Dragonfly Creek Assessment

Dragonfly Creek at the time of Fort Scott’s Construction, courtesy Presidio Trust

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Geography 642
Watershed Assessment

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December 18, 2007
# Table of Contents

Introduction .................................................................................................................. 1

Methods ....................................................................................................................... 8
  
  Field .......................................................................................................................... 8
  
  GIS Analysis ............................................................................................................. 13

Results ......................................................................................................................... 19

Discussion and Conclusions ....................................................................................... 31

References ................................................................................................................... 37

# Figures

1. Management of the Presidio of San Francisco ....................................................... 2
2. Watersheds within the Presidio ............................................................................. 3
3. Corps Jurisdictional Wetlands .............................................................................. 4
4. Presidio Soils .......................................................................................................... 5
5. Establishing an Artificial Coordinate System ...................................................... 14
6. Modifying the DEM ............................................................................................. 15
7. Modeling the Watershed ....................................................................................... 16
8. Survey Points ........................................................................................................ 19
9. Longitudinal Profile – thalweg and bankfull ....................................................... 21
10. Longitudinal Profile – waters edge, thalweg and bankfull ................................. 21
11. Watershed TIN .................................................................................................... 22
12. Watershed Area .................................................................................................. 23
13. San Francisco Bay Area Regional Curve .......................................................... 23
14. Cross Section at Palms ....................................................................................... 24
15. Cross Section at Willows .................................................................................... 25
16. Cross Section at Fill ........................................................................................... 26
17. Sediment Supply vs. Transport Capacity .......................................................... 27
18. Dragonfly Creek Plan View – upper reach ......................................................... 29
19. Dragonfly Creek Plan View – lower reach ......................................................... 30
INTRODUCTION

Document Overview

This report outlines our final project for Geography 642: Watershed Assessment and Restoration and includes our geomorphic and hydrologic assessment of the Dragonfly Creek Corridor in the San Francisco Presidio. Here within we define the scope of our work at Dragonfly Creek, the purpose of our study in conjunction with existing restoration plans, site history, site description, materials and field methods, GIS methods and analysis, our results, and a discussion of our findings.

Project Purpose

This survey was conducted in collaboration with the Presidio Trust to provide geomorphic and hydrologic data for the restoration of Dragonfly Creek which began in 2007. Data collected in this survey will be used as a baseline to inform geomorphic design for the next phase of Dragonfly Creek Restoration. Specifically, Restoration Project Manager, Mark Frey, requested we survey the creek corridor in order to create a longitudinal profile, cross sections and a generalized topographic overview of the reach’s watershed. Restoration plans call for fill removal and new channel construction. In the words of Mark Frey, “gathering data on the current site will allow the restoration team to estimate fill removal required and to better establish design parameters for the ‘new’ creek” (Mark Frey, Ecologist, Presidio Trust, electronic letter, November 19, 2007).

Presidio History

The San Francisco Presidio is 1,490 acres of land located at the northern tip of the San Francisco peninsula. It is bordered by the San Francisco Bay, the Pacific Ocean and the City of San Francisco. The Presidio and its watersheds have transformed with time and use requirements. Initially, the Muwekema Ohlone Tribe settled near this year-round fresh water source and the ecosystems supported by it. Later, with its strategic views of the Pacific Ocean and the Golden Gate, the Presidio served as an Army post to Spain,
Mexico and finally the US Army in 1846 (http://www.nps.gov/prsf/historyculture/index.htm, accessed 12/5/07). As the army base grew, modifications were made to the watersheds. Many creeks were filled and routed into underground pipes. Planting of the non-native Presidio forest, construction of housing and infrastructure and use of creek channels as waste fill sites further altered water flow and vegetation within the watersheds (http://en.wikipedia.org/wiki/Presidio_of_San_Francisco, accessed 11/29/07).

When the US Army pulled out in 1994, the Park was turned over to the National Park Service (NPS) as part of the Golden Gate National Recreation Area (GGNRA). In 1996, Congress created the Presidio Trust (Trust) to work in partnership with the NPS. The Trust began plans for park rehabilitation which included decontamination of many sites in preparation of public use.
The Presidio consists of three main watersheds: Lobos Creek Valley to the west, Tennessee Hollow to the East and the Fort Scott watershed in the center, where Dragonfly Creek is located. Surface waters in the Presidio are Lobos Creek, Crissy Marsh, Mountain Lake, Tennessee Hollow, El Polin Spring and Dragonfly Creek (see Figure 2: http://library.presidio.gov/archive/documents/stratplan.pdf, accessed 11/26/07). Dragonfly Creek and Tennessee Hollow are the healthiest natural channels in the Presidio (Frey, 2006). Furthermore, there are 28 acres of United States Fish and Wildlife Services (USFWS) classified wetlands in the Presidio which meet all 3 criteria of supporting wetland soils, wetland vegetation, and wetland hydrology. 0.35 acres at Dragonfly Creek have been designated as wetland habitat.
Project Area Overview

Site History and Description

Dragonfly Creek is a 1.3 square mile drainage fed by a perennial spring that flows through Crissy Marsh into San Francisco Bay. Dragonfly Creek discharge averages 5 gal/min (Castellini, 2001). Dragonfly Creek is located southeast of Fort Scott and is downhill and approximately 125’ south of the Native Plant Nursery. Within the Fort Scott watershed, the creek is the only major remnant riparian system.

Dragonfly Creek is a first order perennial stream. This stream has been significantly altered. The upper portion of the system flows through a ravine which is surrounded by 3 impervious surfaces consisting of a parking lot, tennis courts and a clubhouse. Below the historic foot bridge, underneath an intense bramble of creeper, blackberry and cave ivy, subsurface flow emerges at the surface immediately upstream from a spring box where it is captured. It appears (in an area highly obscured by Eucalyptus duff) that the water captured by the spring box then enters a pipe and is released into the main creek channel further downstream. The creek then flows in a northeast direction over a mostly sandy substrate for 200 meters prior to entering a concrete
channel and then disappearing into a culvert that crosses under Lincoln Avenue on its way to San Francisco Bay (Castellini, 2001).

During our assessment the vegetation community was in a state of transition due to the ongoing restoration activities. The more upland areas around the watershed had been cleared of the Eucalyptus trees that until recently surrounded the stream. On the south side there remains a forest dominated by Monterey Cyprus (Cupressus macrocarpa). Only a small portion of dragonfly creek fit into an existing vegetation classification (as per The Manual of California Vegetation, 1995), the arroyo willow (Salix lasiolepis) patch that made up its only remnant riparian vegetation. This patch was dominated by a weedy understory which included cape ivy, a notorious riparian weed. The lower portion of the watershed were mostly a ruderal mix with two marshy areas dominated by small-fruited bulrush (Scirpus microcarpus) and a couple plantings from the adjacent native plant nursery (Cornus sericea, etc.). The revegetation efforts associated with the ongoing restoration outline the desired post-restoration communities as bulrush wetland, arroyo willow, coastal scrub and oak woodland (Frey 2006).

Soils and Geology
The Presidio consists mainly of unconsolidated sandy sediments resting on Franciscan Complex rocks. In addition, the Colma formation, consisting of fine-to medium-grained sand with clay and silt, underlies Presidio soils in various locations.

Soils within the site are well drained, consisting of fine sandy and loamy fine-sand above a Colma formation. Groundwater may be channeled into confined aquifers via the hydrophobic Colma formation, resulting in a spring. This may explain the origins of the Dragonfly Creek headwaters (Mark Frey, Ecologist, Presidio Trust, electronic letter, November 19, 2007).

There is evidence of significant anthropogenic soil modification at the site, particularly in the form of artificial fill resulting from the construction of roads, paths, ditches, etc.
Restoration Plans

According to the project draft prepared by Mark Frey, the restoration of Dragonfly Creek will create 625 feet of free-flowing creek. The restoration work outline is as follows (Frey, 2006):

- Restore more natural channel morphology
- Increase microtopographic complexity within creek
- Establish ecosystem with attributes important to native fauna
- Restore native dominated riparian plant community
- Improve water quality

Figure 4. Presidio Soils (from Frey 2006)
• Highlight historic Presidio landscape features within project area

The restoration of the creek to a more natural condition while highlighting Presidio landscape features within the site will focus on restoring natural stream morphology including restoration of hydrologic function and reestablishment of natural vegetation and wildlife habitat. To accomplish this, significant fill removal is required from the lower section of the creek.

As part of the restoration plan, non-native vegetation has been removed around the stream. In addition to cape ivy and other riparian weeds, Eucalyptus trees, which used to shade the stream, have been recently removed. Downstream of the palm trees below the bridge live fascines of willow have been installed as an erosion control method.
METHODS

-FIELD-

In order to create a three-dimensional approximation of the physical structure of the stream, and to assess the geomorphic state, we surveyed a longitudinal profile, several cross sections and some additional points deemed important such as the historic terraces and roadbeds adjacent to the site. We augmented our spatial analysis of the stream with a limited botanical survey and reference to geological survey reports.

Choice of Stream Reach

Dragonfly Creek is the only portion of the Fort Scott watershed with surface flow. We chose to survey the main course of Dragonfly creek where the restoration project was planned. We excluded the very upper portion of the “headwaters”, including the springbox, from our survey because no creek restoration is currently planned for this area and dense vegetation prevented effective surveying.

Equipment

Our field data collection primarily made use of a total station. With the exception of our notebooks and some walky-talkies and wooden stakes borrowed from the Presidio Trust, all our essential tools were borrowed from the San Francisco State University Department of Geography Map Library. We used the below list of field tools:

- Topcon GTS-235 Total Station (with tripod)
- Topcon FC-100 Data Collector
- Stadia rod
- 19” length 1.25” diam. Soil probe
- Handheld two-way radios (Walky-talkies)
- Wooden stakes
- Orange flagging tape
- Measuring stick
- Cement nails
Establishing a coordinate system

All survey points were recorded using an artificial coordinate system defined specifically for this survey and established using a Topcon GTS-235 Total Station and Topcon FC-100 Data Collector. We chose to conduct our survey using a created coordinate system because, when we initiated our survey, there were no georeferenced benchmarks within sight of our study location. Upon completing the survey, we used GPS to identify the locations of two of our survey points with which we spatially adjusted our entire survey into the NAD 1927 State Plane California III coordinate system.

To create an artificial coordinate system appropriate for our survey, we set up the Total Station above the headwaters of Dragonfly creek and established a benchmark (Figure 5, page 14) following user-guide instructions outlined in the “Topcon GTS-235 Total Station: Basic Use for Recording Coordinates” guide posted on the Geology 642 class website. After creating a new point, we manually entered an arbitrary N (northing), E (easting) and Z (elevation) of 2000, 2000, and 100, respectively, to define our benchmark. After entering the height of our instrument and selecting Occ. Point for our created benchmark, we sighted with the Total Station to a backsight chosen at the far, downhill end of the creek. Using the BS Azimuth option we entered 0 azimuth and measured the distance to the backsight. All survey points were subsequently recorded as NEZ coordinates.

Surveying

We used the Topcon Total Station to survey spatial data about our stream. The total station allowed us to record points into a three-dimensional co-ordinate
system, thus giving us their location relative to each other in space. The Topcon Total Station surveyor was placed (using a laser plummet) directly over one of several temporary stakes interspersed across the site such that all sections of the creek could be matched. Where permanent benchmarks could be placed, we drove nails into the concrete. To set up the Topcon it was first leveled using a combination of air bubble initial leveling with fine tuning using the instruments own internal level. Each day the Topcon was resurveyed in place by inputting fore- and back-sight readings of known/previous surveyed locations. Readings from the total Station unit were recorded in a handheld data logger.

To create the stream profile and cross-sections one member operated the Topcon unit itself while another held an optical reflector attached to a rod at a known height. The total station unit was focused on the reflector, and by triangulation from the horizontal and vertical angle of the instrument in combination with a prism which measures the distance to the reflector by analyzing the spread of light waves through the prism, the instrument is able to calculate the coordinates of each point at which the reflector rod is placed in three dimensional space with a distance accuracy of ~2mm (Topcon 2007). As the height of the reflector and of the Topcon unit are measured and inputted, it is able to subtract these from consideration of the coordinates. Data from the total station was additionally entered into a field
notebook for the purpose of duplication and of adding additional notes to the point data.

**Longitudinal Profile**

A longitudinal profile of a stream attempts to characterize the change in elevation of a stream or stream reach over its length. It shows the relative elevations of the stream thalweg (or deepest portion of the channel) to the bankfull elevation of the stream and other features such as the location of former terraces or the height of canyon walls, etc.

**VIPs**

In order to complete the longitudinal profile the group had to choose VIPs or very important points. Points were generally deemed of importance in locations where the shape of the stream channel underwent significant alteration. At each place the channel changed we took points at left and right bankfull, at the top of the clear channel incision of different from bankfull, at the left and right edges of the water (LEW and REW) and in the thalweg, or deepest point in the channel. In many locations the channel was quite shallow (1-2 inches deep) and fairly uniform, so the thalweg point was taken in the channel midpoint.

**Cross Sections**

Cross-sections perpendicular to the direction of flow were taken at several locations in the stream reach. This were taken for two purposes: to create an outline of the shape of the valley through which our reach flows, as well as former terraces and other features (such as an old road bed to be removed, in this project) and in order to create a detailed reference with which future changes in the valley shape could be characterized. Like the longitudinal profile, the cross sections were created using the total station. VIPs were defined as those locations
in which a discernable change in slope occurred. Features such as larger logs and fascines that were intentionally left in place were also included in the cross section.

**Choice of Cross-Sectional Locations**

We ultimately did three cross-sections. The first cross section was done at the upstream star point of the reach we chose, between two distinct palm trees. This was just below the point where the stream disappeared into a culvert, so there was no channel. This location was chosen in part as a point of comparison with a potential, future, daylighted channel. Approximately 90ft downstream, after the reappearance of the channel, we surveyed a second cross section through a portion of the stream dominated by an overstory of arroyo willow. The portion upstream of this cross-section, also dominated by a willow overstory, had been very recently cleared as a result of restoration activities. The portion we chose still retained its mostly non-native understory – it had not yet been cleared so it we felt it to be another important representative of pre-restoration condition. In addition, while the understory was slated to be cleared, the overstory of willows was the only portion of the watershed that had been mapped as a part of the Presidio’s vegetation mapping effort (as per *The Manual of California Vegetation*, 1995). The final site, downstream of the willow patches, was done at the site of two piezometers. This site was chosen because it was associated with semi-permanent markers that could easily be re-surveyed, and because potential benefit of having a detailed stream cross-section at the same location as the piezometer readings, and because these points had a fairly representative spread over this lower section. The lower section of the northwest bank and slope is on fill from early Army waste disposal. The Presidio Trust plan to remove that fill as part of the restoration project. We captured the elevation of the filled area in the cross section to supply them with some preliminary survey data.
Soil cores

A soil probe was used to take soil samples at numerous locations throughout the stream reach. At each location the soil core was taken of the upper 15” of soil. The soil core was visually assessed and recorded and then returned to the creek in as close to the original position as possible.

-GIS Analysis-

Data Acquisition:

Excluding our survey data, files and layers used in this project were provided by the Presidio Trust. Hans Barnall, the Trust’s GIS Specialist, provided us with the following shapefiles, all in the NAD 1927 State Plane coordinate system and clipped to the extent of the Presidio:

- 5ft contour
- Roads
- Structures
- Surficial geology

Using GIS to locate the survey:

To georeference our survey we used GPS to measure the true location of two of our survey points (Figure 5). We chose widely separated points in order to minimize error in spatial adjustment of our survey resulting from variability in our horizontal control. We georeferenced these points using a Trimble GeoXH GPS receiver with Terrasink 3.01 data collector. Points were WAAS corrected and error in both horizontal and vertical directions determined to be less than 10 cm.
Figure 5: An artificial coordinate system was created using the line displayed above as the survey’s zero azimuth. Red and green dots show survey points which were GPS located to spatially adjust the survey into the NAD 1927 California State Plane system.

Data Preparation and adjustments

After the survey, points were downloaded using ActiveSink, saved as an Excel file, added to ArcMap, and displayed using XY coordinates. Survey points were viewed in ArcScene to check for irregularities, and points which were obvious errors, deleted. The survey’s attribute table was then exported back into Excel and descriptions of each point (thalweg, right bankful, etc) were added, sorted by description, and saved as text files.
Text files were converted into polylines using the **Import 3D lines or points** script provided in the **Survey** toolbox on the class website. Resulting polyline shapefiles of thalweg, edge of water, top of bank, and bankfull were used as a control to create a plan view of Dragonfly creek and to graph its longitudinal profile.

Survey points were adjusted to the NAD1927 California State Plane coordinate system using the **Editor** toolbar in ArcMap. The **Spatial adjustment** tool was selected and **transformation- similarity** was selected as the **adjustment method**. With the spatial adjustment toolbar, a **new displacement link** was created for the two GPS points (Figure 5) and using the **view link table** button we entered the GPS identified coordinates as a **new X Y Destination**. We chose **set adjustment data**, selected the **all features in these layers** option, then selected **adjust** from the spatial adjustment drop down menu.

**Watershed Analysis**
In order to identify the size of the Dragonfly creek watershed and derive predicted bankfull width, a digital elevation model (DEM) was prepared for
watershed analysis. First, 5ft contour polylines were converted into a Triangulated Irregular Network (TIN) using 3-D analyst, create/modify tin. The TIN was then converted into a 5ft cell resolution DEM using the tin to raster conversion tool. This first DEM had false elevation rises around road structures, especially Doyle Drive (Figure 6). To remove these false rises, the Presidio “roads” layer was buffered, turned into a raster, and the conditional function used to remove elevation data from cells where buffered roads were present. The nibble function was then used to “fill” removed elevation data based on neighboring elevations. The resulting DEM had fewer false elevation rises and was better suited for watershed analysis (Figure 6).

The watershed draining into Dragonfly creek was determined by using the altered DEM and following instructions described in Geology 642, exercise 3. Using spatial analyst, hydrology tools, the DEM was used to identify flow direction, depressions were filled, flow accumulation measured, pour points identified, and the watershed delineated. The functions and step-wise possesses used are displayed in model-builder (Figure 7). The watershed map derived from this process was used to calculate watershed area. Bankfull width was estimated based on regional curves (Riley, 2002).

Figure 7: Model builder was used to derive watershed and hence watershed area from a DEM of the Presidio.
**Rosgen Stream classification and Discharge:**

Dragonfly creek was classified according to the Rosgen stream classification system (Rosgen, 1998). Based on the longitudinal profile, the following measurements were obtained:

\[
\text{Sinuosity} = \frac{\text{valley gradient}}{\text{stream gradient}}
\]

\[
\text{Valley gradient} = \frac{\text{max thalweg elevation} - \text{min thalweg elevation}}{\text{Distance from max- min thalweg}}.
\]

\[
\text{Stream gradient} = \frac{\text{max thalweg elevation} - \text{min thalweg elevation}}{\text{Distance between all thalweg points summed}}.
\]

**Cross Section Analysis**

Northing and Easting data of from the Total Station for cross sections were converted using the Pythagorean Theorem into relative distance from one point to the next. For each cross section, these points were graphed against the Z values from the Total Station for elevation (in feet) at corresponding relative distance points.

Maximum depth, bankfull width and floodprone width were measured from the data in graphical and numerical form with Excel. Specifically, maximum depth was generated from the NEZ points for right and left top of bank, taking the elevation difference from the thalweg. The floodprone width was measured on each cross section graph at the height of 2(max depth). Bankfull width was generated with the Pythagorean Theorem from the NEZ of bankfull points on either side of the creek at the cross sections. The three estimates were averaged.
to produce floodprone width and bankfull width for the whole stream, which we divided respectively to estimate entrenchment ratio.

**Creating a Plan View**

The plan view was created by overlaying the thalweg, left and right waters edge, and bankfull lines with the point file of the georeferenced data points downloaded from the total station. These points were used to in conjunction with the plan-view sketch made in our field note books to digitize in other features of the watershed such as the location of logs, pronounced vegetation patches, and the location of our soil cores.
RESULTS

Coordinate System transformation
We were able to successfully transfer our survey data from our artificial coordinate system into the State Plane coordinate system. This can be seen when our survey points are displayed over a contour map of the Presidio (Figure 8). Note the road layer displayed appears to pass through the lower portion of the survey, but in actuality is located where there is a break in our survey data. Because of the accuracy of our GPS measurements and the tight correlation between our survey, the contour map, and the structures layer, it’s likely the roads data is inaccurately spatially situated.

Figure 8: Survey data points were successfully projected in the NAD 1927 California State Plane coordinate system
Longitudinal Profile

Dragonfly creek’s longitudinal profile shows a relatively steep gradient (7.1%) and increasing entrenchment over the course of the reach. Figure 9 shows the entire length of the survey based on thalweg and bankfull data. There is a break in thalweg data as the creek enters a culvert and passes under a road. Figure 10 shows the additional data collected for the longitudinal profile, including the water’s edge.

Using the longitudinal profile, and the following statistics were calculated:

Summary Statistics

Max thalweg elevation: 185.92 ft
Min thalweg elevation: 129.87 ft
Change in thalweg elevation: 56.05 ft
Total length of thalweg: 789.57 ft
Thalweg slope (56.05/789.57): .071
Thalweg gradient: 7.1 %
Valley length: 768 ft
Valley slope (56.05/768): .0738
Valley gradient: 7.4%

Sinuosity (.0738/.071): 1.04
Average flood prone width: 9
Average bank full width: 15.98

Entrenchment ratio: 0.56
Rosgen classification: A5 (unstable)
Figure 9: Longitudinal profile displaying all thalweg and bankfull survey points.

Figure 10: Longitudinal Profile displaying thalweg, bankfull and water’s edge survey point for portion of the stream reach above the road displayed in Figure 5.
**Watershed Analysis**

A TIN was created using all survey points and the thalweg line (Figure 11). This TIN may be used to compare pre and post restoration fill removal by the Presidio Trust Restoration Manager.

A watershed map was produced, from which watershed area was derived (Figure 12). This area was used to estimate bank full width based on regional curves (Figure 9). This area was used to estimate bank full width based on regional curves (Figure 10).

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**Figure 11:** The TIN created using all survey points and the thalweg polyline and may be used to analyze changes in fill elevation after creek restoration.
Figure 12: Spatial Analyst, hydrology tools were used to derive the area (.09 miles^2) of the portion of Dragonfly Creek we surveyed.

Regional Curve for the San Francisco Bay

Figure 13: Using a regional curve and based on a drainage area of .25 square miles (derived from watershed analysis), bankfull cross-sectional area of Dragonfly creek is approximately 10 feet.
Cross Sections

The three cross section surveys show the stream to have increasing entrenchment in a downstream direction. The cross section at the head of the watershed, where the stream was not yet flowing, is not incised at the thalweg. The steep hillside, shown on the right of the cross section graph in Figure 14, is already cleared of invasive brush and eucalyptus. The bumps in the profile represent recently installed live fascines.

**Figure 14. Cross Section at Palms**

Figure 14. Dragonfly Creek cross section at the top of the restoration area, called “Palms” because of the two historic palm trees that mark the site. The cross section is shown looking up stream. The estimate of flood prone width is shown as a black line. Bankfull width is shown as a green line.
The second cross section was surveyed among the willow stand, the last larger vegetation left on Dragonfly Creek at the time of this study. Live fascines had been placed on both sides of the creek. Large woody debris (LWD) was left down the bank slope of the fascines, presumably for added erosion abatement. The stream was running in a low trickle at the time of survey, often obscured by thick duff and, as shown in Figure 15, is beginning to be incised.
The third and final cross section was made in the middle-lower section of the restoration area, where managers believe a large amount of fill is buried. This cross section was an easy traverse, given that the bulk of the terrestrial vegetation had been removed. Low stumps of eucalyptus trees, covered in a thick layer of black plastic, hallmark both sides of the cross section line close to the stream banks. The stream is clearly incised, the banks were loose and the terrain in general recently disturbed.
Entrenchment

At the cross sections, we found bankfull width to be 7.38 ft at the fill, 10.5 ft at the willows, and 30.49 ft at the palms. The max depth was calculated to be 0.385 ft at the fill, 0.64 ft at the willows, 0.89 ft at the palms. Using the equation for floodprone width, \( FW = \text{distance across at } 2 \times \text{Max Depth} \), and entrenchment ratio of floodprone width/bankfull width, our results are as follows:

<table>
<thead>
<tr>
<th>Cross Section:</th>
<th>Fill</th>
<th>Willows</th>
<th>Palms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodprone width:</td>
<td>4 ft</td>
<td>5 ft</td>
<td>18 ft</td>
</tr>
<tr>
<td>Bankfull width:</td>
<td>7.38 ft</td>
<td>10.05 ft</td>
<td>30.5 ft</td>
</tr>
<tr>
<td>Entrenchment per Cross Section:</td>
<td>0.54</td>
<td>0.50</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Dragonfly Creek is transport limited, \( Q_s > Q_c \).

Sediment Supply vs. Transport Capacity

![Sediment Supply vs. Transport Capacity](image)

Figure 17: *from* Montgomery and Buffington 1993

Soil cores

In all instances the soil core found sand or sand thinly overlain by silt, except in one point where the soil core hit what appeared to be either a large rock or fill at a depth of 6”. Although assessment of the streambed persuaded us to believe that it was uniformly sand with occasional duff and silt input, the restoration manager at Presidio Trust
believes that some fill was placed in the streambed as well. His opinion was informed by the Tennessee Gulch restoration cleanup.

**Watershed Plan View**

The overhead views of the watershed on the following pages give some idea of the different features through which our longitudinal and cross-sectional profiles passed, and the different habitats of the watershed.
Figure 18
DISCUSSION AND CONCLUSIONS

Challenges to our Assessment

Generally, when surveying a new location, it is customary to sight off of locations of known coordinates, or off of established benchmarks in order to create survey data grounded in real-world NEZ coordinates. Several factors made this problematic in our case. We did not have immediate access to an accurate GPS unit. In addition, a significant portion of the perimeter of our watershed was rimmed with large trees which obscured our view and limited our ability to sight known locations. For these reasons proceeding with our data collection in an artificial coordinate system seemed expedient, given the circumstances. Though relocating our points in real coordinates post-survey added an extra step to our assessment, in the end, there was no impact on the quality of the data we were able to produce.

The nature of our site made choosing profile points particularly difficult. The damaged and transitional nature of our stream channel meant that there were many debris objects in the creek, ranging in size from small to large, making decisions about what to include, and how much detailing these features required, at times difficult. Because these protrusions into the channel were so numerous, some were necessarily excluded from characterization in the interests of time. Logs and other forms of debris that were clearly left as structure were included in the stream profile. Another confounding aspect to our stream profile was the recent removal of a large stand of eucalyptus and the ongoing stream restoration work occurring at the site. In addition to providing the source of the aforementioned woody debris, they were also responsible for a large quantity of duff that was being scraped away. In a couple brief sections it was clear that a part of the stream flow was above ground, but below this layer of duff. As this
duff was very thick and interlaced with branches, and the flow braided, a full description of the course of flow in these areas was impossible. We were thus only able to evaluate the stream channel where running water was visible. The restoration activity itself may have been a partial contributor to the large amount of woody debris and duff present in the channel, or it could simply have been the accumulation of years with insufficient stream power to scour out this copious input of organic matter and obscuring the stream channel along much of its path.

An additional difficulty we had in mapping this stream was the presence of what appears to be a small hillside seep approximately half way up the channel on the northwest-facing slope. The channel and banks were indistinct and wetland vegetation (Scirpus microcarpus, wetland obligate: USFWS 1988 and 1993) was contiguous which made the channel characteristics ambiguous. The large equipment used to clear unwanted vegetation left the stream and southeastern slope at stream edge rutted and puddling as well. The combination made the determination of bankfull extremely problematic in that area.

Visual clues and signatures from this stream system are not consistent with the prototypical stream morphology outlined in class. As a result, identifying Bankfull, max depth, and therefore floodprone width and entrenchment ratio was akin to blind dart-throwing. The value we generated for entrenchment ratio (0.56) does correlate with the Rosgen classification that most fits Dragonfly Creek (A6). The team’s best guesses at bankfull location in the field seemed exaggerated once we assessed the stream profiles on the computer. If we were to repeat the survey, we would have taken bankfull measurements closer to stream edge, also to calculate the height of twice max depth and measured both spans on the spot with the surveyors tape. True bankfull is also best measured at high water and we guessed at it during the dry season. Therefore, we would like to
propose that the top of bank points be substituted for bankfull points. This
generates a very different entrenchment ratio.

<table>
<thead>
<tr>
<th>Cross Section:</th>
<th>Fill</th>
<th>Willows</th>
<th>Palms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodprone width:</td>
<td>4 ft</td>
<td>5 ft</td>
<td>8 ft</td>
</tr>
<tr>
<td>Bankfull width:</td>
<td>4.64 ft</td>
<td>2.74 ft</td>
<td>No stream channel</td>
</tr>
<tr>
<td>Entrenchment:</td>
<td>0.86</td>
<td>1.82</td>
<td>0.26</td>
</tr>
</tbody>
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Modified Stream Entrenchment Ratio: **1.34**

But is it a reasonable Entrenchment ratio for Dragonfly Creek? We think not. Watershed area (.09 miles²) corresponds to a bankfull area of 5 ft² on Leopold’s regional curve (date?), which is smaller than our bankfull area estimate of 8.44 ft² (6.22 ft² and 10.66 ft²). This difference supports the impression that Dragonfly Creek is a spring-fed stream.

**Potential Challenges to the Restoration Project**

There may be several ongoing challenges to the restored Dragonfly Creek functioning as a natural system. While Dragonfly Creek gets its perennial flow from a natural seep, it is a small pocket in an area surrounded by impervious surfaces from which several storm-drains empty into the creek channel. During our surveying we discovered one culvert flowing in from the adjacent nursery complex in the middle-lower portion of the stream (see the plan view). Below the road crossing there is large concrete culvert inflow that drains numerous storm-drains from the forested hillside to the south and from various locations on the Presidio grounds. The catchment area for Dragonfly Creek is therefore not seeing more gradual flow from sheetflow and infiltration from rainfall, but rather episodic pulses of potentially contaminated road run-off and nutrient enriched water from the grounds. Unfortunately, the restoration project will not be able to address this artificial aspect of the flow regime.
Our survey of Dragonfly Creek showed it to be distinctly lacking in sinuosity (1.04). The proposed removal of fill adjacent to the stream channel will lower elevation the middle-lower portion of the restoration area (above the road crossing). One possible result of increasing the space over which the stream can move is that there may be a subsequent increase in sinuosity. There is no plan to add a meander as part of the restoration activities, but they do call for the creation of microtopographic features including windthrow mounds and microdepression, which they anticipate will “add topographic roughness and hydrologic complexity to the floodplain” (Frey 2006). This will allow the stream to mimic a (mini) oxbow lake system and allow the middle reach to and could further create a more sinuous flow path. Alternatively, it may divert flow in multiple ways if a small wetland develops (likely the bulrush wetland referred to in the restoration plan (Frey 2006). The existing seep upstream may extend down gradient with the removal of fill. However, the stream will be somewhat limited in the extent to which it can relocate its channel by the culvert downstream through which it passes under the road.

We felt some concern for the potential filling in of pools with the increased sediment transport from the upper sections into the lower gradient, post-fill section. The Trust calls for “manual transport” of the sediment upstream in such a case. In addition, the Presidio Trust plans include the use of large woody debris (LWD) to trap sediment and maximize the floodplain area. They anticipate channel sediments to be sorted in the first few seasons of the restoration. The local channel slope and morphology will go through a rapid series of adjustments, but they predict the stream will stabilize.

Since all fill in the lower middle portion of our project area will not be removed, there is concern that some contamination from the fill will continue to impact the stream channel and its associated wetlands and riparian areas. Soil
contamination left from fill can’t all be removed, and could be detrimental in the microtopography of the site in particular, where it will be trapped.

Our cross sections demonstrate progressively more incised stream channel in the downstream direction. Because the Presidio Trust restoration plan does not include meander construction in the fill area where incision is most pronounced, there is potential for increased incision. Biological engineering restoration, in the form of thickly placed native riparian vegetation, may reinforce the banks when it has taken hold. The first few seasons of post-fill removal, however, may result in deeper incision and heightened sediment transport. Our semi-permanent benchmarks, left at the base of the tree and aligned by the peizometers, could be used by the Presidio Trust to repeat cross section assessments. Light revetment, such as erosion control blankets, may serve to protect the lower middle stream banks during that time of transition.

The removal of cape ivy (*Delairea odorata*), already underway, will be extensive when finished. It is a tenacious invasive plant. Merely an inch of root fragment can re-establish (personal observation, Amelia Ryan, biologist, National Park Service, *in conversation* December 13, 2007). Permanent eradication requires several years of vigilance and follow-up. Without concerted monitoring and re-clearing efforts, biological engineering restoration efforts may be undermined.

In a more speculative vein, there is some possibility that the removal of the Eucalyptus stand could result in some shift in stream inflow. Stream gage data at Redwood Creek in the Marin Headlands showed a marked increase in average discharge after the removal of Eucalyptus from a portion of that stream’s riparian corridor (Mary Cooprider, LSA, formally San Francisco Bay Area Network Hydrologist, National Park Service (2002-2005), *in conversation* September 29, 2007). On the other hand, with more vegetation on the slopes
likely to develop in the removal of the allelopathic (plant suppressing) duff and litter of the Eucalyptus trees perhaps there will be a subsequent drop in surface flow from the banks into the channel. Unless changes are pronounced, they may be difficult to trace to single cause.

Dragonfly Creek is a relatively small remnant system that has been highly impacted over the years. The challenges to the restoration project are numerous, (imported fill, invasive species, etc.) and the Presidio Trust is limited by the mandate for multiple uses. Daylighting of this stream between the culvert where it disappears at the end of our study area and the Bay is not currently possible. Yet, while there are multiple obstacles in the restoration of this small creek, its future seems promising. Even after the initial restoration activities take place, monitoring and adaptive management are planned. Dragonfly Creek is situated directly adjacent to the Presidio’s impressive native plant nursery and will be under the eyes of a legion of volunteers. It seems likely that the chances of the successful return to at least some stream ecological function are much better for Dragonfly Creek than many a maligned and neglected urban stream.
REFERENCES


Additional Websites visited: