Restoring Steelhead Habitat in the Los Angeles River

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Signatures

Restoring Steelhead Habitat
in the
Los Angeles River

A Senior Project Presented
to the
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In Partial Fulfillment of the requirement for the
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Accepted and Approved by:

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Abstract

The purpose of this study is to research causes of the declining steelhead populations in Southern California and to find strategies to re-introduce them to the Los Angeles River. In addition to habitat restoration, a recreational use of the site is proposed. The overall goal of the project is to redesign a portion of the Los Angeles River estuary to restore steelhead habitat and to incorporate community use of the site. Data for this project was obtained through researching literature, analyzing graphs and other diagrams, and an on-field site inventory and analysis. It should be noted that my research is meant to be a small supplemental study to the current LA river restoration project and simply proposes a design for the LA River estuary with steelhead trout habitat restoration and recreational use by humans as the main focus. This study should be integrated with other ecological studies as well as socio-economic research of the site for a successful restoration project.

Dedication

I would like to dedicate this book to my moms, my pops, and my homeboys Ronnick and the Todd Squad Conglomerate.

Acknowledgements

I would like to thank all those in my committee for your time, support, and assistance in helping me complete my senior project.

Thank you

Eric Larsen
Greg Pasternack
Peter Moyle

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Introduction

History of the Los Angeles River

The LA River has played a crucial role in Southern California since its early inhabitants. The Tongva tribe, more commonly known as the Gabrielino tribe, inhabited Los Angeles before Spanish arrival. Prior to the 1700's, the Gabrielinos relied on the rich diversity of plant and animal life along the LA River (Gumprecht, 1999).

In its pristine condition, the Los Angeles River and adjacent landscapes differed dramatically from what we see today. The lowlands around the LA River were covered by a floodplain forest which was comprised of cottonwoods, hackberries, willows, and sycamores. Undergrowth consisted of native grape vines, briars, and brambles. Marshes containing cattails and bulrushes were also common along the river. Vegetation in the river itself included watercress, water fern, duckweed, pickleweed, cord grass, and tules. The upland landscape was an open woodland that was greatly influenced by how dry the area was. It typically contained alders, willows, junipers, sumacs, oaks, and walnuts, though the location of these trees varied on how likely the landscape was to flooding. Undergrowth was made up of native grasses and herb plants, with cacti and yuccas in drier locations (Gumprecht, 1999).

Fauna along the LA River has also changed over time. For instance, the LA River was once abundant with steelhead trout which would attract grizzly bears from the mountains. The undisturbed river also provided habitat for several bird species including green-backed herons, savannah sparrows, and clapper rails. The floodplain forest also provided habitat to muskrats, coyotes, antelope, and many other species including those that have been extirpated (Gumprecht, 1999).

The river also had a different drainage destination prior to being channelized. In its unmodified conditions, the river would meander into different directions with some seasons draining out West toward Santa Monica Bay. Other times it would drain down South to Long Beach towards San Pedro Bay which eventually became its fixed point of drainage after channelization during the 1930s. During floods, the river would also overflow and completely drain into adjacent countryside to create wetlands, shallow lakes, and ponds that would provide habitat for numerous fauna (Gumprecht, 1999).

Subsurface flow was also very common of the river before it was modified. In fact, most areas appeared dry and only revealed surface flow during periods of great storms. Only stretches with the right topography such as that between Burbank to Downtown LA exhibited water at all times. It is believed that the pre-existing substrate in the San Fernando Valley was capable of storing 3.2 million acres of water underground (Gumprecht, 1999).

Fig 1.1: Painting of Gabrielinos and the LA River Floodplain

During the mid-1700 the Spanish began colonizing California. Missions and presidios began forming all over California. Land surrounding the LA River was fertile with rich soil that was deposited from flood. As a result, Los Angeles was founded in 1781 and became one of three agricultural villages in California that grew food for the missionaries and presidios across the state (Gumprecht, 1999).

The use of these floodplains for agricultural fields continued on through the 1800s. The discovery of gold in Sacramento in 1848 attracted numerous individuals to California. The increase in population led to agricultural expansion as well as the growth of cities with development typically occurring adjacent to the river. By 1870, the river was split into 8 different aqueducts called “zanjas.” . The zanjas were primarily used for irrigating agricultural fields of grapes, wheat, and fruit trees. The increasing population resulted in a polluted and unsanitary zanja system that even spread certain diseases such as dysentery. It was also used as a dump site for local residents before pollution laws were implemented (Gumprecht, 1999).

Fig 1.2: The San Gabriel Mission

Expansion of farmland and cities contributed greatly to the degradation of the river and the zanja system. Waterways were not only used as a dump site, they were also contaminated with agricultural pollution, street runoff, and eventually industrial discharge. Surface water was contaminated and had to undergo chlorination treatment . The only water safe for drinking was subsurface water deep in the aquifers below the river that had undergone natural filtration (Gumprecht, 1999).

Conditions only worsened with the completion of Transcontinental Railroad in 1871 which brought forth a wave of migration from the East to the West, thus further altering the river landscape. LA's population was estimated at 33,881 individuals in 1880, and nearly tripled to 101,454 by 1890. With an increase in population came an increasing demand for water that led to over-pumping of the river. Soon reservoirs and water meters were built across the city in means of water conservancy by the growing populations. The growing demand for water led to the proposal for an aqueduct that would transport water from Owens Valley to Los Angeles. The city approved the 24.5 million dollar project, and by 1913 the Los Angeles-Owens River Aqueduct was completed . The imported water was used for irrigation, but eventually discharged into the river which doubled the volume of water it had in previous years. The aqueduct provided a more reliable supply of fresh water year round and today supplies 40 percent of the city's water (Gumprecht, 1999).

A proposal for a sewer system across the city was also approved by voters in 1892 in order to prevent further pollution of the river. However, companies continued to dump illegaly into the river. Companies such as the Los Angeles Gas Company were known to have dumped large amounts of tar and oil into the river bed, which not only affected the rivers flow, but negatively impacted plants, animals, and people (Gumprecht, 1999). Railroads, factories, and stockyards along the river's edge led to large amount of toxic discharge into the water. Harsh chemicals such as chromium was found in the river and was believed to originate from an aircraft plant upstream. Bacteria was also washed into the stream from adjacent factories. For example a paper mill in Vernon was linked to be the source of an Escherichia coli outbreak in the lower section of the LA River along Long Beach throughout the 1940's . To address the issue of pollution, the Los Angeles River Pollution Committee was formed to create standards of waste discharges. The committee established 17 sampling stations along the river to test the quality of water and record whatever toxins and pollutants are present. The outcome of the committee was somewhat successful as certain odorous pollutants were reduced from 17 in 1948 to just 1 in 1951. In addition, oil field brines previously let out carelessly were almost completely redirected to the sewer system. Despite the committee's early success, pollution persisted in the river. New sources of contamination were developed and other chemicals such as arsenic were found in the waters. As a result the city banned any swimming and bathing deeming it unfit for human use. In 1969 the water was recognized to be too toxic for fish (Gumprecht, 1999).

Fig 1.3: Construction of the LA sewer system

Fig 1.4: The Los Angeles-Owens River Aqueduct

The danger of floods has always shadowed over Los Angeles. While the river was a valuable resource to communities built along its main course, its unpredictable and destructive tendencies ultimately led to it being lined with cement and channelized. Catastrophic floods such as those of 1914, 1934, and 1938 only strengthened the public's opinion for containing the wild river (Gumprecht, 1999). Construction on the river was carried out by the Army Corps of Engineers between 1938 to the 1980s (Kibel, 2007). Modification consisted of straightening, deepening, widening, and lining its containment in concrete in order to allow heavy flows of the wet season to the quickest route out to sea. The elevation of the river was also modified to span about 700 feet in a relatively short distance of about 50 miles (Gumprecht, 1999). Even with its present day levees there are still few locations along the river that aren't adequately prepared for a 100 year flood event (USACE, 2013).

Notable destructive floods date back to 1884, 1914, and 1938. These floods destroyed property, injured civilians, and even claimed some lives (Green, 2007). For instance, the flood of 1914, an El Nino season (Grumpecht, 1999), claimed the lives of 177 people (Green, 2007). The peak flow during this event was estimated to be about 3,000 cubic feet per second (Gumprecht, 1999).

Following the devastating storm of 1914 the city began to focus more on flood control solutions for the city. Immediately after the flood, surveyors mapped the areas with a high risk of flooding and performed interviews with long-time residents to gain a better understanding of the river during peak flows. The following year the flood control bill was approved and brought forth the Los Angeles County Flood Control District. Part of the district was the Board of Engineers that proposed solutions to how flood can be prevented in Los Angeles. Flood control construction along certain areas of the LA River began as early as 1918 and included the development of several dams across the city including the Devils Gate Dam in the Arroyo Seco portion of the river. These few flood control efforts weren't enough as the city was hit by another big flood in 1934. The flood killed at least 49 people, and caused $6.1 million in damage. The magnitude of destruction, even after the completion of the flood control projects of 1918, made the residents of Los Angeles less supportive of the city's ability to carry out flood control projects. When the city proposed to increase taxes to fund a new flood control project in response to the 1934 flood, the residents voted against it, forcing the city to seek funding from the federal government. In 1935 President Roosevelt approved partial funding of the new flood control plan. The US Army Corps of Engineers and local laborers under the WPA relief rolls began construction a month after approval and consisted of widening, deepening, and lining a long stretch of the river from northern Los Angeles to downtown (Gumprecht, 1999). Some edges were concrete lined, while other stretches were lined with rip rap(Gumprecht, 1999).

Fig 1.5: House falls in Flood of 1914

Fig 1.6: Bank Erosion during Flood of 1934

Fig 1.7: Channel Construction of the Arroyo Seco 1935

Flood control construction from the 1934 projects hadn't even been completed when LA was struck with what some consider to be the most damaging flood in the history of LA since colonization by the Spanish. The flood of 1938 lasted a week and had an average peak flow of 99,100 cubic feet per second. The result was over 100,000 acres inundated, 87 confirmed deaths, and the total damage added up to $78 million. Destruction was so great because many dams, channels, and levees were still under construction, while the ones built were incapable of containing a flood of that magnitude. The intensity of this flood drove the Army Corps of Engineers to reevaluate the potential volume and intensity of a max storm event in a project known as the Los Angeles County Drainage Area Project. In order to increase volume of discharge, engineers proposed widening and reinforcing channels and paving the banks and bottoms of the river. In 1941, Congress once again approved the project and funded $25 million to the city. Construction carried on up until 1970, working little by little, whenever funds were available. The total cost of the whole Los Angeles County Drainage Area Project added up to about $1 billion. The finished product was a trapezoidal concrete channel, with reinforced levees, and a series of dams along the 51 mile stretch of the river. The efforts proved to be worthwhile when another great storm event in 1969 with a peak flow of 102,000 cubic feet per second was almost completely contained by the new flood control system (Gumprecht, 1999).

The goal of the Los Angeles County Drainage Area Project was to capture, contain, and flush out storm peak flows as quickly as possible out to the sea. With flood control as the main goal, very little was done to preserve native habitat along the river. Much of the willow-cottonwood riparian habitat was lost due to the drainage area project. The straightening of the river also got rid of marshes and pools along the river's stretch, which provided habitat for several waterfowl, fish, and amphibians. The replacement of gravel bottoms to concrete lining also led to the decline of native fish spawning habitat . The removal of vegetation of the river also took away cover necessary for several fish species. Very few areas, such as the Glendale Narrows section of the river, where the bottom wasn't lined still have some vegetation and appear "natural" within the channel walls (Gumprecht, 1999).

Fig 1.8: Los Angeles County Drainage Area Channel

Following the completion of the drainage area project, individuals such as Lewis MacAdams, Pat Patterson, and Roger Wong founded the Friends of Los Angeles River (FOLAR) during the mid-1980's; an organization dedicated to promoting revitalization of the river (Gumprecht, 1999). FOLAR advocates for ecological restoration of the river and community involvement with the river including kayaking and river clean-ups. The organization has been active in challenging flood control proposals that overlook ecological preservation. One notable case was FOLAR v. the Army Corps and LA County of 1990 in which they fought against a 23 mile project to raise existing walls along a lower LA levee. Despite their loss in preventing the construction project, they did come out with the LA River Revitalization Master Plan as part of their settlement (MacAdams, 2013).

It has been over 20 years since the LA River Revitalization Master Plan was proposed. Over the years, the river landscape and surrounding areas have been studied extensively, with research presented through numerous reports. After analyzing the data, 21 plans varying in price and amount of habitat restored were developed. Those 21 alternatives were then narrowed down to 4 options for the federal officials to select. In fall of 2013, the US Army Corps of Engineers made a tentative selection of alternative 13 which would restore 588 acres of habitat along 11 miles of the river for a total of $453 million. This selection would remove concrete lining at the bottom of the river from Griffith Park to Downtown LA. It also includes widening the river, resloping/terracing of one side of the levee, and the creation of a freshwater marsh in Glassell Park. While alternative 13 aims to restore as much land as possible for the proposed budget, some restoration advocacy groups such as LA River Revitalization Corp.(LARRC) do not support the Army Corps of Engineers selection claiming that it fails to fully promote residential use of the site with only one side of the levee being re-terraced (Barboza, 2013). After lobbying against the Army Corps of Engineers in Washington DC, environmental groups including FOLAR received approval from Congress for the $1 billion dollar Alternative 14 that would include all restoration from Alternative 13 plus the incorporation of both terraced banks that would that allow people to access the water from both sides of the river. Environmental groups hope that this restoration project will be a catalyst for full restoration of all 51 miles (Sahagun, 2014).

Figure 1.9: FOLAR River Clean-Up Flyer

Fig 2.0: LA River Revitilization Project Perspective

Steelhead in the Los Angeles River

Before the Los Angeles River was degraded by the effects of urbanization, it served as one of the southerrnmost passages for winter run steelhead. With a rapid increase of population in Los Angeles during the 1800's and 1900's came about overfishing, pollution, removal of habitat from urbanization, and other factors that resulted in the extirpation of steelhead from the LA River. The last known steelhead to be caught in the LA River was in the Glendale Narrows in 1940 (Gumprecht, 1999).

The decline of steelhead populations in California was analyzed in 1996. The report stated that the number of steelhead in the state of California fell from about 500,00 adults to approximately 250,000 in a matter of 30 years. It also concluded that the current southernmost waterway that still contains steelhead is Malibu Creek (McEwan et al. 1996). A year later, southern steelhead were listed as an endangered specie. In 2002, the range of the endangered southern steelhead was expanded to the US-Mexico border (NOAA, 2012)

A report by the National Oceanic and Atmospheric Administration (NOAA) lists the factors that contributed to the southern steelhead decline in the state of California. Figure 2.1 lists those factors and the level of threat it poses within the Los Angeles River (2012).

Critical habitats for the southern California steelhead distinct population segment (DPS) was defined by NOAA and has become the focus for the implementation of the steelhead recovery plan. In this plan, 32 DPS watersheds have been studied to figure out what kind of intervention would best help in repopulating the specific location. So far the recovery plan has split amongst 5 biogeographic regions that have the highest potential for repopulation. The 5 regions selected for further study are the Monte Arido Highlands, the Conception Coast, the Santa Monica Mountains, the Mojave Rim, and the Santa Catalina Gulf Coast. Of these 5 regions, the Los Angeles River lies within the Mojave Rim (NOAA, 2012). Figure 2.2 lists the priority recovery actions for the Mojave Rim Region.

Sources of Population Decline	Threat Level
Dams and Surface Water Diversions	Very High
Flood Control	Very High
Groundwater Extraction	Very High
Levees and Channelization	Very High
Urban Development	Very High
Recreational Facilities	Low
Culverts and Road Crossings	High
Agricultural Development	Low
Upslope/Upstream Development	High
Wildfires	Low

Fig 2.1: Sources of steelhead population decline. Chart information taken from NOAA, 2012 Recovery Plan Summary

Priority Recovery Action

1. Develop and implement operating criteria to ensure the pattern and magnitude water releases from dams to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile *O. mykiss.*

2. Develop and implement a plan to physically modify dams to allow adult and juvenile *O. mykiss* natural rates of migration between the estuary and upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and ocean.

3. Develop and implement a plan to physically modify or remove fish passage barriers at debris basing, diversions, roads, and highways to allow adult and juvenile O. mykiss natural rates of migration between the estuary and upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and ocean.

4. Develop and implement restoration and management plans for stelhead bearing watershed. To the maximum extent feasible, plans should restore the physical configuration, size, and diversity of the wetland habitats, eliminate exotic species, control artificial breaching of the sand bar, and establish effective buffers to restore estuarine functions and promote *O. mykiss* use of the estuaries.

5. Develop and implement an integrated wildland fire and hazardous fuels management plan, including monitoring, remediation, and adaptive management, to reduce potentially catastrophic wildland fire effects to adult and juvenild *O. mykiss* and their habitat and preserve natural ecosystem processes.

6. Develop and implement flood control maintenannce plan for steelhead bearing watersheds to minimize the frequency and intensity of disturbance of instram habitats and riparian vegetation of the mainstream and tributaries to protect all *O.mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.

Fig 2.2: NOAA Priority Recovery Action for Mojave Rim. Chart information directly taken from (NOAA, 2012) Recovery Plan Summary

Rainbow Trout vs Steelhead Trout

Steelhead trout and rainbow trout are the same species: the difference between them is that steelheads are anadromous and rainbow trout are freshwater (Raleigh et al, 1984). Rainbow trout become steelheads when they enter undergo a physiological change called smoltification (NOAA, 2012). In smoltification, the gills of the fish change to acclimate to the change in salinity from freshwater to saltwater (or vice versa if returning to natal streams from the ocean). The smoltification process typically occurs in lagoons and estuaries where salinity levels are in between freshwater and saltwater. Appearance is also altered when rainbow trout undergo smoltification and enter the ocean to become steelheads. Ocean going steelheads tend to be more silvery and larger than freshwater only rainbow trout (Raleigh et al, 1984). Once out in ocean, steelheads follow a migration range that can span along the pacific West Coast of America, up North to the Alaskan Peninsula. Like salmon, steelhead usually return back to their natal streams to spawn, however they are also capable of spawning in non-natal streams. Unlike other anadromous fish that die after spawning, steelheads are capable of having multiple spawning seasons (NOAA, 2012). Steelheads can live to be 4-8 years while landlocked rainbow trout typically live for 3-5 years (Raleigh et al, 1984). Rainbow trout don’t necessarily migrate to the ocean and become steelheads. Some remain in freshwater all their life (NOAA, 2012). If they don’t migrate to see, rainbow trout typically spend 2 years in the stream and 2 years in a lake before returning back to their natal stream to spawn (Raleigh et al, 1984).

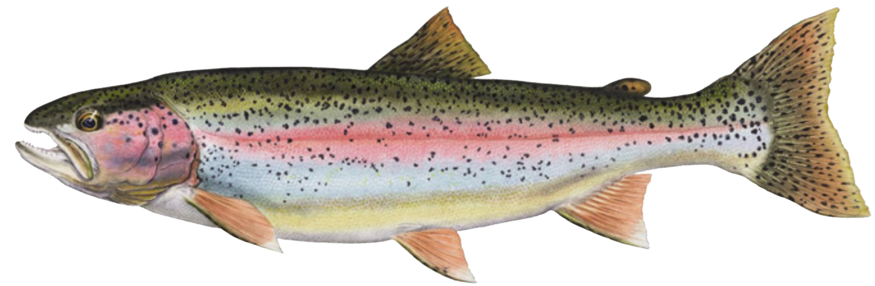


Fig 2.3: Rainbow Trout

Fig 2.4: Steelhead Trout

Steelhead Trout Life Stages

Adult steelheads in Southern California mate during Winter in gravel bottomed streams and create nests called redds in which the female may deposit anywhere between 200-12,000 eggs. After being fertilized by the male, the eggs can take anywhere from 3-4 weeks to hatch. Upon hatching the small fish called alevin spend another 2-3 weeks buried in the gravel with their yolk sac still attached to them. The steelhead then emerges from the gravel and spends another 1-3 years in freshwater growing from a fry to a smolt. Once the juvenile undergoes smoltification in brackish water it enters the ocean and may spend up to 2 years in saltwater before returning to its natal streams to reproduce (Calfish, 2014).

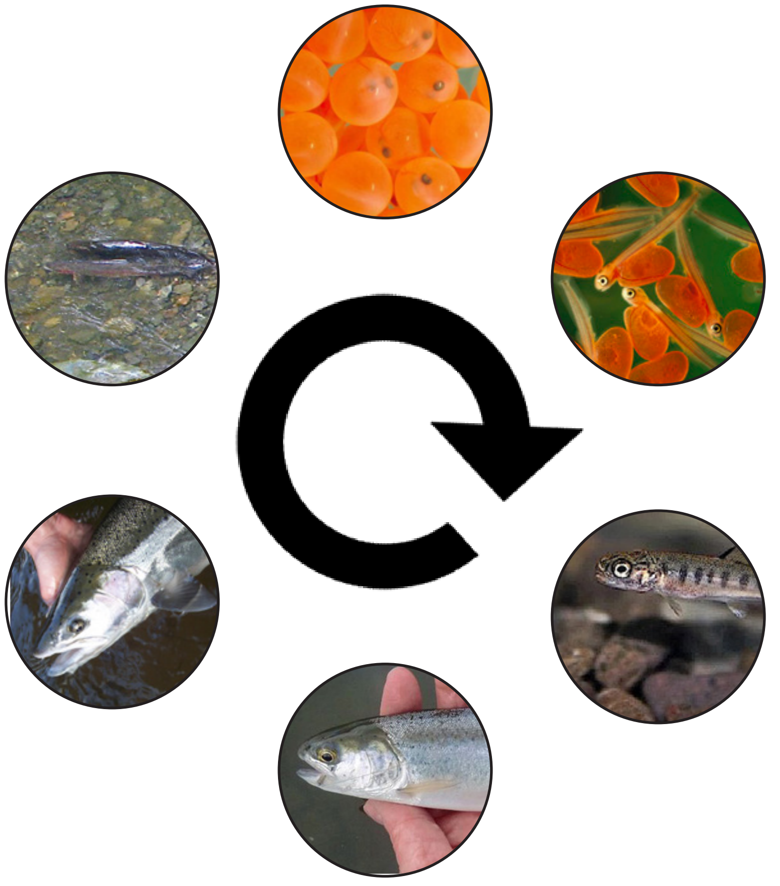


Fig 2.5: Steelhead Trout life cycle

Steelhead Reproduction

Steelheads primarily spawn in freshwater streams, however there have been rare instances in which they spawn in freshwater lake. Male steelheads sexually mature at 2-3 years, while females sexually mature at 3 years. Steelheads require a stream with a gravel substrate in order to create a nest. Prior to spawning the female selects a site along a riffle to create a nest called a redd. She uses her body to dig up a pit within the gravel that is approximately as long as her body length and about 15 cm deep. After depositing her eggs the male will then come in and fertilize the eggs with his milt (Raleigh et al, 1984).

Fig 2.6: Spawning Steelhead

General Habitat Requirement

Fig 2.7: Typical Steelhead Stream

Fig 2.8: Typical Steelhead Pool

Rainbow trout and steelhead riverine habitat is typically comprised by clear, cold water with gravel substrat. Ideal streams have a 1:1 pool to riffle ratio that provide areas of slow flowing, deep water. Vegetation is also important especially along the stream banks for the fish to use as cover from predators. In stream cover is also important and may be comprised by vegetation, debris piles, snags, and large rocks. Also, 50-75% midday shade is optimal for trout streams. A flow of 15 cm per second or less is also a common trait in the ideal stream (Raleigh et al, 1984).

Optimal lacustrine habitat includes clear, cold lakes that tend to be somewhat oligotrophic. The size and chemical quality of the lake or pool may vary depending on location. Also, trout prefer deep pools with low velocity and plenty of cover through overhanging vegetation, submerged vegetation, and undercut banks. Canopy provides the benefit of shade, cooler temperature, and debris material that can be used as cover (Raleigh et al, 1984).

Specific Habitat Requirements

Incubation Habitat Requirements

Spawning almost always occurs in a riffle with fast flowing water moving around 30 to 70 cm per second. Gravel substrate that is 0.3 to 10 cm in diameter is preferred for spawning. Cobble substrate is also okay for creating a spawning red. Redds are generally 0.6 to 8.2 feet below the stream surface.Preferred temperature for spawning is between 2 and 15 degrees Celsius. Meanwhile, the optimal temperature for embryonic incubation lies within 7 to 12 degrees Celsius. After hatching, alevin remain in the same environment for another 2 weeks before moving out to slower waters (Raleigh et al, 1984).

Fig 2.9: Steelhead Eggs

Fry/Parr Habitat Requirements

Fig 3.0: Steelhead fry

The alevin eventually moves into a stream or lake with shallow water and slow flow. They usually inhabit this environment throughout their fry and parr life stages. Fry and parr prefer water between 13 to 19 degrees Celsius. They also prefer a flow velocity no greater than 8 cm per second. Fry and parr also utilize aquatic vegetation, debris piles, and the crevices between rocks as cover (Raleigh et al, 1984).

Smolt Habitat Requirements

Steelhead in their smolt life stage head for brackish water such as estuaries (Raleigh et al, 1984). Optimal temperature is between 4 to 13 degrees Celsius (Raleigh et al, 1984). Smolts require an environment with some sort of cover such as upturned roots, snags, debris piles, overhanging banks, and small boulders. Optimal water velocity for a smolt is typically between 10 and 12 cm per second (Raleigh et al. 1984). Once smolt undergo the smoltification process they enter the ocean environment and may remain there for up to 4 years

Fig 3.1: Steelhead Smolt

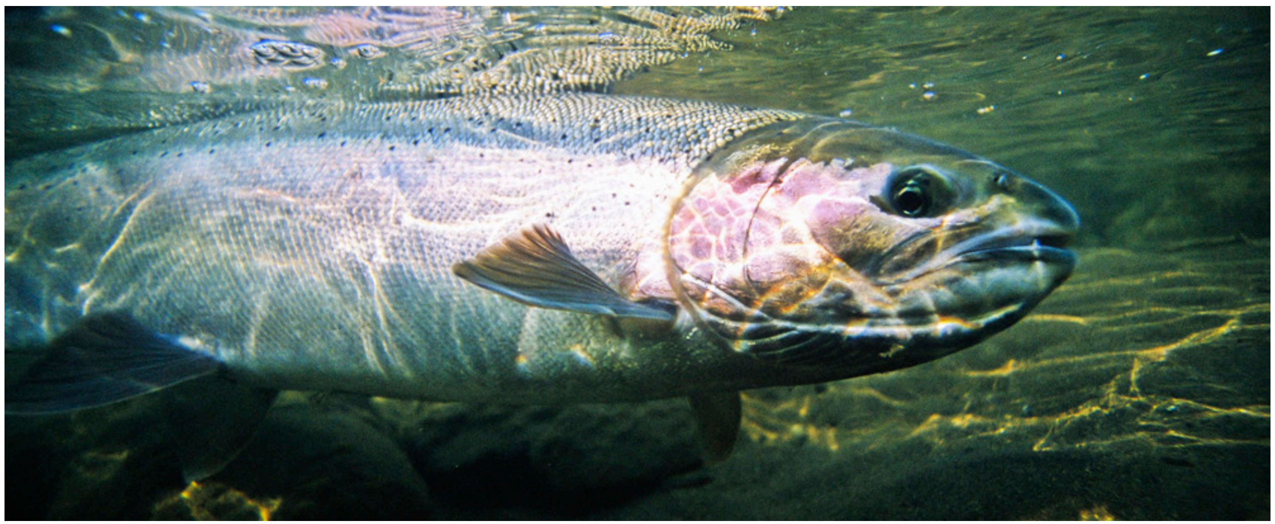


Fig 3.2: Steelhead Adult

Adult Habitat Requirements

Steelhead in their smolt life stage head for brackish water such as estuaries (Raleigh et al, 1984). Optimal temperature is between 4 to 13 degrees Celsius (Raleigh et al, 1984). Smolts require an environment with some sort of cover such as upturned roots, snags, debris piles, overhanging banks, and small boulders. Optimal water velocity for a smolt is typically between 10 and 12 cm per second (Raleigh et al. 1984). Once smolt undergo the smoltification process they enter the ocean environment and may remain there for up to 4 years

Benefits of Restoring Steelhead Habitat

The benefits of restoring steelhead trout habitat goes beyond helping just the single species Steelhead trout are unique in the sense that they inhabit several different habitats and environments at different stages of their life. For example, steelhead may occupy stream, lakes, estuaries, and even ocean ranges. Thus, restoring steelhead habitat will also mean restoring habitat for other organisms that inhabit the same environment (NOAA, 2012).

In addition, the restoration will lead to repopulation of steelhead in areas with low or dwindling populations. From here the newly established population can be used as an indicator of the health of the whole watershed being that steelheads utilize all parts of the river during their different life stages. (NOAA, 2012).

Once populations are stable, a sustainable fishing season of steelhead can be established that can bring forth economic and social value to the state of California. A 1996 report for the Department of Fish and Game concluded that sport fishing can bring in $37.5 million per year to the state economy if steelhead populations are at least doubled (McEwan et al. 1996).

Project Goals

1. Locate best place along river to begin intervention.

2. Utilize discharge from discharge points to allow for upstream movement.

3. Propose water treatment system.

4. Incorporate community use of the restoration site.

5. Implement monitoring strategy.

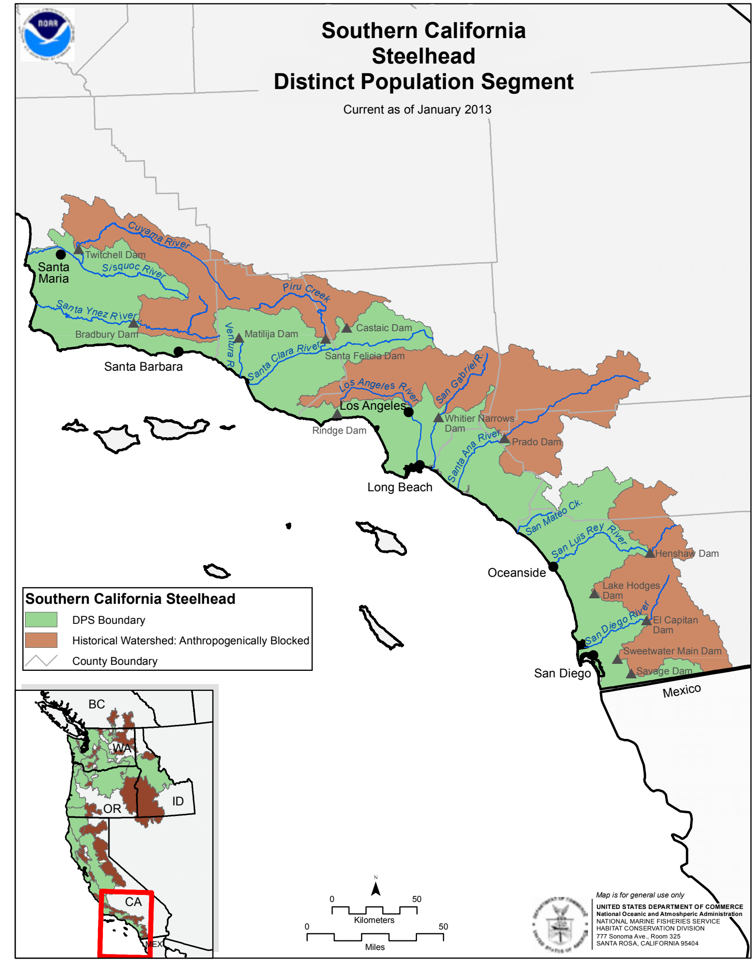


Fig 3.3: Southern California Steelhead DPS Range from NOAA

Precedent Studies

Precedent Study

Cheonggyecheon Stream

Location: Seoul, South Korea

Size: 3.6 miles long

Budget: $380 million

Completion Date: 2005

The Cheonggyecheon Stream Restoration Project was an urban stream restoration plan in Seoul, South Korea in which a massive highway over the stream was planned to be removed. City officials were hesistant at first, fearing that the removal of the road would result in high car traffic through the city streets. To address the issue, they implemented a no parking zone around the river, increased bus and light rail services, and encouraged bike and pedestrian travel with bike lanes and more accessible sidewalks (LAF, 2014).

With the new traffic adjustments along the river, the city was able to focus more on the river itself. The river was restored to a green corridor for people and wildlife. Also, the connection points between the stream to other waterways were restored to wetlands. The stream was planted with native vegetation along the numerous swamps, shallows, and marshes to improve habitat for amphibians, insects, and birds and to restore a spawning ground for fish (LAF, 2014).

While the river is a major tourist attraction it also serves as a flood control channel. Situated in the middle of the city, it must contain large discharges from city outfalls during heavy rain. The river claims to be capable of containing large volumes of water including the region's 200 year flood. While it is able to contain all that water, the average water depth is only about 40 centimeters. Historically, the river would be dry during the summer months, but a series of pump stations along the river release a consistent flow of treated water to create habitat for numerous aquatic organisms (LAF, 2014).

Fig 3.4: Cheonggyecheon Perspective 1

Fig 3.5: Cheonggyecheon Perspective 2

Fig 3.6: Cheonggyecheon Night Perspective

Fig 3.7: Guadalupe River Perspective 1

Fig 3.8: Guadalupe River Perspective 2

The Guadalupe River Restoration Project is a multi-objective program to restore habitat, control floods, remediating soil and water quality, and promote community use of the site.The Guadalupe River is situated along a historic mercury mine resulting in the contamination of mercury in the soil and water (Renn et al. 2008).

Much of the surrounding community was susceptible to flooding so in 1992 the United States Army Corps of Engineers began construction of a concrete channel to contain the floods. Construction was halted after a 1996 habitat impact study revealed that the concrete channel would negatively impact steelhead trout and chinook salmon populationsRenn et al. 2008).

Construction continued in 2002, however it followed new, ecological guidelines. Under the new plan, the concrete channels were replaced with gradual earthen slopes with adjacent floodplains. In addition, an underground culvert was built to redirect overflow of water during periods of intense rain. Also, more vegetation was included in the restoration project to slow the flow of stormwaater and to provide habitat to wildlife. Finally, community involvement was promoted with the creation of parks and a trail system that runs alongside the river (Renn et al. 2008).

In addition, a water releasing system from upstream pump stations has been implemented to allow for steelhead and salmon to migrate upstream in order to compensate for the usual low water levels of the river (Renn et al. 2008).

Soil contamination was addressed initially by excavating it and treating it elsewhere. Soil and water contamination is currently being treated via phytoremediation through the constructed wetlands along the river. A 2005 study under the Guadalupe River Watershed Mercury Total Maximum Daily Load Project concluded that mercury levels have reduced since the restoration project began (Renn et al 2008).

Location: San Jose, California

Size: 80 miles long

Budget: +$16 million

Completion Date: On-going

South Platte River

Location: Colorado/Nebraska

Size: 10.5 miles long

Budget: $1.9 million

Completion Date: On-oing

The South Platte River Restoration Project focuses on flood and wastewatter management. Historically, the Southern Platte River experienced low flow during dry months, and extremely high flows during the winter. Early inhabitants scoffed the river claiming it had no potential as it was too shallow, too hot, and lacked adequate riparian habitat (Renn et al. 2008).

As the surrounding areas turned toward industrialization, what little water available from the river was diverted for use in the factories. At the same time, industries would use the river as a dumping zone for their byproducts. In addition, a newly designed sewer system added to the degradation of the river by releasing untreated stormwater (Renn et al. 2008).

In 1965 a 100 year flood flushed through the river. The flow was so great that it carried the mountains of debris piled within it as it ran through the surrounding city. The flood and the debris it carried destroyed anything in its path from houses to bridges (Renn et al. 2008).

In 1975 the Platte River Development Committee initiated a redesign of a small portion of the river with a budget of $1.9 million. With the funding they were able to plant various trees and shrubs along the banks, modify the river with riffles and pools, and addressed the water issue of pollution. Part of the project included shutting down older sewer outflows into the river to reduce input of untreated water into the river. Today, discharge of reated water from pumping stations is strategically released to allow for water activities year round. In addition the increase in subsurface water from its original condition has allowed trout and other introduced sport-fishes to exist in the area (Renn et al. 2008).

Fig 3.9: South Platte River Perspective 1

Fig4.0: South Platte River Perspective 2

Site Analysis

The Los Angeles River Estuary

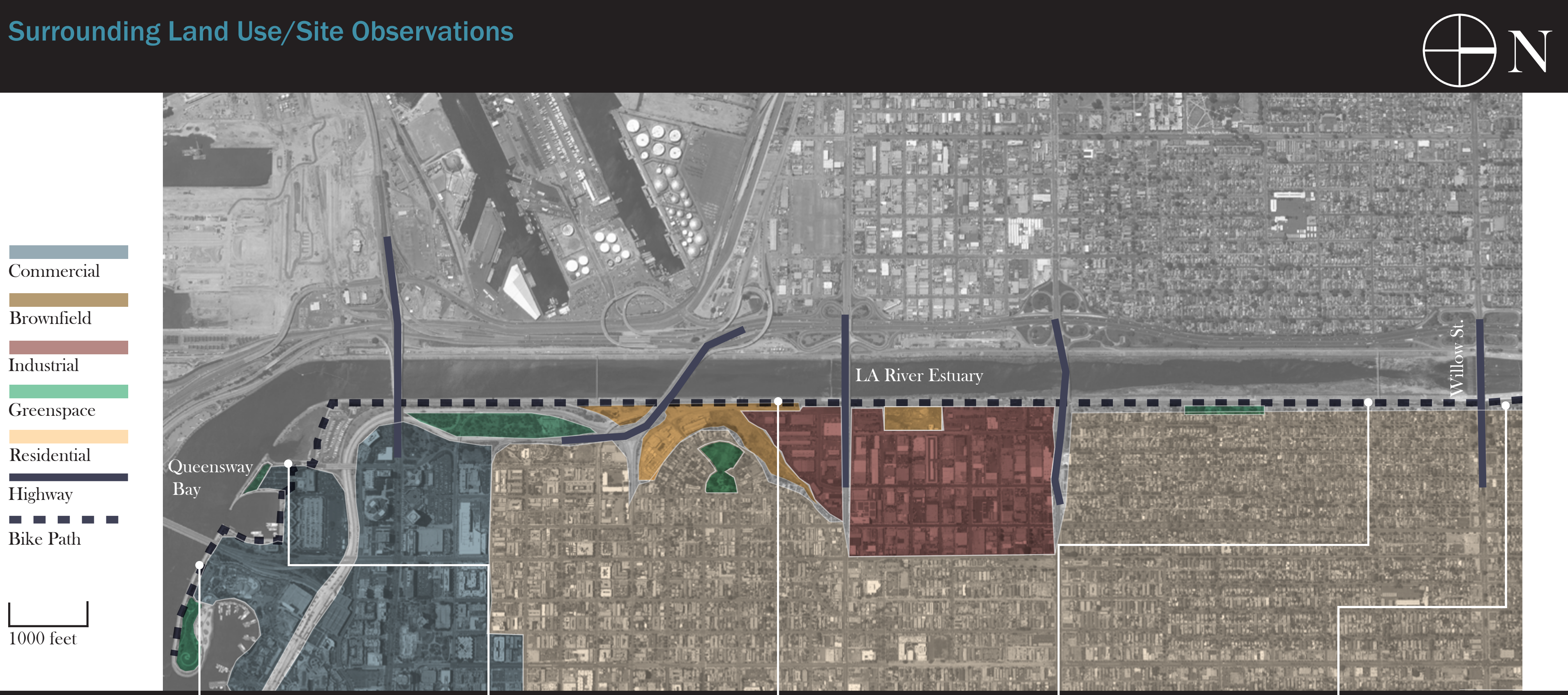
Fig 4.1: The Los Angeles River Estuary

Figure 4.2: Panorama at Willow St.

The Los Angeles River estuary is the southernmost portion of the LA River and is where the river drains off into the Pacific Ocean. The highlighted area in Figure 4.0 is one of the only areas of the river that isn't lined with concrete (Imhoff, 2009). I chose to focus on the LA River estuary because of its importance to steelhead habitat for smoltification, and also because it would be easier to work with since it isn't concrete lined. Figure 4.1 is a panorama of the Willow Street overpass where the LA River begins to take on its concrete trapezoidal form. Everything downstream from here is soft-bottomed and lined with rip-rap. Figure 4.2 is a panorama of Queensway Bay from which I began my 3 mile site analysis. In my visit to the estuary I made 5 stops along the levee and recorded my observations. My recorded data is illustrated in Figure 4.3.

Figure 4.3: Panorama at Queensway Bay

Surrounding Land Use/Site Observations



Stop 1

-Rip-Rap Levee
-Boulders About 6' Wide
-Heavy Littering
-Shellfish Present in Rip-Rap
-Good Flow to the Water
-Water Temperature is About 15.5 Degrees Celsius (60 Fahrenheit)
-Small Piers Provide Outlook Over Water

Stop 2

-Golden Shore Marine Preserve
-Partial Rip-Rap Within Preserve
-Wide Boulder Rip-Rap Levee Past Preserve
-Reconstructed Wetland
-Some Walls are Cement
-Partial Vegetated Edges
-Plastic Drape at Mouth of Wetland Catches Solid Debris
-Pollution is Still Present
-Stagnant Water
-Preserve is Closed Off From Public
-Water Temperature is about 18.3 Degrees Celsius (65 Degrees Fahrenheit).

Stop 3

-Change in River Elevation
-Possible Obstacle For Fish
-Brownfields on Other Side of Levee
-Inner Rip-Rap Levee Begins to Break Down to Smaller Boulders
-Rip-Rap and Bike Path is Separated by a 4 Foot Wall
-Some Vegetation Beginning to Appear
-Small Wetland Patches Along River Banks
-Sand Paths Along River Edge
-Many Wadin Birds Present Where River Changes in Elevation

Stop 4

-Inner Levee Comprised of Wetland Patches, Sand Path, Wild Grasses and Trees, and Rip Rap Boulder
-River Begins to Narrow
-Faster Flowing Water
-This Section of River Contains the Most Vegetation
-Water Temperature is about 25 Degrees Celsius (78 Fahrenheit)
-Concrete Slope Separates This Side of River With the Cement Channel Just Upstream

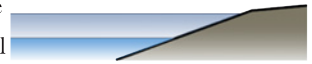
Stop 5

-River Walls Comprised of Cement
-Shallow Water About 5 Inches Deep
-Many Sea Gulls Present in This Area
-Few Wading Birds
-Break Waters Just Upstream Slow the Flow of Water Dramatically
-Water Temperature is about 27 Degrees Celsius (81 Fahrenheit)

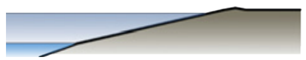
Figure 4.4: Surrounding Site Use/ Site Inventory

100 Year Flood Line

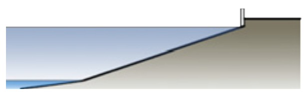
Average Water Level



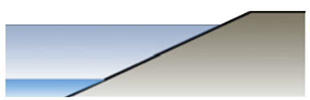
Stop 1 - Gradual Rip Rap



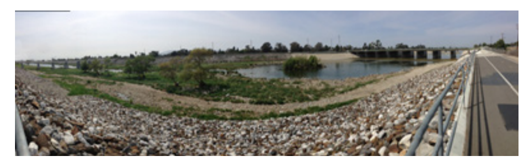
Stop 2 - Boulders in Rip Rap is Smaller

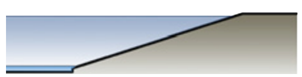


Stop 3 - Rip Rap Levee With Containment Wall



Stop 4 - Gradual Rip Rap Levee With Vegetation





Stop 5 - Steep Concrete Levee

Figure 4.5: Diagramatic Levee Section Along the River+ Panoramas

Opportunities and Constraints

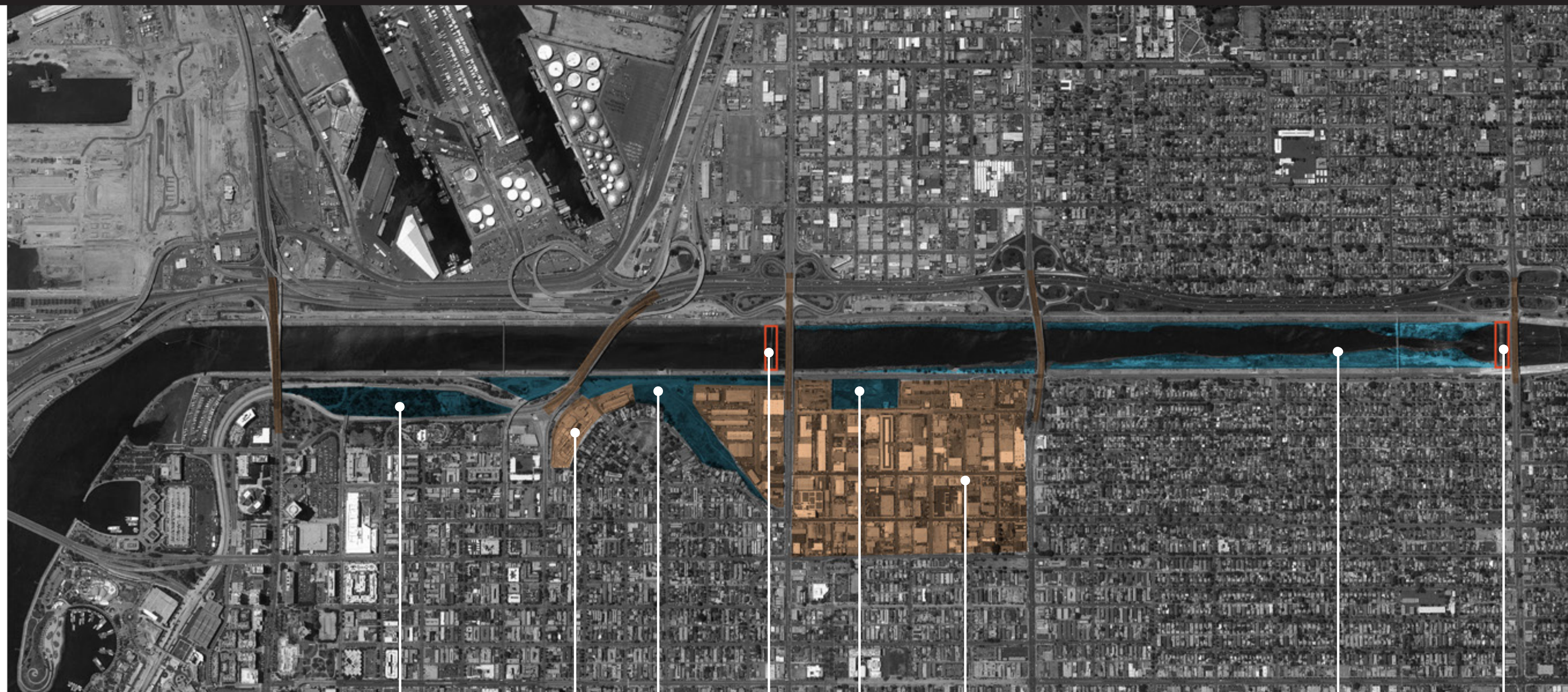
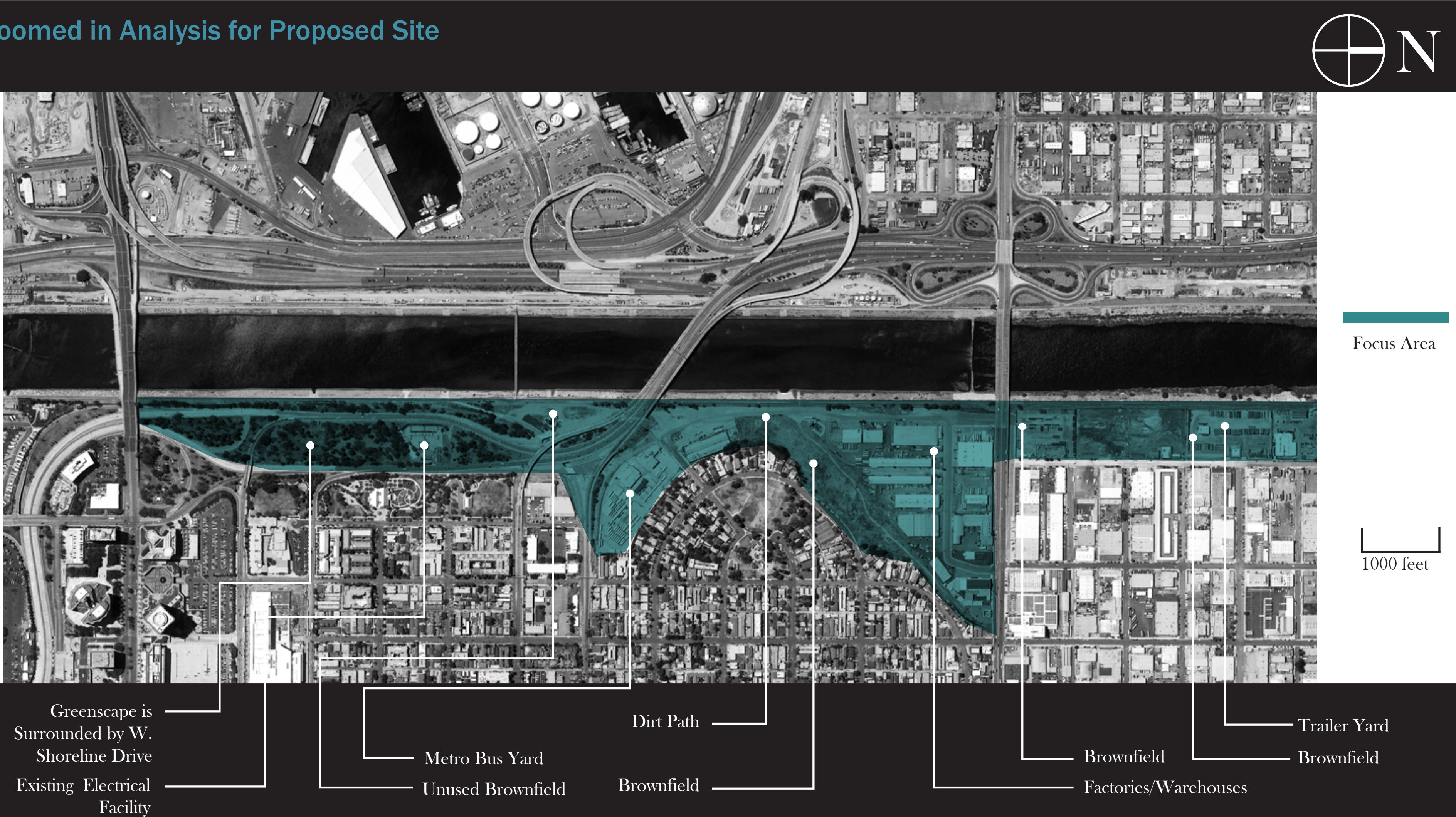


Figure 4.6: Opportunities and Constraints Map

Zoomed in Analysis for Proposed Site



After reviewing the opportunities and constraints of the estuary, I decided to focus on the portion highlighted in blue above. Within this area lies a large unused brownfield that has potential for a pool that can be used by adult and juvenile steelhead as a resting area, as well as a place for smoltification to take place.

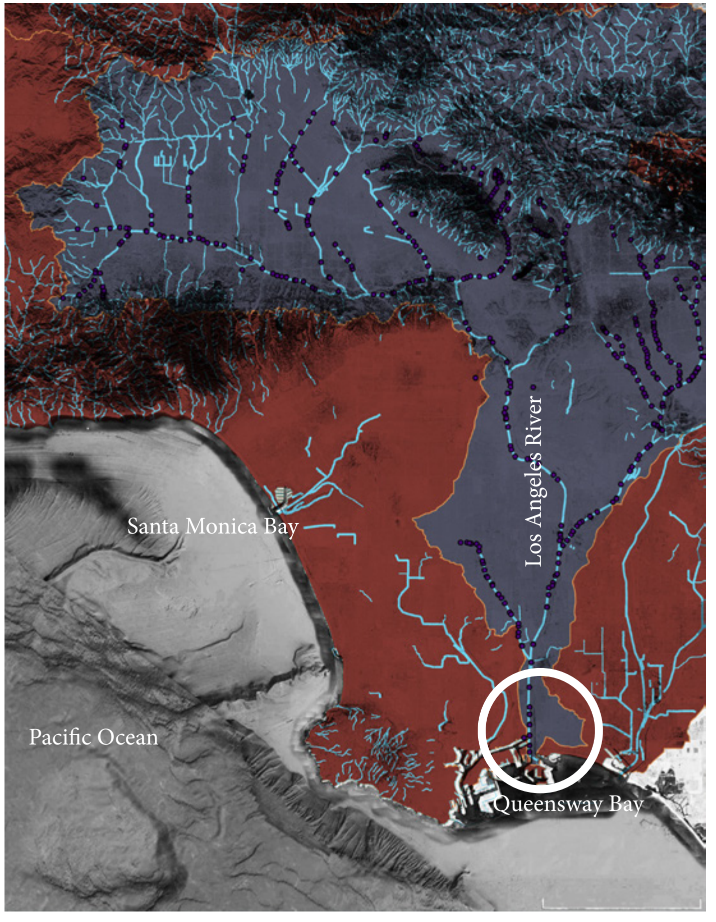
Figure 4.7: Zoomed in Site Analysis

The Los Angeles River Watershed

LA River Watershed Bounndary

Surrounding Watershed

MS4 Outfall



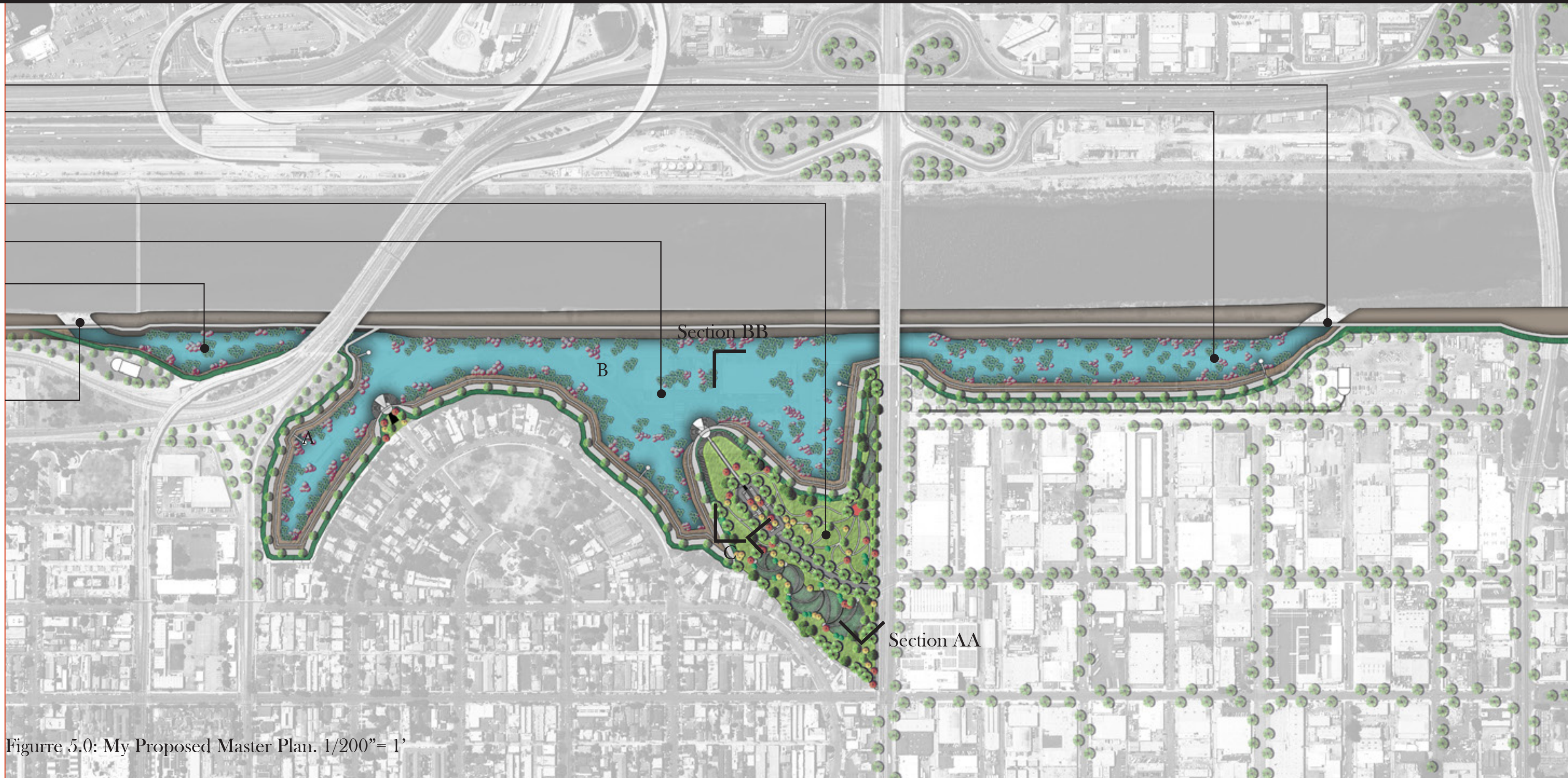
Figurre 4.8: MS4 Outfall Along the LA River. GIS Information Retrieved From the LA County GIS Data Portal

Figurre 4.9: Zoomed in MS4 Outfall Along the LA River. GIS Information Retrieved From the LA County GIS Data Portal

The water in the LA River is supplied year round from street runoff as well as several pump stations found along the river. Water collected at the pump stations is treated and pumped out through gates throughout the river (USACE, 2013). As can be seen from the maps above, there are numerous ms4 gates that can be utilized strategically for the benefit of steelhead migration. Water that isn't treated prior to discharge may still find its way into to the river which is why it is importanct to intercept the water before it reaches the river.

Site Design

Proposed Master Plan



Figurre 5.0: My Proposed Master Plan. 1/200"= 1'

For my master plan I am proposing that the city buyback some of the land that is currently occupied by industrial companies. Tbe brownfield and parts of the industrial yards will be excavated and allowed to fill with water from the breaks in the existing levee. A new levee with a gradual slope will be built around the new side channel and will have a mid slope and top of the levee pathway that will connect back to the existing levee. Water at the first break will flow into the first shallow, wetland pool that will help treat the water via phytoremediation. From here, water will overflow into the next large, deep pool that will be accessible to kayakers. It will be well vegetated and stocked with boulders and snags for the steelhead and other fish to use as cover. Finally, water will overflow into the exit pool which will also be a shallow wetland and will function similarly to the first pool in which it will treat water via phytoremediation. In order to accomodate for the high and low discharge rate of the LA River, I am proposing a channel gate system at the first levee break that will narrow or widen depending on the highs or lows to adjust the amount of water drawn in by the channel. During low flows, the gate will widen to draw at least 30 percent of the total discharge. During high flows, it will narrow so it only draws about 1.5 percent of the total discharge. Percentages were calculated based of the high and low flows of a 1992 discharge log. The excavation of the side channel will also maximize the volume of water that could be contained during a flood.

Zoom-In Master Plan

Figurre 5.1: Zoom in Community Park

The site will be open to the community and will offer a bike path, lower levee walkway, kayaking, birdwatching from inside a bird blind, and provides a community park. The site is designed primarily for steelhead, though may also provide suitable habitat for various other organisms. The middle pool will always be at least 5 feet deep, even during low flow of the river. During periods of high flows it may increase up to 9 feet.The area will be beneficial to steelhead as a resting area between their travel from freshwater to seawater and vice versa, to help them acclimate to the salinity change. The side channel levees will reach up to 25 feet high, thus increasing the volume containment capacity of the river which would be beneficial during flood periods. Section AA reveals the elevation change through the proposed terraced rain garden that will have 6 resting areas along the main path that educate visitors about steelhead and their life stages. The community park also offers an amphiteatre surrounding open recreational fields. My proposed planting plan consists of sea breeze tolerant trees and marsh vegetation such as Oleander, Coast Live Oak, Ornamental Fig, Rush, Cattails, California Lilac, and Rosemary to name a few.

Site Amenities

Reacreational opportunities at the site includes kayking in the middle pool, running or walking along one of the trails on the levee, cycling along the top of the levee, picnicking in the community, bird watching, and open space play in the greenspace. Fishing within the site may one day be an opportunity if steelhead populations are increased and kept stable enough for it to occur.

The site provides adequate greenspace for the city and even includes several stormwater management gardens. The flow through garden also includes a walkway with 6 stops that contain informative signs to educate the community on the history of steelhead as well as how the site is beneficial to the fish. The site also has a curling pathway throughout the north/west community park that was inspired by the meandering tendencies of the natural LA River.

Figurre 5.2: Informative Exploded Axon

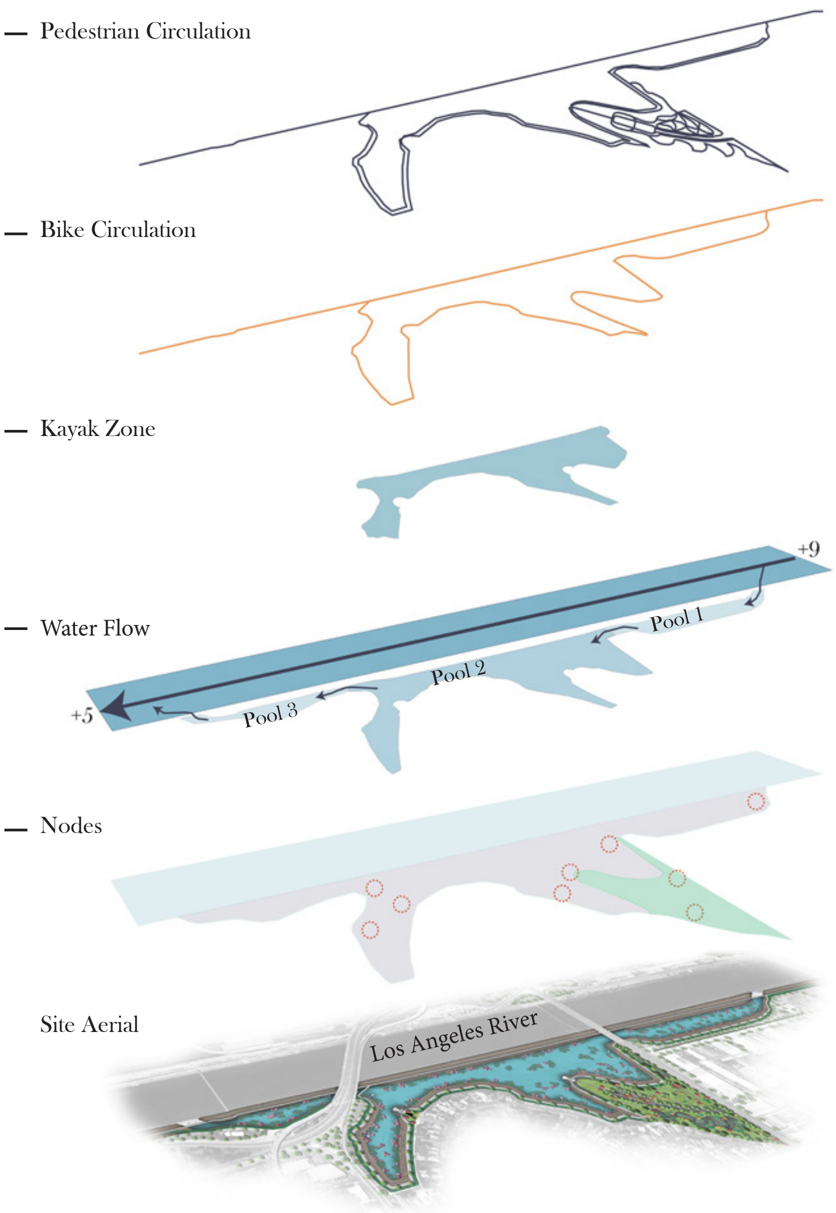
Pedestrian circulation is present throughout the entire site.

Bike circulation is primarily along the top of the levee. Bike circulation within the site reconnects with the existing bike lane along the existing levee accross the pools.

Kayaking will only be permitted in the large middle pool.

Water from the river runs along a slope with a difference of about 4 feet. The side channel will divert a portion of that water to fill the proposed pools.

Several nodes, or areas of gathering are spread throughout the site.



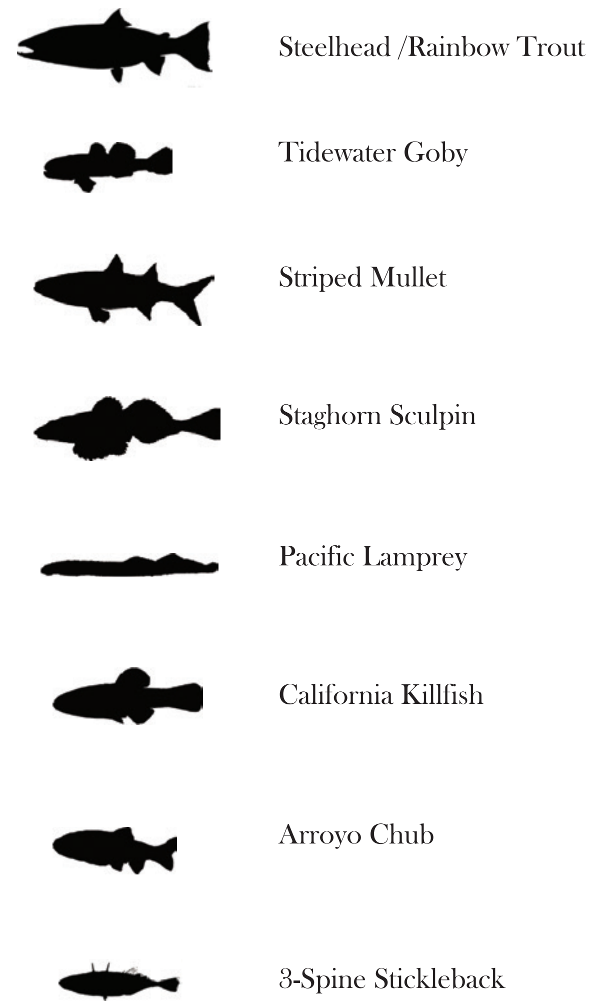
The main use of the site is meant to provide year round habitat for adult and juvenile steelhead and rainbow trout. The site can be utilized as a resting area for migrating fish , or as a permanent rearing habitat for multiple fish specie. The location is optimal because it is one of the only places along the river that can reach cooler water temperatures needed by steelhead. It is also one of the only areas that isn't lined with cocrete making it easier to work with..

The resotration project may also benefit other wildlife. The vegetated pools may attract an assortment of wetland birds such as the native least sandpiper, the double-crested cormorant, or the great blue heron. Also, improved waterways may help repopulate other native fish species that may have dwindled over the years.

The planting of the wetland plant species can be utilized to improve soil and water health. Wetland plants will act like a filter that remove contaminants in the water and soil through root uptake (EPA, 2012).

Native Fish that can benefit from the restoration project:

Information taken from (Calfish, 2014)



Figurre 5.3: Native Fish Diagram

Planting Plan

Wetland Plants

Alnus rubra	Red Alder
Aster chilensis	California Aster
Atriplex patula	Spear Oracle
Batis maritima	Beachwort
Carex fracta	Fragile Sheathed Sedge
Cressa truxillensis	Cressa
Distichlis spicata	Saltgrass
Juncus acutus ssp. leopoldii	Spiny Rush
Juncus leseurii	Salt Rush
Salicornia subterminale	Pickleweed
Typha latifolia	Broadleaf Cattail
schoeneoplectus californicus	Tule

Information taken from (LPN, 2014)

Figurre 5.4: California Wax Myrtle

Figurre 5.5: California Aster

Community Park Plants/Trees

R. lentii	Pink Flowering Sumac
P. radiata	Monterey Pine
P. torreyana	Torrey Pine
Myrica californica	California Wax Myrtle
Rhus integrifolia	Lemonade Berry
Encelia californica	Bush Sunflower
Quercus Agrifolia	Coast Live Oak
C. griseus	California Lilac
C. maritimus	Maritime Ceanothus
L. floribundis ssp. asplenifolius	Fern Leaf Catalina Ironwood
E. cinereum	Ashyleaf Buckwheat
E. latifolium	Coast Buckwheat
Artemisia californica	Sagebrush

Information taken from (RSABG, 2012)

Figurre 5.6: Coast Live Oak

Figurre 5.7: Salt Rush

Figurre 5.8: Tule

One way to prevent untreated stormwater run-off from contaminating the river and the site is to implement a series of green street restoration techniques. Techniques such as curb extensions, swales, and infiltraation/flow through planters can be created alongside streetss in order to intercept run-off and have be treated early on as opposed to running for distances and accumulating contaminants only to dump into the river. These green street components can collect water and have it naturally filter into the earth instead of having to run it through a treatment facility (Perry, 2014).

Figurre 5.9: Curb Extension

Figurre 6.0: Infiltration/Flow Through Planters

Figurre 6.1: Swale

Phasing

-The first step is for the city to obtain the land back from the owners of the various factories and warehouses found throughout the proposed site.

-Next the soil must be excavated and treated to remove harsh contaminants such as heavy metals that may be found throughout the site.

-This may be done through incineration, chemical treatment, or by capping the contaminated soil (EPA, 2012).

-Implement a series of “green street” stormwater management systems throughout the surrounding streets of the river to minimize the amount of untreated urban runoff entering the site (Perry, 2014).

-Create levee walls from earth excavated and treated. Import soil if more is necessary.

-Grade pool to have a gradual flow.

-The existing drop in elevation between the two levee breaks of about 4’ should be preserved for proper drainage.

-Reinforce levee with geotextiles and planted vegetation (Dendurent, 2014).

-Begin constructing the community park portion of the site.

-Large existing trees should be preserved if not in the way of hardscape design.

-Plant vegetation/trees

-Develop the gate system and create the breaks in the existing levee.

-Adjust gates according to measured monthly discharge levels. I.E. allow 30% discharge during periods of low flow and 1.5% during wet months to maintain at least 5 feet of water in the middle pool.

-Allow water to flow through wetland to begin phytoremediation

-Re-introduce hatchery born steelheads into the site

-Can only accept juvenile and adult steelheads.

-Steelheads should be from a local hatchery such as the Fillmore Fish Hatchery located in Ventura County.

-Some local wild steelhead should also be introduced to the new site if possible for more diverse genetic pool.

-Allow public access to the site/water

Section Elevations

Figure 6.2: Section AA

Scale: 1” = 20’

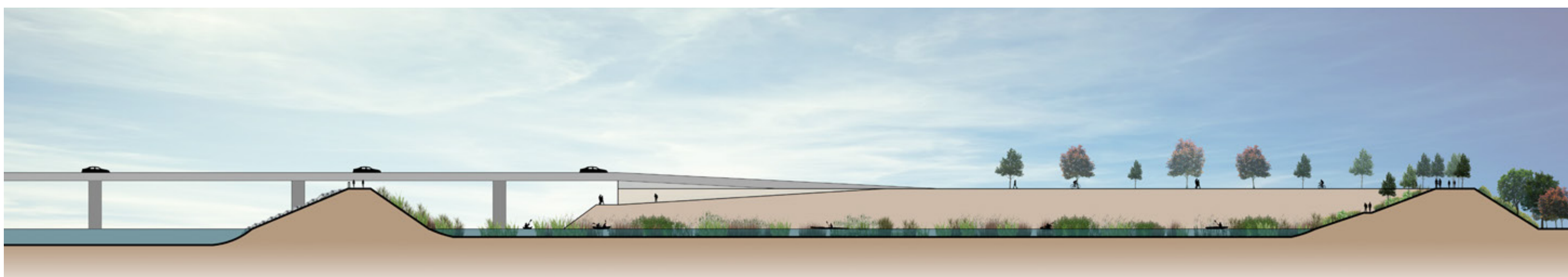


Figure 6.3: Section BB

Scale: 1” = 30’

Figure 6.4: Perspective A - From inside the Bird Blind

Figure 6.5: Perspective B - A foggy morning kayaking on the water.

Figure 6.6: Perspective C - Sunset From the Top of Levee Bike Lane

Conclusion

Conclusion

Further research, monitoring, and labor must continue upon construction of the park in order to maintain a healthy habitat. Monitoring practices such as beach seining and fyke netting which utilize nets to trap fish survey samples can be implemented to get an idea of population numbers and the overall well-being of the introduced steelhead (Tidal Marsh Monitoring). Labor such as cutting and replacing wetland plants over the course of a few years is also necessary to extract contaminants taken up through the roots completely out of the ecosystem. In addition, other labor such as general up-keep of the gardens and grounds will be necessary for aesthetic purposes.

The long term success of this restoration project is highly dependant on future upstream habitat restoration. The Los Angeles Estuary is only one of the various habitats along the river that can be occupied by steelheads. In order for a population to increase, upstream spawning habitat must also be completed. While this project doesn't completely resolve the Southern California steelhead population crisis, it does offer a short term solution that may kickstart an entire river restoration program. It also draws upon restoration and repopulation project components from several sources that can be applied to the Los Angeles River. For instance, while the LA River currently lacks fish access to some upstream locations, a water treatment plant discharge system similar to that done in the Guadalupe River can be implemented within the vicinity to allow fish to overcome their barriers.

The restoration of the LA River and its native steelhead habitat won't be carried out in one big project, but it can be split up into smaller restoration efforts until little by little, the overall goal is met.

Figure 6.7: Steelhead Swimming Upstream

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