buckwheat	*Eriogonum fasciculatum*	1'			
T03b	11' – 12'	Shrub	1		California wild rose	*Rosa californica*	3'			
T03b	14'	Shrub	1		Poison hemlock	*Conium maculatum*	2'			
T03b	15'	Shrub	1		Poison hemlock	*Conium maculatum*	3'			
T03b	17' – 21'	Patch		50%	California mugwort	*Artemisia douglasiana*	3'			
T03b	17' – 21'	Patch		50%	Poison hemlock	*Conium maculatum*	3'			
T03b	21'	Shrub	1		?	*?*	10'		D	
T03b	21'	Shrub	1		California wild rose	*Rosa californica*	2'			
T03b	23' – 25'	Shrub	1		Coyote brush	*Baccharis pilularis*	6'	6'		

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T03b	27'	Shrub	1		California mugwort	*Artemisia douglasiana*	1'			
T03b	28'	Shrub	1		Coyote brush	*Baccharis pilularis*	2'			
T03b	31'	Shrub	2		California mugwort	*Artemisia douglasiana*	2'			
T03b	34' – 35'	Shrub	2		Legume/vetch (annual)	*Vicia spp.?*	3'			
T03b	39'				(deadwood branch of willow crosses transect; live trunk is adjacent)					
T03b	41'	Tree	1		California buckeye	*Aesculus californica*	3'			seedling
T03b	45' – 55'	Patch		20%	Legume/vetch (annual)	*Vicia spp.?*	1'			
T03b	46' – 47'	Shrub	1		Pacific blackberry	*Rubus ursinus*	2'			
T03b	49'	Shrub	1		Legume/vetch (annual)	*Vicia spp.?*	1'			
T03b	50'	Shrub	1		Pacific blackberry	*Rubus ursinus*	1'			
T03b	55' – 58'	Tree	1		Willow	*Salix spp.*	30'			12" diameter
T03b	63'	Shrub		100%	Watercress	*Nasturtium officinale*	0'			
T03b	63'				(water's edge)					water is flowing here, but stagnant at transects further downstream
T04	-2'	Shrub	1		Coyote brush	*Baccharis pilularis*	1'	4'		area is very overgrown, difficult to access
T04	4'	Shrub	1		California coffeeberry	*Frangula californica*	6'			mostly branches intersecting
T04	4'	Tree	1		Blue elder	*Sambucus nigra ssp. caerulea*	15'			this elder was only 7 ft tall in 2006 survey
T04	10'	Tree	1		Pacific madrone	*Arbutus menziesii*	8'			
T04	14'	Tree	1		Coast live oak	*Quercus agrifolia*	2'			visual estimate, could not place measuring tape due to dense veg
T04	17'	Shrub	1		Pacific blackberry	*Rubus ursinus*	2'			visual estimate, could not place measuring tape due to dense veg
T04	17'	Tree	1		Willow	*Salix spp.*	10'			visual estimate, could not place measuring tape due to dense veg
T04	19'	Shrub	1		Pacific blackberry	*Rubus ursinus*	5'			visual estimate, could not place measuring tape due to dense veg

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T05	-2'				(start between two utility boxes on ground)					
T05	9'	Shrub	1		Toyon	*Heteromeles arbutifolia*	8'			
T05	12'	Tree	1		Coast live oak	*Quercus agrifolia*	2'			seedling
T05	14'	Tree	1		Coast live oak	*Quercus agrifolia*	2'			seedling
T05	17'	Tree	1		Coast live oak	*Quercus agrifolia*	2'			seedling
T05	18'	Tree	1		Northern California black walnut	*Juglans hindsii*	20'			
T05	19'	Tree	1		Coast live oak	*Quercus agrifolia*	8'			sapling
T05	19'	Shrub	1		California mugwort	*Artemisia douglasiana*	1'			
T05	22'	Tree	1		Coast live oak	*Quercus agrifolia*	4'			seedling
T05	24'	Shrub	7		California mugwort	*Artemisia douglasiana*	1'			
T05	24'	Tree	1		Coast live oak	*Quercus agrifolia*	1'			seedling
T05	33'	Shrub	1		Coyote brush	*Baccharis pilularis*	2'			
T05	37' – 43'	Shrub	1		Toyon	*Heteromeles arbutifolia*	12'			
T05	52'	Shrub	2		California mugwort	*Artemisia douglasiana*	1'			
T05	54'	Shrub	1		Fennel	*Foeniculum vulgare*	1'			
T05	72'	Shrub	1		Pacific blackberry	*Rubus ursinus*	1'			
T05	74' (68' – 81')	Shrub	1		Coyote brush	*Baccharis pilularis*	6'			
T05	75'	Shrub	1		Pacific blackberry	*Rubus ursinus*	1'			
T05	76'				(30'+ cottonwood just out of transect range)					
T05	78'	Shrub	2		California mugwort	*Artemisia douglasiana*	1'			
T05	80'	Shrub	1		California mugwort	*Artemisia douglasiana*	1'			
T05	84'	Tree	1		Coast live oak	*Quercus agrifolia*				seedling
T05	84'				(edge of bank)					
T06	1' – 3'	Tree	1		Valley oak	*Quercus lobata*	1'			seedling
T06	4'	Tree	1		Valley oak	*Quercus lobata*	1'			seedling
T06	6'	Shrub	1		Legume/vetch (annual)	*Vicia spp.?*	1'			
T06	22'				(pass a 20' valley oak and 12' blue elder)					
T06	26'	Shrub	1		Toyon	*Heteromeles arbutifolia*	6'			

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T06	31'	Shrub	1		California sagebrush	*Artemisia californica*	3'			
T06	31' – 43'	Patch		10%	Legume/vetch (annual)	*Vicia spp.?*	2'			
T06	45'				(branch of nearby 12' Oregon ash crosses transect; the tree is growing interleaved with Baccharis)					
T06	52'	Shrub	1		Legume/vetch (annual)	*Vicia spp.?*	1'			
T06	53'	Shrub	1		Fennel	*Foeniculum vulgare*	2'			
T06	62'	Shrub	1		White horehound	*Marrubium vulgare*	1'			
T06	64'	Shrub	1		?		2'		D	
T06	70' – 72'	Patch		50%	Legume/vetch (annual)	*Vicia spp.?*	2'			dense grass throughout this area, in general not captured in survey
T06	72' – 77'	Shrub	1		Coyote brush	*Baccharis pilularis*	2'			
T06	82' – 83'	Shrub	6		California mugwort	*Artemisia douglasiana*	3'			
T06	86' – 92'	Shrub	6		California mugwort	*Artemisia douglasiana*	2'			
T06	87' – 91'	Tree	1		Willow	*Salix spp.*	12'			
T06	92'	Shrub	1		Pacific blackberry	*Rubus ursinus*	2'			
T06	93' – 96'	Patch		100%	California mugwort	*Artemisia douglasiana*	2'			dense mugwort leading off edge of low flow channel (endmark est.)
T07	0'	Shrub	1		California scrub oak	*Quercus berberidifolia*				
T07	16' – 20'	Patch		80%	Legume/vetch (annual)	*Vicia spp.?*	1'			
T07	20' – 32'	Patch		50%	Legume/vetch (annual)	*Vicia spp.?*	1'			
T07	26' (20' – 32')	Tree	1		Coyote brush	*Baccharis pilularis*	6'			
T07	32' – 69'	Patch		80%	Legume/vetch (annual)	*Vicia spp.?*	1'			
T07	60'	Shrub	1		California scrub oak	*Quercus berberidifolia*	8'			
T07	81'	Shrub	1		California wild rose	*Rosa californica*	1'			
T07	83'				(start of overhead willow canopy cover)					
T07	87'	Shrub	1		Legume/vetch (annual)	*Vicia spp.?*	2'			
T07	89'	Shrub	1		California wild rose	*Rosa californica*	3'	2'		
T07	89'	Shrub	1		California scrub oak	*Quercus berberidifolia*	3'			

Transect	Mark	Category	N	Pct	Species	*Scientific Name*	H	W	Dead	Notes
T07	91'	Shrub	1		California wild rose	*Rosa californica*	2'			
T07	92'	Shrub	1		Pacific blackberry	*Rubus ursinus*	3'			
T07	93'	Shrub	1		California wild rose	*Rosa californica*	3'			
T07	94'	Shrub	1		Arrowweed	*Pluchea sericea*	4'			
T07	97'	Tree	1		Willow	*Salix spp.*				ended transect at trunk
T08	5'	Tree	1		Blue elder	*Sambucus nigra ssp. caerulea*	20'			
T08	6'	Tree	1		California buckeye	*Aesculus californica*	3'			
T08	9'				(T-post marking transect alignment)					
T08	12'				(10' valley oak, branch crosses transect)					
T08	13'	Shrub	1		California scrub oak	*Quercus berberidifolia*	1'			
T08	15' – 19'				(3' tall annual grasses)					
T08	22' – 28'	Patch		100%	Legume/vetch (annual)	*Vicia spp.?*	2'			
T08	24'				(start of overhead willow canopy cover)					
T08	42'	Tree	1		California buckeye	*Aesculus californica*	2'			seedling - in general, lots of new buckeye growth in this area
T08	43'	Shrub	1		California wild rose	*Rosa californica*	1'			
T08	44'	Shrub	1		Pacific blackberry	*Rubus ursinus*	1'			
T08	46'				(T-post marking transect alignment)					
T08	48'	Tree	1		Willow	*Salix spp.*				ended transect at trunk
T09	3'				(T-post marking transect alignment)					
T09	3'				?	*?*	4'		D	dead Baccharis?
T09	15' – 22'	Patch		80%	Legume/vetch (annual)	*Vicia spp.?*	2'			interspersed with annual grasses too
T09	21'	Shrub	1		Coyote brush	*Baccharis pilularis*	4'			
T09	25'	Shrub	1		California wild rose	*Rosa californica*	4'			
T09	26' (22' – 32')				Coyote brush	*Baccharis pilularis*	12'			mostly branches intersecting

Transect	Mark	Category	N	Pct	Species	***Scientific Name***	H	W	Dead	Notes
T09	32' – 50'	Patch		50%	Legume/vetch (annual)	*Vicia spp.?*				
T09	50'				(end transect at bank; second T-post not located)					
T10	33'	Shrub	1		California scrub oak	*Quercus berberidifolia*	8'			
T10	33'	Tree	1		California buckeye	*Aesculus californica*	3'			seedling growing very close to scrub oak
T10	69'				(adjacent 15' Oregon Ash)					
T10	71'	Shrub	1		California wild rose	*Rosa californica*	3'			
T10	72'	Shrub	1		California wild rose	*Rosa californica*	4'			
T10	74'	Shrub	1		California wild rose	*Rosa californica*	7'			
T10	81'	Tree	3		Box elder maple	*Acer negundo*	3'			seedlings
T10	83' (76' – 90')	Tree	1		Box elder maple	*Acer negundo*	20'			
T10	108' – 110'	Patch		100%	Legume/vetch (annual)	*Vicia spp.?*				dense approaching edge of bank
T10	110'				(end transect at ~6ft diameter tree stump)					