REPORT

Upper Arroyo Seco Watershed Integrated Spreading Grounds Concept Report

City of Pasadena Water and Power

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Table of Contents

Table of Contents

List of Figures

List of Tables

Section 1
Introduction

Pasadena Water and Power (PWP) owns the right to divert up to 25 cubic feet per second (cfs) of surface water from the Arroyo Seco. An additional 7 cfs of water belonging to the Lincoln Avenue Water Company (Lincoln), diverted from the Arroyo Seco tributary, Millard Canyon Creek, is also available, for a total spreading potential of 32 cfs. In the recently completed Water Integrated Resources Plan (WIRP) (PWP, 2011B) an evaluation was conducted on how to most efficiently utilize this resource. The report concluded that use of this right for groundwater recharge at the spreading grounds in Hahamongna Watershed Park (HWP) would be the most cost effective option. However, the Arroyo Seco diversion facility and HWP spreading basins, adjacent to NASA's Jet Propulsion Laboratory (JPL) campus are inadequate to divert and infiltrate this amount of water. Currently, PWP's diversion capacity is approximately 18 cfs as a result of deposition of sediment at the diversion structure and spreading ground limitations. Thus, PWP is exploring options to improve both intake and spreading capacities with the goal of maximizing the ability to capture their full water right.

Arroyo Seco Spreading Grounds and Aquatic Habitat

1.1 Project Description

This concept report, prepared as part of the Upper Arroyo Seco Watershed Integrated Spreading Grounds, Stream, and Habitat Enhancement Conceptual Design Project, addresses baseline conditions, the existing mass balance surface flow model prepared for the WIRP, the current datalog, data gaps, and opportunities and constraints. Preparation of this concept report provides the basis for studying recharge potential and improving recharge capacity while meeting habitat goals through enhancement of habitat for sensitive species, e.g. alluvial fan scrub and riparian woodland communities and target species restoration. Habitat enhancement will assist in driving development of an integrated design as part of the Conceptual Design Report, the anticipated next step in project development.

The study area extends from the sediment capture and settling basin facility located on the Arroyo Seco channel approximately three-quarters of a mile upstream of the JPL bridge, through the PWP spreading grounds in Hahamongna Park to Devils Gate Dam. This study area includes the diversion structure approximately one-half mile upstream of the JPL bridge. This area includes the sludge pond associated with the Behner Water Treatment Plant, 13 spreading basins, Los Angeles County diversion structure and the floodwater storage area behind Devils Gate Dam. This area also includes a JPL parking facility adjacent to Arroyo Seco that exists on City of Pasadena property (Figure 1-1). In addition, the upper Arroyo Seco sub-watershed will be considered an extended project boundary that incorporates consideration of disturbed areas and sediment production as a result of the extensive 2009 Station Fire that has resulted in greatly increased sediment production rates in the upper sub-watershed.

JPL Parking Lot and Spreading Grounds

This project is linked to the newly awarded Proposition 84 Grant Hahamongna Multi-Use Basin Project that has been funded by the California Department of Water Resources (DWR). Details related to the Proposition 84 Grant funded project are currently under development.

1.2 Upper Arroyo Seco Watershed

The Arroyo Seco is a first-order tributary to the Los Angeles River extending for 22 miles from its headwaters in the Angeles National Forest, within the San Gabriel Mountains. The San Gabriel Mountain range has one of the highest erosion rates in the world (McPhee, 1990). Arroyo Seco feeds the local groundwater aquifer system which is part of the Raymond Basin and is a major source of water for surrounding communities. Located partially within the Los Angeles River coastal watershed, the Arroyo Seco watershed can generally be divided into three distinct segments: the Hahamongna subwatershed beginning at the headwaters and terminating at Devils Gate Dam; the Central Arroyo Seco subwatershed beginning immediately below Devils Gate Dam and terminating at approximately the Colorado Street Bridge crossing; and the Lower Arroyo Seco subwatershed below the Colorado Street Bridge and continuing to its confluence with the Los Angeles River.

The Hahamongna subwatershed, or upper watershed, is mostly undeveloped and partially lies within the Angeles National Forest. This area is managed for multiple purposes, including recreation, watershed protection, groundwater recharge, and wildlife conservation. In the upper watershed stream flow is present even in dry years indicating groundwater contributes to sustaining base flows.

Arroyo Seco Downstream of Los Angeles County Diversion Structure

The combination of geologic, climatic and topographic characteristics of the Arroyo Seco headwaters results in flood hydrographs that have steep ascending and descending limbs and high peak flows. This type of hydrograph is characterized as "flashy." In addition, flood flows are also characterized by high concentrations of sediment and debris.

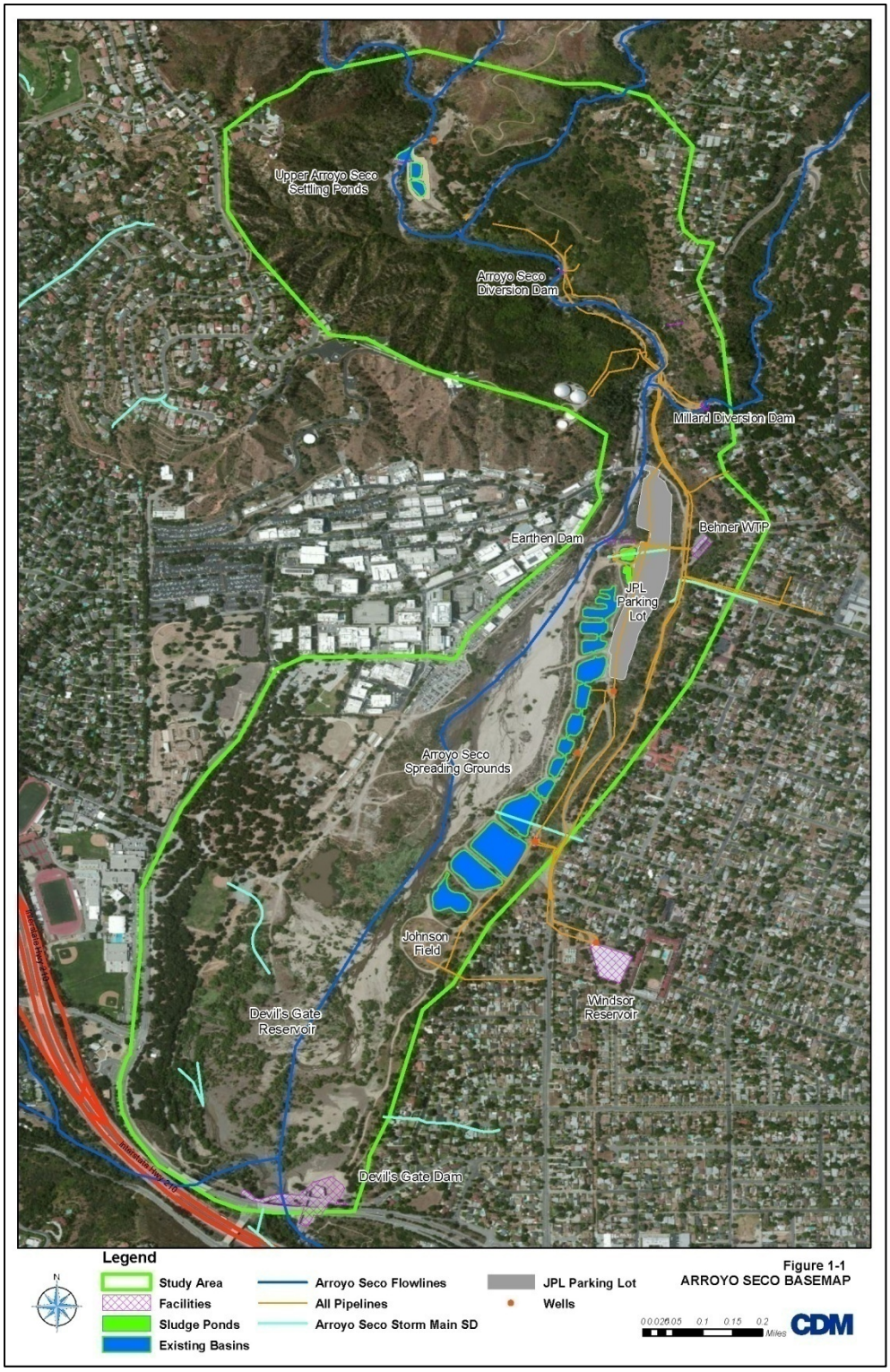

Figure 1-1
ARROYO SECO BASEMAP

1.3 Arroyo Seco Drainageway

Upper Arroyo Seco below PWP Headworks Facility

As the Arroyo Seco channels exits the San Gabriels, its gradient decreases, and conveyance area increases, resulting in decreased velocity and sediment transport capacity. This reduction of sediment transport capacity causes arroyo flows to deposit excess sediment and debris, creating a geomorphic feature called an alluvial fan, located within the HWP, albeit modified by park facilities, the JPL parking facility, water management facilities, and the Devils Gate Dam. Alluvial fans are generally known to be highly dynamic areas where the active channel constantly migrates across the fan as deposited sediment eliminates channel capacity causing the overflow of perched banks and establishment of a new channel in a lower, adjacent location. The combination of flashy hydrology and high volumes of sediment creates a highly dynamic flow situation that can cause extensive damage to development located in the alluvial fan flood inundation zones.

Devils Gate Dam is intended to prevent downstream flooding by retaining excess sediment and flow. This flood control and sediment management strategy requires stringent operational procedures to maintain flood storage capacity that is diminished by trapped sediment. The Los Angeles County Department of Public Works (LACDWP) maintains the operational capability of the dam through the removal of excess sediment and debris and controlled releases of stored floodwaters and base flow intended to sluice sediment downstream, a procedure referred to as "flow-assisted sediment transport."

Although sediment and debris removal behind the dam occurs, high flow releases can still contain large amounts of both resulting in deposition downstream of the concrete-lined channel that occurs through Brookside Park and Golf Course.

Central Arroyo Seco near Brookside Park. (CDM, 2007)

Downstream of the Devils Gate Dam, the Arroyo Seco is a highly manipulated drainageway characterized by long reaches of concrete-lined trapezoidal or rectangular channels designed to efficiently convey large volumes of water downstream to the confluence of the LA River and the Pacific Ocean.

Prior to channelization, stands of alder, willow, and sycamore lined a perennial,

trout-filled stream. The result of this manipulation has included loss of floodplain and habitat throughout the drainageway, a result of encroachment of urban development that in many areas extends up to the edge of the channel. Located throughout the highly urbanized areas are multiple regional and local parks and preserve areas intended to retain natural habitat and open space.

1.4 Arroyo Seco Habitats

Above Devils Gate Dam in the Hahamongna subwatershed, the riparian habitat is relatively undisturbed and supports a diversity of plant and wildlife species. The upper watershed headwaters are largely undeveloped and primarily managed for recreation, watershed conservation, and wildlife protection by the Angeles National Forest. Devils Gate Dam and Reservoir are operated and managed by Los Angeles County Department of Public Works (LACDPW) to control flow and sediment transport downstream.

Information on biological resources in the Arroyo Seco watershed was obtained from previous studies conducted by Northeast Trees and Verna Jigour Associates and Camm Swift as part of the *Arroyo Seco Watershed Restoration Feasibility Study* (ASF, 2006B) and *Arroyo Seco Watershed Management and Restoration Plan* (ASF, 2006A). Information on the distribution of vegetation communities was gathered from the City of Pasadena Arroyo Seco Master Plans (2003).

Special-status plant and wildlife species with the potential to occur in the watershed were identified through a search of the Department of Fish and Game California Natural Diversity Database (CNDDB) for the Pasadena U.S. Geological Survey (USGS) 7.5-minute quadrangle conducted as part of the *Arroyo Seco Watershed Assessment* (ASWA) (ASF, 2011A).

1.4.1 Ecological Regions

The Arroyo Seco watershed spans a diversity of habitat types and conditions that range from relatively undisturbed habitats within Angeles National Forest to highly degraded and fragmented habitats in urban areas of the lower watershed. The US Army Corps of Engineers (USACE) Watershed Management Study (2005) identified the vegetation communities of the upper watershed as Bigcone Spruce-Canyon Oak Forest, Southern Sycamore-Alder Riparian Woodlands, and Southern Mixed Chaparral, while the alluvial fan deposits upstream of Hahamongna Dam support ecologically significant Alluvial Sage Scrub habitat. The City of Pasadena Arroyo Seco Master Plans (2003) identify other vegetation communities that occur in the watershed: Coast Live Oak Woodland, Southern Willow Scrub, Mule Fat Scrub, Sage Scrub, Landscaped and Ruderal Vegetation. These ecological regions support a variety of wildlife species, including mammals, reptiles, fish, and amphibians.

Arroyo Seco and Riparian Woodland Habitat

1.4.2 Threatened and Endangered Species

Multiple special status species have the potential to occur in the Arroyo Seco watershed. Special status species are species that are state or federally endangered or threatened, federally delisted, California species of concern or rare. Special status species in the Arroyo Seco include mammals, plants, birds, reptiles, and amphibians. All native populations of fish that could potentially be special status species are thought to have been extirpated from the watershed. However, the California Department of Fish and Game (CDFG) and US Fish and Wildlife Service (USFWS) are actively monitoring native fish habitat and populations to determine limiting factors and recovery actions needed in the Arroyo Seco and other possible locations. The Central Arroyo stream restoration involved the introduction of 300 native arroyo chub in 2008. Arroyo chub reproduction was confirmed by Camm Swift in 2010 (Swift, 2010.

1.5 Arroyo Seco Spreading Grounds

This project, the Upper Arroyo Seco Watershed Integrated Spreading Grounds, Stream, and Habitat Enhancement Conceptual Design Project, will evaluate the feasibility of maximizing PWP's ability to capture and divert Arroyo Seco flows up to 32 cfs through improvements to sediment capture, diversion and HWP recharge facilities.

Spreading Grounds and JPL Facilities

1.5.1 Existing Spreading Basins

Currently there are 13 spreading basins that comprise the Arroyo Seco Spreading Grounds, located in HWP. The basins are used for recharging the Raymond Basin groundwater aquifer with surface water diverted from upper Arroyo Seco. Captured water is spread into basins and allowed to percolate into Raymond Basin, the underlying groundwater basin. Originally, the basins were constructed and operated by the LACDPW. PWP assumed operations of the spreading grounds in 1988.

Spreading Grounds

The spreading basins are located downstream of the Behner Water Treatment Plant (WTP) on the east side of HWP as illustrated in Figure 1-1. The basins occupy approximately 24 acres with a maximum water surface area of 13.1 acres. The total storage capacity is approximately 30 AF with an estimated percolation rate of 18 cfs or approximately 1.37 cfs per wetted acre (City of Pasadena, 2003 and PWP, 2011B).Current capacity is limited to an inflow of approximately 18 cfs as a result of reductions in the effectiveness of the intake structure and limited spreading ground capacities. The intake structure capacity has been reduced as a result of sediment buildup behind the diversion structure (PWP, 2011B).

View upstream of Arroyo Seco to Headworks Diversion Structure

The 2009 Station Fire, in the Upper Arroyo Seco watershed has degraded water quality throughout natural reaches of the drainageway including the existing PWP diversion and infiltration facilities. During rain events, sediment and debris have clogged the intake structure and upper settling basins and reduced infiltration in the HWP spreading basins as indicated in the 2010 Pasadena Water and Power Urban Water Management Plan (UWMP) (PWP, 2011A). The Upper Arroyo Seco settling basins, upstream of the diversion, are intended to reduce sediment concentrations but were quickly over-whelmed by the post-fire sediment production. PWP's diversion structure was designed to capture 25 cfs, but prior to the fire the current capacity was estimated at approximately 18 cfs. As a result of the fire, PWP is engaged in remedial actions to restore the settling basins to pre-fire conditions. .

1.5.2 Proposed Spreading Capacity Enhancement

PWP is proposing to increase the spreading ground capacity by 14 cfs for a total capacity of 32 cfs, consisting of 25 cfs PWP rights and an additional 7 cfs of Lincoln Avenue Water Company rights. The HWP Master Plan (City of Pasadena, 2003), identifies locations for three new spreading basins within the existing park that would provide some of this increase in the spreading capacity. These proposed basins will be reviewed, in light of other considerations outlined in this concept report, inclusive of naturalizing the area, as one of the potential options for the increasing spreading capacity.

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Section 2
Existing Studies

Multiple existing studies and plans have been prepared that are applicable to analyzing the optimization of the existing and proposed spreading capacity enhancement. These studies include the WIRP (PWP, 2011B), the UWMP (PWP, 2011A), ASWA (ASF, 2011A), HWPMP and addendum (City of Pasadena, 2003 and 2010), ASWRFS (ASF, 2002), and Arroyo Seco Watershed Management and Restoration Plan (ASF, 2006). Applicable goals and objectives and overall relevance of these studies and plans to the project are summarized here.

2.1 Water Integrated Resources Plan

The 2011 WIRP provides a long-term water resources strategy through 2035 to address critical water supply challenges associated with PWP's main water supply sources, local groundwater and imported water from the Metropolitan Water District (MWD). The WIRP was developed using a participatory process, with input from a dedicated stakeholder advisory committee and the public that provided input into the formulation of planning objectives and evaluation criteria metrics used to evaluate various alternatives to meet future water demands.

Applicable goals and objectives include:

- Provide a reliable a water supply
- Maintain affordability while addressing fairness and equity
- Protect and enhance source waters and the environment
- Protect cultural and recreational resources
- Maximize efficiency of water use
- Reduce risk and maximize opportunities
- Reduce energy footprint for water operations
- Ensure safe, high quality drinking water
- Ensure public safety

Approximately 50 water supply and conservation project components were initially considered in the WIRP, including expansion of the Arroyo Seco diversions and spreading capacity. The expansion of the diversions and spreading capacity was considered as part of the overall local surface water option to maximize PWP's existing water rights. After extensive evaluation, a recommended supply portfolio that increases water conservation and local water supplies was determined to be the best strategy, but does not include the subject project.

However, the WIRP recommends that the recharge potential behind Devils Gate Dam be studied further. The subject project Conceptual Design Report is intended to provide this further study.

2.2 2010 Pasadena Water and Power Urban Water Management Plan

All urban water suppliers within the State of California are required to prepare UWMPs per California Water Code Sections 10610 through 10657 at least once every five years in years ending in five and zero. For the 2010 cycle, DWR granted an extension for adoption until July 1, 2011, to incorporate additional requirements, however the UWMP is still considered as a 2010 UWMP. The UWMP requires analyses of management tools and options that will maximize resources and minimize the need to import water from other regions. PWP recently completed its UWMP in 2011. This plan includes analysis of total projected water use compared to water supply sources over the next 25 years. Water quality, as it affects water management strategies and supply reliability was also addressed. Water demand and supply information was compared for single dry year and multiple dry year scenarios. The source document for the UWMP is the aforementioned WIRP. Although optimizing the existing Arroyo Seco spreading grounds and creating additional spreading capacity is not a recommended long–term planned project in the WIRP and is not listed in the UWMP as a future project, the UWMP does recognize the need to increase local supply options through development of new projects to reduce reliance on imported water and increase the reliability of PWP's supplies.

2.3 Arroyo Seco Watershed Assessment

The Arroyo Seco Watershed Sustainability Campaign (ASWSC), developed by the ASF in partnership with stakeholders in the Council of Arroyo Seco Organizations (CASO), is a targeted program to improve the reliability and management of Arroyo Seco water resources. ASWSC provides a unifying foundation for the Council of Arroyo Seco Agencies (CASA) and the CASO, the forum for stakeholders, community and environmental organizations, businesses, and cultural institutions, through a series of programs designed to improve the reliability of local water resources and reduce the reliance on imported water. It is envisioned that he commitment of watershed agencies and organizations will be codified and implemented through an Arroyo Seco Greenway Agreement that will incorporate watershed management goals and programs (ASF, 2011B).

In 2010 the ASWA was completed for the ASF by CDM through funding provided by DWR. The purpose of the ASWA is to:

- Outline projects which address the needs of the Arroyo Seco watershed identified in this and other ASWSC documents.
- Provide a road map for future coordination and collaboration with the USACE and other agencies to implement Arroyo Seco improvement projects by way of the Arroyo Seco Greenway Agreement governance structure.
- Provide a framework for future integration of transportation, energy, water resources, and restoration concerns in the development and rehabilitation of the Arroyo Seco watershed.

The ASWA describes watershed related goals, objectives, priorities, and recommendations for top tier restoration projects, of which, this project is incorporated into one of five identified, as well as watershed-wide projects with the following themes: ecosystem restoration, multi-modal connectivity, water supply,

cultural and historical improvements, streambank stabilization, recreational opportunities and open space, land acquisition for stream stability, BMP and stormwater improvements, and energy efficiency. The ASWA will be used by watershed stakeholders, such as PWP, the City, USACE, and ASF to obtain additional funding for highly integrated projects that maximize opportunities to increase ecosystem functions and values while also improving water resource management and providing multiple benefits.

Watershed restoration goals as outlined in the ASWA and carried forward from the ASWRFS described in Section 2.5, are:

- Restore the natural hydrological functioning of the watershed
- Better manage, optimize, and conserve water resources while improving water quality
- Restore, protect, and augment habitat quality, quantity, and connectivity
- Improve recreational opportunities and enhance open space.

Based upon these goals, five top tier projects were identified. Improvements in optimization and increasing spreading capacity is included within the Arroyo Seco Channel Improvements in the HWP project. The project is based on the HWP Master Plan. Objectives of the project include:

- Improve flood water, sediment and debris storage through reestablishment of a natural alluvial channel/floodplain system
- Improve water quality due to floodplain and groundwater/surface water interactions that remove sediment and filter flows
- Restore endangered riverine and upland ecosystem communities including,
    - Riversidian Alluvial Fan Sage Scrub
    - Southern Sycamore Riparian Woodland
    - Streambed Riparian
    - Mule Fat Scrub
    - Southern Willow Scrub
    - Coast Live Oak Woodland
    - Grassland

Spreading Grounds and Alluvial Scrub Habitat

- Reestablish wildlife migration corridors through restoration of HWP native ecosystems
- Provide active and passive recreational areas that are integrated into native ecosystem habitats.

2.4 Hahamongna Watershed Park Master Plan

The City of Pasadena developed the HWPMP in 2003 and amended it in 2010 to include an additional area known as the Hahamongna Annex. The Hahamongna Annex is 30 acres of land located northwest of the existing HWP, bordering the east side of Oak Grove Drive approximately 500 feet north of Foothill Boulevard. Included within the HWPMP are improvements to expand the existing spreading grounds to optimize groundwater recharge and add new spreading grounds, consisting of three infiltration basins, on the west side of the Arroyo Seco channel. The expansion of the existing facilities is expected to add 6.7 cfs of recharge capacity and 20 AF of storage volume. New spreading basins proposed on the west side of Arroyo Seco are projected to add 7.7 cfs of recharge and 32 AF of storage.

Major themes of the plan are:

- Water and natural resources education and utilization
- The preservation of native plants and habitat
- Native American culture
- Passive and active recreation.

The plan recognizes six guiding principles for the Arroyo Seco:

1. To encourage and promote the stewardship and enjoyment of the Arroyo Seco in Pasadena.
2. To balance and integrate the interrelated issues of water resources, recreation, natural resource preservation and restoration, and flood management in the Arroyo Seco.
3. To provide a safe, secure and accessible Arroyo Seco for public enjoyment.
4. To recognize the importance to Pasadena of the history, cultural resources and unique character of the Arroyo Seco, and to conserve and enhance these assets.
5. To preserve and acquire open space in or adjacent to the Arroyo Seco.
6. To recognize that the Arroyo Seco in Pasadena is comprised of distinct geographical areas that are interconnected by a number of resources and features including, but not limited to, water, habitat, geology, recreation, and culture; and that it is part of a larger watershed.

The master plan provides recommendations for enhancing riverine, riparian and upland habitats, managing flood waters and sediment and debris deposition behind the Devils Gate Dam, conserving and augmenting PWP's water supply through recharge of the Raymond Basin Aquifer, providing passive and active recreational opportunities, and enriching and promoting unique historical and cultural opportunities.

The master plan recognizes that, "issues pertaining to flood management, water conservation, sediment deposition and removal, as well as habitat restoration, are inextricably related." Restoration-related recommendations of the adopted master plan include:

- Preserve and enhance native plants and habitat
- Develop a seasonal pool behind Devils Gate Dam that will support high quality native habitat, increase the capacity behind the dam, and to allow for inflowing sediment accumulation. This feature will consist of a "flood management pool" that can better manage inflowing sediment and floating debris and a "water conservation pool" to allow the seasonal retention of floodwater to pump back to the upstream spreading basins.
- Widen the riparian stream channel directly upstream of the flood control/water conservation pool to reestablish the braided stream course and improve and expand the streambed riparian habitat.
- Realign stream corridor, restore and establish habitat from just south of the Altadena Storm Drain outfall north to the JPL Bridge.
- Restore riversidian alluvial fan sage scrub remnants located south of the Altadena Storm Drain and the narrow mouth of the Arroyo Seco drainage as it opens into the basin.
- Establish sage scrub habitat at the spreading basin location.
- Establish riparian habitat at the perimeter of the seasonal flood management/water conservation pool.

2.5 Arroyo Seco Watershed Restoration Feasibility Study

The ASWRFS was completed in 2002 for ASF for submittal to the California Coastal Conservancy. The document was prepared by North East Trees. Work for this study was split into two phases. Phase one identified existing documentation regarding the watershed, data gaps, defined goals and objectives, and developed stakeholder support. Phase 2 focused on conducting technical studies. Recommendations from the technical studies were combined with project team recommendations to develop feasibility and planning recommendations. Applicable goals and objectives are listed in Section 2.3 as they were carried forward from the ASWRFS to the ASWA.

The ASWRFS process identified a list of over 78 projects that can be used by city, county, regional, state and federal agencies and organizations with an interest in the watershed to perform improvements and/or obtain funding. One of the identified projects applicable to this study consists of percolation and recharge in HWP. This project includes:

- Replacing proposed recharge basins with recharge in the natural streambed and floodplain.
- Designing low flow channels and constructing flow spreaders, if needed, to distribute base flows and runoff over a wide area.
- Developing a monitoring and credit program with Raymond Basin Management Board and regulatory agencies.

2.6 Arroyo Seco Watershed Management and Restoration Plan

In 2006, the ASWMRP was prepared for ASF by North East Trees for submittal to the California State Water Resources Control Board and funded by Proposition 13. Its overall purpose is to develop a plan for the Arroyo Seco watershed that manages and restores water quality and habitat for implementation by government agencies and stakeholders with an interest in the watershed. Objectives of the plan are:

- Improve water quality for beneficial uses, including protecting public health
- Restore habitat for terrestrial and aquatic species.

This plan described the HWP Habitat Restoration and BMP Implementation project, among others. This project eventually evolved into a design-build effort that included aquatic habitat restoration in the natural channel reaches above and below Brookside Park and stormwater treatment BMPs in the Brookside Park parking lots and sub-watershed wide catch basin debris capture inserts. This project used the needs of indicator species, the arroyo chub, to guide restoration as opposed to general restoration of the plant communities, that was reintroduced into the central Arroyo Seco upon project completion. Additionally, the plan states that the proposed maintenance and expansion of existing infrastructure identified in the Master Plan could potentially prevent restoration of habitat, particularly aquatic habitat and southern willow scrub habitat. The plan recommends conducting further studies to determine if the Master Plan project components, such as expansion of the spreading grounds, can be designed to preserve existing functions and simultaneously allow for greater habitat restoration.

Section 3
Existing Data

Existing data applicable to identifying and analyzing project alternatives for optimization and expansion of the spreading grounds for inclusion in the Concept Design Report are summarized in this section. Applicable data types for the geographic study area include existing and proposed facilities and infrastructure, hydrology, sediment transport, and environmental. Available data are limited in certain areas and data gaps are identified. Spreading options are available outside the study area, as defined in Section 1.2, at the Eaton Canyon spreading basins, as discussed in the WIRP, however, this area is outside the scope of this concept report.

3.1 Project Geographic Information System

Data acquired during this project has been placed in an ArcGIS-based project geographic information system (GIS). Geo-referenced data has been collected, analyzed and used to create a spatial layout of existing conditions and proposed facilities within the project site.

A data log has been developed that includes meta-data for all datasets obtained and used as a part of this project. The datalog tracks data storage locations, filenames, descriptions, and sources. Where available links to websites where data was obtained are listed. This resource allows the project team to readily refer to and locate existing data throughout the development of the concept. The current datalog, as of the date of this concept report, is provided as Appendix B.

A project basemap has been developed to illustrate the study area extent and existing conditions as presented in Figure 1-1.This map illustrates existing water related facilities, spreading ground basins, sludge ponds, pipelines, wells, the Jet Propulsion Laboratory (JPL) parking lot, major Arroyo Seco stormdrains, and Arroyo Seco flow lines all overlaid on an aerial to obtain a geographic reference. In addition to the project basemap, various other figures and maps will be developed in GIS during the analysis phase of this project. The GIS will also be used to conduct geospatial analyses of identified alternative project improvements. This GIS and associated data log will be provided to PWP upon the conclusion of this project.

3.2 Hydrology

Arroyo Seco at PWP's Headworks Facility

Surface runoff from the Upper Arroyo Seco is a water supply source for PWP. PWP owns rights to divert instantaneous runoff from Arroyo Seco up to 25 cfs. These water rights are not typically realized due to limitations of PWP's existing facilities and discounts for groundwater recharge when applying the Raymond Basin Management Board (RBMB) spreading credit methodology. As part of the WIRP process, a mass balance surface flow model was developed to simulate daily capture and overflow of surface runoff from Arroyo Seco, Eaton Wash, and urban subwatersheds in the City and La Canada Flintridge.

3.2.1 Upper Arroyo Seco Flows and Water Budget

Runoff in the Arroyo Seco is highly variable and dependent upon localized climate patterns. In wet years, such as 2004-2005, annual runoff can exceed 40,000 acre-feet per year (AFY), most of which is conveyed to the Pacific Ocean via the Los Angeles River. Conversely, in dry years such as 2003-2004, runoff is limited to less than 1,500 AFY. In addition, annual variability, runoff is highly seasonal. During the dry season, runoff can typically be an order of magnitude less than the combined PWP and Lincoln diversion rights (3.2 cfs) or even less.

Often there is not sufficient surface runoff supply to provide source water to fully utilize existing or proposed facilities. However, facilities that are not used during these drier periods provide reserve capacity for use during larger wet weather events, when surface runoff availability constraints are temporarily removed.

During wetter times additional water is available in the Arroyo Seco, beyond PWP's water rights, that currently flows to the ocean. The LACDPW Conservation Planning Section is currently considering a conservation project to capture some of this water behind Devils Gate Dam. The dam was originally constructed to provide detention of large storm events in the Arroyo Seco. However, under current operating conditions, all runoff flows through the dam with no storage. The possibility exists that groundwater recharge could occur behind the dam, and stored water would be pumped and diverted to the Eaton Canyon Spreading basins for recharge.

3.2.2 Spreading Ground Diversions and Capacities

In addition to the City's water rights from Arroyo Seco 7 cfs of water rights belonging to the Lincoln Avenue Water Company, diverted from Millard Canyon, a tributary of Arroyo Seco, are available for spreading for a total of 32 cfs. Lincoln diversions are obtained from a different diversion structure than PWP's known as the Millard Diversion Dam.

Lincoln Avenue Water Company's Millard Diversion Dam

After 1988 when PWP took over responsibility of the spreading grounds, runoff has ranged from 1,000 to 4,000 AFY. The City's diversion structure and pipeline was designed to provide sufficient capacity to capture this flow rate that can be sent to the Behner WTP or the spreading grounds. The Behner WTP was shut down and moth-balled in 1993 as the treatment process could no longer meet the Stage 2 Disinfectants and Disinfection Byproduct Rule and the Long Term 2 Enhanced Surface Water Treatment Rule. Since 1988, sedimentation behind the PWP diversion structure has degraded the capacity of the diversion facility to 18 cfs.

PWP's Diversion Pipeline

In recent years, PWP has improved operations of the spreading grounds to maximize use of the capacity, but the degradation of the diversion structure is a limiting factor in directing flow to the spreading basins. The capacity of the spreading grounds are sufficient to capture most small storms in the watershed, with overflows at the dam limited to larger storms. Over the past ten years, the difference between annual runoff volume below 25 cfs and actual spreading volume (before credits are applied) has averaged approximately 1,300 AFY.

3.2.3 Raymond Basin Recharge Credits Methodology

A 1974 modification to the Raymond Basin Judgment allows for each pumper with surface runoff diversion rights to recharge the Raymond Basin using injection wells or spreading grounds and then pump a portion of the water diverted from any well. The ability to spread surface runoff provides benefits of natural water treatment and storage of water diverted during the wet season for use in periods of higher demand. The RBMB spreading credit methodology, as revised in 2003, provides PWP and Lincoln pumping credits that are 60% of the water recharged at the existing spreading grounds with the

remainder apportioned to right holders in the Western Unit of the Raymond Basin. The recharge credit increases to 80% for recharge at Behner WTP sludge ponds or future spreading basins.

3.2.4 WIRP Surface Flow Model

As part of the WIRP process, a mass balance surface flow model was developed to simulate daily capture and overflow of surface runoff from Arroyo Seco, Eaton Wash, and urban subwatersheds in the City and La Canada Flintridge. The model accounts for surface runoff inflows (from Arroyo Seco, Eaton Wash, or urban runoff), surface storage, supply resulting from recharge within spreading basins or direct delivery (i.e. treatment plant), transfer of runoff from Arroyo Seco to Eaton spreading grounds, recharge losses within Devils Gate Reservoir, and environmental flow in downstream segments of Arroyo Seco. The model uses a hierarchal structure to facilitate simulation of surface runoff yield with a set of supply options that are arranged in order of preference. Thus, during low flows, the most preferred option may be the only one that receives any surface runoff supply.

The period of record used in the model is from 1999 to 2009. This period was selected primarily due to (1) completeness of data and (2) recent hydrologic data is more reflective of current facility practices, such as operation of the spreading basins and management of the dams. Precipitation during the 1999 to 2009 had significant variation and the period contains a broad range of flows. Overall, flow remains less than 5,000 AFY nearly 75% of the time, with most of the simulation falling in this range. The 2005 simulation year is representative of a very wet year.

Estimation of supply yield from spreading of diverted surface runoff involves a daily mass balance of diversion, storage, and recharge. If the basin capacity is expanded on the east side of Arroyo Seco to add 6.7 cfs of recharge capacity and new basins are added on the west side of Arroyo Seco to add 7.7 cfs of recharge capacity, then the additional supply yield is approximately 2,800 AFY with a pumping credit of 2,160 AFY (60% for the existing spreading basins and 80% for new spreading basins). Modeled yields are presented in Table 3-1.

Table 3-1
Supply Yield and Spreading Credit for Potential Arroyo Seco Spreading Ground Basin Projects

Supply Option	Capacity (cfs)	Supply Yield (AFY)		Spreading Credit (AFY)	
		Average (1999 - 2009)	Dry Year (2003-2004)	Average (1999 - 2009)	Dry Year (2003-2004)
New Eastside Spreading Grounds	6.7	1,641	813	1,313	650
New Westside Spreading Grounds	7.7	660	168	528	134
Existing Spreading Grounds [1]	17.6	539	139	323	83
Total	32	2,840	1,119	2,164	868

1) Water is first diverted to new spreading basins to receive maximum recharge credits (80% of amount spread). Any rights in excess of the new spreading basins are captured in existing spreading basins (60% of amount spread)

3.3 Sediment Transport

The introduction of sediment into the spreading areas can result in loss of infiltration capacity and consequently, Raymond Basin pumping credits. Therefore, it is important that Arroyo Seco water

diverted into spreading areas be as free of sediment as possible. This diverted flow will never be entirely devoid of sediment and the spreading areas will require periodic maintenance to maintain their effectiveness. The frequency of this maintenance will be a function of sediment load in the diverted water. Trapping of sediment has been recognized as an important part of the system and attempts have been made to perform this function at the upper settling ponds above the existing PWP diversion. However, these ponds can quickly reach their capacity with only a few high flow events, particularly since the 2009 Station Fire that has dramatically increased sediment production rates in the Arroyo Seco headwaters.

Arroyo Seco Downstream of Headworks Facility

The San Gabriel Mountain range is regarded to have one of the highest erosion rates in the world (McPhee, 1990) resulting in sediment loading within the upper Arroyo Seco and the need to periodically remove accumulated sediments. Depositional zones in Arroyo Seco include the Brown Mountain Dam, high in the headwaters, the settling basins, located approximately 3/4 mile upstream of the JPL parking lot bridge, the PWP diversion structure, located approximately 1/2 mile upstream of the bridge, the Lincoln diversion on Millard Canyon Creek, the Devils Gate Dam flood pool and natural channel reaches above and below Brookside Park. Several of these zones including the upper settling basins, the PWP diversion and the Lincoln diversion are almost completely filled with sediment and capture little additional amounts. Sediments are carried downstream until they are deposited in one of these zones. As a separate project, sediment removal and management from behind Devils Gate Dam is currently being planned by the LACDPW to address the large amount of sediment accumulated behind the dam. Sediment must be removed periodically to allow the dam to properly function and to capture the Design Debris Event (DDE). The DDE is defined by the LACDPW in their Hydrology and Sedimentation Manuals as the estimated amount of sediment that will be captured in the reservoir after the undeveloped portion of the watershed is completely burned and a 50-year design storm event occurs within four years of the burn event. For the dam, the DDE is approximately 2 million (M) cubic yards (cy).

3.3.1 Typical Arroyo Seco Sediment Production

Arroyo Seco sediment production data are sparse; however, some data have been found regarding sediment removal rates upstream of Devil's Gate Dam and theoretical production rates as a result of the Station Fire. Variable sediment loading in the Arroyo Seco occurs as a result of the steep slopes, periodic intense rainfall, and occasional wildfires that remove vegetation as previously described. Devil's Gate Dam creates a backwater pool during high flow events that further reduces conveyance of sediments

downstream resulting in additional sediment deposition, although much sediment and debris is evident in downstream high flows.

Historical data is available regarding the volume of sediment deposited in the reservoir, sediment removal operations, and conveyance downstream. An average of 90 acre feet of sediment is deposited in the reservoir based on a 76 year period. It is estimated that the dam removes 33% of the sediment from the upper Arroyo Seco (ASF, 2011A).

3.3.2 Station Fire Sediment Production

Sediment production in the Arroyo Seco headwaters has dramatically increased as a result of the 2009 Station Fire in which 99% or 13,376 acres of the upper watershed in the Angeles National Forest was burned (BAER, 2009). The dramatic increase is due to slopes denuded of vegetative cover that results in loss of water retention and increased runoff and erosion rates. Vegetative cover is critical in this region to stabilize soils and as a result of the fire the vegetative cover has been denuded throughout the burn area. The Arroyo Seco watershed has been classified as approximately 64% and 11% for moderate to high classes of soil burn severity, respectively, and 35% to 38% has a high to very high erosion hazard rating. Mitigation of hazards is limited as a result of slope characteristics and active hillslope processes (BAER, 2009).

First year hillslope sediment production was estimated in a 2009 study conducted by BAER. A single 2-year storm event is estimated to generate approximately 165,000 tons of sediment and a 10-year event could generate approximately 540,000 tons of sediment. The study indicated offsite impacts related to soil erosion would occur if soils were not stabilized and the additional sediment in runoff has greater erosive power than runoff without sediment. This could lead to negative impacts to facilities, decreases in water quality related to sensitive species needs and water supplies, risks to human life and property, mudslides, and debris flows (BAER, 2009).

Over the two rainy seasons since the fire approximately 1.3M cy of sediment have accumulated behind the dam. This accumulation has reduced the capacity if the dam to less than the DDE. In October, 2010 the Department of Water Resources, Division of Safety of Dams (DSOD) recommended removal of the accumulated sediment and vegetation (LACFCD, 2011).

3.3.3 Devils Gate Dam Sediment Management

Devils Gate Dam is operated to maximize flow assisted sediment transport and minimize sediment excavation. Since 1977 the lowest elevation outlet gate has remained open until water levels behind the dam reach 1,010 feet. This procedure allows maximization of storage capacity for major storm events. During large storm events when water levels exceed an elevation of 1,010 feet, the lowest elevation outlet gate is closed and the 7' x 10' slide gates in the tunnel are opened. By closing the lower gate when this condition is met, sediment deposition tends to occur farther away from the dam thereby reducing clogging at the outlet. Once the dam's pool water elevation reaches 1,040.5 feet, the gates are closed and releases occur through the spillway ports. The secondary ogee spillway has a crest elevation of 1,067 feet and is used for extreme events. Dam operations result in reduced bedload and suspended sediments in discharge waters during high flow events, but large amounts of sediment continue to be deposited downstream.

In 1994, the last major Devils Gate Dam reservoir sediment removal project occurred resulting in the excavation and disposal of 190,000 cy of sediment. In the interim two smaller removal operations have occurred with 14,000 cy removed in 2006 and 3,800 cy removed in 2009. These smaller removal

operations were limited to protect vegetation growing in the sediment. Currently, LACDPW is planning to remove 4M cy of sediment and vegetation growing in the sediment from behind the dam restoring it to its design capacity of containing 2 DDEs and develop a configuration that is more amenable to routine maintenance. Originally, the project was planned to remove 1.67M cy from the reservoir and was determined to be exempt from CEQA, but due to environmental and stakeholder concerns the LA County Board of Supervisors directed LACDPW to complete an EIR that is currently on-going. The EIR will address impacts on local environmental conditions while achieving the overall goal of sediment reduction. The revised planned sediment removal volume accounts for additional sediment loading that will occur before the project begins. The Initial Study prepared assumes sediments will be disposed at a Waste Management site in Azusa, Manning Pit Sediment Placement Site in Irwindale, and/or Scholl Canyon Landfill.

In the interim, to reduce downstream flooding risks, dam modifications to prevent stoppages in the outlet works are occurring and up to 25,000 cy of sediment are being removed per year until the EIR is approved and the project begins. Under this interim plan, 17,000 cy was removed in 2011 and placed at Johnson Field in the Hahamongna Park (see Figure 1-1 for location of Johnson Field).

A Sediment Management Task Force has been formed to further analyze sediment removal issues. Coordination between PWP, LACDPW, and other stakeholders is underway in conjunction with studies and design development analyzing sediment removal. Currently, the locations of sediment removal actions and sediment removal practices have yet to be determined. Data gaps exist in regards to how 4m cy of sediment will be removed, including sediment removal areas, and how future ongoing sediment accumulation will be managed. These data gaps may impact the design and siting of facilities needed to expand recharge capacity.

3.3.4 Hahamongna Watershed Park Flood and Sediment Management

In the *Flood Hazard, Sediment Management, Hahamongna Watershed Park, Pasadena* study (PWA, 2000) multiple recommendations applicable to sediment management are provided, including:

- Provide a reliable a water supply
- Facilities within the Watershed Park outside of the designated flood and debris inundation zones or construct to withstand inundation
- Sediment management should be limited to two areas in the park that are currently active Arroyo Seco sediment and debris inundation zones. Sediment in both areas should be excavated using a strategy that is based on maximum elevations of deposition and not a regular schedule.
- Maintain the primary function of the Devils Gate Dam to control flood volumes and peak flows to minimize downstream property damage, but analyze dam operations to maximize groundwater recharge and "flow-assisted" sediment discharge. Restore a natural Arroyo Seco riparian zone within the park, including an intermittent open water feature, through restoration of a natural flow regime. If the percolation ponds are to be maintained in the park, the ponds 12 and 13 should be eliminated and replaced with ponds to the west of the active Arroyo Channel, removing groundwater recharge facilities from the most active part of the upstream depositional area, described in the PWA report as Area 2 (see figure 3-1).Consider pumping water contained in the water feature up to the spreading ground. However, the study hesitates to recommend such a pump-back system due to its cost and location in the flood and debris inundation zones.

The analyses presented in the PWA Study indicates that careful consideration must be given to siting facilities and enhancements. The current configuration has provided flood control, reduced sediment impacts and groundwater augmentation, but at the expense of habitat and potential recreational opportunities. The PWA study concludes that an approach that integrates all functions into a coherent design rather than the current condition that includes separate facilities for each function could maximize use of the parkland to the benefit of all.

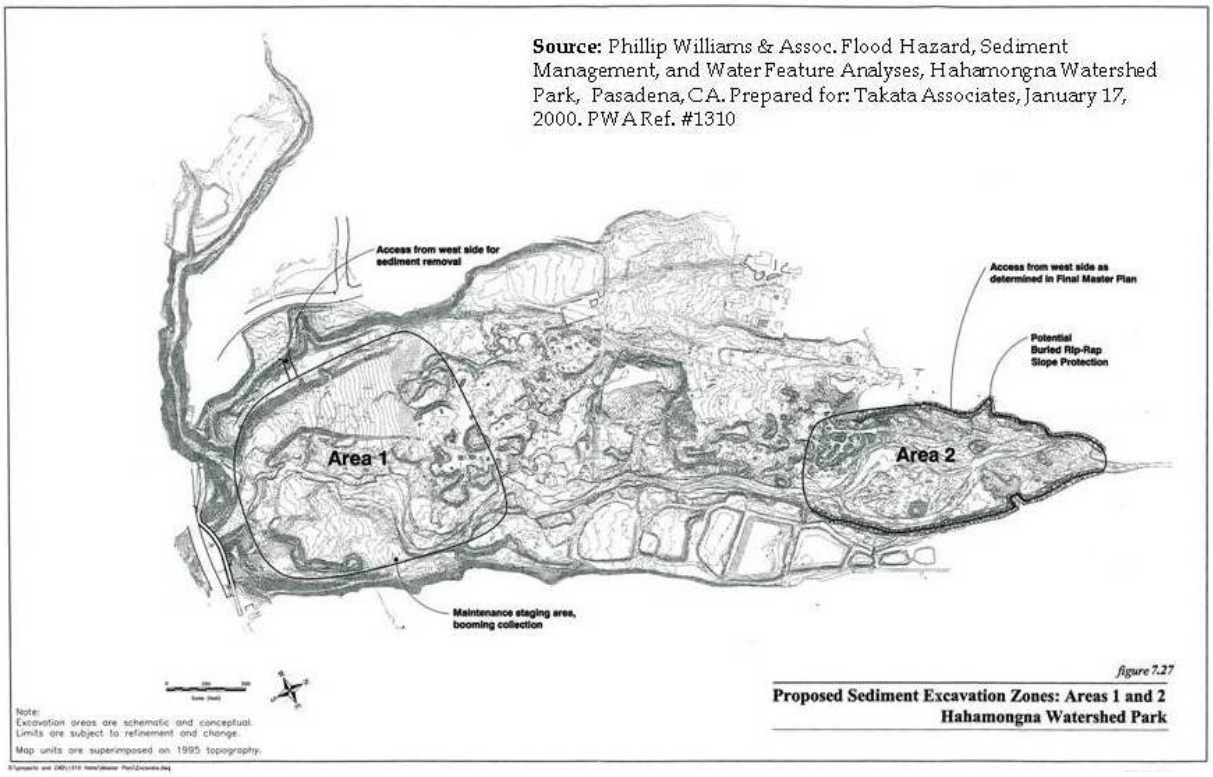

Figure 3-1 Areas 1 and 2 Sediment Deposition Zones

Further review of these recommendations should occur to determine if further recommendations are warranted in light of changes in existing conditions in response to sediment loading from the Station Fire.

3.3.5 Spreading Grounds Sediment Management

Water entering the spreading grounds is known to be relatively free of sediment. Maintenance of the spreading grounds for sediment has not been an issue in the past. No existing data was located regarding sediment management at the existing spreading grounds.

3.4 Environmental

Existing environmental data for the study area consists of wildlife, vegetation, soils, contamination, and recreational opportunities.

3.4.1 Biological Resources

Above Devils Gate Dam in the HWP and upper Arroyo Seco sub-watershed, riparian habitat is relatively undisturbed and supports a diversity of plant and wildlife species. However, portions of existing habitat

areas have been inundated with sediment in response to the Station Fire. Information on biological resources in the Arroyo Seco watershed was obtained from previous studies conducted by Northeast Trees and Verna Jigour Associates and Camm Swift as part of the *Arroyo Seco Watershed Restoration Feasibility Study* and *Arroyo Seco Watershed Management and Restoration Plan*. Information on the distribution of vegetation communities was gathered from the City of Pasadena Arroyo Seco Master Plans.

Riparian Woodland Habitat Recovering from Station Fire and Storm Events

Special-status plant and wildlife species with the potential to occur in the watershed were identified through a search of the Department of Fish and Game California Natural Diversity Database (CNDDB) for the Pasadena U.S. Geological Survey (USGS) 7.5-minute quadrangle conducted as part of the *Arroyo Seco Watershed Assessment*.

Vegetation Communities

The Arroyo Seco watershed spans a diversity of habitat types and conditions that range from relatively undisturbed habitats within Angeles National Forest to highly degraded and fragmented habitats in urban areas of the lower watershed. The USACE Watershed Management Study prepared in 2005 identified the vegetation communities of the upper watershed as Bigcone Spruce-Canyon Oak Forest, Southern Sycamore-Alder Riparian Woodlands, and Southern Mixed Chaparral, while the alluvial fan deposits upstream of Hahamongna Dam support ecologically significant Alluvial Sage Scrub habitat (USACE, 2005).

The City of Pasadena Arroyo Seco Master Plans (City of Pasadena, 2003) identify other vegetation communities that occur in the HWP: Coast Live Oak Woodland, Southern Willow Scrub, Mule Fat Scrub, Sage Scrub, and Ruderal Vegetation.

Each of the vegetation communities that have been identified within the HWP and upper Watershed are described in the paragraphs below. Figure 3-2 provides an overview of vegetation communities present in the HWP.

Bigcone Spruce-Canyon Oak Forest

Bigcone spruce–canyon oak forest is dominated big cone spruce (*Psuedotsuga macrocarpa*) with a shorter, dense sub-canopy of canyon oak (*Quercus chrysolepis*) and a very sparsely vegetated herbaceous layer. This forest type can be found between 1,000 and 8,000 feet above mean sea level (Holland, 1986).

According to a habitat assessment conducted by Jigour et al. (2001) in 2001 bigcone Douglas-fir (also known as bigcone spruce) occurs primarily in the upper riparian zones at mid-elevations of the montane watershed, particularly within the Bear Canyon forest. The more common vegetation community within the watershed is dominated by canyon oak representative of the Canyon Live Oak Forest type described by Holland (1986). Other common species in this vegetation community include California bay (*Umbellularia californica*) and bigleaf maple (*Acer macrophyllum*).

Coast Live Oak Woodland

Coast live oak woodland is typically located on north-facing slopes and shaded ravines in southern California. In HWP it occurs on the more level terrain of old terraces of alluvial fans where it integrates with southern willow scrub, mule fat scrub, and the ruderal vegetation in the central riparian corridor of the Arroyo Seco. On the drier, west-facing and south-facing sidewalls and slopes of the Arroyo Seco drainage to the east, coast live oak woodland patchily merges with sage scrub and ruderal communities. In the central Arroyo Seco, coast live oak woodland intergrades with sage scrub, southern sycamore riparian woodland, southern willow scrub, and ruderal vegetation. In the Lower Arroyo Seco, coast live oak woodland occurs in discontinuous areas on side slopes where it intergrades with sage scrub and ruderal vegetation (City of Pasadena, 2003).

Oak Woodland in Central Arroyo Seco (CDM, 2007)

This section describes the Upper Arroyo Seco Watershed Integrated Spreading Grounds, Stream, and Habitat Enhancement Conceptual Design Project alternatives development process, including alternative concepts, Proposition 84 grant funding requirements, and three preliminary alternatives which were then generated by discussion of the alternative concepts and Proposition 84 grant funding requirements. These alternatives consist of two stand alone alternatives which are feasible within the current funding vehicle, though they are unable to address all stated project objectives. The third, preferred, alternative, presents a long-term strategy capable of satisfying the stated project objectives, the first phase of which could be implemented within Proposition 84 grant funding requirements.

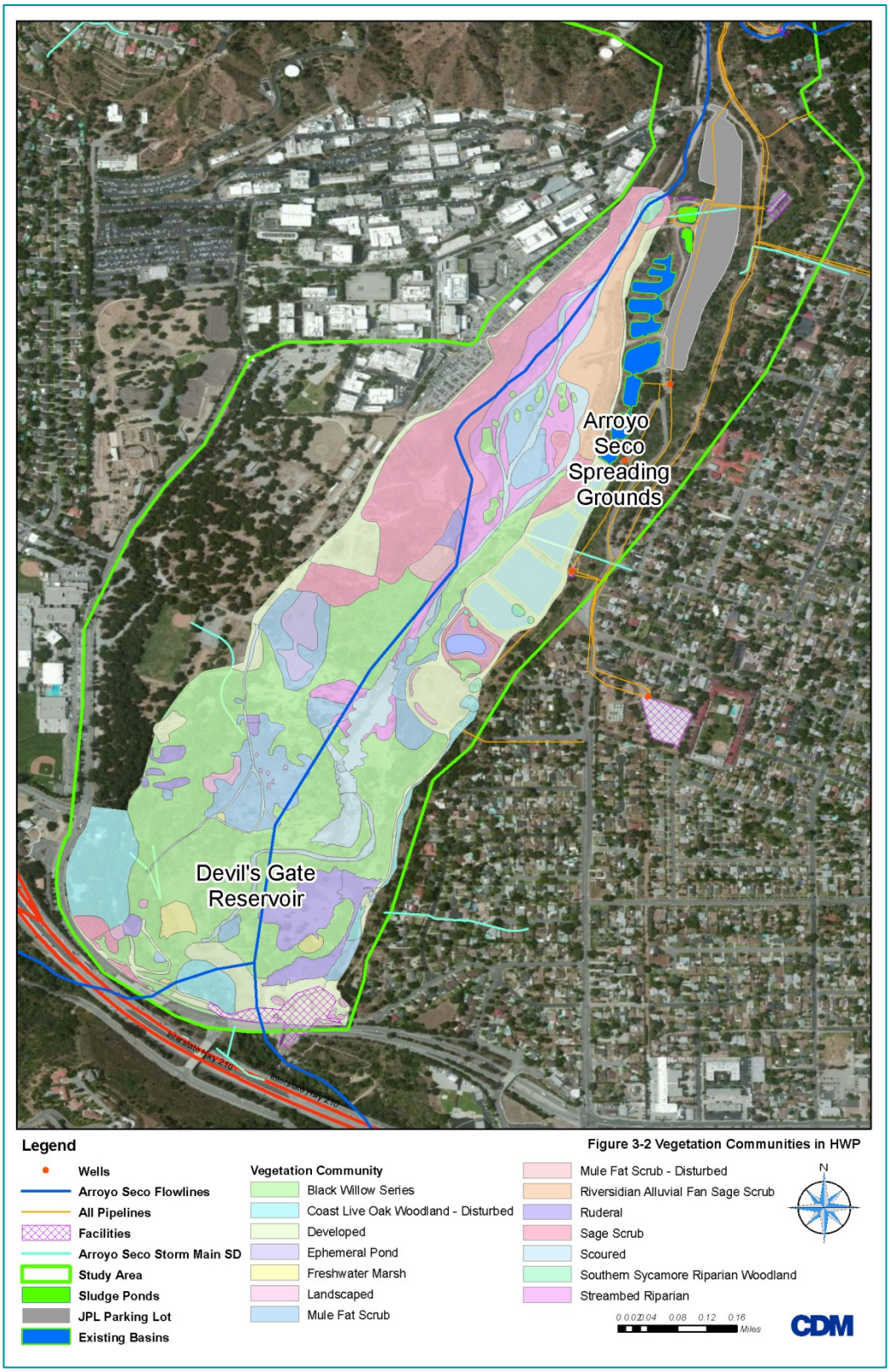

Figure 3-2 Vegetation Communities in HWP

Coast live oaks reach heights as great as 100 feet (30 meters), and the canopy may be continuous, intermittent, or open. Commonly associated shrub understory species in this plant community include black sage (*Salvia mellifera*), California blackberry (*Rubus ursinus*), California bay, California redberry (*Rhamnus californica*), California sagebrush (*Artemisia californica*), chamise (*Adenostoma fasciculatum*), laurel sumac (*Malosma laurina*), western poison oak (*Toxicodendron diversilobum*), scrub oak (*Quercus berberidifolia*), toyon (*Heteromeles arbutifolia)*, Mexican elderberry (*Sambucus mexicana*), bigleaf maple (*Acer macrophyllum*), box elder (*Acer negundo*), hairy ceanothus (*Ceanothus oliganthus*), Engelmann oak (*Quercus engelmannii*), bush monkeyflower (*Mimulus aurantiacus*), and various currant or gooseberry species (*Ribes* spp.). The herbaceous layer component is often continuous and dominated by ripgut (*Bromus diandrus*) and other introduced species such as common chickweed (*Stellaria media*) (City of Pasadena, 2003).

Southern Sycamore-Alder Riparian Woodlands

Southern sycamore-alder riparian woodland is a tall, open canopy, broadleafed, winter-deciduous streamside woodland dominated by western sycamore (*Platanus racemosa*) and often white alder (*Alnus rhombifolia*). This vegetation community typically occurs in very rocky streambeds subject to seasonal high-intensity flooding. The dominance of white alder in these woodlands increases in abundance on more perennial streams, while western sycamore favors more intermittent streams (Holland, 1986).

Within HWP, southern sycamore riparian woodland is limited to areas along the natural stream (City of Pasadena, 2003).

Southern Willow Scrub

Southern willow scrub dominates the riparian areas along the more natural reaches of the upper Arroyo Seco. In HWP, it merges with coast live oak woodland, mule fat scrub, sage scrub, and ruderal vegetation (City of Pasadena, 2003).

Riparian willows in Central Arroyo Seco (CDM

Southern willow scrub is an early seral or successional type that requires repeated flooding to prevent succession to southern cottonwood-sycamore riparian forest. This plant community is comprised of dense, broad-leaved, winter-deciduous riparian thickets dominated by several willow species including arroyo willow (*Salix lasiolepis*), black willow (*S. gooddingii*), red willow (*S. larvigata*), shining willow (*S. lucida* ssp. *lasiandra*), and narrow-leaved willow (*S. exigua*). Southern willow scrub typically occupies sites on flood plains, or in low gradient depositions along streams. Shrubs and trees in this community may reach between 33 to 100 feet in height, and the canopy may be continuous. Most stands often are so dense that the understory vegetation layer of grasses and forbs may vary from sparse to abundant (Holland, 1986).

Also associated with this riparian scrub community are scattered emergent species of Fremont cottonwood (*Populus fremontii* ssp. *Fremontii*)), black cottonwood (*P. balsamifera* ssp. *trichocarpa*), and western sycamore (*Platanus racemosa*). Other commonly associated species include mule fat (*Baccharis salicifolia*), coyote brush (*B. pilularis*), mugwort (*Artemesia douglasiana*), Mexican elderberry, and bigleaf maple (City of Pasadena, 2003).

Mule Fat Scrub

Mule fat scrub often occurs as relatively pure stands and is common in areas along the riparian stream corridor in HWP.

Mule fat scrub is an early seral community that is maintained by frequent flooding (Holland, 1986). Mule fat scrub is typically characterized by tall, herbaceous riparian scrub species dominated by *Baccharis salicifolia*. Mule fat is usually the sole or dominant shrub in the canopy, along with narrow-leaved willow, and the plants may attain heights of 13 feet. The canopy often is continuous and the ground layer of vegetation is sparse. This terrestrial natural community is located along intermittent stream channels with fairly coarse substrate and moderate depth to the water table. Habitats within this community are also seasonally flooded and the ground is saturated. Other commonly associated species in mule fat scrub include arroyo willow, narrow-leaved willow, hoary nettle (*Urtica dioica* ssp. *holosericea*), Mexican elderberry, and sedges (*Carex* spp.).

Sage Scrub

Sage scrub is found on slopes and sidewalls of the Arroyo Seco drainage in HWP. Sage scrub is a mixture of fire-adapted, sclerophyllous (hard-leaved), woody chaparral species, and drought-deciduous sage scrub species. This plant community appears to be post-fire successional and is found on dry, rocky, often steep, south-facing slopes and ridges with shallow or poorly differentiated soils (Holland, 1986). Sage scrub is very similar to mixed chaparral communities identified by USACE (2005) as being present in the Arroyo Seco watershed. Chaparral is dominated by shrubs with thick, stiff evergreen leaves that form a dense, often nearly impenetrable vegetation community with a canopy ranging from 1 to 4 meters tall (Holland, 1986).

Generally, shrubs in coastal sage-chaparral scrub are no more than six to ten feet in height, with a continuous or intermittent canopy, and sparse or absent ground layer is sparse or absent. Understory cover of forbs and grasses is often variable depending upon the fire history of a particular site. Dominant species in this terrestrial natural community include California sagebrush, California buckwheat (*Eriogonum fasciculatum* var. *foliolosum*), chamise, black sage, white sage (*Salvia apiana*), laurel sumac, lemonadeberry (*Rhus integrifolia*), sugar bush (*R. ovata*), Mexican elderberry, toyon, southern California black walnut, scrub oak, birch-leaf mountain mahogany (*Cercocarpus betuloides* var. *betuloides*), holly-leaf cherry (*Prunus ilicifolia* ssp.*ilicifolia*), hoaryleaf ceanothus (*Ceanothus crassifolius*), other ceanothus or California-lilac species (*Ceanothus* spp.), chaparral mallow (*Malacothamnus fasciculatus*), chaparral yucca (*Yucca whipplei*), bush monkeyflower, deerweed (*Lotus scoparius*), golden yarrow (*Eriophyllum confertiflorum*), poison oak, hairy yerba santa (*Eriodictyon crassifolium*), rockrose (*Helianthemum scoparium*), prickly pears (*Opuntia* spp.), bladderpod (*Isomeris arborea*), California encelia (*Encelia californica*), four-wing saltbush (*Atriplex canescens*), brome grasses (*Bromus* spp.), Brazilian pepper (*Schinus terebinthifolius*), and Peruvian pepper (*S. molle*) (City of Pasadena, 2003).

Alluvial Sage Scrub

This community is also known as Riversidian alluvial fan sage scrub and is found on alluvial fan terraces along the Arroyo Seco drainage and bordering the western edges of most of the spreading basins in HWP. The existing spreading basins are largely situated upon what were originally Riversidian alluvial fan sage scrub habitats. This community developed from the flow of water and sediment deposition during flooding as the Arroyo Seco stream emptied into the HWP flood basin from the narrow canyon mouth of the Arroyo Seco north of the JPL Bridge. Today, only remnants of this community remain in HWP. Historically, without the presence of the dam, alluvial fan terraces would have spread across most of the

terrain that is now parkland, and gradually merged with upland areas covered with coast live oak woodland or coastal sage-chaparral scrub (City of Pasadena, 2003).

Holland (1986) states that this terrestrial natural community is very xeric (dry) with coarse soils and some finer soils that are slow to release stored moisture. Shrubs in this vegetation type are generally low in height at five feet (one and one-half meters) and adapted to nutrient poor soils. Drought-deciduous, soft-leaved shrubs typically predominate, but evergreen shrubs, riparian species, and upland annual plants may all be present. Scalebroom (*Lepidospartum squamatum*) is considered an indicator species for this vegetation type.

Landscaped Vegetation

Landscaped vegetation dominates much of the vegetated areas of the central and lower Arroyo Seco and is largely composed of cultivated ornamental, horticultural plants that may be native or nonnative tree, shrub, forb, and grass species. Landscaped plant species are usually aesthetically appealing and require irrigation and management. In the Arroyo Seco, landscaped vegetation occurs near buildings, roads, parking areas, walls, and developed parklands. Representative landscape plants include species of eucalyptus, pine, oak, acacia, fig, olive, pittosporum, cherry, pepper tree, maple, liquidambar, ash, juniper, cypress, pyracantha, walnut, hibiscus, oleander, privet, redwood, elm, palm, coral tree, periwinkle, lantana, ivy, plumbago, poplar, tree of heaven, agave, and many others (City of Pasadena, 2003).

Ruderal Vegetation

Ruderal (or weedy) vegetation dominates parts of HWP in the terrace areas and along the boundaries on side slopes and near bases of the side slopes. Ruderal vegetation also occurs within developed and landscaped areas. Ruderal (or weedy) vegetation is typically associated with site disturbance conditions such as grading, clearing, burning, and even flooding, and may occur on fine-textured, usually clay soils that are moist or waterlogged during the winter rainy season and become very dry during the summer and fall. Sites favored by this plant community are found on gentle slopes or on more level terrain where finer soil particles have a chance to collect favoring the growth of annual species of grasses and showy-flowered forbs or wildflowers. Areas with frequent, repeat occurrences of fire or other disturbances tend to lose the dominant shrub community and allow ruderal vegetation that includes very aggressive nonnative species to become established and persist (City of Pasadena, 2003).

Nonnative, introduced, annual grass and forb species tend to dominate the understory and some forbs may reach heights as great as three feet (one meter) depending on the amount of rainfall received. They germinate with late fall and winter rains; and grow, flower, and set seed during the winter through spring months. With a few exceptions, these weedy plant species are dead but persist as seeds through the summer and fall dry seasons (Holland, 1986). Shrub and tree species are usually absent or are very sparse, and the ground layer of vegetation is continuous or open. The eradication of ruderal vegetation species is difficult to achieve since it is composed of introduced, invasive, and very aggressive species such as annual grasses and forbs.

Commonly observed species in ruderal vegetation and/or nonnative grassland community include slender wild oats, common wild oats, ripgut, red brome (*Bromus madritensis* ssp. *rubens*), soft chess (*B. hordeaceus*), black mustard (*Brassica nigra*), turnip or field mustard (*B. rapa*), shortpod mustard (*Hirschfeldia incana*), red-stem filaree (*Erodium cicutarium*), filaree (*E. botrys*), California poppy (*Eschscholzia californica*), gilias (*Gilia* spp.), tarweed (*Hemizonia fasciculata*), Italian ryegrass (*Lolium multiflorum*), lupines (*Lupinus* spp.), peppergrass (*Lepidium nitidum*), burclover (*Medicago polymorpha*),

phacelias (*Phacelia* spp.), Mediterranean grass (*Schismus barbatus*), star-thistles (*Centaurea* spp.), and vulpias or annual fescues (*Vulpia* spp.) (City of Pasadena, 2003).

Special-Status Plant Species

Special-status plants that have potential to occur in the Arroyo Seco watershed include Parish's gooseberry (*Ribes divaricatum* var. *parishii*), Plummer's mariposa lily (*Calochortus plummerae*), and Nevin's barberry (*Berberis nevinii*) (CNDDB, 2010). Table 3-2 identifies special-status plant species with the potential to occur, based on a CNDDB search of the Pasadena USGS 7.5-minute quadrangle in 2010. The CNDDB considers historical sightings as evidence that species still exist. However, the majority of the observations of special-status plant species are based on historical sightings dating back to as early as 1917. Given the highly developed and degraded nature of the habitat, particularly within the central and lower Arroyo Seco watershed, many of these species are not expected to currently occur within the watershed.

Wildlife

The Arroyo Seco supports as many as 180 species of birds that utilize the variety of habitats as described on the ASF website. Common birds that occur in oak woodlands include the acorn woodpecker (*Melanerpes formicivorus*) and oak titmouse (*Baeolophus inornatus*). Shrub and grassland habitats along the Arroyo Seco support birds including spotted towhee (*Pipilo maculatus*), Bewick's wren (*Thryomanes bewickii*), Western scrub jay (*Aphelocoma californica*), California thrasher (*Toxostoma redivivum*), and California quail (*Callipepla californica*). Riparian specialists, including the yellow warbler (*Dedroica petechia*), common yellowthroat (*Geothlypis trichas*), and red-shouldered hawk (*Buteo lineatus*) also occur in the watershed, as do aquatic birds including mallard American coot (*Fulica americana*) and green heron (*Butorides virescens*).

Green heron in Central Arroyo Seco (CDM 2007)

Riparian areas support other wildlife species including arboreal salamander (*Aneides lugubris*) and Pacific tree frog (*Pseudacris regilla)*. Other common wildlife species inhabiting chaparral and scrub communities in the watershed include California ground squirrel (*Spermophilus beecheyi*) and Western fence lizard (*Sceloporus occidentalis*).

The upper Arroyo Seco watershed also supports large mammals including coyote (*Canis latrans*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), mule deer (*Odocoileus hemionus*), and mountain lion (*Puma concolor*). Wildlife in the upper Arroyo Seco also includes those adapted to living in urbanized environments and include the coyote, striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), and eastern fox squirrel (*Sciurus niger).*

Special-Status Wildlife Species

Historic populations of native fish that occurred in the Arroyo Seco and greater Los Angeles River have largely been extirpated. These species include the unarmored threespine stickleback (*Gasterosteus*

aculeatus williamsoni), a state and federally listed endangered species that is thought to have been extirpated from the watershed in the 1940's. Native rainbow trout (*Oncorhynchus mykiss*) may still occur, although there may be substantial introgression with stocked rainbow trout of different strains as described by John O'Brien of the California Department of Fish and Game (CDFG). However, any project components that reduce or eliminate barriers to fish passage should be incorporated in the overall concept.

The southern steelhead (*Oncorhynchus mykiss irideus*) is a federally endangered, anadromous form of the rainbow trout that once inhabited the Arroyo Seco.

Arroyo chub (CDM, 2007)

Other native fish species that once inhabited the Arroyo Seco include pacific lamprey(*Lampetra tridenta*), pacific brook lamprey (*Lampetra pacifica*), Santa Ana sucker (*Catostomussantaanae*), Santa Ana speckled dace (*Rhinichthys osculus*), and arroyo chub (*Gila orcutti*). Surveys conducted by Camm Swift in 2001 found no native fish species in the Arroyo Seco (Amec, 2001). Native species such as the arroyo chub and southern steelhead have not been collected in the Arroyo Seco since flood control projects channelized portions of the stream in the 1940's. Recent restoration efforts have included creation of habitat for the arroyo chub in the central Arroyo Seco. Three hundred individual arroyo chub were released into these restored areas in 2008 following completion of the Central Arroyo Seco/Brookside Park BMP Project. Juvenile arroyo chub were identified in a backwater pool in the lower Arroyo Seco restoration area—evidence that the arroyo chub were reproducing and rearing.

The southwestern pond turtle (*Clemmys marmorata pallida*), a California Species of Special Concern, historically inhabited the Arroyo Seco. Suitable habitat for the pond turtle, consisting of pools of perennial, slower moving streams, may exist in tributaries in the upper watershed. Critical habitat for the federally endangered southwestern arroyo toad (*Bufo microscaphus californicus*) was designated in a six mile reach of the Arroyo Seco extending from Hahamongna reservoir to Long Canyon in 2001; however, this listing was subsequently removed as verified with Stacy Love of CDFG(Personal communication with Stacey Love, CDFG).

Other special-status species that may occur in the Arroyo Seco watershed include the coast horned lizard (*Phrynosoma coronatum blainvillei*), which inhabits native alluvial fan scrub, coastal sage scrub, and chaparral. Table 3-2 lists the special-status wildlife species with the potential to occur in the watershed based on a CNDDB search of the Pasadena USGS 7.5-minute quadrangle in 2010.

Table 3-2 Special-Status Species with Potential to Occur in the Arroyo Seco Watershed

Common Name	Scientific Name	Status	General Habitat
Plants			
Round-leaved filaree	*California macrophylla*	1B.1	Woodlands and grasslands
Plummer's mariposa-lily	*Calochortus plummerae*	1B.2	Woodlands, scrub, and grasslands
Southern tarplant	*Centromadia parryi ssp. Australis*	1B.1	Marshes and grasslands
Parry's spineflower	*Chorizanthe parryi var. parryi*	1B.1	Sage scrub
Slender-horned spineflower	*Dodecahema leptoceras*	FE/SE/1B.1	Sage scrub and alluvial fan sage scrub
Los Angeles sunflower	*Helianthus nuttallii ssp. Parishii*	1A	Marshes (historical)
Mesa horkelia	*Horkelia cuneata ssp. Puberula*	1B.1	Sage scrub
Orcutt's linanthus	*Linanthus orcuttii*	1B.3	Woodlands and sage scrub
White rabbit-tobacco	*Pseudognaphalium leucocephalum*	2.2	Woodlands and sage scrub
Parish's gooseberry	*Ribes divaricatum var. parishii*	1A	Riparian woodlands
Greata's aster	*Symphyotrichum greatae*	1B.3	Woodlands and sage scrub
Birds			
Western burrowing owl	*Athene cunicularia hypugea*	CSC	Grasslands and open scrub
Southwestern willow flycatcher	*Empidonax traillii extimus*	FE/SE	Riparian woodlands
American peregrine falcon	*Falco peregrinus anatum*	FD	Near wetlands, lakes, rivers, or other water. On cliffs and human-made structures
Amphibians			
Sierra Madre yellow-legged frog	*Rana muscosa*	FE/CSC	Near water
Coast Range newt	*Taricha torosa torosa*	CSC	Slow moving streams and reservoirs
Reptiles			
Western pond turtle	*Actinemys marmorata*	CSC	Requires permanent water with aquatic vegetation
Coast horned lizard	*Phrynosoma blainvillii*	CSC	Sandy shrublands and sage scrub

Table 3-2 Special-Status Species with Potential to Occur in the Arroyo Seco Watershed

Common Name	Scientific Name	Status	General Habitat
Mammals			
Pallid bat	*Antrozous pallidus*	CSC	Woodlands, grasslands, shrublands with open rocky areas
Western mastiff bat	*Eumops perotis californicus*	CSC	Woodlands, grasslands, scrub
Silver-haired bat	*Lasionycteris noctivagans*	None	Woodlands near water
Hoary bat	*Lasiurus cinereus*	None	Open woodland edges
Western yellow bat	*Lasiurus xanthinus*	CSC	Riparian woodlands
Southern grasshopper mouse	*Onychomys torridus Ramona*	CSC	Shrublands
American badger	*Taxidea taxus*	CSC	Shrublands

Notes:

- 1A = Presumed Extinct in California (California Native Plant Society, CNPS)
- 1B = Endangered, Threatened or Rare in California (CNPS)
- 2.2 = Endangered, Threatened or Rare in California but more common elsewhere (CNPS)
- CSC = California Species of Concern (California Department of Fish and Game, CDFG)
- FD = Federally Delisted (U.S. Fish and Wildlife Service, USFWS)
- FE = Federally Endangered (USFWS)
- FT = Federally Threatened (USFWS)
- SE = State Endangered (CDFG)
- ST = State Threatened (CDFG)

The CNDDB includes species presumed extant (still in existence) based on historical sightings until evidence is provided to the contrary (CNDDB, 2010). Given the highly developed and degraded nature of the habitat, particularly within the central and lower Arroyo Seco watershed, many of these species are not expected to occur.

In addition to the species shown in Table 3-2, four other sensitive animal species, coastal western whiptail (*Cnemidophorus tigris multiscutatus*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*A. cooperii*), and loggerhead shrike (*Lanius ludovicianus*) have been observed during biological surveys at HWP but do not appear on the CNDDB list (City of Pasadena, 2003).

Impacts of the Station Fire in the Upper Arroyo Seco Watershed

The Station Fire occurred from August until October 2009 and burned over 160,000 acres (251 square miles) of the San Gabriel Mountains, including the upper Arroyo Seco Watershed.

The U.S. Forest Service (USFS) has established a Station Fire Recovery Area which encompasses nearly 300,000 acres of the Angeles National Forest. The Recovery Area is closed to the public until September 30, 2010. Based on hydrophobic soils, steep terrain and the extent of burn damage to the vegetative cover, USFS determined there was a high potential for significant debris flows in drainages within and downstream of burned areas.

Debris flows and sedimentation within aquatic habitats due to the Station Fire could have significant impacts to water quality, water temperature, riparian and aquatic vegetation and streambed/pool habitat. Thus, populations of aquatic species, including sensitive species, could be locally extirpated. In addition, non-native aquatic species may spread into previously unoccupied habitats (USFS, 2009).

Due to the slow recovery of native vegetation after the fire, there is increased risk from invasive weed introduction and population expansion. Areas of ground disturbance from the presence of equipment and crews during fire suppression operations created a risk of invasive weed introduction, establishment and proliferation. Proliferation of non-native vegetation could affect the structure and function of native plant communities, soil stability, and native wildlife habitat within the upper Arroyo Seco sub-watershed (USFS, 2009).

For both wildlife and vegetation, there is also concern that until enough vegetative recovery has occurred to deter illegal off-road vehicle travel, habitat degradation will continue. Increased access and visibility due to lack of vegetative cover will result in habitat degradation, disturbance of species, and increased risk of collection for some species, including turtles and fish (USFS, 2009).

Aquatic and Riparian Habitat

Aquatic and riparian habitat degradation has occurred in the Arroyo Seco due to alteration of natural stream hydrology and sediment transport in the watershed, primarily due to Devils Gate Dam and channelization of the lower sections of the watershed. Urbanization and development of the watershed has resulted in removal of riparian and upland vegetation and impairment of water quality. Non-native and invasive plant species have significantly impacted wildlife and plant diversity.

Aquatic vegetation does occur within the streambed in areas that are not regularly disturbed by annual flooding or scour and deposition from seasonal rainfall runoff. Examples of streambed vegetation may include dominant or less abundant plant species found in southern willow scrub, riversidian alluvial fan sage scrub, mule fat scrub, and southern sycamore riparian woodland. Other species examples may include sedges (*Carex* spp.), rushes (*Juncus* spp.), cattails (*Typha* spp.), spikerushes (*Eleocharis* spp.),

bulrushes (*Scripus* spp.), willow weed (*Polygonum lapathifolium*), and willow herbs (*Epilobium* spp.) (City of Pasadena, 2003).

Wildlife Corridors and Significant Ecological Areas

The Arroyo Seco is a potential corridor for wildlife passage, which could connect the San Gabriel Mountains to large habitat patches including the San Rafael Open Space in the central Arroyo and the Monterey Hills, Montecito Hills, Debs Park, and Elysian Park in the southwest. However, several major barriers to aquatic and terrestrial habitat connectivity exist between the upper and lower watershed, most notably the Devils Gate Dam and the 210 freeway. Along with Devils Gate Dam, the Brown Canyon Debris Dam in the upper watershed acts as a second major barrier to aquatic habitat connectivity.

The Los Angeles County General Plan (http://planning.lacounty.gov/sea/faqs) designated several Significant Ecological Areas (SEAs) defined as "ecologically important or fragile land and water areas, valuable as plant and animal communities" and classified as one or more of the following: 1) habitats for rare and endangered species of plants and animals; 2) restricted natural communities - ecological areas which are scarce on a regional basis; 3) habitat restricted in distribution in the county; 4) breeding or nesting grounds; 5) unusual biotic communities; 6) sites with critical wildlife and fish value; and 7) relatively undisturbed habitat (County of Los Angeles, 1993).

SEAs have been identified for both the City and County of Los Angeles, and both types of SEA are shown as map layers on the City of Los Angeles Bureau of Engineering, Department of Public Works Navigate L.A. website (City of Los Angeles, 2010). According to the Navigate L.A. database, a portion of the upper Arroyo Seco watershed in the Angeles National Forest is located within a City SEA, and several County SEAs, including the Verdugo Mountains and Tujunga Valley/Hansen Dam are located nearby.

While development within a SEA is not prohibited, the General Plan does require development to be limited and controlled in order to avoid impacting valuable biological resources. Public and semi-public uses essential to the maintenance of public health, safety and welfare would be permitted within an SEA only "where no alternative site or alignment is feasible" (County of Los Angeles, 1993). Further, an extensive analysis of biological impacts would be required for projects located within an SEA.

Wetlands

Wetlands occur in the Arroyo Seco watershed where hydric soils, saturation or inundation, and wetland vegetation criteria are met. These wetlands occur along stream reaches in riparian vegetation communities, including southern willow scrub and mule fat scrub, which support riparian as well as some wetland indicator species that may also be found in wetland habitats (City of Pasadena, 2003). Species including black, red, and narrow-leaved willows are obligate wetland species (those that occur only in wetlands). Thus, areas where these species are found in the Arroyo Seco watershed are likely to be classified as wetlands.

The USACE Watershed Management Study (2005) identified the following opportunities for ecosystem restoration in the watershed:

- Develop a plan to link existing habitat fragments along the Arroyo Seco and tributaries to preserve the integrity of natural communities/ecosystems and provide a wildlife corridor.
- Improve habitat for multiple species including steelhead trout and arroyo toad.
- Implement best management practices (BMPs) throughout the watershed.

- Create wetlands using existing water sources following the example of the Browning Ferris Industries (BFI) Low Flow Diversion Project.
- Identify methods to preserve and manage Flint Canyon, which could provide a connection between Verdugo Hills and the San Gabriel Mountains.
- Develop a basin-wide sediment management plan to protect and improve the health of the watershed and its ecosystems, focusing on the functionality of crib structures and operation of Devils Gate Dam including the hydrologic flows, geomorphology, sedimentation, and potential areas of stream and floodplain restoration.
- Identify restoration areas for sediment erosion control that will provide opportunities for restoration of impacted native plant and wildlife species.
- Investigate the potential for expanding existing floodways to allow creation of wildlife habitat along both the natural and improved channels.

Yellow warbler (iStockphoto)

All project alternatives should consider restoration for indicator species in the watershed as listed in Table 3-3. Species types included umbrella species that have habitat area and quality requirements that encapsulate the needs of an array of other species; flagship species that are charismatic species that can attract the attention and imagination of the general public, and Indicator species. Three types of indicator species were included: ecosystem health indicator species, those that are sensitive to and indicative of anthropogenic (human-caused) disturbances to ecological functions; population health indicator species, those that are predator species whose own population health provides a measure of the health of their assemblage of prey species and a multitude of associated ecological relationships, and keystone species, those that exert disproportionately large influences on the ecosystem relative to their abundance and loss of these species can lead to unraveling of the ecological fabric (Jigour et al., 2001).

Table 3-3: Focal Species for the Arroyo Seco Restoration Project

Common Name	Type of Species	Comments
Steelhead	Flagship/Umbrella	Encompasses requirements for Pacific lamprey
Unarmored threespine stickleback	Umbrella	Encompasses requirements for Arroyo chub, Santa Ana sucker and Santa Ana speckled dace
Arroyo toad	Ecosystem Health Indicator	Indicator of "fluctuating hydrological, geological, and ecological processes operating in riparian ecosystems and adjacent uplands" (USFWS 1999)
Southwestern pond turtle	Ecosystem Health Indicator	Indicator for upper watershed tributaries
Yellow warbler	Umbrella	High quality riparian habitat, shaped by natural fluvial processes
Arboreal salamander	Umbrella	High quality oak, walnut and sycamore woodland habitats, including connectivity to riparian areas
Oak titmouse	Umbrella	Woodlands that may be somewhat fragmented, but still offer significant habitat value for species less effected by loss of terrestrial connectivity
Coast horned lizard	Ecosystem Health Indicator	Indicator for certain aspects of alluvial fan and coastal sage scrubs
Lesser nighthawk	Umbrella	Certain aspects of alluvial fan sage scrub, especially area requirements
Plummer's Mariposa Lily	Ecosystem Health Indicator/Flagship	Alluvial fan sage scrub and chaparral
Cactus wren	Flagship	Alluvial fan and coastal sage scrub – stands of *Opuntia* species
Greater roadrunner	Flagship	Coastal and alluvial fan sage scrub and grassland habitat connectivity
California gnatcatcher	Umbrella	Restoration of coastal sage scrub quantity, quality and habitat connectivity
Grasshopper sparrow	Umbrella	Grassland habitats
California quail	Flagship	Upland habitat connectivity
Bobcat	Population Health Indicator/Umbrella	Viability of prey species and their ecological relationships; landscape-scale connectivity and may serve some of the functions of Mountain Lions, the likely Keystone species, which is essentially excluded from the urbanized portions of the watershed
Gray fox	Population Health Indicator	Viability of prey species and their ecological relationships, as well as indicator of habitat connectivity at possibly finer scales than Bobcat

3.4.2 Soils

The study area bedrock consists of a sequence of thick Tertiary age sedimentary rocks overlying crystalline basement rocks. These rocks are represented in the study area by the Wilson Diorite and Topanga Formation. Wilson Diorite is described as a crystalline granitic basement formation containing slightly foliated diorite. The Topanga Formation contains multiple layers that alternate between

conglomerate, sandstone, and breccia. This bedrock is exposed in areas around the dam and JPL (City of Pasadena, 2002).

Alluvial deposits overlay bedrock. Quarternary older dissected alluvium, based on Dibble, is present. This alluvium is composed of interbedded sands and gravelly sands, inclusive of localized silt layers and clay with a depth of 30 feet or more in some areas. The deposits are characterized as medium dense to very dense, with a brown to reddish brown color, massive to weakly/crudely stratified, and dry to damp (City of Pasadena, 2002).

In most of the study area younger Quaternary (Holocene) alluvial stream deposits overlay older dissected alluvium and bedrock. The deposits consist primarily of sand, gravel, and silt. Other components include cobbles and boulders. If the deposits are saturated below the surface they are susceptible to liquefaction (City of Pasadena, 2002).

Over the years, soils in the HWP have been highly disturbed as a result of sediment removal and construction of the dam. In some areas fill may be present, but is only mapped where significant quantities exist such as at the Woodbury/Oak Grove Road crossing at the dam. However, there may be undisturbed true soil deposits in the study area. Available reports and maps reviewed for the Arroyo Seco Master Plan EIR (City of Pasadena, 2002) suggest that most superficial alluvial material Tujunga stoney loam and Riverwash stoney coarse sand predominately composed of gravel, sand, and silt. Characteristics include high permeabilities, low expansion coefficients, low to moderate compressibility, low to moderate densities, and slight corrosivity to steel and concrete. The soils are suggestive of stable geologic conditions (City of Pasadena, 2002).

The HWPMP suggested expanding the existing spreading basins and developing additional spreading basins on the west side (City of Pasadena, 2003). Soils in these areas consist of stream channel deposits (City of Pasadena, 2002). Design of any additional spreading grounds or expansion of spreading grounds should take into consideration embankment characteristics, seismic stability of slopes, sedimentation foundation adequacy, and liquefaction effects on performance.

3.4.3 Contamination

JPL, located adjacent to the northwest portion of the study area, has been identified as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site and listed on the National Priority List (Superfund) since 1992. Historically, multiple chemicals and chemical waste materials were used and/or disposed at the site, including solvents, solid and liquid rocket propellants, and laboratory wastes. During the 1940's and 1950's buildings at JPL had seepage pits used to dispose of solid and liquid wastes used in the buildings. These pits allowed disposed materials to seep into the soil. In 1990 a remedial soil and groundwater investigation conducted by the California Environmental Protection Agency indicated volatile organic

JPL Parking Lot, Spreading Grounds, and JPL Facilities

compounds were present in the soil and groundwater at the site. Levels were in exceedance of federal and state drinking water standards at depths up to 250 feet below the ground service (City of Pasadena, 2002).

As of 2002 the VOC plume extended beneath 45 acres of the JPL site ranging from 50 to 200 feet, at the water table level, below the ground surface The contaminant plume has extended offsite in a south, southeasterly direction and has impacted PWP and Lincoln Avenue Water Company Wells (NASA, 2011). Quarterly groundwater monitoring began in 1996.

Groundwater monitoring has since identified additional contaminants above state and federal limits including carbon tetrachloride, trichloroethene (TCE), Perchloroethene (PCE), perchlorate, 1,2 DCA, 1,4-Dioxane, total chromium, hexavalent chromium, and lead. Monitoring results from 2001 indicated that TCE, PCE, and perchlorate are the only contaminants remaining in excess of regulatory standards (City of Pasadena, 2002).

NASA has constructed three groundwater treatment plants to address contaminants in groundwater. In 1992 NASA constructed a groundwater treatment facility in Altadena to treat water from 2 VOC impacted wells operated by Lincoln Avenue Water Company. The facility was expanded in 2004 to include a 2,000 gallon per minute (gpm) perchlorate treatment facility constructed by NASA and operated by Lincoln Avenue Water Company. In 2005 an onsite 300 gpm treatment facility became operational. The third facility went online in 2011 to remove perchlorate and VOCs from four PWP operated groundwater wells located in the Monk Hill area (NASA, 2011).

JPL also has 19 underground storage tanks (USTs) in addition to two previous leaking underground storage tanks that closed in 1990 and 1995. Testing results have indicated that these gasoline and diesel tanks leaked hydrocarbons into the surrounding soils, but leaks were confined to the soil and have not impacted groundwater quality.

Multiple reports have been prepared relating to the JPL contaminant plume. In particular, two recent reports have been recently prepared. One report was prepared by Geoscience Support Service, Inc., for the City of Pasadena, *NASA/JPL Perchlorate Contamination of Ground Water in the Raymond Basin* (City of Pasadena, 2009) and another report prepared by NASA for the California Department of Public Health, *CDPH Policy Memorandum 97-005 Documentation of Raymond Basin, Monkhill Subarea* (NASA).

Other potential sources of contamination in the HWP include three septic tanks associated with restrooms located at the Equestrian Staging Area, and restroom and maintenance structures constructed in the 1950s. These structures may have used lead based paint and asbestos containing materials (City of Pasadena, 2002).

The EIR prepared for the HWP describes that any construction activities associated with increasing spreading capacity may potentially expose contaminated materials if it involves excavation below elevation 1040.5 feet above mean sea level (City of Pasadena, 2002). This project will need to consider this constraint during the design process.

3.5 Cultural/Recreation

Existing and potential locations for increasing spreading capacity,, settling basins, and diversion structures or may be located in areas that include, cultural/historical/archeological features and recreational facilities and activities. Any proposed improvements must take into account impacts to these features, facilities and activities.

3.5.1 Cultural

Existing data indicate paleontological resources are likely to be encountered in the HWP area. However, the existing debris area behind the dam is underlain by recent alluvium that has a low sensitivity for paleontological resources (City of Pasadena, 2002).

Within the project vicinity, three historic resources have been identified. Both the Space Flight Operations facility and the 25-foot Space Simulator at JPL are listed on the National Register of Historic Places and Devils Gate Dam is a locally determined historic resource and eligible for National and California Registers of Historic Resources (City of Pasadena, 2002).

Research has indicated than no known archaeological sites are present in the HWP, however, a comprehensive Phase 1 archaeological investigation has not been conducted according to records for the area. The area behind the dam was significantly altered and disturbed during construction. As a result areas below elevation 1040.5 have a low potential to contain archaeological resources. However, undisturbed native soils and hillsides contain archaeological resources (City of Pasadena, 2002)

3.5.2 Recreation

Development of conceptual alternatives to increase spreading must take into consideration existing and planned recreational opportunities. HWP currently provides a multitude of active and passive recreational opportunities. The lower eastern portion of the park contains Johnson Field for recreational sports, group picnics, and activities. The western portion contains Hahamongna Park that includes picnic facilities, restrooms, maintenance buildings, equestrian staging, multi-purpose athletic fields, interpretive elements, a disc golf course, and trails connecting the area to regional and local trails. Trails include the Gabrielino Trail, Arroyo Seco Trail, Equestrian Trails, Inc., Corral 2 Trail, and Flint Wash Trail. Proposed facilities identified in the HWMP include additional parking, roads, athletic fields, restrooms, open play areas, and picnic areas (City of Pasadena, 2002 and 2003).

Currently, the City is developing a proposal to build a multi-purpose athletic field area and parking lot in the just east of the existing Oak Grove field area. The field area is proposed to be constructed on fill approximately 23 feet above the streambed to prevent flooding.

3.6 Data Gaps

A review of existing data indicated multiple data gaps are apparent. Data gaps identified include:

- Detailed management of sediment at spreading grounds, including quantities and frequency of cleanout
- Comprehensive sediment transport data for the Arroyo Seco
- Detailed studies associated with current and planned Sediment Task Force efforts, including development of a sediment management plan
- Current topographic survey of study area
- Geotechnical data adequate for new facilities design
- Stream gauge monitoring to inform design flows
- Evaluation of potential new facilities and increased spreading relative to existing contamination

- Biological survey and assessment to inform targeted habitat improvements
- Defining potential additional recreational opportunities and linkages to other existing/planned improvements associated with concurrent project planning/implementation in the vicinity
- Percolation studies of potential new spreading ground areas.
- Consultations with resource/permitting agencies to determine specific habitat and species needs

Ultimately, completion of these data gaps will assist with the pre-design and final design stages once a selected project alternative is developed.

Section 4
Identification of Opportunities and Constraints

Based on the information provided by PWP and this detailed review of existing conditions, we have identified opportunities and constraints associated with the project that are described in this section.

Opportunities include the following:

- Improve flood water, sediment and debris storage through reestablishment of a more natural alluvial channel/floodplain system
- Relocate or improve the existing County and PWP diversion structures .
- Relocate or improve the upper settling basins
- Increase groundwater recharge from the existing 18 cfs to 32 cfs to maximize use of existing water rights and improve groundwater basin conditions
- Utilize the JPL parking lot for sediment removal and/or additional spreading grounds.
- Create a multiple benefit project
- Enhance habitat and species recovery
- Create wildlife corridor
- Design spreading areas that are aligned with alluvial fan geomorphology and Riversidian alluvial scrub habitat
- Coordinate with LACDPW sediment management activities
- Improve spreading area and facilities operations and maintenance
- Minimize environmental impacts to habitat and species through integrated watershed design, thereby creating net benefits to habitat and species (e.g., aligning with resource agencies to facilitate permitting process)

Specific site opportunities that should be considered when planning and designing for multi-use facilities in the HWP include:

- Improve spreading area and facilities operations and maintenance
- The potential exists to expand the spreading grounds throughout the flood prone area behind the dam; however, this approach will require active sediment management that could disrupt habitat and recreational facilities. Design analysis should be undertaken to develop a sediment depositional zone in the location identified in the PWA study as Area 2 as indicated in Figure 3-1, adjacent to the existing spreading ground ponds and downstream of the JPL bridge. This area currently supports what appears to be a braided channel morphology, and, as identified in the PWA report, an area of coastal sage scrub, an ecosystem that has the potential for high levels of species diversity. The coastal sage scrub is considered an endangered ecosystem that contains a number of endangered species and is listed as an Endemic Bird Area. In particular, the California gnatcatcher (*Polioptila californica*) is currently being used as an umbrella species to protect the endemic flora and fauna of this region from urban development. The coastal sage scrub eco-region is associated with riparian lands and oak woodlands, both of which have been identified in the HWP. Needless to say, a challenge exists between preserving valuable existing habitats and properly managing sediment deposition in such a way that ecological and environmental disruptions are minimized.
- Coastal sage scrub communities could be preserved and encouraged around flood and sediment inundation zones as well as in the riparian corridor between Areas 1 and 2 as indicated in Figure 3-1 and as identified in the PWA study. These communities could be interspersed or associated with oak woodlands communities. An oak grove currently exists on the terrace above the flood prone area. Oak could be encouraged in areas of low recurrence interval flooding (50-year and capital flood inundation zones); perhaps oak groves or savannahs interspersed amongst sage scrub.
- The PWA study identifies an intermittent water feature near the dam, in the vicinity of sediment Area 1. This feature is intermittent because it will fill in response to runoff events, drying up between events. Typically, one would expect the feature to contain water during the wet season (October through May) and dry during the summer months, depending on the weather. This feature can be expected to fill with sediment and debris over time that will require mechanical removal. PWA has recommended that the removal be based on a designated fill elevation as opposed to regularly scheduled excavation. This approach could result in fewer removal events with a lower impact on surrounding vegetation and habitat. However, during wet cycles, it may also result in more excavation events, which would probably be necessary anyway. A review of 2007 GoogleEarth™ aerial imagery indicates the presence of an open water body near the dam, adjacent to Oak Grove Drive. This location is near that described in the PWA report and could be improved to provide recreational and habitat benefits.

Figure4-1 Open Water Pool October, 2007

Constraints identified to date are:

- Providing sufficient conveyance area for high flow events and sediment deposition within the spreading grounds area.
- Designing and permitting potential facility improvements such that appropriate operations and maintenance activities do not present future environmental or jurisdictional challenges or threaten the ability to maintain a 32 cfs infiltration rate.
- Recognizing that areas subjected to high rates of sediment deposition will also experience high rates of disruption as vegetation is inundated and covered. This process can be viewed as one that naturally occurs in alluvial fan environments. Therefore, a potential approach to enhance sediment management is to set aside Area 2 as a depositional zone, alluvial fan remnant, with the expectation that it will be regularly inundated and experience periodic depositional episodes. This area could be adequately sized as a sediment trap forebay to not only the spreading basins, but also the dam flood storage/water conservation pool. Care must be taken that the spreading ground increase proposed in the Master Plan is adequately protected from Area 2 sediment and inundation.
- Providing capability for active sediment management and removal. Suspended sediment in flood flows will be deposited within the flood prone area of the park below the JPL bridge. Depending on the size of the flow and headwater catchment area conditions, such deposition can be considerable, inundating and damaging improvements in the flood prone area. Ideally, this area should be left unimproved, evolving naturally as sediment moves through the system. However, the need to provide

water supply augmentation means that the system will have to be manipulated by mechanical removal of deposited sediment to maintain infiltration rates.

- Coordinating with the LACDPW's sediment removal project, which will likely not be completed until after this project, in order to minimize potential conflicts related to timing, permitting activity delays, and unknown design features of sediment removal project.
- Avoiding existing soil and groundwater contamination. Construction activities associated with increasing spreading capacity may potentially expose contaminated materials if they involve excavation below elevation 1040.5 feet above mean sea level The extent of soils and groundwater contamination will be a design constraint.
- Coordinating with other planned/proposed projects. Recreational activities proposed by City of Pasadena, Department of Parks and Recreation within HWP may limit the design footprint of the project.

Section 5
Alternatives Analysis

This section describes the Upper Arroyo Seco Watershed Integrated Spreading Grounds, Stream, and Habitat Enhancement Conceptual Design Project alternatives development process, including initial concepts, Proposition 84 grant funding requirements, and three preliminary alternatives which were then generated through an alternatives refinement process. These three alternatives consist of two stand alone alternatives that are feasible within the current funding vehicle, though they are unable to address all stated project objectives. The third, preferred, alternative, presents a long-term strategy capable of satisfying the stated project objectives, the first phase of which could be implemented within currently available Proposition 84 grant funds.

5.1 Project Objectives

Project objectives that guided the development of project alternatives include:

- **Diversion Facilities**

  Improve the water diversion facilities to increase the capacity (18 cfs to 32 cfs) and reliability of the diversion and conveyance system and allow for additional storage and diversion of flood waters while enhancing habitat, recreation, and open space.

- **Spreading Facilities**

  Improve water spreading facilities to increase the capacity (18 cfs to 32 cfs) and reliability of the system.

- **Fish Passage**

  Provide passage for fish that may migrate through the diversion structures.

- **Sediment Management**

  Increase the geomorphic stability of the Arroyo channel by restoring its natural transport capacity and increase the ability of the diversion facility to transport sediment through the system.

- **Alluvial Fan Scrub Habitat Restoration**

  Restore rare alluvial fan scrub and other native plant communities.

- **Invasive Species Management**

  Monitor and remove invasive flora within the Project Area

- **Stream Habitat Restoration**

  Restore degraded or altered reaches of the Arroyo with in-stream habitat elements that provide shelter, rearing, and foraging areas for all life stages of native fish and wildlife.

- **Recreation**

  Construct trail improvements to provide public access to reaches of the Arroyo riverine corridor that have been restricted due to fencing.

- **Public Education**

  Provide educational signage to inform the public regarding trails, natural resources, cultural/historic resources, water supply, sediment management, and other related watershed topics.

5.2 Alternatives Development

This section describes the two components of alternatives development, Initial Concept Development - Initial Concepts prior to Proposition 84 Grant Funding requirements and Alternatives Refinement – preliminary alternatives in consideration of Proposition 84 Grant Funding opportunities leading to a recommended alternative.

5.2.1 Initial Concept Development

Three initial concepts were developed that address issues associated with existing and proposed facilities as well as planning vision for areas affected by both the existing and proposed settling, diversion and spreading facilities, as identified in previous studies. These concepts were intended to provide a broad spectrum of possible improvements that were certain to provide at least 32 cfs of diversion and infiltration capacity, better manage sediment and natural resources (e.g., biological and water resources), and provide education and enhanced recreation opportunities in the project area, as described in the project objectives.

Initial Concept A: Rehabilitate/Expand Existing Facilities.

This initial concept proposed to leave all existing facilities in-place and provide improvements that would restore the capacity and function of the Upper Arroyo Seco Headworks and Settling Ponds to their pre-2009 (i.e., Station Fire) condition as well as to improve the capacity of the Arroyo Seco and Millard diversion structures in order to fully capture their allocated flows (25 cfs for Arroyo Seco and 7 cfs for Millard). Additional spreading facilities would be constructed based on locations previously proposed in the HWMP, including the west side ponds and ponds in the JPL parking lot location. Aquatic, riparian and uplands habitat would be preserved to the maximum extent possible, as would channel conveyance and existing sediment transport characteristics and recreational features.

Initial Concept B: Consolidate Settling, Diversion, and Spreading Facilities

This initial concept would consolidate the sediment settling, water diversion and spreading ground facilities near the northern boundary of the Hahamongna Watershed Park within or adjacent to the Arroyo Seco corridor and in the general vicinity of the JPL bridge. The new settling basins would function

as a sediment forebay to the Devil's Gate Dam flood pool and be designed to allow maintenance access for excavators, loaders and dump trucks to avoid jurisdictional issues. The spreading grounds would be increased to include the west and JPL parking lot basins described in the Pasadena WIRP. Included in this concept is the restoration of the existing settling basin and diversion facility locations to a natural condition, including removal of existing fish passage barriers.

Initial Concept C: Consolidate Settling, Diversion, and Spreading Facilities; Reconfigure Spreading Facilities to Provide More Natural Landscape in HWP

This final initial concept proposed, similar to Alternative B, that all facilities would be consolidated near the north boundary of HWP and JPL Bridge. However, the existing spreading basins would be reconfigured to fit more appropriately with a naturalized Arroyo Seco riverine corridor and Devil's Gate Dam flood pool as envisioned in the HWMP. The basins would still be designed to allow periodic maintenance and operations while minimizing jurisdictional issues or mitigation requirements. Habitat features and recreational opportunities around the basins would be coordinated with permitting agencies and Pasadena Recreation and Parks staff to create multiple benefits. Also included in this concept is the restoration of the existing settling basin and diversion facility locations to a natural condition, including removal of existing fish passage barriers.

5.2.2 Proposition 84 Grant Funding Opportunities

PWP, ASF, and Pasadena Recreation and Parks received notification of a Proposition 84 Grant Funding Award through the Department of Water Resources (DWR) Round 1 Proposal Solicitation. The funding award was reduced by DWR, resulting in discussion amongst grantees over grant scope, budget, and schedule. Although the proposed Initial Concepts A, B, and C would achieve many of the stated project objectives, the solutions proposed exceed the scope of the awarded Proposition 84 Round 1 funding vehicle. Proposition 84 grant funding issues include:

- **Total Funds Needed Versus Funding Award**

  Rehabilitation or removal of the current facilities and the implementation of a new diversion, sediment management, and spreading facilities, as suggested in the Initial Concepts would cost on the order of $10-20 million, while the awarded funds are roughly $2 million.

- **Project Timeline**

  The Initial Concepts all propose to utilize the entire existing JPL parking lot footprint, either for sediment management or spreading facilities, or both. Based on best available information, the JPL lot will not be available until 2014, or possibly later. Additionally, sediment management opportunities would best be coordinated with a long-term sediment management plan that is now underway and being lead by the County of Los Angeles. The currently awarded funds target a construction completion date five years from contract execution or approximately 2016. This uncertainty of the JPL parking lot availability and the County planning process affects project planning and implementation.

The Initial Concepts have been revised to maximize the achievement of the project objectives given Proposition 84 grant funding opportunities. The resulting preliminary alternatives are described in the following section.

5.3 Alternatives Refinement

This section describes the Preliminary Alternatives that have been developed to achieve as many of the stated objectives as possible within the constraints and opportunities provided by the current funding vehicle. Three preliminary alternatives are presented hereafter:

- Preliminary Alternative 1: Relocate Existing Arroyo Seco Diversion Structure to Headworks Location
- Preliminary Alternative 2: Rehabilitate Existing Arroyo Seco Diversion
- Preliminary Alternative 3: Enhanced Alluvial Fan and Stream Restoration and Water Supply Repairs and Improvements

The first two preliminary alternatives presented are stand-alone alternatives that focus primarily on diversion facility improvements and habitat improvements, where possible. The third preliminary alternative presents an initial step towards a long-term sustainable strategy to implement projects which, when combined, will achieve the stated objectives of the Upper Hahamongna Basin Multi-Use Project.

5.3.1 Preliminary Alternative 1: Relocate Existing Arroyo Seco Diversion Structure to Headworks Location

Preliminary Alternative 1 proposes to provide diversion at the location of the current Upper Arroyo Seco Headworks and Settling Pond facility to divert 25 cfs in addition to providing sediment management, as illustrated in Figure 5-1. The diversion capacity implemented at this facility would replace the need for diversion at the current Arroyo Seco Diversion structure, which would be demolished. The Millard Diversion Dam would be rehabilitated to divert up to 7 cfs of flow.

The work on the proposed Upper Arroyo Seco Diversion structure would include utilizing one diversion pond as an infiltration gallery, possibly with a French drain, while the other pond would continue to be utilized for sediment management. The structure would also be retrofitted to prevent fish from entering either the sedimentation or diversion pond. The current 30-inch diversion conveyance pipeline runs from the existing Arroyo Seco Diversion structure down to the spreading basins. This pipe would need to be extended 1,500 ft upstream to link to the proposed infiltration gallery drain.

Included in this preliminary alternative is the demolition of the current Arroyo Seco Diversion structure, which would be replaced with habitat improvements. These improvements would include Alluvial Fan Scrub and native fish habitat improvements such as the removal of any existing fish passage barriers, as well as invasive species removal.

This alternative would utilize FEMA guidance and matching funds to address disrepair to the Millard Diversion Dam caused by the combination of the Station Fire and subsequent flooding. This would include increasing the dam crest elevation using a 5-foot deep x 20-foot wide dam, made of either removable wood flashboard slats or an inflatable structure armored with sheet metal. The intake structure bay would also need to be largely rebuilt and enhanced to minimize sediment and organic debris inflow. The 12-inch pipeline connecting the Millard Diversion Dam to the 30-inch diversion conveyance pipeline would also need to be rehabilitated in exposed, damaged sections, as well as in the location of the 90-degree plus junction with the 30-inch pipe.

Figure 5-1 Alternative 1

This alternative has multiple disadvantages. Access to the Arroyo Seco Headworks area is more difficult in comparison the other alternatives. As a result of the Station Fire, large materials and debris are still moving through the watershed and will impact facility improvements at the Headworks. From a regulatory agency perspective, DFG may have issues with the proposed Headworks improvements as this portion of the Arroyo Seco is considered the most connected section of the Arroyo Seco to native trout populations. Additionally, the alluvial fan scrub vegetation in the vicinity of the Headworks is protected by wildlife agencies. Finally, the existing conveyance pipeleine is aging resulting in a higher risk of failure.

This preliminary alternative also provides for all necessary debris and infill removal, design, CEQA, and permitting tasks.

5.3.2 Preliminary Alternative 2: Rehabilitate Existing Arroyo Seco Diversion

Preliminary Alternative 2 proposes to rehabilitate the current Arroyo Seco Diversion facility in order to provide 25 cfs of diversion capacity, as illustrated in Figure 5-2. In addition, this alternative proposes to replace the current Upper Arroyo Seco Headworks and Settling Pond facility with habitat improvements, and rehabilitate the Millard Diversion Dam to divert up to 7 cfs of flow.

The work on the Arroyo Seco Diversion structure would include increasing the 45 foot wide dam crest by 1 to 2 feet using an inflatable dam armored with sheet metal. Modifications to the current flashboard slat gate structures on the east and west side of the diversion, repairs to the diversion intake screen, and extensive debris and infill removal on both sides of the dam crest are also proposed.

This alternative also proposes to remove the wooden diversion structure at the Arroyo Seco Headworks and Settling Pond facility, leaving only the current middle channel and spillway structure. The entire area would be recontoured in order to reestablish Alluvial Fan Scrub vegetation and aquatic/riparian habitat improvements targeting native fish habitat improvements. The rehabilitation of this area would also include invasive species removal, where appropriate.

Finally, this alternative would also address the disrepair to the Millard Diversion Dam caused by the combination of the Station Fire and subsequent flooding. Again, utilizing FEMA guidance and matching funds, this alternative would include increasing the dam crest elevation using a 5 foot deep x 20 foot wide dam, made of either removable wood flashboard slats or an inflatable structure armored with sheet metal. The intake structure bay would also need to be largely rebuilt and enhanced to minimize sediment and organic debris inflow. The 12 inch pipeline connecting the Millard Diversion Dam to the 30 inch diversion conveyance pipeline would also need to be rehabilitated in exposed, damaged sections, as well as in the location of the 90-degree plus junction with the 30 inch pipe.

This alternative also provides for all necessary debris and infill removal, design, CEQA, and permitting tasks.

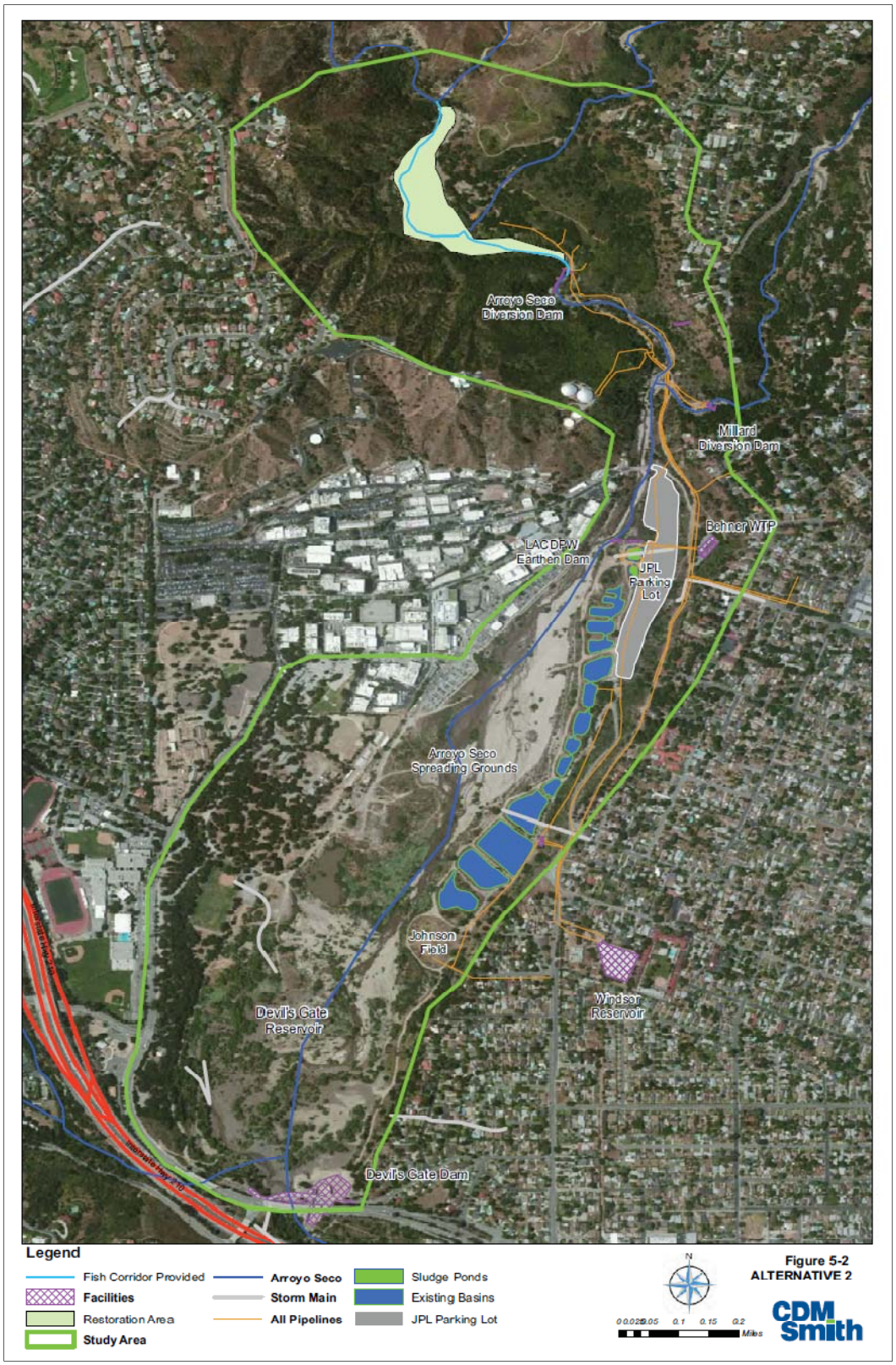

Figure5-2 Alternative 2

5.3.3 Preliminary Alternative 3 (Recommended Alternative): Enhanced Alluvial Fan and Stream Restoration and Water Supply Repairs and Improvements

In conjunction with Proposition 84 grant funding, the Hahamongna Basin Multi-Use Project can provide an excellent first step in achieving project objectives. Preliminary Alternative 3 recommends a long-term strategy that would achieve the objectives of the Project, as well as a phasing plan for implementation.

The Preferred Long-Term Strategy (Strategy) would achieve objectives related to diversion capacity, sediment management, spreading capacity, habitat improvement, and public recreation and education through consolidating sediment management and diversion structures, Arroyo Seco Canyon improvements, expanding spreading facilities, and improving public recreation and education. Figure 5-3 illustrates Preliminary Alternative 3.

Consolidate Sediment Management and Diversion Structures

This portion of the Strategy includes relocating the sediment retention capacities of the Upper Arroyo Seco Headworks and Settling Ponds and the diversion capabilities of the Arroyo Seco and Millard Diversion facilities to a consolidated facility downstream of the JPL Bridge. This facility would include a diversion structure at the location of the former LACDPW erodible dam, and a sediment forebay between this location and the JPL Bridge. This would simplify sediment management and maintenance activities by replacing scattered diversion and sedimentation facilities, presently located within the Arroyo Seco Canyon and accessed by canyon roads which are difficult to navigate and maintain, to a consolidated facility downstream of the mouth of the canyon.

Arroyo Seco Canyon Renaturalization

The proposed consolidated sediment management and diversion facilities would make the Upper Arroyo Seco Headworks and Settling Ponds, Arroyo Seco Diversion and Millard Diversion structures unnecessary. The Strategy proposes to completely demolish these structures, and demolish or abandon the half mile of pipelines currently necessary to support these structures. In their place, this Strategy proposes to rehabilitate the Arroyo Seco between the JPL Bridge and the upstream extent of the Upper Arroyo Seco Headworks and Settling Ponds with Alluvial Fan Scrub habitat, native fish habitat improvements, and invasive species removal. With these large structures removed and the areas rehabilitated, the Arroyo Seco Canyon would be largely pristine, connecting the pristine upper canyon with an additional mile migration corridor for aquatic organisms and other wildlife.

Expanding Spreading Facilities

The current spreading facilities within the HWP have the capacity to spread approximately 18 cfs of water diverted from the Arroyo Seco and Millard Creek. The proposed Strategy includes an additional 5 acres of spreading basins in the area of the current JPL parking lot, providing an additional 6.7 cfs of spreading capacity, as well as an additional 8 acres on the west side of the Arroyo, which would provide an additional 7.7 cfs of spreading capacity. The locations of these additional facilities were identified in the Pasadena WIRP and the HWPMP. Combined with the 18 cfs capacity of the existing basins, this would provide spreading capacity for the entire 32 cfs of the combined PWP and Lincoln Avenue Water Company diversion rights.

The new spreading facilities, as well as reconfiguration of the existing facilities would result in the facilities fitting more appropriately with a naturalized Arroyo Seco riverine corridor and Devil's Gate Dam flood pool as envisioned in the HWMP. The basins would still be designed to allow periodic maintenance and operations while avoiding jurisdictional issues or mitigation requirements, but additional effort would be made to incorporate habitat features around the basins.

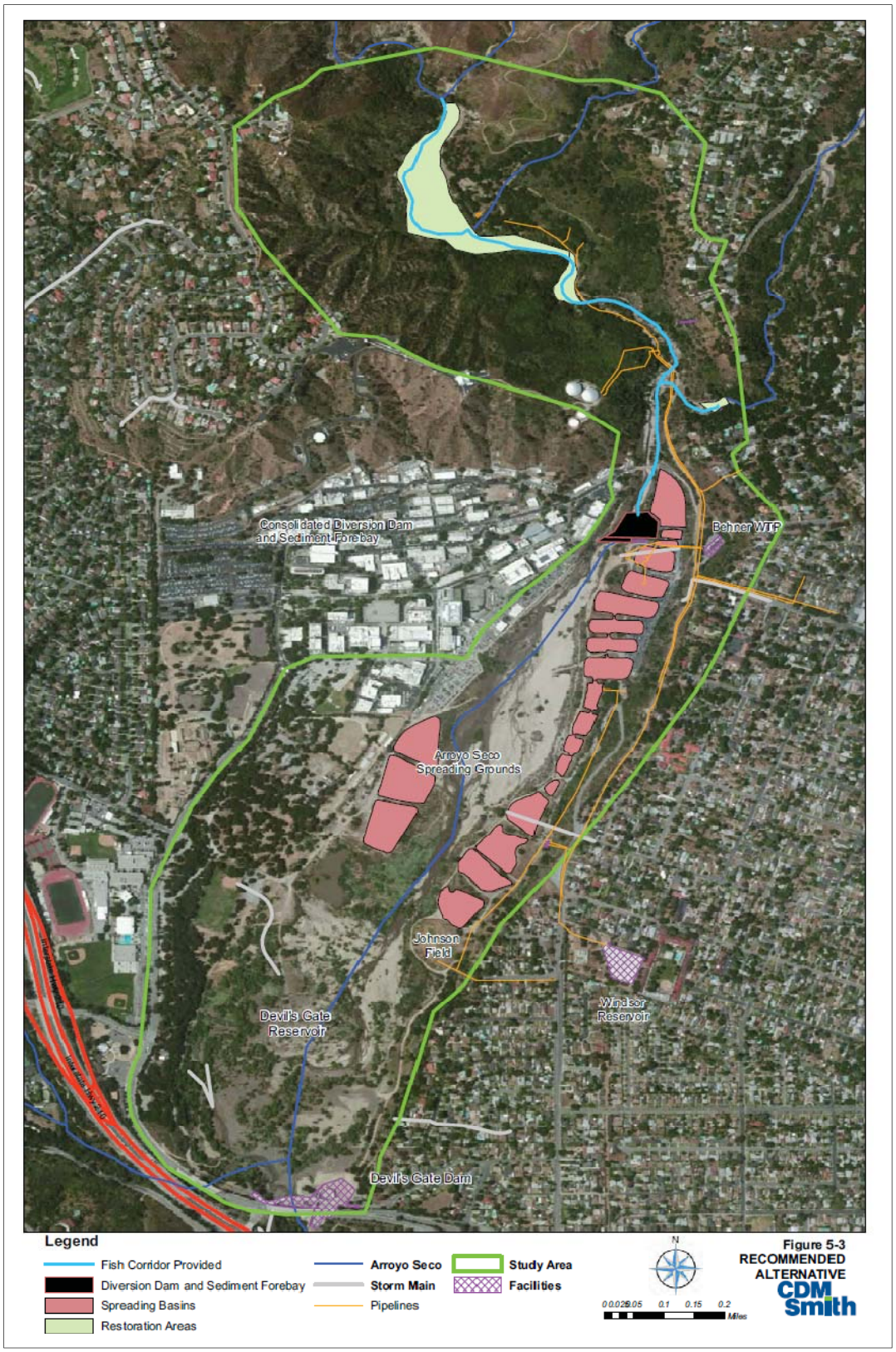

Figure5-3 Recommended Alternative

Improving Public Recreation and Education

In addition to providing a significant benefit to wildlife in the riverine corridor, this Strategy proposes to enhance public recreation and understanding of the ecosystem of the Upper Arroyo Seco Watershed, as well as the purpose and technologies used to utilize the valuable water resources of the Arroyo.

This Strategy proposes to add signage and a viewing area in the former location of the Upper Arroyo Headworks and Settling Ponds, convenient to the trailhead and near the Angeles National Forest campus. This interpretive kiosk would provide a gateway to the wilderness portion of the Arroyo.

Additional signage describing the methods of water diversion and spreading, and sediment management, as well as habitat-related signage would be located in another interpretive kiosk in the vicinity of the proposed spreading basins and consolidated diversion structure.

Finally, the Strategy includes providing a new trail to provide public access to reaches of the Arroyo riverine corridor that have been restricted due to fencing currently necessary for safety considerations in the vicinity of existing facilities.

While Alternative 3 is preferred over the other alternatives, currently available funds are inadequate to completely implement it all at the same time. To address this, a phasing plan has been developed that achieves significant portions of the objectives early on and also provides a mechanism to prepare the future phases for implementation readiness. These phases are described below.

Phase I: Proposition 84 Phase

This section describes the portion of the Recommended Alternative that would be accomplished through the Hahamongna Basin Multi-Use Project funding vehicle. This Phase would include near-term modifications to the Arroyo Seco Diversion structure to increase groundwater recharge and improve water supply, partial demolition of and habitat improvements near the Upper Arroyo Seco Headworks and Settling Ponds facility, and design and engineering tasks to support the implementation of the Preferred Long-Term Strategy.

Near-Term Implementation Tasks: Water Supply Reliability and Habitat Improvement

Phase I work on the Arroyo Seco Diversion structure would include increasing the 45 foot wide dam crest by 1 to 2 feet using removable flashboard slats. Modifications to the current flashboard slat gate structure on the east side of the diversion, diversion intake screen, and extensive debris and infill removal on both sides of the dam crest are also proposed. Historic photographs indicate that a flashboard structure atop the concrete portion of the dam is consistent with the original dam configuration and operations.

Proposed work in the area of the Upper Arroyo Seco Headworks and Settling Pond would include removal of the entire wooden diversion structure and recontouring the former settling pond area to reestablish Alluvial Fan Scrub vegetation and encourage healthy stream morphology in the area.

The bulk of the improvements implemented in Phase I would include habitat improvements between the current Upper Arroyo Seco Headworks and Settling Pond facility and the improved Arroyo Seco Diversion structure. Improvements would include invasive species removal, introduction of specific salmonid habitat improvement options such as a stable channel slope with riffles and runs, and pools, and large woody debris and overhanging banks to provide cover.

This portion of the work also provides for all necessary debris and infill removal, design, CEQA, and permitting to accomplish these tasks.

Design and Engineering Tasks to Support Long-Term Implementation

The second major area of focus in Phase I is to provide the necessary design and engineering tasks to support continued implementation of the Preferred Long-Term Strategy. This includes designing the consolidated diversion and sedimentation facility and the extended spreading facilities, completion of removal of the Upper Arroyo Seco Headworks, and removal of the Arroyo Seco and Millard Diversion facilities. In addition, this design and planning would include the additional rehabilitation of the Arroyo Seco within the Arroyo Seco Canyon and additional public recreation and educational facilities.

This task also includes coordination with, but not limited to, the following stakeholders:

- PWP on water supply optimization,
- LACDPW on sediment management plans currently in development,
- Hahamongna Watershed Master Planning process on the Strategy as a whole,
- Pasadena Parks and Recreation Department on signage and trail design,
- JPL regarding plans for vacating the current parking lot, and implementing their future parking structure, and
- Coordination other public, private, and non-profit stakeholders.

Future Phases

Future phases required to implement the strategy are based on the anticipated availability of grant funding and summarized in Table 5-1. This phasing approach is intended primarily for illustration purposes; actual phasing is flexible and can be modified to fit within available funding opportunities.

Table 5-1 Future Phasing of the Enhanced Alluvial Fan and Stream Restoration and Waters Supply Repairs and Improvements Preliminary Alternative

Task	Phase			
	II	III	IV	V
Short-Term Rehabilitation of Millard Diversion Dam	X			
Demolish JPL Parking Lot	X			
Construct expanded spreading facilities on the east side of the Arroyo	X			
Construct sedimentation forebay above old LACDPW diversion location		X		
Construct diversion structure at old LACDPW diversion location		X		
Construct west side spreading facilities			X	
Construct Trails and Interpretive Signage around Improvements in Hahamongna Watershed Park			X	
Millard Diversion Dam ▪ Demolish facility ▪ Construct Habitat Improvements ▪ Remove Invasive Species				X
Arroyo Seco Diversion facility ▪ Demolish facility ▪ Construct Habitat Improvements ▪ Remove Invasive Species ▪ Construct Trails and Safety Rails				X
Demolish portions of the existing diversion pipelines				X

Table 5-2 summarizes the elements of each of the preliminary alternatives and provides an initial cost estimate for each. Further cost estimate detail is provided in Appendix C.

Table 5-2 Preliminary Alternative Summary and Estimated Costs

Major Improvement Location	Alternative 1 Relocate Existing Arroyo Seco Diversion Structure to Headworks	Alternative 2 Rehabilitate Existing Arroyo Seco Diversion	Recommended Alternative (Phase I) Enhanced Alluvial Fan and Stream Restoration and Water Supply Repairs and Improvements	Proposition 84 Grant Submittal
Arroyo Seco Diversion Structure	▪ Remove Arroyo Seco Diversion Structure ▪ Restore channel in area of the diversion structure	▪ Increase dam crest using an inflatable dam ▪ Repair/ replace existing diversion inlet screen, and excavate infill	▪ Near-term modifications to increase dam crest 1-2 feet using removable wooden flashboard slats ▪ Repair/replace existing diversion inlet screen and excavate infill	▪ Increase dam crest 1-2 feet using removable wooden flashboard slats ▪ Repair/replace existing diversion inlet screen and excavate infill
Arroyo Seco Headworks and Settling Ponds	▪ One pond converted from settling to infiltration gallery with French drain ▪ Retrofit diversion structure to prevent fish from entering infiltration pond	▪ Remove wooden diversion structure ▪ Recontour former settling pond area and reestablish Alluvial Fan Scrub vegetation	▪ Remove wooden diversion structure ▪ Recontour former settling pond area and reestablish Alluvial Fan Scrub vegetation	▪ Remove wooden diversion structure ▪ Recontour former settling pond area and reestablish Alluvial Fan Scrub vegetation
Millard Diversion Structure	▪ Repair conveyance pipeline ▪ Excavate infill at upstream of crest ▪ Increase dam crest elevation ▪ Rebuild diversion intake structure ▪ Clear flood debris	▪ Repair conveyance pipeline ▪ Excavate infill at upstream of crest ▪ Increase dam crest elevation ▪ Rebuild diversion intake structure ▪ Clear flood debris	▪ None	▪ None
Conveyance Improvements	▪ Extend pipeline from infiltration gallery to junction box at Arroyo Seco Diversion (~1,500 ft) ▪ Reinforce channel crossings	▪ Reinforce channel crossings	▪ None	▪ None
Fish Passage	▪ From Arroyo Seco Headworks to JPL Bridge	▪ Discrete segments from Arroyo Seco Headworks to Diversion Structure	▪ From JPL Bridge to, and including, existing Arroyo Seco Headworks area	▪ From upstream of Arroyo Seco Diversion to existing Arroyo Seco Headworks
Est. Budget[a]	$2.82 million[b]	$5.35 million	$4.24 million	$2.85 million

[a] Includes design, CEQA, and permitting tasks.

[b] Budget estimate includes design, CEQA and permitting tasks for Phase I as well as the combined sedimentation and diversion facilities at the site of the former LACDPW earthen dam, as well as expanded, nature-like spreading facilities on the east and west side of Arroyo Seco.

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Appendix A
References

Appendix A
References

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Appendix B
Datalog

Appendix B
Datalog

City of Pasadena
Water and Power Department
Municipal Services
100 N. Garfield Ave., Room N106
P.O. Box 7120
Pasadena, CA 91109-7220

Upper Arroyo Seco Watershed Integrated Spreading Grounds, Stream and Habitat Enhancement Conceptual Design
Data Log

Updated: 25-Aug-11

DataType	CDM Location	File Name	Description	Source
		GIS Data		
Utilities	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Storm Drains	Multiple files	2009 Storm drain network	LA County Department of Public Works
Transportation	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Roads	Pasadena_Roads.shp	Local Roads	City of Pasadena
Transportation	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Roads	Pasadena_Major_Roads.shp	Major Roads	City of Pasadena
Hydrography	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Hydrology	Arroyo_Seco_Flowlines.shp	Rivers/Streams/Channels into Arroyo Seco	California National Hydrology Dataset, 2010
Land Use	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Land Use	Arroyo Seco Land Use.shp	2005 Land Use	Southern California Association of Governments
Soils	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Soils	Soils_2004.shp	2004 soils map	Natural Resources Conservation Service (NRCS)
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Hydrology	Arroyo_Seco_Watershed.shp	2008 NPDES Subwatersheds	Los Anglese County
Topography	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\\GIS Data\Digital Elevation Map	Arroyo Seco DEM.img	Digital Elevation Model (DEM)	US Geological Survey (USGS)
		Flow Data		
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Project Data	Arroyo Seco Consolidated Flow Data.xlsx	Diversion and Spreading in Arroyo Seco and Eaton Spreading Grounds	RBMB
	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Project Data	Arroyo Seco Consolidated Flow Data.xlsx	Arroyo Seco Flow Data	LACDPW
	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Project Data	Arroyo Seco Consolidated Flow Data.xlsx	Arroyo Seco near Pasadena USGS Gauge 11098000	USGS
	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Project Data	Rainfall Devil's Gate Raw.xlsx	Devil's Gate Dam Precipitation	LACDPW
		Documents		
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents	AS_Water_Budget.pdf	Arroyo Seco Water Budget	PWP
Land Use	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents	Hahamongna Watershed Master Plan.pdf	Existing and proposed spreading ground locations	PWP
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents	RB Area Spreading Methodology.pdf	Raymond Basin Area Spreading Methodology	PWP
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents\Pasadena WIRP	Pasadena WIRP Document_Final.pdf	Pasadena Water and Power WIRP	CDM
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents\Pasadena WIRP	A_Arroyo Seco 5.pdf	Pasadena Water and Power WIRP Arroyo Seco Factsheet	CDM
		Models		
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Project Data	Surface Runoff Options3.xlsx	Surface Water Flow Model for Arroyo Seco. Developed for Pasadena Water Integrated Resources Plan (WIRP)	CDM
		Correspondance		
Hydrology	\\lossvr01\projects\Pasadena23698\Upper Arroyo Seco Conceptual Design\Documents\Spreading Ground Capacities	Multiple files	Arroyo Seco Spreading Ground capacities	PWP

Notes: PWP - Pasadena Water and Power Department
RBMB - Raymond Basin Management Board
CDM - Camp Dresser & McKee Inc.
LACDPW- Los Anglese Department of Public Works
USGS - US Geological Survey

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