



## The Urban Gauntlet for Steelhead Trout: A Reconnaissance Study of Habitat in Upper Bollinger and Little Pine Creeks, Contra Costa County

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### ABSTRACT

Poor water quality and concrete structures in the Urban Gauntlet of Walnut Creek Watershed in Contra Costa County have prevented anadromous California Central Coast steelhead trout (*Oncorhynchus mykiss*) from reaching historical spawning sites in the upper tributaries. In response to Contra Costa County's 2009 50-year "Channels to Creeks" plan, in January 2020 Natali et al. (2020a) provided recommendations to improve Walnut Creek's aging flood control infrastructure and allow steelhead to regain access to historical spawning sites. However, the current spawning habitat quality in upper reaches is not fully known. This study builds upon the 50-year plan by investigating whether conditions are still conducive to spawning in upper reaches if the region were to restore the Urban Gauntlet habitat. The field team surveyed two upper reaches, Little Pine Creek and Bollinger Canyon Creek, and two lower, urbanized reaches, Pine Creek and San Ramon Creek. The field team recorded habitat and canopy cover, channel morphology, and water quality at each site. Findings suggested that Bollinger Canyon Creek and Little Pine Creek had steelhead spawning habitat potential, while Pine Creek and San Ramon Creek had poor habitat and water quality due to concrete modifications. Little Pine Creek had the most potential to serve as steelhead spawning habitat. However, planners would require quantitative research as well as monitoring of continuing development to inform restoration strategies.

## PROBLEM STATEMENT

California Central Coast steelhead trout (*Oncorhynchus mykiss*) populations are expected to become extinct in the next 100 years because of factors including climate change, estuary alteration, damming, and urbanization (Moyle et al. 2017). Salmonids such as steelhead trout are considered keystone species, and declines in their population will cause imbalances in ecosystem processes such as nutrient cycling and food web dynamics (Gresh et al. 2000; Power 1990).

Historically, the Walnut Creek Watershed in Contra Costa County had late-winter to spring seasonal spawning migrations of California Central Coast steelhead trout as seen in Appendix A (Center for Ecosystem Management and Restoration (CEMAR) 2005; Moyle et al. 2017; Leidy et al. 2005). Spawning habitat preferences include higher stream gradients (2%-7%), gravel sizes between 1 and 2 inches, and average water depths of 14 inches (CalFish 2020). However, urbanization and extensive stream channel modifications for flood control have resulted in vast reduction of stream and riparian habitat, degraded water quality, and decreased flow, constraining spawning runs to lower reaches of the watershed (Natali et al. 2020a). Much of the Walnut Creek-San Ramon Creek channel contains engineered channels, levees, and drop structures (Leidy 1983). An aerial image of the distribution of drop structures in the Walnut Creek Watershed is available Appendix B. Past studies have noted spawning potential in upper tributaries but were limited by downstream urbanization (Leidy et al. 2005).

In 2009 the Contra Costa County Flood Control and Water Conservation District (CCCFCWCD) adopted “The 50-year plan ‘Channels to Creeks,’” which proposed converting engineered concrete and riprap-lined channels into natural systems. Although the plan was adopted in principle, few actions have been taken to realize the plan. In response to the 50-year

plan Natali et al. (2020a) published “Walnut Creek Watershed Restoration Opportunities” in January 2020 to explore and analyze how to actualize the Flood Control District’s plan. They evaluated social and ecological avenues that could revive Walnut Creek Watershed’s engineered channels into multi-functional corridors. Steelhead trout still exist in lower reaches of the watershed, but they are unable to arrive at their native spawning grounds because of conditions in the “Urban Gauntlet”: the middle, heavily urbanized reaches of the watershed with increased impervious surfaces, degraded water quality, and most importantly, physical barriers to migration such as check dams. If middle reach water quality and connectivity were restored, steelhead trout might be able to access historical upper reaches, but spawning habitat quality in these reaches is not fully known.

We expanded upon research from the 50-year plan and aimed to characterize the upper and middle, urbanized reaches within the Walnut Creek Watershed. The goal was to understand steelhead trout habitat opportunities in upstream reaches and assess potential for steelhead trout recolonization if passage through downstream, Urban Gauntlet, reaches was restored.

## **METHODS**

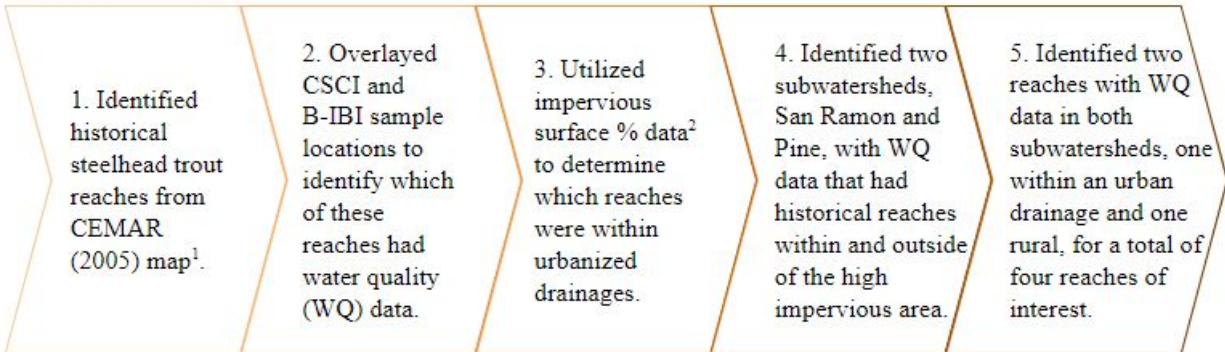
Our team spoke with Jen Natali, an author of “Walnut Creek Watershed Restoration Opportunities” and Ph.D. candidate at UC Berkeley, on November 6, 2020 during our preliminary planning process. She gave us an overview of the 50-year plan and Walnut Creek watershed and provided access to peer-reviewed papers, maps, and supporting documents needed to narrow our research topic. Natali answered follow-up questions and accompanied us in the field, guiding us through spawning habitat and substrate identification.

Unfortunately, due to COVID-19 restrictions there was limited opportunity to do field

work and we could not meet local experts, such as from CCCFCWCD. Likewise, we could not obtain measuring equipment or walk long distances within channels because of safety hazards such as encounters with those experiencing homelessness, barbed wire fences, and wildlife. Thus, our study was at a reconnaissance level only with limited observation sites and serves only to suggest future research directions and potential restoration priorities. Our study was not comprehensive for reasons mentioned above and thus could not satisfactorily answer questions about the suitability of habitat throughout entire stream systems.

## Site Selection

A flowchart outlining our stream reach selection process is provided in Figure 1 for reference while a detailed description is below.

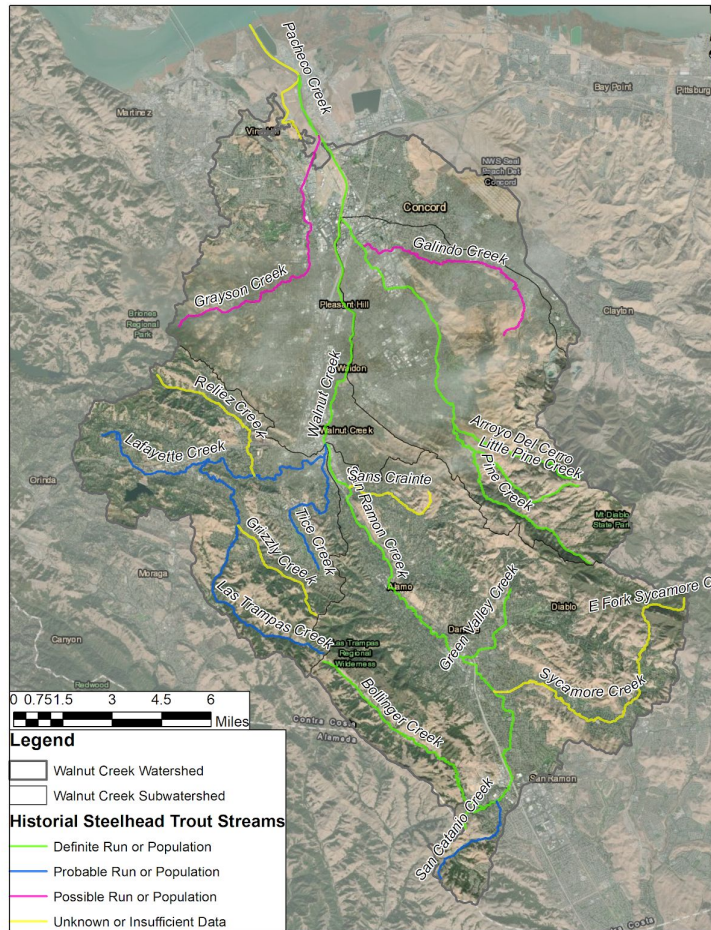


**Figure 1:** Flowchart outlining our stream reach selection process.<sup>1</sup>Appendix A. <sup>2</sup>Appendix C, Map W-4.

To select field observation reaches and points, we began by comparing Benthic Indices of Biotic Integrity (B-IBI) scores, California Stream Condition Index (CSCI) scores to CEMAR historical steelhead trout streams (Appendix A). The California State Water Resources Control

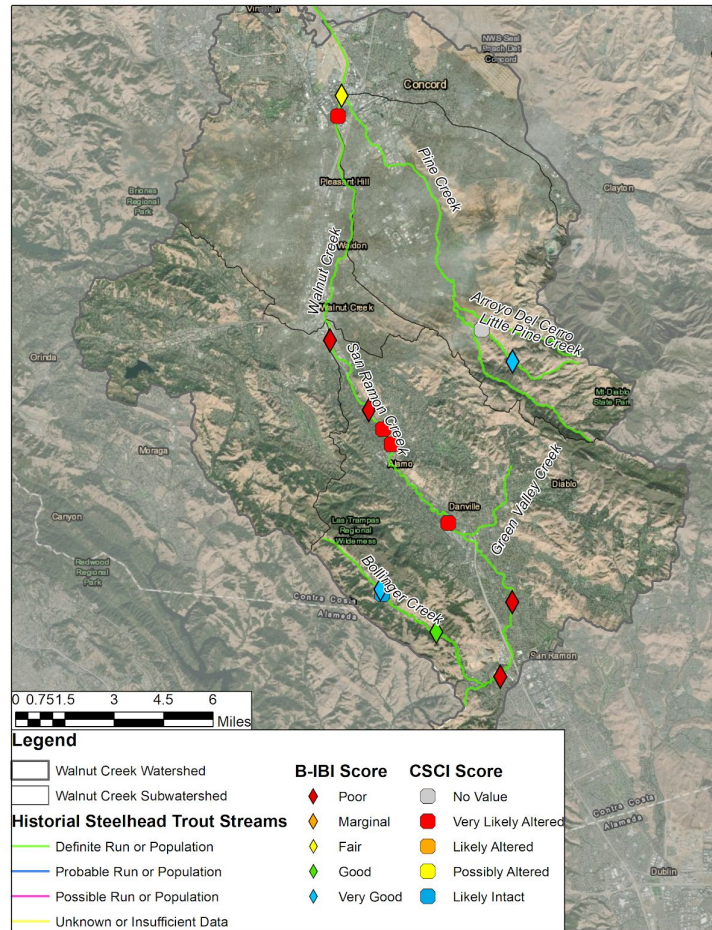
Board's Surface Water Ambient Monitoring Program developed CSCI scores as a tool to translate data about benthic macroinvertebrates into an overall measure of stream health. CSCI is considered to be an advancement over other indices as it is applicable statewide, accounts for a wider range of natural variability, and incorporates measures of species composition and ecological traits into a single condition score. Scores are tabulated using a site's observed condition in comparison to its predicted conditions as determined by statistical modeling. The development of a site's observed condition includes factors such as water quality sampling data, taxonomic completeness, and measures of ecological traits including function and structure (CA Waterboard CSCI Factsheet).

From the CEMAR data we identified Walnut Creek, Pine Creek, Arroyo Del Cerro, Little Pine Creek, San Ramon Creek, Green Valley Creek, and Bollinger Canyon Creek as streams within the Walnut Creek Watershed with historical definite steelhead trout runs or populations as shown in Figure 2 below.



**Figure 2:** Historical steelhead trout runs and populations per the CEMAR 2005 map.

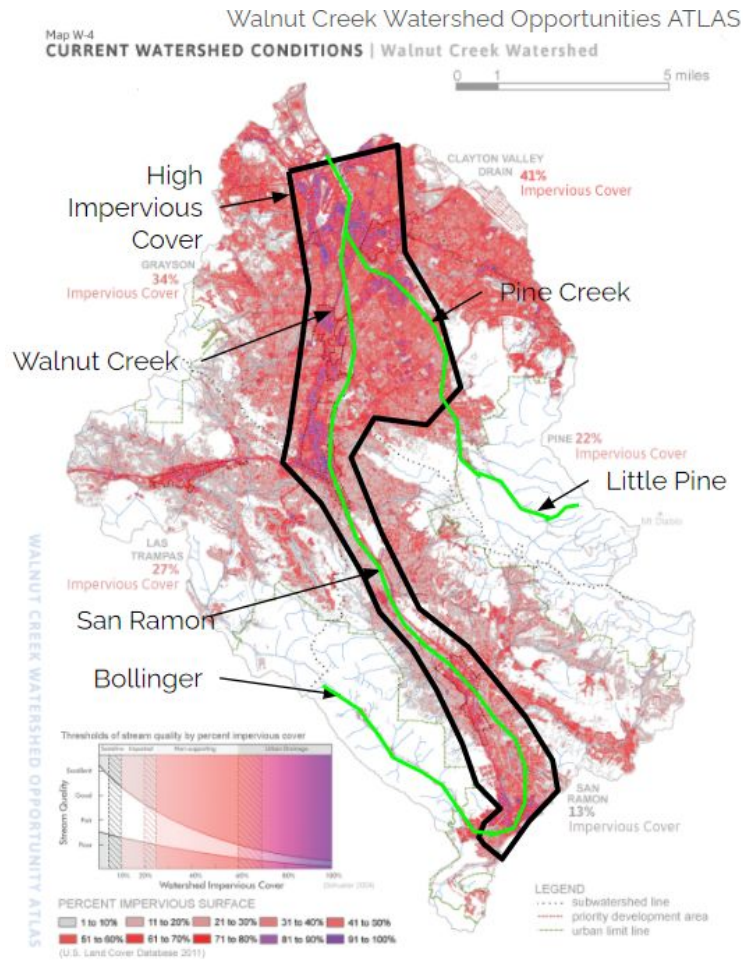
From there we utilized CSCI and B-IBI scores to identify which of these reaches had available water quality data to understand the biological health of a stream reach, shown in Figure 3. From this we eliminated Arroyo Del Cero and Green Valley Creek because there were no previous water quality sampling efforts for these reaches.



**Figure 3:** A spatial analysis of the Walnut Creek watershed and subwatersheds, historical steelhead trout streams, B-IBI scores, and CSCI scores.

Further, we used the percent impervious surface map from the 2020 Walnut Creek Watershed Opportunity Atlas (Appendix C, Map W-4 Current Watershed Conditions) to determine whether a stream reach was within an urban drainage or instead more rural. Since increased urbanization leads to increased impervious surfaces and degraded water quality, we used this percent impervious cover to partially determine the bounds of the Urban Gauntlet (Morse et al. 2003). Figure 4 below shows this determination, where red and purple areas have

high impervious cover, and the black outline is meant to highlight highly urbanized areas as well as which reaches are within dense urban areas or are more rural. Walnut Creek, Pine Creek, and San Ramon creek were all within urban drainages whereas Little Pine Creek and Bollinger Creek are more rural.

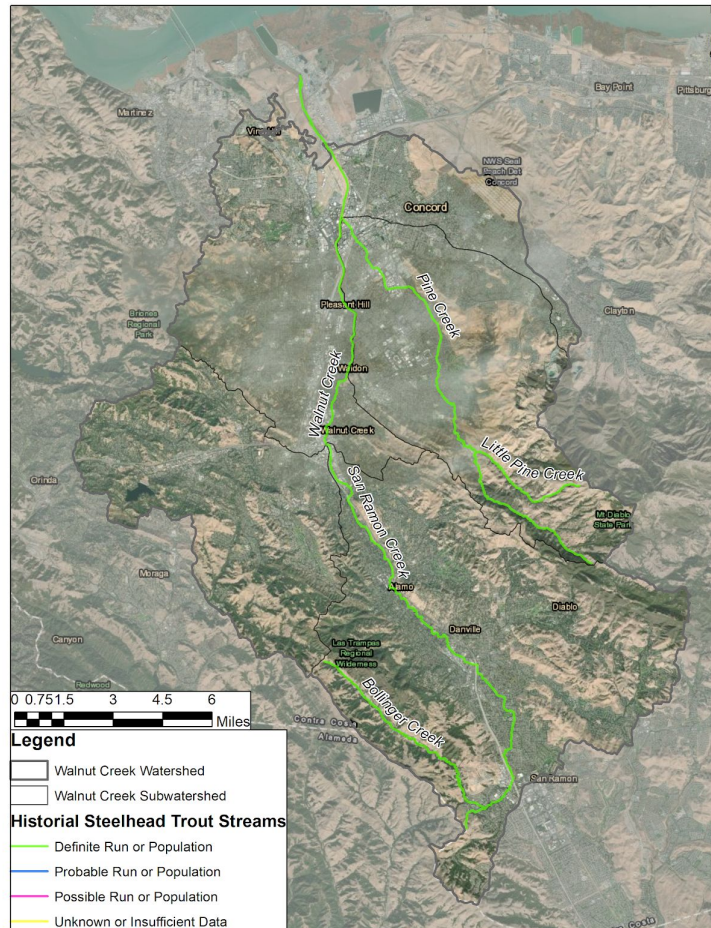


**Figure 4:** Urban Gauntlet boundary analysis using percent impervious cover.

In combination with our previous analysis, we selected four reaches from two subwatersheds, San Ramon Creek subwatershed and Pine Creek subwatershed. From San Ramon Creek Watershed we identified San Ramon Creek as our downstream, urbanized reach and

Bollinger Canyon Creek as upper, biologically intact reach. Similarly, for Pine Creek we identified Pine Creek as our lower, urbanized reach and Little Pine Creek as our upper intact observation location. Figure 5 provides a spatial summary of these streams in relation to each other and the watershed. Below is a summary of these four reaches described:

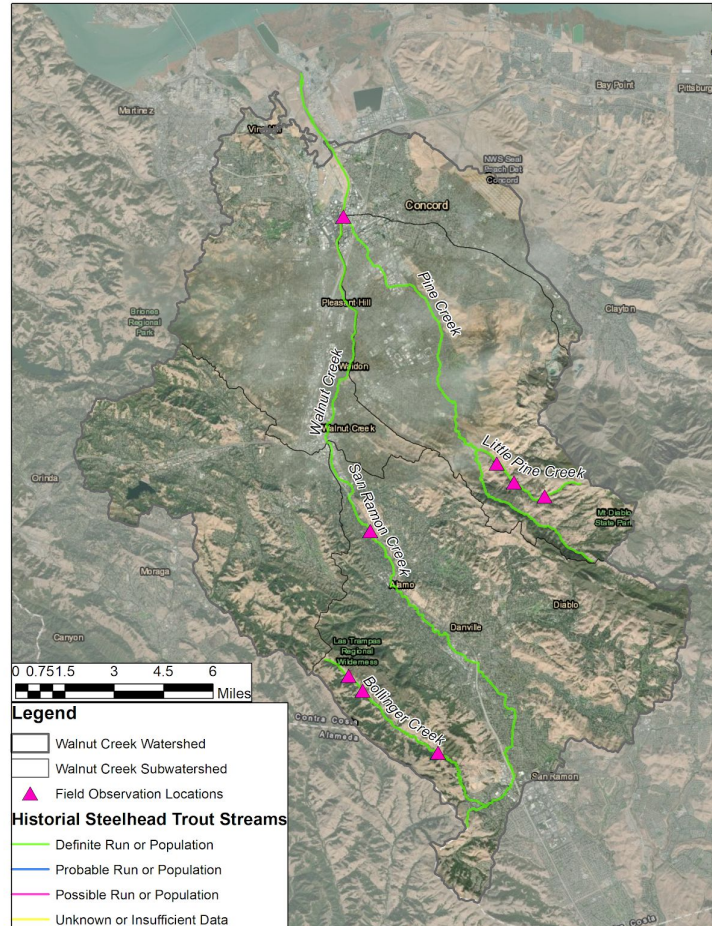
1. Little Pine Creek: Upper tributary stream in Mt. Diablo State Park that flows from the northwest slopes of Mt. Diablo to the confluence with Pine Creek (Leidy et al. 2005). A survey by Cogger and Reineck (1977) characterized the creek as having good steelhead spawning potential.
2. Pine Creek: Lower tributary stream draining the northwest slopes of Mt. Diablo. Mostly channelized and have numerous fish passage barriers (Leidy et al. 2005). Aerial imagery suggests that creek channels are mostly engineered.
3. Bollinger Canyon Creek: Headwater tributary to San Ramon Creek flowing southwest between Las Trampas Ridge and Rocky Ridge. Research identified portions of the creek as suitable steelhead spawning habitat (Leidy et al. 2005).
4. San Ramon Creek: Lower tributary stream that flows north to the confluence with Las Trampas Creek, becoming Walnut Creek. It contains six concrete drop structures that block fish passage and has poor spawning habitat (Leidy et al. 2005).



**Figure 5:** Selected reaches.

Using these stream reaches and B-IBI and CSCI sample locations, we used Google aerial imagery and street view to identify potential access locations along a given stream reach. A summary of these locations is available in Figure 6. We selected three observation points along Little Pine Creek and three along Bollinger Canyon Creek, however locating access points was challenging for the urbanized reaches due to private property and flood control district restrictions. We observed San Ramon Creek from Livorna Road, where both upstream and downstream channel views were visible. The Pine Creek reach however, especially in the vicinity of the CSCI and B-IBI sampling locations, is heavily urbanized and located near a

freeway interchange. We were unable to locate a suitable and safe observation location and for the purpose of this report utilized Google imagery.



**Figure 6:** The above map depicts our selected reaches and field observation locations.

We visited the sites on November 14, 2020. Our reconnaissance-style surveys primarily focused on visual observations, specifically looking for potential steelhead trout habitat and suitable spawning grounds. At each observation location we documented flow, canopy cover, habitat cover, gravel presence, channel material, and channel dimensions and shape, as they are all factors affecting steelhead spawning potential (CalFish.org). A summary table of our findings

can be seen in Appendix D. We hoped to observe our stream reaches at B-IBI and CSCI sampling locations, however, not all locations were directly accessible. Obstacles included private property, county fences, thick vegetation, steep side-slopes, and inadequate parking. We adapted by finding the closest accessible location to our desired points.

The field team assessed habitat cover, which offers protection via overhanging banks and large woody debris (Ridolfi 2006). Without flow required to fully assess habitat cover, “Yes” was documented for woody debris and overhanging banks, or “No” for none. Shade is key to habitat productivity and the field team approximated it through visual inspection of canopy cover (Ridolfi 2006). As mentioned previously, ideal spawning habitat includes gravels sized between 1 to 2 inches (CalFish), thus our reconnaissance effort focused on visually scanning for substrates of this size. We quantified channel dimensions using a tape measure, and estimated channel shape and material by visual survey and confirmed with the 2020 Walnut Creek Watershed Opportunity Atlas’ channel data.

## RESULTS

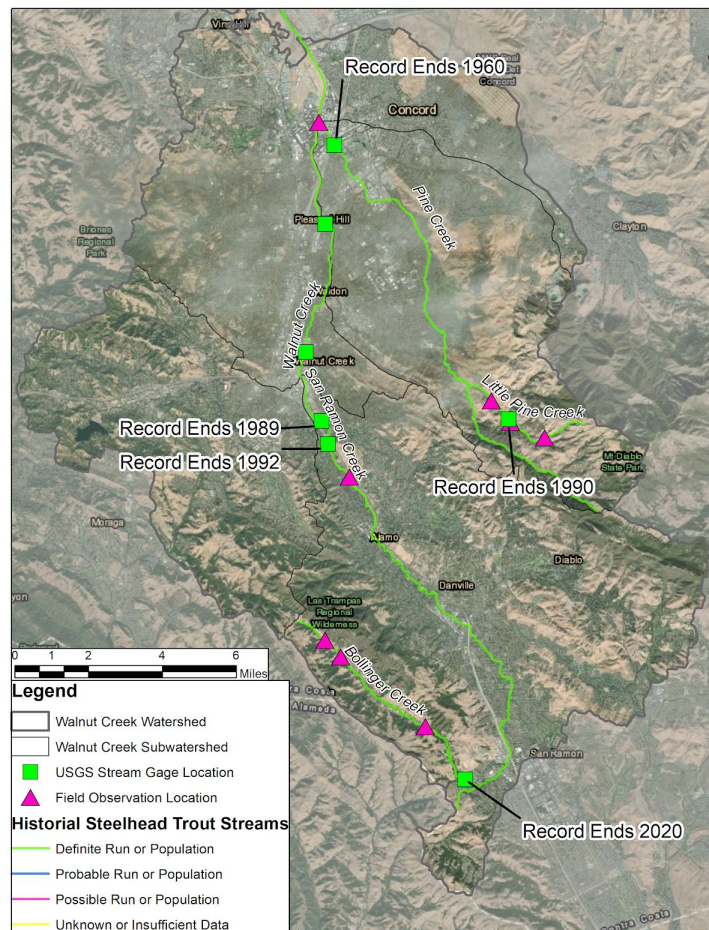
Our field visits primarily focused on visual observations, specifically looking for potential steelhead trout habitat and suitable spawning grounds. A summary table of our findings is in Appendix D.

### Flow and Stream Gage Data

Although there was rain the day prior to our reconnaissance, Bollinger and Little Pine Creeks were dry when we surveyed, so flow velocity, turbidity, and flow depth could not be measured. Further, because these creeks have been dry for several months, accumulated

sediment, leaves, and other debris made it difficult to see the full potential of gravels and habitat and thus difficult to determine optimal spawning sites. Photographs were taken for reference and additional notes documented observations not listed in our fieldnotes spreadsheet.

Available stream gage data and United States Geological Survey (USGS) stations were sparse with many no longer active. Figure 7 below provides stream gage locations plotted against site locations.



**Figure 7:** USGS stream gage locations and record extent.

The only USGS stream gage with recent data was located on Bollinger Creek, just upstream of its confluence with San Ramon Creek and still within the zone with high impervious cover. Considering steelhead trout require a minimum depth of 14 inches, detailed flow data in combination with channel cross sections could further enhance our understanding of potential habitat and spawning. We also hoped to evaluate variations in flow to understand if current and future flow regimes in upper reaches could support steelhead trout. More robust flow data would support this analysis.

## Field Observations and Photos

### Pine Creek

No Field Observations - Satellite Imagery Observed at (37.97675, -122.05204)



**Figure 8:** The confluence of Pine Creek with Walnut Creek.

Pine Creek, part of the Urban Gauntlet, had an engineered channel. Aerial observations and the 2020 Walnut Creek Watershed Opportunity Atlas' impervious cover data (Appendix C,

Map W-4. Current Watershed Conditions) indicated that this site is in a highly impervious drainage area with over 60% of surfaces being impervious. The Atlas' associated this level of impervious cover with urban drainage and poor water quality, consistent with the fair B-IBI score (Appendix D), shown in Figure 8 above.

## San Ramon Creek

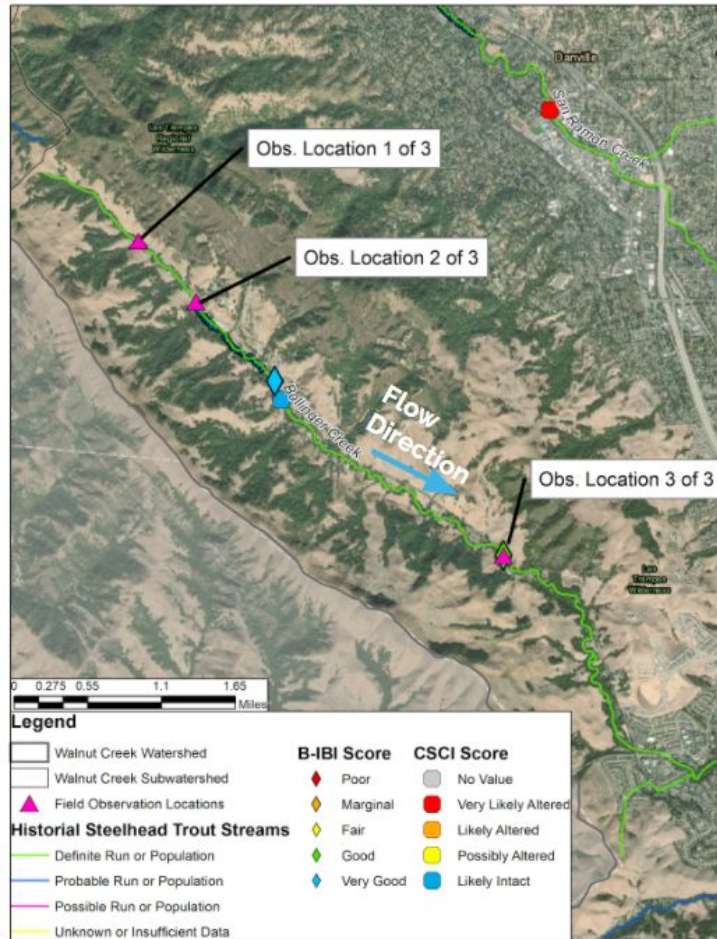
### Observation Point 1 of 1 - Livorna Road (37.86709, -122.04014)

San Ramon Creek was our second Urban Gauntlet observation site with “fair” B-IBI and “very likely altered” CSCI scores. Most notable was a drop structure and brown foamy water with moderate flow (Figure 9a). The engineered channel was earthen and trapezoidal in shape. Gabion structures and boulders lined the bank (Figure 9b). There was minimal canopy cover and channel access was blocked to further observe.



**Figure 9:** San Ramon Creek at Livorna Rd.  
(a) Left: Concrete drop structure. (b) Right: Downstream view.

## Bollinger Canyon Creek



**Figure 10:** Bollinger Canyon Creek and three observation locations.

### Observation Location 1 of 3 - Most Upstream Location (37.816545, -122.049726)

A large culvert, 60-72-inch corrugated metal pipe, flowed underneath the parking lot entrance to the observation site (Figure 11a: outfall to channel bottom, approximately 10 feet (ft)). As seen in Figure 11b, downstream of the culvert, the channel was an earthen trapezoidal channel with a bottom width of approximately 8 ft, depth of approximately 13 ft, and steep

side-slopes. The channel appeared incised for approximately 100 ft, but downstream it became wider with overhanging banks for cover and space for step pools as the creek meandered around mature trees. Grain size decreased moving downstream of the culvert and spawning gravels were observed. Canopy cover remained at 90% along the channel.



**Figure 11:** (a) Left: Facing upstream, corrugated metal pipe culvert pictured. (b) Right: Facing upstream.

#### Observation Location 2 of 3 - Mid-Reach (37.811365, -122.043544)

The second Bollinger Creek observation was approximately 0.8 miles upstream of a B-IBI and a CSCI sampling location, scored at “very good” and “likely intact,” respectively. Clustered boulders formed space for step pools, large woody material added habitat cover, and spawning gravels were present (Figure 12). Canopy cover was approximately 80%. The bottom width of the trapezoidal earthen channel was 30 ft at its widest. Moving downstream, the channel started to narrow and bend.



**Figure 12:** (a) Left: Facing upstream with step pools. (b) Right: Facing downstream.

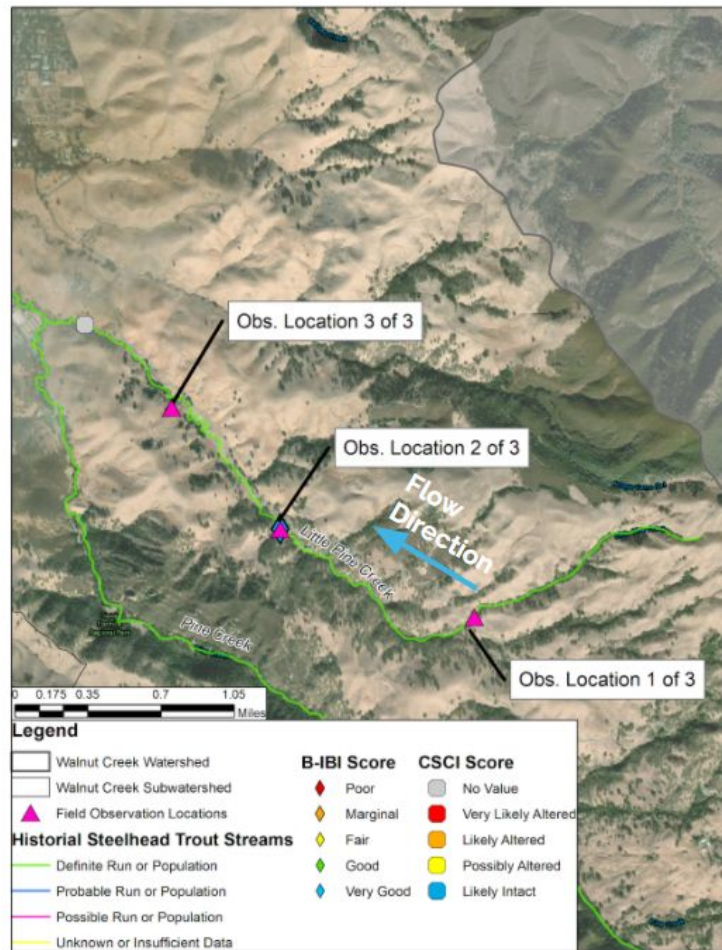
#### **Observation Location 3 of 3 - Most Downstream (37.78972, -122.01037)**

The furthest downstream location observed along Bollinger Creek cut between two private properties. This site had a “good” B-IBI score. The channel passed under Bollinger Canyon Road via a large, corrugated metal pipe approximately 120 inches in diameter (Figure 13a). The earthen trapezoidal channel had one bank significantly steeper and taller (10 ft) than the other. Channel bottom width was 15 ft and canopy cover was 60%. Habitat cover was high with ample large woody debris. Substrates consisted primarily of boulders and gravel suitable for spawning with some cobble, as seen in Figure 13. However, approximately 20% of the boulder sized rocks were riprap (Figure 13b).



**Figure 13:** (a) Facing downstream, corrugated metal pipe culvert. (b) Facing upstream with riprap.

## Little Pine Creek



**Figure 14:** Little Pine Creek and three observation locations.

### Observation Location 1 of 3 - Most Upstream (37.8792, -121.9635)

The creek was a v-shaped channel with steep side-slopes primarily composed of bedrock. A reinforced concrete pipe culvert crossed under the road before traveling down a steep hillside (Figures 15a, 15b). The bottom width and top width measured 3 ft and 30 ft respectively and the steep side-slopes carried the channel depth to approximately 30 ft. There was little observed habitat cover, no spawning gravels, and minimal canopy cover of about 10%.



**Figure 15:** (a) Left: Upstream culvert with pipe (b) Right: Downstream of North Gate Road culvert.

**Observation Location 2 of 3 - Mid-Reach (37.88403, -121.97694)**

This segment started as a narrow, grassy, earthen channel. In contrast, just around a bend the earthen trapezoidal channel transitioned for approximately 400 ft to conditions containing spawning gravels, 70% canopy cover and habitat cover. Substrates were estimated at 20% Boulders, 30% Cobbles, 40% Gravels, and 10% Fines. However, two small drop structures (3ft high) were in this section, shown in Figure 16b. Downstream, the channel returned to a narrow grassy channel and was intersected by a cattle grazing fence (Figure 16a). The B-IBI score at this site was “very good.”



**Figure 16:** (a) Left: Downstream segment with sparse vegetation  
(b) Right: Drop structures

**Observation Location 3 of 3 - Most Downstream (37.8906789, -121.9844849)**

This segment was a trapezoidal earthen channel noticeably shallower than previous Little Pine segments (Figure 17b). There was little habitat cover observed. Canopy cover was approximately 10% and ground cover was high consisting primarily of wild licorice. There was minimal substrate variety; scattered boulders and cobbles, but clay and fines dominated the channel. Notably, the area neighboring the site smelled of manure and a barbed wire fence ran adjacent and across the channel to contain grazing cattle (Figure 17a).



**Figure 17:** (a) Left: Facing upstream. Earthen trapezoidal shape. Bound by fence.  
(b) Right: Facing downstream. Channel becomes narrow and shallow.

## Other Observations

We also noted activity that could be of detriment to future potential steelhead trout populations. Photos are in Appendix E. Other observations included anthropogenic effects that would likely degrade the future quality of spawning and rearing habitat in upstream reaches, such as runoff from new development, disturbed soil.

- A. Bollinger Canyon Creek, field site one, had bank erosion adjacent to the parking lot.
- B. The field team observed an accumulation of trash (plastic wrappers and broken bottles) in the channel at the second Bollinger Canyon Creek site and bank erosion from the adjacent parking lot.
- C. Near private property along Bollinger Canyon Creek, site three, there was tilled land to the edge of the creek bank that created several inches of loose soil, and a large pile of disposed leaves in the channel.

D. The bottom of Bollinger canyon hosts a new housing development adjacent to the creek.

Figure 18 below respectively show pre and post-development aerial images of the downstream Bollinger Creek section.



**Figure 18:** April 2016 near Bollinger Canyon Creek observation location 3, pre-development left, post development right. Approximately 135 acres.

## DISCUSSION

Spawning habitat potential decreased downstream of Bollinger Canyon Creek, consistent with past B-IBI and CSCI Scores. The uppermost observed reach of Bollinger Canyon Creek had the greatest canopy cover, presence of large woody debris, overhanging banks, and gravel; all preferred steelhead spawning habitat attributes (CalFish 2020). Downstream at our second stop along the creek, there was also dense canopy cover (80%), large woody debris, and a mixture of boulders and gravel. Although steelhead trout would not spawn in areas with boulders, they could use those reaches as resting areas as the boulders created space for step pools. This reach had bank erosion at one location adjacent to a parking lot, likely caused by runoff from the impervious surface. The furthest downstream location observed along Bollinger Creek had the lowest amount of canopy cover (60%) and boulder-sized riprap throughout the channel. Thus,

although this part of the creek had high canopy cover, large riprap is not an ideal bed material as it can alter flow velocity. Downstream of the Bollinger Canyon Creek confluence with San Ramon Creek, the habitat quality degraded further. At Livorna Road, a drop structure was flagged as a potential migration barrier. Furthermore, brown foamy water suggested poor water quality, which was consistent with a CSCI score of “very likely altered” and a B-IBI of 24 or “fair.” Therefore, although there may be potential spawning habitat for steelhead trout in the uppermost reaches of Bollinger Canyon Creek, the drop structures and degraded water quality in San Ramon Creek, an Urban Gauntlet reach, may prohibit them from arriving at those sites.

Little Pine Creek had different habitat characteristics than Bollinger Canyon Creek. At the most upstream observed reach, the bedrock v-shaped channel had no gravel and minimal canopy cover, suggesting inadequate spawning habitat conditions. Conversely, the second observation location downstream had 70% canopy cover and had a gravel-dominated bed. These improved habitat conditions were consistent with the “very good” B-IBI score. Although these conditions aligned with steelhead trout habitat preferences, there were two small drop structures observed, which could hinder them from reaching further upstream. The third reach along Little Pine Creek reverted to similar conditions as the uppermost reach, which 10% canopy cover but had primarily fine-grained bed material. Thus, this location was not an optimal spawning habitat, but could serve as a passageway to swim to the better habitat upstream. Lower in the Pine Creek subwatershed, satellite images revealed Pine Creek as a rectangular concrete channel, in addition to the myriad of drop structures, thus would not be an optimal spawning habitat for steelhead trout. Therefore, efforts would need to be made to allow steelhead trout to reach the second observation location along Little Pine Creek.

Our observations aligned with those made by Leidy et al. (2005): There were portions upstream of the Urban Gauntlet in Bollinger Canyon Creek and Little Pine Creek with steelhead trout spawning potential. However, the reaches in the Urban Gauntlet, San Ramon Creek and Pine Creek, were heavily altered and potential habitat was not observed.

The 2020 Walnut Creek Watershed Opportunities report estimated that up to 70% of Walnut Creek's watershed remains unprotected from development. Relevant to our study, land use change near Bollinger Canyon Creek could be of concern, as seen by the new housing development at the bottom of the canyon adjacent to the creek and two newly constructed parking lots located at the top Bollinger Canyon Road. Such land use, development, and hydromodification contributes to erosion and sedimentation on spawning gravels, especially in sections of the creek lacking flow velocity high enough to remove excess sediment.

The observed trash, loose soil, and leaf litter deposited by residents along the creek could also degrade spawning habitat by introducing chemical pollutants, smothering eggs, and decreasing dissolved oxygen (United States Environmental Protection Agency 2020; Reiser and White 2011; Duan et al. 2014). It is worth monitoring these impacts to ensure Bollinger Canyon creek remains a potential steelhead trout spawning tributary.

Since much of Little Pine Creek runs through Mt. Diablo State Park, there are not similar concerns because state regulations protect the reach. It is unlikely land will be developed or altered like Bollinger Canyon Creek and could go on to make for enhanced future (post-Urban Gauntlet restoration) steelhead trout spawning grounds or habitat. Furthermore, because Little Pine Creek is closer to the mouth of Suisun Bay via Walnut Creek, it may allow steelhead to reach their spawning habitat sooner while minimizing the distance of creek restored, and thus

reduce costs. In discussing our observations with Jen Natali, Natali pointed out that the cattle grazing in the Little Pine Creek drainage area could contribute to sedimentation in the creek. Additionally, cattle grazing has the potential to reduce ground cover and soil roots, consequently altering flows. Therefore, research and preservation efforts may be more feasible for Little Pine Creek compared to Bollinger Canyon Creek, but the extent of cattle grazing should be further assessed.

## **NEXT STEPS**

This reconnaissance identified possible spawning grounds for steelhead trout along Bollinger Creek and Little Pine Creek (Figures 10 and 14). Thus, it may be worthwhile to reduce the threats to steelhead trout as they attempt to migrate upstream to spawning grounds through the Urban Gauntlet to reach the suitable habitat. However, the field team was unable to observe all factors that affect steelhead spawning habitat, such as flow, further research is needed to continually assess stream conditions and monitor land development. Next steps could include:

1. Install additional or reactivate stream gages on Little Pine Creek and Bollinger Canyon Creek to analyze current and future flow regimes. There was one gage along Little Pine Creek, but it has been inactive since 1990. Bollinger Canyon creek has an active stream gage located just upstream of its confluence with San Ramon Creek, however an additional gage further upstream would help characterize flows, and habitat potential, throughout the entire reach. As mentioned, steelhead trout require a minimum flow depth and particular velocities so it is pertinent to understand how evolving channel geometries, recent flow histories, and potential impacts of climate change might impact stream depth.
2. Conduct a more in-depth field assessment during various flow conditions to

quantitatively assess habitat/spawning conditions such as substrate type and sedimentation rates. We surveyed when there was no flow and when debris was heavy, and wet weather field work would be more conducive to quantitative approaches associated with flow. Pebble counts can more accurately characterize median grain sizes compared to our visual inspection for gravel presence; Grains could be classified as gravel, but they may be different sizes than what steelhead trout prefer. Turbidity sampling could quantify impacts of erosion from adjacent hydromodification and if steelhead can tolerate those conditions.

3. Invite fish passage experts in the field to assess whether steelhead trout can safely migrate up tributaries across drop structures on Little Pine and through observed culverts and long stretches without canopy cover. If not, ask the experts for recommendations on how to modify structures to permit fish passage.

## CONCLUSION

Our reconnaissance identified possible habitat and spawning reaches for steelhead trout under current conditions assuming the Urban Gauntlet can be restored and they had access to migrate to Bollinger Canyon and Little Pine tributaries. Because of the closer proximity to the main reaches and lesser risk of land development, Little Pine Creek may be more favorable for steelhead spawning. But a substantial consideration is the proposed 50-year timeline to restore the Urban Gauntlet that would eventually grant steelhead trout access to their historical spawning tributaries. Conditions might support steelhead trout today, but circumstances are evolving and may be quite different in 50 years. For instance, Bollinger Canyon is currently undergoing development and may resemble something closer to the lower reaches in the future. Whereas

Little Pine Creek flows through Mt. Diablo State Park with far less urbanization and is located closer to Suisun Bay. Thus the risk of development is lower in the watershed and there is less stream restoration required before tributary access, but cattle grazing hydromodification may pose a risk. Additionally, evolving flow regimes may further modify long-term steelhead habitation and spawning conditions. This project of larger scale and timeframe contains many nuances and certainly would require repeated field visits, but hopefully our efforts can highlight areas of potential or of distress.

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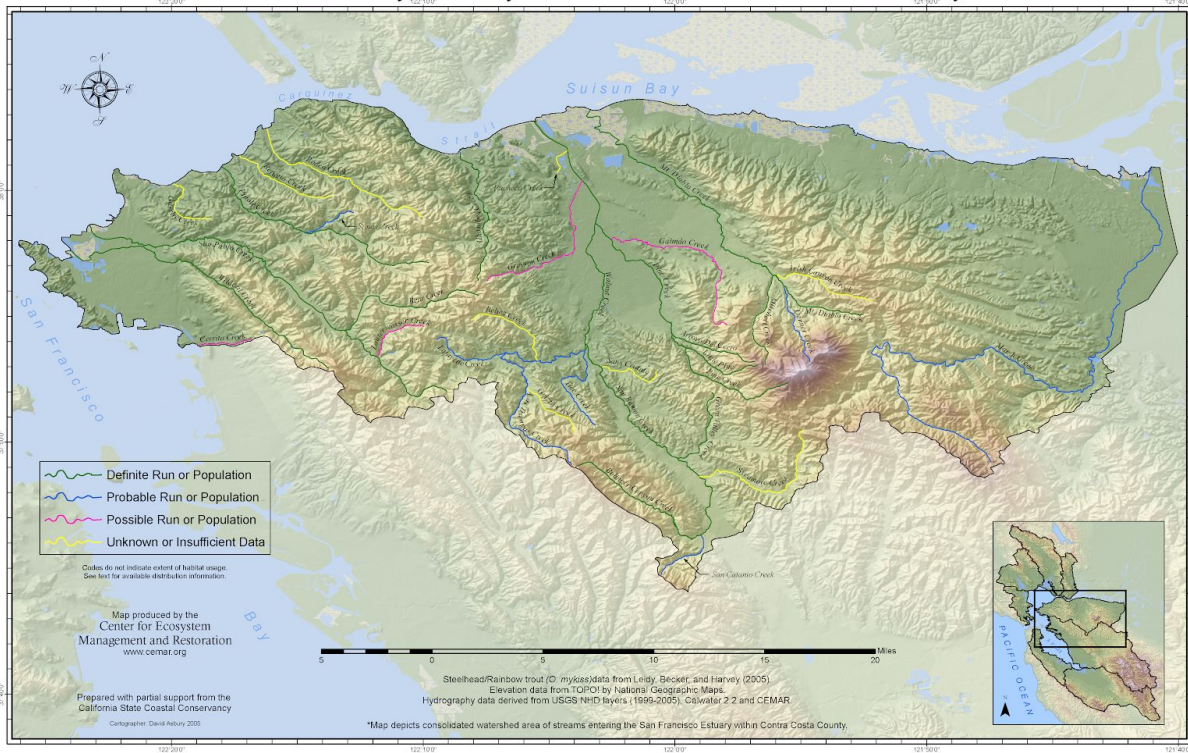
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# APPENDICES

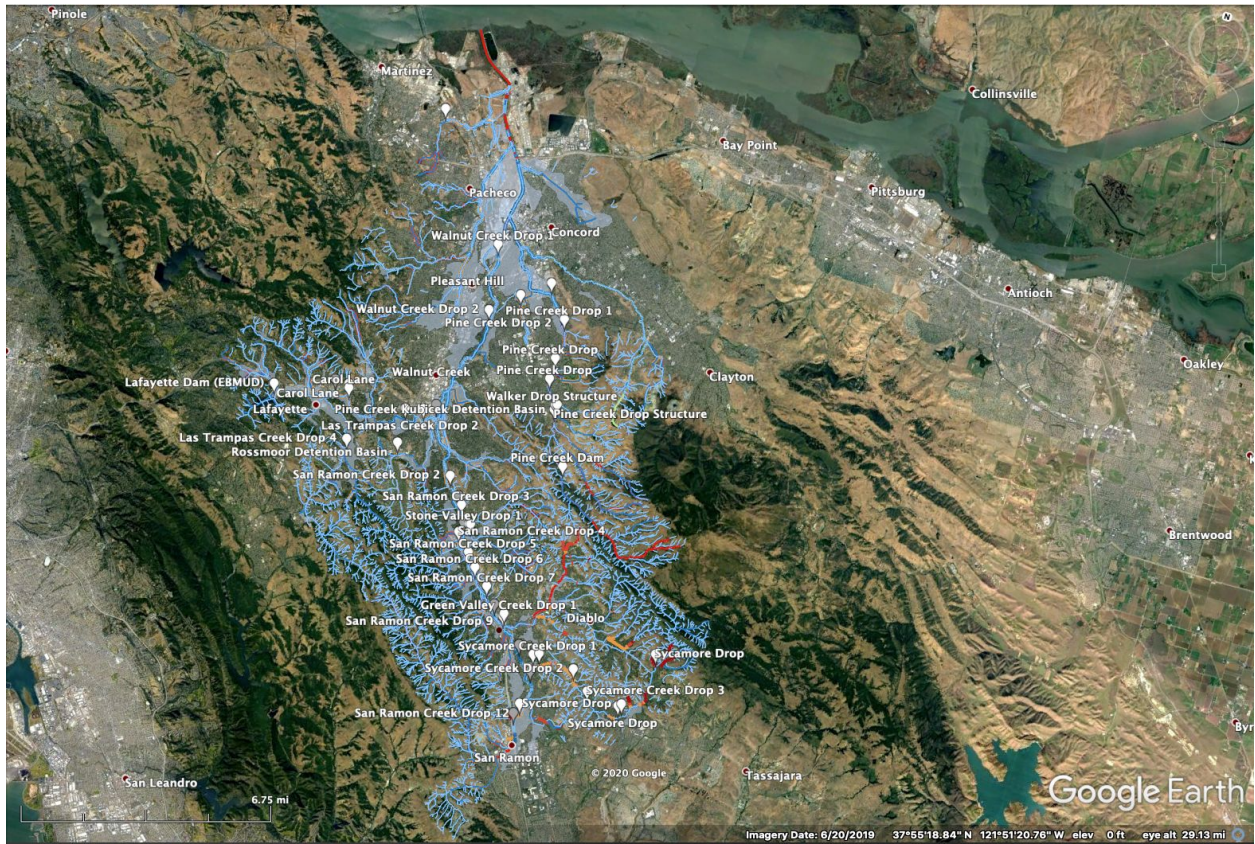
## Appendix A. Historical status of *Oncorhynchus mykiss* in Contra Costa County, California Source: CEMAR, 2005

Historical status of *Oncorhynchus mykiss* in streams of Contra Costa County, California\*



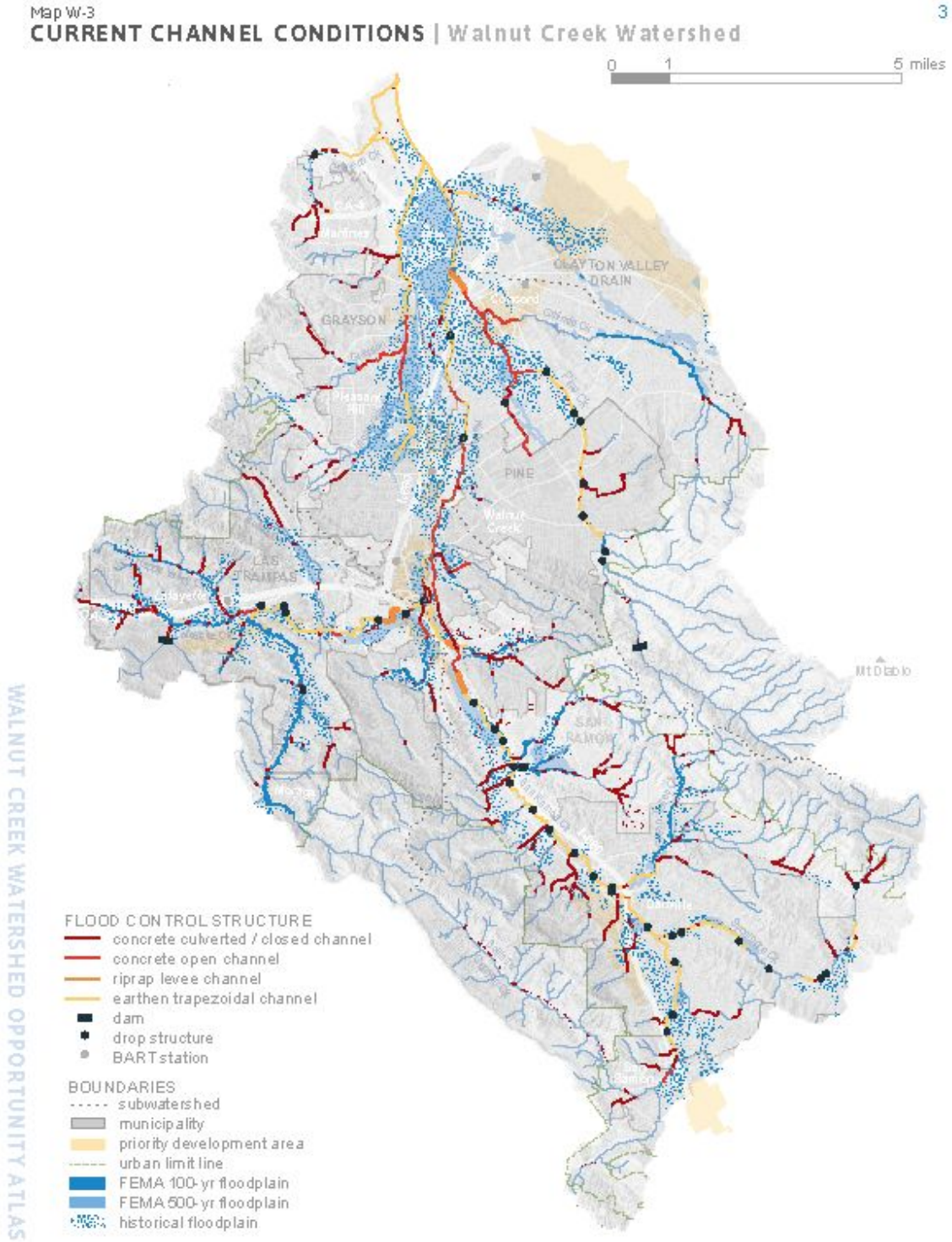
## Appendix B. Drop Structures in the Walnut Creek, California Watershed

Source: Jen Natali



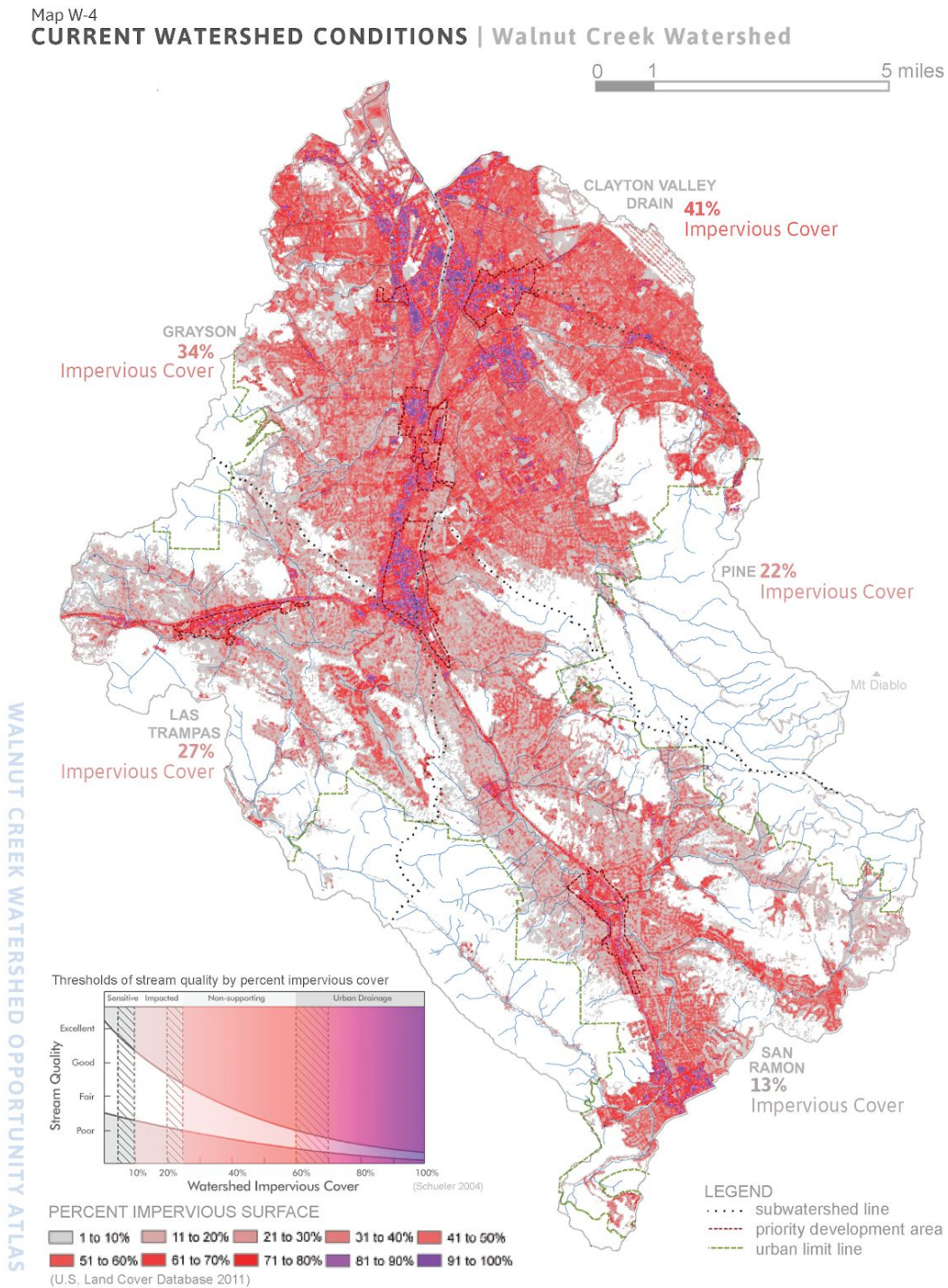
# Appendix C. Walnut Creek Watershed Opportunity Atlas, Maps W-3 and W-4

## Map W-3. Watershed Current Channel Conditions



## Map W-4. Current Watershed Conditions



This map was utilized to determine densely urbanized reaches.



**Appendix D. Field Survey Data**

**(replace page in acrobat with field survey page)**

**Appendix E. Other Observation Photos**

<b>Photo</b>	<b>Description</b>
	<p>Land prepped for new housing development at the bottom of Bollinger Canyon Creek.</p>
	<p>Bank erosion from parking lot runoff at Bollinger Canyon Creek, stop 1.</p>



Leaf pile from adjacent property in Bollinger Canyon Creek, stop 2.



Tilled land created loose dirt right up to creek bank edge, Bollinger Canyon Creek, stop 3.